MOHAVE GROUND SQUIRREL RESEARCH AND MONITORING PROGRAM

EXPLORATORY TRAPPING SURVEYS FOR THE MOHAVE GROUND SQUIRREL IN THREE REGIONS OF THE WESTERN MOJAVE DESERT

2002

PREPARED FOR THE CALIFORNIA DEPARTMENT OF FISH AND GAME
WILDLIFE BRANCH, SACRAMENTO, CALIFORNIA
AND
INLAND DESERTS REGION, ONTARIO, CALIFORNIA

Prepared by Philip Leitner

California State University, Stanislaus
Endangered Species Recovery Program
One University Circle
Turlock, CA 95382

August 10, 2010

Nongame Wildlife Program Report 2010-12

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ABSTRACT

Trapping surveys for the Mohave ground squirrel (*Xerospermophilus* [=*Spermophilus*] *mohavensis*) were carried out in 3 regions of the western Mojave Desert of California during April and May 2002. These surveys were designed to determine the current status and abundance of this State-listed threatened species in 3 regions where a number of older records exist. The 3 study areas were Little Dixie Wash southwest of Inyokern, the Coolgardie Mesa-Superior Valley plateau region north of Barstow, and the region from Saddleback Butte State Park north to Rogers Dry Lake on Edwards Air Force Base. A total of 40 adult Mohave ground squirrels were captured at 11 of 14 trapping sites. The species was present in all 3 study areas. Analysis of fecal samples indicated that the diet composition differed among sites, although shrub and forb materials were generally important.

These results are significant for several reasons. They demonstrate the persistence of relatively abundant Mohave ground squirrel populations in the 3 areas surveyed, suggesting these areas are important for conservation of the species. They identify certain habitat elements that may be associated with Mohave ground squirrel occurrence. Finally, they suggest these 3 areas may provide suitable sites for more intensive ecological research on this species.

The present study clearly indicates these 3 distinct areas continue to support Mohave ground squirrel populations.

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ACKNOWLEDGMENTS

I thank the field crew for their enthusiasm and hard work. Crew members included Christine O'Rourke Gaber, Michelle Hesselbacher, Petra Keiper, Denise LaBerteaux, Barbara M. Leitner, Henning Schreiber, Alison Stanton, and William J. Vanherweg. Dr. James Weigand (Bureau of Land Management, California State Office) provided invaluable support by making it possible for Shirley Ann Asselta, Kevin Keith, Heath McAllister, and Morgan Ruelle of the BLM Desert Monitoring Team to participate in the field effort. Their work was funded by a grant from the Off-Highway Motor Vehicle Recreation Commission of the California Department of Parks and Recreation. I am grateful to staff at Edwards Air Force Base, U.S. Army National Training Center & Fort Irwin, the BLM Barstow and Ridgecrest Field Offices, and California Department of Parks and Recreation for allowing access to lands under their management. The California Department of Fish and Game (DFG) provided funding for this study through agreements with the CSU Stanislaus Foundation and Endangered Species Recovery Program (ESRP). Trapping, marking, and taking tissue samples from Mohave ground squirrels were conducted under authority of a Memorandum of Understanding with DFG.

INTRODUCTION

This report presents the results of exploratory trapping surveys for the Mohave ground squirrel (*Xerospermophilus* [=*Spermophilus*] *mohavensis*) in 3 regions of the western Mojave Desert of California. These surveys are a component of the Mohave Ground Squirrel Research and Monitoring Program funded by California Department of Fish and Game (DFG) through a contract with the Endangered Species Recovery Program (ESRP) at California State University, Stanislaus.

The purpose of these surveys was to determine the status and abundance of the Mohave ground squirrel in three widely separated areas that have a number of previous records for this species. This effort was designed to supplement surveys carried out in other regions in 1999 and 2000 that had little success in detecting Mohave ground squirrel populations (Leitner 2001).

The three study areas were located 1) along Little Dixie Wash southwest of Inyokern, 2) north of Barstow from Coolgardie Mesa to Superior Valley, and 3) from Rogers Dry Lake on Edwards Air Force Base south to Saddleback Butte State Park (Figure 1). Previous field studies recorded significant numbers of Mohave ground squirrel captures and observations in each of these regions (Wessman 1977; Aardahl and Roush 1985; Mitchell et al. 1993; Buescher et al. 1995; Scarry et al. 1996).

SURVEY METHODOLOGY

STUDY SITES

Fourteen study sites were selected for exploratory trapping surveys (Table 1). Seven were located in the Little Dixie Wash area between Inyokern and Red Rock Canyon State Park (Figure 2). Four were in the plateau region north of Barstow that stretches from Coolgardie Mesa to Superior Valley (Figure 3). Two were on Edwards Air Force Base (EAFB) on the east side of Rogers Dry Lake and one was at Saddleback Butte State Park (Figure 4).

Little Dixie Wash Area

During previous field studies, Mohave ground squirrels have been captured at or adjacent to 5 of the 7 study sites in the Little Dixie Wash area. Three of the sites were trapped in 1980 (Aardahl and Roush 1985), while 2 others were sampled in 1994 (Scarry et al., 1996). The Little Dixie Wash grids are described below.

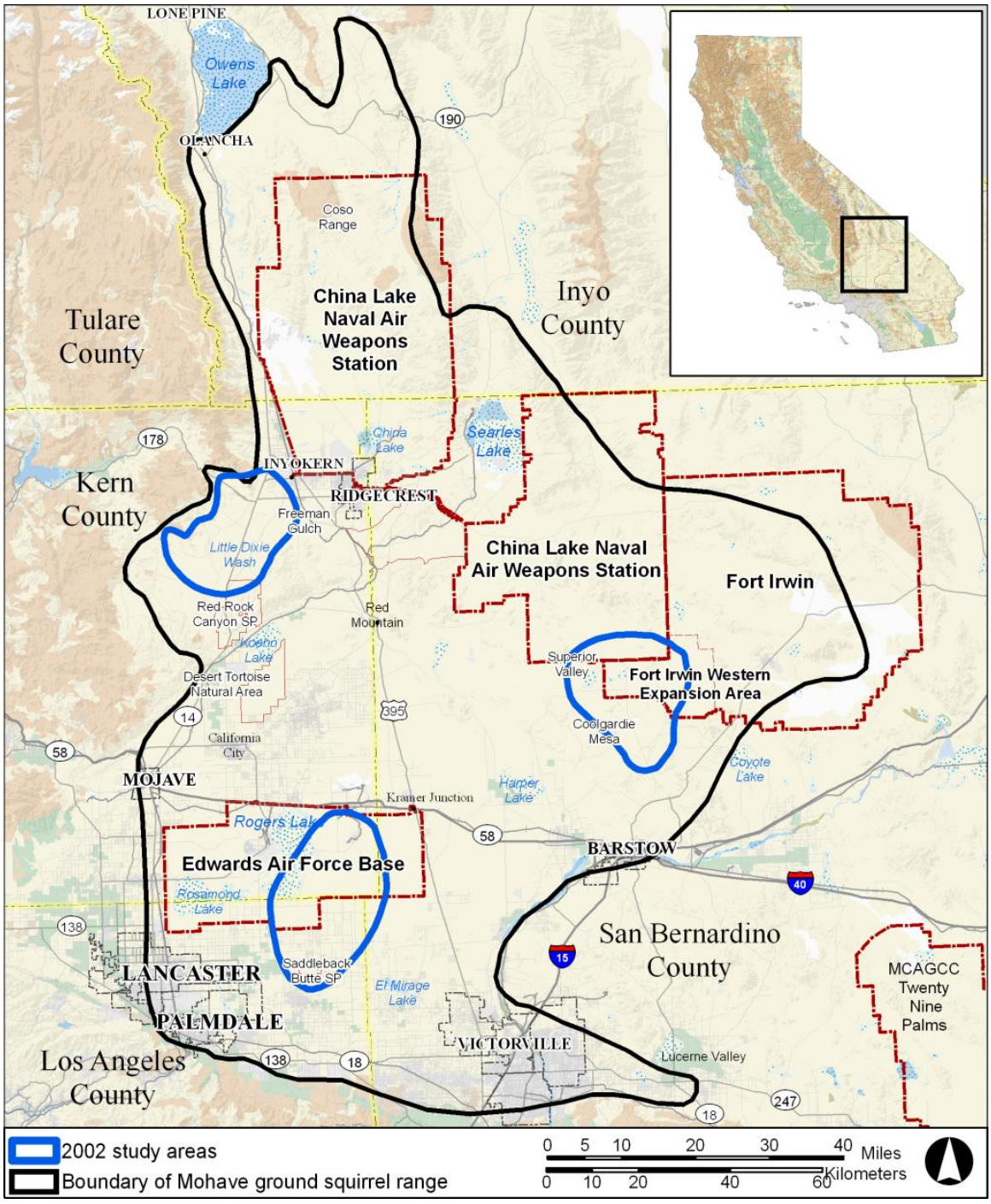

Figure 1. The geographic range of the Mohave ground squirrel showing the locations of the 3 study areas where trapping surveys were conducted in 2002.

Figure 2. Little Dixie Wash study area showing locations of 7 trapping grids.

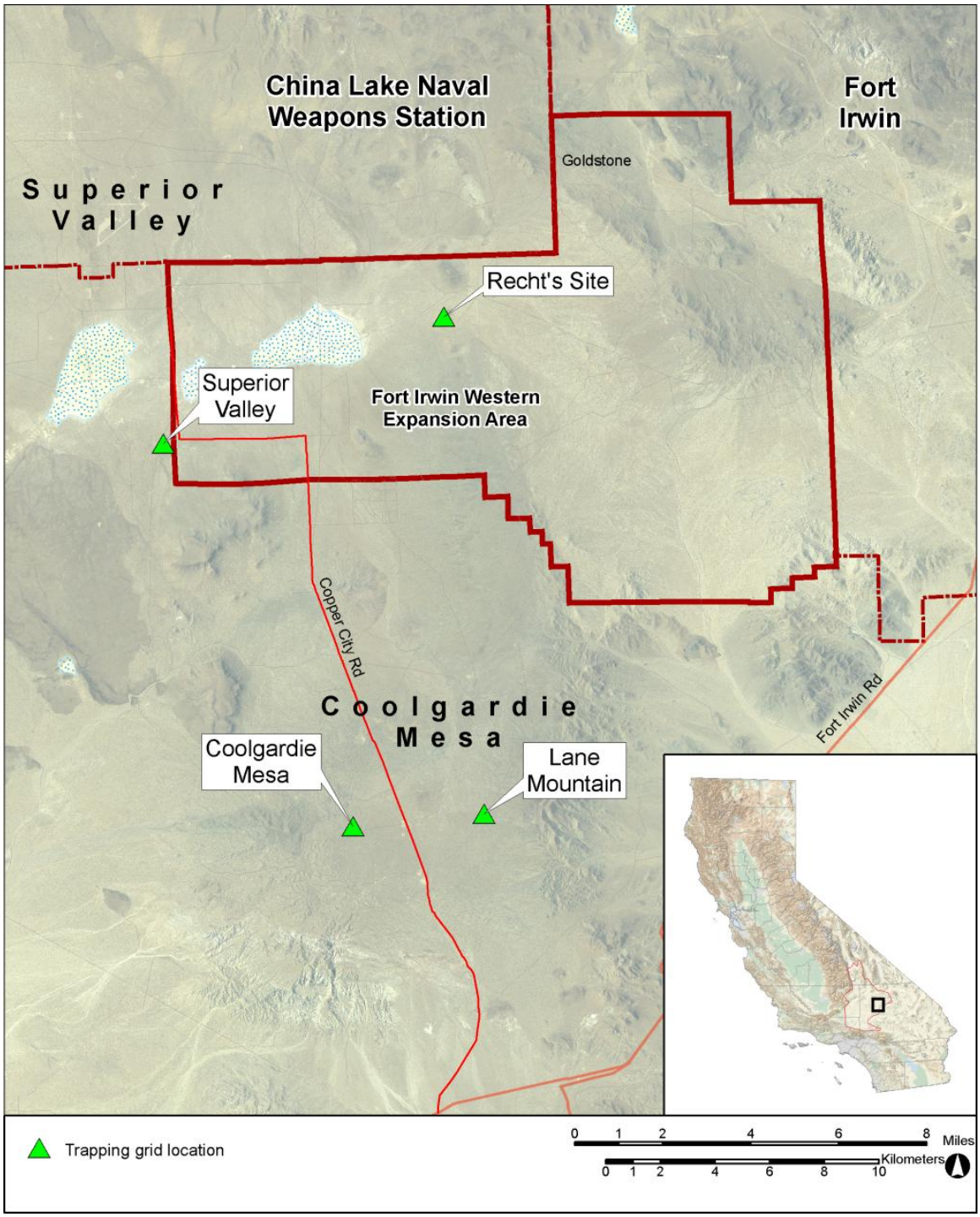

Figure 3. Study area north of Barstow showing locations of 4 trapping grids.

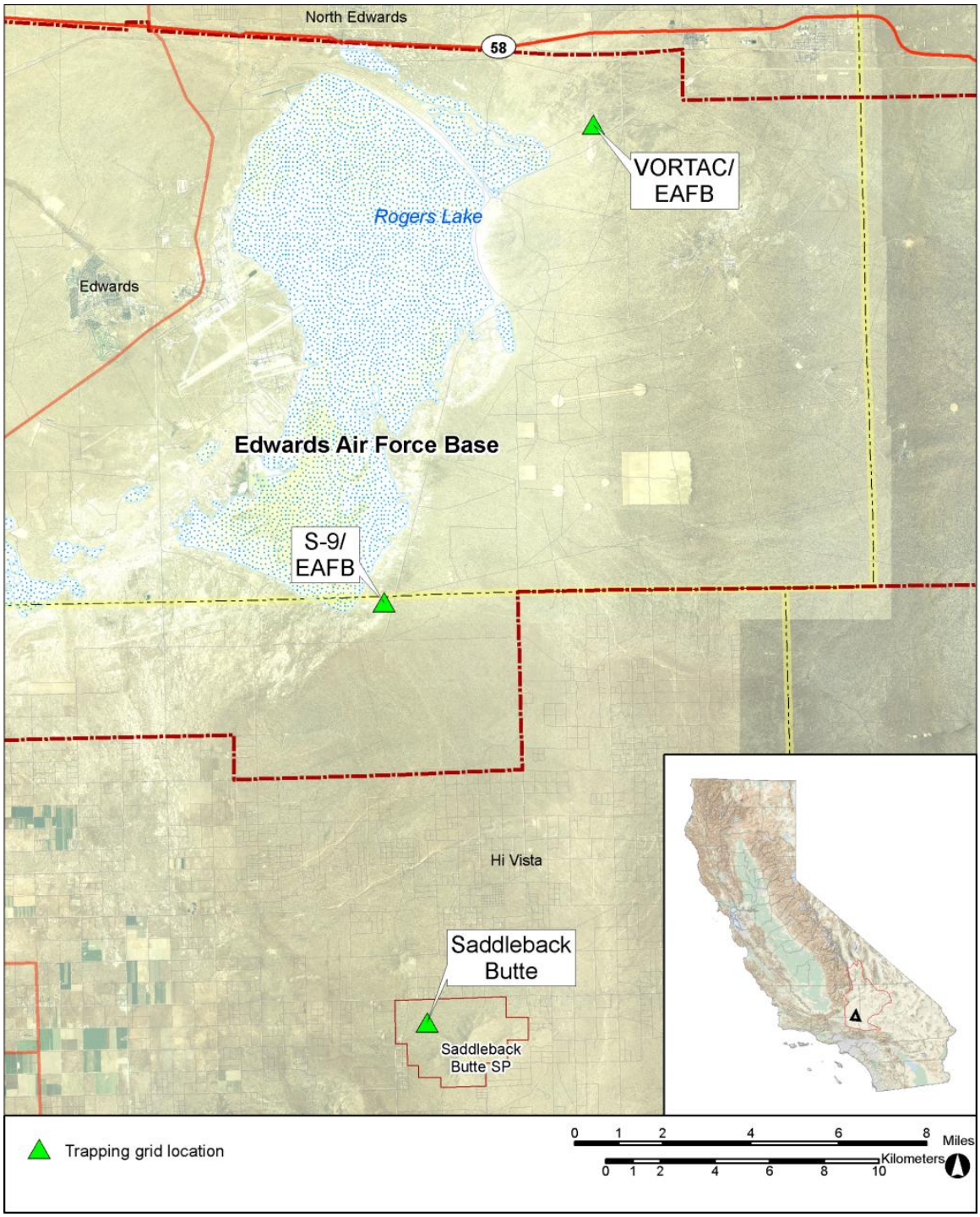

Figure 4. Edwards Air Force Base and Saddleback Butte State Park showing locations of 3 trapping grids.

