MOHAVE GROUND SQUIRREL STUDY IN THE COSO KNOWN GEOTHERMAL RESOURCE AREA INYO COUNTY, CALIFORNIA

March-June, 1993

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under contract to
U.S. Navy Naval Air Weapons Station
China Lake, CA 93555
Contract N60530-90-D-0071, D.O. 0017

additional support provided by
the California Department of Fish and Game
and
Jean Hopkins and Associates, Inc.

December 1993

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SUMMARY

Field studies of Mohave ground squirrel (MGS) populations in the Coso region were carried out at four permanent study sites from March 30-April 11, 1993 and from May 29-June 11, 1993. During the March-April sampling period, a total of 85 individual MGS and 213 AGS were captured on the four study sites. In May-June, trapping yielded a total of 516 individual MGS and 173 AGS over all four study sites.

More adult MGS were captured on each study site during both the March-April and May-June sampling periods than in the corresponding periods in 1992. The number of juvenile MGS produced on all study sites exceeded all previous records. The increased abundance of both adult and juvenile MGS was expected, since MGS populations have been successfully recovering since 1991 from the severe drought of 1989-1990, when we found no evidence of MGS reproduction in the Coso region. Of particular interest was the re-appearance of MGS on Study Site 1 in Rose Valley, where none have been recorded since 1988.

The results of the 1993 MGS food habits studies were somewhat different as compared with earlier years. During March-April 1993, MGS samples at all study sites contained primarily forb material, rather than the usual large proportion of shrub leaf found in previous years. Astragalus leaf comprised a majority of mean relative density at study sites 1, 3 and 4, although this has not been a major food item in past years. During the May-June sampling period, the predominant food item on study sites 2, 3 and 4 was shrub leaf, particularly the foliage of Krascheninnikovia. At Study Site 1, Eremalche leaf and seed were the main food items. The early summer results from study sites 2, 3 and 4 were at variance with previous years, when forb leaf and seed have usually been the predominant food items.

Precipitation in 1992-93 was 213 mm (8.4 in) at Haiwee Reservoir, 38 percent higher than the long-term average. There was little precipitation during either the fall or spring months; nearly all fell during December-March.

Standing crop and species richness of annual plants were relatively high on all study sites. The 1993 results were generally comparable to those recorded in 1991 and 1992, two previous years with favorable precipitation patterns.

BACKGROUND AND JUSTIFICATION

Development of geothermal resources for electric power production in the Coso Known Geothermal Resource Area (KGRA) is resulting in habitat loss for the Mohave ground squirrel (Spermophilus mohavensis), a species listed by the U.S. Fish and Wildlife Service as a candidate species (Category 2) and currently listed as Threatened by the California Department of Fish and Game (CDFG). Under an agreement between the China Lake Naval Weapons Center (NWC), 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 for this species.

The Program consists of several elements, including rehabilitation of degraded vegetation throughout approximately 155 sq km (60 sq mi or 38,000 ac) of the KGRA, thereby improving the quality of habitat for the Mohave ground squirrel (MGS). The Program proposes to accomplish this goal by eliminating grazing by domestic cattle. Cattle may adversely impact MGS populations by direct competition with ground squirrels for limited forage, or indirectly by modification of habitat (Leitner and Leitner 1989). The elimination of grazing livestock is referred to as the Coso Grazing Exclosure. In addition to construction of an exclosure, the Mitigation Program calls for a long-term monitoring study to evaluate the success of the mitigation. This study is referred to as the Coso Grazing Exclosure Monitoring Study, which included annual trapping of MGS and related field studies during 1988-92.

PURPOSE OF THE COSO GRAZING EXCLOSURE AND MONITORING STUDY

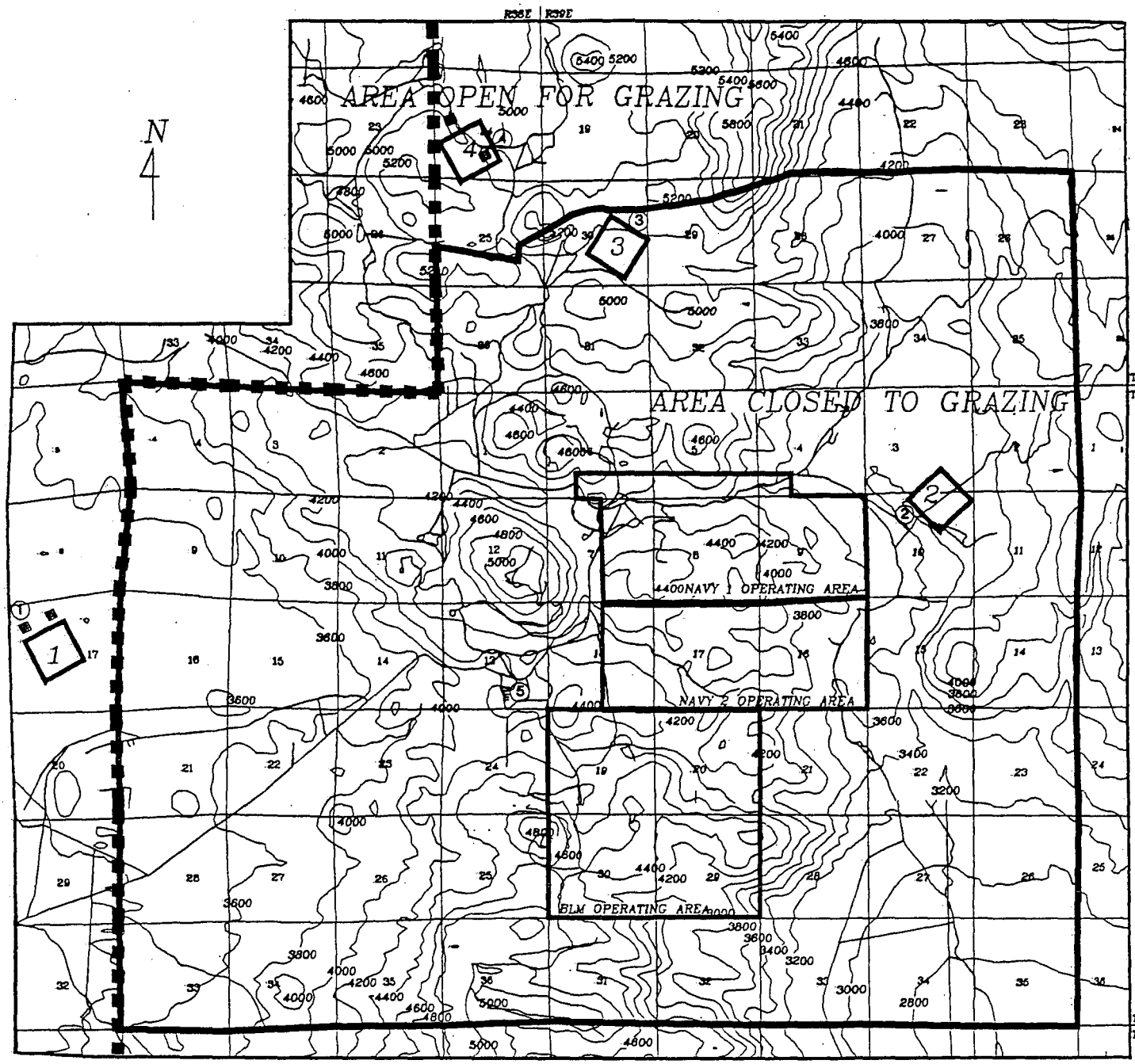
The specific components of the Coso Grazing Exclosure and Monitoring Study elements of the Mitigation Program are:

1) To improve the quality of remaining habitat for MGS within the geothermal development area;

2) To evaluate the effectiveness of the habitat improvement program; and

3) To develop information about MGS habitat requirements.

The first objective has been met by the construction of fences at strategic locations around the perimeter of the Coso Grazing Exclosure (Figure 1). Fencing was built in the fall of 1989, and cattle were excluded from the area beginning in December 1990. Since access to water is a limiting factor for cattle use of desert rangeland and some water sources within the exclosure area were removed, new water sources were installed at sites outside the exclosure in late 1989 to further discourage cattle from attempting to forage inside the fenced area.



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

The second and third objectives are being met by documenting the status of baseline (pre-exclosure) and post-exclosure MGS populations, characterizing the environments in which they are found, and carrying out food habits studies of the MGS and its potential competitors. Baseline studies were carried out in 1988, 1989 and 1990; the results of this work were reported in Leitner and Leitner (1989 and 1990) and Leitner et al. (1991). Limited post-exclosure studies were carried out in 1991 (Leitner and Leitner 1992). The first full-scale post-exclosure investigation was conducted in 1992 (Leitner and Leitner 1993). Additional post-exclosure surveys will be carried out in 1994, 1996 and, contingent on the continued operation of the geothermal field, in the year 2001.

This report presents results from the second full year of post-exclosure studies. These studies were not required as part of the Coso Grazing Exclosure Mitigation Plan. However, the benefit of a continuous record of MGS population parameters was recognized by several parties, who supported the 1993 studies: the U.S. Navy Geothermal Program Office at NAWS; the California Department of Fish and Game; and Jean Hopkins and Associates, Inc.

SCOPE OF WORK FOR 1993 STUDIES

The principal elements of the 1993 studies were: 1) trapping for MGS to establish their distribution and abundance on four study sites, two within the exclosure and two outside; 2) characterization of the herbaceous vegetation within the study sites; 3) observation of local precipitation at five stations; and 4) collection and analysis of fecal samples from MGS.

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 level (Henrickson 1979). 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).

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). It is dominated by Desert Saltbush Scrub, a low-growing, homogene-

ous mixture of two saltbush species Atriplex polycarpa (allscale) and A. confertifolia (shadscale). Study Site 2 is 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, among others. The western edge of the study site contains a narrow strip of Mohave Desert Wash Scrub, a rich mixture of deep-rooted perennials.

Study sites 3 and 4 are high-elevation sites, the former within the grazing exclosure and the latter 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 here 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. The reader is referred to Leitner and Leitner (1989) for a general description of the soils and topography of the four study sites.

Appendix I presents the scientific names of plants observed or expected to occur in the four study sites.

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 at Haiwee Reservoir, where weather records have been maintained for 29 years, is about 154 mm (6.1 in) (Larson and Monahan 1992).

