DISTRIBUTION, RELATIVE DENSITY, HABITAT PREFERENCE AND SEASONAL ACTIVITY LEVELS OF THE MOHAVE GROUND SQUIRREL (*Spermophilus mohavensis*) AND ANTELOPE GROUND SQUIRREL (*Ammospermophilus leueurus*) IN THE WESTERN MOJAVE DESERT, CALIFORNIA

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I. INTRODUCTION

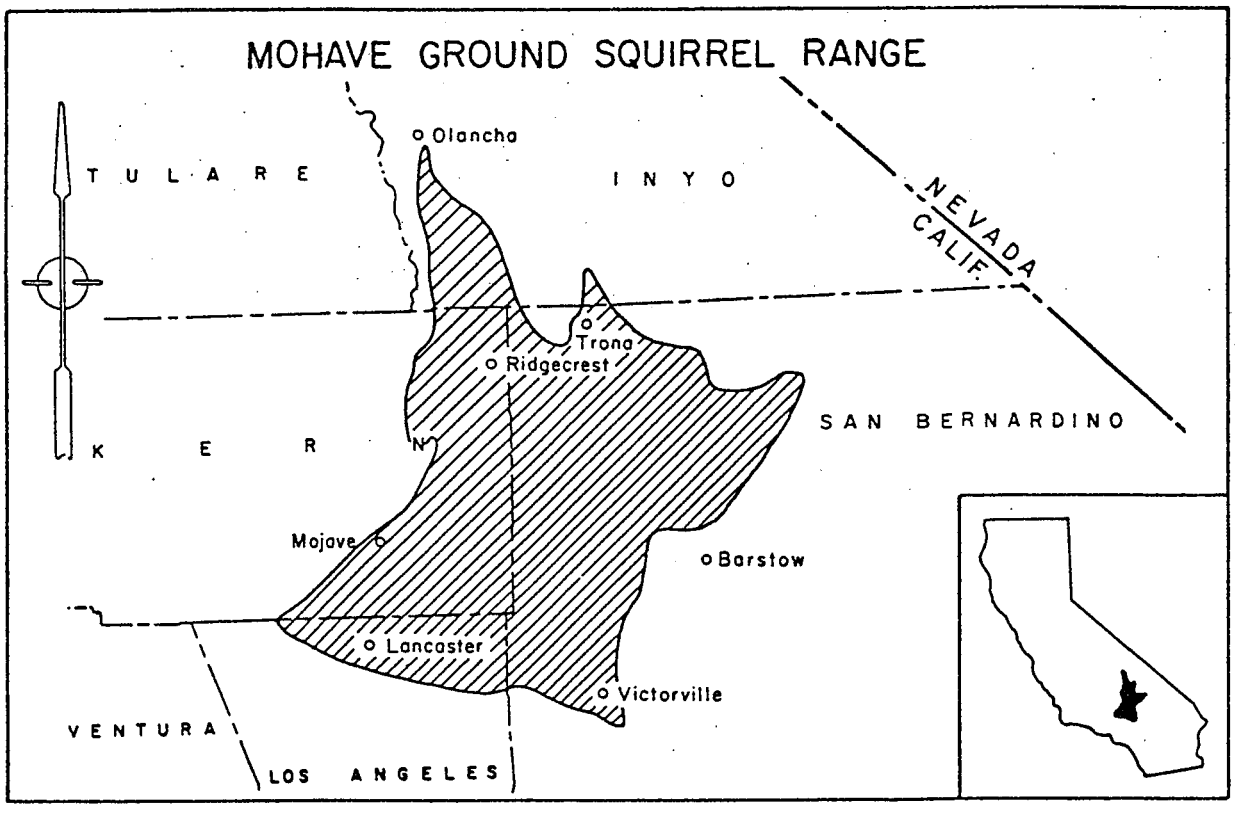
The Mohave ground squirrel (Spermophilus mohavensis Merriam) occurs in a portion of the western Mojave Desert of California and has one of the smallest geographic ranges of the 28 species of ground squirrels occurring in North America (see Figure 1). The antelope ground squirrel (Ammospermophilus leucurus) occurs throughout portions of Baja California, California, Nevada, Oregon, Idaho, Utah, Arizona, New Mexico and Colorado, and is considered common.

According to Hoyt (1972), the California Fish and Game Commission designated the Mohave ground squirrel as rare on May 21, 1971, after learning that field trapping revealed significant declines had occurred in local populations where the species once had been moderately easy to trap. Specific sites studied were not identified but may have been in the Victorville-Palmdale-Lancaster areas. The California Fish and Game Commission designated all state listed rare animals as threatened as of January 1, 1985.

Significant loss of habitat for the Mojave ground squirrel has occurred on private lands due to urban and agricultural development. Such habitat loss has occurred in the Antelope Valley, Victorville-Apple Valley-Hesperia area, along the Mohave River between Barstow and Victorville, western Fremont Valley, Harper Lake basin and Rose Valley.

The behavioral and physiological nature of the Mohave ground squirrel has been studied by several investigators (Burt, 1963; Bartholomew and Hudson, 1960, 1961; Adest, 1972; Recht, 1977). Habitat preferences and geographic distribution have been studied by the Department of Fish and Game and the Bureau of Land Management (Hoyt, 1972; Bureau of Land Management, 1976, 1977, 1980; Wessman, 1977). Wessman (1977) conducted a field study of the distribution and habitat preferences and determined that the Mohave ground squirrel occupied a range 1800 square miles greater than was known at the time it was designated rare.

Figure 1. Range of the Mohave ground squirrel in the western Mojave Desert, California (Department of Fish and Game, 1980).



The purpose of this investigation was to expand our knowledge of the geographic distribution, relative densities in various habitats, habitat preferences and seasonal activity patterns of the Mohave ground squirrel. Corresponding data for the antelope ground squirrel (Ammospermophilus leucurus) was collected to allow for a comparison of the relative densities of the two species; one considered somewhat uncommon and occurring sporadically, and the other considered ubiquitous, or common, and widespread. This investigation also included an effort to collect and consolidate all known locality records for the Mohave ground squirrel (contained in Appendix C).

II. STUDY SITES

The field studies portion of the investigation was conducted in portions of Inyo, Kern, and San Bernardino Counties in California. Except for two range extension study sites in Inyo County (Panamint Valley, Olancha), all field work was conducted in Kern and San Bernardino Counties on 22 sites known to be within the range of the Mohave and antelope ground squirrels (see Figure 2).