Table 1. A list of the 14 trapping grids used during exploratory trapping surveys in 2002, with a legal description, UTM coordinates (NAD 83 at grid center), and elevation for each site.

			Elevation	
Grid name	Legal description	UTM coordinates[1]	Meters	Feet
Bowman Road	NE1/4 Sec 10, T 27 S, R 38 E	421096E; 3940451N	875	2870
North El Paso	S1/2 Sec 27, T 27 S, R 38 E	420716E; 3935051N	860	2830
Freeman Gulch	NW1/4 Sec 33, T 27 S, R 38 E	418459E; 3933994N	880	2880
Last Chance	SW1/4 Sec 29, T 28 S, R 38 E	417084E; 3925143N	985	3230
Los Angeles Aqueduct	NE1/4 Sec 35, T 27 S, R 37 E	413174E; 3933659N	980	3220
Bird Spring Canyon	SW1/4 Sec 11, T 28 S, R 36 E	402877E; 3930190N	1170	3840
Powerline	W1/2 Sec 2, T 29 S, R 37 E	410750E; 3922242N	1005	3300
Coolgardie Mesa	SE1/4 Sec 31, T 12 N, R 1 W	498539E; 3882517N	1140	3740
Lane Mountain	E1/2 Sec 34, T 12 N, R 1 W	503251E; 3882774N	1150	3770
Superior Valley	SE1/4 Sec 19, T 31 S, R 46 E	491694E; 3896905N	925	3030
Recht's Site	NW1/4 Sec 8, T 31 S, R 47 E	502499E; 3900993N	940	3080
VORTAC / EAFB	NE1/4 Sec 8; NW1/4 Sec 9, T 10 N, R 8 W	432516E; 3871017N	710	2330
S-9 / EAFB	SE1/4 Sec 33; SW1/4 Sec 34, T 9 N, R 9 W	424178E; 3853787N	700	2300
Saddleback Butte	N1/2 Sec 22, T 7 N, R 9 W	425282E; 3838376N	830	2720

1. Universal Transverse Mercator, Zone 11, Meters, North American Datum of 1983.

Bowman Road

This study site is located on the south side of Bowman Road about 2.7 km east of its intersection with State Route 14. It is on public land administered by U.S. Bureau of Land Management (BLM). Aardahl and Roush trapped here in 1980, referring to it as the Bowman Road South grid. The vegetation community here is Mojave Creosote Bush Scrub, strongly dominated by creosote bush (*Larrea tridentata*) and white bursage (*Ambrosia dumosa*). The site is characterized by soils developed on the broad apron of alluvium or bajada that slopes eastward from the Sierra Nevada escarpment. The area has been used for seasonal sheep grazing for over 100 years. Bowman Road receives light automobile traffic, but there is no sign of off-highway vehicle (OHV) activity on the trapping grid.

North El Paso

The North El Paso site is on the east side of the Red Rock-Inyokern Road about 0.9 km south of its intersection with Route EP18. It is within the El Paso Mountain Wilderness administered by BLM. This site has never been trapped before. The vegetation is Mojave Creosote Bush Scrub, with creosote bush and white bursage as the dominant species and scattered Joshua trees (*Yucca brevifolia*). The site is at the base of an extensive bajada that descends from the Scodie Mountains to the west and is characterized by fine alluvial soils. This area has been used for sheep grazing in the spring for over 100 years and the recent wilderness designation allows continued livestock use. There is light automobile traffic on the Red Rock-Inyokern Road about 200 m northwest of the site.

Freeman Gulch

This study site is 1.1 km south of Freeman Wash Well. It is located on both sides of an unpaved road that runs WNW from the Red Rock-Inyokern Road to State Route 14. This site is on public land administered by BLM. A trapping survey for Mohave ground squirrel was conducted here in 1994 (Scarry et al. 1996). The vegetation community is Mojave Mixed Woody Scrub, dominated by spiny hopsage (*Grayia spinosa*) and white bursage. The site has fine alluvial soils developed on the bajada descending from the Scodie Mountains. Sheep grazing has been a seasonal land use in this area for over 100 years and the unpaved roads on the site receive occasional vehicle traffic.

Last Chance

The Last Chance site is located north of Route EP15 about 2.1 km east of its intersection with the Red Rock-Inyokern Road. It is within the El Paso Mountain Wilderness administered by BLM. The Last Chance grid was trapped in 1994 (Scarry et al., 1996). The dominant shrubs on this Mojave Creosote Bush Scrub site include creosote bush, white bursage, winterfat (*Krascheninnikovia lanata*), and goldenhead (*Acamptopappus sphaerocephalus*). A few Joshua trees are present. A large wash borders the southern edge of the trapping grid. Most of the site is on the alluvial fan that slopes westward from the El Paso Mountains. The area has been used for sheep grazing for over 100 years. Route EP15 (200-300 m south) receives considerable traffic from recreational vehicles, although motor vehicles are not allowed within the wilderness area.

Los Angeles Aqueduct

This study site is on the east side of Route SC5 about 1.7 km south of its intersection with SC51. It is in the Jawbone-Butterbredt Area of Critical Environmental Concern (ACEC) administered by BLM. In 1980, Aardahl and Roush (1985) carried out surveys at 2 grids about 300 m to the northeast. These sites were referred to as the Los Angeles Aqueduct North and South grids. The vegetation here is Mojave Creosote Bush Scrub, dominated by creosote bush and white bursage. The site is characterized by alluvial soils developed on an extensive bajada. Historically, this area was used for both sheep and cattle grazing, although it has been primarily devoted to cattle grazing for about 35 years. There is occasional OHV travel on Route SC5.

Bird Spring Canyon

The Bird Spring Canyon study site is located along the south side of Route SC106 about 1.25 km southeast of its intersection with Route SC120. This trapping grid is within the Jawbone-Butterbredt ACEC administered by BLM. Aardahl and Roush (1985) trapped here in 1980, when it was designated as the Bird Spring Canyon East grid. Although Aardahl and Roush refer to the vegetation community here as Joshua Tree Woodland, it is best characterized as Blackbush Scrub. There are scattered Joshua trees present, but the diverse shrub understory is dominated by blackbrush (*Coleogyne ramosissima*), Cooper's goldenbush (*Ericameria cooperi*) and spiny hopsage. The grid occupies generally flat terrain on alluvial soils near the mouth of a broad canyon, with low hills in the southwest corner. Land use at this site included both cattle and sheep grazing for many years, although it has been used mainly by cattle for about 35 years. Route SC106 receives

considerable OHV traffic and there are several unauthorized tracks through the trapping grid.

Powerline

This study site is located on the west side of 2 high-voltage electric transmission lines and their unpaved access road. It is about 2.9 km south of the point at which Route SC192 crosses the transmission line and approximately 0.5 km west of State Route 14. This trapping grid is within the Jawbone-Butterbredt ACEC administered by BLM. It has never been trapped before. This site supports Mojave Creosote Bush Scrub, dominated by creosote bush, Cooper's goldenbush, white bursage, and cheesebush (*Hymenoclea salsola*). A few Joshua trees are present. The trapping grid is located on gently rolling terrain. Like the Los Angeles Aqueduct and Bird Spring Canyon sites, this area was used for both sheep and cattle grazing for many years, although cattle grazing has been the primary use for the past 35 years. There is substantial OHV traffic on the access road that parallels the electric transmission line.

North of Barstow

Mohave ground squirrels have been captured at or adjacent to all 4 of the study sites in the area north of Barstow during previous field studies. Wessman (1977) captured or observed Mohave ground squirrels at a number of sites within 2-3 km of the Coolgardie Mesa and Lane Mountain trapping grids. Recht (pers. comm.) trapped Mohave ground squirrels in 1998 at the location described here as Recht's Site. The Superior Valley study site was trapped in 1980 (Aardahl and Roush 1985) and again in 1994 (Scarry et al. 1996). These 4 study sites are described below.

Coolgardie Mesa

The Coolgardie Mesa study site is located about 24 km north of Barstow. It parallels Route CO96 about 3 km northwest of its intersection with Copper City Road. This site is on public land administered by BLM. It has never been trapped before, but several Mohave ground squirrel occurrences have been documented within 3 km. Two vegetation communities are represented on this site. The southern portion supports Mojave Mixed Woody Scrub, with a diverse assemblage of shrubs including cheesebush, Cooper's goldenbush, spiny hopsage, and Cooper's boxthorn (*Lycium cooperi*). Joshua trees are present throughout the grid, some of them quite large. The shrub community on the northern portion of the site is very similar, but includes creosote bush as a visual dominant and would therefore be classified as Mojave Creosote Bush Scrub. The site is relatively flat, sloping gradually to the north. Route CO96 receives considerable usage by OHVs and other recreational vehicles.

Lane Mountain

This study site is about 24 km north of Barstow and 2 km west of Lane Mountain. It is located along an unpaved access road to the Lane Mountain microwave relay station about 3.3 km northeast of the point at which the access road intersects Copper City Road. This site is on public land administered by BLM. While it has never been trapped before, there are several Mohave ground squirrel records within 3 km. This is a Mojave Creosote Bush

Scrub site, dominated by creosote bush, white bursage, cheesebush, and spiny hopsage. A few Joshua trees were noted. The trapping grid is relatively flat and slopes up gently to the north. It is located along an unpaved road that receives occasional vehicular use.

Superior Valley

The Superior Valley study site is located along the north side of an unpaved road about 2.8 km west of its intersection with Copper City Road. This site is on public land administered by BLM. In 1980, Aardahl and Roush (1985) trapped 2 grids (Superior Valley East and West) at this location and a survey was also conducted here in 1994 (Scarry et al. 1996, Superior Lake grid). The vegetation community is Desert Saltbush Scrub, with Mojave saltbush (*Atriplex spinifera*), Cooper's goldenbush, and white bursage as dominants. The site is flat, with fine-textured alkaline soils. This area has received sheep grazing for over 100 years. There is occasional vehicle use on the unpaved road near the south edge of the trapping grid.

Recht's Site

This study site is located about 3 km east of the eastern end of the Superior Lake playa, on an unpaved road that leads to the abandoned Goldstone mining camp. The trapping grid extends south from the Goldstone road across a flat sandy plain. This site lies within the Superior Valley expansion area that has recently been acquired for military training purposes by the National Training Center at Fort Irwin. In 1998, a trapping survey found both Mohave ground squirrels and round-tailed ground squirrels at this location (Recht 1998). The vegetation community is Mojave Mixed Steppe, grassland dominated by big galleta grass (*Pleuraphis rigida*), with scattered Joshua trees and several species of shrubs. This site is on the Superior Valley Grazing Allotment and has historically been designated for sheep use. The road to Goldstone receives light automobile traffic, but there is almost no indication of off-highway vehicle (OHV) activity on the trapping grid.

Edwards Air Force Base / Saddleback Butte State Park

Mohave ground squirrels have been previously captured at or near the 2 study sites on EAFB and have been detected regularly at Saddleback Butte State Park. In 1993, Mohave ground squirrels were trapped in the vicinity of the VORTAC grid on EAFB (Mitchell et al. 1993). Buescher et al. (1995) captured Mohave ground squirrels at the S-9 grid on EAFB. Recht (pers. comm.) observed Mohave ground squirrels at Saddleback Butte State Park from 1973 to 1992, although no trapping was carried out. These 3 study sites are described below.

VORTAC / EAFB

This study site is on EAFB about 1 km west of Rich Road, just southwest of a prominent VORTAC station. The trapping grid was located parallel to an unpaved road that extends southwest from the VORTAC. Mitchell et al. (1993) conducted trapping here in 1993. The site supports Desert Saltbush Scrub dominated by Mojave saltbush. Monotypic stands of Mojave saltbush cover flat areas with fine-textured alkaline soils, while stabilized sand dunes have scattered Joshua trees and a more diverse shrub assemblage including Mojave saltbush, cheesebush, white bursage, and spiny hopsage. This area is closed to livestock

grazing and OHV recreation. Vehicular traffic is not permitted on the unpaved road that adjoins the trapping grid.

S-9 / EAFB

The S-9 study site is on EAFB west of Mercury Boulevard and just north of the boundary between Kern and Los Angeles counties. It extends west across a flat sandy plain and includes stabilized sand dunes adjacent to the southeast corner of the Rogers Dry Lake playa. Buescher et al. (1995) trapped at this location in 1994, when it was first designated as the S-9 grid. The vegetation community here is Desert Saltbush Scrub, with a variety of shrub species including shadscale (*Atriplex confertifolia*), fourwing saltbush (*A. canescens*), Anderson's boxthorn (*Lycium andersonii*), cheesebush, white bursage, and goldenhead. A few Joshua trees were present and a large clay pan extended into the southern edge of the site. This area is closed to livestock grazing and OHV recreation. Mercury Boulevard, a 2-lane paved road about 150 m east of the grid, carries considerable vehicular traffic.

Saddleback Butte

This study site is located in the northwest corner of Saddleback Butte State Park, a 1200 ha unit administered by California Department of Parks and Recreation. The trapping grid was placed along a hiking trail that begins 0.15 km south of the park's picnic area. Although trapping surveys have never been conducted in Saddleback Butte State Park, there have been previous observations of Mohave ground squirrels in this area and in other portions of the park (Recht, pers. comm.). The vegetation community is Mojave Creosote Bush Scrub, strongly dominated by creosote bush, white bursage, and goldenhead. A number of Joshua trees are present and contribute a visually dominant element. The site is located on the lower alluvial slopes of Saddleback Butte and is characterized by loose sandy soils. Since establishment of the state park in 1960, this area has been protected from livestock grazing and OHV recreation. The trail through the grid receives occasional use from hikers. Habitat to the west and south of the park has been altered by agricultural and residential development.

TRAPPING PROCEDURES

The trapping grids used in these surveys were rectangular in shape, measuring 105 x 840 m. On each grid, 100 trap stations were established in 4 parallel lines of 25 stations each. A 35-meter spacing was used between the 4 lines of trap stations and the stations in each line were placed at 35-meter intervals. Field personnel set up the grids using handheld GPS units to place the trap stations. 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. During the period 2-7 April, traps were positioned beside or under shrubs within 1-3 m of the wire flags that marked the trap stations (Table 2). Later in the season (10 April-16 May), cardboard covers were used to shade the traps.

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 grid edges could encounter the outer traps. With an assumed boundary strip of 50 m, each grid sampled an area of about 19 ha.

During exploratory surveys at the 7 grids in the Little Dixie Wash area, traps were pre-baited for 2 days, followed by 5 consecutive days of trapping (Table 2). The bait used was 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 to the bait, providing an odor cue to attract ground squirrels.

Table 2. Comparison of trapping protocols used during exploratory trapping surveys in 3 regions of the western Mojave Desert in 2002, including dates of trapping, sampling effort, and use of pre-baiting, types of bait, and trap covers.