METHODS

Location of Study Sites

Figure 1 shows the location of 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 continue to receive grazing in the same pattern as in the past; study sites 2 and 3 are within the area excluded from grazing. Study sites 2, 3 and 4 are on lands

managed by the NWC, while Study Site 1 is managed by BLM. A discussion of criteria for study site selection and a description of the site selection process are presented in Leitner and Leitner (1989).

Each study site is a square measuring 500 m (1640 ft) on a side, with an area of 25 ha (61.8 ac). Corners were 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 were also placed at the midpoint of each side and at the center point of the study site. This marking system makes it possible to accurately re-establish site boundaries each year. In addition, the locations of all 441 trap stations at each study site were permanently marked with wooden stakes.

Ground Squirrel Trapping and Population Estimates

Live-trapping Methods

During the two trapping periods, in late March-early April and in late May-early June 1993, the abundance of MGS and antelope ground squirrels (AGS) was determined on each of the four study sites by mark-recapture sampling using a standard live-trapping technique. A trapping grid was established on each 500 by 500 m (1640 by 1640 ft) study site. Pymatuning and Sherman live traps were deployed in a 21 x 21 array with 25 m (82 ft) spacing between trap stations. A total of 441 traps were used at each study site, with Pymatuning traps making up 81 percent.

The late March-early April sampling period was chosen because it is a time in the annual cycle of the MGS when all adults are presumed to be active above-ground (Leitner and Leitner 1990 and Recht unpubl.). The second sampling period was scheduled in late May-early June when juvenile MGS are foraging outside their burrows and can be trapped, along with those adults that have not yet entered estivation. At each study site, traps were pre-baited for two days, followed by five days of trapping. The bait used was a commercially available horse feed that includes molasses, rolled oats, cracked corn, wheat, and barley (Kruse's Perfection brand horse feed with molasses, also known locally as "sweet feed"). Traps were placed beside or under a shrub within 1-3 m of the stake marking the trap station. They were opened in the morning between 0730 and 0930 hours and closed in the afternoon between 1600 and 1800 hours. The traps were checked two to three times each day on a regular schedule.

Because of higher ambient temperatures during the late May-early June sampling period, all traps were shaded with a piece of white corrugated cardboard measuring 61 cm by 71 cm (24 by 28 in) and folded to form an A-frame shelter. This shelter was held in place by two to four 6-inch nails inserted through the cardboard and into the soil and by soil pushed over the edges of the

cardboard. During the time the traps were open each day, the internal temperature of a shaded trap was monitored. In order to avoid heat stress to captured animals, all traps on the study site would be checked and closed if the temperature in the test trap reached 39 degrees C.

Captured animals were identified to species, sex, and age class (adult/juvenile). Adults were examined to determine reproductive condition. A 300 g (12 oz) capacity Pesola spring scale was used to determine body mass of all animals upon first capture.

As in each year since 1990, all captured ground squirrels were permanently marked for individual identification with 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 in the ground squirrels 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 an implanted animal, the PIT tag is energized to transmit a unique identification code which is then displayed on a readout unit. This method has been shown to cause no observable effect on the health or behavior of tagged wildlife (Fagerstone and Johns 1986). PIT tags have been used successfully in a live-trapping study of Townsend's ground squirrel in Idaho (Schooley et al. 1993). The technique is of particular value in this study because PIT tags are lost at a very low rate compared to ear tags, providing an effective permanent record of individual identity. All data pertaining to a particular capture were recorded on standard field data forms (examples are included in Appendix II) and the animal then released unharmed.

The study sites are generally located in basins with rather loose sandy soil, and it was thought that treading associated with trapping activities might disrupt the soil, resulting in adverse effects to the ecosystem. To minimize this potential effect, particular effort was made to confine foot traffic to single pathways between trapping stations. If pathways needed to be defined, powdered dolomite was applied to the soil surface in a thin line for a meter or so to indicate the desired route.

Ground Squirrel Abundance and Population Estimates

The trapping results provided data on the abundance of MGS and AGS at each study site, ratio of juveniles to adults, body mass, home range size, and the movements of individual animals. Several methods were used to express the number of ground squirrels present on each study site or to estimate population density.

In this report, we present five measures of abundance: 1) the total number of animals captured on a study site; 2) the number of resident animals on a study site; 3) population size as estimated

by the Schnabel and Lincoln-Petersen mark-recapture methods; 4) population density based upon the number of resident animals per 25 ha study site; and 5) 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.

Number of resident animals. Criteria used to distinguish resident from non-resident animals were the same as those used in past years. Resident animals were defined as those that: 1) were captured on two or more days during the five-day trapping session; and either 2a) had 50% or more of all captures recorded at trap stations not on the periphery of the grid; or 2b) were captured on three out of five days at trap stations not on the periphery of the grid. The underlying assumptions are that animals captured only on one day were transient (not resident) and that animals captured mainly on the edge of the grid had the greater part of their home ranges off the study site. The number of resident animals was then determined by counting the number of individuals meeting these criteria and population density was calculated by dividing the number of resident animals by the size of the study site, 25 hectares.

Population size using mark-recapture methods. The mark-recapture data gathered on each study site was used to estimate population sizes by application of the Lincoln-Petersen and Schnabel methods (Seber 1982). Both methods assume a demographically closed population; that is, one in which birth, death, immigration, and emigration do not act to change the ratio of marked animals to the total number present during the trapping period. This assumption is reasonable for our study, given the short duration of each trapping period.

In the Lincoln-Petersen method, a sample of animals is captured, marked, and released. A second sample is taken from the same population on a later occasion. The population size is estimated based upon the assumption that the ratio of marked to unmarked animals in the second sample reflects the same ratio in the population. For example, suppose that 50 animals are marked and released in the first sample and that a second sampling occasion yields 40, of which one-half (20) are marked. A population estimate (N-hat) of 100 is derived by assuming that the 50 animals in the first sample represented one-half of the total population.

In this study, the Lincoln-Petersen method was used by pooling capture data from different days into an early and a late sample. The five-day trapping periods were divided into an initial three-day capture and marking period and a two-day recapture session. Thus, the data used in calculating population estimates were: (1) the total number of individuals marked during the first three days; (2) the total number of individuals captured over the last two

days; and (3) the number of those individuals that had been marked in the initial three-day period.

The Schnabel model allows marking and recapturing to be conducted over several trapping occasions, with the number of marked animals in each sample noted and all unmarked animals tagged and returned to the population. Thus, the total number of marked animals in the population increases with time and a series of population estimates (N-hat) can be calculated for each occasion on which recaptures are taken.

For purposes of analysis using the Schnabel method, multiple captures on a given day were ignored. An individual was counted as a new capture on the day it was first marked and released. It was not counted as a recapture until it was taken on a subsequent day and multiple recaptures on a single day were not considered. The number of trapping occasions was considered to be equal to the five days on which trapping was conducted on each study site. As a result, there were four trapping occasions on which recaptures could be taken and four successive population estimates of increasing reliability could be obtained. The final population estimate for the fifth trapping day was considered to be the definitive value.

Population density using a movement-based estimator. It is not valid to calculate population density by simply dividing a population estimate derived from mark-recapture data by the area of the trapping grid (White et al. 1982). The number of individuals caught in such a trapping study will include some animals whose home ranges extend well beyond the boundary of the grid. Thus, the effective trapping area to which the population estimate (N-hat) is related will include a boundary strip around all four sides of the grid. If the width in meters of the boundary strip (W) can be estimated, the effective trapping area (A(W)) in hectares can be determined and a more accurate population density estimate (D-hat) obtained by the formula D-hat = N-hat/A(W).

We selected two measures of movement to estimate the width of the boundary strip and thus the effective trapping area. They are: 1) average distance moved between successive captures (AVDM) and 2) one-half of the mean maximum distance moved (MMDM). We used movement data only from resident individuals, and calculated the distance moved using only data on distance moved between captures on successive days; data on distance moved between captures within the same day were not utilized. The AVDM and MMDM were calculated separately for each species on each study site by pooling data from resident individuals. Data from males and females were always pooled, except where distance moved differed significantly between males and females. Separate values for AVDM and MMDM were calculated for juvenile and adult MGS captured in the May-June sampling period.

See White (1982) chapter on density estimator

this technique of using their definition of "resident" and adding a boundary leads to underestimation of population.

Herbivore Food Habits

The diet of the Mohave ground squirrel (MGS) was studied by the microscopic examination of undigested food material found in fecal samples.

All fecal samples for MGS were obtained fresh during the two live-trapping periods at each study site. Samples were collected on the first occasion that each individual MGS was captured by removing three fresh fecal pellets from the live trap. The pellets were placed in a small envelope which was sealed and labeled to indicate the species, sex, age class, PIT tag number, date, study site and trap station. After each capture, all fecal pellets were cleared from the trap, thus ensuring that a subsequent sample could be accurately attributed to a known individual.

Where fewer than 10 individual MGS were captured from a study site during a trapping period, all fecal samples were analyzed. For example, at Study Site 1 in March-April, only three individuals were captured, but all five samples collected were analyzed. Where samples were collected from 10 to 20 individuals, all first-capture samples were sent for analysis. If a higher number of samples were collected, between 20 and 30 samples were analyzed to allow for unusable samples due to high proportions of bait (see section following). The samples were selected from the available pool so as to include 10 samples for each sex and age class (adult and juvenile) and to provide coverage of all parts of the study site.

Samples from other herbivores--antelope ground squirrels, jackrabbits, cattle and burros--were collected according to earlier protocols (Leitner and Leitner 1993). If and when funding permits, these will be analyzed to determine food items consumed.

Fecal samples were analyzed for botanical composition at the Composition Analysis Laboratory, Colorado State University (CSU), Fort Collins, Colorado. The microhistological technique used is described in detail in Hansen et al. (1974) and Foppe (in prep.). Each fecal 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. Plant fragments were identified to genus and species where possible; seed and leaf material from the same plant could often be differentiated by this technique. Twenty fields containing at least three identifiable plant fragments were examined on each slide 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 species. Relative density for a food item is thus considered to be a reasonable estimate of its dry weight contribution to the diet.

Precipitation Measurements

Precipitation can vary considerably over short distances in the Mohave Desert. Since some differences in vegetation growth at the four study sites may be attributable to precipitation, gauges were set out to record local precipitation. Clear plastic direct-reading rain gauges 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 few millimeters of mineral oil was placed in the collection tube to prevent evaporation of precipitation between readings. The gauges were installed on February 6, 1989, and have been serviced, usually monthly, by reading precipitation levels, emptying the collection tube, and then cleaning and recoating with mineral oil.

