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April 28, 2010

Commissioner Anthony Eggert, Presiding Member
Vice Chair James D. Boyd, Associate Member
Mr. Craig Hoffman, Project Manager
Abengoa Mojave Solar Project (09-AFC-5)
California Energy Commission
1516 Ninth Street
Sacramento, CA 95814

Re: Abengoa Mojave Solar Project (09-AFC-5): Responses to CURE's Data Requests, Set 1 – for which Extension of Time Requested

Dear Commissioners Eggert and Boyd:

Abengoa Solar Inc. (the "Applicant") hereby files these written responses to certain data requests in CURE's Data Requests - Set 1 promulgated by CURE on March 17, 2010. An extension of time was requested for these responses on April 6, 2010.

Thank you for your time and consideration of this matter.

Sincerely,

Christopher T. Ellison
Shane E. Conway
Ellison, Schneider & Harris, L.L.P.

Attorneys for Abengoa Solar Inc.

Attachment

MOJAVE SOLAR PROJECT
RESPONSES TO CURE'S DATA REQUESTS, SET 1

25. Please discuss how the lack of annual plants in the sampling area during the 2006 and 2007 Mohave ground squirrel trapping surveys may have influenced Mohave ground squirrel trapping results.

    Response:

    There is no reason to believe that the relative scarcity of annual plants in 2006 and 2007 influenced Mohave ground squirrel trapping results in those years. The winter of 2004-05 brought very high rainfall and food resources were abundant during spring 2005. As a result, there was good reproduction and survival in Mohave ground squirrel populations throughout its range in 2005. Population levels were high for the next two years and Mohave ground squirrels were successfully captured elsewhere in both 2006 and 2007. The species was captured by live-trapping at 29 locations in 2006 and 21 locations in 2007. In fact, a Mohave ground squirrel was observed and captured adjacent to an alfalfa field within the Project Area in 2007. This strongly suggests that if Mohave ground squirrels had been present elsewhere within the Project Area, they would have been detected visually or by trapping.

27. Please clarify whether Dr. Leitner conducted assessments of Mohave ground squirrel habitat at the Project site beyond what is presented in Dr. Leitner's May 1, 2008 report.

    Response:

    No, Dr. Leitner did not conduct additional habitat assessments beyond what is presented in his May 1, 2008 report.

29. Please provide a copy of the Leitner and Leitner (1998) study cited in the Mohave ground squirrel habitat assessment.

    Response:

    A PDF version of this report is provided with these responses.

30. Please clarify whether the Leitner and Leitner (1998) study cited in the Mohave ground squirrel habitat assessment tested Mohave ground squirrel food *requirements* or whether it collected observational data on food *preferences*.

Response:

The dietary study cited utilized 754 fecal samples collected at 4 study sites over a period of 9 years. The results of this analysis revealed what Mohave ground squirrels actually ate – males and females, juveniles and adults, spring and summer, in wet and dry years. This is by far the most complete and comprehensive study of Mohave ground squirrel diet to date. It would not be feasible to conduct studies of food requirements on a listed species, since animals would have to be kept in captivity for long periods and fed experimental diets to determine the needed intake of calories and various nutrients. The value of such a study would be extremely questionable because of the lack of appropriate natural foods and the artificial conditions in which the experimental animals would have to be kept.

31. Please provide any studies that support the conclusion that two years of negative trapping results indicate absence of a permanent Mohave ground squirrel population.

Response:

It seems logical that if trapping is carried out in an appropriate manner with a sufficient number of traps to effectively sample the area of interest, the absence of captures over two years would indicate that a population is not present. If there are no animals detected for two years, then *ipso facto* a permanent population would appear to be absent. This could not rule out the possibility that a transient animal could briefly intrude on the area during a period when trapping was not under way. There do not appear to be any studies in which Mohave ground squirrels were detected (visually or by other means) but trapping failed to capture the observed animals.

32. Please provide criteria used to define "permanent population" with regards to a Mohave ground squirrel population, especially in the context of the organism's adaptive population dynamics.

Response:

A permanent Mohave ground squirrel population is one that occupies a site continuously over a period of several years, through both wet and dry winters. Although there have been few long-term population studies of this species, examples of such populations are provided in Leitner and Leitner (1998).

33. Please provide a reference to scientific literature that supports the AFC's conclusion that small, isolated patches of allscale (such as the ones present on the Project site) cannot support resident populations of Mohave ground squirrels.

Response:

There is no evidence available in any form (published or unpublished) that demonstrates the occurrence of Mohave ground squirrels on small, isolated patches of monotypic allscale that have become established on formerly disturbed lands.

34. Please identify the "protocol trapping efforts in monotypic allscale stands on abandoned agricultural land in Kern and Los Angeles counties" referenced on page 5.3-53 of the AFC.

Response:

The protocol trapping effort in Kern County was conducted by Phoenix Ecological Consulting in 2009 and involved five grids located approximately 1-3 miles east of the town of Mojave. The protocol trapping effort in Los Angeles County was conducted by Environmental Science Associates in 2006 and involved six grids located about 10 miles east of Rosamond.

35. Please provide evidence that Mohave ground squirrels were known to occur in other habitats in the vicinity of the referenced Kern and Los Angeles counties trapping efforts.

Response:

Mohave ground squirrels were detected at two locations near the six Kern County protocol trapping sites. One location was in Mojave Creosote Bush Scrub 4.4 miles to the north and the second location was in Mojave Mixed Woody Scrub 6.3 miles to the east. Mohave ground squirrels were detected at four locations near the seven Los Angeles County protocol trapping sites. Three locations were in Halophytic Saltbush Scrub 5.5 miles northeast, while the fourth location was in Halophytic Saltbush Scrub 3.5 miles northeast.

36. Please confirm that in his status review, Leitner (2008) accurately reported "[p]rotocol trapping has been conducted at 52 grid locations in the desert portion of Los Angeles County during the period 1998-2007, but no Mohave ground squirrels have been detected by this method."

Response:

It can be confirmed that Leitner (2008) accurately reported that "Protocol trapping has been conducted at 52 grid locations in the desert portion of Los Angeles County during the period 1998-2007, but no Mohave ground squirrels have been detected by this method."

37. Please indicate how many of the Mohave ground squirrel trapping efforts in Kern and Los Angeles counties referenced on page 5.3-53 of the AFC were south of State Route 58.

Response:

All of the Mohave ground squirrel trapping efforts in Kern and Los Angeles counties referenced on page 5.3-53 of the AFC were located south of State Route 58.

40. Please clarify whether the AFC's reference to the Project Area being "inspected again in April 2008", and during which there was no sign of Mohave ground squirrels or active burrows, refers to Dr. Leitner's single site visit or a different survey effort.

Response:

This reference in the AFC is to the site visit conducted by Dr. Leitner on April 13, 2008.

41. Please indicate the vegetation communities for which Mohave ground squirrel presence is assumed.

Response:

The Applicant has not assumed presence of the Mohave ground squirrel in any vegetation communities or land cover types within the Project Area.

43. Please indicate which of the vegetation communities discussed in the AFC do not provide food or cover resources for Mohave ground squirrels, and cite to scientific literature or that supports applicant's conclusion(s).

Response:

The following vegetation communities or land cover types discussed in the AFC do not provide the appropriate combination of food and cover resources necessary for the long-term survival of Mohave ground squirrels. The presence of one or a few resources that may be used by the species is irrelevant.

Disturbed-Desert Saltbush Scrub
Alkali Marsh
Desert Sink Scrub
Unvegetated Dry Lake
Tamarisk Scrub
Disturbed
Disturbed – Saltbush Scrub Regrowth

Fallow Agricultural – Saltbush Scrub Regrowth
Fallow Agricultural – Ruderal
Active Agricultural
Developed
Evaporation Pond

Evidence for this conclusion may be found in Gustafson (1993). In addition, this conclusion is based upon Dr. Leitner's more than 30 years of experience studying the species.

44. Please discuss the measures that will be implemented to avoid and minimize impacts to Mohave ground squirrels.

Response:

General avoidance and minimization measures as described in pages 5.3-41 through 5.3-42 of the AFC, and BIO-12 of the Staff Assessment Conditions of Certification will be implemented to avoid and minimize impacts to Mohave ground squirrels.

COSO GRAZING EXCLOSURE MONITORING STUDY

MOHAVE GROUND SQUIRREL STUDY
COSO KNOWN GEOTHERMAL RESOURCE AREA
MAJOR FINDINGS
1988-1996

FINAL REPORT

by

Philip Leitner and Barbara Malloch Leitner
2 Parkway Court
Orinda, CA 94563

May 1998

Table of Contents

Executive Summary

During the nine-year period from 1988 through 1996, extensive studies of the Mohave ground squirrel (*Spermophilus mohavensis*) were conducted in the Coso region of southwestern Inyo County, California.

This research was carried out as part of the Coso Mohave Ground Squirrel Mitigation Program, which was designed to address impacts to the Mohave ground squirrel resulting from geothermal energy development within the Coso Known Geothermal Resource Area.

The mitigation program included the establishment of the Coso Grazing Exclosure which removed domestic livestock grazing from approximately 43,500 acres of desert habitat, and provided the funding for a long-term ecological investigation, the Coso Grazing Exclosure Monitoring Study (the Study).

The **Coso Grazing Exclosure Monitoring Study** focused on two objectives:

1) evaluation of the effectiveness of the habitat improvements brought about as a result of the removal of domestic livestock grazing, and

2) development of information regarding the habitat requirements of the Mohave ground squirrel that would be of value in the conservation of the species.

The Study collected three years of baseline data (1988 - 1990) prior to the establishment of the Coso Grazing Exclosure in December 1990. This was followed by six years of monitoring studies (1991 - 1996) designed to evaluate the effects of the Exclosure and to provide long-term data on the biology of the Mohave ground squirrel.

The research program consisted of five major elements:

1. **Selection of permanent study sites**
   Selection of four permanent study sites, study sites 2 and 3 within the Coso Grazing Exclosure and study sites 1 and 4 in areas that have remained open to domestic livestock grazing;
2. **Mohave ground squirrel live trapping**
   Live trapping of Mohave ground squirrels to establish their distribution and abundance on the four study sites;
3. **Vegetation surveys**
   Characterization of the shrub and herbaceous vegetation within the study sites;
4. **Herbivore diet analysis**
   Documentation of the diet of the principal vertebrate herbivores, (Mohave ground squirrels, antelope ground squirrels, black-tailed jackrabbits, feral burros and domestic cattle) by collecting and analyzing fecal samples; and
5. **Meteorological data**
   Collection of monthly data on precipitation and temperature at five stations (begun in 1989)

This report describes and summarizes the major findings of the research program over the full nine years of the Study. A total of eight detailed reports covering all results of the Study have been issued previously (see Section VIII - References). Annual reports are available for the period from 1988 through 1994, while the 1995-1996 data were presented together as a single volume.

An earlier summary report entitled A Comparison of the Diets of Mohave Ground Squirrels and Cattle - Results of a Long-term Study in the Coso Region of Inyo County, Philip and Barbara M. Leitner, May 1996 focuses more specifically on one aspect of the study, the dietary overlap between Mohave ground squirrels and domestic cattle. There is some repetition between these two reports, which is intentional to ensure that each report may be read independently.

The major findings of the Coso Grazing Exclosure Monitoring Study

New information has been developed on Mohave ground squirrel population biology

The Study has provided a substantial amount of new information on population dynamics and habitat relationships, including population parameters such as longevity, survivorship, sex ratios, and age at first reproduction, as well as long-term trends in abundance in relation to winter precipitation and habitat quality.

Winter precipitation affects Mohave ground squirrel abundance and reproduction

Trends in Mohave ground squirrel abundance over the nine-year study were dominated by the extreme year-to-year fluctuations in winter precipitation. The Study has demonstrated that the success or failure of reproduction in Mohave ground squirrel populations is strongly correlated with precipitation totals during the preceding winter. Reproduction is dependent on specific minimal levels of winter rainfall and spring annual plant production. Mohave ground squirrels undertake reproduction only in those years when food production, in the form of annual herbaceous plants, is adequate to ensure success.

Radio-telemetry has yielded new data on Mohave ground squirrel home range and movement

Radio-telemetry research has documented variation in adult Mohave ground squirrel home range size and movements that is correlated with winter precipitation and food availability. Studies of the movements of young Mohave ground squirrels show that juvenile males are more likely to disperse from the natal area than juvenile females. Young males were found to disperse from 500 to 1400 meters in their first summer, considerably farther than young females who generally moved from 200 to 300 meters.

Habitat quality is critical for Mohave ground squirrel persistence though drought

In severe drought years, Mohave ground squirrels may enter dormancy in poor nutritional condition and survivorship may be low. The Study has demonstrated that in drought episodes, Mohave ground squirrel populations may fail to persist in low quality habitat,

but survive in areas of higher habitat quality from which they may expand again under better conditions.

The Study has identified habitat features, particularly the presence of certain key shrub species, that may be of great importance in determining Mohave ground squirrel abundance levels and ability to persist through drought periods.

Information on Mohave ground squirrel diet has been expanded

The Study has provided details of food habits of the Mohave ground squirrel that were previously unknown. The findings include a comprehensive view of the overall composition of the diet, the temporal pattern of variation within the active season, differences in the diet between drought and non-drought years, the range of variation among individuals in a population, and dietary overlap between Mohave ground squirrels and domestic livestock. A significant finding of the Study is the fact that shrub leaf makes up a large proportion of the diet and is especially important in drought years.

Dietary overlap exists between Mohave ground squirrels and domestic livestock

A comparison of the Mohave ground squirrel diet with that of cattle and sheep in the Coso region has revealed important dietary overlap between the ground squirrel and the two types of livestock. The discovery that both livestock and Mohave ground squirrels depend heavily on a shrub species (winterfat) that is relatively uncommon is a completely new finding.

List of Tables

List of Figures

Section I - Purpose of Report

This report summarizes the major findings of the Coso Grazing Exclosure Monitoring Study (the Study), a long-term field investigation of the biology of the Mohave ground squirrel. The research was conducted from 1988 through 1996 at four sites in the Coso region of southwestern Inyo County, California.

This report describes and summarizes the major findings of the research program over the full nine years of the Study. A total of eight detailed reports covering all results of the Study have been issued previously (see Section VII - References). Annual reports are available for the period from 1988 through 1994, while the 1995-1996 data were presented together as a single volume.

