MOHAVE GROUND SQUIRREL RESEARCH AND MONITORING PROGRAM

MOHAVE GROUND SQUIRREL TRAPPING SURVEYS IN THE SPANGLER HILLS OHV OPEN AREA AND THE WESTERN RAND MOUNTAINS ACEC

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ABSTRACT

The current status of the state-listed Mohave ground squirrel (*Xerospermophilus* [=*Spermophilus*] *mohavensis*) was investigated in 2 large blocks of public land in the western Mojave Desert of California. Live-trapping surveys were carried out during April 2002 at 2 study sites in the Spangler Hills Off-Highway Vehicle Open Area and during May-June 2003 at 4 sites in the Western Rand Mountains Area of Critical Environmental Concern. No Mohave ground squirrels were captured or observed during 3,000 trap-days. However, white-tailed antelope squirrels (*Ammospermophilus leucurus*) were present at all study sites. Shrub vegetation was sampled by a belt transect technique. The natural communities at all study sites were dominated by creosote bush (*Larrea tridentata*). The lack of Mohave ground squirrel captures and the almost complete absence of previous records in these 2 areas suggest that the species may not be present. The scarcity of important food resources such as chenopod shrubs and a diverse assemblage of native forbs could limit habitat suitability. The region in which these 2 public land units are located should serve as a connection between important Mohave ground squirrel populations to the north and south. However, the possible absence of Mohave ground squirrels here may restrict the potential for dispersal and gene flow through this region. Further studies are needed to fully evaluate the potential for habitat corridors and to inform management decisions in this critical portion of the Mohave ground squirrel range.

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INTRODUCTION

The Mohave ground squirrel (*Xerospermophilus* [=*Spermophilus*] *mohavensis*) is listed as Threatened by the State of California. Current information on its status range-wide is urgently needed to plan conservation and management actions. This report describes trapping surveys that were conducted in the western Mojave Desert on public lands administered by the U.S. Bureau of Land Management (BLM) and the California Department of Fish and Game (DFG). These studies were carried out during April 2002 in the Spangler Hills Off-Highway Vehicle (OHV) Open Area and during May-June 2003 in the Western Rand Mountains Area of Critical Environmental Concern (ACEC).

The Spangler Hills Open Area was established by the BLM in 1980 under the California Desert Conservation Area Plan (CDCA Plan) to provide opportunities for dispersed OHV recreation. Motorized vehicles may travel anywhere within such open areas and are not limited to designated routes. The Spangler Hills Open Area includes 25,123 hectares (62,080 acres) of desert terrain located southeast of Ridgecrest. Almost all of the area is public land administered by BLM, although it includes 259 hectares (640 acres) of state lands and about 182 hectares (450 acres) of private lands.

The Western Rand Mountains ACEC was established by the BLM in 1980 through the CDCA Plan and comprises 7,325 hectares (17,877 acres) managed primarily for protection of the desert tortoise (*Gopherus agassizii*) and its habitat. This ACEC lies within the Rand Mountains-Fremont Valley Management Area, which includes a total of 26,313 hectares (65,020 acres) and is administered by the BLM with the primary objective of ensuring a viable desert tortoise population. The DFG manages the Rand Mountains Unit of the Fremont Valley Ecological Reserve, which is a 259-hectare (640-acre**)** block of state land entirely within the boundaries of the ACEC. In 1993, the BLM developed a management plan for the entire Rand Mountains-Fremont Valley area, including the ACEC. The Management Area had been heavily used for OHV recreation for several decades and there were over 1,127 km (700 mi) of designated routes at the time the Plan came into effect. The Plan called for closure of about 90% of OHV routes within the ACEC, leaving ~47 km (~29 mi) of designated routes open for OHV use. In recent years, a high incidence of non-compliance with the route network resulted in legal action by various private conservation groups. As a result, BLM agreed to implement an interim vehicle closure of the ~47 km route network in order to further protect the desert tortoise and its habitat. This interim measure was terminated with the Record of Decision on the West Mojave Plan, but an administrative vehicle closure will be maintained pending the completion of work needed to implement the educational program and permit system for recreational users of the Western Rand Mountains ACEC (U.S. Bureau of Land Management 2006).

It is important to determine the current status of the Mohave ground squirrel in the Spangler Hills Open Area and Western Rand Mountains ACEC because these public lands are located in a region that may provide connections between northern and southern populations of this species. The purpose of the trapping surveys described in this report was to determine whether Mohave ground squirrel populations were present in these 2

areas and, if so, to collect data on their demographic characteristics, e.g. abundance, spatial distribution, and sex and age structure. Following the recommendations of Brooks and Matchett (2002), detailed information on trapping protocol, weather parameters, and site characteristics are included in this report. The results of this study should assist the BLM and DFG in developing a conservation strategy for the Mohave ground squirrel.

METHODS

STUDY SITES

Six sites were selected for trapping surveys, 2 in the Spangler Hills Open Area and 4 in the Western Rand Mountains ACEC (Figure 1). Table 1 presents the location and elevation of each trapping grid.

Site selection was accomplished by driving through the Spangler Hills Open Area and Western Rand Mountains ACEC on established routes and visually assessing key habitat characteristics. The most important criteria were presence of alluvial soils, vegetation cover and species richness, adequate spatial sampling, and the practical consideration of vehicular access. In the Spangler Hills Open Area, the 2 sites selected represented the most suitable habitat in each of the major physiographic units, the Spangler Hills and Teagle Wash. In the Western Rand Mountains ACEC, 3 sites were dispersed geographically to sample the extensive bajada (alluvial apron) on the north slope of the Rand Mountains, while the 4th site was located to the south near the crest of the mountains. A description of the 6 study sites is provided below.

Table 1. A list of the 6 trapping grids used during surveys in the Spangler Hills Open Area in April 2002 and in the Western Rand Mountains ACEC in May-June 2003, with a legal description, UTM coordinates at grid center, and elevation for each site.