Region	Grid name	Trapping period	Trap-days	Pre-baiting	Bait type[1]	Trap covers
Little Dixie Wash	Bowman Road	2-6 April	500	2 days	Grain	No
	North El Paso	2-6 April	500	2 days	Grain	No
	Freeman Gulch	2-6 April	500	2 days	Grain	No
	Last Chance	2-6 April	500	2 days	Grain	No
	Los Angeles Aqueduct	3-7 April	500	2 days	Grain	No
	Bird Spring Canyon	3-7 April	500	2 days	Grain	No
	Powerline	3-7 April	500	2 days	Grain	No
North of Barstow	Coolgardie Mesa	10-14 April	500	None	BB/grain	Yes
	Lane Mountain	10-14 April	500	None	BB/grain	Yes
	Superior Valley	11-15 April	500	None	BB/grain	Yes
	Recht's Site	11-15 April	500	None	BB/grain	Yes
EAFB/Saddleback	VORTAC / EAFB	6-10 May	500	None	BB/grain	Yes
	S-9 / EAFB	7-11 May	500	None	BB/grain	Yes
	Saddleback Butte	12-16 May	500	None	Grain	Yes

1. Grain is livestock feed consisting of rolled oats, rolled barley, and cracked corn with molasses; BB is a mixture of livestock feed, peanut butter, and honey formed into 1 cm diameter spheres (bait balls).

The protocol used at the other grids differed in two respects. First, trapping was conducted for 5 consecutive days with no pre-baiting, a procedure that conforms to the DFG guidelines for presence/absence surveys (DFG 2003). Second, a different method of presenting bait was tested at 6 of these 7 grids. At these grids, traps were baited with either the livestock feed (mixed grain) and rolled oats/peanut butter powder or with a mixture of livestock feed, peanut butter, and honey formed into 1 cm diameter spheres (bait balls). The mixed grain and the bait balls were used every day in an alternating spatial pattern, with every other trap in each lettered line receiving a different type of bait. When traps were re-set, the old bait was placed in a plastic bag.

During each 5-day trapping period, traps were normally opened in the morning between 0800 and 1000 hours and closed in the afternoon between 1600 and 1800 hours. Trap checks were conducted twice each day on a regular schedule. Traps were open for an average of 8.1 h/d, with the mean ranging from 7.8 h/d at the Los Angeles Aqueduct grid to 8.5 h/d at the VORTAC / EAFB grid.

All captured ground squirrels were identified to species, sex, and age class (adult/juvenile). Juvenile white-tailed antelope squirrels were recognized by their short, smooth pelage and by body mass (<80 g). 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. Body mass was determined upon first capture using a 300-g capacity Pesola® spring scale. In addition, body measurements (head length and width, foot/tarsus, and leg length) were taken for Mohave ground squirrels. Mohave ground squirrels were permanently marked for individual identification with a 10-mm passive integrated transponder (PIT) tag (BioSonics® 400 kHz). The tags were implanted subcutaneously between the shoulder blades using a veterinary syringe and 12-gauge needle. Both Mohave ground squirrels and white-tailed antelope squirrels 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. After all information was recorded on standard field data forms, the animal was released at the place of capture.

COLLECTION OF TISSUE SAMPLES

Tissue samples were collected from all captured Mohave ground squirrels for future genetic studies. Disposable dermal biopsy punches were used to obtain 2-mm diameter tissue samples from the external ear. Samples were placed in labeled microvials and preserved in 95% ethanol.

FOOD HABITS ANALYSIS

The diet of Mohave ground squirrels captured during the field studies was determined by microscopic examination of undigested food material found in fecal samples. Fecal samples were obtained from all Mohave ground squirrels captured during the 2002 exploratory trapping surveys. Three fresh fecal pellets were removed from the trap after an animal was captured, processed, and released. The sample was placed in a small envelope that was sealed and labeled to indicate the species, sex, age class, PIT tag number, date, study site, and trap station. After each capture, all remaining fecal pellets were cleared from the trap, thus ensuring that a subsequent sample could be accurately attributed to a known individual.

Fecal samples were analyzed to estimate diet composition at the Wildlife Habitat Laboratory, Washington State University, Pullman, Washington. Each sample was prepared and processed in the laboratory and transferred to a microscope slide for the identification of discernable plant fragments and other food materials. The relative cover of plant cuticle and epidermal fragments was quantified for 25 randomly located microscope views at 100X power. A grid mounted in the eyepiece of the microscope was used to measure the area covered by each positively identified fragment. Greater magnifications (200-450X) were used to aid in identification of discernable fragments. Plants in the fecal material were identified to genus and species where possible. Percentage of diet composition by percent cover was estimated by the dividing the area on the slide covered by each plant type by the total area covered by all plant types. Percent cover for a food item is considered to be a reasonable estimate of its percent dry weight contribution to the diet.

In some cases, bait material was found during analysis of fecal samples, especially when pre-baiting was done prior to trapping. If bait contributed $\geq$50 percent of total cover in a

given sample, that sample was not used in presenting diet results. Where bait materials were present but amounted to <50 percent cover, the cover due to bait was subtracted from the total and the cover made up by natural food items was recalculated so that they totaled 100 percent.

VEGETATION SAMPLING

The winter of 2001-2002 was very dry throughout the western Mojave Desert. As a result, there was almost no annual plant growth observed at the 14 study sites that were trapped in April and May 2002. A few forb and grass seedlings were observed in scattered areas, but they were desiccated and dead by May. The seedlings were mainly fiddleneck (*Amsinckia tessellata*) and 2 non-native species, filaree (*Erodium cicutarum*) and Mediterranean grass (*Schismus* spp.). Because of the almost total lack of herbaceous standing crop, no attempt was made to sample this component of the 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). Since the grids each covered about 88,000 m^2 or 8.8 ha, the area sampled was approximately 1.4% of the trapping site. Belt transects began at a point 5 m from the trap station on a pre-determined randomly chosen 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 decimeter (dm) tall and 1 dm in greatest horizontal dimension. Shrubs smaller than this were assumed to have no significant value as Mohave ground squirrel habitat, either as cover or food. 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, 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, cover, and volume for each grid could then be 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 equipped with a thermistor probe. Wind speed was determined with a handheld anemometer or estimated by use of a USFS 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

Little Dixie Wash

Five days of trapping (3500 trap-days) in the Little Dixie Wash area resulted in the capture of 19 individual Mohave ground squirrels during the period 2-7 April 2002 (Table 3). Captures were recorded at 6 of the 7 grids in this area. The number of Mohave ground squirrels ranged from 1 at the Bowman Road grid to a maximum of 6 individuals at the North El Paso grid. No Mohave ground squirrels were trapped at the Powerline grid. A total of 52 Mohave ground squirrel captures was recorded due to recaptures of many individuals.

Table 3. Trapping results for Mohave ground squirrels at 7 grids in the Little Dixie Wash area during the period 2-7 April 2002.

	Adults					
Grid name	Male	Female	Juveniles	Total number of individuals	Recaptures	Total number of captures
Bowman Road	0	1	0	1	0	1
North El Paso	0	6	0	6	7	13
Freeman Gulch	0	5	0	5	9	14
Last Chance	0	2	0	2	7	9
Los Angeles Aqueduct	0	3	0	3	8	11
Bird Spring Canyon	0	2	0	2	2	4
Powerline	0	0	0	0	0	0
Totals	0	19	0	19	33	52

All Mohave ground squirrels captured in the Little Dixie Wash area were adult females (Table 4). None of these animals showed any indication of reproductive activity, such as pregnancy or lactation. The mean body mass was 133.0 g (s = 24.8) with a minimum of 98 g and a maximum of 183 g.

Table 4. Characteristics of Mohave ground squirrels captured in the Little Dixie Wash area during the period 2-7 April 2002.

Grid name	PIT tag number	Sex	Body mass (g)	Reproductive condition
Bowman Road	1F64040574	F	165	Non-reproductive
North El Paso	1F65133435	F	103	Non-reproductive
North El Paso	1F66630216	F	110	Non-reproductive
North El Paso	1F605B2A7C	F	101	Non-reproductive
North El Paso	Not pit-tagged	F	112	Non-reproductive
North El Paso	1F67417742	F	138	Non-reproductive
North El Paso	1F64076115	F	183	Non-reproductive
Freeman Gulch	1F655F100D	F	151	Non-reproductive
Freeman Gulch	1F650A747E	F	118	Non-reproductive
Freeman Gulch	1F64621E7D	F	143	Non-reproductive
Freeman Gulch	1F62183D2A	F	120	Non-reproductive
Freeman Gulch	1F606F286A	F	124	Non-reproductive
Last Chance	1F632F311E	F	130	Non-reproductive
Last Chance	1F65735D2C	F	172	Non-reproductive
Los Angeles Aqueduct	1F65636E2B	F	134	Non-reproductive
Los Angeles Aqueduct	1F617B4F36	F	98	Non-reproductive
Los Angeles Aqueduct	1F65525A50	F	129	Non-reproductive
Bird Spring Canyon	1F64024D2E	F	132	Non-reproductive
Bird Spring Canyon	1F614F723F	F	164	Non-reproductive

White-tailed antelope squirrels were captured on all 7 grids in the Little Dixie Wash area during the period 2-7 April (Table 5). A total of 123 individuals were trapped in this area, ranging from a minimum of 6 at the North El Paso grid to a maximum of 26 at the Powerline grid. A total of 271 white-tailed antelope squirrel captures were recorded due to many recaptures.

Table 5. Trapping results for white-tailed antelope squirrels captured on 7 grids in the Little Dixie Wash area during the period 2-7 April 2002.

	Adults			Total number of		Total number of
Grid name	Male	Female	Juveniles	individuals	Recaptures	captures
Bowman Road	7	9	0	16	17	33
North El Paso	2	3	1	6	8	14
Freeman Gulch	7	9	0	18[1]	37	55
Last Chance	13	9	0	22	27	49
Los Angeles Aqueduct	8	9	4	21	31	52
Bird Spring Canyon	6	8	0	14	5	19
Powerline	13	11	2	26	23	49
Totals	56	58	7	123	148	271

1. The sex was not recorded for 2 white-tailed antelope squirrels; therefore the total number of individuals captured at the Freeman Gulch grid was 18.

Approximately equal numbers of adult male and female white-tailed antelope squirrels were captured in the Little Dixie Wash area. Juveniles were trapped at 3 of the 7 grids.

Two pregnant and 9 lactating adult females were recorded on grids in the Little Dixie Wash area. Some adult males were still in reproductive condition, with 8 noted as having scrotal testes.

North of Barstow

A total of 2000 trap-days of sampling effort in the area north of Barstow during the period 10-15 April yielded 14 individual Mohave ground squirrels (Table 6). This species was captured on all 4 grids. The number of individuals ranged from 2 at the Lane Mountain and Superior Valley grids to 7 at the Coolgardie Mesa grid. Trapping was conducted for a sixth day (15 April) at Coolgardie Mesa to see if additional sampling effort would add new Mohave ground squirrels. Since only recaptures were recorded on 15 April, these data were excluded from the analysis to facilitate better comparison of the study sites. A total of 45 Mohave ground squirrel captures was recorded from all 4 grids, since many individuals were recaptured one or more times.

Table 6. Trapping results for Mohave ground squirrels on 4 grids in the area north of Barstow during the period 10-15 April 2002.

	Adults			Total number of		Total number of
Grid name	Male	Female	Juveniles	individuals	Recaptures	captures
Coolgardie Mesa	3	4	0	7	15	22
Lane Mountain	1	1	0	2	9	11
Superior Valley	0	2	0	2	0	2
Recht's Site	3	0	0	3	7	10
Totals	7	7	0	14	31	45

All Mohave ground squirrels captured in the area north of Barstow were adults (Table 7). The sex ratio was 1:1. All females were non-reproductive and all males had non-scrotal testes. Mean body mass was 162.6 g (s = 35.6) with a minimum of 112 g and a maximum of 216 g.

White-tailed antelope squirrels were captured on all 4 grids in the area north of Barstow during the period 10-15 April (Table 8). A total of 73 individuals were trapped in this area, ranging from a minimum of 11 at the Superior Valley grid to a maximum of 25 at the Coolgardie Mesa grid. A total of 106 white-tailed antelope squirrel captures were recorded due to recaptures of some individuals.

In the area north of Barstow, adult male white-tailed antelope squirrels were more numerous than females on 3 of the grids and the overall sex ratio was 1.3:1. Juveniles were trapped at 3 of the 4 grids. One pregnant and 1 lactating adult female were recorded on grids in this area. One adult male was noted as having scrotal testes.

Table 7. Characteristics of Mohave ground squirrels captured in the area north of Barstow during the period 10-15 April 2002.

Grid name	PIT tag number	Sex	Body mass (g)	Reproductive condition
Coolgardie Mesa	Not pit-tagged	F	160	Non-reproductive
Coolgardie Mesa	1F62152446	F	182	Non-reproductive
Coolgardie Mesa	1F663A2918	F	165	Non-reproductive
Coolgardie Mesa	1F63675F38	F	216	Non-reproductive
Coolgardie Mesa	1F6151230C	M	190	Testes non-scrotal
Coolgardie Mesa	1F68664D46	M	158	Testes non-scrotal
Coolgardie Mesa	1F655B2D74	M	202	Testes non-scrotal
Lane Mountain	1F64755236	M	210	Testes non-scrotal
Lane Mountain	1F666E0E7F	F	119	Non-reproductive
Superior Valley	Not pit-tagged	F	134	Non-reproductive
Superior Valley	1F651D302F	F	132	Non-reproductive
Recht's Site	1F67205C7E	M	180	Testes non-scrotal
Recht's Site	1F61374900	M	116	Testes non-scrotal
Recht's Site	1F681C0855	M	112	Testes non-scrotal

Table 8. Trapping results for white-tailed antelope squirrels on 4 grids in the area north of Barstow during the period 10-15 April 2002.

	Adults			Total number of		Total number of
Grid name	Male	Female	Juveniles	individuals	Recaptures	captures
Coolgardie Mesa	11	9	5	25	9	34
Lane Mountain	11	5	5	21	8	29
Superior Valley	1	7	3	11	7	18
Recht's Site	11	5	0	16	9	25
Totals	34	26	13	73	33	106

Edwards Air Force Base / Saddleback Butte

A total of 1500 trap-days of sampling effort in the EAFB / Saddleback Butte area during the period 6-16 May yielded 7 individual Mohave ground squirrels (Table 9). This species was found only on the S-9 / EAFB grid, where the 7 individuals were captured. A total of 15 Mohave ground squirrel captures was recorded on the S-9 / EAFB grid, since several individuals were recaptured one or more times.

Table 9. Trapping results for Mohave ground squirrels at 3 grids at Edwards Air Force Base and Saddleback Butte State Park during the period 6-16 May 2002.

	Adults			Total number of		Total number of
Grid name	Male	Female	Juveniles	individuals	Recaptures	captures
VORTAC / EAFB	0	0	0	0	0	0
S-9 / EAFB	4	3	0	7	8	15
Saddleback Butte	0	0	0	0	0	0
Totals	4	3	0	7	8	15

All Mohave ground squirrels captured on the S-9 grid at EAFB were adults (Table 10). Four males and 3 females were recorded, for a sex ratio of 1.3:1. All females were non-reproductive and all males had non-scrotal testes. The mean body mass was 159.3 g (s = 17.9) with a minimum of 139 g and a maximum of 183 g.

White-tailed antelope squirrels were captured on all 3 grids in the EAFB / Saddleback Butte area during the period 6-16 May (Table 11). A total of 107 individuals were trapped in this area, ranging from a minimum of 3 on the Saddleback Butte grid to a maximum of 61 on the VORTAC / EAFB grid. A total of 187 white-tailed antelope squirrel captures were recorded due to recaptures of some individuals. In addition, a single adult California ground squirrel (*Otospermophilus* [=*Spermophilus*] *beecheyi*) was captured at the Saddleback Butte grid.

In the EAFB / Saddleback Butte area, adult male white-tailed antelope squirrels were more numerous than females on all 3 grids and the overall sex ratio was 1.5:1. Juveniles were trapped on 2 of the grids. None were found on the Saddleback Butte grid, but juveniles were very abundant on the VORTAC / EAFB grid. Four post-lactating adult females were recorded on grids in this area. No scrotal males were captured.

