MOHAVE GROUND SQUIRREL
Spermophilus mohavensis

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Management Status: Federal: None
California: Threatened (CDFG, 1998)

General Distribution:

The Mohave ground squirrel occupies portions of Inyo, Kern, Los Angeles and San Bernardino counties in the western Mojave Desert. The species ranges from near Palmdale on the southwest to Lucerne Valley on the southeast, Olancha on the northwest and the Avawatz Mountains on the northeast (Gustafson, 1993).

The species is one of two members of the subgenus *Xerospermophilus*, which also includes the round-tailed ground squirrel (*Spermophilus tereticaudus*) of the eastern Mojave and Sonoran deserts (Hall,1981; Nowak, 1991). The ranges of the two species are in contact along a broad front, although they do not overlap (Best, 1995). There is some evidence that the species hybridizes near Helendale (Wessman, 1977), but the area in question is ecologically disturbed, which may have resulted in the breakdown of behavioral isolating mechanisms (Hafner and Yates, 1983). Analysis of chromosomal and genetic data supports the separation of *S. mohavensis* and *S. tereticaudus* as full species (Hafner and Yates, 1983).

Distribution in the West Mojave Planning Area:

Virtually the entire range of the Mohave ground squirrel is within the WMPA. The following description is based on a review of all known locality records conducted by CDFG and adopted by the Mohave Ground Squirrel Working Group in 1992 (Gustafson, 1993). The species ranges from Palmdale on the southwest north to Olancha. The species occupies canyons in the eastern foothills of the Sierra Nevada up to 5600 ft. (1706 m). In the northwest, the species occupies the Coso Range and Argus Range. The northeast part of the range extends to the Avawatz Mountains and Soda Mountains. The Mojave River roughly marks the southeastern extent of its range, although the species historically occupied an area east of the Mojave River as far as Lucerne Valley. The southern edge of the distribution of the species is limited by the abrupt rise of the San Bernardino and San Gabriel Mountains. Although the species likely occupied the Antelope Valley historically, widespread conversion of native habitats has apparently resulted in the extirpation of the species from west of Palmdale and Lancaster. Recent trapping records and observations are lacking in the southern portion of the range, between Palmdale and Lucerne Valley, and persistence of the species in this highly developed area is in question (Gustafson, 1993).

Natural History:

The Mohave ground squirrel is a medium-sized ground squirrel that measures 8.3-9.1 in. (210-230 mm) in total length, 2.2-2.8 in. (57-72 mm) in tail length, and 1.3-1.5 in. (32-38 mm) in hind foot length (Hall, 1981). There is little difference in size between the sexes. Dorsal coloration is uniformly light gray or brown, often with a wash of cinnamon or pink, while ventral coloration is creamy. The ears are small and the eyelids are white. *S. mohavensis* can be distinguished from *S. tereticaudus* by a shorter, flatter tail with a white ventral surface and brown rather than white cheeks. It is significantly larger than *S. tereticaudus* in most cranial measurements (Best, 1995).

Mohave ground squirrels feed on a variety of foods, but primarily on the leaves and seeds of forbs and shrubs. The diet varies greatly over the course of a season. Leaves of perennial shrubs make up a large part of the diet, and are consumed with greater frequency when annual plants are not available. If herbaceous annuals become available, Mohave ground squirrels forage on their leaves, flowers, seeds and/or pollen. Invertebrates are consumed regularly, but make up a relatively small proportion of the diet. Shrub species that were consumed most often at the Coso study area were winterfat (*Krascheninnikovia lanata*), spiny hopsage (*Grayia spinosa*) and saltbush (*Atriplex* sp.; Leitner and Leitner, 1998). However, it is not known of the results of this study can be extrapolated to the more southerly portions of the range of the species. Additional research concerning the food habits of Mohave ground squirrels in the southern portion of its range is clearly required.

The Mohave ground squirrel exhibits a strongly seasonal cycle of activity and torpor. The species typically emerges from hibernation in early- to mid-March (Leitner and Leitner, 1998). The timing of emergence appears to vary geographically, and individuals in the southern portion of the range may emerge as early as mid-January (Recht, unpublished data). Males typically emerge up to two weeks prior to females (Best, 1995). Once a sufficient amount of fat has been accumulated, individuals enter a period of aestivation and hibernation (Bartholomew and Hudson, 1961). Aestivation generally begins anytime between July and September, but during drought conditions, may begin as early as April or May (Leitner, et al., 1995).

The reproductive success of the Mohave ground squirrel is dependent on the amount of fall and winter rains. A positive correlation between fall and winter precipitation and recruitment of juveniles the following year has been demonstrated (Leitner and Leitner, 1998). Following low rainfall, annual herbaceous plants are not readily available, and the species may forego breeding entirely (Leitner and Leitner, 1998).

Adults of the species are solitary except during breeding, which occurs soon after emergence from hibernation. Gestation lasts 29-30 days, and litter size is between four and nine (Best, 1995). Juveniles emerge from natal burrows within four to six weeks. Mortality is high during the first year (Brylski, et al., 1994). Females will breed at one year of age if environmental conditions are appropriate, while males do not normally mate until two years of age (Leitner and Leitner, 1998).