Vegetation Surveys

Herbaceous species composition and above-ground standing crop were recorded during late May and early June when herbaceous growth was presumed to be near its peak. Species composition and standing crop were measured on each study site in a minimum of 100 between-shrub and 100 under-shrub square plots each measuring 0.09 sq m (1 sq ft). In addition, 25 between- and under-shrub plots were randomly selected in each pair of "mini-exclosures" at study sites 1 and 4. Since these study sites continue to have cattle grazing, the mini-exclosures were constructed to allow on-site comparison of grazed and ungrazed lands.

The between-shrub plots were distributed throughout the study site in the vicinity of alternating trap stations on alternating rows (e.g., stations B-2, B-4, B-6 and so on, then D-2, D-4, D-6 and so on). The location of the between-shrub plot was randomly selected by an observer standing at the station stake and throwing the plot frame into an open area. The under-shrub plot was selected by the convention of placing the frame under the shrub nearest the between-shrub plot. Within each plot, all herbaceous plant species present were recorded, and annual grasses and most forbs were clipped at ground level and placed into a labeled envelope. Perennial grasses and herbs with perennial leaves and stems (e.g., Eriogonum inflatum and Sphaeralcea ambigua) were excluded from the clipping procedure because of the difficulty of separating current year's growth from previous years' growth and the probability of causing extreme damage to the plant by clipping the entire above-ground biomass.

Species frequency was calculated based on the number 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.

RESULTS

Ground Squirrel Abundance

As described in the methods section, five indicators of ground squirrel abundance were calculated from the trapping data. The results of trapping and the indicators of abundance are presented in the section that follows.

Total Number of Individuals Captured

March-April 1993. Tables 1-4 show the number of individual animals captured on each study site by species, sex, and age class during the March-April sampling period. Adult MGS and AGS were found on all four study sites. The live-trap sampling effort of 8,820 trapdays resulted in the capture of a total of 85 individual MGS and 213 AGS over all four study sites. A total of 211 MGS and 378 AGS captures were recorded due to recaptures of many individuals.

85
211
what percent of individuals were recaptured?

Study Site 3 yielded by far the largest number of individual MGS, more than double the numbers taken on study sites 2 and 4. Three MGS were captured on Study Site 1, marking the first record of the species at this location since 1988. As an incidental observation, we noted that the one adult female MGS trapped on Study Site 1 experienced a 60 g drop in body mass between April 1 and 3, suggesting that she gave birth to a litter of young on April 2. Although one adult female MGS captured on Study Site 3 was noted as lactating, all other females captured on study sites 2, 3, and 4 were still pregnant during the March-April sampling period.

The number of individual AGS captured did not differ greatly among the four study sites, ranging from a low of 44 on Study Site 4 to a high of 61 on Study Site 3. If the total number of individuals captured is used as an index of species abundance, AGS were substantially more abundant than MGS on all four of the study sites during the March-April sampling period.

The adult MGS sex ratio was strongly biased in favor of females, as in all previous years of this study. A total of 20 male MGS was taken on all study sites, compared with 65 females. Among AGS, the sex ratio favored males on all four study sites, with a total of 129 males and 84 females captured.

May-June 1993. Tables 5-8 show the number of individual animals captured on each study site by species, sex and age class during the May-June sampling period. As in April, both MGS and AGS were captured on all study sites. The sampling effort of 8,820 trap-days resulted in the capture of a total of 516 individual MGS and 173 AGS over all four study sites. Since some animals were captured two or more times, a total of 1674 captures of MGS and 216 captures of AGS were recorded.

Table 1. Summary of trapping results by species, sex and age of animal, Study Site 1 (Rose Valley), during March 30-April 3, 1993.

MOHAVE GROUND SQUIRREL

	Male	Female	Total
Juvenile	0	0	0
Adult	2	1	3
Total	2	1	3

ANTELOPE GROUND SQUIRREL

	Male	Female	Total
Juvenile	0	0	0
Adult	28	22	50
Total	28	22	50

Table 2. Summary of trapping results by species, sex and age of animal, Study Site 2 (Coso Basin), during March 30-April 3, 1993.

MOHAVE GROUND SQUIRREL

	Male	Female	Total
Juvenile	0	0	0
Adult	5	15	20
Total	5	15	20

ANTELOPE GROUND SQUIRREL

	Male	Female	Total
Juvenile	0	0	0
Adult	33	25	58
Total	33	25	58

Table 3. Summary of trapping results by species, sex and age of animal, Study Site 3 (Cactus Peak), during April 7-11, 1993.

MOHAVE GROUND SQUIRREL

	Male	Female	Total
Juvenile	0	0	0
Adult	8	35	43
Total	8	35	43

ANTELOPE GROUND SQUIRREL

	Male	Female	Total
Juvenile	0	0	0
Adult	43	18	61
Total	43	18	61

Table 4. Summary of trapping results by species, sex and age of animal, Study Site 4 (Pumice Mine), during April 7-11, 1993.

MOHAVE GROUND SQUIRREL

	Male	Female	Total
Juvenile	0	0	0
Adult	5	14	19
Total	5	14	19

ANTELOPE GROUND SQUIRREL

	Male	Female	Total
Juvenile	0	0	0
Adult	25	19	44
Total	25	19	44

Table 5. Summary of trapping results by species, sex and age of animal, Study Site 1 (Rose Valley), during May 29-June 2, 1993.

MOHAVE GROUND SQUIRREL

	Male	Female	Total
Juvenile	11	14	25
Adult	0	2	2
Total	11	16	27

ANTELOPE GROUND SQUIRREL

	Male	Female	Total
Juvenile	16	15	31
Adult	12	18	30
Total	28	33	61

Table 6. Summary of trapping results by species, sex and age of animal, Study Site 2 (Coso Basin), during May 29-June 2, 1993.

MOHAVE GROUND SQUIRREL

	Male	Female	Total
Juvenile	36	69	105
Adult	3	12	15
Total	39	81	120

ANTELOPE GROUND SQUIRREL

	Male	Female	Total
Juvenile	14	15	29
Adult	9	20	29
Total	23	35	58

Table 7. Summary of trapping results by species, sex and age of animal, Study Site 3 (Cactus Peak), during June 7-11, 1993.

MOHAVE GROUND SQUIRREL

	Male	Female	Total
Juvenile	83	129	212
Adult	1	20	21
Total	84	149	233

ANTELOPE GROUND SQUIRREL

	Male	Female	Total
Juvenile	9	9	18
Adult	11	6	17
Total	20	15	35

Table 8. Summary of trapping results by species, sex and age of animal, Study Site 4 (Pumice Mine), during June 8-12, 1993.

MOHAVE GROUND SQUIRREL

	Male	Female	Total
Juvenile	59	61	120
Adult	3	13	16
Total	62	74	136

ANTELOPE GROUND SQUIRREL

	Male	Female	Total
Juvenile	5	1	6
Adult	4	9	13
Total	9	10	19

Juveniles of both ground squirrel species were captured during this sampling period. A total of 462 juvenile MGS were taken over all four study sites. The number of juvenile AGS captured was much smaller, with a total of 84 recorded on all study sites.

As in the March-April sampling period, by far the greatest number of individual MGS was captured on Study Site 3. The numbers of individuals recorded on study sites 2 and 4 were only 52 and 58 percent, respectively, of the total on Study Site 3. The numbers of both adult and juvenile MGS were much lower on Study Site 1 than on the other three study sites. This was not unexpected, since the species had only just become re-established on Study Site 1 in spring 1993 after a four-year absence.

The greatest numbers of individual AGS were captured on study sites 1 and 2. The number of AGS recorded from Study Site 3 was substantially less and, as in the March-April sampling period, Study Site 4 had the lowest number of individual AGS captured. Only on Study Site 1 did the total number of AGS captured exceed the number of MGS; on the three other study sites, the numbers of individual AGS captured were substantially below those of MGS.

Among both adult and juvenile MGS, the sex ratio was again biased toward females. Only 7 of 54 adults and 189 of 462 juveniles were males. The AGS sex ratio was more closely balanced, with a total of 80 males and 93 females captured on all study sites.

Number of Resident Animals

The total number of animals captured on a study site is almost certainly greater than the number of resident ground squirrels. Some captures may represent transient individuals, while some animals captured near the periphery may have home ranges extending well outside the study site. The number of resident MGS and AGS on each study site was determined by use of the criteria described in the methods section and population density was calculated by dividing the number of resident animals by the area of the study site (25 hectares).

Why have 2 methods of determining area?

March-April 1993. The results for the March-April sampling period are shown in Table 9. Resident adult MGS and AGS were recorded on all four study sites. The number of resident MGS on each study site followed the pattern of abundance shown for total number of individuals captured. Study Site 3 had the highest number of resident MGS, followed by study sites 2 and 4, with only one resident MGS recorded on Study Site 1. On the other hand, the number of resident AGS was highest on Study Site 1, rather than on study sites 2 or 3, which were the locations with the greatest number of individual AGS captured. Using the standard criteria, approximately one-half of the adult MGS captured were classified as residents, while only about 35 percent of the AGS captured qualified as residents.

50% combined MGS resident

Table 9. The number of resident adult Mohave and antelope ground squirrels (MGS and AGS, respectively) on each study site in March-April 1993 and calculated adult population density for each species.

Study Site Number	Number of Resident Adult Animals		Adult Population Density (number/hectare)	
	MGS	AGS	MGS	AGS
1	1	27	0.04	1.08
2	10	20	0.40	0.80
3	27	16	1.08	0.64
4	6	12	0.24	0.48

Population density values were higher for AGS than for MGS on study sites 1, 2, and 4. Only on Study Site 3 did the population density of MGS exceed that of AGS.

May-June 1993. Table 10 presents the total number of resident adult and juvenile ground squirrels by study site in the May-June sampling period. As in the March-April sampling period, the number of resident MGS on each study site followed the pattern of abundance shown for total number of individuals captured. Again, Study Site 3 had the highest number of resident MGS, followed by study sites 2 and 4, while by far the lowest number was recorded on Study Site 1. Study sites 1 and 2 were highest in number of resident AGS, just as in number of individuals captured. However, very few AGS taken on study sites 3 and 4 met the residency criteria because of a very low rate of recapture. Over all study sites, 58 percent of MGS were classified as residents, but only 11 percent of AGS.