Table 10. Characteristics of Mohave ground squirrels captured on the S-9 grid at Edwards Air Force Base during the period 7-11 May 2002.

Grid name	PIT tag number	Sex	Body mass (g)	Reproductive condition
S-9 / EAFB	1F6539271C	F	143	Non-reproductive
S-9 / EAFB	1F6512600A	F	178	Non-reproductive
S-9 / EAFB	1F630E3E32	F	163	Non-reproductive
S-9 / EAFB	1F642A5E75	M	166	Testes non-scrotal
S-9 / EAFB	1F68420037	M	183	Testes non-scrotal
S-9 / EAFB	1F61572801	M	143	Testes non-scrotal
S-9 / EAFB	1F66142C3B	M	139	Testes non-scrotal

Table 11. Trapping results for white-tailed antelope squirrels on 3 grids at Edwards Air Force Base and Saddleback Butte State Park during the period 6-16 May 2002.

	Adults			Total number of		Total number of
Grid name	Male	Female	Juveniles	individuals	Recaptures	captures
VORTAC / EAFB	14	9	38	61	44	105
S-9 / EAFB	21	14	8	43	36	79
Saddleback Butte	2	1	0	3	0	3
Totals	37	24	46	107	80	187

FOOD HABITS

Little Dixie Wash

The results of diet analysis for Mohave ground squirrels in the Little Dixie Wash area are shown in Table 12. These data are based upon fecal samples from 7 individuals at 4 of the trapping grids. Although samples were analyzed for a total of 18 Mohave ground

squirrels, many were not usable because they contained more than 50 percent bait materials, a consequence of the pre-baiting procedure used at these sites.

Table 12. Summary of food habits results for Mohave ground squirrels at 4 grids in the Little Dixie Wash area during the period 2-7 April 2002.

		Average Percent Cover of Food Items in Fecal Samples (Frequency of Food Item Occurrence in Parentheses)			
Food Item		**North El Paso**	**Freeman Gulch**	**Last Chance**	**Los Angeles Aqueduct**
Grasses and allies	*Achnatherum hymenoides*	28.7 (1.0)	1.2 (0.5)	8.7 (0.5)	
	Achnatherum speciosum	16.2 (1.0)		11.9 (0.5)	
	Bromus spp.			3.9 (0.5)	
	Poa spp.	11.2 (1.0)		7.2 (0.5)	
	Grass flower			4.0 (0.5)	
	Total, grasses	**56.1 (1.0)**	**1.2 (0.5)**	**35.6 (1.0)**	
Shrubs	*Ambrosia* spp.	2.5 (1.0)	0.6 (0.5)		
	Chrysothamnus spp.		0.6 (0.5)	15.9 (0.5)	
	Grayia spinosa leaf, stem	11.3 (1.0)	29.8 (1.0)	5.2 (0.5)	65.2 (1.0)
	Gutierrezia microcephala	2.5 (1.0)			
	Krascheninnikovia lanata	2.5 (1.0)			
	Lycium spp.			2.5 (0.5)	
	Shrub stem		2.3 (0.5)		
	Total, shrubs	**18.8 (1.0)**	**33.3 (1.0)**	**23.6 (1.0)**	**65.2 (1.0)**
Forbs	*Camissonia* sp.	5.0 (1.0)	7.8 (1.0)		1.9 (1.0)
	Chaenactis sp.		1.8 (0.5)	8.9 (0.5)	
	Eriogonum sp.	2.5 (1.0)			
	Erodium cicutarium	1.2 (1.0)			
	Flower parts		32.1 (1.0)		
	Legume (*Astragalus*/*Lupinus*)		3.7 (1.0)		
	Lepidium spp. leaf, seed		12.0 (1.0)		
	Mentzelia spp.			2.3 (1.0)	
	Monardella sp.	3.8 (1.0)	6.6 (1.0)	1.6 (0.5)	5.2 (0.5)
	Nama/*Phacelia*			1.3 (0.5)	
	Salsola tragus leaf, flower		1.7 (0.5)	5.2 (0.5)	5.4 (1.0)
	Total, forbs	**12.5 (1.0)**	**65.6 (1.0)**	**19.3 (1.0)**	**12.5 (1.0)**
Other plant material	Pollen			0.7 (0.5)	
	Thorn			5.1 (0.5)	
	Unknown seed	3.8 (1.0)		6.4 (0.5)	
	Total, other plant material	**3.8 (1.0)**		**12.2 (0.5)**	
Arthropod Material		8.8 (1.0)		9.3 (1.0)	22.3 (1.0)
TOTAL		**100.0**	**100.0**	**100.0**	**100.0**
Number of samples		**1**	**2**	**2**	**2**
Number of individuals		**1**	**2**	**2**	**2**
Mean number of items / sample		**13**	**9**	**9.5**	**4.5**
Range in number of items / sample		**13**	**6-12**	**8-11**	**4-5**

There was considerable variation in the diet among the sites, but the results for the North El Paso and Last Chance grids showed some similarities. At both sites, native perennial grasses were the largest component of the diet, followed by shrub and forb materials.

However, within each category, there were differences in the genera and species consumed.

Samples from the Freeman Gulch and Los Angeles Aqueduct grids were similar in that grasses were almost completely absent and shrub material (spiny hopsage leaf) was an important component. They differed in other respects, with forbs contributing about two-thirds of the diet at Freeman Gulch and shrub material an equivalent proportion at Los Angeles Aqueduct. Arthropod (insect) material made up almost one-fourth of relative cover in the samples from Los Angeles Aqueduct, but was not recorded from Freeman Gulch.

North of Barstow

Table 13 presents the results of food habits analysis for a total of 12 Mohave ground squirrels drawn from all 4 of the trapping sites in the area north of Barstow. Pre-baiting was not used here and only 2 samples were rejected because bait made up more than 50 percent of relative cover. Bait material was <3 percent in all 12 samples shown in Table 13.

At the 2 southern trapping grids, Coolgardie Mesa and Lane Mountain, shrub material, especially spiny hopsage, made up almost one-half of the diet. A variety of forb species contributed 45 percent relative cover at Coolgardie Mesa, while arthropod (insect) material and forbs each provided about one-quarter of the diet at Lane Mountain. At the Superior Valley grid, saltbush leaf was the most important individual food item in the single sample that was analyzed. A variety of forb species totaled >50 percent relative cover and insects were also a significant part of the diet here. At Recht's Site, the diet was strongly dominated by the shrub winterfat, which accounted for >73 percent relative cover. Insects were second in importance here (22 percent relative cover), while forbs made up the remainder of the food items (12.5 percent relative cover). In general, very little grass was found in the samples from this area.

Table 13. Summary of food habits results for Mohave ground squirrels at 4 grids in the area north of Barstow during the period 10-15 April 2002.

		Average Percent Cover of Food Items in Fecal Samples (Frequency of Food Item Occurrence in Parentheses)			
Food Item		**Coolgardie Mesa**	**Lane Mountain**	**Superior Valley**	**Recht's Site**
Grasses and allies	*Achnatherum hymenoides*	0.9 (0.2)			
	Achnatherum speciosum			4.1 (1.0)	
	Bromus madritensis var. *rubens*	0.6 (0.2)			
	Total, grasses	**1.4 (0.2)**		**4.1 (1.0)**	
Shrubs	*Ambrosia* spp.	4.6 (0.5)	0.8 (0.5)		
	Artemisia spp.				0.8 (0.3)
	Atriplex spp. leaf			20.6 (1.0)	2.4 (0.3)
	Chrysothamnus spp.	1.1 (0.2)			
	Coleogyne ramosissima	0.4 (0.2)			
	Grayia spinosa leaf, stem, flower	39.6 (0.8)	45.6 (1.0)	4.1 (1.0)	
	Krascheninnikovia lanata		2.3 (0.5)	4.1 (1.0)	73.3 (1.0)
	Solanum spp.				0.8 (0.3)
	Total, shrubs	**45.7 (0.8)**	**48.6 (1.0)**	**28.8 (1.0)**	**81.1 (1.0)**
Forbs	*Amsinckia tesselata*	1.0 (0.5)			
	Asteraceae (Composite) flower			8.3 (1.0)	
	Camissonia sp.	14.8 (0.8)	12.8 (1.0)	7.2 (1.0)	
	Chaenactis sp.	6.5 (0.2)		6.2 (1.0)	
	Coreopsis sp.	0.4 (0.2)		2.1 (1.0)	
	Erodium cicutarium	3.2 (0.3)			1.6 (0.3)
	Flower parts	6.6 (0.3)		4.1 (1.0)	5.5 (0.7)
	Legume (*Astragalus*/*Lupinus*)	0.8 (0.2)	2.6 (0.5)	12.4 (1.0)	3.8 (0.7)
	Monardella sp.	8.0 (1.0)	7.6 (1.0)	4.1 (1.0)	
	Nama/*Phacelia*	0.8 (0.2)			0.8 (0.3)
	Oenothera spp.	1.2 (0.2)		6.2 (1.0)	
	Salsola tragus	1.4 (0.3)	0.9 (0.5)		
	Salvia sp.				1.5 (0.3)
	Sphaeralcea ambigua	0.4 (0.2)			4.1 (0.3)
	Total, forbs	**45.1 (1.0)**	**23.8 (1.0)**	**50.6 (1.0)**	**17.3 (1.0)**
Other plant material	Moss	0.7 (0.2)			
	Pollen	1.1 (0.3)	0.5 (0.5)		
	Unknown seed	1.9 (0.3)			
	Total, other plant material	**3.7 (0.5)**	**0.5 (0.5)**		
Arthropod material		4.3 (0.7)	27.2 (0.5)	16.5 (1.0)	5.5 (0.3)
TOTAL		**100.3**	**100.1**	**100.0**	**100.1**
Number of samples		**6**	**2**	**1**	**3**
Number of individuals		**6**	**2**	**1**	**3**
Mean number of items / sample		**7.8**	**5.5**	**13**	**5**
Range in number of items / sample		**6-10**	**5-6**	**13**	**4-6**

Edwards Air Force Base / Saddleback Butte

Food habits results are available for 7 Mohave ground squirrels captured at the S-9 grid on Edwards Air Force Base (Table 14). There was no pre-baiting at this site and all samples could be used in the analysis. Six samples contained no bait materials, while 36 percent relative cover was attributed to bait in the seventh sample.

Table 14. Summary of food habits results for Mohave ground squirrels at the S-9 grid, Edwards Air Force Base during the period 7-11 May 2002.

Food Item		Average Percent Cover of Food Items in Fecal Samples	(Frequency of Food Item Occurrence in Parentheses)
Grasses and allies	*Achnatherum hymenoides*	0.9	(0.1)
	Achnatherum speciosum	2.1	(0.1)
	Total, grasses	**3.0**	**(0.3)**
Shrubs	*Ambrosia* spp.	4.1	(0.3)
	Atriplex spp. leaf	7.3	(0.6)
	Atriplex spp. stem	1.9	(0.1)
	Grayia spinosa leaf	1.3	(0.3)
	Tetradymia spp. flower	0.4	(0.1)
	Shrub leaf	0.4	(0.1)
	Total, shrubs	**15.4**	**(0.7)**
Forbs	*Asteraceae* (Composite) flower	6.0	(0.3)
	Eriogonum sp.	1.1	(0.3)
	Erodium cicutarium	0.5	(0.1)
	Flower parts	9.2	(0.3)
	Gilia/*Linanthus*	3.9	(0.3)
	Lepidium spp.	0.4	(0.1)
	Lepidium spp. Flower	0.4	(0.1)
	Legume (*Astragalus*/*Lupinus*)	4.9	(0.3)
	Total, forbs	**26.4**	**(1.0)**
Other plant material	Pollen	55.1	(1.0)
	Total, other plant material	**55.1**	**(1.0)**
TOTAL		**99.9**	
Number of samples		7	
Number of individuals		7	
Mean number of items / sample		4.6	
Range in number of items / sample		(3-8)	

Pollen was the most important dietary item here, accounting for over 55 percent relative cover. All 7 samples showed a high proportion of pollen, ranging from 39-78 percent relative cover. It was not clear whether the pollen was derived from forbs or shrubs, but flower parts from forbs were also abundant, suggesting that the pollen might be from forb sources. Forb material contributed about one-quarter of the total relative cover, with shrub leaf making up just over 15 percent cover. There was no insect material and grasses were barely represented.

SHRUB VEGETATION

General Description of Shrub Vegetation

Shrub vegetation was sampled by belt transects on all 14 grids where live-trapping surveys were conducted in 2002. Table 15presents data on the number of shrub species, percent shrub cover, and total shrub density found at these sites. The number of shrub species recorded (species richness) varied from a low of 5 at the Saddleback Butte grid to a high of

17 at the Last Chance and S-9 / EAFB grids. Shrub cover was lowest at the Recht's Site grid and highest at the Last Chance grid. Total shrub density also varied over a wide range, from just 1,400 shrubs/ha at the Saddleback Butte grid to 10,872 shrubs/ha at the Bird Spring Canyon grid.

Table 15. Number of shrub species, percent shrub cover, and shrub density at 14 trapping grids in 3 regions of the western Mojave Desert.

Region	Grid name	Number of shrub species	Percent shrub cover	Shrub density (plants/hectare)
Little Dixie Wash	Bowman Road	6	25.0	6,008
	North El Paso	9	36.3	8,888
	Freeman Gulch	10	23.9	6,800
	Last Chance	17	50.3	8,472
	Los Angeles Aqueduct	9	39.6	9,824
	Bird Spring Canyon	14	45.7	10,872
	Powerline	13	28.0	6,888
North of Barstow	Coolgardie Mesa	16	37.8	5,736
	Lane Mountain	14	37.6	6,968
	Superior Valley	9	13.6	4,096
	Recht's Site	13	9.3	1,776
EAFB/Saddleback	VORTAC / EAFB	14	16.8	3,296
	S-9 / EAFB	17	19.7	3,144
	Saddleback Butte	5	25.0	1,400

A wide range of Mojave Desert natural communities was represented on these 14 study sites (Table 16). Mojave Creosote Bush Scrub was present at 8 of the grids and Desert Saltbush Scrub at 3 study sites. Other communities included Mojave Mixed Woody Scrub (2), Mojave Mixed Steppe (1), and Blackbush Scrub (1).

Table 16. Natural communities found at 14 trapping grids in 3 regions of the western Mojave Desert. Brief descriptions of these communities are presented in Holland (1986).

Region	Grid name	Natural communities
Little Dixie Wash	Bowman Road	Mojave Creosote Bush Scrub
	North El Paso	Mojave Creosote Bush Scrub
	Freeman Gulch	Mojave Mixed Woody Scrub
	Last Chance	Mojave Creosote Bush Scrub
	Los Angeles Aqueduct	Mojave Creosote Bush Scrub
	Bird Spring Canyon	Blackbush Scrub
	Powerline	Mojave Creosote Bush Scrub
North of Barstow	Coolgardie Mesa	Mojave Mixed Woody Scrub/ Mojave Creosote Bush Scrub
	Lane Mountain	Mojave Creosote Bush Scrub
	Superior Valley	Desert Saltbush Scrub
	Recht's Site	Mojave Mixed Steppe
EAFB/Saddleback	VORTAC / EAFB	Desert Saltbush Scrub
	S-9 / EAFB	Desert Saltbush Scrub
	Saddleback Butte	Mojave Creosote Bush Scrub

Shrub Vegetation at Little Dixie Wash Sites

Nineteen shrub species were recorded on belt transects over the 7 trapping grids (Table 17). The species composition of the local shrub vegetation varied considerably among grids; just 3 shrub species were present at all sites: goldenhead, white bursage, and Cooper's goldenbush. The 5 grids classified as Mojave Creosote Bush Scrub shared only these 3 widespread species plus creosote bush. In species richness, they ranged from Bowman Road with only 2 other minor shrub species to Last Chance where 13 other shrubs were recorded, including 8 species with densities >100 plants/hectare.