Study sites selected were representative of the habitats commonly found in the western Mojave Desert. The following habitats and sites were selected:

A. Mojave Saltbush Community

Two sites were located in Superior Valley and two in the area west of Fremont Peak. All sites have been grazed by sheep for up to 100 years on a seasonal basis.

B. Creosote Bush and Scrub/Mojave Saltbush Community

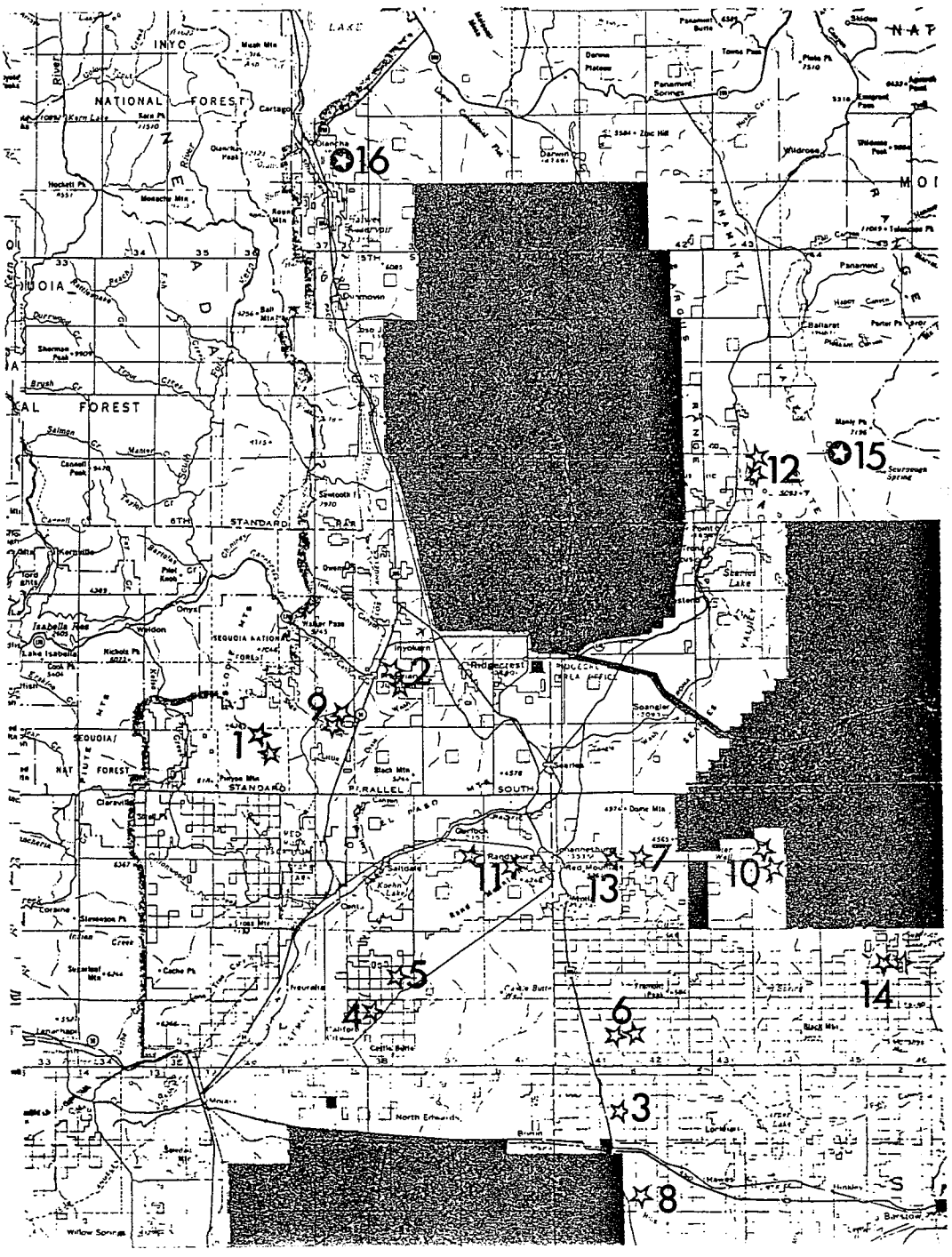
One site was located approximately five miles north of Kramer Junction in a transition zone between Creosote Bush Scrub and Mojave saltbush. The site is on land owned by the Department of Fish and Game. Sheep grazing has

Figure 2. Map showing location of relative density and range extension study sites for the Mohave ground squirrel and white-tailed antelope squirrel in the western Mojave Desert, California.

☆ relative density study sites

✪ range extension study sites

1	Bird Spring Canyon (east, west)
2	Bowman Road (north, south)
3	Department of Fish and Game
4	Desert Tortoise Natural Area (Section 4)
5	Desert Tortoise Natural Area (Section 14)
6	Fremont Peak (east, west)
7	Golden Valley
8	Kramer Hills
9	L.A. Aqueduct (north, south)
10	Pilot Knob (north, south)
11	Rand (west, east)
12	Searles Valley (south, north)
13	Steam Well
14	Superior Valley (east, west)
15	Panamint Valley (range extension)
16	Olancha (range extension)



occurred seasonally for up to 100 years.

C. Creosote Bush Scrub

This is the most extensive habitat within the range of the Mohave ground squirrel. Seven locations were selected for study. Creosote bush (*Larrea tridentata*) is an indicator, but the understory vegetation can vary significantly.

1. Fremont Valley

Two study locations were located in the valley between the Rand Mountains and Garlock. Sheep grazing has occurred seasonally for up to 100 years, and off-road motorcycling has been popular for about 15 years.

2. Desert Tortoise Natural Area

Two study sites were located within the boundary, which was fenced in 1978 to protect habitat from sheep grazing and off-road vehicle use. The El Paso Unit Resource Analysis (Bureau of Land Management, 1976) indicates the area supports high densities of the Mohave ground squirrel.

3. Kramer Hills

One study site was located approximately five miles south of Kramer Junction on the north slope of the Kramer Hills. Sheep grazing has occurred seasonally for up to 100 years and there is limited off-road vehicle use.

4. Indian Wells Valley

Four study sites were located in the southwest portion of the valley. Two are east of State Highway 14, in an area which has been grazed by

sheep on a seasonal basis for up to 100 years. The other two are west of State Highway 14 near the Los Angeles Aqueduct, and historically were grazed by sheep and cattle up to about 1966, when the grazing was changed to primarily cattle use.

5. Northern Searles Valley

Two study sites were located north of Trona in relatively undisturbed habitat. Periodic, low intensity use by feral burros was the only apparent unnatural activity.