An earlier summary report entitled A Comparison of the Diets of Mohave Ground Squirrels and Cattle - Results of a Long-term Study in the Coso Region of Inyo County, Philip and Barbara M. Leitner, May 1996 focuses more narrowly on dietary overlap between the Mohave ground squirrel and cattle. There is some repetition between these two reports, which is intentional to ensure that each report may be read independently

Section II - Coso Grazing Exclosure Monitoring Study

- The long-term ecological research described in this report was carried out as part of the Coso Mohave Ground Squirrel Mitigation Plan, which was designed to address impacts to the Mohave ground squirrel resulting from geothermal energy development within the Coso Known Geothermal Resource Area (Coso KGRA).
- The mitigation program included the establishment of the Coso Grazing Exclosure, which removed domestic livestock grazing from approximately 43,500 acres of desert habitat, and provided the funding for the Coso Grazing Exclosure Monitoring Study.
- The research conducted under the Coso Grazing Exclosure Monitoring Study included three years of baseline studies (1988 - 1990) and six years of monitoring (1991 - 1996) following the establishment of the Coso Grazing Exclosure in December 1990.
- The research consisted of these major elements:
    1. live-trapping studies of Mohave ground squirrel populations to measure trends in abundance at four study sites, two within and two outside the Coso Grazing Exclosure;
    2. characterization of the shrub and herbaceous vegetation within the four study sites;
    3. documentation of the diet of the principal vertebrate herbivores (Mohave ground squirrel, antelope ground squirrel, black-tailed jackrabbit, feral burro, and cattle) by collecting and analyzing fecal samples.
    4. collection of monthly data on precipitation and temperature at five stations in the Coso region.
- The locations of the four permanent study sites selected for the Coso Grazing Exclosure Monitoring Study are shown in Figure 1. Study sites 2 and 3 are within the boundaries of the grazing exclosure, while study sites 1 and 4 are located outside, in areas that have remained open to livestock use. Figures 2 through 5 are photographs showing the general aspect of vegetation and topography on the four sites.

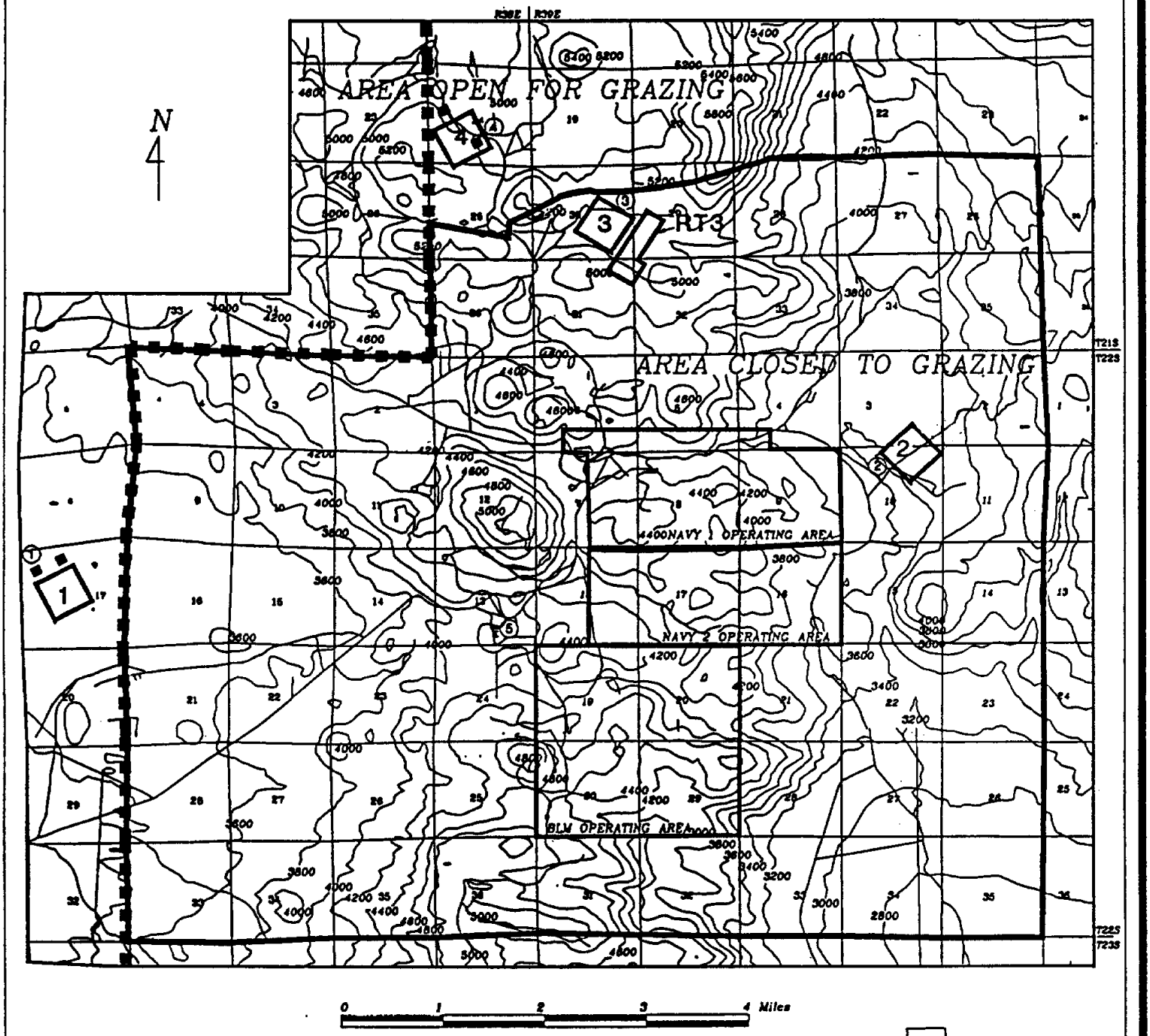


Figure 1

COSO GRAZING EXCLOSURE MONITORING STUDY

LOCATION OF STUDY AREA AND STUDY SITES

91EXCL 3/14/91

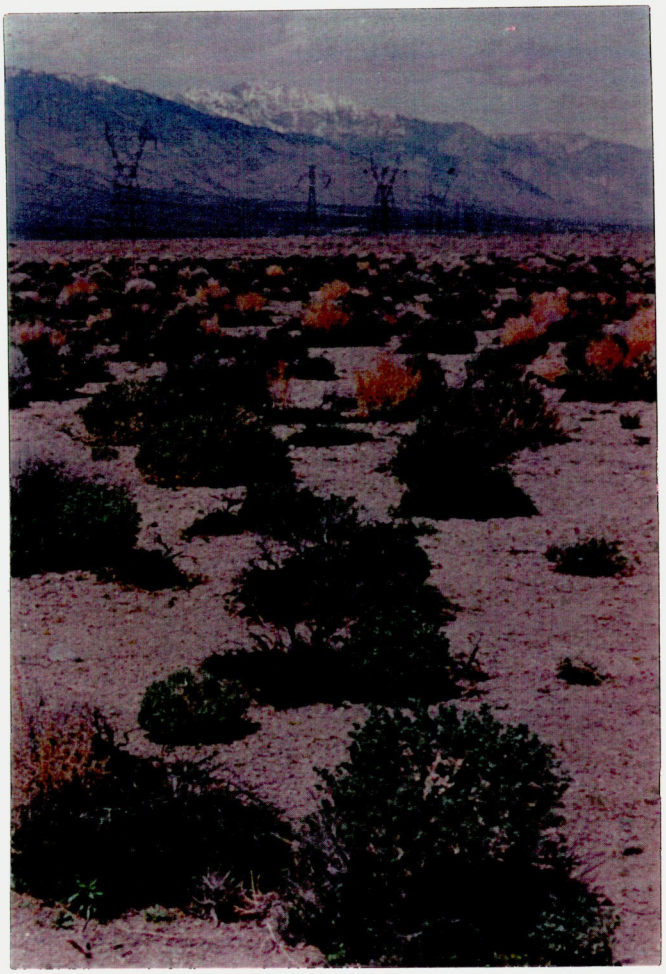
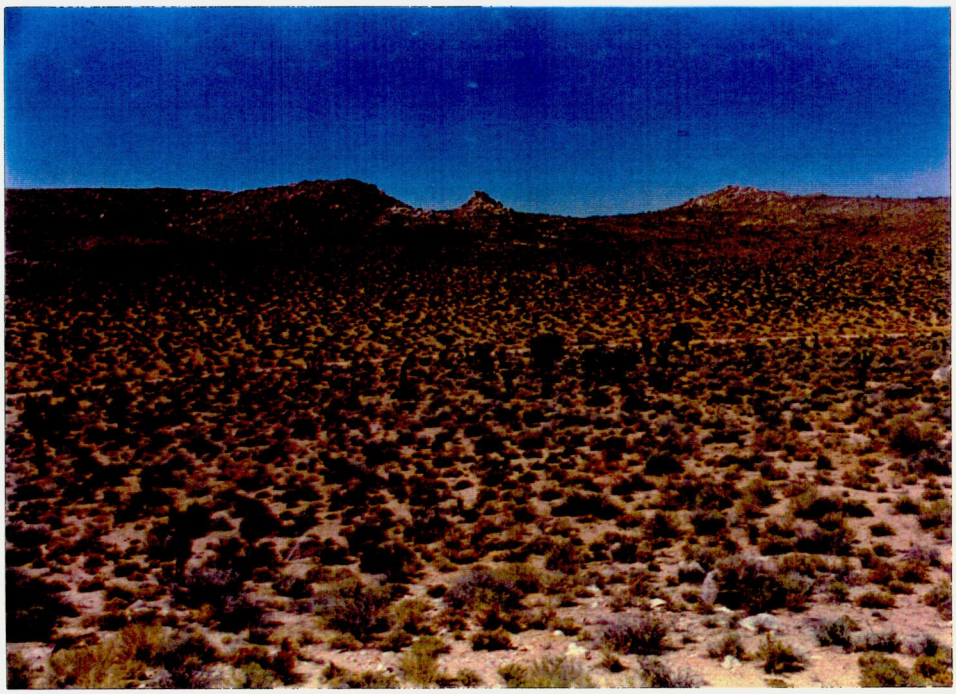


Figure 2
Photograph of Study Site 1

Figure 3 - Photograph of Study Site 2

Figure 4 - Photograph of Study Site 3

Figure 5 - Photograph of Study Site 4



Section III - Background on the Mohave Ground Squirrel

The Mohave ground squirrel (Spermophilus mohavensis) is found only in the western Mojave Desert of California, where it has been recorded in a variety of shrub-dominated plant communities. It is a diurnal burrowing rodent about nine inches in total length, with a pelage that is uniformly brown above and white on the underparts (Figures 6 and 7). Mohave ground squirrels are active in spring and summer, when the desert environment is most likely to provide the green vegetation that they require. They spend the rest of the year underground in a state of physiological dormancy (estivation/hibernation), surviving on fat reserves accumulated during their brief active period. These animals are not easily observed, since their color blends well with the desert soil and they quickly take refuge in burrows when approached.

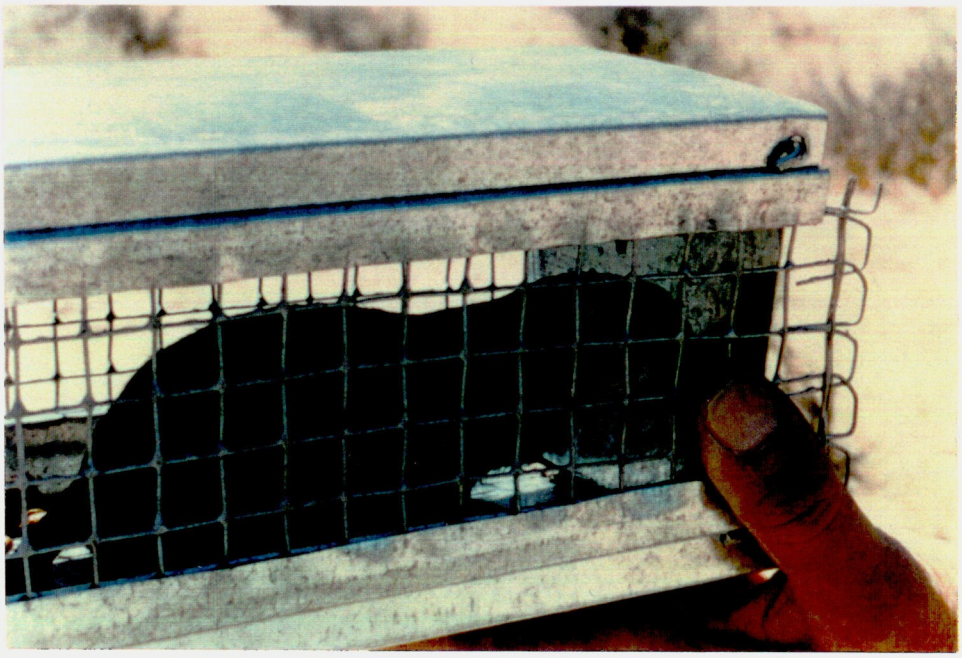
Not only is the geographic range of the species quite restricted, but its distribution appears to be patchy and discontinuous within apparently suitable habitat. Even in areas where Mohave ground squirrels are present, they are usually far from abundant and can often be difficult to capture.

The Mohave ground squirrel was listed as Rare by the California Fish and Game Commission in 1971 under authority of the State Endangered Species Act of 1970. This decision was based upon an internal status review by California Department of Fish and Game staff and an evaluation by outside experts, who referred to its limited distribution and relatively low abundance. When the revised California Endangered Species Act became law in 1985, the Mohave ground squirrel and all other species designated as Rare were automatically re-classified as Threatened, in order to bring state terminology into conformance with the definitions of the federal Endangered Species Act of 1973.

In 1993, the California Fish and Game Commission voted to remove the Mohave ground squirrel from the state list of Threatened species, a decision that was subsequently litigated. The California Court of Appeal ruled the delisting decision to be invalid because the Commission had not followed legally mandated procedures. The California State Supreme Court acted in July 1997 to uphold this ruling. As a result, the Mohave ground squirrel retains its protected status as a Threatened species under California law.

Figure 6
Photograph of a Mohave ground squirrel

Figure 7
Photograph of a live trap containing a Mohave ground squirrel



Although the Mohave ground squirrel was first described as a newly-discovered species over 100 years ago (Merriam, 1889), there has been very little scientific study of the most basic aspects of its natural history. Most of the information that is available on the biology of the Mohave ground squirrel has come from laboratory investigations of its physiology, development, and behavior.

- The physiological aspects of estivation and body temperature regulation in this species were described by Bartholomew and Hudson (1960) and its physiological and behavioral adaptations to the desert environment were compared to those of the antelope ground squirrel (*Ammospermophilus leucurus*) (Bartholomew and Hudson, 1961).
- Additional laboratory studies regarding the effect of environmental variables on dormancy were carried out by Pengelley (1969) and Pengelley and Kelly (1966). Growth and development of young Mohave ground squirrels under laboratory conditions were described by Pengelley (1966).
- Behavioral interactions between individual Mohave ground squirrels and between Mohave ground squirrels and antelope ground squirrels were observed in a controlled setting by Adest (1972).
- Finally, Hafner and Yates (1983) investigated the relationship between the Mohave ground squirrel and a similar species, the round-tailed ground squirrel (*Spermophilus tereticaudus*), that ranges through the eastern Mojave Desert into Arizona. Using evidence from karyotypic (chromosomal) and protein analysis, they concluded that the Mohave ground squirrel is a distinct species, although the two taxa are closely related and show a high level of genetic similarity.

While a number of research papers have presented data on the Mohave ground squirrel that were collected under laboratory conditions, very few field studies have been carried out. After the Mohave ground squirrel was listed as a Rare species in 1971, a series of live-trapping surveys were conducted by the California Department of Fish and Game and the U.S. Bureau of Land Management in order to better define the distribution of the species (Hoyt 1972; Wessmann 1977; Aardahl and Roush 1985).