Table 17. Species composition and densities of shrub vegetation at 7 trapping grids in the Little Dixie Wash area.

	Shrub density (plants/hectare)						
Shrub species	**Bowman Road**	**North El Paso**	**Freeman Gulch**	**Last Chance**	**Los Angeles Aqueduct**	**Bird Spring Canyon**	**Powerline**
Acamptopappus sphaerocephalus	128	1112	856	1544	656	352	472
Ambrosia dumosa	4760	5600	2760	1536	4672	992	920
Atriplex canescens				16			
Coleogyne ramosissima				136		1320	496
Ephedra nevadensis				1680		952	344
Ericameria cooperi	680	464	592	384	3272	4480	2984
Eriogonum fasciculatum				144		112	504
Grayia spinosa		808	1432	288	528	888	64
Gutierrezia microcephala				32			
Hymenoclea salsola		16	280	968	200	1376	824
Krascheninnikovia lanata		64	432	1000	80	96	8
Larrea tridentata	384	728		376	304		216
Lycium andersonii		72	144	120		184	16
Lycium cooperi			64	48	24	56	
Mirabilis bigelovii	16	24	96		88		8
Opuntia echinocarpa	40			16		8	32
Salazaria mexicana				160			
Tetradymia sp.			144			40	
Yucca brevifolia				24		16	
Total live shrub density	**6008**	**8888**	**6800**	**8472**	**9824**	**10872**	**6888**
Total density of standing litter	**752**	**1536**	**1208**	**1640**	**1536**	**784**	**2160**

Although the shrub vegetation at the Freeman Gulch grid was best described as Mojave Mixed Woody Scrub, overall species composition was almost identical to that the 2 closest grids, North El Paso and Los Angeles Aqueduct, except for the absence of creosote bush.

The Bird Spring Canyon grid was characterized as Blackbush Scrub because of the high density of blackbrush (*Coleogyne ramosissima*) combined with absence of creosote bush. However, overall species composition was very similar to that of the 2 other southern grids, Powerline and Last Chance. These were the only grids where blackbrush, Mormon-tea (*Ephedra nevadensis*), and California buckwheat (*Eriogonum fasciculatum*) were detected.

Thirteen shrub species had cover values ≥0.5% on at least 1 of the 7 trapping grids (Table 18). Creosote bush made an important contribution to shrub cover on all 5 of the grids designated as Mojave Creosote Bush Scrub, making up 15-47% of total cover. White bursage also provided significant cover on 5 study sites, as did Cooper's goldenbush on 3 grids. Four other shrub species had cover values >5% on 1 or 2 study sites, including blackbush, Mormon-tea, spiny hopsage, and cheesebush.

Table 18. Percent shrub cover for species that showed cover ≥0.5% on at least 1 of the 7 trapping grids in the Little Dixie Wash area.

	Percent cover[1]						
Shrub species	**Bowman Road**	**North El Paso**	**Freeman Gulch**	**Last Chance**	**Los Angeles Aqueduct**	**Bird Spring Canyon**	**Powerline**
Acamptopappus sphaerocephalus		3.5	2.0	4.2	1.7	1.2	1.3
Ambrosia dumosa	11.6	12.1	7.6	5.5	13.8	1.8	2.6
Coleogyne ramosissima				2.1		13.8	4.6
Ephedra nevadensis				7.8		4.3	1.5
Ericameria cooperi	1.1	1.6	1.2	1.3	12.6	11.3	5.3
Eriogonum fasciculatum							0.6
Grayia spinosa		3.0	7.4	2.1	4.5	5.2	0.5
Hymenoclea salsola			1.6	6.0	0.7	4.7	2.7
Krascheninnikovia lanata			0.9	2.3			
Larrea tridentata	11.8	15.6		16.9	6.0		8.7
Lycium andersonii			1.0	0.6		1.0	
Lycium cooperi			1.4			1.5	
Tetradymia sp.			0.7				
Percent cover of standing litter	**1.4**	**2.3**	**3.3**	**3.9**	**3.3**	**0.5**	**3.5**

1. 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).

Shrub Vegetation at Sites North of Barstow

A total of 20 shrub species were documented on the 4 trapping grids in the area north of Barstow (Table 19). Six shrub species were present at all 4 grids: goldenhead, white bursage, spiny hopsage, cheesebush, winterfat, and Anderson's boxthorn. Species richness was moderate at the Superior Valley study site with 9 species, while the number of species was relatively high on the other 3 grids, ranging from 13-16 per grid.

Shrub species composition was quite similar on the 2 southernmost sites, Coolgardie Mesa and Lane Mountain. The Lane Mountain grid and a portion of the Coolgardie Mesa grid were categorized as Mojave Creosote Bush Scrub. Creosote bush was absent from the remainder of the Coolgardie Mesa site, which was classified as Mojave Mixed Woody Scrub. These 2 grids shared 13 shrub species, including Joshua tree as a visual component.

The Superior Valley grid was classified as Desert Saltbush Scrub and was dominated by Mojave saltbush. White bursage and Cooper's goldenbush were also present at high densities. No creosote bush or Joshua trees were recorded at this site.

The Recht's Site grid supported Mojave Mixed Steppe, a vegetation community dominated by big galleta grass and several shrub species, including goldenhead, four-wing saltbush (*Atriplex canescens*), cheesebush, and winterfat. Overall shrub density at this site was very low (>2000 plants/hectare), reflecting the relative importance of big galleta grass. Creosote bush and Joshua tree were present at low densities, but quite obvious visually.

Table 19. Species composition and densities of shrub vegetation at 4 trapping grids in the area north of Barstow.

	Shrub density (plants/hectare)			
Shrub species	**Coolgardie Mesa**	**Lane Mountain**	**Superior Valley**	**Recht's Site**
Acamptopappus sphaerocephalus	248	224	240	296
Ambrosia dumosa	504	88	576	176
Atriplex canescens				232
Atriplex confertifolia			16	
Atriplex spinifera			1832	
Ephedra nevadensis	376	680		
Ericameria cooperi	1760	2600	976	
Grayia spinosa	792	960	176	24
Hymenoclea salsola	1040	528	16	464
Krascheninnikovia lanata	224	520	144	328
Larrea tridentata	112	96		8
Lycium andersonii	136	944	120	120
Lycium cooperi	200			48
Mirabilis bigelovii		40		24
Opuntia echinocarpa	8	16		24
Salazaria mexicana	64			
Tetradymia spinosa	40	40		8
Thamnosma montana	136	216		
Xylorhiza tortifolia	32			
Yucca brevifolia	64	16		24
Total live shrub density	**5736**	**6968**	**4096**	**1776**
Total density of standing litter	**1016**	**1480**	**2320**	**424**

Fourteen shrub species were represented by cover values $\geq$0.5% on at least 1 of the 4 trapping grids (Table 20). At the Coolgardie Mesa and Lane Mountain grids, spiny hopsage showed the highest percent cover, followed by creosote bush and Cooper's goldenbush. Mojave saltbush and Cooper's goldenbush were important contributors to cover at the Superior Valley grid. In general, shrub cover was low at Recht's Site, with four-wing saltbush, cheesebush, and Joshua tree the largest contributors.

Table 20. Percent shrub cover for species that showed cover ≥0.5% on at least 1 of the 4 trapping grids in the area north of Barstow.

	Percent cover[1]			
Shrub species	**Coolgardie Mesa**	**Lane Mountain**	**Superior Valley**	**Recht's Site**
Acamptopappus sphaerocephalus	1.0	0.7	0.5	0.8
Ambrosia dumosa	1.4		1.4	0.5
Atriplex canescens				2.1
Atriplex spinifera			6.5	
Ephedra nevadensis	2.0	2.0		
Ericameria cooperi	6.4	7.5	3.2	
Grayia spinosa	9.1	10.6	0.9	
Hymenoclea salsola	5.6	1.6		1.7
Krascheninnikovia lanata	0.7	1.3	0.5	0.7
Larrea tridentata	7.9	7.2		
Lycium andersonii	0.7	3.4		
Lycium cooperi	1.8			1.3
Thamnosma montana	0.6	1.0		
Yucca brevifolia		1.4		1.8
Percent cover of standing litter	**2.0**	**2.7**	**17.9**	**1.0**

1. 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).

Shrub Vegetation at Edwards Air Force Base / Saddleback Butte Sites

Twenty-four shrub species were noted on belt transects at the 3 trapping grids on EAFB and Saddleback Butte State Park (Table 21). Shrub species composition differed significantly among the 3 grids, with only goldenhead, white bursage, and winterfat recorded at all locations. While shrub species richness was low at Saddleback Butte, where only 5 species were found, the 2 other sites had high species richness, with 14 species recorded at VORTAC and 17 species at S-9.

Although the VORTAC and S-9 study sites on EAFB were both characterized as Desert Saltbush Scrub, the dominant saltbush species differed considerably. The VORTAC grid showed a high density of Mojave saltbush, while four-wing saltbush and shadscale dominated the S-9 grid. The overall shrub community composition differed substantially on these 2 sites, with only 9 shrub species shared by both, but 11 other shrub species found only at 1 of the 2 grids. Although no Joshua trees were encountered on the belt transects, this species was present at low densities on both study sites.

The Saddleback Butte grid was classified as Mojave Creosote Bush Scrub and was strongly dominated by just 3 shrub species: creosote bush, goldenhead, and white bursage. Overall shrub density was very low (<2000 plants/hectare). Joshua trees were present at low density throughout the study site.

Table 21. Species composition and densities of shrub vegetation at 3 trapping grids at Edwards Air Force Base and Saddleback Butte State Park.

	Shrub density (plants/hectare)		
Shrub species	**VORTAC / EAFB**	**S-9 / EAFB**	**Saddleback Butte**
Acamptopappus sphaerocephalus	120	208	376
Ambrosia dumosa	960	48	520
Atriplex canescens		464	
Atriplex confertifolia	152	592	
Atriplex polycarpa	80		
Atriplex spinifera	984		
Chrysothamnus nauseosus		32	
Croton californicus		24	
Ephedra nevadensis	224	64	
Grayia spinosa	208	48	
Gutierrezia microcephala		112	
Hymenoclea salsola	424	344	
Isocoma acradenia		56	
Krascheninnikovia lanata	56	528	40
Larrea tridentata			456
Lepidium fremontii	8	8	
Lycium andersonii	48	328	
Lycium cooperi	16		
Mirabilis bigelovii	8		
Sphaeralcea ambigua	8		
Sueda moquinii		248	
Tetradymia glabrata.		8	
Tetradymia stenolepis		32	
Yucca brevifolia			8
Total live shrub density	**3296**	**3144**	**1400**
Total density of standing litter	**3184**	**3392**	**408**

Fourteen shrub species were represented by cover values ≥0.5% on at least 1 of the 3 trapping grids (Table 22). At the VORTAC and S-9 grids, saltbush species provided the highest percent cover, although different pairs of species were involved at each of these 2 sites. White bursage and cheesebush were also important contributors to shrub cover at the VORTAC grid, while winterfat and cheesebush showed relatively high cover values at the S-9 grid. Shrub cover was strongly dominated by creosote bush at Saddleback Butte, with goldenhead and white bursage as the only other important species.

Table 22. Percent shrub cover for species that showed cover ≥0.5% on at least 1 of the 3 trapping grids at Edwards Air Force Base and Saddleback Butte State Park.

	Percent cover[1]		
Shrub species	**VORTAC / EAFB**	**S-9 / EAFB**	**Saddleback Butte**
Acamptopappus sphaerocephalus		0.7	2.2
Ambrosia dumosa	3.0		2.7
Atriplex canescens		5.2	
Atriplex confertifolia	0.9	3.9	
Atriplex polycarpa	2.7		
Atriplex spinifera	4.7		
Ephedra nevadensis	0.9	0.9	
Grayia spinosa	1.3		
Hymenoclea salsola	2.5	2.5	
Krascheninnikovia lanata		2.4	
Larrea tridentata			19.7
Lycium andersonii		1.5	
Sueda moquinii		0.7	
Tetradymia stenolepis		0.5	
Percent cover of standing litter	**13.7**	**14.0**	**0.9**

1. 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 April and May trapping periods. There was no precipitation and skies were clear to partly cloudy, with only one overcast day (5 April) recorded. As is typical of the Mojave Desert in the spring, wind conditions were variable and wind velocities were sometimes quite high. During much of the 2-7 April trapping session, maximum shade temperatures were warm (24-26 ^{o}C) and wind speeds were low (<10 km/h). A frontal disturbance on 5-6 April brought cool temperatures (18-20^{o}C) and westerly winds up to 45 km/h. The 10-15 April trapping session was generally characterized by warm weather (daily maxima 29-32^{o}C) and low wind conditions (<10 km/h). Cool temperatures (16^{o}C) and wind speeds as high as 40 km/h were recorded on 14-15 April as another storm system passed through. The weather was warm during the final trapping session (6-16 May), with daily maximum temperatures from 24-32^{o}C. Winds were low to moderate (10-20 km/h), with 2 episodes of wind speeds as high as 30 km/h on 6-7 May and 10 May.

DISCUSSION

CONSERVATION STATUS OF THE MOHAVE GROUND SQUIRREL

The conservation status of the Mohave ground squirrel is not well understood. There have been no comprehensive range-wide surveys to determine where populations still exist and there is no systematic monitoring program to document trends in abundance over time. The best long-term data come from the Coso region in southwestern Inyo County, near the northern limit of the geographic range. Field studies conducted from time to time since 1978 have shown that this region has continued to support Mohave ground squirrel populations, although abundance has been relatively low since 2001 (Leitner 2010).

However, the status of the species in the central and southern parts of its range has become a serious concern. Brooks and Matchett (2002) analyzed the results of 19 trapping studies conducted between 1972 and 2000. They found a significant decrease in trapping success at sites in the central and southern portions of the range since 1980, in spite of increased winter rainfall over that period. Recent field studies in this region detected Mohave ground squirrels at only 4 out of 8 trapping sites and reported very low numbers of animals captured (Leitner 2001).

The exploratory trapping surveys described in this report were designed to investigate the distribution and abundance of Mohave ground squirrels in 3 widely separated areas in the central and southern portions of the range. These study areas were chosen because of numerous records of Mohave ground squirrel occurrence in the past. It was hypothesized that significant populations might still exist in these areas.

This discussion summarizes previous Mohave ground squirrel records in the 3 study areas, considers the results of the current study, and evaluates evidence for trends in abundance over the past few decades. It also examines the possible factors that make these 3 areas particularly suitable as Mohave ground squirrel habitat. Finally, it provides perspective on the findings of this study regarding food habits and reproductive biology.

MOHAVE GROUND SQUIRREL RECORDS IN THE CURRENT STUDY AREAS

There is substantial evidence that the 3 study areas have supported Mohave ground squirrel populations in the past. The historical records of Mohave ground squirrel occurrence in each area are summarized below, with occurrence numbers from the California Natural Diversity Data Base (CNDDB) indicated where appropriate.

Little Dixie Wash

Mohave ground squirrels were first recorded in the Little Dixie Wash region in 1931 and 1932, when specimens were collected at Freeman Junction and on the east side of Walker Pass (CNDDB Occ. #21 and #52). Trapping surveys by the BLM in 1974 and 1975 resulted in 17 captures at 7 localities in Dove Springs Canyon and Bird Spring Canyon (CNDDB Occ. #84, #174, #175, and #191-194). Aardahl and Roush (1985) reported capturing a total of 94 individuals (both adults and juveniles) at 6 grids in the Little Dixie Wash area from April-July 1980. Finally, trapping at 2 sites in 1994 yielded a total of 12

Mohave ground squirrels (Scarry et al. 1996). Additional occurrences were documented at 10 other locations in this region during the period 1974-1990. Thus, Mohave ground squirrels have been recorded at 26 locations in the Little Dixie Wash area since 1931, with a significant number of detections over the past 3 decades (Figure 5).