6. Almond Mountain Area

Two sites were located east of Red Mountain is an area which has been subjected to sheep grazing for up to 100 years on a seasonal basis. Cattle grazed the area for an unknown period, which ended about 50 years ago.

D. Joshua Tree Woodland

Four study sites were located; two in Bird Spring Canyon, on the east slope of the southern Sierra Nevada, and two in the area immediately west of Pilot Knob. All of these sites have been grazed by cattle for up to 100 years.

E. Range extension investigations were conducted in Panamint Valley and in the Olancha area in habitats appearing suitable for the Mohave ground squirrel. Maps and photographs of each study site are in Appendix A and B, respectively.

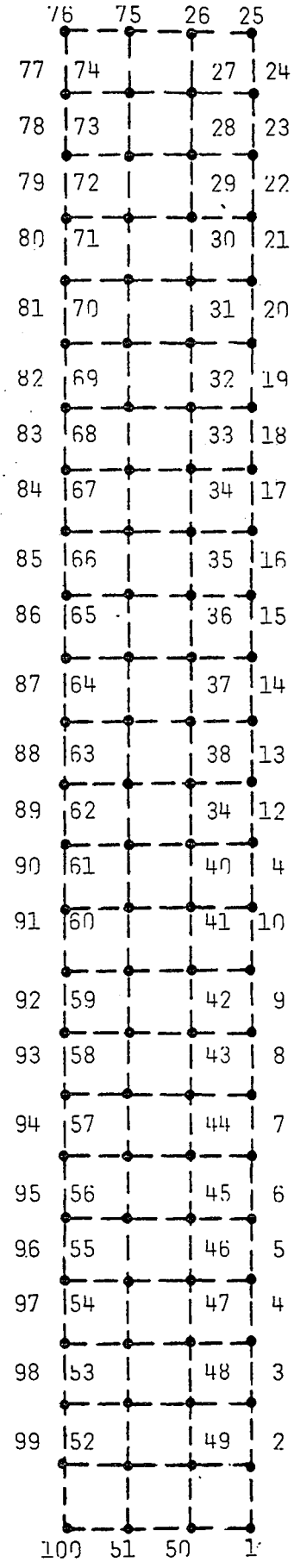
III. METHODS

Relative population densities in the various habitats, habitat preferences and

seasonal activity patterns for the Mohave and antelope ground squirrel were determined by a live-trapping program in each of 22 sites. Each site was trapped with 100 Sherman live traps in a rectangular grid, four traps wide by 25 traps long, with traps spaced 25 yards apart. The area sampled was 100 yards by 625 yards or 12.9 acres. The 25-yard spacing between traps was considered most appropriate for this investigation; each trap station covered an area of 0.13 acres, the approximate minimum home range for the Mohave ground squirrel reported by Recht (1977). This trapping arrangement theoretically allowed for sampling the greatest area and determining each species' dispersal patterns through a maximum number of recaptures. The elongated trapping area was selected so that results were representative of the area in general and not influenced by minor abnormalities in habitat that could have been highly influential in an area sampled that was square.

Trap stations within each study site were marked with surveyor's flagging prior to trapping to facilitate accurate and efficient trap placement and recovery. Traps were located at the nearest shrub or rock to provide shade for trapped animals so that animals so that stress or mortality from solar heat would be minimal. Baiting and setting were done in the early morning, usually between 0600-0700 hours. Bait consisted peanut butter and oatmeal and was placed on the trigger plate. Three to four hours later all unsprung traps were closed and captured animals were identified to species, sex and age, and banded with sequentially numbered metal leg bands. In the case of recaptured animals, the band number and tap station number were recorded. (Refer to Figure 3 for a scale diagram of the trapping grid and numbering.) A large nylon net bag was used to hold the squirrels for identification.

Figure 3. Diagram showing trapping grid and trap station numbering system. Trap spacing was 25 yards.



Each study site was trapped for three consecutive days during each of three sequences, between April 29 and July 14, 1980. The three sequences were equally spaced over the duration of the field investigation to correspond with late spring, early summer and mid-summer. The Mohave ground squirrel is known to be active from approximately March through July, depending on climatic and vegetation conditions.

Point-step linear transects, either 100 or 200-points, were made in each study site. Hits on plants were recorded if they were within the crown cover. The first several inches of soil was described in general terms. Climatic data (i.e., maximum daily high and low) from various weather stations in the western Mojave Desert corresponding to the dates of the trapping were correlated with trapping success for each species of ground squirrel. Range extension investigations were conducted in Panamint Valley and the vicinity of Olancha from June 24 - 26, 1980. Trapping sites were selected based upon habitat features considered most suitable for the Mohave ground squirrel; relatively flat topography typically found in a large alluvial-filled valley, fine to medium textured soil and absence of rocks, and presence of a variety of shrubs including creosotebush, bursage (Ambrosia dumosa) and saltbush (Atriplex spp.). One-hundred Sherman live traps were set in a grid five traps by twenty traps, with twenty-five yard spacing between traps. Traps were baited with peanut butter and oatmeal on the trigger plate and set in the late afternoon. Rodents captured were identified at sunrise the next day, and the traps were rebaited and set. Approximately three hours later, traps were checked, specimens identified, and traps collected. A 100 or 200 point-step transect was made in each trapping site and photographs were taken. Photographs of some of the field procedures are in Appendix C.

IV. RESULTS

A total of 343 Mohave ground squirrels and 371 antelope ground squirrels were captured from 22 study sites within the known range of the Mohave ground squirrel. Approximately 72,600 trap-hours were logged (22 sites x 3 trapping sequences x 11 hours/sequence x 100 traps). Both the Mohave and antelope ground squirrel were trapped at each of the 22 study sites. Total captures of the Mohave ground squirrel per study site ranged from one (Desert Tortoise Natural Area - Section 14) to 69 (Golden Valley). Total captures of the antelope ground squirrel per study site ranged from five (Bird Spring Canyon - west site) to 44 (Fremont Peak - west site) (see Figures 4 - 6). Captures of Mohave and antelope ground squirrels showed a significant degree of correlation ($r = .61$, $N = 66$; refer to Figure 7).

Recaptures of Mohave ground squirrels were made on 51 occasions, and on 24 occasions for the antelope ground squirrel. Distances between capture and recapture ranged from 0 to 750 yards for the Mohave ground squirrel and averaged 64 yards. Distances between capture and recapture for the antelope ground squirrel ranged from 0 to 155 yards and averaged 69 yards. (Refer to Figure 8 for dispersal distances of adults and juveniles of each species.) Juvenile animals displayed a greater dispersal distance than adults, especially in the case of the Mohave ground squirrel.