The most complete information to date on the behavior of the Mohave ground squirrel in its natural habitat was provided by Recht (1977). This study was carried out near Lancaster, Los Angeles County, in the southern part of the species range and utilized radio-telemetry to follow the activities of a sample of four adult and five juvenile animals.

Detailed observations on home range, daily activity patterns, foraging and weight gain, and thermoregulatory behavior were made during the spring and summer of 1974.

Prior to the present investigation, there have been no reported field studies of the Mohave ground squirrel that documented basic population parameters or compared ecological data for multiple sites over more than one year. The lack of data on the most fundamental aspects of Mohave ground squirrel ecology is perhaps not surprising, considering the cryptic behavior, patchy distribution, and low abundance of the species. Nonetheless, it has severely handicapped efforts to conserve and manage the species and has contributed to the recent controversy regarding its protected status.

Section IV - Methods

Section IV. A - Location and Configuration of Study Sites

Figure 1 shows the location of the four study sites. Study sites 1 and 4 are in areas that continue to be open to domestic livestock grazing; study sites 2 and 3 are within the area excluded from grazing. Study sites 1 and 2 are low-elevation sites, at 1160-1225 meters (3600-3800 feet); sites 3 and 4 are higher, both at about 1600 m (5000 ft). Each study site is a square measuring 500 m (1640 ft) on a side, with an area of 25 hectares (61.8 acres). They are located in vegetation characterized as Desert Saltbush Scrub or Mohave Mixed Woody Scrub. Each study site contains a 21 by 21 array of permanently marked trap stations spaced 25 m apart, for a total of 441 trap stations.

Section IV. B - Ground Squirrel Trapping and Population Estimates

Section IV. B. 1 - Live-trapping Methods

Generally, a trapping session consisted of two days of pre-baiting followed by five days of mark-recapture sampling using a standard live-trapping technique. The bait used was a commercially available horse feed. A Pymatuning or Sherman live trap was placed beside or under a shrub within 1-3 m of the stake marking the trap station. In warm weather the traps were placed under a cardboard shelter for more complete shading. Traps 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. To avoid heat stress to captured animals, the temperature inside a closed, sheltered trap was monitored, and all traps were checked and closed if the temperature in the test trap reached 39°C.

Captured squirrels were identified to species, sex, and age class (adult/juvenile). On first capture, body weight and reproductive condition were recorded. Prior to 1990, each captured ground squirrel was marked with a small aluminum ear tag numbered for individual identification. Since 1990, individual identification consisted of a passive integrated transponder (PIT) tag implanted subcutaneously. PIT tags are lost at a very low

rate compared to ear tags, providing a more effective permanent record of individual identity. All data pertaining to a particular capture were recorded on standard field data forms and the animal then released unharmed.

Table I shows the times at which live-trap sampling was conducted each year of the study. In 1988, the first baseline year, trapping was carried out from late May through June because previous studies had suggested that all adults and juveniles were active above-ground at this time. However, limited sampling in March and April 1989 on Study Site 3, combined with the results of the regular trapping session in June clearly indicated that some of the adults which had been active in the spring were already dormant by early summer. Thus, in 1990 two trapping sessions (late March-early April and late May-early June) were initiated at all study sites in order to adequately sample both adult and juvenile age classes.

Table 1

Trapping periods for the Coso Grazing Exclosure Monitoring Study (See note)

May-June 1988	5 days trapping, all sites
March 1989	5 days trapping, 132 stations, Site 3 only, no pre-baiting
April 1989	5 days trapping, 132 stations, Site 3 only, no pre-baiting
May-June 1989	5 days trapping, all sites
March-April 1990	5 days trapping, all sites
May-June 1990	3 days trapping, 121 stations, all sites, no pre-baiting
May-June 1991	3 days trapping, 121 stations, all sites, no pre-baiting
April 1992	5 days trapping, all sites
May-June 1992	5 days trapping, all sites
March-April 1993	5 days trapping, all sites
May-June 1993	5 days trapping, all sites
March-April 1994	5 days trapping, all sites
May-June 1994	5 days trapping, all sites
March-April 1995	5 days trapping, all sites
May-June 1995	5 days trapping, all sites
March-April 1996	5 days trapping, all sites
May-June 1996	5 days trapping, all sites

Note: Unless otherwise stated, trapping was conducted at 441 trap stations on each site and was preceded by two days of pre-baiting.

Section IV. B .2 - Mohave Ground Squirrel Abundance and Population Estimates

Five measures of abundance were used to express the number of ground squirrels present on each study site or to estimate population density:

1) total number of animals captured on a study site;
2) 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;
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.

Measure 1 is self-explanatory. Measures 2, 3, 4, and 5 are described in more detail below:

Measure 2 and Measure 4 - Numbers and population density of resident animals

Resident animals were defined as those that met the following criteria:

a) were captured on two or more days during the five-day trapping session; and
b) had 50% or more of all captures recorded at trap stations not on the periphery of the grid; or 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.

Measure 3 - Population size using mark-recapture methods.

The mark-recapture data gathered on each study site were 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. Such an assumption is reasonable for this 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.

Measure 5 - 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).

Two measures of animal movement were selected 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). Only movement data from resident individuals was used, and the distance moved was calculated 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 study site by pooling data from resident individuals. Data from males and females were always pooled, since there were no significant differences between the sexes in distance moved between captures.

Section IV.C - Radio-telemetry Studies

Section IV. C. 1 - Radio-telemetry Procedures

Radio-telemetry studies were carried out on separate study sites adjacent to study sites 2 and 3 in 1990. In 1994, 1995, and 1996, subsequent radio-telemetry research was conducted only at the location near Study Site 3, designated as Radio-telemetry Site 3

(RT3). A live-trapping grid was utilized to capture Mohave ground squirrels for radio-telemetry studies. Captured animals were equipped with radiocollars, each carrying a 5-gram transmitter and an antenna built into a flexible collar that fitted snugly around the animal's neck. The sex, age, reproductive condition, and body weight were recorded for all captured Mohave ground squirrels. During later radio-telemetry work, individual animals were captured occasionally in order to determine body weight and collect fecal samples for food habits analysis.

Radiocollared Mohave ground squirrels were located using portable receivers. Locations were determined by following radio signals until a squirrel was either seen or located within 2 m by signal strength and direction. Each location was recorded by measuring compass bearing and distance of the animal from the nearest trap station. Attempts were made to locate each squirrel at least once on each day of radio-telemetry field work. Radio-telemetry studies were conducted when trapping was in progress on the regular grids, as well as at other times during the active season of the Mohave ground squirrel.

An animal was judged to be estivating if it was located by radio-telemetry in the same burrow on two or more succeeding days. To confirm that it was inactive, several baited traps were placed in the immediate vicinity of the burrow. Lack of capture success was considered to be another indication that the animal had entered estivation. On each subsequent radio-telemetry occasion, all estivating animals were checked to determine that they had not moved.

Section IV. C. 2 - Home Range Estimation

Home range size was estimated by using map locations derived from radio-telemetry. All location data were plotted and home range size calculated with the microcomputer program McPAAL (Stuwe and Blohowiak 1985). Two kinds of home range size estimates were made for each individual: (1) the minimum convex polygon and (2) the 95 percent ellipse. These are the most frequently used methods for estimating home range size (White and Garrott 1990).

Home ranges of Mohave ground squirrels on study sites 1, 2, 3, and 4, were estimated from live-trapping data only. The size of the home range was calculated by determining the area within an ellipse drawn around the mapped trap stations at which the individual was captured. Home range size was calculated using data only from resident animals that

were captured three or more times and that appeared to have stable home range locations.

Section IV. D - Herbivore Food Habits

The diet of the Mohave ground squirrel and other vertebrate herbivores was studied by the microscopic examination of undigested food material found in fecal samples. Fecal samples from the two ground squirrel species were obtained by removing three fresh fecal pellets from the trap where the animal was captured. The pellets were placed in a small labeled envelope, then all remaining fecal pellets cleared from the trap. For black-tailed jackrabbits, burros, sheep, and cattle, up to 10 fecal samples were collected at each study site where fresh material was available.

Fecal samples were analyzed for botanical composition at the Composition Analysis Laboratory, Fort Collins, Colorado. Each fecal sample was prepared and processed in the laboratory and transferred to a microscope slide for the identification of discernible plant fragments and other food materials. Twenty fields containing at least three identifiable plant fragments were examined on each slide using a phase-contrast microscope at 100X power. The number and identity of discernible 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.

Section IV. E - 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 weather station in Section 13, T22S R38E. Several millimeters of mineral oil are placed in the collection tube to prevent evaporation of precipitation between readings. The gauges were installed on February 6, 1989, and are serviced, usually monthly, by reading precipitation levels, emptying the collection tube, and then cleaning and recoating with mineral oil.

Section IV. F - Vegetation Surveys

Section IV. F. 1 - Herbaceous Sampling

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 m^2 (1 ft^2). The plots were located randomly in the vicinity of alternate trapping stations. In addition, 25 between- and under-shrub plots were randomly selected in each pair of "mini-exclosures" at study sites 1 and 4. Within each plot, all herbaceous plant species present were recorded. Annual grasses, annual forbs and perennials with non-persistent above-ground parts were clipped at ground level, placed into a labeled envelope and later air-dried and weighed.

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

Section IV. F. 2 - Shrub Sampling

Shrub sampling has been carried out to characterize the species composition, cover, frequency, density and condition of the shrubs present at each study site. Line-intercept transects were located between trap stations along north-south lines. Species and length of intercept (to the nearest 10 cm) were recorded for each shrub intercepted, as well as maximum shrub width perpendicular to the intercept, height, and an index of live canopy cover.

Section V - Results

Section V. A - Introduction

The Coso Grazing Exclosure Monitoring Study has resulted in a comprehensive set of biological data that spans nine years at four study sites. Originally designed to investigate the response of Mohave ground squirrel populations to the removal of domestic livestock grazing, it has yielded a wealth of new insights into the biology of the species under natural conditions.

Important new findings have included the relation of winter rainfall to reproduction; timing of critical events in the annual cycle; characteristics of the home range; movement patterns of both adults and juveniles; food habits of the Mohave ground squirrel and other major herbivores; and many aspects of population dynamics.

The long-term nature of this study has afforded the opportunity to investigate the responses of Mohave ground squirrel populations to the highly variable winter rainfall regime characteristic of the western Mojave Desert. During the past nine years, precipitation in the Coso region for the period Sept. 1-Mar. 31 has varied from 20 mm (1989-1990) to 230 mm (1994-1995). As a result, it has been possible to document the dramatic effects on this desert ecosystem of a greater than 10-fold range in winter precipitation totals.

Another advantage of this study has been the ability to collect detailed longitudinal data on individual animals marked for permanent identification with passive integrated transponder (PIT) tags and collar-mounted radiotransmitters. These techniques have made it possible to study reproductive patterns, survivorship and longevity, food habits, body weight, home range, and movements in relation to key environmental variables such as winter rainfall, annual plant production, and shrub layer composition.

Section V. B - Reproductive Biology

One of the most significant findings of this study has been the complete absence of Mohave ground squirrel reproduction in 1989, 1990, and 1994. Reproductive failure was correlated with low fall and winter precipitation and with low standing crop of

annual herbaceous plants. In each of the three years with no recruitment of young, the rainfall total for the period Sept. 1-Mar. 31 was below 65 mm and mean herbaceous standing crop was well below 1.0 g/ft^2. On the other hand, the years with successful reproduction (1988, 1991, 1992, 1993, and 1995) were preceded by fall and winter rainfall totals above 85 mm and herbaceous standing crop greater than 1.0 g/ft^2.

Precipitation during the 1995-96 fall and winter season was 77 mm, falling somewhat below the apparent 85 mm threshold for reproduction. Standing crop of annual herbaceous plants was low at the Coso study sites in 1996, well below 0.5 g/ft^2 on study sites 2, 3, and 4. There was no evidence of reproduction in the Mohave ground squirrel populations on study sites 2, 3, and 4. However, two juvenile males were captured in Rose Valley in late May, one in the northeast corner of Study Site 1 and another on an adjoining auxiliary trapping grid.

Mean herbaceous standing crop at Study Site 1 was about 0.5 g/ft^2, measured after intensive sheep grazing which removed much plant material. Mean standing crop at the other three sites was less than one-half of this value. It is likely that local conditions allowed the successful production of one or more Mohave ground squirrel litters to the east or north of Study Site 1 in 1996. The 1996 results seem to provide additional support for a threshold model which relates winter precipitation and spring annual plant production to reproduction in the Mohave ground squirrel.

Section V. C - Annual Activity Cycle

Recht (unpublished) has reported that Mohave ground squirrels first emerge from hibernation between mid-January and late February. In an effort to establish the timing of emergence in the Coso region, limited live-trapping was conducted on study sites 2 and 3 at various times in late February and early March in 1994, 1995, and 1996. The number of Mohave ground squirrels captured on these occasions was much lower than during the subsequent trapping periods in late March-early April. These data suggest that less than 50 percent of the total adult population is active in early March and that very few (about 10 percent) have emerged from hibernation by late February. Because of temperature variation as a function of elevation, Mohave ground squirrels at elevations of 1200 to 1600 m (3600 to 5000 ft) may emerge later than animals at the lower elevation sites studied by Recht.

The pattern of entry into estivation varies from year to year. In general, the abundance of herbaceous plant growth and the occurrence of reproduction appears to be correlated with late entry into estivation. In 1995, abundant winter rainfall resulted in a substantial herbaceous standing crop and there was successful Mohave ground squirrel reproduction. The radio-telemetry data show that all adults and juveniles were active through mid-June and that adults and many juveniles had entered estivation by the end of July. A few juveniles were still active at the end of August. These results are consistent with those of Recht (1977), who reported radiocollared adults to enter estivation from the end of June through mid-August, while juveniles entered dormancy from mid-July through early September.

By contrast, in 1994 and 1996, both low-rainfall years, there was no juvenile recruitment. In the absence of the high energy demands associated with reproduction, most adult Mohave ground squirrels fattened quickly to pre-estivation body weights (180 g or more). By the end of April 1994, 4 of 9 radiocollared animals had already entered dormancy and 8 of 9 were inactive by mid-June of that year. Results were comparable in 1996, with 6 of 13 radiocollared Mohave ground squirrels in estivation by mid-May and 12 of 13 dormant by the end of June. In 1990, the most severe drought year of the study period, there was almost no annual herbaceous growth and shrub foliage was the principal source of water and nutrition for these animals. The radiocollared ground squirrels that were followed through the active season were unable to reach and maintain adequate pre-estivation body weights and none entered estivation before mid-May. Five of these individuals entered dormancy between May 16 and June 21, while the remaining animal remained active into late June or early July.

Recht (unpublished) reported that adult Mohave ground squirrels undergo a remarkable change in body weight during their active period, emerging from hibernation in early spring at weights of 75-85 grams and fattening to 180-220 grams just prior to entry into dormancy again in mid-summer.