Because of the large number of juvenile MGS captured in May-June, population density values were 5-10 times higher than in the March-April sampling period. In contrast, AGS density values were much lower in May-June, reflecting the relatively small number of AGS juveniles captured and the low recapture rates, even among adult AGS.

Table 10. The number of resident Mohave and antelope ground squirrels (MGS and AGS, respectively) on each study site in May-June 1993 and calculated total (adult and juvenile) population density for each species.

Study Site Number	Number of Resident Animals		Population Density (number/hectare)	
	MGS	AGS	MGS	AGS
1	14	10	0.56	0.40
2	72	7	2.88	0.28
3	132	0	5.28	--
4	80	2	3.20	0.08

Population Size Estimated by Mark-Recapture Methods

Population estimates based upon the Schnabel and Lincoln-Petersen methods are presented for MGS in Table 11. In the March-April sampling period, both Schnabel and Lincoln-Petersen estimates indicated that the adult MGS population on Study Site 3 was significantly larger than on study sites 2 and 4. There was no statistically significant difference in estimated population size between study sites 2 and 4. Since only 3 individual MGS were captured on Study Site 1 during the March-April sampling period, mark-recapture data were insufficient for estimation of population size.

In the May-June sampling period, both the Schnabel and Lincoln-Petersen estimates showed that Study Site 3 supported the largest juvenile MGS population. The juvenile population on Study Site 4 was second largest, followed closely by Study Site 2, while Study Site 1 was by far the smallest. All comparisons of juvenile population size between study sites indicated that differences were statistically significant ($p<0.05$).

Mark-recapture estimates of adult MGS population size were quite similar for study sites 2, 3, and 4 in the May-June sampling period. Although Study Site 3 had the largest adult population estimate, comparisons with study sites 2 and 4 were statistically significant only with the Schnabel method. Because only 2 adult MGS were taken on Study Site 1, the mark-recapture data were not adequate for estimation of adult population size.

Table 11. Population estimates with 95% confidence intervals (C.I.) for Mohave ground squirrels in March-April (adults only) and in May-June 1993 (adults and juveniles), as calculated by the Lincoln-Petersen (Lincoln) and Schnabel methods.

Study Site Number	Population Estimate (N-hat +/- 95% C. I.) April Schnabel	April Lincoln	May-June Schnabel	May-June Lincoln
1 (Adults)	(1)	(1)	(1)	(1)
(Juveniles)			25 ± 4	29 ± 6
(Adu & Juv)			28 ± 5	31 ± 6
2 (Adults)	20 ± 3	22 ± 4	15 ± 2	15 ± 0
(Juveniles)			101 ± 5	112 ± 6
(Adu & Juv)			116 ± 5	124 ± 5
3 (Adults)	43 ± 4	47 ± 5	21 ± 3	24 ± 5
(Juveniles)			200 ± 6	229 ± 11
(Adu & Juv)			221 ± 7	253 ± 12
4 (Adults)	22 ± 11	26 ± 11	16 ± 1	19 ± 5
(Juveniles)			116 ± 5	127 ± 7
(Adu & Juv)			132 ± 4	145 ± 8

(1) data insufficient for population estimates

Although large numbers of individual AGS were captured on all four study sites during both 1993 sampling periods, recapture rates were generally quite low compared to those typical of MGS populations. The recapture rate during the May-June sampling period was particularly low on all study sites. Population estimates for this period were not used because of the excessively broad 95% confidence intervals. The March-April data did provide useful mark-recapture population estimates, although the 95% confidence intervals were still relatively wide for study sites 2, 3, and 4.

Table 12 presents the March-April AGS population estimates using the Schnabel and Lincoln-Petersen methods. These estimates suggest that during this sampling period AGS abundance was highest on study sites 2 and 3. Few inter-site comparisons of population size yielded differences that were statistically significant ($p<0.05$). The Lincoln-Petersen population estimates for study sites 2 and 3 were both significantly higher than the estimate for Study Site 1, while the Schnabel value for Study Site 3 was higher than the corresponding estimate for Study Site 1. Because of the wide confidence intervals, the AGS population estimates for study sites 2, 3, and 4 could not be statistically differentiated.

Table 12. Population estimates with 95% confidence intervals (C.I.) for antelope ground squirrels in March-April (adults only) and in May-June 1993 (adults and juveniles), as calculated by the Lincoln-Petersen (Lincoln) and Schnabel methods.

	Population Estimate (N-hat +/- 95% C. I.)			
Study Site	March-April		May-June	
Number	Schnabel	Lincoln	Schnabel	Lincoln
1	56 ± 7	53 ± 5	(1)	(1)
2	83 ± 29	81 ± 20	(1)	(1)
3	82 ± 19	78 ± 16	(1)	(1)
4	57 ± 15	68 ± 24	(1)	(1)

(1) data insufficient for population estimates

Population Density Using Movement-Based Estimators

Tables 13-16 present population densities for MGS and AGS determined by using two movement-based estimators: (1) average distance moved between successive captures (AVDM) and (2) one-half of the mean maximum distance moved (MMDM). Population estimates (N-hat) employed in calculating densities are those derived from the mark-recapture data by the Schnabel method as shown in tables 11 and 12.

During the March-April sampling period, adult MGS population density estimates were highest on Study Site 3, ranging from 1.30 to 1.44 individuals per hectare (Table 13). Adult densities on study sites 2 and 4 varied from 0.53 to 0.73 individuals per hectare, about 50% of that estimated for Study Site 3. In May-June, density estimates for the adult segment of the population were lower than in March-April on all three study sites (Table 14). Study Site 3 showed the greatest percentage reduction, although population density was still higher here than on study sites 2 and 4.

The May-June estimates of total MGS population density were much higher than in March-April because of the addition of large numbers of juveniles to the population (Table 14). Study Site 3 yielded the highest population densities, both for juveniles and for adults and juveniles combined. Study sites 2 and 4 showed juvenile and total density levels about one-half of the comparable

Table 13. Population density estimates for adult Mohave ground squirrels in March-April 1993, using two movement-based estimators. Distances moved based on number of animals in parentheses. Mean ± SE maximum distance moved (MMDM), mean ± SE distance moved (AVDM), width of boundary strip (W), effective trapping area (A-hat(W)), population size estimated by Schnabel method (N-hat), and density reported as number of animals per hectare (D-hat = N/A(W)).

based on # individuals captured not N, estimated population size

Study Site No.	Measure of Movement	Distance Moved±SE (m)	W (m)	A-hat(W) (ha)	N-hat (no. of inds.)	D-hat (inds./ha)
1	Data insufficient for population estimates					
2	MMDM	70.6 ± 15.7	35	32.6	20	0.61
(n=14)	AVDM	57.8 ± 14.9	58	37.9	20	0.53
3	MMDM	47.0 ± 5.9	23	29.9	43	1.44
(n=31)	AVDM	38.2 ± 4.2	38	33.2	43	1.30
4	MMDM	48.9 ± 17.7	24	30.1	22	0.73
(n=8)	AVDM	47.9 ± 17.5	48	35.5	22	0.62

estimates for Study Site 3. Juvenile and total population densities could be estimated for Study Site 1 in the May-June sampling period and, as expected, were much lower than those recorded on the other three study sites.

Adult AGS population densities for the March-April sampling period are presented in Table 15. On study sites 1 and 2, density estimates are given separately for males and females because distances moved between captures were significantly higher for males. Population density values for males and females reflect the fact that on these two study sites the effective trapping area was larger for males. For example, the male AGS population sampled on Study Site 1 was distributed over an area almost twice as large as that inhabited by the females. As a result, male density estimates for Study Site 1 were only about 55-60 percent of those for females although the male population was slightly larger. On study sites 3 and 4, male and female movement data were pooled either because the female sample was very small (Study Site 4) or because there appeared to be no significant difference in distances moved between captures (Study Site 3).

When the combined male and female population density estimates are compared, Study Site 2 was highest, with densities from 1.64 to 2.21 individuals per hectare. It was followed closely by Study Site 3, where densities ranged from 1.47 to 1.99 individuals per hectare. Population densities at study sites 1 and 4 fell somewhat

Table 14. Population density estimates for adult and juvenile Mohave ground squirrels in May-June 1993, using two movement-based estimators. Distances moved based on number of animals in parentheses. Mean ± SE maximum distance moved (MMDM), mean ± SE distance moved (AVDM), width of boundary strip (W), effective trapping area (A-hat(W)), population size estimated by Schnabel method (N-hat), and density reported as number of animals per hectare (D-hat = N/A(W)).

Population	Measure of Movement	Distance Moved±SE (m)	W (m)	A-hat(W) (ha)	N-hat (no. of inds.)	D-hat (inds./ha)
Study Site 1						
Adults (n=1)	Insufficient Data					
Juveniles (n=15)	MMDM	76.4 ± 11.3	38	33.2	25	0.75
	AVDM	62.3 ± 9.3	62	39.0	25	0.64
Adu.+Juv. (n=16)	MMDM	76.6 ± 10.6	38	33.3	28	0.84
	AVDM	62.2 ± 8.7	62	39.0	28	0.72
Study Site 2						
Adults (n=14)	MMDM	77.7 ± 8.7	39	33.4	15	0.45
	AVDM	55.8 ± 5.8	56	37.4	15	0.40
Juveniles (n=81)	MMDM	105.1 ± 9.3	53	36.6	101	2.76
	AVDM	74.5 ± 5.8	75	42.1	101	2.40
Adu.+Juv. (n=95)	MMDM	101.0 ± 8.0	51	36.1	116	3.21
	AVDM	71.8 ± 5.0	72	41.4	116	2.80
Study Site 3						
Adults (n=13)	MMDM	54.4 ± 14.7	27	30.7	21	0.68
	AVDM	38.1 ± 6.0	38	33.2	21	0.63
Juveniles (n=144)	MMDM	86.9 ± 5.9	43	34.5	200	5.80
	AVDM	67.6 ± 4.8	68	40.4	200	4.95
Adu.+Juv. (n=157)	MMDM	84.2 ± 5.6	42	34.1	221	6.48
	AVDM	65.2 ± 4.5	65	39.7	221	5.57
Study Site 4						
Adults (n=9)	MMDM	52.1 + 9.0	26	30.5	16	0.52
	AVDM	40.9 ± 5.8	41	33.8	16	0.47
Juveniles (n=91)	MMDM	111.9 + 9.6	56	37.4	116	3.10
	AVDM	82.1 ± 5.8	82	44.1	116	2.63
Adu.+Juv. (n=100)	MMDM	106.5 + 8.9	53	36.8	132	3.59
	AVDM	78.4 ± 5.5	78	43.1	132	3.06

Table 15. Population density estimates for adult antelope ground squirrels in March-April 1993, using two movement-based estimators. Distances moved based on number of animals in parentheses. Mean ± SE maximum distance moved (MMDM), mean ± SE distance moved (AVDM), width of boundary strip (W), effective trapping area (A-hat(W)), population size estimated by Schnabel method (N-hat), and density reported as number of animals per hectare (D-hat = N/A(W)).