Average daily high temperatures were suppressed in early May and were accompanied by cloud cover, precipitation and high winds. Ground squirrel captures, as indicated by trapping data, remained relatively low during this period. Between May 10 and May 20, the mean daily high temperature of six desert localities in the western Mojave Desert ranged from 63 to 95 degrees F. Ground squirrel captures increased dramatically and remained high throughout most of the trapping period.

Total adjusted captures of Mohave ground squirrels - presented in decending order according to trapping site. Associated Antelope ground squirrel captures presented for comparison.

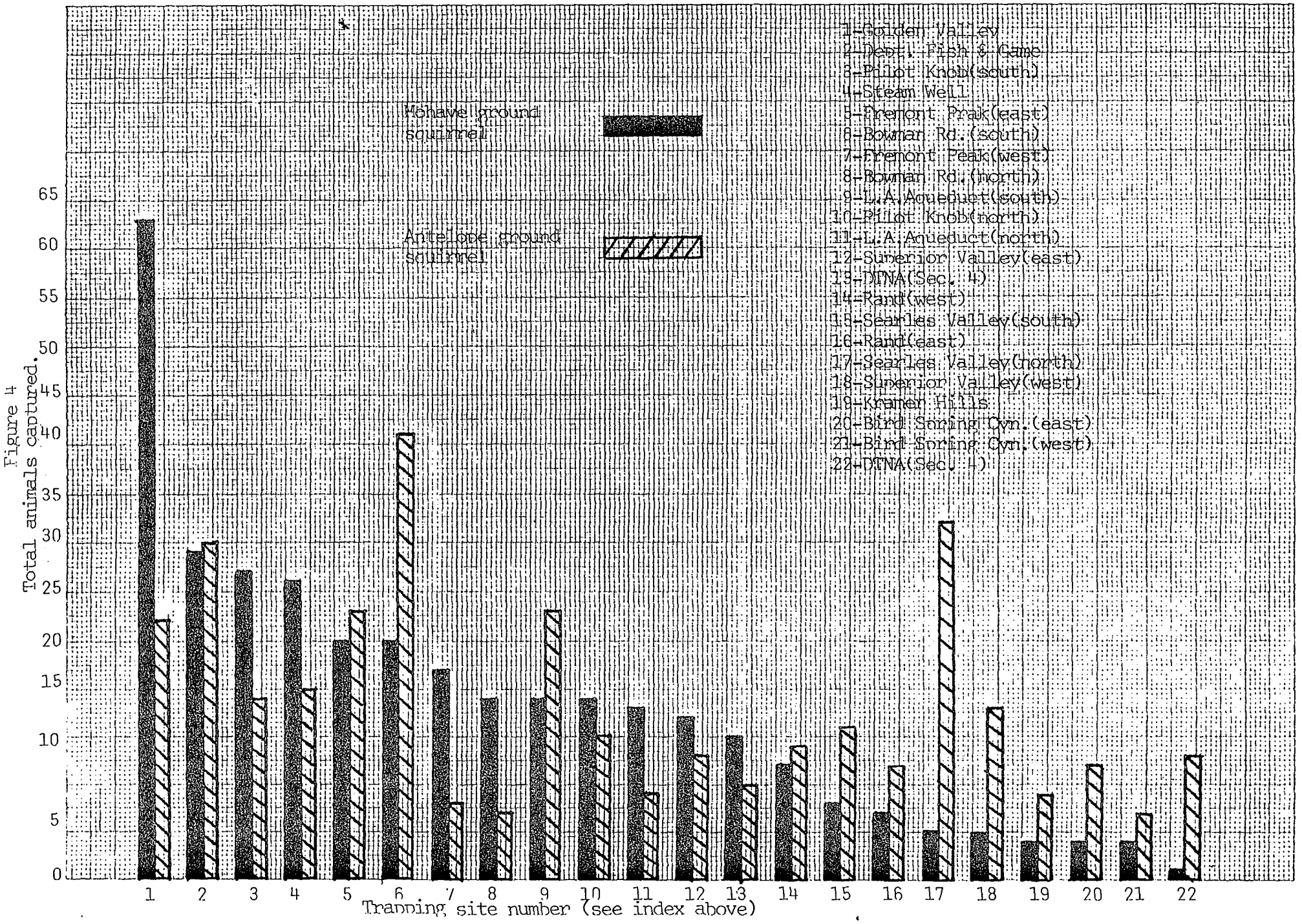


Figure 4

Figure 5 -- Mohave Ground Squirrel Trapping Results

	Actual Capture/Recaptures				Adjusted Captures			
	Sequences				Sequences			
	1	2	3	Total	1	2	3	Total
Golden Valley	15/1	26/1	28/5	69/7	16	24	28	68
Department of Fish and Game	0	15/1	22/4	37/5	0	13	21	34
Steam Well	10/1	8/2	13/2	31/5	10	8	14	32
Pilot Knob - south	2/0	9/0	11/3	22/3	2	11	18	31
Fremont Peak - east	1/0*	9/0	14/3	24/3	2	9	14	25
Fremont Peak - west	0*	5/0	19/6	24/6	0	6	19	25
Bowman Road - south	3/0**	18/2	3/0	24/2	3	16	3	22
Bowman Road - north	4/0	14/3	5/0	23/3	4	11	4	19
L.A. Aqueduct - south	1/0	19/3	1/0	21/3	1	17	1	19
Pilot Knob - north	6/2	2/0	9/1	17/3	6	2	11	19
Superior Valley - east	3/0	5/1	11/2	19/3	2	5	11	18
L.A. Aqueduct - north	1/0	15/3	4/0	20/3	1	12	4	17
Desert Tortoise Natural Area - Sec 4	4/1	6/1	3/0	13/2	4	7	4	15
Rand - west	0	10/1	1/0	11/1	0	11	1	12
Searles Valley - south	7/0	1/0	0	8/0	7	1	0	8
Rand - east	0	5/0	2/1	7/1	0	6	1	7
Searles Valley - north	3/0	1/1	1/0	5/1	3	1	1	5
Superior Valley - west	0**	3/0	2/0	5/0	0	3	2	5
Kramer	0	2/0	2/0	4/0	0	2	2	4
Bird Spring Canyon - east	0**	2/0	1/0	3/0	0	3	1	4
Bird Spring Canyon - west	1/0**	2/0	0	3/0	1	3	0	4
Desert Tortoise Natural Area - Sec 14	0	0	1/0	1/0	0	0	1	1
TOTAL	61/5	177/19	153/27	391/51	62	171	161	394