The Coso study has confirmed this general pattern, but has indicated that there can be significant differences among age classes within a Mohave ground squirrel population. Since most individuals trapped in 1994 could be assigned to a known age class, it was possible to show that mean body weights in the spring were strongly related to age. Yearlings in late March-early April averaged only 121 grams, while individuals 3 years or

more of age were heaviest, with a mean weight of 180 grams. This suggests that yearlings had emerged from hibernation with essentially no fat reserves, while older animals had already attained pre-estivation weight by early April.

Section V. D - Home Range and Movements

Radio-telemetry studies have yielded extensive data on Mohave ground squirrel home range and movements in the Coso region. The use of spatial resources in this species seems to vary as a function of rainfall, forage production, and reproductive condition. In three of the four years in which radio-telemetry studies were conducted (1990, 1994, 1996), winter precipitation was low and no reproduction occurred at the radio-telemetry site (Table 2). Mean home range size in 1990, an extremely dry year with no herbaceous production, was significantly greater than in 1994 and 1996, years of moderate drought with some herbaceous production. In 1990, radio-collared Mohave ground squirrels carried out frequent intra-day movements of 200 to 400 meters, moving much longer distances than in 1994 or 1996. Mohave ground squirrels reproduced in 1995, following a winter with abundant rainfall. In that year, home range size of adult females was intermediate between the large home ranges recorded in 1990 and the significantly smaller home ranges of 1994 and 1996.

Table 2

Number of Mohave Ground Squirrels Studied With Radio-telemetry in 1990, 1994, 1995, and 1996. Winter Rainfall and Mohave Ground Squirrel Reproductive Status Indicated for Each Study Year.

YEAR	1990	1994	1995	1996
RAINFALL (mm) Sept. 1-Mar. 31	20 mm (severe drought)	58 mm (moderate drought)	ca. 230 mm (high rainfall)	ca. 60 mm (moderate drought)
REPRODUCTION	No	No	Yes	No
SAMPLE SIZE	12 adults	16 adults	5 adults, 13 juveniles	15 adults

It seems likely that the very large home ranges and extensive movements observed in 1990 were a direct consequence of meager food resources and the need to travel long distances to find sufficient food. In 1994 and 1996, the density of food resources was adequate to allow non-reproductive adults to fatten for estivation without undertaking

long foraging movements. The additional energy demands of pregnancy and lactation in 1995 may have made it necessary for adult females to utilize larger home ranges than in 1994 or 1996.

The 1995 radio-telemetry study provided data on the movement patterns of juvenile Mohave ground squirrels during their first summer. A total of 13 juvenile Mohave ground squirrels from several litters were equipped with radiocollars in early June, shortly after weaning. The natal burrow (place of birth) was known for most of these juveniles and, in many cases, their movements were followed until they entered estivation later in the summer.

During early June, juveniles of both sexes regularly undertook exploratory excursions of up to several hundred meters, often returning to their natal area within the same day. By the end of June, young Mohave ground squirrels had usually taken up new locations at some distance from their natal burrows. The data strongly suggested that juvenile males tended to disperse farther than young females. While most juvenile females settled within 200 to 300 meters of their natal area, several males moved over 500 meters, and one entered estivation at a site more than 1400 meters (0.85 mi.) distant from the radio-tracking grid. This represents by far the longest movement ever recorded for a Mohave ground squirrel and contrasts with the previously accepted image of the species as extremely sedentary.

Section V. E - Food Habits

Section V. E. 1 - Summary of Prior Knowledge

In spite of the protected status of the Mohave ground squirrel, little was known of its food habits prior to the Coso study. Recht (1977) made visual observations of the feeding behavior of eight radio-collared individuals at a study site near Lancaster (Los Angeles County) from April through August 1974.

Recht (1977) reported that they fed almost exclusively on one plant species at any given time, but that the particular food item being utilized shifted through the season. His observations began in early April, when Mohave ground squirrels were seen to consume boxthorn (*Lycium* sp.). Soon after, they switched to coreopsis (*Coreopsis* sp.), then to fiddleneck (*Amsinckia tessellata*) and finally to Russian thistle (*Salsola tragus*).

Recht (1977) concluded that the ground squirrels selected as their primary food the plant species that had the highest water content and was the most abundant at a particular time. In the only other report on their diet, Zembal and Gall (1980) noted that Mohave ground squirrels in the Coso region heavily utilized the seeds of Joshua trees when they were available.

Recht (1977) suggested that the Mohave ground squirrel could be viewed both as a specialist, seeking out and consuming largely one food item at a time, and a generalist, taking a sequence of food items as they became available. Zembal and Gall (1980) recorded Mohave ground squirrels exploiting a relatively scarce but palatable food resource. Both studies relied entirely on visual observations. The most comprehensive effort was that of Recht (1977), since it followed eight radio-collared animals through a full season. The amount of information presented in these reports is impressive given the difficulty inherent in studying this wary, cryptic animal.

While consistent with earlier food habits observations, the Coso study provides a much more detailed picture of the Mohave ground squirrel diet. As might be expected from its scope, methods and duration, this investigation has revealed considerable seasonal, year-to-year, site-to-site, and individual variation in the food items selected by the Mohave ground squirrel.

Section V. E. 2 - The Coso Study: An Overview of the Mohave Ground Squirrel Diet

The Coso study has shown that Mohave ground squirrels feed on a wide variety of food items, but primarily the foliage and seeds of forbs (broadleaf herbaceous plants) and shrubs. They also consume flower parts, fungus, roots, Joshua tree leaves and seeds, and grasses, as well as animal material, consisting primarily but not exclusively of invertebrates.

A significant and unexpected result of this research is the high degree of dependence on shrubs shown by the Mohave ground squirrel. Shrub material, mostly foliage, averaged over 45 percent mean relative density among the total of 751 samples analyzed in this study. The shrubs contributing most to mean relative density were winterfat (*Krascheninnikovia lanata*) (averaging 18 percent of mean relative density overall), spiny hopsage (*Grayia spinosa*) (12 percent), and saltbush (*Atriplex* sp.) (7 percent).

Forb materials made up nearly 42 percent of mean relative density of the samples analyzed. The taxa contributing most to the total were rattleweed leaf (*Astragalus lentiginosus*); *Gilia* and *Linanthus* leaf and seed (two closely related genera); composite leaf, flower and seed; white mallow (*Eremalche exilis*) leaf and seed; and buckwheat leaf (*Eriogonum* sp.). Many other plant taxa contributed small amounts to the Mohave ground squirrel diet. Some of the herbaceous taxa that are most abundant in the Coso region appeared only occasionally and to a minor extent in the fecal samples analyzed: *Camissonia, Mentzelia, Phacelia,* and members of the families Boraginaceae and Brassicaceae.

Section V. E. 3 - Seasonal Variation in the Mohave Ground Squirrel Diet

In the Coso region, Mohave ground squirrels emerge from hibernation in February and early March when herbaceous vegetation is developed only slightly or not at all. Analysis of fecal samples collected in spring 1989, early in the Mohave ground squirrel's active period, showed that shrub leaf comprised over 90 percent of relative density in March, decreasing to about 12 percent in April when forbs were at their peak. Shrub leaf again made up a larger proportion of the diet in late May, probably because herbaceous material had become dry.

The progression from a shrub leaf-dominated diet early in the active period to a forb-dominated one later appears quite consistent. Data from 1994, 1995, and 1996 confirmed that shrub leaf made up a very high proportion of the diet in early to mid-March, when forbs were not yet well-developed. Mohave ground squirrels greatly increased their consumption of forbs from late March through April and then often reverted to shrub material as forbs dried out in May and June. However, the data also suggest that the timing of the transition to forbs and then back to greater reliance on shrubs may vary from year to year depending on the timing of winter and spring rains and the phenology of forb growth, reproduction, and desiccation.

Section V. E. 4 - Variation in the Mohave Ground Squirrel Diet Between Drought and Non-Drought Years

In the nine years of the Coso study, one year was so dry that virtually no herbaceous material was produced, and in several years the annual herbaceous growth was

extremely low and consisted mainly of non-native annual grasses rarely consumed by the Mohave ground squirrel. Clearly, the mainstay of the Mohave ground squirrel diet must be something more reliable than ephemeral annuals.

This study has established the critical importance of shrub leaf when forbs are scarce, particularly the special reliance upon the foliage of winterfat, spiny hopsage and saltbush. It is also noteworthy that the Mohave ground squirrel makes heavy use of *Astragalus*, one of a small number of perennial herbs on the study sites, and a species that appears in all but the most extremely dry years.

During drought years, the Coso food habits data show that Mohave ground squirrels depended to a great extent on shrub leaf and seed to sustain them during their active period. During non-drought years, Mohave ground squirrels consumed primarily forb and other materials as they were available.

Section V. E. 5 - Individual Variation in the Mohave Ground Squirrel Diet

On every study site and at every trapping session, we found individual variation in the contents of fecal samples taken from different Mohave ground squirrels. Most individual samples contained 50 percent or more of a single food item, but the dominant food item differed among animals.

For example, in the May-June samples collected from Study Site 2 in 1992, 18 out of 27 samples contained more than 50 percent mean relative density of a single food item, but five different food items were present as predominant among these samples. This finding supports the conclusion of Recht (1977) that Mohave ground squirrels continuously sample available foods in the environment, but take primarily one or two types of food within one feeding period.

Section V. E. 6 - Consumption of Intermittently Available Foods by the Mohave Ground Squirrel

Our results revealed that Mohave ground squirrels would readily utilize intermittently available food items. For example, Joshua trees occurred on study sites 3 and 4 and, like Zembal and Gall (1980), we observed Mohave ground squirrels harvesting Joshua tree fruits and seeds. However, the fruits were present for only a brief period in late spring or

early summer and, even then, not reliably in every year. Although Mohave ground squirrels would readily take Joshua tree fruits when available, this material was found only rarely in fecal samples. It is possible that the seeds were not consumed when harvested, but stored for later use.

In 1989, a dry year following several wet years, there was a very high seed set in the shrub *Lycium andersonii*, a member of the tomato family, especially at study sites 2 and 3. The fruits of this species are fleshy red berries about 3 mm in diameter. *Lycium* fruit and seed in Mohave ground squirrel fecal samples taken during the May-June trapping period averaged 74 and 91 percent relative density on study sites 2 and 3, respectively. This was the only occasion on which *Lycium* fruit figured as a major dietary item.

In May-June 1991 there was an enormous hatching of lepidopteran larvae (caterpillars) of several species. Local observers said the last time they had seen that phenomenon was in the mid-1960s. Although few Mohave ground squirrels were captured in 1991, arthropod fragments, mostly lepidopteran larvae, ranged from 15 to 70 percent of mean relative density in the fecal samples analyzed.

A final example illustrates the consistent exploitation of a rare and intermittent resource. Cactus of the genus *Opuntia* make up less than 0.05 percent cover on all study sites, and less than 0.01 percent on study sites 1 and 2. They occasionally produce large, soft fruit containing many small seeds. Although the plants themselves are uncommon on the study sites, and the fruits are produced only every few years on an individual plant, *Opuntia* seed averaged 2.5 percent of mean relative density in the 751 samples analyzed. The preference index for this food item was by far the highest of any food item calculated (Leitner and Leitner 1996).

Section V. E. 7 - Dietary Overlap between the Mohave Ground Squirrel and Domestic Livestock

Several important points have emerged from the comparison of cattle and Mohave ground squirrel food habits to date. First, winter range allotments such as the Lacey-Cactus-McCloud (including study sites 2, 3 and 4) are generally used by cattle from November through May. Until late March or early April, when annual plants have achieved enough growth to provide a food source, cattle must depend on the available forage which consists of shrubs and dead herbaceous material, mostly grasses. On winter range,

therefore, livestock utilize perennial (usually shrubby) material as a protein source, and consume dead grasses as a nitrogen-poor carbohydrate source.

The Coso Grazing Exclosure food habits study confirms that cattle consume primarily grass and shrub material. In the 220 cattle samples analyzed, grasses comprised 40 percent of mean relative density, shrub leaf 40 percent, and forbs and miscellaneous plant material made up the remainder. Winterfat alone accounted for over 24 percent of mean relative density in the cattle diet, while saltbush contributed about 13 percent of the total. Unlike the deciduous spiny hopsage and box-thorn, winterfat and saltbush keep their leaves year-round, making them available as winter forage for cattle.

Winterfat is the shrub species most preferred and taken in largest quantity by both cattle and Mohave ground squirrels. However, it is not a dominant shrub species, never exceeding 1.5 percent absolute cover and 9 percent relative cover in the shrub layer on the four Coso study sites. Therefore, winterfat represents a significant element of dietary overlap for these two herbivore species. While there is also dietary overlap between cattle and Mohave ground squirrels for saltbush, it is a much more common shrub and is not as highly preferred by either herbivore.

In both 1995 and 1996, sheep were present in Rose Valley during April and May. Fecal samples were collected on Study Site 1 in both years. In 1995, following a high rainfall winter, sheep fed primarily upon the abundant forbs (51 percent of mean relative density) and grasses (32 percent of mean relative density). Shrub material comprised only about 17 percent of the diet. It was noteworthy that winterfat accounted for three-quarters of the shrub component, since it is rare in Rose Valley and made up just 0.01 percent cover on Study Site 1. In 1996, after a dry winter, shrub leaf comprised 51 percent of mean relative density in sheep fecal samples and almost 99 percent of the shrub material was winterfat. Grasses and forbs each contributed about 25 percent of the diet in that year. As with cattle, it appears that there is substantial dietary overlap between sheep and Mohave ground squirrels for winterfat, a scarce food item that is highly preferred and of key importance in dry years.

Section V. F - Population Dynamics

A long-term investigation of Mohave ground squirrel population dynamics was conducted from 1988 through 1996 on four sites within the Coso region. Study sites 2 and 3 were located within the boundaries of the Coso Grazing Exclosure, while study sites 1 and 4 were in areas that remained open to domestic livestock grazing. Live-trapping was used throughout the study to collect mark-recapture data for estimation of Mohave ground squirrel abundance and population densities. All animals captured were marked for permanent individual identification, first with metal ear tags, then since 1990 with the more reliable passive integrated transponder (PIT) tags.

This study has provided the first information on Mohave ground squirrel longevity and survival patterns. Several individuals marked as juveniles in 1988 survived the severe 1989-1990 drought episode and reached five years of age, the maximum lifespan thus far recorded for the species. In general, overall survivorship of juveniles is quite low; the majority do not persist to reach one year of age. Evidence from radio-telemetry and weight gain patterns suggests that juvenile survivorship is low because of predation and the frequent failure of juveniles to accumulate sufficient fat reserves for their first season of dormancy. However, once individual ground squirrels successfully reach yearling status and become established in a home range, survivorship tends to be high.

A consistent feature of Mohave ground squirrel populations is the high ratio of females to males. In samples of the adult population in the spring, when all animals are active above-ground, observed ratios range from 7:1 to 1.3:1 with an average of approximately 2.6 females per male. When the juvenile population is first sampled at about two months of age in late May-early June, typical ratios are about 1.5 females per male. Since the sex ratio at birth is unknown, it is not clear whether males and females have different survival rates during the first two months of life. However, it does appear that a higher proportion of juvenile females than males survive to reach adult status, as shown by the higher female to male ratio in the adult population.