Grid name	Legal description	UTM coordinates (Zone 11, NAD83)	Elevation	
			Meters	Feet
Spangler Hills Open Area				
Racetrack	NW1/4 Section 15, T 28 S, R 41 E	450300E; 3928900N	790	2600
Charlies Place	SW1/4 Section 21, T 27 S, R 41 E	448200E; 3937000N	940	3080
Western Rand Mountains ACEC				
Fremont Valley Route R43	W1/2 Section 2, T 30 S, R 39 E	430200E; 3912345N	720	2360
Fremont Valley Route R50 East	SE1/4 Section 10 & NE1/4 Section 15, T 30 S, R 39 E	429470E; 3909860N	760	2490
Fremont Valley Route R50 West	SE1/4 Section 17, T 30 S, R 39 E	426410E; 3908755N	690	2265
Rand Mountains Route R37	W1/2 Section 25, T 30 S, R 39 E	431420E; 3905780N	1120	3675

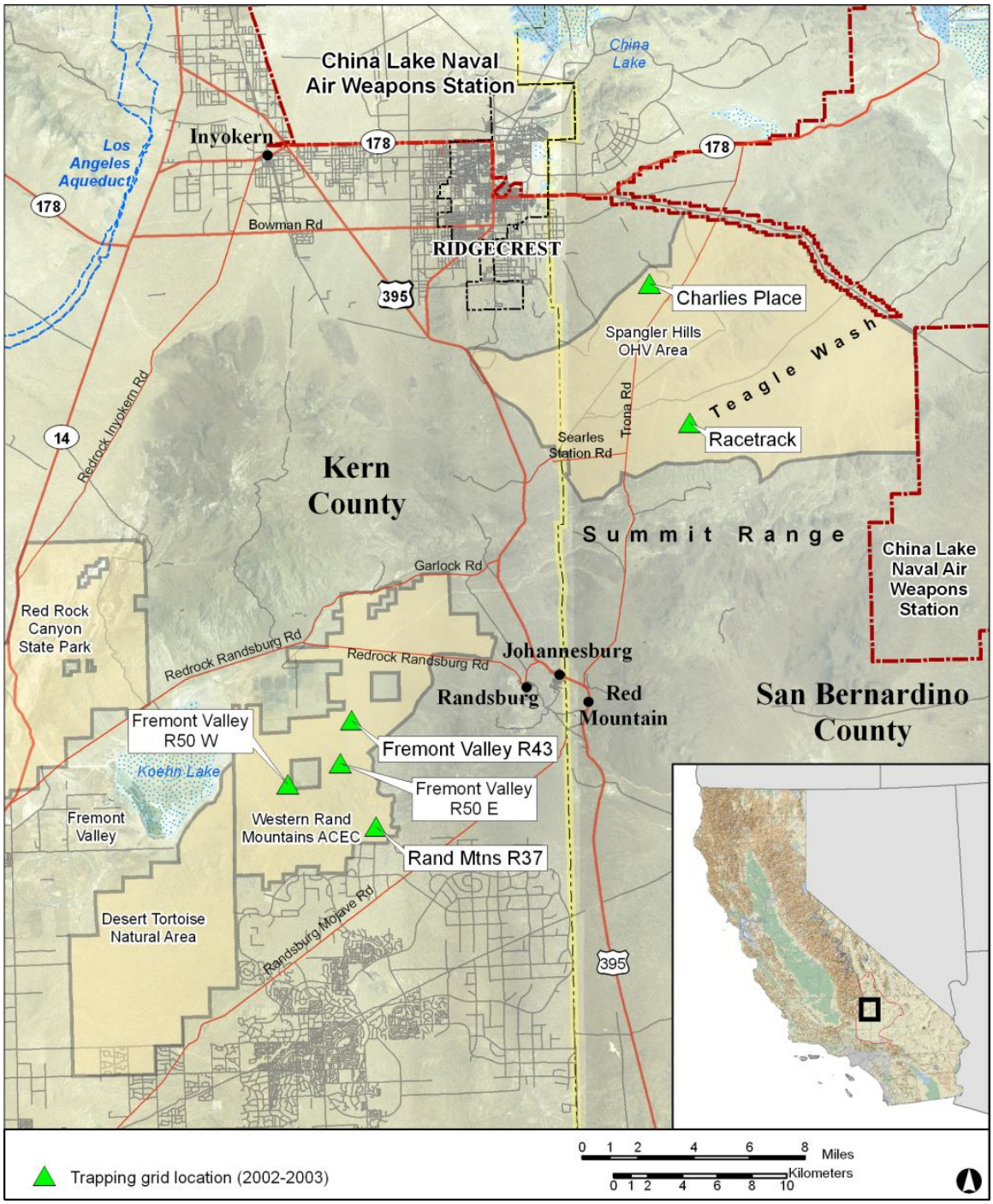

Figure 1. The locations of 6 trapping grids in the Spangler Hills Open Area and in the Western Rand Mountains ACEC.

Racetrack

This site was located on the upper reaches of Teagle Wash in the southern portion of the Spangler Hills Open Area. Small tributary washes with sandy substrate crossed the trapping grid. The dominant shrubs were creosote bush (*Larrea tridentata*) and white

bursage (*Ambrosia dumosa*), with bladder sage (*Salazaria mexicana*) and cheesebush (*Hymenoclea salsola*) in the washes. Some spiny hopsage (*Grayia spinosa*) and Anderson's boxthorn (*Lycium andersonii*) were also present in the vicinity of small washes. There were OHV camping and play areas about 0.4 km (0.25 mi) north of the site, but there was little disturbance within the grid itself except for a narrow dirt track.

Charlies Place

This site was in the northern portion of the Spangler Hills Open Area about 1.6 km (1 mi) west of the Charlies Place OHV camping area. The trapping grid was located south of and parallel to Jarvis Road on a broad wash that drains northwest toward Ridgecrest. The shrub vegetation was fairly diverse, with creosote bush and white bursage as the dominants. Cheesebush, spiny hopsage, and Anderson's boxthorn were important subdominants. There was very little surface disturbance within the grid due to OHV use.

Fremont Valley Route R43

Located in the northeastern corner of the Western Rand Mountains ACEC, this site was parallel to and just to the west of Route R43. It was about midway down the broad bajada that slopes northward from the base of the Rand Mountains. The shrub community here was characterized by low species richness and was heavily dominated by creosote bush and white bursage. Two small washes ran through the trapping grid. There was very little surface disturbance due to OHV use.

Fremont Valley Route R50 East

This site was situated in the Western Rand Mountains ACEC, on alluvial soils near the upper edge of the bajada. The steep, rocky slopes of the Rand Mountains begin to rise about 0.5 km (0.3 mi) to the south. The trapping grid ran parallel to and just downslope from Route R50. Shrub vegetation was almost completely made up of creosote bush with white bursage as the only other shrub species present. There was very little surface disturbance due to OHV use.

Fremont Valley Route R50 West

Located in the western portion of the Western Rand Mountains ACEC, this trapping grid crossed over Route R50 and its eastern end was very close to the western boundary of the Fremont Valley Ecological Reserve. Like the Fremont Valley Route R50 East site, it was on alluvial soils near the upper edge of the bajada and just downslope from the point where the steep slopes of the Rand Mountains began. The shrub community here was very strongly dominated by creosote bush. There was very little sign of OHV use.