Study Site No.	Measure of Movement	Distance Moved±SE (m)	W (m)	A-hat(W) (ha)	N-hat (no. of inds.)	D-hat (inds./ha)
Study Site 1						
Males	MMDM	275.9 ± 42.6	138	60.2	29	0.48
(n=15)	AVDM	199.1 ± 29.1	199	80.7	29	0.36
Females	MMDM	72.8 + 11.1	36	32.8	27	0.82
(n=12)	AVDM	70.6 ± 11.2	71	41.1	27	0.66
Both	MMDM	185.6 + 31.0	93	47.0	56	1.19
(n=27)	AVDM	142.0 ± 20.9	142	61.5	56	0.91
Study Site 2						
Males	MMDM	138.2 ± 17.7	69	40.7	48	1.18
(n=13)	AVDM	133.3 ± 16.9	133	58.8	48	0.82
Females	MMDM	65.6 + 11.8	33	32.0	35	1.09
(n= 7)	AVDM	52.9 ± 6.1	53	36.7	35	0.95
Both	MMDM	112.8 + 14.4	56	37.6	83	2.21
(n=20)	AVDM	105.2 ± 14.1	105	50.5	83	1.64
Study Site 3						
Both	MMDM	142.6 ± 19.9	71	41.3	82	1.99
(n=16)	AVDM	123.1 ± 18.1	123	55.7	82	1.47
Study Site 4						
Both	MMDM	137.8 ± 17.9	69	40.7	57	1.40
(n=12)	AVDM	129.7 ± 18.8	130	57.7	57	0.99

← more variance in these estimates than indicated by a poi estimate

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should use a binomial confidence interval, at the very least to calculate a confidence interval.

Table 16. Population density estimates for adult and juvenile antelope ground squirrels in May-June 1993, using two movement-based estimators. Distances moved based on number of animals in parentheses. Mean ± SE maximum distance moved (MMDM), mean ± SE distance moved (AVDM), width of boundary strip (W), effective trapping area (A-hat(W)), population size estimated by Schnabel method (N-hat), and density reported as number of animals per hectare (D-hat = N/A(W)).

Study Site No.	Measure of Movement	Distance Moved±SE (m)	W (m)	A-hat(W) (ha)	N-hat (no. of inds.)	D-hat (inds./ha)
1	Insufficient Data					
2	Insufficient Data					
3	Insufficient Data					
4	Insufficient Data					

below these levels, with estimates from 0.91 to 1.40 individuals per hectare. In general, these results support the conclusions based upon mark-recapture population estimates that indicated greatest AGS abundance on study sites 2 and 3 during the March-April sampling period.

It was not possible to calculate movement-based estimates of AGS population densities for the May-June sampling period because of the very low rate of recaptures. Lack of adequate recapture data resulted in mark-recapture estimates of population size that had such wide confidence limits as to be unusable. Furthermore, there were so few data on distance moved between captures that values for AVDM and MMDM were not reliable.

Over the course of this study, it has been noted that AGS are often less likely to be recaptured than MGS. In both 1992 and 1993, recapture rates among AGS have been at their lowest during the May-June sampling period. The general tendency of AGS toward a lower probability of recapture may be exaggerated at a time when the juveniles are just beginning to become active above ground. In any event, this difference in behavior between the two ground squirrel species suggests that interspecific comparisons of abundance based upon numbers of resident animals or upon mark-recapture population estimates may not be appropriate.

good

Food Habits

March-April 1993. Table 17 presents food habits results for MGS in March-April 1993. In general, the March-April samples were composed largely of forb leaf, with a much smaller contribution by shrub leaf. Arthropod parts and seed contributed very little to the mean relative density.

At Study Site 1, 84 percent of relative density was contributed by Astragalus leaf. Flower parts were the only other substantial food item. Among the three animals caught, the sample from one individual was all Astragalus leaf; from another, about two-thirds flower parts; and the three samples from the third contained Astragalus ranging from 85 to 100 percent of relative density. Multiple samples were analyzed at Study Site 1 since the number of individuals was small and it was desirable to obtain as much data as possible about the diet of MGS recolonizing this site.

At Study Site 2, shrub leaf averaged nearly 30 percent of mean relative density, while forb material contributed about two-thirds. The most important food items were flower parts (about 40 percent of mean relative density), Krascheninnikovia (=Eurotia) leaf (about 28 percent), and Eriogonum leaf (about 11 percent). Individual animals varied in the principal food items taken. Four of ten usable samples contained primarily (that is, over 50 percent relative density) flower parts, three contained mostly Krascheninnikovia leaf, and one each primarily Eriogonum leaf and Descurainia leaf.

Samples from Study Site 3 were dominated by Astragalus leaf, which averaged over two-thirds of mean relative density. The importance of this food item was fairly consistent among individual animals; 12 of the 16 usable samples contained primarily Astragalus. One sample was dominated by Eriogonum, another by Krascheninnikovia, and two samples had no food items contributing more than 50 percent relative density.

Study Site 4 also had a remarkable predominance of Astragalus leaf; this food item averaged 56 percent of relative density among all samples. The other important food items were Eriogonum leaf, at 18 percent, and Atriplex leaf, at 10 percent. Of the 17 samples analyzed (none had excessive bait), ten contained primarily Astragalus leaf, while four were dominated by Eriogonum leaf and one each by flower parts and by Gilia/Linanthus leaf.

Table 17. Summary of food habits results for Mohave ground squirrels at study sites 1-4 in March-April 1993. 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 1 (Rose Valley)	Site 2 (Coso Basin)	Site 3 (Cactus Peak)	Site 4 (Pumice Mine)	Mean relative density all sites
GRASSES AND ALLIES					
Achnatherum (Oryzopsis)				0.2 (0.1)	
Bromus		0.5 (0.1)	0.3 (0.1)	1.1 (0.4)	
Schismus				0.7 (0.1)	
Total, grasses	0.0	0.5 (0.1)	0.3 (0.1)	2.0 (0.5)	0.9 (0.2)
SHRUBS					
Atriplex leaf	0.6 (0.2)	1.4 (0.2)	6.2 (0.5)	10.0 (0.6)	
Krascheninnikovia leaf		27.5 (0.5)	6.2 (0.3)	0.5 (0.2)	
Total, shrubs	0.6 (0.2)	28.9 (0.7)	12.4 (0.7)	10.5 (0.8)	13.9 (0.7)
FORBS					
Astragalus leaf	84.1 (1.0)	1.6 (0.2)	69.4 (1.0)	56.4 (0.9)	
Borage leaf			0.1 (0.1)		
Chenopod leaf		2.5 (0.2)			
Delphinium leaf		0.5 (0.1)	0.2 (0.1)		
Descurainia leaf		7.9 (0.1)			
Eriogonum leaf		11.4 (0.3)	3.7 (0.1)	18.2 (0.4)	
Erodium leaf		0.5 (0.1)			
Flower parts	14.2 (0.4)	39.5 (0.7)	3.3 (0.2)	6.1 (0.4)	
Gilia/Linan.lf.		1.0 (0.2)	8.7 (0.6)	6.0 (0.4)	
Legume seed			0.2 (0.1)		
Lupinus leaf		0.9 (0.2)			
Monardella leaf		0.3 (0.1)			
Plantago leaf				0.1 (0.1)	
Salvia leaf		1.0 (0.1)			
Stephanomeria leaf				0.2 (0.1)	
Unknown seed			0.4 (0.1)	0.5 (0.2)	
Total, forbs	98.3 (1.0)	67.1 (1.0)	86.0 (1.0)	87.5 (1.0)	83.9 (1.0)
ANIMAL					
Arthropod parts	1.1 (0.4)	3.4 (0.5)	1.2 (0.3)	0.0	1.2 (0.3)
Total	100.0	99.9	99.9	100.0	99.9
No. samples	5	10	16	17	48
No. individuals	3	10	16	17	46
Mean items/sample	2.4	4.6	4.4	4.6	4.1
range	(1-4)	(2-7)	(2-6)	(2-7)	(1-7)

The importance of forb leaf in March-April 1993 was unusual in comparison to previous years, when shrub leaf was the primary component of relative density in spring samples. Another remarkable finding was the dominance of a single food item, Astragalus leaf, at study sites 1, 3 and 4. This was especially noteworthy because Astragalus has been a fairly frequent perennial on these study sites and yet was not a major food item in past years.

May-June 1993. Table 18 presents food habits results for the May-June sampling period at study sites 1-4. These samples contained substantial amounts of shrub and forb leaf and seed material, but differed widely from site to site in principal food items and in the proportion of shrub and leaf components.

Samples from Study Site 1 were dominated by a single species, Eremalche, which contributed nearly 60 percent of mean relative density from leaf and seed material. This species was an important item in 1988 when MGS were last captured on Site 1, but it has not been a significant component at the other study sites. Eremalche was a consistent part of the diet at Study Site 1; of the 22 usable samples, 15 contained 50 percent or more Eremalche leaf and seed. Among other samples, two were made up primarily of unknown seeds, and one each of Krascheninnikovia leaf and Astragalus leaf. Three contained no items comprising over 50 percent relative density.

Samples from Study Site 2 were overwhelmingly dominated by Krascheninnikovia leaf, which averaged 93 percent of mean relative density. The samples from this site were extraordinary in that all 24 of the usable samples contained more than 80 percent relative density of this species. Considering the great diversity of shrubs at this site and the relatively high production of annuals in 1993, this consistent preference for a single food item is very unusual.