* 2 Trap days rather than 3 due to weather

** Cold, Wind, Rain

Figure 6 -- Antelope Ground Squirrel Trapping Results

SITES	Actual Captures/Recaptures				Adjusted Captures			
	Sequences 1	2	3	Total	Sequences 1	2	3	Total
Fremont Peak - west	2/0*	8/1	34/6	44/7	3	9	34	46
Searles Valley - north	10/1	11/1	9/0	30/2	10	15	12	37
Department of Fish & Game	2/0	18/1	19/4	39/5	2	15	18	35
L.A. Aqueduct - south	1/0	20/0	10/2	31/2	1	17	10	28
Fremont Peak - east	4/0*	4/0	18/1	26/1	6	4	18	28
Golden Valley	4/0	4/0	19/3	27/3	4	4	19	27
Pilot Knob - south	2/0	3/0	9/0	14/0	2	4	14	20
Steam Well	7/0	5/0	6/0	18/0	7	5	7	19
Superior Valley - west	4/0	3/0	12/0	19/0	3	3	12	18
Searles Valley - south	11/0*	3/1	1/0	15/1	11	4	1	16
Pilot Knob - north	4/0	5/0	4/0	13/0	4	6	5	15
Rand -west	2/1	7/1	4/0	13/2	2	8	4	14
L.A. Aqueduct - north	0	10/0	5/0	15/0	0	8	5	13
Desert Tortoise Natural Area - Sec 14	0	10/1	2/0	12/1	0	11	2	13
Rand - east	1/0	6/0	3/0	10/0	1	7	4	12
Bird Spring Canyon - east	0	5/0	4/0	9/0	0	7	5	12
Desert Tortoise Natural Area - Sec 4	2/0	3/0	4/0	9/0	2	3	5	10
Superior Valley - east	4/0	0	6/0	10/0	3	0	6	9
Kramer Hills	0	1/0	8/0	9/0	0	1	8	9
Bowman Road - south	1/0	8/0	0	9/0	1	7	0	8
Bowman Road - north	2/0	4/0	2/0	8/0	2	3	2	7
Bird Spring Canyon - west	0	5/0	0	5/0	0	7	0	7
TOTAL	63/2	143/6	179/16	385/24	64	148	191	403

* 2 Trap days rather than 3 due to weather

** Cold, Wind, & Rain

Figure 7

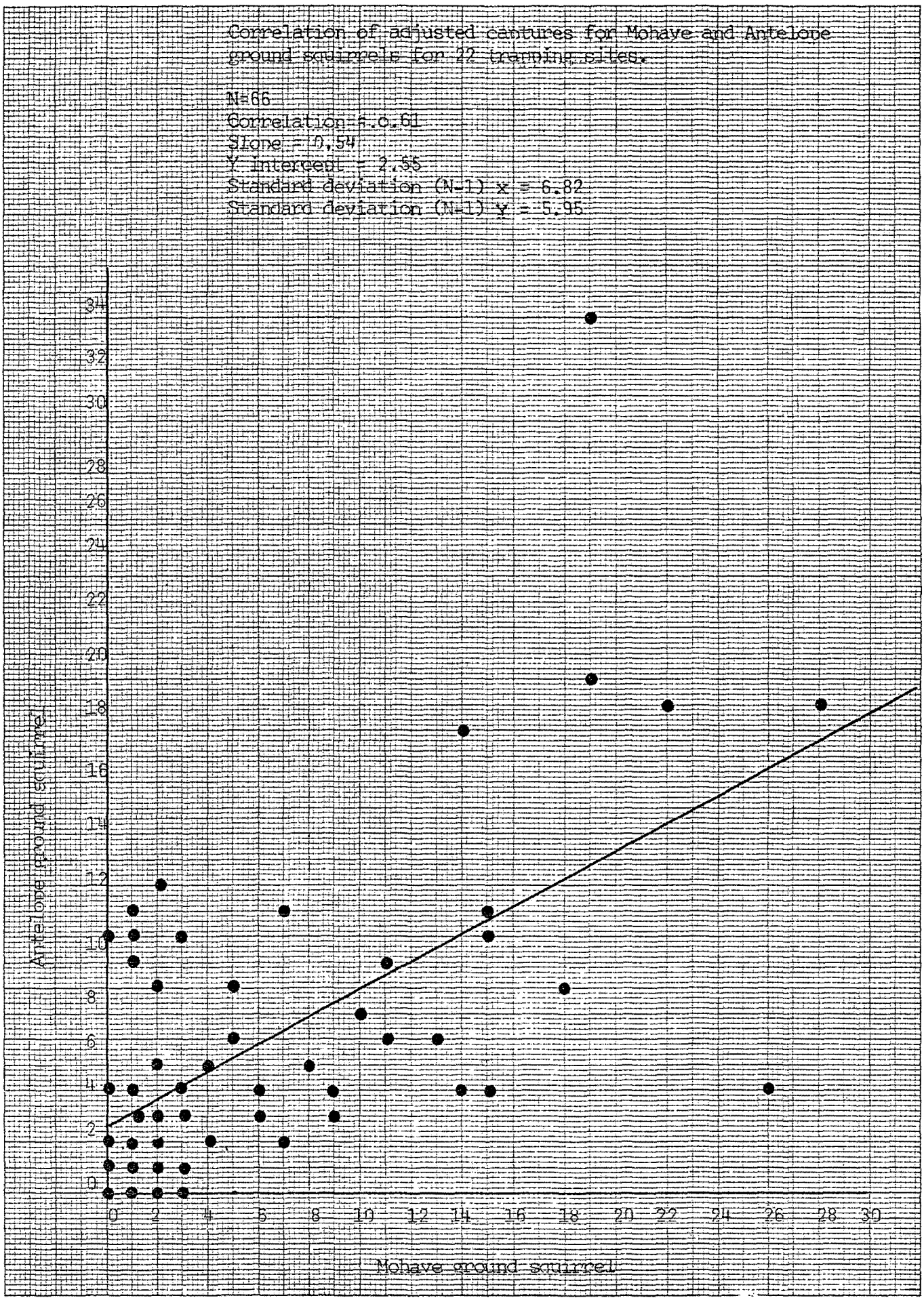
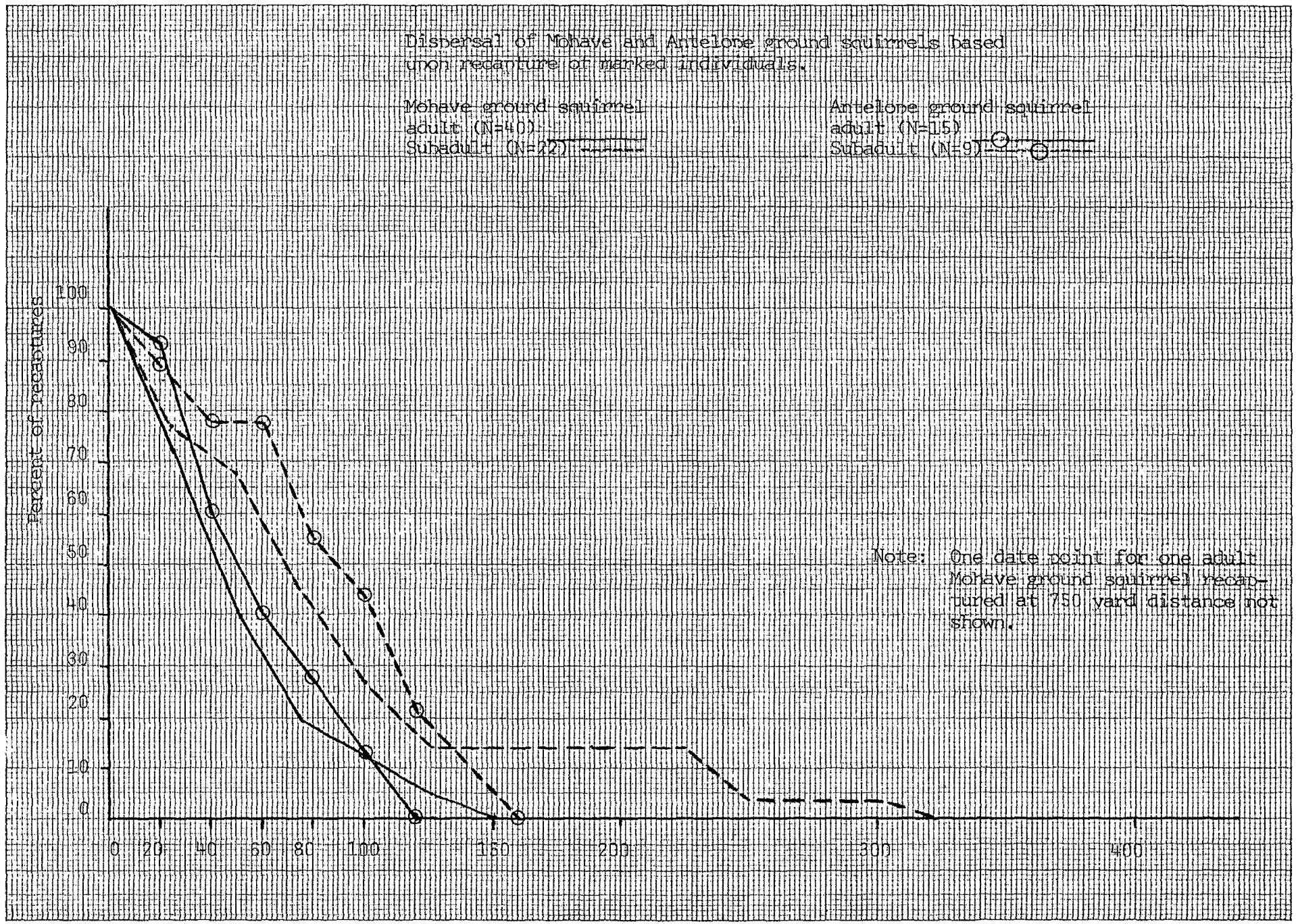