Data on reproductive condition have been recorded for all individuals captured in the course of the Mohave ground squirrel population studies. This has made it possible to document age at first reproduction, a critical demographic parameter that was previously unknown for the species. These data have demonstrated that in years when reproduction does occur, females of all age classes (including yearlings) produce young. Reproduction

among adult males is generally restricted to individuals two years of age or older, since yearling males rarely come into reproductive condition. These results suggest that the ratio of females to reproductive males is even higher than would be expected from overall adult sex ratios that include the yearling males.

Trends in Mohave ground squirrel abundance on the four Coso study sites during this nine-year study have been dominated by the extreme year-to-year fluctuations in fall and winter precipitation.

In 1988, the first year of the study, moderate numbers of juvenile Mohave ground squirrels were recorded on all four study sites. The western Mojave Desert then experienced a drought lasting almost three years. There was no significant precipitation from the spring of 1988 until late February-early March of 1991, when a series of late-season storms resulted in substantial herbaceous growth.

The absence of Mohave ground squirrel reproduction in 1989 and 1990, combined with extremely limited food resources, led to a dramatic decline in abundance. Although limited trapping in late May-early June 1991 demonstrated that reproduction had taken place, the surviving adult population was minimal. The only Mohave ground squirrels captured were three adult females, two on Study Site 2 and one on Study Site 3; the juveniles were born so late in 1991 that they were still confined to the natal burrows during the trapping period.

Rainfall was well above the long-term average over the next two winters and Mohave ground squirrel populations responded in a very positive manner. By early summer of 1993, record numbers of juvenile Mohave ground squirrels were captured on all four study sites. In spring 1994, the total of adult Mohave ground squirrels on all four study sites reached 115, the highest level observed during this study. Lack of sufficient rainfall during the 1993-1994 winter resulted in reproductive failure, however, and the total of adults in spring 1995 declined to 54. Recruitment of young in 1995, along with improved survivorship, was reflected in an increase to 89 adults on all four study sites in spring 1996. With almost complete reproductive failure again in 1996, adult Mohave ground squirrel populations at the Coso study sites would be expected to be substantially reduced in spring 1997.

Although it is clear from this study that the overwhelming influence on Mohave ground squirrel population dynamics is variation in winter precipitation and the resulting herbaceous plant production, site-to-site variation in habitat characteristics seems to be a significant mediating factor, as well.

In particular, Mohave ground squirrel abundance on Study Site 1 in Rose Valley has followed a different pattern from that observed on the other three study sites. Moderate numbers of juvenile Mohave ground squirrels have been captured throughout Study Site 1 only twice, once in 1988 and again in 1993.

The species was not present on this site during the period 1989-1992. A few adult females have been found here each year since 1993, but they have been restricted to a small area on the northeastern edge of the site. This is also the only portion of Study Site 1 where the production (as opposed to the presence) of young has been documented.

In 1995 and 1996, supplementary trapping in a 250 x 500 m area adjoining the northeastern edge of Study Site 1 established the presence of a sparse adult Mohave ground squirrel population. In 1995 and 1996, a few juveniles were trapped there, as well as on the adjoining northeastern strip of Study Site 1 itself. On the other hand, most of the area of Study Site 1 appears to conform to the definition of a population "sink", habitat of relatively poor quality where reproduction is not sufficient to maintain a population. Individuals found in sink habitats are primarily immigrants from more-productive "source" areas nearby where reproduction produces a surplus of dispersing young (Pulliam, 1988). If most of Study Site 1 is, in fact, low quality habitat that acts as an ecological "sink", it could explain the presence of juvenile Mohave ground squirrels throughout Study Site 1 in 1988 and 1993 and their subsequent failure to persist.

It would appear that: (1) the habitat on Study Site 1 was inadequate to support a Mohave ground squirrel population through the severe drought which lasted from summer 1988 through spring 1991; and (2) the site was not recolonized until 1993, two years after the drought was broken. In order for successful recolonization, a few animals must have been able to persist through the drought in nearby habitat (perhaps to the north and east). By spring 1993, a few Mohave ground squirrels had dispersed from the postulated drought refugium to reach the northeast edge of Study Site 1. In the period 1993-1996,

conditions were favorable enough to allow a small population to persist in this portion of the site and in adjoining habitat.

In contrast to Study Site 1, Mohave ground squirrel populations on the other three sites persisted throughout the 1988-1991 drought, although at greatly reduced levels of abundance. A comparison of the habitat characteristics of the four sites reveals major differences in the properties of the shrub layer that may help to explain the unique population dynamics of Study Site 1. In particular, Study Site 1 differs from the others in having a lower diversity of shrubs and a considerably lower percent cover of live shrubs.

Winterfat and spiny hopsage, the two shrub species that are most highly preferred as forage by the Mohave ground squirrel and that appear to be most important as a food source under drought conditions, are almost entirely absent from Study Site 1. These two shrubs are relatively abundant on the other three study sites. It may be particularly significant that the northeastern edge of Study Site 1 and the areas adjoining it that seem to have the best habitat suitability for the Mohave ground squirrel also support (very sparse) populations of winterfat and spiny hopsage.

Thus, this study has demonstrated for the first time that in drought episodes, Mohave ground squirrel populations may fail to persist in low quality habitat, but survive in areas of higher habitat quality (drought refugia) from which they may expand again under better conditions. It has also identified habitat features, particularly the presence of certain key shrub species, that may be of great importance in determining Mohave ground squirrel abundance levels and ability to persist through drought periods.

The results of these population studies suggest that differences in habitat quality between sites (shrub vegetation) and between years (winter rainfall) may be the most important factors in explaining spatial and temporal variation in Mohave ground squirrel presence and abundance throughout its range.

Section VI. Conclusions

Section VI. A - Reproductive Biology

Precipitation totals during the fall and winter are strongly correlated with the success or failure of reproduction in Mohave ground squirrel populations during the following spring. Reproduction failed to occur on all four Coso study sites in 1989, 1990 and 1994. In each of these years, the rainfall total for the preceding September 1 - March 31 period was below 65 mm and the mean standing crop of annual herbaceous plants was well below 1.0 g/ft^2. A threshold model for reproduction is proposed for this species, with the decision to reproduce dependent on winter rainfall and annual plant production attaining specific minimal levels.

The reproductive strategy of the Mohave ground squirrel is well adapted to the uncertain winter rainfall of the western Mojave Desert. The species undertakes reproduction only in those years when food production in the form of annual herbaceous plants is adequate to ensure success. In years when winter precipitation is insufficient for reproduction, Mohave ground squirrels channel all surplus energy into fat reserves, thus maximizing their probability of surviving the long period of dormancy and emerging in good condition the following spring.

Section VI. B - Annual Activity Cycle

Mohave ground squirrels in the Coso region begin to emerge from hibernation in February. By mid-March all adults appear to be active above-ground. However, radio-telemetry data indicate that the timing of entry into estivation is quite variable and appears to be correlated with the availability of herbaceous plant growth and the occurrence of reproduction. In years with reproduction, most adults are active through June but have all entered estivation by the end of July. Juveniles begin to enter dormancy in July, but some are still active at the end of August. In drought years, when there is no reproduction, entry into estivation may begin as early as April and is essentially completed by the end of June. In the most severe drought years, such as 1990, Mohave ground squirrels may enter dormancy with relatively low body weight and it may be inferred that survivorship is low.

The Coso study has confirmed that Mohave ground squirrels emerge from hibernation with low body weights and fatten substantially during their active period as they prepare for dormancy. However, there are significant differences in mean body weights between age classes in early spring, with yearlings showing the lowest weights (and presumably lowest energy reserves) and members of the oldest class (3 years old or more) the highest. This finding suggests that juveniles have difficulty during their first summer accumulating adequate fat reserves and often emerge as yearlings the next spring in relatively poor nutritional condition. On the other hand, these data suggest that once Mohave ground squirrels reach adult status, their nutritional condition improves, enhancing their probability of survival.

Section VI. C - Home Range and Movements

Radio-telemetry studies of the home range and movements of adult Mohave ground squirrel were carried out in 1990, 1994, 1995, and 1996. These data show differences among years in patterns of spatial behavior that seem to be related to winter rainfall, spring forage production, and reproductive condition. Mohave ground squirrels did not reproduce during the low rainfall years of 1990, 1994, and 1996. However, drought conditions were much more severe in 1990 than in 1994 and 1996, when winter rainfall was relatively low but there was moderate growth of spring annual plants. In 1990, mean home range size was 3-5 times that recorded in 1994 and 1996. Furthermore, in 1990 radio-collared animals were frequently observed to move 200-400 m during the course of a day, a pattern not seen in 1994 or 1996. It seems likely that the much larger home ranges and more extensive movements observed in 1990 were a direct consequence of the very low availability of food resources and the need to travel long distances to find foraging sites. In 1995, reproductive females had home ranges of intermediate size, probably because of the greater energy demands of pregnancy and lactation.

In 1995, for the first time in this study, radio-telemetry data were collected on juvenile Mohave ground squirrels during their first summer. These observations provide insights into the movements of juveniles from the time when they begin to venture outside their natal area until their entry into estivation. During early June, the first exploratory excursions were noted, with juveniles of both sexes often moving several hundred meters during the day only to return to their natal area by nightfall. By the end of June, young Mohave ground squirrels had generally taken up residence at some distance from their

place of birth. The data strongly suggest male-biased natal dispersal, a phenomenon that has been noted in other ground squirrel species. Most juvenile females settled within 200-300 m of their natal area, while males moved longer distances, including one that entered estivation more than 1400 m from the location of initial capture. These are the first data on juvenile dispersal in this species and suggest that at least young Mohave ground squirrels can move substantial distances.

Section VI. D - Food Habits

The Coso study presents a much more detailed picture of the food habits of the Mohave ground squirrel than has been known previously. The new findings include a comprehensive view of the overall composition of the diet, the temporal pattern of variation within the active season, differences in the diet between drought and non-drought years, the range of variation among individuals in a population, and dietary overlap between Mohave ground squirrels and domestic livestock.

This investigation has shown that Mohave ground squirrels feed primarily on the foliage and seeds of forbs (broadleaf herbaceous plants) and shrubs. A significant and unexpected result is the finding that shrub leaf makes up a large proportion of the diet, with three species (winterfat, spiny hopsage, and saltbush) contributing about 60 percent of this component. Forb materials consumed by Mohave ground squirrels are derived from a number of the annual and perennial herbs that emerge after the winter rains.

Shrub leaf is the mainstay of the diet in early spring, before forb growth is available and often again in summer, after the herbaceous plants have become dry. It becomes critically important in drought years, when the supply of forb material is greatly reduced. Winterfat and spiny hopsage appear to be key elements in the Mohave ground squirrel diet under these circumstances. Even under drought conditions, the foliage of these two species is available and forms a highly palatable and strongly preferred food source.

The Coso study has documented a wide range of individual variation in Mohave ground squirrel food habits. While most individual fecal samples were dominated by one food item, the dominant food commonly differed among animals within the same population and at the same time period. This confirms the conclusion that Mohave ground squirrels continuously sample foods available in the environment, but take primarily one or two items within one feeding period.

Mohave ground squirrels have also been shown to readily exploit food sources that are available only intermittently. Examples include the fruits of Joshua trees, cactus, and certain shrubs, as well as lepidopteran larvae (caterpillars). These findings suggest that Mohave ground squirrels not only take a broad range of foods, but are capable of quickly shifting to new or unusual high-quality food items as they become available.

A comparison of the Mohave ground squirrel diet with that of cattle and sheep in the Coso region has revealed important dietary overlap between the Mohave ground squirrel and both types of domestic livestock. Cattle are grazed in this area from November through May and for most of this period the available forage consists of shrub material plus dry grasses from the prior growing season. Green herbaceous growth, both grasses and forbs, is available to cattle only in April and May. The Coso food habits study has shown that cattle consume primarily grass and shrubs, with grasses and shrub leaf each contributing about 40 percent of mean relative density in the diet. Winterfat foliage made up over 24 percent of cattle diet, with saltbush leaf comprising about 13 percent. Thus, winterfat is not only a key food plant for Mohave ground squirrels when forbs are unavailable, it is the shrub species most preferred and taken in largest quantity by cattle as well. Sheep were grazed in Rose Valley in April and May of 1995 and 1996. While their diet was made up mostly of forbs and grasses in 1995, a wet year, almost all of the shrub component consisted of winterfat. In 1996, a dry year with low abundance of forbs, winterfat alone comprised 50 percent of the sheep diet. This high degree of selectivity for winterfat was extraordinary, considering its rarity on and near Study Site 1. The documentation of dietary overlap between livestock and Mohave ground squirrels for a food species that is relatively uncommon is a completely new finding of the Coso Grazing Exclosure Monitoring Study.

Section VI. E - Population Dynamics

Monitoring Mohave ground squirrel populations over a nine-year period on four study sites has yielded a great deal of new information on population dynamics and habitat relationships. These new data include fundamental population parameters such as longevity, survivorship, sex ratios, and age at first reproduction, as well as long-term trends in abundance in relation to winter precipitation and habitat quality.

This study has demonstrated that maximum longevity is at least five years, but that only a small fraction of juveniles persist to enter the yearling age class. The juvenile population contains significantly more females than males and the adult female to male ratio is as high as 7:1 in some populations, with an average of about 2.6:1. Adult females of all age classes produce young in years when reproduction occurs, but reproduction among males is generally restricted to those two years or more of age.

Trends in Mohave ground squirrel abundance over this nine year study have been dominated by the extreme year-to-year fluctuation in fall and winter precipitation. Soon after the study began in 1988, a severe three-year drought resulted in a dramatic and general decline in abundance. The few remaining animals produced young following spring rains in 1991. Successful reproduction in 1992 and 1993 followed two winters with above-average rainfall and, by the summer of 1993, record numbers of juveniles were captured on all four study sites. As a consequence, adult populations reached the highest levels seen during this study in spring 1994. Two of the past three years (1994 and 1996) were characterized by below-average winter precipitation and correlated reproductive failure. Adult Mohave ground squirrel abundance has varied as would be predicted, declining from 1994 to 1995 (no juvenile recruitment in 1994) and then increasing again in 1996 (successful reproduction in 1995).

Mohave ground squirrel abundance on Study Site 1 in Rose Valley has followed a different pattern from that on the other three sites. Moderate numbers of juveniles were taken throughout the site only in 1988 and 1993. No Mohave ground squirrels were recorded on Study Site 1 during the intervening four years (1989-1992). From 1993 on, a few adult female Mohave ground squirrels have established home ranges and on two occasions reared young in a small area on the northeastern edge of the site. There is no evidence that the species has been able to persist elsewhere on Study Site 1, although supplementary trapping has revealed a sparse Mohave ground squirrel population in the area to the northeast of the study site. It seems probable that most of Study Site 1 is a population "sink," an area where habitat quality is too poor to allow a self-sustaining population (Pulliam 1988). Juveniles present here in 1988 and 1993 may have been dispersing from more productive "source" habitat nearby. A drought refugium may exist in better quality habitat to the northeast and this area may have been the source for the recolonization of the northeastern edge of Study Site 1 in 1993.