Samples from Study Site 3 had a more equal proportion of shrub and forb materials, with Krascheninnikovia leaf and legume seed being the most important food items, comprising 43 and 36 percent of mean relative density, respectively. Individual samples tended to contain a predominance of a single food item, but differed in the preferred item consumed. Twelve samples contained 50 percent or more of Krascheninnikovia, while 11 contained primarily legume seed, one sample contained mainly Sphaeralcea leaf, and three had no single predominant item. Unfortunately, the Composition Analysis Lab could not determine whether the legume seed belonged to the genus Lupinus or to Astragalus, both well-represented on the site.

Study Site 4 samples contained primarily Krascheninnikovia leaf, which averaged over 75 percent of relative density. Only one other food item, Astragalus leaf, at 12 percent, contributed substantially to mean relative density. Of 24 usable samples, 20 contained 50 percent or more of Krascheninnikovia, while one each

Table 18. Summary of food habits results for Mohave ground squirrels at study sites 1-4 in May-June 1993. 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 1 (Rose Valley)	Site 2 (Coso Basin)	Site 3 (Cactus Peak)	Site 4 (Pumice Mine)	Mean relative density all sites
GRASSES AND ALLIES					not useful - sites are different
Achnatherum (Oryzopsis)		0.4 (0.1)			
Bromus	1.2 (0.3)	0.8 (0.3)	2.9 (0.4)	0.4 (0.2)	
Schismus	0.2 (0.1)	0.6 (0.2)		0.1 (0.1)	
Total, grasses	1.4 (0.3)	1.8 (0.5)	2.9 (0.4)	0.5 (0.2)	1.6 (0.4)
SHRUBS					
Atriplex leaf	2.6 (0.5)	1.1 (0.2)	2.3 (0.3)	1.0 (0.1)	
Ephedra leaf				0.2 (0.1)	
Krascheninnikovia lf	5.8 (0.3)	93.2 (1.0)	43.5 (0.7)	75.8 (1.0)	
Larrea seed			0.1 (0.1)	0.3 (0.1)	
Opuntia stem	0.4 (0.1)	0.2 (0.1)		0.1 (0.1)	
seed	2.1 (0.2)				
Total, shrubs	10.9 (0.7)	94.5 (1.0)	45.9 (0.9)	77.4 (1.0)	57.8 (0.9)
FORBS					
Astragalus leaf	5.0 (0.5)	0.1 (0.1)	4.1 (0.3)	12.3 (0.7)	
Composite seed	2.0 (0.3)	1.5 (0.4)	2.9 (0.3)	1.1 (0.2)	
Eremalche leaf	35.7 (0.9)				
seed	23.3 (0.6)				
Eriogonum leaf	0.3 (0.1)	0.1 (0.1)	0.2 (0.1)		
Erodium leaf	0.1 (0.1)	0.1 (0.1)	0.1 (0.1)		
seed	0.3 (0.1)		0.1 (0.1)		
Flower parts	3.8 (0.4)				
Gilia/Linan.lf.	0.9 (0.2)		3.5 (0.3)	1.5 (0.3)	
Legume seed	2.2 (0.2)	0.1 (0.1)	35.9 (0.8)	3.4 (0.4)	
Lily leaf		0.1 (0.1)			
Lupinus leaf	1.5 (0.1)	0.1 (0.1)	0.6 (0.1)		
Mentzelia leaf	0.3 (0.1)	0.1 (0.1)			
Sphaeralcea leaf	1.4 (0.1)		2.0 (0.1)		
Unknown seed	8.3 (0.5)		0.5 (0.1)	3.0 (0.1)	
Total, forbs	84.1 (1.0)	2.2 (0.5)	49.9 (0.9)	21.3 (0.9)	39.0 (0.8)
OTHER PLANT MATERIAL					
Fungus	0.2 (0.1)	0.4 (0.1)	0.9 (0.1)	0.1 (0.1)	0.4 (0.1)
ANIMAL					
Arthropod parts	1.4 (0.3)	1.1 (0.4)	0.5 (0.1)	0.6 (0.3)	
Bone	0.9 (0.1)				
Total, other	2.3 (0.3)	1.1 (0.4)	0.5 (0.1)	0.6 (0.3)	1.1 (0.2)
Total	99.9	100.0	100.1	99.9	99.9
No.samples	22	24	27	24	97
No.individuals	22	24	27	24	97
Mean items/sample	6.1	3.7	4.5	3.5	4.4
range	(3-10)	(1-7)	(1-8)	(2-6)	(1-10)

was dominated by Astragalus leaf and unknown seed, and two contained about equal amounts of Astragalus and Krascheninnikovia leaf.

Overall, these samples were remarkable for their consistency within study sites and their high proportion of a single shrub species, Krascheninnikovia lanata, at study sites 2, 3 and 4. Preference for this shrub has been seen earlier, as in March-April samples from 1990 and 1992, but in the past the May-June samples have been dominated by annual forb leaf and seed. A possible explanation for the importance of Krascheninnikovia in the diet in early summer 1993 might be that competition from other herbivores was low, permitting MGS to consume the palatable Krascheninnikovia.

Precipitation

Table 19 presents the raingauge results from the LADWP weather station at Haiwee Reservoir. (At the time of this writing, data collected from the five Coso Grazing Exclosure stations could not be verified, and so are not presented here.) Although many agencies maintain records for California on a precipitation year beginning July 1, we used a September 1-August 31 precipitation year to distinguish fall rains from summer thundershowers. Fall rains are presumed to be of more importance to the growth of winter annuals (Bowers 1987).

Table 19. Average and 1992-1993 precipitation records for five stations associated with the Coso Grazing Exclosure, and a nearby station operated by the Los Angeles Department of Water and Power.

Station and Location	Precipitation (in mm) 9/1/92-12/4/92	12/5/92-4/5/93	4/6/93-8/31/93	Cumul., 1992-93	Long-term average
Coso Grazing Exclosure					
Site 1					
Site 2					
Site 3	Data Not Verified				
Site 4					
Sec. 13					
LADWP Haiwee Reservoir	13.7	197.6	2.0	213.3	154.6 (1)

(1) Long-term average based on 1963-92 values (Larson and Monahan 1992).
Source of Haiwee Reservoir data: NAWS Geothermal Program Office (fax from Judy Sprouse dated December 7, 1993).

There was little precipitation during the fall period, September-November. One series of storms during October 24-31 brought all 13.7 mm of the precipitation reported for this period; measurable amounts of rainfall fell on five days. The winter season (December-March) brought substantial rain (20 mm or more) during each of the four months. Storms arrived about 2-4 weeks apart during the period from December through mid-February, followed by some light precipitation in late February, then a final major storm in late March. Essentially no precipitation was recorded during the spring and summer months, April-August.

Overall, the 213 mm of precipitation recorded for 1992-93 was 38 percent higher than the long-term average. Of the 30 years for which records are available for Haiwee Reservoir, eight had precipitation higher than in 1992-93. The distribution of storms was not unusual; the fall and spring periods received very little rain, and most precipitation fell during the winter months.

Standing Crop and Species Richness of Annual Plants

Table 20 presents species frequency, mean standing crop and species richness for the four study sites in 1993. Also, the reader is referred to Appendix I for a summary of species observed throughout the study sites.

Study Site 1. The most frequently-occurring (frequency above 40 percent) species at Study Site 1 were the native annual grass six-weeks fescue (*Vulpia octoflora*), and the non-natives Russian thistle (*Salsola tragus*) and schismus (*Schismus arabicus*). Also occurring frequently were desert-calico (*Loeseliastrum matthewsii*) in between-shrub plots, and pincushions (*Chaenactis stevioides*) and the non-native cheatgrass (*Bromus tectorum*) in under-shrub plots.

Study Site 2. The most frequently-occurring species at Study Site 2 were schismus, six-weeks fescue, purple-rooted cryptantha (*Cryptantha micrantha*), coreopsis (*Coreopsis bigelovii*) and red brome (*Bromus madritensis* ssp. *rubens*). Other frequently-occurring species were western cryptantha (*Cryptantha circumscissa*) in between-shrub plots and pincushions in the under-shrub plots.

Study Site 3. The most frequently-occurring species at this study site were vinegar weed (*Lessingia lemmonnii* var. *ramosissima*) and pincushions. Also present in high frequency were sun-cups (*Camissonia campestris*), Pringle's eriophyllum (*Eriophyllum pringlei*), golden gilia (*Linanthus aureus*), fragrant lupine (*Lupinus odoratus*) and desert-calico in between-shrub plots. Frequently-occurring species in under-shrub plots were wing-nut cryptantha (*Cryptantha pterocarya*), spotted eriogonum (*Eriogonum maculatum*), desert-dandelion (*Malacothrix glabrata*), wild-heliotrope (*Phacelia distans*), and tall stephanomeria (*Stephanomeria exigua*).

Table 20. Frequency and standing crop of herbaceous layer plants in between-shrub and under-shrub plots in May-June, 1993.