Rand Mountains Route R37

This site was situated near the southern boundary of the Western Rand Mountains ACEC, about 0.8 km (0.5 mi) to the east of Route R37. The trapping grid had a north-south orientation, running along the side of a small valley that drained toward the extensive alluvial slopes on the south side of the Rand Mountains. The vegetation at this higher

elevation site was dominated by creosote bush with Cooper's goldenbush (*Ericameria cooperi*) as the most important subdominant. There was very little surface disturbance due to OHV use.

TRAPPING PROCEDURES

The trapping grids were rectangular, measuring 105 x 840 m. On each grid, 100 trap stations were established in 4 parallel lines of 25 stations each. The 4 lines of trap stations were spaced 35 m apart and the stations in each line were placed at 35-m intervals. Field personnel set up the grids and placed the trap stations using handheld GPS units. Each of the 4 lines of traps was given a letter designation (A-D). The trap stations in each of the lettered lines were assigned sequential numbers from 1 to 25 and marked with wire flags bearing the appropriate station number. A single Pymatuning live trap (10 x 10.5 x 39 cm) was placed near each trap station. Cardboard covers were used to shade traps and protect captured animals from the heat.

The 4 x 25 rectangular grids covered an area of about 8.8 ha. However, Mohave ground squirrels often move as much as 50 m during daily foraging activities, so animals with home range centers up to 50 m from the outer edges of the grid could encounter the outer traps. If a boundary strip of 50 m is assumed, each grid sampled an area of about 19 ha.

Traps were baited with a commercial livestock feed consisting of mixed grain (rolled oats, rolled barley, and cracked corn) coated with molasses. A powdered mixture of rolled oats and peanut butter was added, providing an odor cue to attract ground squirrels. During the Spangler Hills survey in April 2002, traps were pre-baited for 2 days and this was followed by 5 consecutive days of trapping. Traps were opened in the morning between 0800 and 0900 hours and closed in the afternoon between 1600 and 1700 hours, so that trapping was conducted for an average of 8 hours/day. Trap checks were conducted twice each day, between 1130 and 1300 hours and again when traps were closed in late afternoon. During the Western Rand Mountains survey in 2003, trapping was conducted for 5 consecutive days with no pre-baiting. In May 2003, traps on the 3 Fremont Valley grids were opened for an average of 8.4 hours/day. Trap checks were carried out between 1100 and 1400 hours and again when traps were closed in late afternoon. Temperatures were higher during trapping at the Rand Mountains Route R37 grid in June 2003, requiring that traps be opened and closed earlier and reducing the trapping period to an average of 5.75 hours/day. On this grid, traps were opened between 0600 and 0800 hours and closed between 1100 and 1400 hours. Traps were checked once, when they were closed for the day.

All animals captured were identified to species, sex, and age class (adult/juvenile). Juvenile ground squirrels were recognized by their small size, short pelage, and lack of evidence of reproductive activity, such as scrotum or previous lactation. Reproductive condition in adult male ground squirrels was based on position of the testes (scrotal/abdominal). Adult females were examined for signs of pregnancy or lactation. White-tailed antelope squirrels (*Ammospermophilus leucurus*) were marked on the ventral surface with a colored felt-tip pen so that they could be recognized as recaptures if trapped later in the sampling period. By using this marking system, the total number of individual white-tailed antelope squirrels captured on a trapping grid could be determined. The study protocol specified that any Mohave ground squirrels captured

would be permanently marked by implanting 10-mm passive integrated transponder (PIT) tags (BioSonics® 400 kHz) subcutaneously. After all information was recorded in the field on standard data forms, the animal was released at the place of capture.

SAMPLING SHRUB VEGETATION

Shrub vegetation was sampled on each trapping grid using a belt transect technique. Belt transects were located at 25 randomly chosen trap stations out of the total of 100 on each grid. Each transect was 2 x 25 m and sampled an area of 50 m^2. The total area sampled on each grid was 1,250 m^2 (50 m^2 x 25 belt transects).

Belt transects began at a point 5 m from the trap station on a random compass bearing and extended out on that bearing for another 25 m. The edges of the belt transects were marked by laying out two 25-m tape measures. Transects were subdivided into five 5-m segments and data were recorded separately from each segment in turn.

All perennial woody plants within the belt transects were recorded if they were at least 1 dm tall and 1 dm in greatest horizontal dimension. Plants were counted if they were rooted inside the transect or had over 50% of their stem structure at ground level within it. Each plant was identified to species and measurements of canopy cover and height were taken. The greatest horizontal extent of the crown was taken as the measure of canopy cover and the distance between ground surface and the tallest vegetative component was taken as the measure of height. These two dimensions were recorded by size class in decimeters (dm), so that a height value of 7 would indicate that the height was $\geq$7 dm but not exceeding 7.9 dm.

Shrub clumps containing 2 or more species of woody perennials were sometimes encountered. In these cases, each individual shrub was measured and data were recorded separately. Because of partially overlapping canopies, this approach would result in an upward bias to cover estimates. Shrub clumps consisting of the same species sometimes exhibited a series of multiple root structures. If separations within the shrub crown were great enough to allow two or more individuals to be recognized, data were recorded independently for each individual shrub. If there were no obvious separations, the entire mass was considered a single individual.

The standard measurements were taken for any dead shrub material that was still attached by roots and was of at least the minimal size (1 dm tall and 1 dm wide). Dead material was not identified to species and was simply recorded as “standing litter”.

With this technique, it was possible to estimate density and cover for each species detected within the belt transects. Total shrub density and cover for each grid were then calculated by aggregating values for all species.

WEATHER CONDITIONS

Weather variables such as precipitation, wind, and temperature may affect Mohave ground squirrel activity and thereby influence capture success. Weather conditions were recorded during the trapping sessions, usually 3 times a day. Temperatures were measured in the shade using an electronic thermometer. Wind speed was determined with a handheld anemometer or estimated by use of a United States Forest Service code that

relates wind velocity to movement of vegetation and other objects (Hamel et al. 1996). Other variables noted were degree of cloud cover and presence or absence of precipitation.

RESULTS

GROUND SQUIRREL CAPTURES

There were no captures of Mohave ground squirrels at any of the 6 study sites during a total trapping effort of 3,000 trap-days. Furthermore, no Mohave ground squirrels were observed during these field surveys.