Correlation of adjusted captures for Mohave and Antelope ground squirrels for 22 trapping sites.
N=66
Correlation=+.61
Slope = 0.54
Y intercept = 2.55
Standard deviation (N-1) x = 6.82
Standard deviation (N-1) Y = 5.95
Antelope ground squirrel
Mohave ground squirrel
0
2
4
6
8
10
12
14
16
18
20
22
24
26
28
30
32
34

Figure 8


Dispersal of Mohave and Antelope ground squirrels based upon recapture of marked individuals.
Mohave ground squirrel
adult (N=40)
Subadult (N=22)
Antelope ground squirrel
adult (N=15)
Subadult (N=9)
Percent of recaptures
100
90
80
70
60
50
40
30
20
10
0
0
20
40
60
80
100
150
200
300
400
Note: One date point for one adult Mohave ground squirrel recaptured at 750 yard distance not shown.

Comparison of Mohave and Antelope ground squirrel captures vs. date and mean daily temperature.

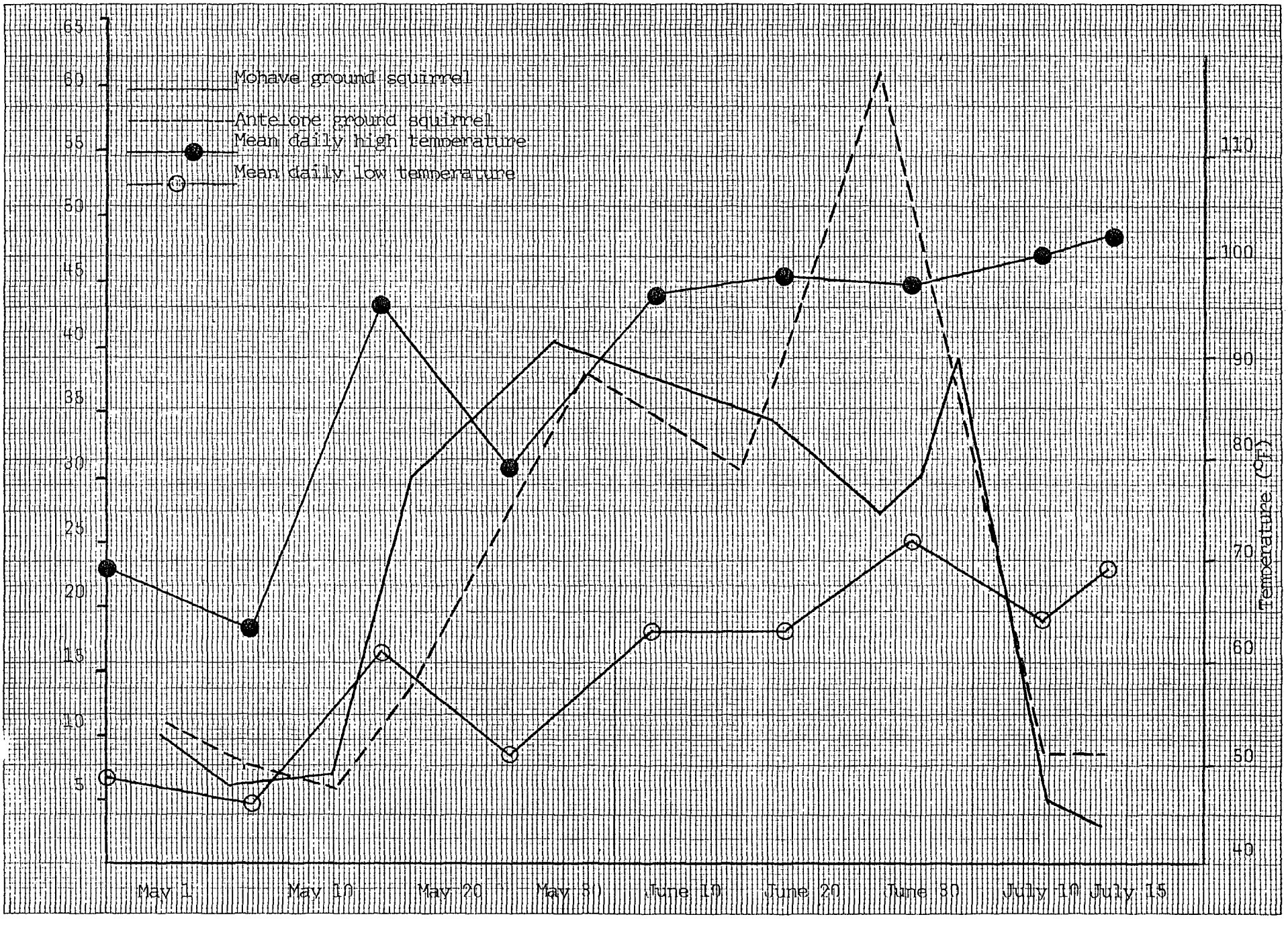


Figure 9

Figure 10 -- Habitat descriptions based upon transects for study sites

	PERCENT COMPOSITION PARAMETERS																		
	Bare Ground	Perennial Plants	Annual Plants (forbs, grasses) incl. dessicated plants	Litter	Rocks (small)	Acamptopappus sphaeocephalus	Ambrosia dumosa	Atriplex spp.	Coleogyne ramosissima	Ephedra nevadensis	Cerratoides lanata	Grayia spinosa	Happlopappus linearifolius	Hymenoclea salsola	Larrea tridentata	Lycium spp.	Mirabilis bigelovil	Sphaeralcea ambigua	Tetradymia axillaris	Perennial grass
Almond Mountain - east	54	10	34	2	0	1.5	1.5								5.5	.5			1	
Department of Fish and Game	54	19	18	9	0		.5	11.5							6				1	
Pilot Knob - south	55	16	26	3	0	.5	6			.5					8	1				
Almond Mountain - west	59	12	24	5	0	1.5	2.5								7.5					
Fremont Peak - east	49	16	30	5	0	4.5	.5	8.5						2		.5				
Bowman Road - south		NO	DATA																	
Fremont Peak - west	50	18	26	6	0	.5	3.5	14			.5									
Bowman Road - north	36	14	42	6	2		7						1		6					
L.A. Aqueduct - south	33	23	38	6	0		6					2	12		3					
Pilot Knob - north	49	19	28	4	0	.5	8								8.5	2				
L.A. Aqueduct - north	52	19	22	7	0	4	3					2	6	1	3					
Superior Valley - east	52	12	36	0	0		.5	11								.5		.5		
Desert Tortoise Natural Area - Sec 4	46	9	37	8	0		1.5							1.5	4.5	1				.5
Rand - west	18	22	42	15	3	6	8								8					
Searles Valley - south	63	22	2	9	2		16.5								3.5	2.5				
Rand - east	6	9	41	7	37		1								8					
Searles Valley - north	51	29	11	9	0		13	5							1	10				
Superior Valley - west	66	14	20	0	0	.5	1.5	12												
Kramer Hills	58	9	29	4	0		3					.5			5.5					
Bird Spring Canyon - east	44	18	33	5	0	1	1		10				1	1		4				
Bird Spring Canyon - west	35	29	30	5	1		1		12		2	3	6	2		3				
Desert Tortoise Natural Area - Sec 14	51	18	28	4	1	2	7				.5	.5		.5	5.5	1.5				
Panamint Valley - range extension	69	14	15	2	0		3	8							3					
Olancha - range extension		NO	DATA																	

However, captures of both species declined abruptly in late June and continued in a similar manner until the end of the trapping period on about July 15 (refer to Figure 9).

No Mohave or antelope ground squirrels were captured at the range extension study sites in the Panamint Valley and Olancha areas. However, on June 26 at 1830 hours, several ground squirrels were observed running across the Walker Creek Road, a dirt road leading west from U.S. Highway 395, approximately 1.5 miles north of Olancha. One of these squirrels was seen at a close distance and identified as a Mohave ground squirrel. The dominant plant in the area was saltbush (Atriplex spp.). Perennial plant cover for 22 of the sites studied ranged from 9 to 29 percent with an average of 17 percent. Bare ground ranged from 18 to 69 percent, with an average of 49 percent. Annual plant cover ranged from 11 to 42 percent and averaged 27 percent (see Figure 10).

V. DISCUSSION

Actual captures were converted to adjusted captures for comparison and evaluation purposes. Adjusted captures were based on 11 hours of trapping for each sequence. Actual trapping hours for each sequence ranged from 7 to 17, with a mean value of 11 (N = 66). Adjusted capture data is not significantly different from actual capture data (refer to Figures 5 and 6).

Assuming equal rates of initial capture, the average relative population densities for the Mohave and antelope ground squirrels for the study sites are similar. Within the region trapped (western Mojave Desert), the Mohave ground squirrel was common and it occurred at all trapping sites. The significant correlation coefficient for capture of one species vs. the other at each site for each trap

day suggests that when one species is present, the other will be also. At 9 of the 22 trapping sites, the total adjusted captures for the Mohave ground squirrel exceeded those for the antelope ground squirrel. Again, both species were captured at each of the 22 trapping sites.

Bartholomew and Hudson (1960, 1961) identified thermal neutral zones for the Mohave and antelope ground squirrels; 88-98.1 degrees F for the Mohave ground squirrel and 90-107 degrees F for the antelope ground squirrel. Behavioral studies by Recht (1978) confirmed the neutral zone concept for the Mohave ground squirrel. At or above the maximum temperature the animal becomes inactive.

Average maximum temperatures during the trapping sessions of the investigation were low (63.2 degrees F) on May 10, and increased to 95 degrees F by May 20. During this period the trapping success increased dramatically and remained high throughout most of the trapping period. This increase in trapping success, an index of above-ground activity, could be predicted as daily high temperatures corresponded with the thermal neutral zone for both species.