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								
Achnatherum speciosum (=Stipa s.)			1		1	5		7	1	8	4	40
Ambrosia acanthicarpa			2									
Amsinckia tessellata					1		6	25		1		
Anisocoma acaulis					1		2	2				
Astragalus lentiginosus			18				9	3	11	6	16	4
Baileya pleniradiata					5	8		1				
Bromus madritensis ssp. rubens (=Bromus rubens)		16	19	35	64	88	22	73	10	45	4	40
Bromus tectorum	4	48	37	49		13	3	9	1	5		
Bromus trinii				6		2	3	24	3	29		32
Calycoseris parryi				1								
Calyptridium monandrum						1						
Camissonia boothii	12	24	11	16	1	2	2	3	20	30	24	40
Camissonia campestris et al.	28	8	14	11	32	17	47	25	12	9	12	4
Camissonia claviformis							1	1				
Caulanthus cooperi						1	1	35		8		12
Centrostegia thurberi (=Chorizanthe t.)			1		14	9	4	35	34	13	16	4
Chaenactis frem./stev.	12	36	33	59	22	64	58	83	9	35	4	32
Chamaesyce albomarginata (=Euphorbia a.)	4	8	3	1			10	5	1		12	
Chamaesyce micromeria (=Euphorbia m.)			2	1			2					
Chorizanthe brevicornu			1			1			1			
Chorizanthe watsonii					3	1	2		5	4		4
Coreopsis bigelovii	60	36	35	18	43	45	35	26				
Cryptantha barbigera							3					
Cryptantha decipiens				2	3	25						
Cryptantha circumscissa		4	7	1	48	21	3	18	39	42	16	28
Cryptantha dumetorum		32		18	1	22		1		2		4
Cryptantha intermedia						1						
Cryptantha micrantha	12	12	6	1	84	64	1	1	1	1		
Cryptantha nevadensis		4		4	1	18		5	1	9		4
Cryptantha pterocarya	12	24	6	21	3	10	8	50	5	60		52
Cryptantha sp.			1	2		1	1	1				
Cuscuta sp.					1	2						
Descurainia pinnata		4			4	8	6	19	3	39	4	56
Descurainia sophia						2						
Elymus elymoides (=Sitanion hystrix)								2		8		
Emmenanthe penduliflora										1		
Eremalche exilis	4	8	3	9						1		
Eriastrum eremicum			2	1			2	1	13	5		
Eriogonum brachyanthum							6	10	3	4	4	8
Eriogonum deflexum			2		2			1				
Eriogonum gracillimum			1				1					
Eriogonum maculatum	44	20	37	34	18	21	34	48	28	42	16	32
Eriogonum nidularium			1				4	8	36	47		8
Eriogonum pusillum				1	5	2	1	7	1	3		4
Eriogonum sp.			2	1	1	3	1		1			
Eriophyllum pringlei	4		16	11	18	8	50	23	70	57	84	44
Eriophyllum wallacei	68	8	24	4	37	16	1					
Erodium cicutarium					16	13						
Eschscholzia minutiflora		4										
Gilia leptomeria/G. micromeria		4	4	3	11	23	9	19	12	40	12	44
Gilia latiflora				1	4	4	22	12	1	26		8
Gilia ochroleuca												
Gilia sinuata												
Gilia sp.		4										
Glyptopleura marginata (=G. setulosa)			2	2	2				1	1		
Langloisia punctata												4
Layia glandulosa										7		
Lepidium flavum var. flavum	4		3	7	8	11	4	1	4	5		
Lepidium lasiocarpum			1	1		2						
Lessingia lemmonii var. r.	60	40	35	20	1	1	87	77	85	82	100	80
Pectocarya recurvata												

(continued on next page)

Table 20 (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.
Linanthus aureus					2	16	51	32	86	72	100	88
Linanthus dichotomus					4	12		9	1	2	4	4
Linanthus parryi					1		1					
Loeseliastrum matthewsii (=Langloisia m.)	84	16	74	2	28	9	43	16	8	4	24	
Lupinus odoratus	28	4	33	12	1	2	59	20	4	7	28	12
Lupinus sp.										1		
Malacothrix coulteri								1				
Malacothrix glabrata	4		2	12	15	39	12	41	1	16		12
Mentzelia albicaulis		12	5	32	1	5	5	28	2	32		48
Monardella exilis	4	4	19	5			13	2	4	2	4	4
Monoptilon bellidiforme	40	8	6									
Nama demissum	12		8				15	3	4	2		
Nemacladus sp.	36		1						1			
Oenothera primiveris	4											
Oxytheca perfoliata			1						1	2		
Pectocarya heterocarpa					9	14						
Pectocarya linearis					1	1						
Pectocarya penicillata					2							
Pectocarya platycarpa											8	
Pectocarya recurvata						2						
Pectocarya setosa							1	1	7	10		
Phacelia distans/P. tanacetifolia		4	1	3		4	3	43		24		60
Phacelia fremontii	8	20	9	9		1	5	25	1	19	4	20
Poa secunda							1	1				
Salsola tragus (=S. iberica)	32	36	69	68			1	1		2		
Salvia carduaceae						1						
Schismus arabicus	80	100	51	71	89	97	7	19	2	13		4
Sphaeralcea ambigua			4			1						
Stephanomeria exigua	4	16	5	13	2	6	8	52	8	55	4	84
Stephanomeria parryi								4				
Stillingia paucidentata				1								
Streptanthella longirostris						1						
Stylocline micropoides				1	4	3	1		2	2		
Syntrichopappus fremontii			9	7	1	1			1	1		
Tiquilia nuttallii (=Coldenia n.)	52	4	22	4								
Thelypodium lasiophyllum						1						
Vulpia microstachys var. pauciflora (=Festuca reflexa)									2	2		
Vulpia myuros var. hirsuta (=Festuca megalura)					1	2		4	2	14		36
Vulpia octoflora (=Festuca o.)	68	44	87	77	65	48	6	10	20	20	8	16
Unknown forb				1		2						
Unknown forb #2				1								
Unknown mustard						1						
SPECIES RICHNESS												
species/sample	7.84	6.12	7.46	6.88	6.98	8.07	7.44	9.82	5.69	9.77	5.12	9.84
range	2-11	2-10	2-13	1-14	0-15	2-15	2-13	3-19	1-12	2-17	3-9	5-18
n=	25	25	100	100	100	100	100	100	100	100	25	25
STANDING CROP												
grams/square foot	2.19	6.77	5.3	6.5	1.36	5.14	4.73	6.55	1.41	3.24	2.08	5.66
n=	25	25	99	100	100	100	90	92	100	100	25	25

*A slash indicates two similar species combined for the purposes of this summary.

Study Site 4. The most frequently-occurring species at this study site were Pringle's eriophyllum, vinegar weed, and golden gilia. Frequently-occurring species in under-shrub plots were red brome, western cryptantha, wing-nut cryptantha, spotted eriogonum, bird's-nest eriogonum (*Eriogonum nidularium*), small gilia (*Gilia leptomeria*), and tall stephanomeria.

Standing crop. In 1993, standing crop was highest at study sites 1 and 3. At both sites, standing crop was about 5 g/sq ft in between-shrub plots and 6.6 g/sq ft in under-shrub plots. Standing crop at study sites 2 and 4 was somewhat lower; both had between-shrub standing crop of 1.4 g/sq ft, while under-shrub standing crop was 5.1 g/sq ft at Study Site 2 and 3.2 g/sq ft at Study Site 4. At many sites, a large amount of standing crop was contributed by non-natives--Russian thistle, schismus, and cheatgrass at Site 1, schismus and red brome at Site 2, and red brome at Site 3.

In comparison with past years, overall primary production of annual plants was good in 1993. Standing crop was on a par with results from 1991 and 1992; although Site 1 had a substantially higher standing crop in between-shrub plots than in any past year. As noted above, non-native grasses and Russian thistle were major contributors there.

Species richness in 1993 was highest at Study Site 3, slightly less at Study Site 4, and lowest at sites 1 and 2. The difference between the study sites was not as pronounced as in some past years, primarily because Study Site 1, which has usually had the lowest species richness, was higher in 1993, both among between- and under-shrub plots.

ACKNOWLEDGMENTS

We acknowledge with deep gratitude the support of the Geothermal Program Office of the U.S. Naval Air Weapons Station, China Lake, the California Department of Fish and Game, and Jean Hopkins and Associates, Inc. for this 1993 study. In addition, we thank California Energy Company, Inc. and MHA Environmental Consulting, who provided administrative support. Finally, we thank Dr. John Harris of Mills College, who collaborated with us on the fieldwork, and the entire Coso Grazing Exclosure crew, who worked long hours in the field to make this study a success.

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APPENDIX I. PLANTS OBSERVED OR EXPECTED IN THE COSO GRAZING EXCLOSURE MONITORING STUDY SITES

(P=perennial species; 93=annual species observed in 1993; X=annual species observed on study site, but not in 1993; e=species expected to occur on or near study site)

PLANT SPECIES	STUDY SITE WHERE OBSERVED 1	2	3	4
AGAVACEAE				
Yucca brevifolia		P	P	P
APIACEAE				
Lomatium mohavense	P			P
ASCLEPIADACEAE				
Asclepias fascicularis				P
ASTERACEAE				
Acamptopappus sphaerocephalus	P	P	P	P
Ambrosia acanthicarpa	93	X		X
Ambrosia dumosa	P	P		
Anisocoma acaulis	93	93	93	X
Artemisia spinescens	P			P
Artemisia tridentata		P		
Baileya pleniradiata	93	93	93	X
Calycoseris parryi	93			93
Chaenactis carphoclinia	e	e	X	X
Chaenactis fremontii	X	X	93	93
Chaenactis stevioides	93	93	93	93
Chaenactis xantiana	X	X	93	93
Chrysothamnus nauseosus		P		
Chrysothamnus teretifolius	P	P	P	P
Chrysothamnus viscidiflorus ssp. puberulus				P
Coreopsis bigelovii	93	93	93	93
Encelia actonii (=E. virginensis ssp. a.)		P		
Ericameria cooperi var. cooperi (=Haplopappus c.)	P	P	P	P
Eriophyllum pringlei	93	93	93	93
Eriophyllum wallacei	93	93	93	93
Glyptopleura marginata (=G. setulosa)	93	93		93
Gutierrezia microcephala		P		P
Hymenoclea salsola var. salsola	P	P	P	P
Layia glandulosa				93
Lepidospartum squamatum	P	P		
Lessingia lemmonii var. ramulosissima	93	93	93	93
Malacothrix coulteri	e	X	93	e
Malacothrix glabrata	93	93	93	93
Monoptilon bellidiforme	93	93		

PLANT SPECIES	STUDY SITE WHERE OBSERVED 1	2	3	4
ASTERACEAE (contd.)				
Niccoletia occidentalis		P		
Psathyrotes annua	X			
Rafinesquia neomexicana		X	93	e
Stephanomeria exigua	93	93	93	93
Stephanomeria parryi	X?	93	93	93
Stylocline micropoides	93	93	93	93
Syntrichopappus fremontii	93	93	X	93
Tetradymia axillaris var. longispina		P	P	P
Tetradymia stenolepis	P	P	P	P
Xylorhiza tortifolia var. tortifolia (=Machaeranthera t.)				P
BORAGINACEAE				
Amsinckia tessellata	93	93	93	93
Cryptantha barbigera	e	93	93	e
Cryptantha circumscissa	93	93	93	93
Cryptantha decipiens	93	93	X	e
Cryptantha dumetorum	93	93	93	93
Cryptantha intermedia		93		X
Cryptantha micrantha	93	93	93	93
Cryptantha nevadensis	93	93	93	93
Cryptantha pterocarya	93	93	93	93
Pectocarya heterocarpa		93		
Pectocarya linearis		93		X
Pectocarya penicillata		93	X	X
Pectocarya platycarpa		93		
Pectocarya recurvata		93	X	X
Pectocarya setosa		93	93	93
Plagiobothrys arizonicus		93		
Tiquilia nuttallii (=Coldenia n.)	93	X		X
Tiquilia plicata (=Coldenia p.)		X		
BRASSICACEAE				
Arabis pulchra var. gracilis			P	P
Caulanthus cooperi	X	93	93	93
Descurainia pinnata	93	93	93	93
Descurainia sophia		93		X
Dithyrea californica	e			
Lepidium flavum	93	93	93	93
Lepidium fremontii		P		P
Lepidium lasiocarpum	93	93	X	X
Stanleya pinnata ssp. pinnata				P
Streptanthella longirostris	X	93	X	e
Thelypodium lasiophyllum	X	93		
Thysanocarpus curvipes				X
Tropidocarpum gracile		e		