White-tailed antelope squirrels were captured on all 6 grids (Table 2). A total of 11 individuals were trapped at the Spangler Hills grids and 21 at the Western Rand Mountains grids. The number of white-tailed antelope squirrels captured per grid ranged from a minimum of 1 at the Fremont Valley Route R50 East grid to a maximum of 13 at the Rand Mountains Route 37 grid. Recaptures were recorded at several of the trapping sites, especially at the Racetrack and Rand Mountains Route 37 grids.

Table 2. Trapping results for white-tailed antelope squirrels on 6 grids in the Spangler Hills Open Area (April 2002) and the Western Rand Mountains ACEC (May-June 2003).

Grid name	Adults		Juveniles	Total number of individuals	Recaptures	Total number of captures
	Male	Female				
Spangler Hills Open Area						
Racetrack	2	2	5	9	3	12
Charlies Place	0	1	1	2	1	3
Totals	**2**	**3**	**6**	**11**	**4**	**15**
Western Rand Mountains ACEC						
Fremont Valley Route R43	1	2	0	3	0	3
Fremont Valley Route R50 East	1	0	0	1	0	1
Fremont Valley Route R50 West	0	2	2	4	0	4
Rand Mountains Route R37	4	5	4	13	5	18
Totals	**6**	**9**	**6**	**21**	**5**	**26**

Overall, the sample of adult white-tailed antelope squirrels was slightly biased toward females. Juveniles were trapped at 4 of the 6 grids. Adult females were post-reproductive and almost all adult males were non-reproductive, with non-scrotal testes. Only 1 scrotal male was captured on 17 May at the Fremont Valley Route R50 East grid.

SHRUB VEGETATION

The natural communities at the 6 trapping grids in the 2 study areas are best described as Mojave Creosote Bush Scrub (Holland 1986). Creosote bush was the visual dominant and contributed the highest percentage of total shrub cover on all 6 grids. It was also the only shrub species found on every site.

Table 3 presents data on the number of shrub species, percent shrub cover, and total shrub density at these sites. The number of shrub species recorded (species richness) varied from a low of 2 at the Fremont Valley Route R50 East grid to a high of 11 at the Charlies Place grid. Shrub cover was lowest (18.7 percent) at the Fremont Valley Route R50 West site, but reached 35.9 percent at the Racetrack grid. Total shrub density ranged from 528 shrubs/hectare at Fremont Valley Route R50 West to 5032 shrubs/hectare at Charlies Place.

Table 3. Number of shrub species, percent shrub cover, and shrub density on 6 trapping grids in the Spangler Hills Open Area and the Western Rand Mountains ACEC.

Grid name	Number of shrub species	Percent shrub cover	Shrub density (shrubs/hectare)
Spangler Hills Open Area			
Racetrack	9	35.9	2896
Charlies Place	11	28.8	5032
Western Rand Mountains ACEC			
Fremont Valley Route R43	5	29.2	1016
Fremont Valley Route R50 East	2	23.5	848
Fremont Valley Route R50 West	4	18.7	528
Rand Mountains Route R37	8	22.2	2752

A total of 16 shrub species were recorded on belt transects over all of the trapping grids (Table 4). The 3 Fremont Valley grids were notable for their low species richness, with only 2 to 5 shrub species per grid. Only 1 shrub species, creosote bush, was present on all 6 grids, although white bursage was recorded on all grids with the exception of Rand Mtns. Route R37.

White bursage was the most abundant shrub species on the Racetrack and Charlies Place grids in the Spangler Hills. Other shrubs recorded at densities $\geq$100 plants/hectare on at least 1 of the Spangler Hills trapping grids were goldenhead (*Acamptopappus sphaerocephalus*), white bursage, Cooper's goldenbush, spiny hopsage, cheesebush, creosote bush, Anderson's boxthorn, and desert senna (*Senna armata*).

The 3 Fremont Valley grids in the Western Rand Mountains ACEC were very similar in shrub species composition. Creosote bush and white bursage were by far the most abundant species and were, in fact, the only shrubs recorded on the Fremont Valley Route R50 East. The Rand Mtns. Route R37 grid was quite different in species composition, with Cooper's goldenbush making up >80% of the shrub community by density. Four other shrub species found only on this grid and not at the 3 Fremont Valley sites were Mormon tea (*Ephedra nevadensis*), California buckwheat (*Eriogonum fasciculatum*), spiny hopsage, and bladder sage.

Table 4. Species composition and densities of shrub vegetation on 6 trapping grids in the Spangler Hills Open Area and the Western Rand Mountains ACEC.

	Shrub density (plants/hectare)					
Shrub species	**Racetrack**	**Charlies Place**	**Fremont Valley Route R43**	**Fremont Valley Route R50E**	**Fremont Valley Route R50W**	**Rand Mtns. Route R37**
Acamptopappus sphaerocephalus	416	112			24	40
Ambrosia dumosa	1616	3064	376	280	32	
Ephedra nevadensis						16
Ericameria cooperi		568				2440
Eriogonum fasciculatum						64
Grayia spinosa		224				8
Hymenoclea salsola	136	328	8			8
Larrea tridentata	592	288	592	568	456	168
Lycium andersonii	32	256				
Mirabilis bigelovii	8					
Opuntia basilaris		8				
Opuntia echinocarpa	8	24				
Psorothamnus sp.			24			
Salazaria mexicana	24					8
Senna armata	64	144	16		16	
Tetradymia sp.		16				
Total live shrub density	2896	5032	1016	848	528	2752
Total density of standing litter	200	800	144	24	8	312

Creosote bush was the shrub species with the highest percent cover at all 6 of the trapping grids (Table 5). White bursage also contributed significant cover on the Racetrack and Charlies Place grids in the Spangler Hills. Cooper's goldenbush was second only to creosote bush in percent cover on the Rand Mtns. Route R37 site. Other shrub species that reached $\geq$1 percent cover were goldenhead (Racetrack), white bursage (Fremont Valley Route R43 and Route R50 East), and spiny hopsage, cheesebush, and Anderson's boxthorn on Charlies Place. Dead shrubs ("standing litter") provided very little cover, reaching a maximum of 2.7 percent cover on the Charlies Place grid.

Table 5. Percent cover for shrub species that showed cover ≥0.5% on at least 1 of the 6 trapping grids in the Spangler Hills Open Area and the Western Rand Mountains ACEC.

