MOHAVE GROUND SQUIRREL STUDY

IN THE COSO GRAZING EXCLOSURE

COSO KNOWN GEOTHERMAL RESOURCES AREA

INYO COUNTY, CALIFORNIA

May-June, 1991

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SUMMARY

Studies of the Mohave ground squirrel (Spermophilus mohavensis) were conducted at four study sites in the Coso Known Geothermal Resources Area (KGRA), Inyo County, California, in May-June, 1991. Mohave and antelope ground squirrels (Ammospermophilus leucurus) were live-trapped, herbaceous vegetation was sampled, precipitation was monitored, and the diets of the five principal vertebrate herbivore species were investigated.

The sampling effort of 1,452 trap-days extended from May 28 through June 3, 1991. Live-trapping resulted in the capture of a total of three Mohave ground squirrels (MGS), one on Study Site 3 and two on Study Site 2. All were adult females. Although no juveniles were captured, the three females had been lactating, suggesting that MGS reproduction took place in 1991. Body mass for the three individuals was 144, 156 and 170 grams, with a mean of 157 grams.

Only one antelope ground squirrel (AGS) was captured in 1991, an adult male on Study Site 4. It is not clear whether AGS reproduction occurred in 1991. AGS populations have declined drastically due to unusually harsh conditions in 1989 and 1990 and the apparent lack of reproduction in 1990.

Fecal samples for dietary analysis were collected from MGS, AGS, black-tailed jackrabbits, cattle, and feral burros during the May-June trapping period. The MGS and AGS samples were similar in being composed primarily of two food items: lepidopteran larvae (caterpillars) and seed, mainly of Opuntia (cholla and/or beavertail cactus) and Eremalche (white mallow). The black-tailed jackrabbit diet was mainly Schismus (schismus) at Study Site 2. At study sites 3 and 4 the black-tailed jackrabbit diet was herb and shrub foliage, mainly Eurotia (winterfat) leaf. The cattle samples from Study Site 4 contained mainly Bromus (brome), Atriplex (saltbush) leaf and Eurotia leaf. Feral burro samples from Study Site 2 contained mainly annual grasses, especially Bromus and Schismus. At Study Site 4, burro samples contained mainly Bromus and Eurotia leaf.

Raingauges documented precipitation levels at five locations. Precipitation ranged from 117 to 124 mm for the one-year period September 1, 1990-August 31, 1991. During this period the Haiwee Reservoir station received 114 mm of precipitation, which was 76 percent of the 28-year average. The 1990-91 period was unusual in that about 80 mm, or three-fourths of the annual total, fell during a one-week series of storms beginning on February 27.

Herbaceous vegetation at each study site was characterized using randomly-placed square-foot plots. Herbaceous vegetation was unusually diverse and plentiful in 1991, with species richness and overall standing crop higher than in any of the previous years studied.

INTRODUCTION

Development of geothermal resources for electric power production in the Coso Known Geothermal Resources Area (KGRA) is resulting in habitat loss for the Mohave ground squirrel (Spermophilus mohavensis, or MGS). This species is listed as Threatened by the California Department of Fish and Game (CDFG) and listed by the U.S. Fish and Wildlife Service as a candidate species (Category 2). Under an agreement between the China Lake Naval Weapons Center (NWC)(now known as the China Lake Naval Air Weapons Station, or NAWS) the Bureau of Land Management (BLM), and CDFG (BLM et al. 1988), the Coso Mohave Ground Squirrel Mitigation Program was developed to compensate for loss of habitat to this species resulting from geothermal development in the Coso KGRA.

The Mitigation Program consists of several elements, including the elimination of grazing by domestic cattle over an approximately 155 sq km (60 sq mi or 38,000 ac) portion of the KGRA (Figure 1). Cattle may adversely impact MGS populations by direct competition with ground squirrels for limited forage and indirectly by modification of habitat (Leitner and Leitner 1989). In addition to construction of an exclosure, the Mitigation Program calls for a long-term monitoring study to evaluate the success of the mitigation. Baseline studies were carried out in 1988, 1989 and 1990; the results of these studies were reported in Leitner and Leitner (1989 and 1990) and Leitner et al. (1991). Post-exclosure studies are required in 1992, 1994, 1996, and 2001.

Additional studies were recommended for 1991 because of the unusual results found during the drought years of 1989 and 1990: no juvenile MGS were trapped, and it was concluded that no reproduction took place. It was felt that the 1992 trapping results could be better interpreted if it could be determined whether the MGS reproduced in 1991, a year with somewhat below-average and late-arriving precipitation.

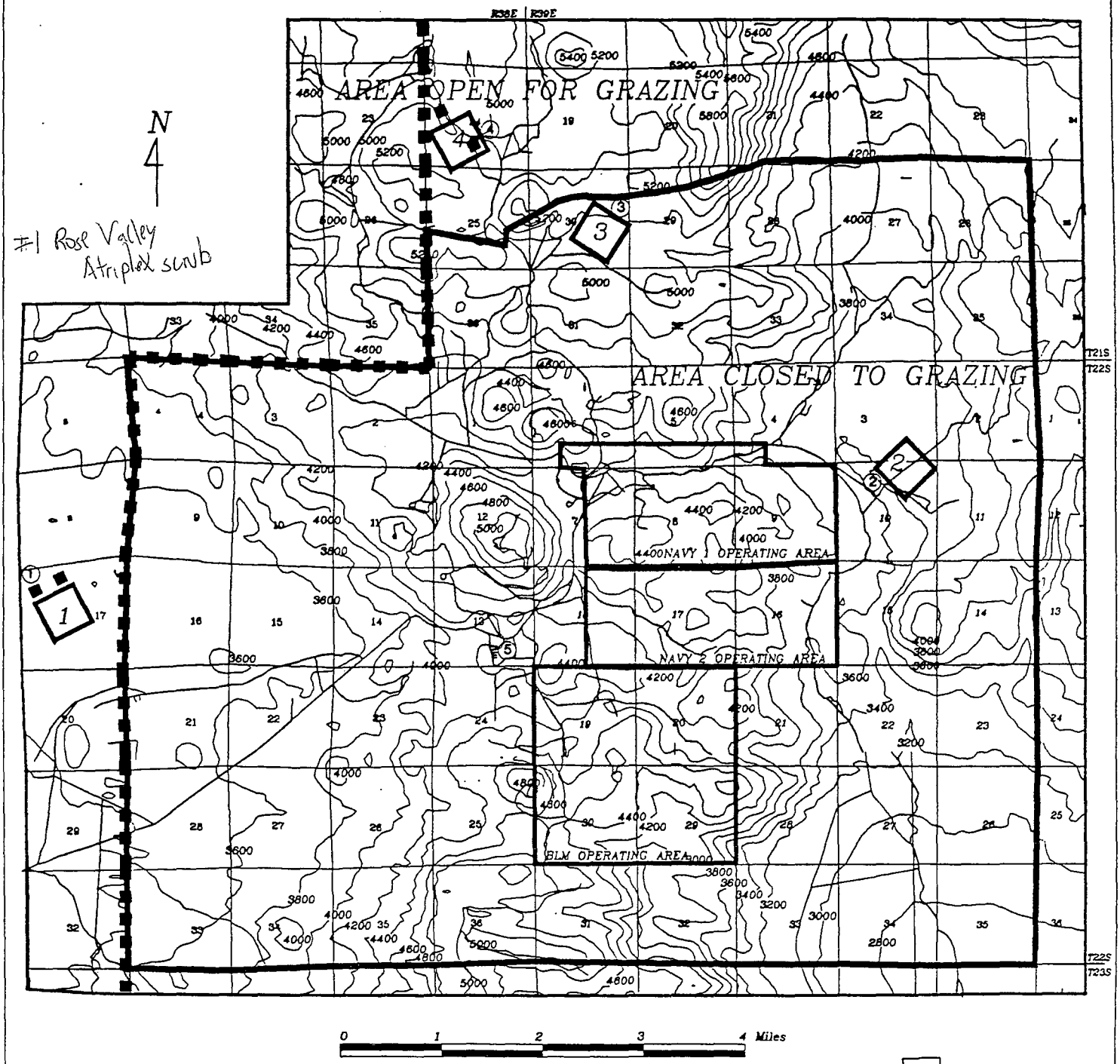
not justified?