North of Barstow

Mohave ground squirrels were first reported in 1977 north of Barstow on the plateau that stretches from Coolgardie Mesa north to Superior Valley (Wessman 1977). The species was detected at 9 locations, with 1-3 individuals reported at each site. In 1980, Aardahl and Roush (1985) trapped 2 grids in Superior Valley, capturing 24 individuals (both adults and juveniles). A total of 24 Mohave ground squirrels were subsequently recorded at 5 sites in 1981 and 1982 (CNDDB Occ. #206-210). In 1994, 4 individuals were captured at 2 trapping grids in this area (Scarry et al. 1996). More recently, Recht (1998) reported 3 Mohave ground squirrels at a site east of the Superior Lake playa. Since the presence of the species in this region was first confirmed in 1977, it has been recorded at 18 locations (Figure 6).

Edwards Air Force Base / Saddleback Butte

There are many previous records of Mohave ground squirrels in the vicinity y of Saddleback Butte State Park and on Edwards Air Force Base (Figure 7).

Mohave ground squirrels were first reported at Saddleback Butte State Park and its environs in 1973 (CNDDB Occ. #227, #228, and #278). In 1974 and 1975, Recht (1977) conducted studies on their behavioral ecology at a site near Blue Rock Butte, about 1.6 km (1 mi) north of the state park (CNDDB Occ. #190). There are 4 other records within 8 km (5 mi) of Saddleback Butte State Park to the west and southwest (CNDDB Occ. #226, #229, #230, and #256). The last confirmed observations at Saddleback Butte State Park were in 1992 (Recht, pers. comm.).

A number of surveys have documented the occurrence of Mohave ground squirrels on Edwards Air Force Base, with most records located to the north, east, and south of Rogers Dry Lake. The earliest observations were made during the period 1973-1977 in the area south of Rogers Dry Lake (CNDDB Occ. #265). Seventeen Mohave ground squirrels were trapped in 1988 at 3 sites northeast of Rogers Dry Lake (ERC Environmental and Energy Services Company 1989). Additional trapping in 1993 in this same area resulted in captures of many adults and juveniles (Deal et al. 1993; Mitchell et al. 1993). Surveys at Mt. Mesa to the southeast of Rogers Dry Lake yielded 9 Mohave ground squirrels in 1992 (U.S. Fish & Wildlife Service 1993) and over 30 individuals in 1993 (Deal et al. 1993; Mitchell et al. 1993). A total of 13 Mohave ground squirrels were trapped in 1994 at 4 sites in halophytic saltbush scrub to the south and southwest of Rogers Dry Lake (Buescher et al. 1995). The species was recorded at 4 additional locations to the east of Rogers Dry Lake during the period 1981-1991. A more recent survey yielded 4 Mohave ground squirrel captures at a site in Joshua tree woodland near Rogers Dry Lake (Vanherweg 2000).

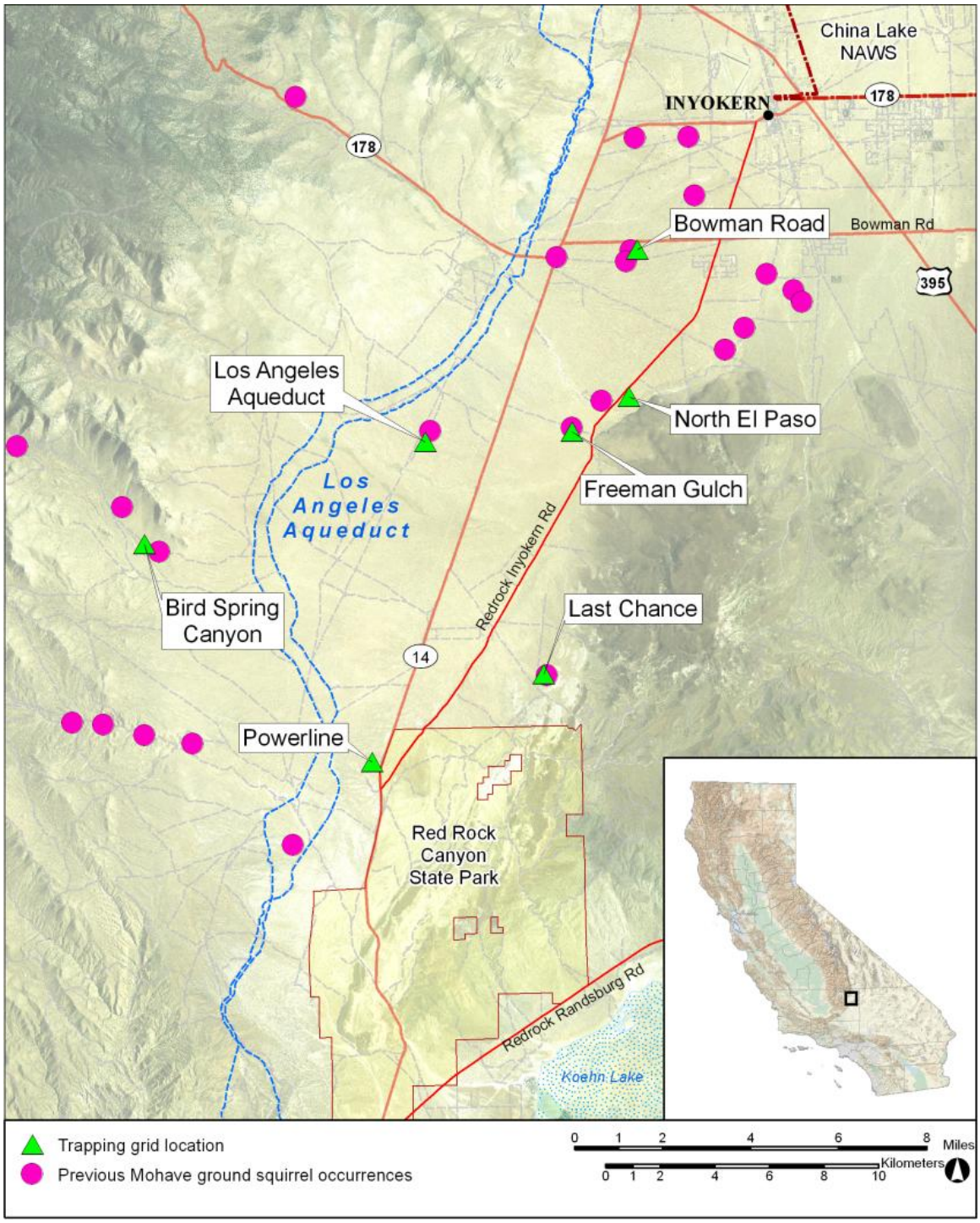

Figure 5. Locations of previous Mohave ground squirrel occurrences in the Little Dixie Wash study area, Kern County.

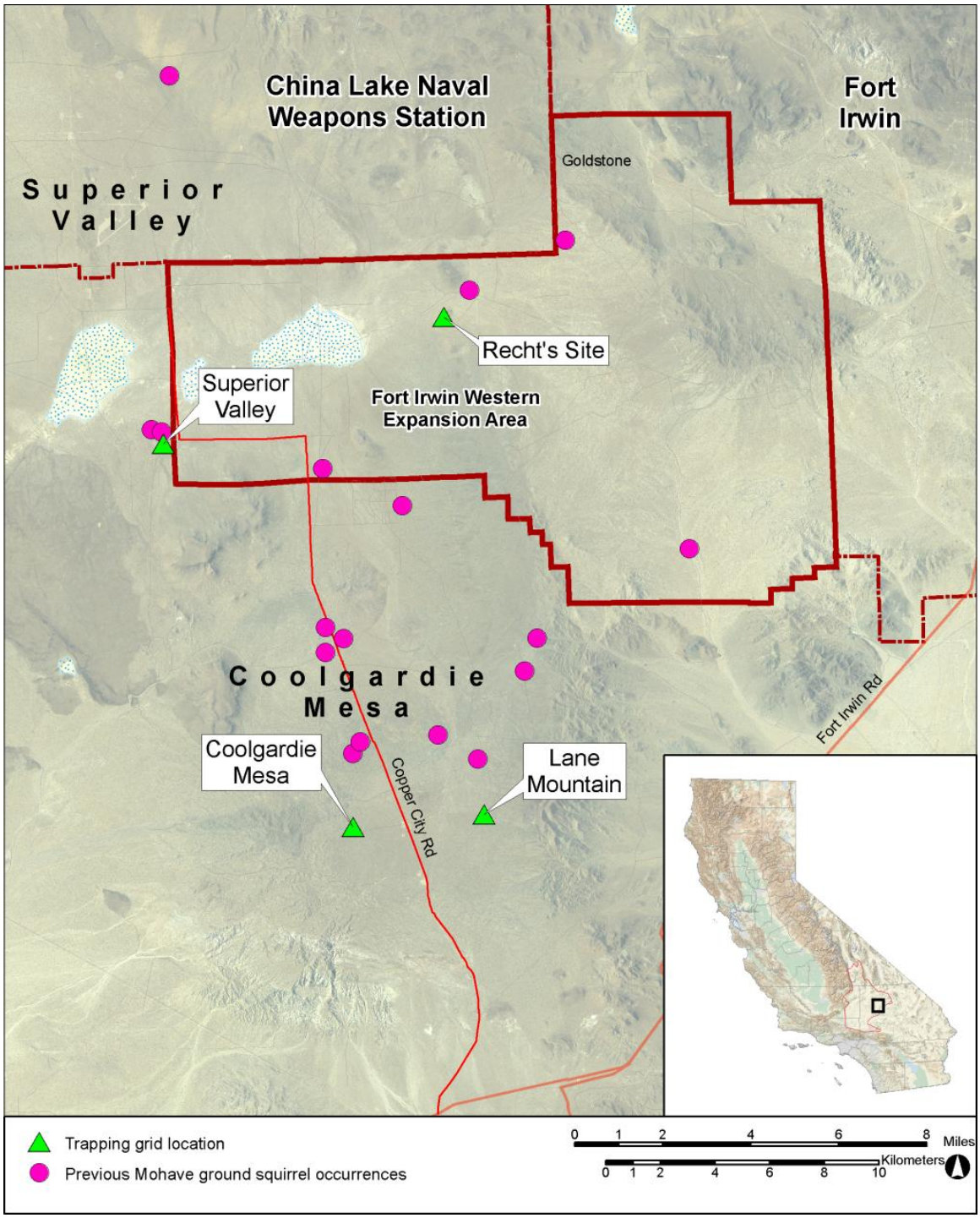

Figure 6. Locations of previous Mohave ground squirrel occurrences in the study area north of Barstow, San Bernardino County.

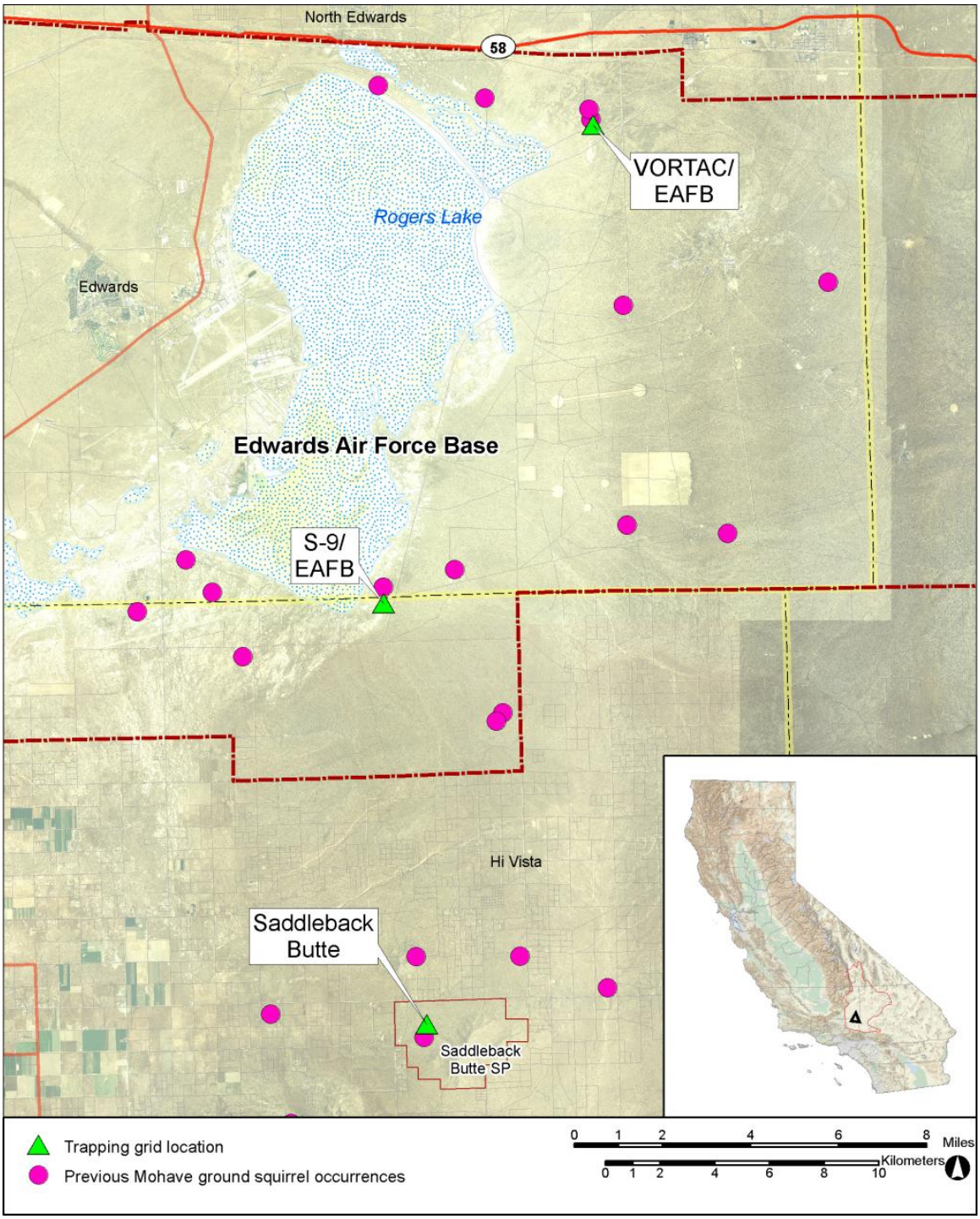

Figure 7. Locations of previous Mohave ground squirrel occurrences on Edwards Air Force Base and Saddleback Butte State Park, Los Angeles and Kern counties.

SIGNIFICANCE OF CURRENT STUDY RESULTS

The present study clearly indicates that these 3 distinct areas continue to support Mohave ground squirrel populations. A total of 40 adult Mohave ground squirrels were captured during the period 2 April-16 May 2002. The species was present at 11 of the 14 trapping sites.

Mohave ground squirrels were trapped at 6 of the 7 grids in the Little Dixie Wash region, indicating that the species is widely distributed there. They were present at the 3 sites where Aardahl and Roush (1985) found them in 1980 and at the 2 sites where they were recorded in 1994 (Scarry et al. 1996). In the region north of Barstow, Mohave ground squirrels were captured at all 4 grids, including 2 sites where earlier records exist (Aardahl and Roush 1985; Scarry et al. 1996; Recht 1998). These results indicate a broad distribution throughout this region as well.

In the EAFB / Saddleback Butte area, the S-9 / EAFB grid yielded 7 Mohave ground squirrel captures, the identical number that were trapped at this site in 1994 (Buescher et al. 1995). However, the species was not detected at VORTAC / EAFB, the other grid on Edwards Air Force Base. There are several previous records from the vicinity of this study site (Deal et al. 1993; Mitchell et al. 1993), so the absence of captures here is somewhat surprising. However, Mohave ground squirrel surveys in the region east of Rogers Dry Lake in 2003 and 2004 resulted in the capture of 22 individuals at 6 sites (Leitner 2003, Air Force Flight Test Center 2004).