The dramatic decrease in trapping success for both species, corresponding to maximum daily temperatures of approximately 98-102 degrees F , indicates both species curtailed activity concurrently. This finding is somewhat contrary to the conclusion of Bartholomew and Hudson (1961) that the antelope ground squirrel has a greater tolerance for high temperature than the Mohave ground squirrel. However, both squirrels may respond in a like manner when food supplies (green vegetation) become unavailable even though temperatures are within the tolerance range for one or both species. During this investigation the lack of food

supplies may have been the controlling factor in dramatically reducing the activity of the antelope ground squirrel, even though the maximum daily temperatures were within the thermal neutral zone (90-107 degrees F). Hall and Kelson (1959) report that in arid portions of Nevada the Townsend's ground squirrel (Spermophilus townsendii) enters a dormant period when green food becomes dry, and remains inactive for up to eight months, corresponding to aestivation and hibernation. Recht (1977) reports that ground squirrel activity may continue throughout the summer as long as green vegetation is available, but the animals avoided excessive heat gain by thermo-regulatory behavior (i.e., remaining in shadows).

Recapture rates indicate the antelope ground squirrel is significantly more trap-shy than the Mohave ground squirrel. Dispersal of marked individuals based upon recaptures (Figure 8) is an index of the home range. The data indicates immatures have a larger home range than adults. Home ranges for adults of both species are similar. This supports the concept that the two species exist sympatrically in the same habitat as revealed in the data for total adjusted captures for each species at each trapping site (Figures 5 and 6). Their compatibility is probably based upon unknown differences in habitat utilization.

VI. HABITAT FEATURES & ASSOCIATED GROUND SQUIRREL POPULATIONS

There was no correlation between total adjusted captures at each site and percent cover for bare ground, perennial or annual plants. However, the abundance of surface rock (desert pavement) at the Rand (east) study site and the relatively low capture of each species suggests that this feature suppresses ground squirrel abundance, especially for the Mohave ground squirrel. However, surface rock is apparently not the only habitat feature which suppresses populations. Six other

study sites have even lower total captures of the Mohave ground squirrel, and these sites did not exhibit an abundance of surface rock as did the Rand (east) site(see Figure 4). These other sites included four in areas where topography resulted in shallower soils and more rapid drainage; Kramer Hills, Bird Spring Canyon (east, west), and Desert Tortoise Natural Area (Section 14).

Perhaps the range of values for two habitat features on each study plot, namely bare ground and perennial plants, did not vary significantly enough to replace in a significant change in the results for total adjusted captures. Smith and Johnson (1958) studied a population of Townsend ground squirrels in southern Idaho and reported population density was reduced by more than 50 percent by drought, and that successful reproduction was related primarily to the availability of grasses and forbs, which comprised 81 percent of the diet. They found the availability of these food sources ultimately depended on the amount of rainfall from the preceding fall and winter.

The availability of annual grasses and forbs is likely an important factor in reproduction and ultimately population stability in the Mohave and antelope ground squirrels. This investigation did not include an evaluation of availability of grasses and forbs or rainfall patterns, and transect data for annual plants was collected at different times during the trapping season. As a result, some annuals were studied in a succulent form, whereas others were in a dried state.

Field studies of small mammals in the Coso Geothermal Study Area located in southern Inyo County indicate Mohave ground squirrels rarely occur in mountainous areas or rocky terrain (Zembal, 1978; Leitner, 1979). Field studies conducted by Leitner (1979) also revealed that the live-trapping capture rate for Mohave ground squirrels was lowest in the Joshua Tree Woodland plant community. Similar results

were obtained in this study for Joshua Tree Woodland in Bird Spring Canyon. Wessman (1977) found Mohave ground squirrels were absent on very rocky areas and sterile playas, but they were present in a wide variety of habitats. Unfortunately, his study did not include an evaluation of relative densities in the occupied habitats.

Large alluvial-filled valleys with deeper fine to medium textures soils, absence of rocks (desert pavement) and vegetation classified as Creosote Bush Scrub, Shadscale Scrub, and Alkali Sink appear to be the best habitat for both the antelope and Mohave ground squirrels. Within these areas, reproduction and survival rates are likely dependent on the availability of annual grasses and forbs. Rainfall naturally affects these food supplies, and can have a significant effect on year-to-year population levels.

Land uses which affect the availibility of annual forbs and grasses, namely grazing by sheep and cattle, have the potential of influencing the long-term population of the Mohave ground squirrel. This does not necessarily mean that properly managed livestock grazing will cause a significant negative impact on the Mohave ground squirrel. All of the study sites in the investigation, except for those in the Desert Tortoise Natural Area, were grazed by sheep or cattle in varying degrees. The highest total adjusted captures for the Mohave ground squirrel were from a study site which showed considerable signs of grazing and trampling by sheep. However, the site evidently did not have a diminished value for annual forbs and grasses.

Maintenance of shrub cover for soil stabilization and shelter from solar heat, plus availability of annual grasses and forbs during the time the thermal neutral

zone temperatures (88-98 degrees F) are present, are probably the best management practices to follow to assure the longterm stability of populations of the Mohave ground squirrel. Similar practices are in effect for the desert tortoise (Gopherus agassizi) in portions of the California Desert Conservation Area. Here the Bureau of Land Management has restricted grazing by domestic sheep until tortoises have "emerged" from hibernation and until the range has a minimum of 350 pounds per acre of annual plant forage (air dry weight) per acre (Bureau of Land Management, 1980).

VII. MANAGEMENT RECOMMENDATIONS

A. Evaluate and modify "Crucial Habitat" for the Mohave ground squirrel, as identified in the California Desert Conservation Plan (1980) - Map No. 4, polygon 29. In addition, determine if the concept of "Crucial Habitat" is viable.

B. Expand the minimum available ephemeral forage value of 350 pounds/acre within the geographic range of the Mohave ground squirrel.

C. Evaluate, in concert with the Department of Fish and Game, the current listing (Rare) for the Mohave ground squirrel based upon the finding of this and other investigations. The Rare listing is based upon a "yes" answer to any of the following questions (Department of Fish and Game, 1977).

1. Is it confined to a relatively small and specialized habitat, and is it incapable of adapting to different environmental conditions?
2. Although found in other parts of the world, is it nowhere abundant?
3. Is it so limited that any appreciable reduction in range, numbers or habitat would cause it to become endangered?
4. If current management and protection programs were diminished in any degree, would it become endangered?

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