SCOPE OF WORK FOR 1991 STUDIES

The principal elements of the 1991 studies were: 1) trapping MGS to establish their relative abundance on four study sites, two within the exclosure and two outside; 2) characterizing herbaceous vegetation within the study sites; 3) recording local precipitation at five stations; and 4) collecting and analyzing fecal samples from the principal vertebrate herbivores in the Coso KGRA: MGS, antelope ground squirrels (Ammospermophilus leucurus), black-tailed jackrabbits (Lepus californicus), cattle, and feral burros.

DESCRIPTION OF THE STUDY AREA AND STUDY SITES

The Coso KGRA occupies 294 sq km (113.5 sq mi) in the Mohave Desert in southwestern Inyo County, California. The elevation range of the KGRA is from 833 to 1814 m (2730 to 5947 ft) above sea



1 Location of Study Sites

Area Closed to Grazing

Naval Weapons Center Boundary

Cattle Grazing Exclosures at study sites 1 & 4

① Precipitation Stations

COSO GRAZING EXCLOSURE MONITORING STUDY

LOCATION OF STUDY AREA AND STUDY SITES

Figure 1: Location Map

EXCLOS 2/20/90

SAN

level. The western boundary of the KGRA lies in Rose Valley, a broad alluvial valley lying between the eastern edge of the Sierra Nevada and the Coso Range. Eastward from Rose Valley rise the rugged uplands of the Coso Range, a series of steep-sided granitic and metamorphic hills, rhyolitic domes, and rolling plains and basins composed of pyroclastic sediments. In the southwest portion of the KGRA are rough basalt cinder cones and basalt lava flows. To the east, alluvial fans extend from the granitic uplands into a major alluvial valley, Coso Basin (WESCO 1980).

Figure 1 shows the location of the grazing exclosure and the four study sites. A description of the location of each site is as follows:

Study Site 1: T22S R38E, Sec. 17 (central portion)
Study Site 2: T22S R39E, SE 1/4 Sec. 3 and NE 1/4 Sec. 10
Study Site 3: T21S R39E, SE 1/4 Sec. 30
Study Site 4: T21S R38E, SW 1/4 Sec. 24; all MDB&M.

Study sites 1 and 4 are in areas that will continue to receive grazing in the same pattern as in the past; study sites 2 and 3 are within the grazing exclosure. Study sites 2, 3 and 4 are on lands managed by NAWS, while Study Site 1 is managed by BLM.

Study sites 1 and 2 are low-elevation sites, the first outside the grazing exclosure and the second inside. Study Site 1 lies on the east side of Rose Valley at an elevation of 1015 m (3350 ft) and is dominated by Desert Saltbush Scrub, a low-growing, homogeneous mixture of two saltbush species Atriplex polycarpa (allscale) and A. confertifolia (shadscale). Study Site 2 is situated to the southeast of Coso Hot Springs in Coso Basin at an elevation of 1085 m (3580 ft). The natural community there is Mohave Mixed Woody Scrub, a diverse mixture including Acamptopappus sphaerocephalus (goldenhead), Ephedra nevadensis (Mormon-tea) and A. confertifolia. The western edge of the site contains a narrow strip of Mohave Desert Wash Scrub, a rich mixture of deep-rooted perennials.

non-comparable sites floristically elevation fairly similar. 230' diff

elevation?

Study sites 3 and 4 are high-elevation sites, the first within the grazing exclosure and the second outside. Study Site 3 is located to the southeast of Cactus Peak in a large upland basin at an elevation of 1470 m (4840 ft). The vegetation consists of the bajada phase of Mohave Mixed Woody Scrub grading into Desert Saltbush Scrub in the lowest portions of the basin. Important shrub species are Grayia spinosa (spiny hopsage), A. canescens (fourwing saltbush) and A. confertifolia with scattered Yucca brevifolia (Joshua tree). Study Site 4 lies in a valley to the northwest of Cactus Peak at an elevation of 1500 m (4920 ft). The vegetation there resembles that found at Study Site 3, but is richer in species and more strongly dominated by Grayia. For a more detailed description of soils, topography, and shrub and herbaceous vegetation, the reader is referred to Leitner and Leitner (1989).

Weather in the KGRA is characterized by hot dry summers and cool to cold winters. Most precipitation falls as rain or snow in the winter months, from November to April, although irregular summer thundershowers may be a significant source of precipitation. The average annual precipitation in Coso Basin over the past 12 years is about 102 mm (4 in) (Monahan and Condon 1991).

METHODS

Study Site Configuration

~1/2 km²

Each study site is a square measuring 500 m (1640 ft) on a side, with an area of 25 ha (61.8 ac). The corners are marked with both a 1.8 m (6 ft) steel fencepost and a 40 cm (16 in) orange plastic stake. A steel fencepost and a plastic stake are also placed at the midpoint of each side and at the center point of the study site. The locations of 441 trap stations, spaced 25 m apart, at each study site are permanently marked with wooden stakes.

1/4 km²

Ground Squirrel Trapping and Abundance

Live-trapping Methods

period of estivation for some adults

Trapping was carried out from May 28 through June 3, 1991. This period was chosen because it is a time in the annual cycle of the MGS when juveniles usually are active above-ground. Pymatuning traps were deployed at 50 m intervals on alternating trap stations, for a total of 121 traps at each study site.

Traps were operated, without prebaiting, for three days at each study site. They were placed beside a shrub within 1-3 m of the stake marking the trap station. To protect trapped animals from heat stress, each trap was shaded with a cover. The covers were white corrugated cardboard measuring 61 cm by 71 cm (24 by 28 in), folded to form an A-shape, and the lower edges secured with nails and loose soil. Traps were opened in the morning between 0730 and 0930 hours and closed in the afternoon between 1630 and 1800 hours. They were checked on a regular schedule, usually two to three times each day.

As in previous years, traps were baited with a commercially available horse feed that includes molasses, rolled oats, cracked corn, wheat, and barley (Kruse's Perfection brand horse feed with molasses, known locally as "sweet feed").

The trapping protocol was identical to that used in the same sampling period of 1990. It differed from the procedure used in late May-June 1988 and 1989 and in March-April 1990 in two ways: (1) 121 traps were arrayed in the 500 m-square grid at 50 m intervals rather than 441 at 25 m intervals; and (2) only three days of trapping were conducted with no pre-baiting rather than

five days of trapping with two days of pre-baiting. The reduced trapping effort was adequate to determine the reproductive status of MGS populations and to provide an index of abundance as well. big assumption

Captured animals were identified to species, sex, and age class (adult/juvenile). Females were checked to determine whether they were pregnant or lactating. A 300 g (12 oz) capacity Pesola brand spring scale was used to determine body mass of all animals upon first capture. All MGS and AGS were marked for individual recognition by ear-tagging with a No. 1 fingerling tag and the tag number was painted on the ventral pelage with indelible ink. These two marking methods were adequate to provide identification during the three-day trapping period.

In addition, all captured ground squirrels received a passive integrated transponder (PIT) tag. Each PIT tag measures 2x10 mm and contains a microprocessor chip and wire antenna encased in glass. The tags were implanted subcutaneously between the shoulder blades using a veterinary syringe and 12-gauge needle. When a battery-operated detector emitting a 400 kHz radiofrequency signal is passed over a tagged animal, the PIT tag is energized to transmit a unique identification code which is then displayed on a readout unit. This tagging method has been shown to cause no observable effect on the health or behavior of tagged wildlife (Fagerstone and Johns 1986). It is of particular value in this study because the PIT tags (unlike ear tags) cannot be lost and thus provide a permanent record of individual identity. Both the PIT tag and ear tag numbers were recorded for each animal. All data pertaining to a particular capture were recorded on standard field data forms (see Appendix I) and the animal then released unharmed.