The failure to detect Mohave ground squirrels at Saddleback Butte was unexpected, considering the number of records for this area from 1973-1992. It suggests that additional field studies are needed to clarify the status of the species in this area south of Edwards Air Force Base.

These results confirm that Mohave ground squirrel populations persist in the 3 areas that were surveyed in 2002. This study also demonstrates that the species is widespread and relatively abundant in the Little Dixie Wash, in the Coolgardie Mesa-Superior Valley region north of Barstow, and on the eastern portion of Edwards Air Force Base. The Coso Range in Inyo County is the only other region that is known to share these characteristics. These appear to be 4 core areas that are important for conservation of the species.

TRENDS IN MOHAVE GROUND SQUIRREL CAPTURE SUCCESS

Since this study has demonstrated that Mohave ground squirrel populations are still present in 3 regions within the central and southern parts of the range, it is of great interest to determine if there have been trends in abundance over time. Unfortunately, the available trapping data are not adequate to estimate abundance directly in terms of population size or density. However, trapping success can be used as an index of abundance (Brooks and Matchett 2002) since the number of individuals captured per unit of trapping effort should be related to population size or density. In this analysis, the number of individual Mohave ground squirrels captured per standard unit of trapping effort is used as an indicator of abundance.

The most useful comparative data come from the 1980 survey conducted at 22 sites by Aardahl and Roush (1985) and the 1994 survey at 9 grids (Scarry et al. 1996). During

these 2 studies, trapping was conducted at a number of locations scattered widely throughout the central and southern parts of the Mohave ground squirrel range. The locations of these study sites in relation to those of the present study are shown in Figure 8. In order to make comparisons of capture success more meaningful, only the Aardahl and Roush (1985) spring trapping data (April 29-May 30) were used. Thus, trapping results from all 3 studies represent the period from early April through mid-June, prior to the time at which most adult Mohave ground squirrels begin to enter dormancy. Since 1980 was a reproductive year for Mohave ground squirrels, while there was reproductive failure in 1994 and 2002, only the numbers of adult individuals trapped were used to calculate capture success. This ensured that rates of capture success were not biased upward by inclusion of juveniles in 1980. Finally, the capture data for each of the 3 studies should be comparable because the preceding years (1979, 1993, and 2001) had abundant winter rainfall. As a result, successful Mohave ground squirrel reproduction would have occurred throughout the central and southern portions of the range in each of those preceding years.

Nevertheless, differences in methodology make it difficult to compare trapping success in the 2 earlier surveys to that of the present study (Table 23). For example, Aardahl and Roush (1985) conducted trapping only in the morning and for just 3 consecutive days, yielding by far the lowest level of trapping effort per grid (1086 trap-hours/grid). Scarry et al. (1996) used a much larger grid and trap spacing as compared to the other two studies. The differences in trapping effort can be normalized by expressing capture success in relation to a standard unit of effort, such as 1000 trap-hrs or 100 trap-days. However, the net effect on capture probability due to differences in trap spacing, grid shape, and grid area is unfortunately not clear.

Table 24 presents several different ways of comparing the results of the present study with those of the 1980 and 1994 surveys. The percent of study sites occupied by adult Mohave ground squirrels should reflect their distribution and abundance. This comparison shows a higher percent of trapping sites occupied in 1994 and 2002, a result that does not support the concept that Mohave ground squirrel abundance is declining. However, the 2002 sites were not randomly selected but were located in areas where there were previous occurrence records. The high percent of sites occupied in the present study may simply confirm that Mohave ground squirrels are more likely to be found where they have occurred in the past. There are 2 ways of expressing capture success as a function of trapping effort: 1) the number of individuals captured per 100 trap-days and 2) the number of individuals captured per 1000 trap-hours. The 2 methods yielded quite similar rates of capture success for the 1994 and 2002 studies, when traps were kept open all day. However, the 2 methods give very different results for the 1980 survey because traps were operated for only 3-4 hours in the morning each day. It is probably best to express capture success in relation to the actual hours of trapping effort. If this is done, there appears to have been a considerable decline in trapping success from 1980 to 1994, followed by a partial recovery in 2002.

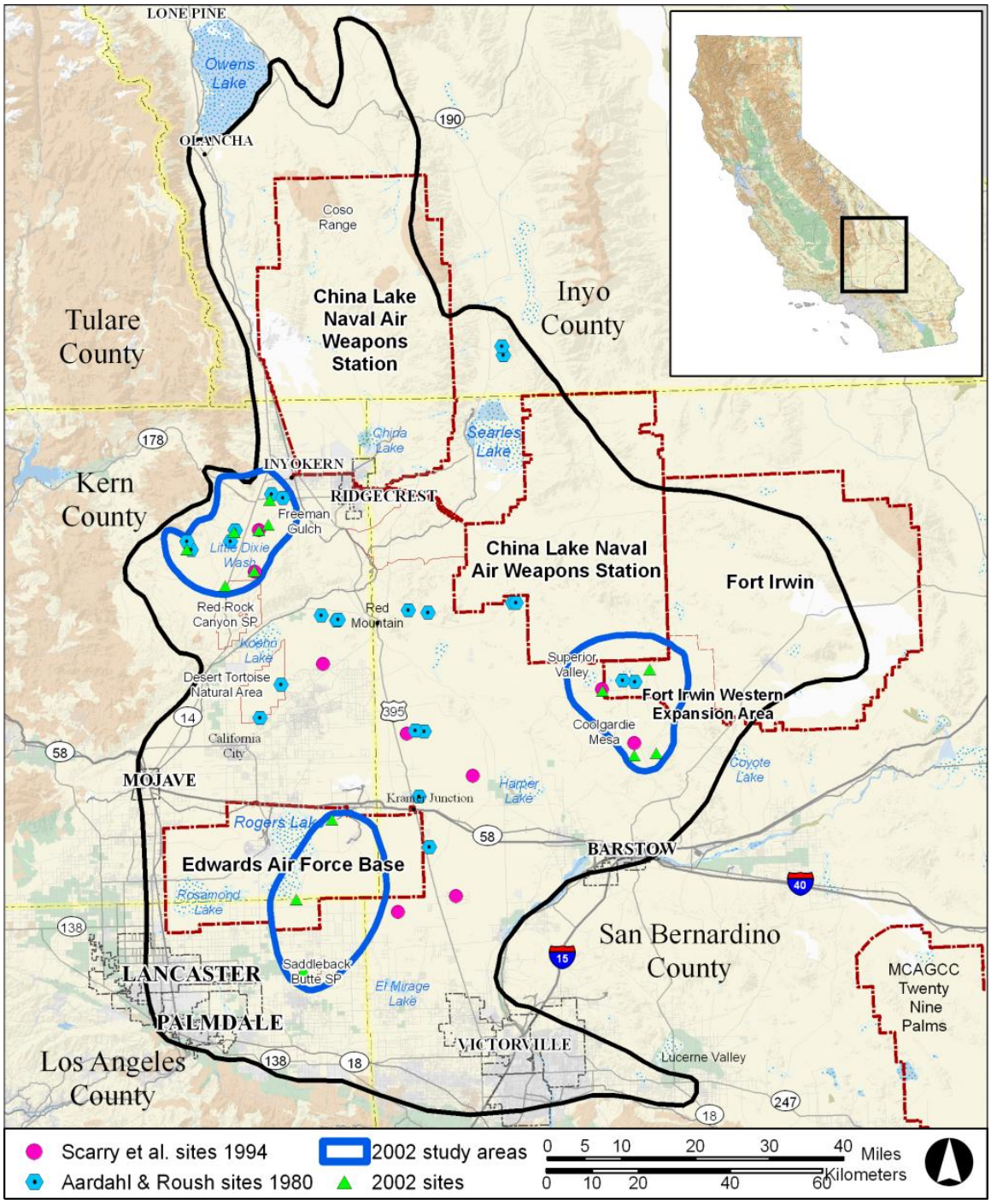

Figure 8. Locations of trapping grids used in the present study in comparison to trapping sites used by Aardahl and Roush (1985) and Scarry et al. (1996).

Table 23. Comparison of trapping protocols used by Aardahl and Roush (1985), Scarry et al. (1996), and the present study (2002).

	Aardahl & Roush (1985)	Scarry et al. (1996)	Present study (2002)
Pre-baiting	No	No	7 of 14 grids
Number of traps / grid	100	121	100
Trap spacing (meters)	22.9	50	35
Trap arrangement	4 x 25	11 x 11	4 x 25
Area of grid (hectares)	5.2	25.0	8.8
Number of days / grid	3	5	5
Trap-hours / grid	1086	5748	4500
Survey dates	April 29-May 30, 1980	May 1-June 17, 1994	April 2-May 16, 2002

Table 24. A comparison of the results of 3 Mohave ground squirrel trapping surveys in the central and southern portions of the geographic range.

	Aardahl and Roush (1985)	Scarry et al. (1996)	Present Study (2002)
Survey dates	29 Apr-30 May, 1980	1 May-17 June, 1994	2 Apr-16 May, 2002
Number of sites	22	9	14
Sites occupied	11	7	11
% sites occupied	50.0%	77.8%	78.6%
Number of adults captured	34	20	40
Trapping effort (trap-days)	6600 trap-days	5445 trap-days	7000 trap-days
Trapping effort (trap-hours)	23,892 trap-hrs	51,732 trap-hrs	63,000 trap-hrs
Captures / 100 trap-days	0.52	0.37	0.57
Captures / 1000 trap-hours	1.42	0.39	0.64

In addition to considering overall trends in capture success, it may be useful to compare capture success over time at specific trapping sites that were sampled in previous surveys. Six of the 14 grids trapped in 2002 were <1 km from grids used in 1980 (Aardahl and Roush 1985) and in 1994 (Scarry et al. 1996). A seventh grid (S-9 / EAFB) was at the exact location of a grid trapped in 1994 by Buescher et al. (1995). Table 25 presents the numbers of adult Mohave ground squirrels captured at these 7 sites during previous surveys in comparison to the results of the present study. Since the numbers of captures are small, there is no attempt to correct for the effects of different trapping protocols or trapping effort.

There was no consistent temporal trend in numbers of adult Mohave ground squirrels captured at these 7 sites. The total number of captures in 2002 at the Bowman Road, Bird Spring Canyon, and Los Angeles Aqueduct grids was 6 as compared to 4 in 1980. On the other hand, the number of adult Mohave ground squirrel captures declined somewhat from 1994 to 2002 at Freeman Gulch and Last Chance, 2 other Little Dixie Wash grids. At Superior Valley and S-9 / EAFB, capture success did not appear to change over time.

The ability to detect trends in Mohave ground squirrel capture success over time in the central and southern portions of the range is seriously limited. Only 2 extensive surveys have been conducted in this region and there has been little attempt to sample the same study sites on a regular basis. There have been important differences in study methodology, particularly in the size and shape of trapping grids, the number and spacing

of traps, and the level of trapping effort. Furthermore, the present study was focused on geographic areas that were characterized by numerous records of previous occurrences. Such areas might be expected to support more abundant Mohave ground squirrel populations, resulting in relatively high capture success.

Table 25. Numbers of adult Mohave ground squirrels captured at specific sites during trapping surveys in the central and southern portions of the geographic range.

Name of Site	Aardahl and Roush (1985)	Scarry et al. (1996)	Buescher et al. (1995)	Present Study (2002)
Bowman Road	3	--	--	1
Bird Spring Canyon	1	--	--	2
Los Angeles Aqueduct	0	--	--	3
Freeman Gulch	--	9	--	5
Last Chance	--	3	--	2
Superior Valley	3	2	--	2
S-9 / EAFB	--	--	7	7

Recognizing these limitations, the existing data do not provide evidence for a clear downward trend in Mohave ground squirrel abundance in the central and southern parts of the range since 1980. The various indicators of capture success do not present a consistent picture of change over time. While the proportion of trapping sites occupied by adult Mohave ground squirrels has increased since 1980, the number of captures per 1000 trap-hours was highest in 1980. Finally, the number of Mohave ground squirrels trapped at specific study sites does not show a clear trend, with some grid locations showing slightly increasing numbers of captures, some showing decreasing numbers, and others with essentially no change.

HABITAT SUITABILITY AND SHRUB COMMUNITY CHARACTERISTICS

The fact that the 3 core areas identified in this study continue to support viable Mohave ground squirrel populations suggests that soils, vegetation, and other environmental variables are highly suitable for the species. All 3 areas include alluvial soils that are suitable for burrow construction. The lack of herbaceous plant growth in spring 2002 made it impossible to evaluate this component of the vegetation. However, extensive data were collected on the shrub community at each of the study sites. It is of interest to consider whether particular characteristics of the shrub vegetation are correlated with Mohave ground squirrel presence and abundance.

The 11 sites at which Mohave ground squirrels were captured in this study represented all 5 of the broad natural communities present in the region (Table 16). This pattern of occurrence supports the position of the California Department of Fish and Game that the Mohave ground squirrel is found in all plant communities within its range (Gustafson 1993). It is also consistent with an analysis of 252 California Natural Diversity Data Base records, which found that the percent of Mohave ground squirrel occurrences in various desert scrub plant communities was in direct proportion to the land area covered by each community within the range of the species (U.S. Bureau of Land Management 2003). This study provides additional evidence that Mohave ground squirrels are not restricted to particular desert shrub communities, but can occur in any of them.

However, it is possible that the occurrence and abundance of Mohave ground squirrels is related to general properties of desert shrub communities, such as shrub species richness (number of species present), percent total live shrub cover, or total shrub density. Table 26 shows the number of individual Mohave ground squirrels captured at the 14 sites sampled in this study in relation to these 3 community characteristics. Mohave ground squirrels were not captured at 3 grids (Powerline, VORTAC / EAFB, and Saddleback Butte) and there was only 1 capture at Bowman Road. Mohave ground squirrel absence or low capture success at these 4 sites did not appear to be correlated with any obvious patterns of shrub species richness, cover, or density. While shrub species richness was very low (5-6 species) at Bowman Road and Saddleback Butte, it was quite high at the other 2 sites (13-14 species). Shrub cover was low (16.8 percent) at VORTAC / EAFB, but relatively high (25.0-28.0 percent) at the other 3 sites. Finally, shrub density was very low at Saddleback Butte, but attained moderate values at the other 3 sites.

The number of Mohave ground squirrels captured was highest at 4 grids: Freeman Gulch, North El Paso, Coolgardie Mesa, and S-9 / EAFB. At these sites, the ranges of values for shrub species richness, cover, and density were somewhat higher, but overlapped broadly with those for the 4 sites where Mohave ground squirrels were absent or at very low abundance. It is notable that the pattern for Freeman Gulch (5 captures) was very similar to that for Powerline (0 captures) and that for S-9 / EAFB (7 captures) closely resembled VORTAC / EAFB (0 captures).

Table 26. Number of individual Mohave ground squirrels captured and number of shrub species, percent shrub cover, and shrub density at 14 trapping grids in 3 regions of the western Mojave Desert.

Region	Grid name	Mohave ground squirrels captured	No. of shrub species	Percent shrub cover	Shrub density (plants/hectare)
Little Dixie Valley	Bowman Road	1	6	25.0	6,008
	North El Paso	6	9	36.3	8,888
	Freeman Gulch	5	10	23.9	6,800
	Last Chance	2	17	50.3	8,472
	Los Angeles Aqueduct	3	9	39.6	9,824
	Bird Spring Canyon	2	14	45.7	10,872
	Powerline	0	13	28.0	6,888
North of Barstow	Coolgardie Mesa	7	16	37.8	5,736
	Lane Mountain	2	14	37.6	6,968
	Superior Valley	2	9	13.6	4,096
	Recht's Site	3	13	9.3	1,776
EAFB/Saddleback	VORTAC / EAFB	0	14	16.8	3,296
	S-9 / EAFB	7	17	19.7	3,144
	Saddleback Butte	0	5	25.0	1,400

While the occurrence and abundance of Mohave ground squirrels do not seem to be related to general shrub community properties, it is possible that there may be significant correlations with the distribution of particular shrub species. Certain widespread, abundant shrubs such as creosote bush or saltbush are clearly not an essential habitat element, since one or both were absent at sites where Mohave ground squirrels were present. Although Mohave ground squirrels readily consume Joshua tree fruits, the presence of Joshua trees

was not a predictor of Mohave ground squirrel presence in this study. Mohave ground squirrels were present at sites where Joshua trees were absent (Freeman Gulch, Superior Valley) and were absent where Joshua trees were an important component of the community (Powerline, VORTAC / EAFB, Saddleback Butte).