	Percent cover[a]					
Shrub species	**Racetrack**	**Charlies Place**	**Fremont Valley Route R43**	**Fremont Valley Route R50E**	**Fremont Valley Route R50W**	**Rand Mtns. Route R37**
Acamptopappus sphaerocephalus	1.8					
Ambrosia dumosa	5.3	10.1	1.8	1.3		
Ericameria cooperi		0.9				9.4
Grayia spinosa		1.5				
Hymenoclea salsola		2.1				
Larrea tridentata	26.8	10.8	26.4	22.2	18.1	12.1
Lycium andersonii		2.2				
Psorothamnus sp.			0.8			
Senna armata	0.7	0.7				
Percent cover of standing litter	0.4	2.7	1.0	0.0	0.2	1.0

[a] Percent cover calculated by summing cover values in m^2 for all individuals of a given species and dividing by the total area sampled on a grid (1250 m^2).

WEATHER CONDITIONS

Weather conditions were generally favorable during the survey period at the Spangler Hills Open Area (15-19 April 2002). Skies were clear, although there were strong winds (20-40 km/hr) for the first 4 days of trapping. Temperatures were cool in the mornings (10-14^{o}C), but by mid-afternoon reached 17-23^{o}C.

Trapping was conducted at the 3 Fremont Valley grids in the Western Rand Mountains ACEC during the period 5-9 May 2003. There was no precipitation and skies were clear to partly cloudy. Morning temperatures were moderate (12-16^o C) and afternoons were warm (16-26^{o}C). Wind velocities were generally low (<10 km/hr), but reached 20-40 km/hr on May 7 and 8.

During the trapping period at the Rand Mtns. Route R37 site (9-13 June 2003), there was no precipitation and skies were clear. Temperatures were warm in the mornings (17-20^{o}C) and hot by mid-day (33-36^{o}C) when traps were checked and closed. Wind velocities were generally low (<5 km/hr), although winds reached 12-20 km/hr by mid-day on June 9 and 11.

DISCUSSION

MOHAVE GROUND SQUIRREL STATUS

The lack of Mohave ground squirrel captures at 6 study sites in the Spangler Hills Open Area and the Western Rand Mountains ACEC was the most significant result of these trapping surveys. Although trapping efforts can never conclusively prove the absence of a species, at the very least these studies provide no evidence for the presence of Mohave

ground squirrels in these 2 large management units. It is noteworthy that Mohave ground squirrels were captured in 2002 and 2003 at many other locations in the western Mojave Desert, including Little Dixie Wash, Desert Tortoise Natural Area (DTNA), Edwards Air Force Base, Coolgardie Mesa, and Superior Valley (Leitner 2003; Leitner 2005; Leitner 2010).

Records in the California Natural Diversity Data Base (CNDDB) provide little evidence that the Spangler Hills Open Area and the Western Rand Mountains ACEC have supported Mohave ground squirrel populations in the past. The CNDDB lists only 1 known Mohave ground squirrel occurrence within the Spangler Hills Open Area and 1 occurrence within the boundaries of the Western Rand Mountains ACEC. Both of these records date from >30 years ago. Although the paucity of previous records in these 2 areas may reflect a low level of trapping effort, it is quite consistent with the lack of capture success in the current study.

The only Mohave ground squirrel record for the Spangler Hills Open Area (CNDDB Occ. #55) was a collection of 19 individuals on 4 June 1979 about 14.5 km (9 mi) NNE of Johannesburg (Hafner and Yates 1983). This location was near the Trona Road approximately 1.6 km (1 mi) inside the Spangler Hills Open Area on the bajada sloping north from the Summit Range (Figure 2).

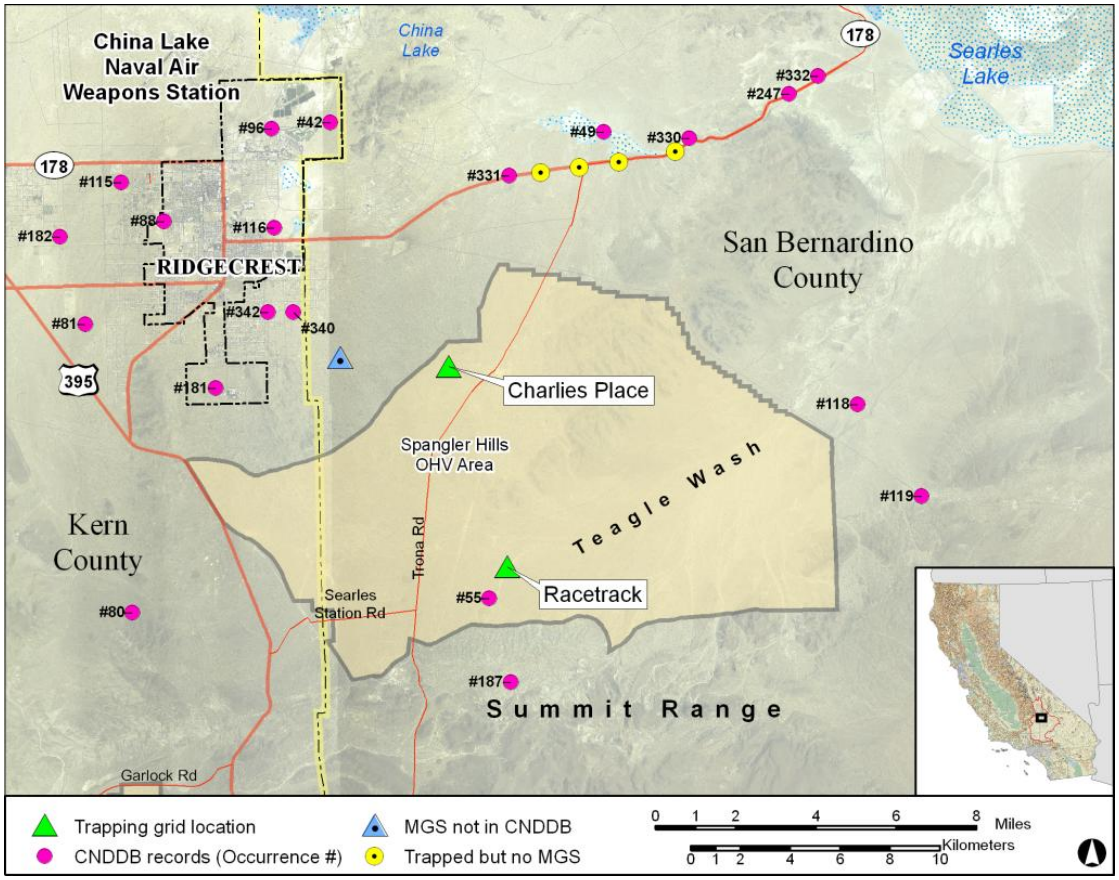

Figure 2. Locations of Mohave ground squirrel occurrences and trapping sites in and near the Spangler Hills Open Area. Occurrence numbers are from the California Natural Diversity Data Base.