The study sites are generally located in basins with rather loose sandy soil, and it was thought that human treading associated with trapping activities might disrupt the soil structure and thus the development of beneficial soil microorganisms. Particular effort was made to confine foot traffic to single pathways between trapping stations. If pathways needed to be defined more clearly, a thin line of powdered dolomite was applied to the soil surface for a meter or so to indicate the desired route.

Ground Squirrel Abundance

The 1991 trapping results provide data on the abundance of MGS and AGS at each study site as measured by the total number of animals captured. In previous reports, we have used several other methods to estimate abundance, population size, and population density. These have included: 1) the number of resident animals on a study site; 2) population size as estimated by the Schnabel and Lincoln-Petersen mark-recapture methods; 3) population density based upon the number of resident animals per 25-ha study site; and 4) population density based upon population size from the Schnabel or Lincoln-Petersen methods and effective trapping area as

estimated by mean distances moved by animals between successive captures. Because of the small number of animals captured in 1991 and the paucity of recaptures, it is not possible to use these methods to evaluate abundance.

Herbivore Dietary Analysis

The diets of the MGS and four other herbivore species -- AGS, black-tailed jackrabbit, cattle, and feral burro -- were studied by the microscopic examination of undigested food material found in fecal samples.

Relatively fresh, undecomposed samples of black-tailed jackrabbit, cattle, and feral burro fecal material were collected during late May and June, 1991. Cattle and burro samples consisted of a small fragment taken from a single defecation. Each black-tailed jackrabbit fecal sample consisted of three pellets collected from a single pellet group. Although these samples were taken from widely separated locations over each study site, there is no assurance that each represents the diet of a different individual animal, nor is there any certainty as to when the material was deposited. Up to ten samples of each species were collected from each study site where material was available. If no fresh material was available, samples were not collected.

Fecal samples for MGS and AGS were obtained at the time of the live-trapping surveys during May 28-June 3, 1991. Each time an animal was captured, three fresh fecal pellets were collected from the trap and placed in a small envelope which was sealed and labeled to indicate the species, sex, age class, ear tag and PIT tag numbers, date, study site, and trap station. Then all remaining pellets were removed from the trap to ensure that a subsequent fecal sample could be accurately attributed to a known individual animal.

All fecal samples were sent for analysis to the Composition Analysis Laboratory, Fort Collins, Colorado. The microhistological technique used is described in Hansen et al. (1974) and Foppe (in prep.). Each fecal sample was ground and cleared, then transferred to a microscope slide for the identification of discernable food materials. Plant fragments were identified to genus where possible; the species can often be inferred from those known to be present in the study site. Seed and leaf material from the same plant could often be differentiated. On each slide, twenty fields containing at least three identifiable fragments were examined using a phase-contrast microscope at 100X power. The occurrence of discernable fragments was recorded for each field and was used to compute the percent frequency for all material present in the sample. Percent frequency was then converted to percent relative density for each plant taxon. Relative density for a food item is thus considered to be a reasonable estimate of its dry weight contribution to the diet.

assuming all food items digest similarly.

Precipitation Measurements

Since some of the differences in vegetation growth between the four study sites might be attributable to precipitation, gauges were set out to record local precipitation. Clear plastic direct-reading raingauges were wired to metal fenceposts at each of the four study sites. A fifth gauge was placed near a continuously-recording precipitation station in Section 13, T22S R38E which is operated by the Great Basin Air Pollution Control District. A layer of mineral oil few millimeters thick was placed in the collection tube to prevent evaporation of precipitation between readings. The gauges were serviced monthly by reading precipitation levels, emptying the gauge, cleaning, and recoating with mineral oil.

Vegetation Surveys

Herbaceous species composition and above-ground standing crop were recorded during late May and early June, a time when growth was presumed to be essentially completed. Species composition and standing crop were measured on each study site in square plots each measuring 0.09 sq m (1 sq ft). A minimum of 61 between-shrub and 61 under-shrub plots were sampled on each study site. The plots were taken either near alternating trap stations on alternating rows, or on every station on every fourth row. Twenty-five between- and under-shrub plots were randomly selected in each pair of cattle grazing mini-exclosures at study sites 1 and 4.

The between-shrub plot was randomly selected by throwing the plot frame into an open area near the trap station. The under-shrub plot was selected by the convention of placing the frame under the shrub nearest the between-shrub plot. All herbaceous plant species present, both annual and perennial, were recorded on data sheets. All annual grasses and most forbs were clipped at ground level and placed into a labeled envelope or bag. Perennial grasses and coarse perennial herbs (such as *Eriogonum inflatum*) were excluded from the clipping procedure because of the difficulty of separating current year's growth from previous years' growth and the likelihood of causing damage to the root crown. omission

Species frequency was calculated based on the percentage of plots in which the species was recorded. For each study site, the average number of species per plot was calculated as a measure of species richness. In addition, the average standing crop was calculated for between-shrub plots and under-shrub plots for each study site.

% occurrence, not area

RESULTS

Ground Squirrel Abundance

As explained in the methods section, the 1991 trapping data provide only one indicator of ground squirrel abundance. The total number of individuals captured on each study site will be used as the sole measure of abundance in the section that follows.

Total Number of Individuals Captured

Live-trapping was carried out for three days on each of the four study sites in late May and early June 1991. This sampling effort of 1,452 trap-days resulted in the capture of a total of three individual MGS and one AGS over all study sites. Since one of the MGS was recaptured once, a total of four captures of MGS were recorded. Tables 1-4 show the number of individual animals captured on each study site by species, sex and age class.

The three MGS captured were adult females and all had been lactating. Thus, for the first time since 1988, there was clear evidence of reproduction in MGS populations in the Coso region. The lack of juvenile captures was unexpected, since young MGS are normally active above ground by mid-May.

As in 1989 and 1990, there were no MGS captures on Study Site 1, suggesting that the species was still not present at this location. It is not clear whether the lack of MGS captures on Study Site 4 indicates a local extinction at this site as well. An alternative possibility is that any surviving resident adults on Study Site 4 may already have entered estivation at the time of the trapping study.

The capture rate for AGS was extraordinarily low in 1991. Only one adult male was taken, at a trap station on the periphery of Study Site 4. No adult females or juveniles were captured, so we have no evidence regarding AGS reproduction in the Coso region. Although another AGS was seen but not captured on Study Site 4 and a few may have escaped capture at other study sites, it is clear that overall AGS abundance in the region had declined to an exceedingly low level in 1991.

Body Mass

Body mass was recorded for the three adult MGS captured. The recorded values were 144, 156 and 170 grams, with a mean of 157 grams.

Table 1. Summary of trapping results by species, sex and age of animal, Study Site 1 (Rose Valley), during May 28-30, 1991.

MOHAVE GROUND SQUIRREL

	Male	Female	Total
Juvenile	No MGS Captured		
Adult			
Total			

ANTELOPE GROUND SQUIRREL

	Male	Female	Total
Juvenile	No AGS Captured		
Adult			
Total			

Table 2. Summary of trapping results by species, sex and age of animal, Study Site 2 (Coso Basin), during May 29-31, 1991.

MOHAVE GROUND SQUIRREL

	Male	Female	Total
Juvenile	0	0	0
Adult	0	2	2
Total	0	2	2

ANTELOPE GROUND SQUIRREL

	Male	Female	Total
Juvenile	No AGS Captured		
Adult			
Total			

Herbivore Diets

Mohave Ground Squirrels

Table 5 presents the results of fecal sample analysis of MGS from study sites 2 and 3 during the May-June trapping period. Since only three samples were collected, the data were not averaged. All three samples were from adult females.