In contrast to Study Site 1, Mohave ground squirrel populations on study sites 2, 3 and 4 were able to persist throughout the 1988-1991 drought, although at greatly reduced levels of abundance. These study sites are characterized by a much higher shrub species diversity and cover. Winterfat and spiny hopsage, the two shrub species most highly preferred as food sources during drought conditions, are relatively common on these three study sites, but are almost totally absent from Study Site 1. It may be significant that the northeastern edge of Study Site 1 and adjoining areas seem to have the best habitat suitability for Mohave ground squirrels and also support (very sparse) populations of winterfat and spiny hopsage.

Thus, this study has demonstrated for the first time that in drought episodes, Mohave ground squirrel populations may fail to persist in low quality habitat, but survive in areas of higher habitat quality (drought refugia) from which they may expand again under better conditions. It has also identified specific habitat features, particularly the presence of certain key shrub species, that may be of great importance in determining Mohave ground squirrel abundance levels and ability to persist through drought periods. The results of these population studies suggest that differences in habitat quality between sites (shrub vegetation) and between years (winter rainfall) may be the most important factors in explaining spatial and temporal variation in Mohave ground squirrel presence and abundance throughout its range.

Section VI. F - Conservation Implications

The Coso Grazing Exclosure Monitoring Study has not only contributed greatly to an understanding of the basic biology of the Mohave ground squirrel, but has provided a new basis for the conservation and management of the species. Some of the more important applications of this research are summarized below.

The methodology developed through the Coso study has been used as a model for field investigations of the Mohave ground squirrel elsewhere within its range. In 1994 and 1995, the California Department of Fish and Game funded studies in Kern and San Bernardino counties in order to provide current data regarding the status of the species within areas proposed as core reserves under the Western Mojave Coordinated Management Plan. Field work was conducted at 12 sites to determine the presence of Mohave ground squirrels, obtain data on relative abundance, document food habits, and characterize the habitat by vegetation sampling (Scarry et al. 1996). Many aspects of

the research protocols were inspired by and designed to be consistent with those developed for the Coso Study.

The timing of the annual activity cycle at the Coso sites suggests that live trapping studies of the Mohave ground squirrel must be carefully scheduled in order to sample the desired segment of the population. Even in reproductive years, some adults enter estivation in June; in years with no reproduction, some adults may be dormant as early as the end of April. In general, sampling of the adult population is best conducted during late March and early April. Juveniles begin to forage outside their natal burrows by mid-May and do not begin to enter estivation until July at the earliest. Thus, all juveniles are active and trappable from mid-May through the end of June. Because they may disperse from their natal site in late May-early June, it may be difficult to determine site-specific production of juveniles.

Live-trapping when some or all of a Mohave ground squirrel population has already entered estivation may give misleading impressions of abundance and may even lead to the mistaken conclusion that the species is absent from a particular site. This is most likely to occur when trapping is conducted in late spring or early summer following a winter of low precipitation. Conversely, trapping from late May through August in a year of successful reproduction may result in the capture of dispersing juveniles, leading to the mistaken conclusion that a site supports a resident population.

The extreme and unpredictable year-to-year variation in winter rainfall that is typical of the western Mojave Desert appears to be the primary influence on abundance of the Mohave ground squirrel, through its effects on reproduction and survival. Drought episodes of 2-3 years lead to drastic population declines and disappearance of the species from marginal habitats. It is critical that acquisition of habitat for conservation purposes focus on areas that can support Mohave ground squirrel populations through prolonged drought.

The persistence of Mohave ground squirrel populations through long droughts depends upon perennial food plants, particularly shrubs such as winterfat and spiny hopsage. These plants provide green foliage when no other source of food or moisture is available. There is also solid evidence that sites where these shrubs are relatively common support the greatest Mohave ground squirrel abundance. Careful consideration should be given to areas with high cover of these shrubs when conservation reserves are being selected.

However, herbaceous annual plants are also necessary to sustain a Mohave ground squirrel population, since reproduction does not take place unless there is adequate herbaceous annual production. Management of habitat for the Mohave ground squirrel should include a consideration of the timing and intensity of domestic livestock grazing so that both important perennial food resources and annual herbaceous production are sufficient to support a viable ground squirrel population.

The effects of prolonged drought episodes on Mohave ground squirrel population dynamics must be considered in any comprehensive long-range planning for the conservation of the species. During the nine years of the Coso study, there were four years with low winter rainfall and Mohave ground squirrel reproductive failure. Long-term weather records for the western Mojave Desert indicate that a number of drought periods as long as 4-5 years have been recorded during this century. A system of conservation reserves such as that envisioned in the Western Mojave Coordinated Management Plan should be geographically dispersed in such a way as to minimize (insofar as possible) spatial correlation of drought conditions.

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Appendix A

Chronological Summary of Study Data and Results 1988 - 1996

Appendix A

Chronological Summary of Study Data and Results

1988 to 1996

This appendix summarizes the Study results by year and provides insight into the development and refinement of the Study as knowledge of Mohave ground squirrel biology grew over time. A series of eight annual reports (1995 and 1996 results were combined in one report) present complete details (see Section VIII - References).

1988 Baseline Studies

Baseline monitoring began in 1988 with the selection of four permanent study sites. Study sites 2 and 3 were located within the area planned for the future grazing exclosure, while study sites 1 and 4 were located in the area that was to remain open to grazing by domestic livestock. Live-trap sampling was conducted once at each study site in 1988. Trapping began on Study Site 1 in late May and ended on Study Site 4 in late June. Based on information available at that time, it was assumed that both adult and juvenile Mohave ground squirrels would be active and trappable during this time period. Although live trapping resulted in the capture of numerous juvenile Mohave ground squirrels at all four study sites, very few adults were recorded (Table 1a).

The food habits of the major herbivores, including Mohave ground squirrel, cattle and feral burros, were studied by collection and analysis of fecal samples. Microscopic analysis of these samples indicated that the diet of Mohave ground squirrels in early summer 1988 was primarily forbs (broadleaf herbaceous plants), that cattle consumed a combination of shrub and grass materials, and burros took almost exclusively grasses (Table 1b).

Shrub vegetation at each study site was characterized by extensive line-intercept surveys. The standing crop and species composition of herbaceous vegetation was documented in 1 ft^2 survey plots located between and under shrubs. Forb production was substantial in 1988, following a winter with relatively good rainfall.

1988 BASELINE STUDY – TABLE 1a MGS CAPTURES AT ALL FOUR STUDY SITES (May-June 1988 – winter rainfall 119% of normal)				
# MGS captured	**Study Site 1**	**Study Site 2**	**Study Site 3**	**Study Site 4**
Juvenile	21	17	50	20
Adult	0	3	1	3
19 ± 1	20 ± 1		47 ± 1	24 ± 7

1988 BASELINE STUDY – TABLE 1b PERCENT OF SHRUBS, FORBS AND GRASSES IN DIET BY HERBIVORE			
Herbivore	**Shrubs**	**Forbs**	**Grasses**
MGS (see note 1)	9.3%	65.6%	8.7%
Cattle (see note 2)	30.1%	14.7%	53.7%
Burro (see note 3)	6.3%	2.5%	91.1%

Note 1 Data for study sites 1 - 4

Note 2 Data for study sites 1 - 4 and 5 other locations in the Coso region

Note 3 Data for study sites 2 and 3 other locations in the Coso region

1989 Baseline Studies

The results of the 1989 baseline studies were very different from those reported in 1988. Live-trapping was carried out on all study sites from late May through late June, as in 1988. Although a few adult Mohave ground squirrels were captured on study sites 2, 3, and 4, there was no evidence of reproduction among the adult females and no juveniles were found (Table 2a). No Mohave ground squirrels were captured at Study Site 1. However, limited trapping conducted in March and April 1989 on Study Site 3 revealed that substantial numbers of adults were active in the spring. This evidence, together with the small number of adults recorded in early summer, strongly suggested that most adults had already entered estivation by the time of full-scale trapping in late May and June.

The differences between the 1988 and 1989 results appeared to reflect the drought conditions that began in the summer of 1988. Rainfall during the preceding fall and winter season (1988-1989) was about 50% of the long-term average. Sampling of

herbaceous standing crop revealed much lower levels of primary production, as would be expected. This suggested that Mohave ground squirrels might have to utilize shrub materials more heavily during this drought year, especially upon emergence from hibernation and just prior to entry into estivation (Table 2b). The primary food materials taken on Study Site 3 during the active period were the following:

March	Shrub leaf
April	Forb foliage and seed
June	Shrub and forb seed

The 1989 data also indicated potential dietary overlap between cattle and Mohave ground squirrels, specifically for shrub materials (Table 2c). At Study Site 2, for example, shrubs were the predominant food of both species and they made up a large component of both the cattle and Mohave ground squirrel diet at Study Site 3 as well.

1989 BASELINE STUDY -- TABLE 2a
MGS CAPTURES AT ALL FOUR STUDY SITES
(May-June 1989 -- winter rainfall 49% of normal)

# MGS Captured	Study Site 1	Study Site 2	Study Site 3	Study Site 4
Juvenile	0	0	0	0
Adult	0	3	2	1
Population Estimate by Schnabel Meth.	Data insufficient for population estimates.			

1989 BASELINE STUDY – TABLE 2b
% OF SHRUBS, FORBS & GRASSES IN DIET OF MGS OVER ACTIVE PERIOD
(Study Site 3)

	Shrubs			Forbs			Grasses		
	March	April	June	March	April	June	March	April	June
MGS	97.4	16.4	75.3	0.9	68.0	7.1	0.9	3.6	16.7

1989 BASELINE STUDY -- TABLE 2c % OF SHRUBS, FORBS & GRASSES IN DIET BY STUDY SITE AND HERBIVORE (May-June 1989 -- winter rainfall 49% of normal)												
Herbivore	**Shrubs (by study site)**				**Forbs (by study site)**				**Grasses (by study site)**			
	2	**3**	**4**	**total**	**2**	**3**	**4**	**total**	**2**	**3**	**4**	**total**
MGS	97.0	75.3	5.4	57.7	0	7.1	62.9	24.8	1.6	16.7	31.6	16.7
Cattle	72.3	45.7	9.1	38.7	1.8	0.5	0.2	0.7	25.6	53.8	90.7	60.5
Burro	26.0	62.7	-	43.0	6.8	0	-	4.1	65.7	37.2	-	52.3

1990 Baseline Studies

The baseline research conducted in 1988 and 1989 showed in low numbers of captures of adult Mohave ground squirrels in both years and no juvenile recruitment in 1989. As a result, it was recommended that a third year of baseline studies be performed in 1990. This recommendation preceded the actual issuance of the Second Year Baseline Report due to the need to gain all necessary approvals from CEC, NAWS, BLM, and CDF&G prior to the spring trapping period for 1990.

The 1988 and 1989 baseline studies yielded significant new information on Mohave ground squirrel biology and suggested that the original study design should be modified. These new findings were:

- Prior research suggested that adult Mohave ground squirrels did not enter estivation until July, but the Coso baseline studies clearly indicated that dormancy in adults could begin as early as mid-May. Therefore, the trapping period needed to be changed from early summer (late May-June) to spring (March-April) in order to assess the abundance of the adult Mohave ground squirrel population.

- In addition, the 1989 study showed no Mohave ground squirrel reproduction following low fall and winter precipitation. This indicated a potential relationship between Mohave ground squirrel reproduction and drought conditions that resulted in reduced production of annual plants.

Thus, a third year of baseline research was approved with certain modifications of the study procedure in order to confirm trends noted in 1988 and 1989 and obtain better information about Mohave ground squirrel biology. The additional objectives of the 1990 study were:

1. to establish with certainty the timing of activities within the Mohave ground squirrel annual cycle; and
2. to collect population data during the spring to serve as a baseline for adult abundance.

In order to accomplish these objectives, the following changes were proposed:

1. use radiotransmitters to monitor Mohave ground squirrel activity;
2. live trap in March and April to obtain a better estimate of the adult Mohave ground squirrel population;
3. use passive integrated transponder tags (PIT tags) for identification rather than ear tags;
4. allow grazing within the exclosure area during 1990 to maintain existing grazing pressure throughout the baseline study period.

The modifications recommended in the Proposal for Third Year of Baseline Studies were approved by all parties to the Stipulation.[1] The approved actions were:

1. Extend the baseline study for one year to include 1990;
2. Use radiotransmitters to determine time of entry into estivation;
3. Live-trap during March and April;
4. Keep entire exclosure open to grazing in 1990.

Based upon the extension of baseline studies for an additional year, the time period for all other monitoring activities was extended by a year. With the approval of these changes by all parties, the final year of baseline research and the subsequent monitoring studies proceeded as modified.

[1] *See* Letter from BLM to CDF&G modifying the Mitigation Plan to add 1990 as a baseline study year. This letter was signed by all signatories to the Stipulation: BLM, CDF&G, and NAWS.

The lack of Mohave ground squirrel reproduction found in 1989 was repeated in 1990, with winter rainfall only 19% of the long term average in the Coso region (Table 3a). No evidence of reproduction was found during either the spring or early summer trapping sessions.

1990 BASELINE STUDY -- TABLE 3a
MGS CAPTURES AT ALL FOUR STUDY SITES
(March - April 1990 – winter rainfall 19% of normal)

# MGS Captured	Study Site 1	Study Site 2	Study Site 3	Study Site 4
Juvenile	0	0	0	0
Adult	0	6	19	8
Population Estimate by Schnabel Meth.	See note	See note	See note	See note
Population Estimate by Lincoln-Petersen Meth.	See note	See note	See note	See note

Note: Data insufficient for population estimates.

As shown in Table 3a, substantial numbers of adult Mohave ground squirrels were captured in late March and early April. Trapping in late May and early June yielded only 8 adults on Study Site 3 and 2 on Study Site 4. As in 1989, no Mohave ground squirrels were recorded from Study Site 1. The 1990 results confirmed that, due to the earlier than expected entry into estivation by adult Mohave ground squirrels, trapping of adults should be conducted in late March and April.

Due to drought conditions in 1989 and 1990 (records show that rainfall was 49% and 19% of normal, respectively), there was very little forb production on the Coso study sites. As a result, the available food was largely limited to grasses and shrubs during both spring and early summer. The 1990 data confirmed the limited availability of forbs for Mohave ground squirrels and highlighted the importance of shrubs for both ground squirrels and cattle.

The 1988, 1989 and 1990 baseline studies showed that Mohave ground squirrels rarely consumed large amounts of grasses; shrubs were the primary food item when forbs were not available. During these years cattle ate 30% to 50% shrubs as well. Thus, shrubs made up a large portion of the diet of both species; this situation was particularly pronounced in 1990 when annual forb production was very limited. The 1990 data showed that dietary overlap was greatest during March and April when food options were most severely limited (Table 3b).