There are several other records at localities within 8 km (5 mi) of the boundary of the Spangler Hills Open Area from the period 1975-1990. Figure 2 shows the locations of Mohave ground squirrel occurrences in the vicinity of the Spangler Hills Open Area.

Two Mohave ground squirrels were trapped in February 1975 in the Summit Range about 2.4 km (1.5 mi) south of the boundary (CNDDB Occ. #187).

There are also 2 records (CNDDB Occ. #118 and #119) near the eastern end of the Randsburg Wash Access Road near the Christmas Canyon Guard Gate to the Mojave B Range. It is not clear whether they represent captures or visual sightings (Michael Brandman Associates, Inc. 1988). These occurrences are 1.6-3.2 km (1-2 mi) beyond the eastern boundary of the Spangler Hills Open Area.

Finally, a number of Mohave ground squirrel occurrences have been documented from the Ridgecrest area east to the vicinity of Searles Lake (CNDDB Occ. #42, #49, #96, #116, #181, #247, #330, #331, #332, #340, and #342).

There is only 1 Mohave ground squirrel record in the Western Rand Mountains ACEC (CNDDB Occ. #94). However, there are also 2 occurrences from 1975 and 1980 in eastern Fremont Valley near the Red Rock-Randsburg Road (Figure 3).

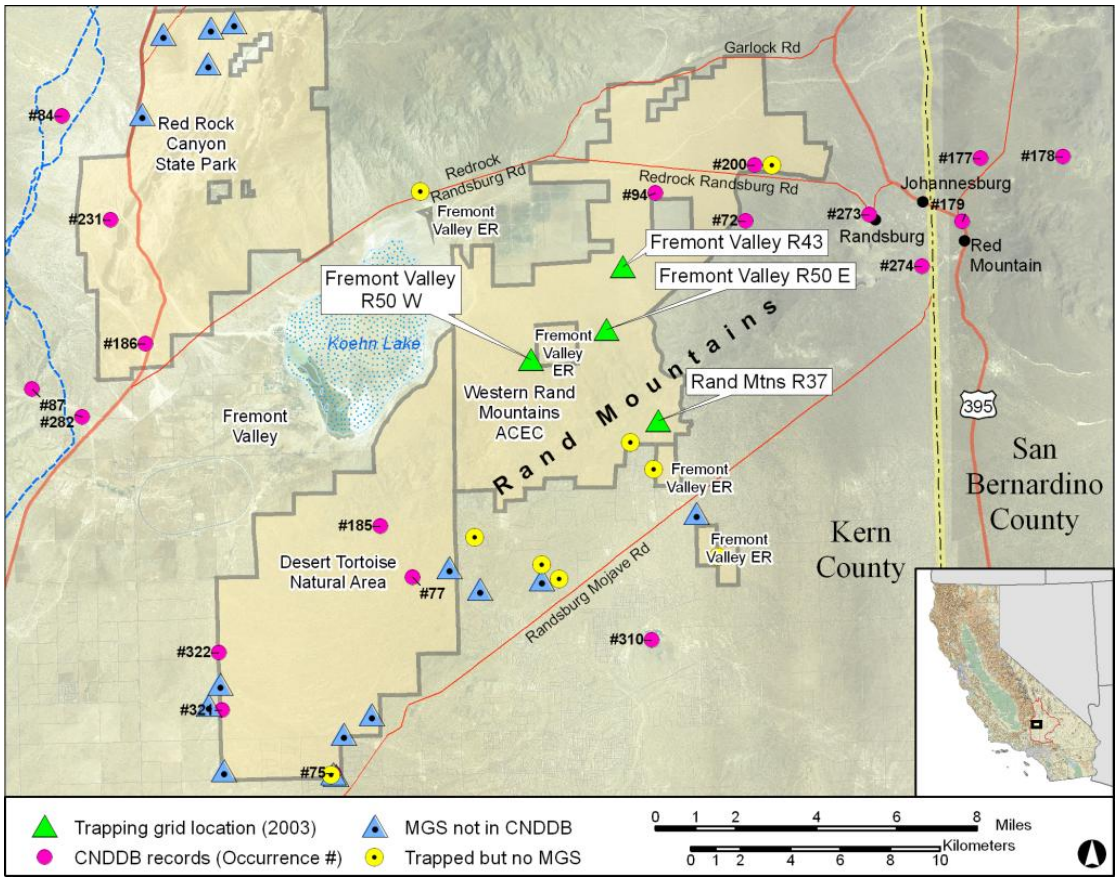

Figure 3. Locations of Mohave ground squirrel occurrences and trapping sites in and near the Western Rand Mountains ACEC. Occurrence numbers are from the California Natural Diversity Data Base.

In one case, a Mohave ground squirrel was trapped on 27 March 1975 just north of the Red Rock-Randsburg Road (CNDDB Occ. #200).

During the period 29 April-14 July 1980, a total of 11 Mohave ground squirrels were trapped at a site (CNDDB Occ. #72) south of the Red Rock-Randsburg Road (Aardahl and Roush 1985).

A more recent trapping study was conducted in eastern Fremont Valley during May 1995, very close to Occurrence #200. No Mohave ground squirrels were captured or observed during the 5-day trapping period. In May 1994 and April 1995, trapping was also carried out at 2 sites within 0.8 km (0.5 mi) of the Rand Mountains Route R37 grid. No Mohave ground squirrels were captured or observed at these sites (Scarry et al. 1996).

There are a number of Mohave ground squirrel records from 2 areas near the Western Rand Mountains ACEC. One of these areas is the Desert Tortoise Natural Area (DTNA), which adjoins the Western Rand Mountains ACEC on the southwest. It is noteworthy that there have been Mohave ground squirrel occurrences in and near the DTNA over a 30-year period (1973-2003).

- There were sightings of Mohave ground squirrels in 1973 and 1974 at a location in the northeastern DTNA (CNDDB Occ. #185).
- One Mohave ground squirrel was trapped in 1980 (Aardahl and Roush 1985), again in the northeastern DTNA (CNDDB Occ. #77).
- During the period 26-30 March 1999, a single Mohave ground squirrel was captured on the eastern boundary of the DTNA about 1.6 km (1 mi) east of Occurrence #77 (Leitner 2001).
- More recently, two juveniles were captured on 23-27 June 2003 just east of the boundary of the DTNA (Leitner 2005)

There are also a number of older Mohave ground squirrel occurrences from the region around Johannesburg, east of Fremont Valley, spanning the period from 1977 through 1992. These records are clustered in an area where elevations range from 1000-1140 m (3300-3750 ft).