The two most important food items were arthropod parts and *Opuntia* (beavertail and/or cholla cactus) seed, which together made up 70-85 percent of the relative density of each sample. The arthropod parts were mainly larvae of the order Lepidoptera, or caterpillars. The large proportion of caterpillars in the MGS diet was consistent with the availability of this high-protein food source. We observed exceptional numbers of caterpillars, representing several species, on all of the study sites during the

Table 5. Results of dietary analysis for Mohave ground squirrels at study sites 2 and 3 in May-June, 1991. Data are presented as percent relative density.

	Percent Relative Density of Food Items in Individual Fecal Samples		
	Study Site 2 (Coso Basin)		Study Site 3 (Cactus Peak)
Food Item	Female	Female	Female
SHRUBS			
Opuntia seed	58.3	0	71.2
Eurotia leaf	1.9	0	0
Total, shrubs	60.2	0.0	71.2
FORBS			
Boraginaceae leaf	12.9	3.0	0
Composite flower	0	0	11.4
seed	0	0	2.6
Eremalche seed	0	20.8	0
Gilia-Linanthus lf.	0	6.1	0
Plantago leaf	1.9	0	0
Total, forbs	14.8	29.9	14.0
ANIMAL			
Arthropod parts	25.1	70.1	14.8
Total	100.1	100.0	100.0
No. items/sample	5	4	4

variability

trapping period. Checkerspot butterfly and sphinx moth larvae were especially numerous. Although we did not observe large quantities of Opuntia fruits or seeds, rains in the summer of 1990 may have stimulated the flowering and fruiting of the Opuntia species common on the study sites.

Antelope Ground Squirrels

Table 6 presents the results of dietary analysis from the single AGS capture in 1991 on Study Site 4. The diet of this animal, an adult male, closely resembled that of the three Mohave ground squirrels captured at study sites 2 and 3. About half the relative density was composed of arthropod parts, almost all lepidopteran larvae. About one-third was composed of Opuntia seed, with small amounts of shrub and forb leaf included as well.

perhaps if MGS diets were averaged

Table 6. Results of dietary analysis for the single antelope ground squirrel captured at Study Site 4 in June, 1991. Data are presented as percent relative density.

Food Item	Percent Relative Density of Food Items in Fecal Sample Study Site 4 (Pumice Mine) Male
SHRUBS	
Opuntia seed	32.5
Eurotia leaf	6.7
Total, shrubs	39.2
FORBS	
Boraginaceae leaf	6.7
Gilia-Linanthus lf.	3.3
Total, forbs	10.0
ANIMAL	
Arthropod parts	50.8
Total	100.0
Number of samples	1
No.items/sample	5

Black-tailed Jackrabbits

Table 7 presents a summary of fecal sample analysis for black-tailed jackrabbits at study sites 2-4 in May-June 1991. The samples varied considerably, perhaps reflecting differences in availability of preferred foods. The two samples from Study Site 2 were both comprised of about three-fourths Schismus. Other annual grasses made up another 10 percent of relative density of black-tailed jackrabbit samples at Study Site 2, while shrub and forb leaf comprised another 13 percent.

Table 7. Results of dietary analysis for black-tailed jackrabbits at study sites 2-4 in 1991. Results are presented as average percent relative density and frequency.

	Average Percent Relative Density of Food Items in Fecal Samples (Frequency of food item occurrence in parentheses)		
Food Item	Site 2 (Coso Basin)	Site 3 (Cactus Peak)	Site 4 (Pumice Mine)
GRASSES			
Bromus	6.8 (1.0)	0	0
Grass seed	3.3 (0.5)	0	0
Schismus	77.7 (1.0)	1.0 (0.3)	0
Total, grasses	87.8 (1.0)	1.0 (0.3)	0
SHRUBS			
Antennaria leaf	4.7 (0.5)	0	0
Atriplex leaf	1.0 (0.5)	0	0
Eurotia leaf	0	64.0 (0.7)	66.7 (1.0)
Grayia leaf	0	0.5 (0.3)	33.3 (1.0)
Total, shrubs	5.7 (1.0)	64.5 (0.7)	100.0 (1.0)
FORBS			
Composite seed	1.0 (0.5)	2.1 (0.3)	0
Eremalche sd&pod	0	0.5 (0.3)	0
Erodium leaf	5.6 (1.0)	28.1 (0.3)	0
Lupinus leaf	0	1.0 (0.3)	0
Plantago	0	2.7 (0.7)	0
Total, forbs	6.6 (1.0)	34.4 (0.7)	0
Total	100.1	99.9	100.0
No. samples	2	3	1
Items/sample	5	3.3	2
range	4-6	1-5	2

Three samples were collected from Study Site 3. Of these, one was completely comprised of Eurotia, and one was 92 percent Eurotia with a little shrub and herb leaf and seed parts. The third sample was composed of 84 percent Erodium leaf with minor amounts of other forb and grass parts.

Only one black-tailed jackrabbit fecal sample was collected from Study Site 4. It was composed of two-thirds Eurotia leaf and one-third Grayia leaf.

Cattle

Table 8 presents results of dietary analysis for cattle from Study Site 4 in 1991. About half the relative density of samples consisted of Bromus. About one-fourth was Eurotia leaf, and one-sixth Atriplex leaf. The fact that the samples contained no discernable fragments of annual forbs suggests that the samples were deposited earlier than March, when growth of these plants is assumed to have begun. By contrast, Bromus most likely began growth in the early fall, since rainfall then was sufficient to stimulate its germination.

perhaps cattle digest forbs more completely (4-chambered stomach) Perhaps. Not comparable to rodent fecal samples

Burros

Table 9 presents results of burro dietary analysis based on samples taken from study sites 2 through 4 in 1991. At Study Site 2, the eight samples averaged 82 percent relative density of grass, 7 percent shrub leaf, and 10 percent forb leaf and seed. By far the most important species was the annual grass Schismus, which contributed 53 percent of the overall average. Bromus was the next most important genus, contributing 21 percent of overall density.

At Study Site 3, a single sample consisted mainly of Bromus, with about 9 percent each of Poa secunda (bluegrass) and shrub leaf, with no annual forb material present.

At Study Site 4, the samples were dominated by Bromus, which comprised two-thirds of mean relative density, and Eurotia leaf, which comprised one-fourth of relative density. A small amount of annual forb material was present.

Precipitation Measurements

During the 1990-91 season, raingauges were operated at the four study sites plus the weather station in Section 13 west of the Navy 2 operating area. The raingauges were read and emptied approximately monthly, except when range closures prevented access.

Table 10 presents raingauge results from our study sites together with data from NAWS raingauge stations in Coso Basin and the Los Angeles Department of Water and Power (LADWP) weather station at Haiwee Reservoir. We used a September 1-August 31

Table 8. Results of dietary analysis for cattle at Study Site 4 in 1991. Data are presented as average percent relative density and frequency.

Food Item	Average Percent Relative Density of Food Items in Fecal Samples (Frequency of food item occurrence in parentheses) Site 4 (Pumice Mine)
GRASSES AND ALLIES	
Bromus	54.1 (1.0)
Schismus	3.5 (0.7)
Stipa	0.4 (0.1)
Total, grasses	58.0 (1.0)
SHRUBS	
Atriplex leaf	16.2 (0.7)
Ephedra leaf	1.4 (0.4)
Eurotia leaf	24.2 (0.8)
Total, shrubs	41.8 (0.9)
OTHER	
Yucca leaf	0.2 (0.1)
Total	100.0
No. samples	10
Items/sample mean	3.8
range	2-5

Table 9. Results of dietary analysis for burros at study sites 2-4 in 1991. Data are presented as average percent relative density and frequency.