1990 BASELINE STUDY – TABLE 3b
% OF SHRUBS, FORBS & GRASSES IN DIET BY STUDY SITE AND HERBIVORE
(March - April 1990 -- winter rainfall 19% of normal)

Herbivore	Shrubs (by study site)				Forbs (by study site)				Grasses (by study site)			
	2	3	4	total	2	3	4	total	2	3	4	Total
MGS	97.1	89.8	91.8	92.4	1.3	2.7	2.9	2.3	1.2	3.5	1.3	2.5
Cattle	45.5	67.7	39.3	51.7	7.8	1.0	0	2.2	44.4	31.2	60.7	45.6
Burro	38.5	32.4	-	36.3	0.5	0	-	0.3	60.9	67.6	-	63.4

% OF SHRUBS, FORBS & GRASSES IN DIET OF MGS OVER ACTIVE PERIOD (Study Site 3)

	Shrubs				Forbs				Grasses			
	Mar	Apr	May	Jun	Mar	Apr	May	Jun	Mar	Apr	May	Jun
MGS	92.4	88.9	36.2	69.9	1.2	3.3	51.2	15.8	1.2	4.5	0.3	2.9

1991 Monitoring Study

Although no monitoring was originally required in 1991, it was recommended that additional field studies be carried out to determine whether Mohave ground squirrel reproduction occurred following unusually late storms that finally broke the long drought in late February and early March of 1991. It was felt that the results of the regularly-scheduled 1992 studies could be better interpreted if field data for 1991 were available. Through funding from the CDFG, and the authorization and assistance of the NAWS China Lake, it was possible to conduct limited trapping in late May - early June on all four study sites, to sample herbaceous vegetation, and to collect data on food habits for Mohave ground squirrel and other herbivore species. Three days of live-trapping on each study site revealed that Mohave ground squirrel abundance had reached an extremely low

level in the Coso region (Table 4a). A total of only three Mohave ground squirrels were captured, all adult females that had reproduced in 1991. No juveniles were taken, as they were evidently still confined to their natal burrows. No Mohave ground squirrels were captured on study sites 1 and 4.

1991 MONITORING STUDY – TABLE 4a
MGS CAPTURES AT ALL FOUR STUDY SITES
(May - June 1991 – winter rainfall 88% of normal)

# MGS Captured	Study Site 1	Study Site 2	Study Site 3	Study Site 4
Juvenile	0	0	0	0
Adult	0	2	1	0
Population Estimate by Schnabel Meth.	See note	See note	See note	See note
Population Estimate by Lincoln-Petersen Meth.	See note	See note	See note	See note

Note: Data insufficient for population estimates.

As a result of the late rains, herbaceous vegetation was unusually diverse and abundant in 1991. Species richness and standing crop were the highest recorded since the beginning of the study in 1988, although development of the herbaceous vegetation was unusually late, with almost all growth occurring after the storms of late February and early March.

Analysis of the small number of Mohave ground squirrel fecal samples collected indicated that the diet was composed primarily of lepidopteran larvae (caterpillars) and cactus seed (Table 4b). Although forb material was abundant, Mohave ground squirrels may have selected the available foods with the greatest nutritional value, underscoring their dietary flexibility.

Cattle fed mainly on annual grasses and shrub leaf, with the uncommon shrub winterfat making up over 24 percent of the total diet. Burros also concentrated on annual grasses and shrubs, including some winterfat foliage as well.

1991 MONITORING STUDY – TABLE 4b % OF SHRUBS, FORBS & GRASSES IN DIET BY STUDY SITE AND HERBIVORE (May - June 1991 -- winter rainfall 88% of normal)												
Herbivore	**Shrubs (by study site)**				**Forbs (by study site)**				**Grasses (by study site)**			
	2	3	4	total	2	3	4	total	2	3	4	total
MGS(See note)	30.1	71.2	-	43.8	22.4	14.0	-	19.6	0	0	-	0
Cattle	-	-	41.8	41.8	-	-	0	0	-	-	58.0	58.0
Burro	7.4	9.2	26.2	16.4	9.7	0	1.8	5.4	82.4	90.8	71.4	77.7

Note: total < 100% because other food categories (i.e., arthropods) made up 36.7% of relative density

1992 Monitoring Study

The 1992 monitoring study yielded additional evidence of a close relationship between Mohave ground squirrel reproduction and precipitation during the preceding winter. During the winter of 1991-1992, rainfall was 155% of the long-term average. Juvenile Mohave ground squirrels were captured during the spring sampling period (April 1992) on study sites 3 and 4 (Table 5a). Although Mohave ground squirrels were still absent from Study Site 1, the number of juveniles recorded on each of the other three study sites during the May-June trapping period was comparable to that in 1988. In general, Mohave ground squirrel populations showed good recovery from the effects of the 1989-1990 drought, with the exception that none were captured on Study Site 1 in 1992.

1992 MONITORING STUDY -- TABLE 5a MGS CAPTURES AT ALL FOUR STUDY SITES (April - June 1992 -- winter rainfall 155% of normal)								
# MGS Captured	**Study Site 1**		**Study Site 2**		**Study Site 3**		**Study Site 4**	
	April	**My/Jn**	**April**	**My/Jn**	**April**	**My/Jn**	**April**	**My/Jn**
Juvenile	0	0	0	37	4	51	1	15
Adult	0	0	10	7	8	5	0	2
Population Estimate by Schnabel Meth.	See note		See note	45 ± 10	See note	54 ± 2	See note	16 ± 7
Population Estimate by Lincoln-Petersen Meth.	See note		14 ± 8	52 ± 9	10 ± 5	58 ± 3	See note	20 ± 5

Note: Data insufficient for population estimates.

Rainfall during the winter of 1991-1992 reached 155% of the long-term average and herbaceous standing crop as sampled in late Mary-early June was higher than in any of the four preceding years. Mohave ground squirrel food habits followed the same general pattern as in previous years, with primary dependence on shrub and forb leaf (Table 5b). An increase in seed consumption was noted in early summer when seed became more available.

In April, the Mohave ground squirrel diet consisted of about 50% relative density of forb leaf and 40% shrub material (assuming that pollen consumed at Study Site 2 was from shrubs). Thus, with above average rainfall and abundant herbaceous annual growth, forbs were the predominant food. Nevertheless, shrubs remained an important part of the Mohave ground squirrel diet in spring 1992, even under non-drought conditions.

Food habits data for early summer were somewhat different from previous years, in that shrub leaf was more important in the diet than in spring. In May and June, shrubs and forbs made up 52 percent and 43 percent, respectively, of the Mohave ground squirrel diet. There was a strong preference for foliage of the shrub winterfat, especially at study sites 2 and 3. It is likely that consumption of shrub leaf increased in early summer as the water content of herbaceous plant material began to decline.

The 1992 food habits study demonstrated the continued importance of shrub leaf in the Mohave ground squirrel diet, even in years with heavy winter rainfall. Samples collected in April at Study Site 4 showed that cattle were eating primarily grasses and shrub leaf. The data on cattle diet showed a strong preference for winterfat among the available shrubs. The 1992 study indicated substantial dietary overlap between Mohave ground squirrels and cattle with both species consuming considerable shrub foliage and evidencing a strong preference for winterfat.

1992 MONITORING STUDY -- TABLE 5b
% OF SHRUBS, FORBS & GRASSES IN DIET BY STUDY SITE AND HERBIVORE
(April 1992 -- winter rainfall 155% of normal)

Herbivore	Shrubs (by study site)				Forbs (by study site)				Grasses (by study site)			
	2	3	4	total	2	3	4	total	2	3	4	total
MGS	4.9 *	32.1	29.3	19.7	40.6	64.4	57.2	53.3	0	0	0	0
Cattle	-	-	45.0	45.0	-	-	0	0	-	-	55.0	55.0
Burro	0	37.2	27.0	24.9	0	3.4	0	0.9	100	59.3	72.9	74.1

% OF SHRUBS, FORBS & GRASSES IN DIET OF MGS BY STUDY SITE OVER ACTIVE PERIOD

	Shrubs				Forbs				Grasses			
	2	3	4	total	2	3	4	total	2	3	4	total
April	4.9 *	32.1	29.3	19.7	40.6	64.4	57.2	53.3	0	0	0	0
May/June	65.1	46.0	42.1	52.2	29.4	48.5	54.8	42.8	0.3	0.4	0.3	0.3

* MGS consumed 43.6% pollen at study site 2 which may well have been from wind pollinated shrubs.

1993 Monitoring Study

Although monitoring studies were not required in 1993 under the Coso Grazing Exclosure Mitigation Plan, the benefit of a continuous data record was recognized by all parties to the agreement. As a result, the full range of field studies was authorized in 1993 and funding was supplied by the NAWS China Lake and the California Department of Fish and Game.

Precipitation during the fall and winter of 1992-1993 was high once again, with 138% of the long-term average recorded in the Coso region. As expected after two previous years of successful reproduction, more adult Mohave ground squirrels were captured in 1993 than ever before. In addition, Mohave ground squirrels reappeared on Study Site 1, where they had not been found since 1988. The number of juveniles captured on all study sites exceeded previous records as well (Table 6a).

1993 MONITORING STUDY-- TABLE 6a
MGS CAPTURES AT ALL FOUR STUDY SITES
(March-April & May-June 1992 -- winter rainfall 138% of normal)

# MGS Captured	Study Site 1		Study Site 2		Study Site 3		Study Site 4	
	Mr/Ap	My/Jn	Mr/Ap	My/Jn	Mr/Ap	My/Jn	Mr/Ap	My/Jn
Juvenile	0	25	0	105	0	212	0	120
Adult	3	2	20	15	43	21	19	16
Population Estimate by Schnabel Meth.	See note	28±5	20±3	116±5	43±4	221±7	22±11	132±4
Population Estimate by Lincoln-Petersen Meth.	See note	31±6	22±4	124±5	47±5	253±12	26±11	145±8

Note: Data insufficient for population estimates.

High rainfall the preceding winter resulted in abundant food resources in 1993. During the late March - early April sampling period, the Mohave ground squirrel diet consisted primarily of forb material, rather than the usual large proportion of shrub leaf found at this time in previous years (Table 6b). However, in late May - early June the predominant food was shrub leaf, probably because herbaceous material had become dry.

As in 1992, Mohave ground squirrels showed a striking preference for winterfat foliage (Table 6c). On study sites 2, 3, and 4, this species made up 95% of the shrub component of the diet in the summer sample. On Study Site 1, where winterfat is almost non-existent, it still comprised over 50% of the shrub material taken.

In June samples, shrub leaf was by far the largest component of the cattle diet at Study Site 4, with winterfat contributing over 98 percent of the shrub materials (Table 6d). Grasses, especially the annual *Bromus*, made up almost all of the remainder of the cattle diet at this site, comprising about 38 percent. In contrast, forbs were the predominant food items at Study Site 1, where they contributed 75 percent. Annual grasses made up almost all of the rest of the cattle diet at Study Site 1.

1993 MONITORING STUDY – TABLE 6b
% OF SHRUBS, FORBS & GRASSES IN DIET OF MGS BY STUDY SITE OVER ACTIVE PERIOD
(March-April and May-June 1993 -- winter rainfall 138% of normal)

	Shrubs (by study site)					Forbs (by study site)					Grasses (by study site)				
	1	2	3	4	Total	1	2	3	4	Total	1	2	3	4	Total
March/ April	0.6	28.9	12.4	10.5	13.9	98.3	67.1	86.0	87.5	83.9	0.0	0.5	0.3	2.0	0.9
May/ June	10.9	94.5	45.9	77.4	57.8	84.1	2.1	49.9	21.3	39.0	1.4	1.8	2.9	0.5	1.6

1993 MONITORING STUDY – TABLE 6c
% OF WINTERFAT AND TOTAL SHRUBS IN MAY-JUNE DIET OF MGS
(winter rainfall 138% of normal)

	Study Site 1	Study Site 2	Study Site 3	Study Site 4
Winterfat	5.8	93.2	43.5	75.8
Total Shrubs	10.9	94.5	45.9	77.4

1993 MONITORING STUDY – TABLE 6d
% OF SHRUBS, FORBS & GRASSES IN DIET BY STUDY SITE AND HERBIVORE
(May-June 1993 – winter rainfall 138% of normal)

	Shrubs					Forbs					Grasses				
	1	2	3	4	Total	1	2	3	4	Total	1	2	3	4	Total
MGS	10.9	94.5	45.9	77.4	57.8	84.1	2.1	49.9	21.3	39.0	1.4	1.8	2.9	0.5	1.6
Cattle	3.9	-	-	61.6		75.0	-	-	0.0		20.7	-	-	38.4	

1994 Monitoring Study

The fall and winter of 1993-1994 saw a return to below-average precipitation, with rainfall in the Coso region totaling only 45% of the long-term average. As a result, the standing crop of herbaceous annual plants was quite low, comparable to the drought year of 1989 but higher than in 1990, when essentially no annual plant production was observed. There was no evidence of Mohave ground squirrel reproduction on any of the four study sites. The number of adults captured on each study site during the spring live-trapping session was the highest on record, reflecting the very large juvenile cohort produced in 1993 (Table 7a). Radio-telemetry studies were carried out in 1994 to monitor ground squirrel activity and the timing of estivation. Entry into estivation was earlier than in 1990, with almost one-half of the radio-collared Mohave ground squirrels in dormancy by May 1 and only one individual still active above ground in mid-June.

1994 MONITORING STUDY -- TABLE 7a
MGS CAPTURES AT ALL FOUR STUDY SITES
(March-April & May-June 1994 -- winter rainfall 45% of normal)

# MGS Captured	Study Site 1		Study Site 2		Study Site 3		Study Site 4	
	Mr/Ap	My/Jn	Mr/Ap	My/Jn	Mr/Ap	My/Jn	Mr/Ap	My/Jn
Juvenile	0	0	0	0	0	0	0	0
Adult	5	1	32	16	46	13	32	12
Population Estimate by Schnabel Meth.	See note	See note	31 ± 1	16 ± 1	47 ± 2	13 ± 1	35 ± 6	12 ± 1
Population Estimate by Lincoln-Petersen Meth.	5 ± 0	See note	32 ± 1	16 ± 0	47 ± 3	13 ± 0	32 ± 2	12 ± 0

Note: Data insufficient for population estimates.

In 1994, Mohave ground squirrel food habits at the Coso study sites reflected the limited availability of annual forb leaf and seed (Table 7b). Shrub leaf was heavily utilized by Mohave ground squirrels throughout their active period, but especially early in the spring before there was any significant growth of annual herbaceous plants.

Again, winterfat made up much of the shrub component of the diet, but other shrub species, such as spiny hopsage and saltbush were also important. Since the only significant rains were late, falling between early February and late April, forb availability was greatest in May and June. As a result, forbs were the predominant element in the Mohave ground squirrel diet in late May-early June, in contrast to 1993, a high rainfall year in which the ground squirrels had already switched back to shrub material by early summer.

Burro samples were available for late May-early June from study sites 2 and 4. As in previous years, grasses contributed the overwhelming majority of the diet, with shrub and forb material comprising small percentages (Table 7b). The only 1994 data for cattle food habits were derived from samples taken in the vicinity of Study Site 4 in June. Forb leaf was the most important category, comprising 68 percent of the diet; shrub leaf made up 19 percent, with winterfat contributing over 81 percent of all shrub material.