- A total of 12 Mohave ground squirrels were trapped near the town of Red Mountain during May 1977 (CNDDB Occ. #177, #178, #179).
- One Mohave ground squirrel was captured near Randsburg on 16 July 1977 (CNDDB Occ. #273).
- Mohave ground squirrels were detected in August 1992 about 2.4 km (1.5 mi) south of Johannesburg (CNDDB Occ. #274).

Taken together, the failure to capture Mohave ground squirrels during the 2002-2003 studies, other unsuccessful trapping efforts in 1994-1995, and very few previous records are all consistent with the hypothesis that the species is not currently present within the Spangler Hills Open Area and the Western Rand Mountains ACEC. The only record in the Spangler Hills Open Area (CNDDB Occ. #55) was just 1.6 km (1 mi) inside the southern boundary and dates from 1979. Other records (CNDDB Occ. #118, #119, #187) suggest that Mohave ground squirrels were present in upland habitat to the south and east of the Spangler Hills Open Area during the period 1975-1988. In the Ridgecrest area to the west and north there are a number of records from 1975 through 2006. There is 1

Mohave ground squirrel occurrence from the Western Rand Mountains ACEC in 1980, but no evidence of the species in Fremont Valley since then. The nearest known population appears to be located in the DTNA to the southwest and on the southern slope of the Rand Mountains to the south. There are also several older records in the region around Red Mountain to the east. Although the available data cannot prove that Mohave ground squirrels are completely absent from the Spangler Hills Open Area and the Western Rand Mountains ACEC, there is no reason to suppose that they are present.

HABITAT ASSESSMENT

Since there is no evidence to suggest that Mohave ground squirrels are currently present in the Spangler Hills Open Area or in the Western Rand Mountains ACEC, it is important to consider whether the habitat in these areas is capable of supporting the species.

While a comprehensive habitat suitability model for the Mohave ground squirrel does not exist, there is a reasonably good understanding of the environmental variables that are important to the species. Mohave ground squirrels are usually associated with sandy to gravelly alluvial soils that allow construction of their burrow systems. They often utilize burrows under large shrubs that provide thermal cover and protection from predators. Their dietary requirements are rather complex, with foliage and floral parts from a variety of forbs needed for successful reproduction, both shrub and forb seeds used to supply energy for fat deposition prior to dormancy, and shrub leaf consumed as a source of energy and moisture during dry periods when forbs are unavailable. Studies of Mohave ground squirrel food habits in the Coso region indicate that 2 species of chenopod shrubs, spiny hopsage and winterfat (*Krascheninnikovia lanata*) are the most important forage plants during drought (Leitner and Leitner 1998).

Both the Spangler Hills Open Area and the Western Rand Mountains ACEC include extensive areas of alluvial soils that appear to be suitable for burrow construction. The fact that white-tailed antelope squirrels were captured at all 6 study sites strongly indicates that soil properties are not a limiting factor for burrowing mammals. Total shrub cover on the 6 trapping grids ranged from about 19-36 percent and appeared to be quite adequate. The great majority of shrub cover was contributed by creosote bush, which was by far the largest shrub species present. Mohave ground squirrels often locate burrows under creosote bushes and have been observed to use these shrubs as escape cover from predators. Visual observations at the trapping grids and along travel routes within the 2 management units suggested that native forbs were neither abundant nor diverse. A very large proportion of aboveground herbaceous production was contributed by 2 non-native species, red-stemmed filaree (*Erodium cicutarium*) and Mediterranean grass (*Schismus arabicus*). Although Mohave ground squirrels are known to feed on the fruits and seeds of red-stemmed filaree, they rarely utilize Mediterranean grass (or other grasses). Creosote bush seeds were the only other potential food source that would be widespread throughout the Spangler Hills Open Area and the Western Rand Mountains ACEC. Winterfat was not detected at any of the study sites during shrub sampling and a substantial presence of spiny hopsage was recorded only at the Charlies Place grid, where it was relatively uncommon.

In summary, the soils and the general structure of shrub vegetation in the Spangler Hills Open Area and the Western Rand Mountains ACEC seem suitable for Mohave ground

squirrels. The apparent absence of this species may be related to the scarcity of certain critical food resources, especially a diverse array of native forbs and the 2 chenopod shrubs, winterfat and spiny hopsage. It is not clear whether the lack of adequate forage plants is a result of natural environmental conditions or of anthropogenic changes in land use. Both management units have been heavily used for OHV recreation in recent decades. There has clearly been some habitat loss and degradation as a result, but most of the land surface has not been physically altered. It does not seem plausible that OHV use could have had widespread effects on vegetation, specifically impacting certain forb and shrub species. However, both areas are included in the BLM grazing allotments known as Cantil Common and Spangler Hills. Sheep grazing has been practiced in this region for over 100 years. Livestock grazing is known to have broad effects across the landscape, including disturbance of soil structure, facilitation of the invasion by non-native plants, and selection against palatable native forage species (Webb and Stielstra 1979). The observed dominance of non-native herbaceous plants and the rarity or absence of palatable shrubs such as winterfat and spiny hopsage may be related to long-term sheep grazing. However, it is also possible that unsuitable natural conditions may have been responsible for the relative lack of food resources that are important to the Mohave ground squirrel. Unfortunately, there are no baseline data that document the original conditions and provide evidence of changes correlated with domestic livestock usage.

CONSERVATION ISSUES

The Spangler Hills Open Area and Western Rand Mountains ACEC are located in a region that should provide a linkage between Mohave ground squirrel populations to the north and south (Figure 4). This region extends northeast from Fremont Valley across the uplands north of Johannesburg to Searles Lake. To the north are significant Mohave ground squirrel populations in the Coso Range, in the vicinity of Ridgecrest, and in the Little Dixie Wash area southwest of Inyokern (Leitner 2008). To the south, there is evidence that the DTNA and its environs, the Cuddeback Lake-Pilot Knob area, and the region north of Boron and Kramer Junction currently support Mohave ground squirrel populations.

The current status of the Mohave ground squirrel in the region that includes the Spangler Hills Open Area and Western Rand Mountains ACEC is therefore of great conservation interest. Unfortunately, much of the region that stretches from Fremont Valley northeast to Searles Valley appears to consist of unsuitable habitat. The western portion of Fremont Valley from State Route 14 to Garlock Road includes former agricultural lands and the Koehn Lake playa. At the eastern end of this region, the Searles Lake playa and the sparsely vegetated area around Trona Pinnacles and in the lower reaches of Teagle Wash do not appear to provide suitable habitat for the Mohave ground squirrel.