Average Percent Relative Density of Food Items in Fecal Samples
(Frequency of food item occurrence in parentheses)

Food Item	Site 2 (Coso Basin)	Site 3 (Cactus Peak)	Site 4 (Pumice Mine)
GRASSES			
Bromus	20.6 (1.0)	81.3	67.4 (1.0)
Bouteloua	3.8 (0.6)	0	0
Oryzopsis	0	0	0.5 (0.2)
Poa secunda	3.6 (0.4)	9.5	0.4 (0.1)
Schismus	53.3 (1.0)	0	2.6 (0.9)
Sporobolus	1.1 (0.2)	0	0
Stipa	0	0	0.5 (0.2)
Total, grasses	82.4 (1.0)	90.8	71.4 (1.0)
SHRUBS			
Antennaria leaf	0.5 (0.1)	0	0
Atriplex leaf	1.7 (0.5)	3.0	0.7 (0.1)
Ephedra leaf	1.6 (0.1)	0	0.2 (0.1)
Eurotia leaf	2.4 (0.4)	6.2	25.1 (1.0)
Opuntia seed	1.2 (0.2)	0	0
Symphoricarpos lf.	0	0	0.2 (0.1)
Total, shrubs	7.4 (0.8)	9.2	26.2 (1.0)
FORBS			
Composite flower	1.1 (0.2)	0	0
seed	1.2 (0.2)	0	0
Erodium leaf	0.5 (0.1)	0	0
seed	1.4 (0.4)	0	0
Gilia-Linanthus leaf	0.3 (0.1)	0	0.4 (0.1)
Mentzelia leaf	1.7 (0.1)	0	0
Plantago leaf	3.1 (0.2)	0	0
Phacelia/Nama leaf	0.4 (0.1)	0	0
Sphaeralcea leaf	0	0	1.4 (0.2)
Total, forbs	9.7 (0.9)	0	1.8 (0.2)
OTHER			
Yucca leaf	0	0	0.5 (0.1)
Total	99.8	100	99.9
No. samples	8	1	8
Items/sample: mean	6.2	4	4.4
range	3-8	4	3-7

Table 10. Average and 1990-1991 precipitation records for five stations within the Coso Grazing Exclosure, and Naval Air Weapons Station and Los Angeles Department of Water and Power precipitation stations in and near the Grazing Exclosure.

Station and Location	Precipitation (in mm) 9/1/90-1/4/91	1/5/91-4/1/91	4/2/91-8/31/91	Total, 1990-91	Long-term average
Coso Grazing Exclosure	(1)				
Site 1	30.2	92.3	1.0	123.5	--
Site 2	28.7	93.0	0.4	122.1	--
Site 3	43.2	78.1	tr	121.3	--
Site 4	40.2	82.0	tr(2)	122.2(2)	--
Sec. 13	38.4	78.1	0.2	116.7	--
NAWS Coso Basin					
Stn. 1	23.9	94.7	1.8	120.4	102.0 (3)
Stn. 2	18.3	17.3	0	35.6	
Stn. 3	13.7	62.0	0.3	76.0	
Stn. 4	1.5	5.8	0	7.3	
Stn. 5	13.5	26.9	0.2	40.4	
LADWP Haiwee Reservoir	29.7	83.3	1.3	114.3	151.2 (4)

(1) Based on continuously reading raingauges maintained by NAWS, all precipitation recorded at Coso Grazing Exclosure stations 1-5 between August 17 and September 20 is assumed to have fallen after September 1.
(2) Range closure precluded data collection; values shown are estimated.
(3) Long-term average based on the mean of 1979-90 calendar year values for all five stations in Coso Basin.
(4) Long-term average based on 1963-90 calendar year values.

Sources of NAWS and Haiwee Reservoir data: Bjornstad et al. 1991; Monahan and Condon 1991.

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precipitation year. We believe it better shows cumulative rainfall as related to plant response, since fall and winter rains appear critical to plant growth and development the following spring.

The 1990-91 rainfall season had total precipitation somewhat below average, with a highly unusual distribution. An early storm system brought a moderate amount of rain in mid-September, followed by a protracted dry period, with only a few millimeters falling during the next five months. Then a series of storms during a one-week period in late February and early March brought nearly two-

thirds of the year's total precipitation to most of the stations. Most stations received little or no additional precipitation during the rest of the season, April through August.

Although this pattern held for all the Coso Grazing Exclosure stations, the LADWP Haiwee Reservoir station and several of the Coso Basin stations maintained by NAWS, it should be noted that three of the stations in Coso Basin received very little precipitation from the late February-early March rains, and recorded total precipitation that was well under 50 percent of the average for Coso Basin.

Vegetation Surveys

Sampling of herbaceous vegetation for species richness and standing crop was carried out in late May and early June, 1991 using square-foot plots. Table 11 presents herbaceous sampling results for between- and under-shrub plots.

The species richness and standing crop of annual herbs was substantially higher in 1991 than in the years 1988-90. The phenological development of the vegetation was late in 1991 and most of the annuals were still green or flowering during our sampling period.

Study Site 1

Between-shrub plots. In the between-shrub plots, the most frequently-encountered herbs and grasses were *Chaenactis fremontii* (pincushions), *Eriophyllum wallacei* (Easter-bonnets), *Festuca octoflora* (fescue), *Langloisia matthewsii* (desert calico), *Nama demissum* (purple mats) and *Schismus arabicus* (schismus). Each was recorded in 40 percent or more of the plots sampled. Species richness averaged 6.29 species per square-foot plot, slightly lower than the highest values which were recorded from sites 3 and 4. Standing crop was 2.1 g/sq ft, the highest of all the study sites. The genera contributing the most to standing crop were *Chaenactis*, *Schismus* and *Mentzelia*.

Under-shrub plots. Five species occurred in 40 percent or more of under-shrub plots: *Chaenactis fremontii*, *Festuca octoflora*, *Langloisia matthewsii*, *Mentzelia albicaulis*, and *Schismus arabicus*. Species richness averaged 6.56 species per plot, the lowest of all study sites for under-shrub plots. Standing crop was 4.14 g/sq ft, the lowest of all study sites, but comparable to Study Site 2. Species contributing the most to standing crop were *Mentzelia albicaulis*, *Chaenactis fremontii*, *Langloisia matthewsii*, *Malacothrix glabrata* and *Cryptantha dumetorum*. Study Site 1 was unusual in that species richness of between-shrub plots was higher than under-shrub plots, and also in the number of plant species that occurred with high frequency in both.

Table 11. Frequency and standing crop of herbaceous layer plants in between-shrub and under-shrub plots in May-June, 1991.