1994 MONITORING STUDY - TABLE 7b
% OF SHRUBS, FORBS & GRASSES IN DIET BY STUDY SITE AND HERBIVORE
(May-June 1994 – winter rainfall 45% of normal)

	Shrubs					Forbs					Grasses				
	1	2	3	4	Total	1	2	3	4	Total	1	2	3	4	Total
MGS	0	45.9	17.6	5.2	21.6	25.6	21.8	59.6	89.6	57.0	74.4	31.2	16.4	4.7	18.6
Cattle	-	-	-	19.0	19.0	-	-	-	67.7	67.7	-	-	-	12.6	12.6
Burro	-	10.7	-	4.1	9.6	-	4.9	-	0	4.1	-	84.5	-	95.9	86.4

% OF SHRUBS, FORBS & GRASSES IN DIET OF MGS BY STUDY SITE OVER ACTIVE PERIOD
(March-April and May-June 1994 – winter rainfall 45% of normal)

	Shrubs					Forbs					Grasses				
	1	2	3	4	Total	1	2	3	4	Total	1	2	3	4	Total
Mid-March	-	88.2	90.7	-	89.6	-	10.3	6.8	-	8.3	-	1.1	0.4	-	0.7
March /April	54.0	67.9	49.3	59.5	57.7	39.0	28.5	42.1	34.5	35.9	2.8	2.0	2.8	0.7	1.8
May/ June	0	45.9	17.6	5.2	21.6	25.6	21.8	59.6	89.6	57.0	74.4	31.2	16.4	4.7	18.6

1995 Monitoring Study

As in 1993, monitoring studies were not required in 1995 under terms of the Coso Grazing Exclosure Mitigation Plan. However, the full scope of field studies was carried out and the results presented in the combined 1995-1996 annual report.

Precipitation during the winter of 1994-1995 was substantially above the long-term average. The standing crop of annual herbaceous plants was very high on all study sites and successful Mohave ground squirrel reproduction was also documented on all sites. The lack of juvenile recruitment in 1994 resulted in a smaller adult population in late March-early April 1995 (Table 8a). However, the total number of juveniles produced on all study sites in 1995 was second only to that in 1993. Once again, the relationship between winter rainfall, herbaceous standing crop, and Mohave ground squirrel reproduction was confirmed.

1995 MONITORING STUDY – TABLE 8a
MGS CAPTURES AT ALL FOUR STUDY SITES
(March-April & May-June 1995—winter rainfall 180% of normal)

# MGS Captured	Study Site 1		Study Site 2		Study Site 3		Study Site 4	
	Mr/Ap	My/Jn	Mr/Ap	My/Jn	Mr/Ap	My/Jn	Mr/Ap	My/Jn
Juvenile	0	10	0	55	0	73	0	39
Adult	2	1	21	14	17	12	14	11
Population Estimate by Schnabel Meth.	See note	13 ± 4	22 ± 2	70 ± 5	20 ± 5	88 ± 7	15 ± 4	53 ± 12
Population Estimate by Lincoln-Petersen Meth.	See note	11 ± 0	22 ± 3	78 ± 10	17 ± 0	90 ± 7	15 ± 3	58 ± 9

Note: Data insufficient for population estimates

Mohave ground squirrel food habits in 1995 reflected the fact that forb material was abundant through most of the active season (Table 8b). Only in early March, when forbs were not yet available, did shrub leaf predominate in the diet. At this time, spiny hopsage and winterfat were the most important shrub species, followed by saltbush. Forb materials made up over one-half of the diet in late March-early April and somewhat less than one-half in late May-early June, while the shrub component was smaller in the spring and increased again in early summer.

Fecal samples from cattle were collected in and near Study Site 4 in June 1995. Shrub leaf made up 45 percent of the cattle diet, with winterfat contributing over 70 percent of the shrub material (Table 8d). Burro samples from the vicinity of Study Site 2 showed the usual pattern of heavy reliance on annual grasses, especially *Schismus* and *Bromus*. In 1995, for the first time in this study, sheep were grazed in Rose Valley. Fecal samples from Study Site 1 showed that a variety of forbs made up the largest category of food items, for a total of 51 percent of the sheep diet. Grasses contributed 32 percent and shrub leaf (of which three-quarters was winterfat) made up the remaining 17 percent.

1995 MONITORING STUDY – TABLE 8b
% OF SHRUBS, FORBS & GRASSES IN DIET OF MGS BY STUDY SITE OVER ACTIVE PERIOD
(March-April and May-June 1995 – winter rainfall 162% of normal)

	Shrubs (by study site)					Forbs (by study site)					Grasses (by study site)				
	1	2	3	4	Total	1	2	3	4	Total	1	2	3	4	Total
Early March	-	48.9	90.8	-	63.7	-	14.8	8.5	-	12.6	-	1.2	0.0	-	0.8
March/ April	2.6	35.3	27.6	25.5	28.9	93.3	33.4	69.5	62.5	55.3	1.6	0.6	0.7	1.7	1.0
May/ June	17.7	73.4	31.9	26.8	40.3	69.7	10.2	54.2	60.7	45.6	0.0	0.1	0.2	0.1	0.1

1995 MONITORING STUDY -- TABLE 8c
% OF WINTERFAT AND TOTAL SHRUBS IN MAY-JUNE DIET OF MGS
(winter rainfall 162% of normal)

	Study Site 1	Study Site 2	Study Site 3	Study Site 4
Winterfat	0.0	29.8	22.3	3.6
Total Shrubs	17.7	73.4	31.9	26.8

1995 MONITORING STUDY - TABLE 8d
% OF SHRUBS, FORBS & GRASSES IN DIET BY STUDY SITE AND HERBIVORE
(May-June 1995 – winter rainfall 162% of normal)

	Shrubs					Forbs					Grasses				
	1	2	3	4	Total	1	2	3	4	Total	1	2	3	4	Total
MGS	17.7	73.4	31.9	26.8	40.3	69.7	10.2	54.2	60.7	45.6	0.0	0.1	0.2	0.1	0.1
Cattle	-	-	-	44.7	44.7	-	-	-	40.0	40.0	-	-	-	14.9	14.9
Burro	-	10.4	-	-	10.4	-	5.3	-	-	5.3	-	80.6	-	-	80.6
Sheep	16.8	-	-	-	16.8	51.3	-	-	-	51.3	31.9	-	-	-	31.9

1996 Monitoring Study

Rainfall totals for the 1995-1996 winter were well below the long-term average and close to the postulated lower threshold of 65 mm for Mohave ground squirrel reproduction. Although the number of adults captured during the late March-early April trapping period was the second highest in record, there was no evidence of reproduction on study sites 2, 3 and 4 (Table 9a). No pregnant or lactating adult females were found and no juveniles were captured. On Study Site 1, however, a single juvenile male was captured in late May and another juvenile male was trapped on the auxiliary grid just to the northeast. It seems likely that one or more Mohave ground squirrel litters were produced in the area northeast of Study Site 1 in 1996.

1996 MONITORING STUDY – TABLE 9a
MGS CAPTURES AT ALL FOUR STUDY SITES
(March-April & May-June 1996)

# MGS Captured	Study Site 1		Study Site 2		Study Site 3		Study Site 4	
	Mr/Ap	My/Jn	Mr/Ap	My/Jn	Mr/Ap	My/Jn	Mr/Ap	My/Jn
Juvenile	0	1	0	0	0	0	0	0
Adult	3	0	25	8	40	7	21	9
Population Estimate by Schnabel Meth.	See note	See note	26±4	8±1	43±13	See note	26±18	10±0
Population Estimate by Lincoln-Petersen Meth.	See note	See note	22±4	124±5	47±5	See note	25±6	9±0

Note: Data insufficient for population estimates.

Since 1995-1996 winter rainfall was well below the long-term average, it was not surprising that 1996 herbaceous standing crop was low. Mean herbaceous standing crop was below 0.2 g/ft^2 on study sites 2, 3 and 4, but about 0.5 g/ft^2 at Study Site 1 even after sheep grazing removed a noticeable quantity of annual production. The fact that this was the only site at which Mohave ground squirrel reproduction was recorded in 1996 may be related to the somewhat higher herbaceous standing crop recorded here.

The Mohave ground squirrel diet reflected the low 1995-96 rainfall and the limited availability of forbs (Table 9b and 9c). Shrub leaf was the largest component of the diet in early March and again in late March-early April, with saltbush, spiny hopsage, and winterfat all making important contributions. The exception was Study Site 1, where shrub materials were negligible in spite of the abundance of saltbush here. In late May-early June, Mohave ground squirrels utilized forb leaf as available, but shrub leaf was also well-represented, especially at study sites 2, 3, and 4 where preferred shrub species were most abundant. Again, the small sample from Study Site 1 was almost entirely made up of forb material, especially rattleweed leaf.

Analysis of burro fecal samples collected in the vicinity of Study Site 2 in June 1996 indicated that the diet included over 75 percent grasses and about 18 percent shrub leaf, very similar to previous years (Table 9d). As in 1995, sheep were grazed in Rose Valley in 1996. In this relatively dry year, about one-half of the sheep diet was made up of shrub material. Surprisingly, almost all of the shrub leaf consumed was from winterfat, which is quite scarce in this area. Grasses and forbs each made up about one-quarter of the remaining food items consumed by sheep in 1996.

1996 MONITORING STUDY – TABLE 9b
% OF SHRUBS, FORBS & GRASSES IN DIET OF MGS BY STUDY SITE OVER ACTIVE PERIOD
(March-April and May-June 1996 – winter rainfall 62% of normal)

	Shrubs (by study site)					Forbs (by study site)					Grasses (by study site)				
	1	2	3	4	Total	1	2	3	4	Total	1	2	3	4	Total
Early March	-	89.2	-	-	89.2	-	10.1	-	-	10.1	-	0.2	-	-	0.2
March/ April	1.9	77.4	58.6	87.3	63.3	97.2	17.8	38.2	9.9	33.6	0.1	2.1	0.2	1.0	0.9
May/ June	0.8	63.5	20.4	37.3	37.9	96.7	22.7	73.4	60.9	56.2	0.0	11.1	1.2	0.3	3.3

1996 MONITORING STUDY -- TABLE 9c
% OF WINTERFAT AND TOTAL SHRUBS IN MAY-JUNE DIET OF MGS
(winter rainfall 62% of normal)

	Study Site 1	Study Site 2	Study Site 3	Study Site 4
Winterfat	0.0	20.3	1.2	0.0
Total Shrubs	0.8	63.5	20.4	37.3

1996 MONITORING STUDY - TABLE 9d
% OF SHRUBS, FORBS & GRASSES IN DIET BY STUDY SITE AND HERBIVORE
(May-June 1996 – winter rainfall 62% of normal)

	Shrubs					Forbs					Grasses				
	1	2	3	4	Total	1	2	3	4	Total	1	2	3	4	Total
MGS	0.8	63.5	20.4	37.3	37.9	96.7	22.7	73.4	60.9	56.2	0.0	11.1	1.2	0.3	3.3
Burro	-	17.9	-	-	17.9	-	5.3	-	-	5.3	-	75.8	-	-	75.8
Sheep	51.2	-	-	-	51.2	25.3	-	-	-	25.3	23.6	-	-	-	23.6

Overview of Mohave Ground Squirrel Population Data 1988-1996

Table 10 presents an overview of Mohave ground squirrel population data for all four study sites over the nine-year span of the Coso study. The data represent mark-recapture population estimates, which could not be calculated for trapping sessions on which the number of captures or recaptures were small.

- Study Site 1 has generally had the lowest population levels and no Mohave ground squirrels were recorded on this site from 1989 through 1992.

- Study Site 3 has almost always shown the highest population and the greatest number of juveniles produced, as illustrated by large numbers of young animals in early summer of 1988, 1992, 1993 and 1995.

- In the drought years of 1994 and 1996, the number of adults captured in early summer was never more than 50 percent of the adult population recorded in early spring, suggesting an early entry into estivation by adults.

- The relation of heavy winter rainfall to Mohave ground squirrel reproduction is evident in the large populations (made up mostly of juveniles) found in early summer 1988, 1992, 1993 and 1995.

- The size of adult populations in the early spring reflects the extent of juvenile recruitment during the preceding year, as demonstrated on study sites 2, 3 and 4 over the period from 1993 through 1996.

During this nine-year study, Mohave ground squirrel abundance varied in a parallel manner on all four study sites, as variation in winter rainfall affected reproduction and survival. Moderate production of juveniles in 1988 was followed by reproductive failure and drastic population decline through the severe drought episode that began in summer 1988 and continued until early spring 1991. Three years of good rainfall and Mohave ground squirrel reproduction (1991-1993) resulted in the highest recorded numbers of adults on all four study sites in early spring 1994. Following reproductive failure in 1994, adult populations were significantly lower in early spring 1995. Successful reproduction in 1995 led to a partial recovery in adult numbers by early spring 1996.

MOHAVE GROUND SQUIRREL POPULATIONS BY STUDY SITE FROM 1988 TO 1996 - TABLE 10

(early summer estimates for 1988, 1992, 1993, and 1995 include both adults and juveniles)

Year	1988	1989	1990	1991	1992		1993		1994		1995		1996	
Rainfall (% of long-term average)	119%	49%	19%	88%	155%		138%		45%		162%		62%	
Trapping Season	Early Summer	Early Summer	Early Spring	Early Summer	Early Spring	Early Summer	Early Spring	Early Summer	Early Spring	Early Summer	Early Spring	Early Summer	Early Spring	Early Summer
Study Site 1	20±1	0	0	0	0	0	*	31±6	5±0	*	*	11±0	*	*
Study Site 2	19±1	*	*	*	14±8	52±9	22±4	124±5	32±1	16±0	22±3	78±10	25±1	8±1
Study Site 3	47±1	*	21±2	*	10±5	58±3	47±5	253±12	47±3	13±0	17±0	90±7	43±5	*
Study Site 4	24±7	*	8±2	0	0	20±5	26±11	145±8	32±2	12±0	15±3	58±9	25±6	9±0
Method for Population Estimate	Schnabel	Schnabel	Lincoln-Petersen	Lincoln-Petersen	Lincoln-Petersen		Lincoln-Petersen		Lincoln-Petersen		Lincoln-Petersen		Lincoln-Petersen	

* Data insufficient for population estimates

STATE OF CALIFORNIA

Energy Resources Conservation
and Development Commission

Application for Certification for the ***ABENGOA MOJAVE SOLAR POWER PLANT***	)	Docket No. 09-AFC-5

PROOF OF SERVICE

I, Karen A. Mitchell, declare that on April 28, 2010, I served the attached *Responses To CURE's Data Requests – Set 1 For Which an Extension Of Time Was Requested* via electronic mail and United States Mail to all parties on the attached service list.

I declare under the penalty of perjury that the foregoing is true and correct.

Karen A. Mitchell

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APPLICATION FOR CERTIFICATION
FOR THE *ABENGOA MOJAVE SOLAR POWER PLANT*

Docket No. 09-AFC-5
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