If the Spangler Hills Open Area and the Western Rand Mountains ACEC do not support Mohave ground squirrel populations, there may be a very limited opportunities for Mohave ground squirrel dispersal and gene flow between northern and southern populations. The most likely potential movement corridor would be a strip of natural habitat about 20 km (12 mi) wide along US Highway 395 north of Johannesburg. The location of this potential corridor is indicated on Figure 4 as an opening between the 2

possible dispersal barriers identified in this study. Most of this area is public land administered by BLM, although it includes several parcels of private land and numerous designated OHV routes and camping sites. Nothing is known of the current status of the Mohave ground squirrel in this potential corridor.

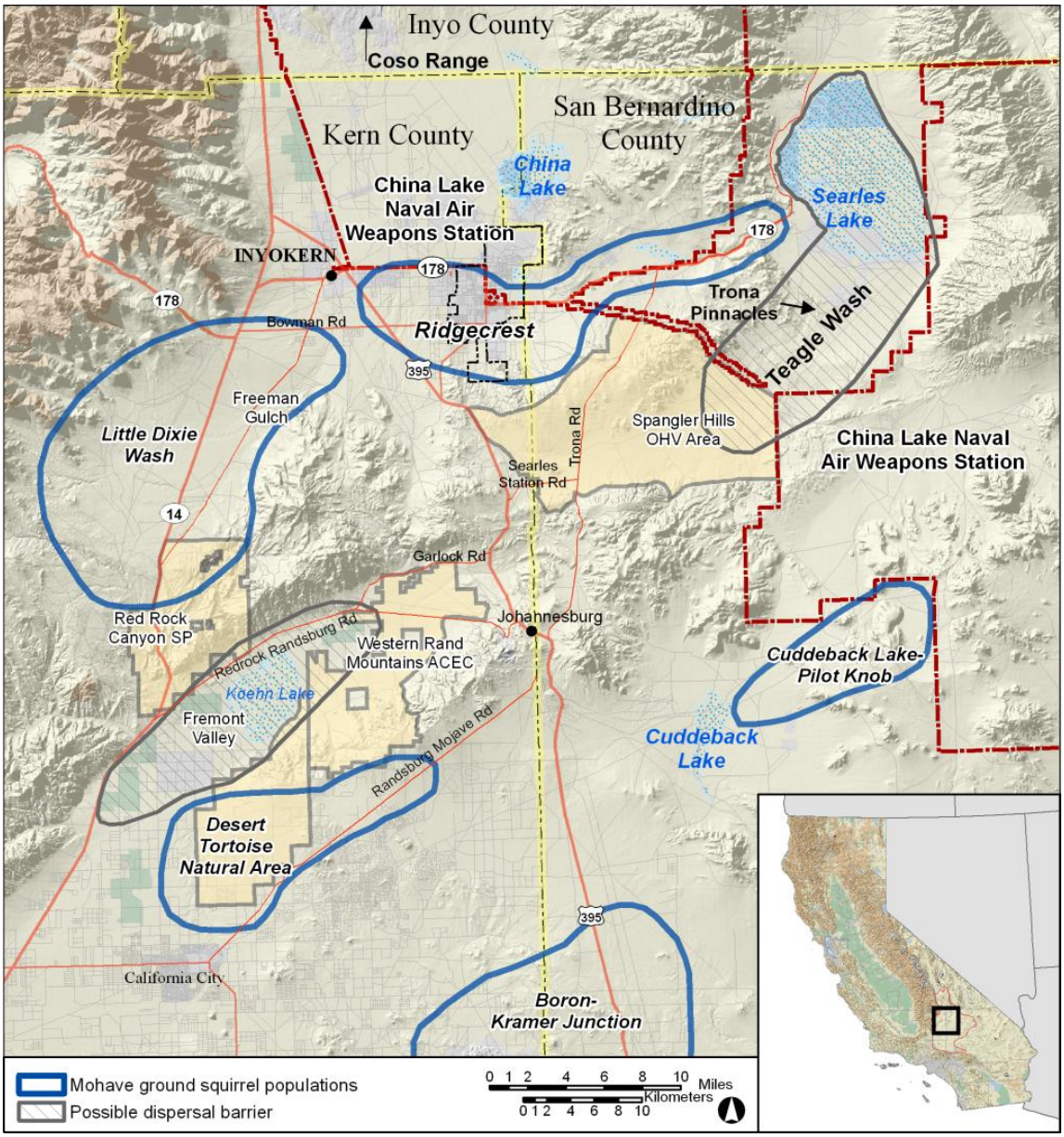

Figure 4. The approximate location of possible barriers to Mohave ground squirrel dispersal stretching from Fremont Valley northeast to Searles Lake. The Spangler Hills Open Area and Western Rand Mountains ACEC are shown in relation to these possible barriers. Areas known to support Mohave ground squirrel populations are indicated: DTNA, Cuddeback Lake-Pilot Knob, Boron-Kramer Junction, Little Dixie Wash, Ridgecrest, and Coso Range.

CONCLUSIONS AND RECOMMENDATIONS

Effective conservation of the Mohave ground squirrel will require that connections be maintained between areas that support significant populations. The region that stretches northeast from State Route 14 through Fremont Valley to the Spangler Hills and on to Searles Lake could provide a critical linkage between northern and southern populations. However, much of this region does not appear to be suitable habitat, since it includes agricultural lands, extensive playas, and areas with little natural vegetation. The results of the present study suggest that Mohave ground squirrel populations may not be present in 2 BLM management units within this region. This analysis raises the possibility that a significant portion of this broad region may constitute a barrier to Mohave ground squirrel movement rather than an important connector.

The narrow corridor of natural habitat along US Highway 395 north of Johannesburg may still support a Mohave ground squirrel population and could function as an ecological connection. It is strongly recommended that field studies be undertaken to determine the status of the species in this critical area.

An important conclusion to be drawn from the present study is that there is no substitute for current biological data on which to base conservation and management decisions. Because of their protected status, it might be assumed that the Western Rand Mountains ACEC and the DFG Fremont Valley Ecological Reserve could provide important conservation benefits for the Mohave ground squirrel. Furthermore, this area occupies a critical location within the Mohave Ground Squirrel Conservation Area designated under the West Mojave Plan (U.S. Bureau of Land Management 2005). The lack of any recent evidence that the species is present here should be a sobering reminder of the risks of making conservation decisions in the absence of adequate data.

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