STUDY SITE	Frequency of occurrence, by percent											
	Exclos. 1		Site 1		Site 2		Site 3		Site 4		Exclos. 4	
SPECIES	Bet.	Und.	Bet.	Und.	Bet.	Und.	Bet.	Und.	Bet.	Und.	Bet.	Und.
Abronia pogonantha				1								
Ambrosia acanthicarpa				1		1						
Amsinckia tessellata							5	11		2		
Anisocoma acaulis							6	1	2		4	
Astragalus lentiginosus			8		19	8	5		1	5	4	4
Baileya pleniradiata			2									
Bromus rubens		4	2	16	5	73	5	53	5	39		16
Bromus tectorum	4	4	4	8		2	4	15	2	3		8
Calyptridium monandrum					1	2		1				
Camissonia boothii			1	1		1		1			4	4
Camissonia campestris	56	28	38	12	30	31	38	15	10	8	4	8
Camissonia claviformis	4		2	6		1	5	7				12
Caulanthus cooperi			5	7	2	11	3	52	2	16		4
Chaenactis fremontii	12	36	55	65	6	24	47	80	5	33		16
Chaenactis stevioides				4		1	5	6	8	5		4
Chaenactis sp.			1	2								4
Chorizanthe brevicornu					11	1						
Chorizanthe thurberi			1	5	7		22	12	36	21	4	8
Chorizanthe watsonii			1	2	1				11	5		
Coldenia nuttallii	32	8	23	6								
Coreopsis bigelovii	32	2	10	6	22	28	30	23				
Cryptantha decipiens				1	2	10		2				
Cryptantha circumscissa	4	4	7	2	45	34	40	15	72	28	48	56
Cryptantha dumetorum	12	32	1	22	2	17	1	15		2		12
Cryptantha micrantha	52	32	25	11	97	90	10		2	3		
Cryptantha nevadensis				1	3	16		7		10		
Cryptantha pterocarya		12	1	9	1	3	10	48	18	49	12	56
Cryptantha sp.				2		4		6	3	5		
Descurainia pinnata		4	1	1	4	5	6	17	2	43	8	24
Eremalche exilis		24	8	27	2							
Eriastrum sp.			2	6	1	1			3	2		4
Eriogonum gracillimum			2				1					
Eriogonum maculatum	4	4	6	14	11	7	22	27	30	31	12	24
Eriogonum nidularium				1					8	20		
Eriogonum pusillum				1	1	3				2		
Eriogonum reniforme			1	1	1		1					
Eriogonum sp.	4		1		3	2	1	2				
Eriophyllum pringlei			7		14	16	68	42	90	62	92	72
Eriophyllum wallacei	72	20	57	25	48	35		1	8	3		
Erodium cicutarium	4	4			5	12	1	1		2		
Eschscholzia minutiflora			1	1		1						
Euphorbia albomarginata			4			9	2	2				
Festuca octoflora	36	16	85	62	55	55	51	5	23	25	8	16
Gilia micromeria	28	44	11	4	2	1	1	2	2	2		
Gilia sp. II		8	5	4	15	30	32	32	75	79	72	80
Glyptopleura setulosa			5		1							4
Langloisia matthewsii	60	24	63	40	16	17	35	12	21	5	40	8
Langloisia punctata					1	1						
Lepidium flavum var. flavum	4		15	26	6	10	9	5	10	11	20	12
Lepidium lasiocarpum						1						
Lessingia lemmonii var. r.		22	17		1	10	13	25	36	48	76	
Linanthus aureus					5	1	44	25	79	54	100	76
Linanthus dichotomus					3	7		15	3	3	20	8
Lupinus odoratus					3	1	35	9	5			16
Lupinus sp.			2		1	1	1	2		1		
Malacothrix glabrata	32	60	10	21	2	27	11	52	2	18		16
Mentzelia albicaulis	28	64	27	42	9	33	43	72	8	70	12	68
Monardella exilis	4		11	8			16	6	7		4	74
Monoptilon bellidiforme	28		12	1	1							
Muilla maritima							1					
Nama demissum	56	8	42	9	28	5	73	3	25	18	40	4
Nemacladus sp.	4		1		2							
Oenothera primiveris	4											
Oryzopsis hymenoides										2		
Pectocarya heterocarpa					11	14						
Pectocarya linearis					6	1						
Pectocarya platycarpa					2	2						
Pectocarya recurvata					2	1						

(continued on next page)

Table 11 (contd.)

STUDY SITE	Frequency of occurrence, by percent											
	Exclos. 1		Site 1		Site 2		Site 3		Site 4		Exclos. 4	
SPECIES	Bet.	Und.	Bet.	Und.	Bet.	Und.	Bet.	Und.	Bet.	Und.	Bet.	Und.
Pectocarya setosa						1			15	21		
Pectocarya sp.						2		1				
Phacelia distans				1	1	1	1	40		25	8	44
Phacelia fremontii	28	48	17	32	12	22	25	48	10	30	8	60
Rafinesquia neomexicana				2								
Salsola iberica		4		14				1				
Salvia columbariae							1					
Schismus arabicus	76	100	42	80	68	95	1	19	2	13	8	12
Sphaeralcea ambigua			2				1			2	4	
Stephanomeria exigua	4	8		4			4	17	2	11	8	12
Stillingia paucidentata	4											
Stipa speciosa								1	7	33	4	4
Stylocline micropoides					5	10						
Syntrichopappus fremontii	8	4	10	7			1	1	5	5		
Thelypodium lasiocarpum					1	2		1				
Thysanocarpus curvipes										3		
Unknown grass												8
Unknown Forb	4		4	1		4	3	4	5	2	4	4
Unknown Forb #2				1								
Unknown Mustard					2	4		1				
SPECIES RICHNESS												
(species/sample)	7.08	6.24	6.29	6.56	5.77	7.93	7.05	8.73	6.75	8.61	6.28	8.40
(std. deviation)	(2.2)	(2.2)	(2.4)	(2.3)	(2.3)	(2.3)	(2.7)	(3.2)	(2.3)	(2.8)	(1.9)	(2.7)
STANDING CROP												
(grams/square foot)	1.46	4.20	2.10	4.14	1.27	4.25	2.06	6.15	0.85	2.69	1.24	3.00
(std. deviation)	(1.4)	(1.4)	(1.3)	(2.3)	(1.2)	(2.4)	(2.1)	(3.7)	(0.7)	(2.3)	(0.8)	(2.2)
n=	25	25	84	85	94	93	79	81	61	61	25	25

Exclosures at Study Site 1. The herbaceous vegetation within the two mini-exclosures adjacent to Study Site 1 visually resembled the study site itself. Between-shrub species richness was slightly higher and standing crop somewhat lower within the exclosure as compared with the study site. Under-shrub species richness and standing crop were very close in the exclosure and the study site. The most frequently-occurring plant species differed somewhat between the exclosure and the study site; of the species occurring in 40 percent or more of the plots, about two-thirds were common to both the study site and the mini-exclosure.

Study Site 2

Between-shrub plots. The most frequently-occurring species were *Cryptantha circumscissa* (western forget-me-not), *C. micrantha* (purple-rooted forget-me-not), *Eriophyllum wallacei*, *Festuca octoflora*, and *Schismus arabicus*. Borages were especially well-represented at Site 2: six species of *Cryptantha* and four species of comb-fruit (*Pectocarya*) were found there in 1991, and the common *Cryptantha* nearly formed a carpet in some areas. Species richness in between-shrub plots at Study Site 2 was lowest of all the study sites, at 5.77 species per sample. Standing crop was second lowest, at 1.27 g/sq ft. The greatest contributors to standing crop in between-shrub plots were the *Cryptantha* species, *Schismus*, and *Camissonia campestris* (field primrose).

Under-shrub plots. Among the under-shrub plots, the most frequently-occurring species were the annual grasses *Bromus rubens* (red brome), *Festuca octoflora*, and *Schismus arabicus*, as well as the forb *Cryptantha micrantha*. Species richness was 7.93 species per plot, the third-highest of all study sites. Standing crop averaged 4.25 g/plot, the second-highest under-shrub value among all study sites. The plant species contributing the most to the standing crop was *Schismus*, which was present in 95 percent of all under-shrub plots and was unusually large and vigorous. Other important contributors to standing crop were *Bromus rubens*, *Festuca octoflora*, *Malacothrix glabrata*, and *Mentzelia albicaulis*.

Study Site 3

Between-shrub plots. This study site had the most spectacular floral display. Between-shrub species richness was the highest of all the study sites at 7.05 species per plot, a little higher than sites 1 and 4. The most frequently-occurring species were *Chaenactis fremontii*, *Cryptantha circumscissa*, *Eriophyllum pringlei* (Pringle eriophyllum), *Festuca octoflora*, *Linanthus aureus* (golden gilia), *Mentzelia albicaulis*, and *Nama demissum*. Between-shrub standing crop was 2.06 g/plot, similar to the highest value, at Study Site 1. The greatest contributor to standing crop in between-shrub plots was *Lupinus odoratus* (royal desert lupine). Others were *Chaenactis fremontii*, *Coreopsis bigelovii* (Bigelow coreopsis), several *Gilia* species which tended to grow rather large, *Langloisia*

matthewsii, Mentzelia albicaulis and Phacelia fremontii (yellow-throats).