However, food habits data from the Coso study sites have demonstrated that Mohave ground squirrels depend heavily on the foliage of 2 shrub species, winterfat and spiny hopsage, when forb materials are not available (Leitner and Leitner 1998). Long-term population monitoring also showed that Coso Study Site 1 (Rose Valley), where winterfat and spiny hopsage were almost completely absent, was unable to support a permanent Mohave ground squirrel population during a prolonged drought. These 2 shrubs also made important contributions to the Mohave ground squirrel diet at a number of the grids trapped during the present study. Table 27 indicates a possible relationship between Mohave ground squirrel presence and abundance and the combined density of spiny hopsage and winterfat. Only 1 Mohave ground squirrel was captured at the 4 grids with total spiny hopsage and winterfat density <300 plants/hectare, while 39 individuals were recorded at the 10 grids where combined densities were >300 plants/hectare. This strongly supports the hypothesis that spiny hopsage and winterfat are significant habitat elements for the Mohave ground squirrel. It will be important to test this hypothesis as new data on shrub communities and Mohave ground squirrel distribution and abundance become available for other localities.

Table 27. Number of individual Mohave ground squirrels captured and densities of spiny hopsage (*Grayia spinosa*) and winterfat (*Krascheninnikovia lanata*) at 14 trapping grids in 3 regions of the western Mojave Desert.

Region	Grid name	Mohave ground squirrels captured	Shrub density (plants/hectare)		
			Spiny hopsage	Winterfat	Total
Little Dixie Wash	Bowman Road	1	0	0	0
	North El Paso	6	808	64	872
	Freeman Gulch	5	1432	432	1864
	Last Chance	2	288	1000	1288
	Los Angeles Aqueduct	3	528	80	608
	Bird Spring Canyon	2	888	96	984
	Powerline	0	64	8	72
North of Barstow	Coolgardie Mesa	7	792	224	1016
	Lane Mountain	2	960	520	1480
	Superior Valley	2	176	144	320
	Recht's Site	3	24	328	352
EAFB/Saddleback	VORTAC / EAFB	0	208	56	264
	S-9 / EAFB	7	48	528	576
	Saddleback Butte	0	0	40	40

Ground Squirrel Biology

Reproduction and Winter Rainfall

There was clear evidence of white-tailed antelope squirrel reproduction in 2002 in all 3 of the study areas, with juveniles captured at 8 of the 14 grids. As would be expected, the number of juveniles captured was highest during trapping in May at Edwards Air Force Base when most juveniles had become active outside their natal burrows.

In contrast, no juvenile Mohave ground squirrels were trapped during the present study and none of the adult females showed evidence of pregnancy or lactation. The Mohave ground squirrel populations at 2 monitoring sites in the Coso Range in Inyo County were also non-reproductive in 2002 (Leitner 2010). It appears that reproductive failure was widespread throughout the range of the species in 2002, just as it was in 1994 (Buescher et al. 1995, Leitner et al. 1995).

Mohave ground squirrel reproduction is closely linked to winter rainfall and spring production of herbaceous forage (Leitner and Leitner, 1998). Successful reproduction appears to require total winter precipitation of at least 65-85 mm. Rainfall was well under 65 mm during the winter of 2001-2002 throughout the western Mojave Desert (Table 28). Many Mojave Desert weather stations recorded <65 mm of rainfall during the 1993-1994 winter which also preceded widespread Mohave ground squirrel reproductive failure. The 9-year winter rainfall data presented in Table 28 suggest that reproductive failure over all or extensive portions of the range is not uncommon in this species.

Table 28. Winter rainfall totals (mm) for weather stations located in the central and southern portions of the range of the Mohave ground squirrel. Totals in bold are below 65 mm. Data from the National Climatic Data Center, NOAA. Rainfall data are missing for Lancaster 1999-2000.

	Weather Station				
Rainfall period[1]	**Inyokern**	**Randsburg**	**Mojave**	**Lancaster**	**Barstow**
1993-1994	**35.3**	72.4	**60.2**	92.7	**19.3**
1994-1995	160.3	262.6	273.1	205.5	113.5
1995-1996	**60.5**	88.7	65.5	75.4	**21.3**
1996-1997	**41.9**	92.2	83.1	79.0	**60.2**
1997-1998	168.9	278.1	294.6	311.9	207.0
1998-1999	**18.3**	**23.6**	**24.9**	**62.0**	**7.4**
1999-2000	**45.0**	104.1	77.2	No data	**24.1**
2000-2001	134.6	153.4	154.2	133.0	112.3
2001-2002	**6.6**	**55.4**	**36.8**	**51.6**	**31.2**
Long-term mean[2]	101.1	161.5	142.8	178.5	88.5
Period of record	25 yrs	25 yrs	25 yrs	25 yrs	25 yrs

1. Winter rainfall period extends from Oct. 1 through Mar. 31.
2. Long-term mean represents winter rainfall period.

Mohave Ground Squirrel Food Habits

The results of the food habits analysis must be interpreted with caution for several reasons. First, the samples were drawn from just 26 individuals distributed over 9 study sites, so

sample sizes were generally small. One-half of the samples were from just 2 sites: Coolgardie Mesa (n = 6) and the S-9 grid (n = 7) on Edwards Air Force Base. At the other 7 sites, the number of samples used ranged from 1 to 3. Second, the results represent the diet on only 1 day during the entire active season, which usually extends from February through July. Third, precipitation during the 2001-2002 winter was below average and many herbaceous plants were not well represented in the spring flora. The reduced availability of herbaceous vegetation, especially forbs, during April and May 2002 may have affected the proportion of these items in the diet.

The composition of the Mohave ground squirrel diet differed considerably among the 9 sites, although shrub and forb materials were important at all locations (Table 29). The contribution from these 2 food categories combined ranged from 32 to 99 percent relative cover over all trapping grids. Shrub leaf and stem was the most important dietary component at 4 of the grids: Los Angeles Aqueduct, Coolgardie Mesa, Lane Mountain, and Recht's Site. Forb materials made up the largest portion of the diet at 2 sites: Freeman Gulch and Superior Valley. In the Little Dixie Wash area, samples from the North El Paso and Last Chance grids were unusual in that grasses were the dominant food category. The results for the S-9 / EAFB grid were unique because over 70 percent relative cover was pollen and flower parts. All 7 individual samples from this site showed pollen as the most important food item. It was not possible to identify the source of the pollen, but forb flower parts were important in the diet here.

Table 29. Comparison of diet composition by major food category for 9 grids during period 2 April – 11 May 2002. The data are expressed as average percent relative cover.

Grid name	Sample size	Food categories				
		Grasses	Shrubs	Forbs	Pollen	Arthropods
North El Paso	1	56	19	13	0	9
Freeman Gulch	2	1	33	66	0	0
Last Chance	2	36	24	19	1	9
Los Angeles Aqueduct	2	0	65	13	0	22
Coolgardie Mesa	6	2	46	45	1	4
Lane Mountain	2	0	49	24	1	27
Superior Valley	1	4	29	51	0	17
Recht's Site	3	0	77	17	0	6
S-9 / EAFB	7	3	15	26	55	0

These results are similar to those of the multi-year Mohave ground squirrel diet study in the Coso region (Leitner and Leitner 1998). The importance of shrubs at these 9 sites (15-77 percent relative cover) is consistent with the pattern at the Coso sites, where shrub material accounted for 45 percent of the diet. As at Coso, the most important shrubs were spiny hopsage, winterfat, and saltbush. Although the diet at Coso tended to shift from shrubs in March to forbs in April and May, shrub material predominated over forbs at 6 of the 9 sites sampled in the present study. This may have been due to the relative scarcity of forbs in spring 2002, following a dry winter. However, many of the forb taxa that were important dietary components in the Coso region were also identified in this study, including *Monardella* sp. (7 sites), a legume that was either *Astragalus* or *Lupinus* (6 sites), *Camissonia* sp. (6 sites), and *Salsola tragus* (5 sites).

Grasses contributed <5 percent of the overall diet during the Coso study, but in the present analysis they formed the most important food category at the North El Paso and Last Chance grids. However, only 1 individual at each site showed such a high proportion of grass material. This was also observed in the Coso region, where in dry years a few individual samples also showed a high proportion of grasses (Leitner et al. 1995). The importance of pollen seen at the S-9 / EAFB grid was also noted in occasional samples from Coso sites. Arthropods (chiefly insects) made up a small proportion (<5 percent) of the total diet documented in the Coso study, but when lepidopteran larvae were extremely abundant in 1991 they made up 15-70 percent of food items (Leitner and Leitner 1998). The prevalence of arthropod fragments in a few samples from the Los Angeles Aqueduct, Lane Mountain, and Superior Valley grids probably reflect the local availability of arthropod prey at these sites.

In general, the findings of the food habits analysis for the 9 sites sampled in the present study are consistent with the results for the Coso diet study. Shrub and forb materials appeared to be the mainstay of the diet at these sites in the central and southern portions of the range, as they did at the Coso sites. Nonetheless, there was considerable variation in diet composition among individual samples and among the 9 sites, with grasses, pollen, and arthropod materials occasionally making a large contribution. This is similar to the patterns of variability found in the Coso study and suggests that flexibility in food habits is a general feature of Mohave ground squirrel foraging strategy.

Mohave Ground Squirrel Body Mass and Preparation for Dormancy

There was a wide range in body mass among the Mohave ground squirrels captured at each of the 3 study areas (Table 30). This probably reflects differences in mean body mass among age classes, as documented at the Coso study sites (Leitner et al. 1995). It is likely that those individuals with the lowest body masses were yearlings, while the heaviest animals may have been 3 or more years of age. In non-reproductive years, Mohave ground squirrels can begin to accumulate fat in April as preparation for entry into dormancy as early as late May or early June (Leitner and Leitner 1998). Some individuals in each of the study areas had already attained the minimum body mass of 180 g that appears required for dormancy.

Table 30. Body mass data for Mohave ground squirrels captured in 3 regions of the western Mojave Desert during the period 2 April – 11 May 2002.

Study area	Mean body mass (g)	Range of body mass (g)	Sample size	Trapping period
Little Dixie Valley	133.0	98-183	19	2-7 April
North of Barstow	162.6	112-216	14	10-15 April
Edwards Air Force Base	159.3	139-183	7	6-11 May

DISTRIBUTION AND ABUNDANCE OF WHITE-TAILED ANTELOPE SQUIRRELS

White-tailed antelope squirrels were present on all 14 study sites and were captured in much greater numbers than Mohave ground squirrels. A total of 303 white-tailed antelope squirrels were recorded, including 66 juveniles. In comparison, a total of 40 adult Mohave ground squirrels were captured. Previous studies conducted during years with no Mohave

ground squirrel reproduction have reported similar findings. In 1994, Scarry et al. (1996) captured 373 white-tailed antelope squirrels and only 20 adult Mohave ground squirrels. A trapping study conducted at Edwards Air Force Base in the same year yielded 1535 white-tailed antelope squirrels, but just 16 Mohave ground squirrels (Buescher et al. 1995). However, the extensive 1980 survey by Aardahl and Roush (1985) resulted in the capture of 371 white-tailed antelope squirrels and 343 Mohave ground squirrels, many of them juveniles. In general, capture success for white-tailed antelope squirrels tends to be much higher than for adult Mohave ground squirrels. However, if the Mohave ground squirrel sample includes juveniles, capture success can be roughly comparable for the 2 species.

RECOMMENDATIONS

A number of recommendations that will support the conservation of the Mohave ground squirrel follow from the findings of this study.

First, habitat within the 3 core areas that have been identified in this study should be protected from future loss and degradation. The primary responsibility falls to the land management agencies in each area. There may be opportunities for the Department of Fish and Game to collaborate with these agencies in Mohave ground squirrel conservation through such mechanisms as Memorandums of Understanding.

In the Little Dixie Wash core area, the BLM is the most important land management agency. Almost all of this core area is included within the Mohave Ground Squirrel Conservation Area that was established under the West Mojave Plan (U.S. Bureau of Land Management 2003). BLM lands west of SR 14 are administered as the Jawbone-Butterbredt Area of Critical Environmental Concern. California Department of Parks and Recreation has stewardship over Red Rock Canyon State Park in the southern portion of this core area. The DFG manages a small Ecological Reserve on Little Dixie Wash toward the northern edge of the core area. OHV recreation and livestock grazing are important land uses throughout and should be managed in a manner consistent with Mohave ground squirrel conservation. DFG should consider purchase of key private inholdings, as well as establishment of one or more permanent study plots to monitor Mohave ground squirrel populations here.

In the Coolgardie Mesa-Superior Valley core area north of Barstow, the BLM is also the prime land management agency. The BLM lands are included within the Mohave Ground Squirrel Conservation Area under the West Mojave Plan. However, the National Training Center at Fort Irwin has recently acquired a large parcel (Western Expansion Area) in the northern part of this core area. It is likely that the core area extends northward to include those parts of Superior Valley located on the Mojave B test ranges of China Lake Naval Air Weapons Station. Finally, DFG owns and manages a few parcels in the northwestern part of this core area. OHV recreation and recreational mining are popular activities on BLM lands in this core area. Military training and test activities are also important on lands managed by Fort Irwin and China Lake NAWS. There are extensive private inholdings in this core area. Fort Irwin has purchased some of the private parcels and transferred them to the BLM as mitigation for the impacts of expanded training activities. As at Little Dixie Wash, DFG should consider purchase of remaining private inholdings, as

well as establishment of one or more permanent study plots to monitor Mohave ground squirrel populations here.

The third core area appears to be entirely within the boundaries of Edwards Air Force Base (EAFB) and is located to the east and south of Rogers Dry Lake. EAFB manages its lands under the guidance of an Integrated Natural Resource Management Plan (INRMP). It is also conducting a multi-year inventory program that will help to identify the most important areas of the base for the Mohave ground squirrel. Because this core area is located entirely on a military installation, it is not subject to the variety of impacts that are found on public lands. One or more permanent study plots designed to monitor Mohave ground squirrel populations on an annual basis would be very useful here. There are also opportunities to collaborate with EAFB in the acquisition of private lands to the north, east, and south in order to protect Mohave ground squirrel populations in the surrounding habitat.

Second, in addition to protecting Mohave ground squirrel habitat within the core area, field studies are needed to clarify the status of the species at Saddleback Butte State Park and the surrounding area. Because of numerous and well-documented previous occurrences, the state park itself and a corridor to the north linking the park to EAFB have been included in the Mohave Ground Squirrel Conservation Area under the West Mojave Plan (U.S. Bureau of Land Management 2003). If the species is still present at Saddleback Butte State Park, it would help to justify acquisition of private lands in the corridor stretching north EAFB.

Third, it is recommended that additional field studies be carried out in an effort to identify other core areas within the range of the Mohave ground squirrel. The Coso core area on China Lake NAWS is well-documented, but it is entirely possible that there are other areas that support viable populations. Aside from the Coso area, there is almost no information available about the status or distribution of Mohave ground squirrels on the test ranges managed by China Lake NAWS. Surveys in these areas are a high priority, especially because the China Lake lands are key connectors between known core areas.

Fourth, because the known core areas are widely scattered within the Mohave ground squirrel range it is important to protect and maintain connectivity among them. It is recommended that the status of Mohave ground squirrel populations in critical corridors between core areas be investigated by means of field surveys. It may also be necessary to acquire private lands within these corridors to ensure that they are maintained.

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