PLANT SPECIES	STUDY SITE WHERE OBSERVED 1	2	3	4
CACTACEAE				
Opuntia basilaris var. basilaris		P	P	P
Opuntia echinocarpa var. echinocarpa	P	P	P	P
CAMPANULACEAE				
Nemacladus sp.	93	X	X	93
CHENOPODIACEAE				
Atriplex canescens	P	P	P	P
Atriplex confertifolia	P	P	P	P
Atriplex polycarpa	P	P	P	
Chenopodium rubrum			X	
Chenopodium sp.				X
Grayia spinosa	P	P	P	P
Krascheninnikovia lanata (=Eurotia l.)	P	P	P	P
Salsola tragus (=S. kali var. tenuifolia)	93	X	93	93
CUCURBITACEAE				
Cucurbita palmata		e		
CUSCUTACEAE				
Cuscuta cf. denticulata	X	93	93	93
EPHEDRACEAE				
Ephedra nevadensis		P	P	P
Ephedra viridis				P
EUPHORBIACEAE				
Eremocarpus setigerus	X			
Chamaesyce albomarginata (=Euphorbia a.)	P	P	P	P
Chamaesyce micromera (=Euphorbia m.)	93		93	X
Stillingia paucidentata	P			
FABACEAE				
A. lentiginosus var. variabilis	P	P	P	P
Lupinus bicolor	X			
Lupinus brevicaulis			e	e
Lupinus concinnus	X			X
Lupinus odoratus	93	93	93	93
Lupinus shockleyi		X	X	X
Lupinus subvexus		X		
Lupinus sp.				93
Psorothamnus arborescens var. minutifolius	P	P	P	P

PLANT SPECIES	STUDY SITE WHERE OBSERVED 1	2	3	4
GERANIACEAE				
Erodium cicutarium	X	93	X	X
HYDROPHYLLACEAE				
Nama aretioides	93		X	93
Nama demissum	93	X	93	93
Nama depressum	e	X	e	e
Phacelia distans	93	93	93	93
Phacelia fremontii	93	93	93	93
Phacelia tanacetifolia		X	93	93
Tricardia watsonii		P	P	P
LAMIACEAE				
Monardella exilis	93	X	93	93
Salazaria mexicana		P		
Salvia carduacea		93	e	e
Salvia columbariae		X		X
LILIACEAE				
Calochortus kennedyi			e	e
Dichelostemma pulchella	P	P	P	P
Muilla sp.	P			P
Zigadenus brevibracteatus	e			
LOASACEAE				
Mentzelia albicaulis	93	93	93	93
Mentzelia veatchiana			e	e
Petalonyx thurberi		P		
MALVACEAE				
Eremalche exilis	93	X	93	93
Sphaeralcea ambigua ssp. ambigua	P	P	P	P
NYCTAGINACEAE				
Abronia pogonantha	93	e	X	93
Mirabilis bigelovii		P	P	P
ONAGRACEAE				
Camissonia boothii ssp. desertorum	93	93	93	93
Camissonia campestris	93	93	93	93
Camissonia claviformis ssp. claviformis	X	X	93	e
Camissonia pterosperma	X			
Oenothera primiveris ssp. primiveris	93	93	93	
PAPAVERACEAE				
Eschscholzia minutiflora	93	X		X

PLANT SPECIES	STUDY SITE WHERE OBSERVED 1	2	3	4
PLANTAGINACEAE				
Plantago purshii var. oblonga		e		
POACEAE				
Achnatherum hymenoides (=Oryzopsis h.)	P	P	P	P
Achnatherum speciosum (=Stipa s.)	P	P	P	P
Bromus madritensis ssp. rubens (=B. rubens)	93	93	93	93
Bromus tectorum	93	93	93	93
Bromus trinii	93	93	93	93
Elymus elymoides (=Sitanion hystrix)	P	P	P	P
Poa secunda (=P. scabrella)	e	P	P	P
Schismus arabicus	93	93	93	93
Vulpia microstachys var. pauciflora (=Festuca reflexa)		X	e	93
Vulpia octoflora (=Festuca o.)	93	93	93	93
POLEMONIACEAE				
Eriastrum eremicum	93	X?	93	93
Eriastrum sapphirinum				X
Gilia cana ssp. cana (=G. latiflora ssp. cosana)	93	93	93	93
Gilia leptomeria	93	93	93	93
Gilia micromeria	93	93	93	93
Gilia ochroleuca			X	X
Gilia sinuata				93
Langloisia setosissima ssp. punctata (=L. punctata)	X			93
Loeseliastrum matthewsii (=Langloisia m.)	93	93	93	93
Linanthus aureus		93	93	93
Linanthus dichotomus		93	93	93
Linanthus parryae	X	93	93	X
POLYGONACEAE				
Centrostegia thurberi (=Chorizanthe t.)	93	93	93	93
Chorizanthe brevicornu	X	93	X	93
Chorizanthe rigida	X			X
Chorizanthe watsonii	X	93	93	93
Eriogonum brachyanthum		X	93	93
Eriogonum deflexum	93	93	93	93
Eriogonum fasciculatum ssp. polifolium	P	P	P	P
Erioginum gracillimum	93	X	93	X
Eriogonum inflatum		P		

APPENDIX II. FIELD SURVEY FORMS FOR COSO GRAZING EXCLOSURE MONITORING STUDY

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. PREGNANT (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 1993 HERBACEOUS FREQUENCY AND STANDING CROP DATA SHEET

DATE_____ STUDY SITE____ LOCATION_____ OBSERVERS_____

(write in addt'l. species below!) *=name change SPECIES STDG CROP.	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
*Achnatherum speciosum (Stip)																				
Amsinckia tessellata																				
Anisocoma acaulis																				
Astragalus lentiginosus																				
*Bromus madritensis rubens																				
Bromus tectorum																				
Camissonia campestris+al																				
Camissonia claviformis																				
Caulanthus cooperi																				
*Centrostegia thurb.(Chor)																				
Chaenactis fremont/stev																				
*Chamaesyce albomarg.(Euph)																				
*Chamaesyce micromera(Euph)																				
Chorizanthe brevicornu																				
Chorizanthe watsonii																				
Coreopsis bigelovii																				
Cryptantha circumscissa																				
Cryptantha decipiens																				
Cryptantha dumetorum																				
Cryptantha micrantha																				
Cryptantha nevadensis																				
Cryptantha pterocarya																				
Descurainia pinnata																				
Eremalche exilis																				
Eriastrum eremicum																				
Eriogonum macul.brachy.																				
Eriogonum nidularium																				
Eriogonum pusillum																				
Eriophyllum pringlei																				
Eriophyllum wallacei																				
Erodium cicutarium																				
Gilia leptomeria/micro.																				
Gilia latiflora/cana																				
*Glyptopleura marginata																				
Lepidium flavum v. fl.																				
Lessingia lemmonii v.r.																				
Linanthus aureus																				
Linanthus dichotomus																				
Linanthus parryi																				
*Loeseliastrum matthewsii																				
Lupinus odoratus																				
Malacothrix glabrata																				
Mentzelia albicaulis																				
Monardella exilis																				
Nama demissum																				
Pectocarya heterocarpa																				
Pectocarya linearis																				
Pectocarya setosa																				
Phacelia distans/tanac.																				
Phacelia fremontii																				
*Salsola tragus (=S. iberica)																				
Schismus arabicus																				
Sphaeralcea ambigua																				
Stephanomeria exigua																				
Stillingia paucidentata																				
Stylocline micropoides																				
Syntrichopappus fremon.																				
*Tiquilia nuttallii(Cold)																				
*Vulpia octoflora (Fest)																				

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

Abronia pogonantha
*Achnatherum hymenoides (=Oryzopsis h.)
Ambrosia acanthicarpa
Arabis pulchra var. gracilis
Baileya pleniradiata
Bromus trinii
Calycoseris parryi
Calyptridium monandrum
Camissonia boothii ssp desertorum
*Castilleja angustifolia (=C. chromosa)
*Castilleja exserta ssp. venusta
(=Orthocarpus purpurascens var. ornatus)
Chaenactis carphoclinia
Chaenactis xantiana
Chorizanthe rigida
Cryptantha barbigera
Cryptantha intermedia
Cuscuta sp.
Delphinium parishii
Descurainia sophia
Dichelostemma pulchella
*Elymus elymoides ssp. elymoides
(=Sitanion hystrix)
Eriogonum gracillimum
Eriogonum reniforme
Eschscholzia minutiflora
Gilia ochroleuca
Gilia sinuata
*Guillenia lasiophyllum
(=Thelypodium l.)
*Langloisia setosissima ssp. punctata
(=Langloisia p.)
Layia glandulosa
Lepidium lasiocarpum
Linanthus dichotomus
Lomatium mohavense
Lupinus bicolor
Lupinus brevicaulis
Lupinus concinnus ssp. orcuttii
Lupinus shockleyi
Malacothrix coulteri
Mentzelia veatchiana
Microseris linearifolia
Mimulus bigelovii
Mirabilis bigelovii
Monoptilon bellidiforme
Muilla maritima
Nama aretioides
Nemacladus sp.
Nicolletia occidentalis
Oenothera primiveris
Oxytheca perfoliata
Pectocarya platycarpa
Pectocarya recurvata
Pectocarya penicillata
Phacelia tanacetifolia
*Plantago patagonica
(=P. purshii var. oblonga)
Poa secunda
Petalonyx thurberi
Psathyrotes annua
Rafinesquia neomexicana
Salvia columbariae
Sisymbrium altissimum
Streptanthella longirostris
Thysanocarpus curvipes
Tricardia watsonii
*Vulpia reflexa