Under-shrub plots. The under-shrub plots had extremely high species richness, averaging 8.73 species per plot, the highest of all the study sites. One plot contained 22 species, the highest we have ever recorded. Frequently-occurring species were Bromus rubens, Caulanthus cooperi (Cooper caulanthus), Chaenactis fremontii, Cryptantha pterocarya (wing-nut cryptantha), Eriophyllum pringlei, Malacothrix glabrata, Mentzelia albicaulis, Phacelia distans (climbing phacelia) and Phacelia fremontii. Standing crop was also quite high; at 6.15 g/plot, it was nearly 50 percent more than the under-shrub average at study sites 1 and 2, the next highest sites. All of the frequently-occurring species contributed substantially to standing crop, and many individual plants were extremely robust.

Study Site 4

Between-shrub plots. Between-shrub species richness averaged 6.75 species per plot, the second-highest among study sites. The most frequently-occurring species were Cryptantha circumscissa, Eriophyllum pringlei, Gilia spp., and Linanthus aureus. Between-shrub standing crop was much lower than the other study sites, at 0.85 g/plot. Many of the more common plant species were relatively small, and some of the larger or coarser species found at the other study sites were infrequent or absent at Study Site 4.

Under-shrub plots. The under-shrub plots at Study Site 4 were nearly the highest in species richness at 8.61 species per plot, second only to Study Site 3. The most frequently-occurring species were Cryptantha pterocarya, Descurainia pinnata (tansy mustard), Eriophyllum pringlei, Gilia spp., Lessingia lemmonii var. ramulosissima (vinegar weed), Linanthus aureus, and Mentzelia albicaulis. The standing crop, however, was by far the lowest of the under-shrub plots at any of the study sites: 2.69 g/plot, compared with 4 to 6 g/plot at the other three study sites. Again, Study Site 4 supported a great number of rather diminutive plants, had little grass, and lacked several of the larger species of annual herbs.

Exclosures at Study Site 4. Between the mini-exclosures and the study site, standing crop and species richness of between- and under-shrub plots were fairly similar. Like Study Site 1, half to two-thirds of the highest-frequency species (occurring in more than 40 percent of plots) were common to both the study site and the mini-exclosures.

DISCUSSION

Precipitation Patterns and Plant Growth

The weather patterns at Coso were unusual in 1990-91 in providing rainfall during the early and late portions of the winter, separated by a long dry period. A storm system on September 21-22, 1990 brought 12-20 mm to most stations. Then, from October 1 through February 27, each month brought 5 mm or less of precipitation. Cumulative precipitation at Haiwee Reservoir on February 26, 1991 was only 16 percent of the long-term annual average. Then, the one-week period beginning on February 27 brought 70-90 mm of precipitation, enough to bring the annual total up considerably, although the year ended somewhat below average.

Table 12 presents a summary of the herbaceous species richness and standing crop measurements taken at the four study sites during our studies in 1988-91. The 1991 standing crop and species richness were generally higher than 1988, the highest preceding year. Despite the fact that total seasonal precipitation was well below average, its distribution, especially the late February-early March rains, was evidently beneficial to herbaceous growth.

Table 12. Comparison of average herbaceous standing crop and species richness taken in square-foot plots between and under shrubs, at study sites 1-4, 1988-1991.

	1988		1989		1990		1991	
	Betw.	Under	Betw.	Under	Betw.	Under	Betw.	Under
Study Site 1								
Standing crop (g)	1.1	2.0	0.8	0.5	0.0	0.0	2.1	4.1
Species richness (species/sq ft)	5.0	3.8	2.7	1.3	0.0	0.0	6.3	6.6
Study Site 2								
Standing crop (g)	1.1	1.6	0.1	0.2	0.0	0.0	1.3	4.2
Species richness (species/sq ft)	3.3	0.8	0.1	0.4	0.0	0.0	5.8	7.9
Study Site 3								
Standing crop (g)	1.8	2.3	0.3	0.3	0.0	0.0	2.1	6.2
Species richness (species/sq ft)	5.3	4.6	0.9	1.0	0.0	0.0	7.0	8.7
Study Site 4								
Standing crop (g)	1.3	2.1	0.6	0.4	0.0	0.0	0.8	2.7
Species richness (species/sq ft)	4.9	4.7	3.8	2.9	0.0	0.0	6.8	8.6

Bowers (1987) postulated that late fall and early winter rainfall was the best predictor of high abundance and variety of annual plants in the northern Mohave Desert. However, the 12-20 mm that fell in late September 1990 seems insufficient to explain the very high standing crop and species richness encountered in spring 1991. The September rains were probably sufficient to stimulate growth of readily-germinating species such as the annual grasses Schismus and Bromus, but it seems likely that many of the annual herbs did not germinate until after the late winter rains in February-March 1991.

Although 1991 proved favorable for annual herbs, the perennial grasses did not experience such a comeback. Many tussocks appeared dead and had no new growth.

Perhaps as a result of the February-March rains, shrubs showed vigorous new growth by May 1991. Many of the shrubs displayed long leaders of new growth which were browsed very little. Based on our incidental visual observations of black-tailed jackrabbits, the populations of this important native browser have declined during the extended drought of 1988-90 and remained low in 1991. Cattle numbers, which are determined by BLM in accordance with long-term grazing plans and adjusted in early winter each year based on fall rains, was low in 1991 in the areas still subject to grazing. Thus 1991 provided an opportunity for substantial shrub growth and recovery following the extended drought.

Ground Squirrel Diet

The small sample size of MGS and AGS prevents generalization about dietary habits in 1991. However, the fact that both species selected caterpillars and Opuntia seeds, both rather uncommon in the MGS diet in past years, underscores their flexibility in exploiting available high-quality food resources, even though these resources may change from one year to the next. Although we expected greater use of the abundant annual forb leaf and seed, Opuntia seeds and caterpillars may have been the highest nutritional-value food available and therefore were selected in preference to the forb material.

Ground Squirrel Abundance and Reproduction

Since many adult MGS normally enter estivation by the late May-June sampling period, it is not possible to directly estimate adult abundance by the number of individuals captured at this time. Nevertheless, the number of adult MGS captured during late May-June 1991 was clearly the lowest since the beginning of the Coso Monitoring Study in 1988 (Table 13). These results were expected in view of the prolonged drought conditions in the Coso region and the lack of MGS reproduction in 1989 and 1990.

Table 13. Total number of adult Mohave ground squirrels captured, by study site, during trapping periods in 1988, 1989, 1990, and 1991.

Trapping Period	Study Site 1	2	3	4	Total
May-June 1988	0	3	1	3	7
May-June 1989	0	3	2	1	6
March-April 1990	0	6	19	8	33
May-June 1990 (1)	0	0	8	2	10
May-June 1991 (1)	0	2	1	0	3

(1) Three days of trapping with 121 traps used; all other periods consisted of five days of trapping with 441 traps used.

#♀/#♂?

random variable: hardly a real difference plus different trapping effort

The fact that all three MGS captured in 1991 were females that had been lactating provided evidence of successful reproduction for the first time since 1988. Since juvenile MGS are normally active above ground and trappable by mid-May, the failure to capture young animals in late May-early June was surprising. The most likely explanation is that MGS reproduction was delayed by a month or more in spring 1991 due to the dry winter and lack of plant growth until after the late February-early March rains. If the MGS breeding and birth periods were unusually late in spring 1991, juveniles may still have been largely confined to their nest burrows at the time of our trapping study (May 28-June 3).

known or speculated?

Data from the past four years at the Coso study sites indicate that successful MGS reproduction has occurred only in 1988 and 1991, years in which there was substantial growth of annual herbaceous vegetation. This suggests that there may be a critical level of annual plant productivity needed to support MGS reproduction. In both 1988 and 1991, average herbaceous standing crop on plots both between and under shrubs was almost always 1.0 g/sq ft or greater, while in 1989 and 1990 it was never greater than 0.8 g/sq ft (Table 12). Thus, it can be hypothesized that an herbaceous standing crop of approximately 1.0 g/sq ft is the minimum required for reproduction in the MGS. This hypothesis should be tested further in the Coso region and at other sites. If it can be confirmed, it would provide a convenient indicator of the minimum annual plant productivity necessary to sustain MGS populations and may be helpful in identifying sites suitable as preserves for the species.

based on how many ♀?

Sample size too small to base minimum g/ft² = reproduction but there are trap biases (MGS can be present, but not captured) How truly repeatable are the veg. measurements? Truly random?

The total number of AGS captured reached its lowest level since the initiation of the Coso Monitoring Study in 1988 (Table 14). There was a drastic decline from 62 individual adult AGS captures in late May-June 1990 to only a single adult in the same sampling period in 1991. This suggests that AGS abundance was not only severely affected by lack of juvenile recruitment in 1990, but also by very low adult survivorship from 1990 to 1991. Whether such a high annual mortality rate is typical for the species or is simply a reflection of the severe environmental conditions that prevailed from late May-June 1990 to March 1991 is not known.

Table 14. Total number of adult antelope ground squirrels captured, by study site, during trapping periods in 1988, 1989, 1990, and 1991.

	Study Site				
Trapping Period	1	2	3	4	Total
May-June 1988	15	7	13	9	44
May-June 1989	19	7	31	25	82
March-April 1990	13	20	23	26	82
May-June 1990 (1)	16	14	17	15	62
May-June 1991 (1)	0	0	0	1	1

different trap intensities

(1) Three days of trapping with 121 traps used; all other periods consisted of five days of trapping with 441 traps used.

Body Mass

The body mass measurements of the three adult female MGS captured in 1991 were 144, 156 and 170 grams, with a mean value of 157 grams. However, the mean body mass of adult MGS for the same sampling period in 1988 (the last year in which MGS reproduction occurred) was substantially higher at 175 grams. The 1988 value closely approached the usual pre-estivation range of 180-220 grams (Recht unpubl.) and suggests that MGS were relatively well-prepared for estivation by the first half of June in 1988.

very small sample! Not valid for wide inferences

The comparatively low mean adult female body mass recorded in late May-early June 1991 may have been related to the delay in MGS reproduction resulting from the late spring rains. It seems likely that adult female MGS do not begin pre-estivation fattening until lactation is completed and the young are weaned. The three females

Not likely statistically different!

captured had been recently lactating and may have only just begun to fatten in preparation for dormancy.

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COSO GRAZING EXCLOSURE STUDY

COLLECTOR:_____ EAR TAG NO: _____ PIT TAG NO: _____

DATE: ___/___/___ MILITARY TIME: _____ (e.g., 2:15 pm = 14:15) GRID/STATION: _____/_____

SPECIES: MGS AGS SEX: M F (circle one) AGE: ADU JUV (circle one)

BODY MASS: _____ g (squirrel + bag) - _____ g (bag) = _____ g (body mass)

REPRO. CONDITION (female): LACTATING PREV. LACT. NON-LACT. (circle one)

REPRO. CONDITION (male): TESTES SCROTAL TESTES NON-SCROTAL (circle one)

RECAPTURES:

DATE:	TIME:	STATION:	DATE:	TIME:	STATION:

COSO GRAZING EXCLOSURE STUDY

DATE: ____/____/____ GRID: _____/_____ (no.) (name) COLLECTOR:_____

STATION	SPECIES		EAR TAG NO.	SEX		AGE		RECAP	NEW TAG	PIT TAG NO.
	MGS	AGS		M	F	ADU	JUV			

COSO GRAZING EXCLOSURE 1992 HERBACEOUS FREQUENCY AND STANDING CROP DATA SHEET

DATE_____STUDY SITE____LOCATION_____ OBSERVERS_____

(write in addt'l. species below!) SEE OVER FOR MORE SPP

SPECIES	PLOT B	PLOT U	PLOT B	PLOT U	PLOT B	PLOT U	PLOT B	PLOT U	PLOT B	PLOT U	PLOT B	PLOT U	PLOT B	PLOT U	PLOT B	PLOT U	PLOT B	PLOT U	PLOT B	PLOT U
STDG CROP.																				
Amsinckia tessellata																				
Anisocoma acaulis																				
Astragalus lentiginosus																				
Bromus rubens																				
Bromus tectorum																				
Camissonia campestris																				
Camissonia claviformis																				
Caulanthus cooperi																				
Chaenactis fremontii																				
Chaenactis stevioides																				
Chorizanthe brevicornu																				
Chorizanthe thurberi																				
Chorizanthe watsonii																				
Coldenia nuttallii																				
Coreopsis bigelovii																				
Cryptantha decipiens																				
Cryptantha circumscissa																				
Cryptantha dumetorum																				
Cryptantha micrantha																				
Cryptantha nevadensis																				
Cryptantha pterocarya																				
Descurainia pinnata																				
Eremalche exilis																				
Eriastrum sp.																				
Eriogonum maculatum																				
Eriogonum nidularium																				
Eriogonum sp.																				
Eriophyllum pringlei																				
Eriophyllum wallacei																				
Erodium cicutarium																				
Euphorbia albomarginata																				
Festuca octoflora																				
Gilia I sm. ~~white fl.~~ Leptomeria																				
Gilia sp. II																				
Glyptopleura setulosa																				
Langloisia matthewsii																				
Lepidium flavum v. fl.																				
Lessingia lemmonii v.r.																				
Linanthus aureus																				
Linanthus dichotomus																				
Lupinus odoratus																				
Lupinus sp.																				
Malacothrix glabrata																				
Mentzelia albicaulis																				
Monardella exilis																				
Nama demissum																				
Pectocarya heterocarpa																				
Pectocarya linearis																				
Pectocarya setosa																				
Phacelia distans																				
Phacelia fremontii																				
Schismus arabicus																				
Sisymbrium altissimum																				
Sphaeralcea ambigua																				
Stephanomeria exigua																				
Stillingia paucidentata																				
Stipa speciosa																				
Stylocline micropoides																				
Syntrichopappus fremon.																				

ADDITIONAL SPECIES KNOWN OR EXPECTED TO OCCUR IN STUDY SITES--MAY APPEAR IN PLOTS!

Abronia pogonantha
Ambrosia acanthicarpa
Arabis pulchra var. gracilis
Astragalus--other spp.
Baileya pleniradiata
Bromus trinii
Calyptridium monandrum
Camissonia boothii ssp desertorum
Camissonia pterosperma
Castilleja chromosa
Chaenactis carphoclinia
Chaenactis xantiana
Chorizanthe rigida
Cryptantha intermedia
Delphimium parishii
Dichelostemma pulchella
Eriogonum gracillimum
Eriogonum pusillum
Eriogonum reniforme
Eschscholzia minutiflora
Langloisia punctata
Lepidium lasiocarpum
Linanthus parryae
Lomatium mohavense
Lupinnus bicolor
Lupinus brevicaulis
Lupinus concinnus ssp. orcuttii
Lupinus shockleyi
Malacothirx coulteri
Mentzelia veatchiana
Mimulus bigelovii
Mirabilis bigelovii
Monoptilon bellidiforme
Muilla maritima
Nemacladus sp.
Niccoletia occidentalis
Oenothera primiveris
Orthocarpus purpurascens var. ornatus
Oryzopsis hymenoides
Oxytheca perfoliata
Pectocarya platycarpa
Pectocarya recurvata
Pectocarya penicillata
Phacelia tanacetifolia
Plantago purshii var. oblonga
Poa secunda
Petalonyx thurberi
Psathyrotes annua
Rafinesquia neomexicana
Salsola iberica
Salvia columbariae
Streptanthella longirostris
Sitanion hystrix
Thysanocarpus curvipes
Tricardia watsonii