Individuals may maintain several home burrows that are used at night, as well as accessory burrows that are used for temperature control and predator avoidance. The aestivation burrow is dug specifically for use during the summer and winter period of dormancy (Best, 1995). Burrows are often constructed beneath large shrubs (Leitner, et

al., 1995). Home ranges of adults vary between years and throughout a season, presumably as a result of variation in quantity and quality of food resources. Juveniles are gregarious and initially stay close to the natal burrow. Beginning in June, juveniles begin making exploratory movements away from the natal burrow, and some individuals eventually disperse (Brylski, et al., 1994). Recent radio-telemetry data suggest that females are more likely than males to remain in the vicinity of their natal burrows (Harris et al., 1997). During this study, the majority of radio-collared juvenile males moved greater than 0.6 mi. (1 km), up to a maximum of 3.9 mi. (6.2 km; Harris, et al., 1997). These distances are far greater than had been previously recorded.

Habitat Requirements:

The Mohave ground squirrel occupies all major desert scrub habitats in the western Mojave Desert. It has observed in habitats described by Holland (1986) as Mojave Creosote Scrub, dominated by creosote bush (*Larrea tridentata*) and burrobush (*Ambrosia dumosa*), Desert Saltbush Scrub, dominated by various species of saltbush (*Atriplex*), Desert Sink Scrub, which is similar in composition to saltbush scrub, but is sparser and grows on poorly drained soils with high alkalinity, Desert Greasewood Scrub, with very sparse vegetation generally located on valley bottoms and dry lake beds, Shadscale Scrub, which is dominated by *Atriplex confertifolia* and/or *A. spinescens*, and Joshua tree woodland, which includes Joshua trees (*Yucca brevifolia*) widely scattered over a variety of shrub species (Gutafson, 1993). These habitat types are distributed throughout the range of the Mohave ground squirrel. In the northern portion of the range of the Mohave ground squirrel, it is found in a plant association described as Mojave Mixed Woody Scrub, typically occurring on hilly terrain and composed of a variety of shrub species (Holland, 1986).

The Mohave ground squirrel inhabits flat to moderate terrain and is not generally found in steep contours. However, juveniles can apparently traverse steep terrain during dispersal (Leinter, pers. comm.). The species has been found most frequently in sandy, alluvial soils, but is also found in gravelly, and occasionally rocky soils (Wessman, 1977; Zembal and Gall, 1980; Best, 1995). It is not known to occupy areas of desert pavement (Aardahl and Rousch, 1985).

Critical habitat features center on availability of food resources and soils with appropriate composition for burrow construction. The presence of shrubs that provide reliable forage during drought years may be critical for a population to persist in a particular area. In the Coso Range, spiny hopsage (*Grayia spinosa*), winterfat (*Krascheninnikovia lanata*) and saltbush (*Atriplex* sp.) were consumed extensively in the early spring before annuals were available, during the summer after annuals dried, and during drought years (Leitner and Leitner, 1998). However, critical forage plants in the southern portion of the range of the species may be different, and further investigation is warranted.

Population Status:

Determining the status of the Mohave ground squirrel is difficult due to behavioral and demographic aspects of the species. The species is inactive throughout much of the year, and abundance as well as the period of surface activity varies from year to year.

Live-trapping studies must be scheduled carefully and even then cannot necessarily establish the absence of the species from a site (Gustafson, 1993). Further, Mohave ground squirrel populations are dependent on the amount of fall and winter precipitation (Leitner and Leitner, 1998). If poor conditions persist for several seasons, local extirpation can occur. Re-colonization of these areas can take place after conditions favoring reproduction resume. Therefore, suitable habitat can be unoccupied during some years but occupied during others (Gustafson, 1993).

The Mohave ground squirrel is not distributed continuously throughout its range (Gustafson, 1993). This was true prior to widespread conversion of habitats within its range. The dynamic nature of its distribution, both spatially and year-to-year, makes accurate estimates of overall population size impractical.

Threats Analysis:

The primary cause of the decline of the Mohave ground squirrel is destruction of its habitat and conversion to urban, suburban, agricultural, military and other uses (Gustafson, 1993).

Urbanization has resulted in the loss of native habitats, particularly surrounding the cities of Palmdale/Lancaster and Victorville/Adelanto/Hesperia/Apple Valley. Urban development has accelerated in recent years in these and other areas, such as Mojave, California City and Ridgecrest. Urban development can result in the direct mortality of individuals and loss of habitat, but also in indirect effects such as fragmentation of the remaining habitat, increased on- and off-highway vehicle use, and increased abundance of domestic and feral cats. Local extirpations can result in the loss of genetic variability for the species as a whole, which can lead to a reduced ability to adapt to environmental change (Meffe, et al. 1997). Although Mohave ground squirrels have been observed at the edge of urbanization (e.g. Barstow), it is highly unlikely that the species can persist in urban settings.

Agricultural development has resulted in the loss of occupied and potential habitat in large areas, notably the western triangle of the Antelope Valley, Lucerne Valley and the Mohave River Basin. Agriculture affects the species through conversion of habitat, exposure to pesticides and herbicides and increases in California ground squirrel populations (Wessman, 1977).

Military operations, including weapons testing and troop training, have disturbed or destroyed habitat in certain areas, most notably on Fort Irwin. Energy development, including geothermal and solar energy development, has resulted in habitat loss for Mohave ground squirrels, and several such projects are under consideration.

Fragmentation of habitat resulting from the activities outlined above is another factor in the decline of the Mohave ground squirrel (Gustafson, 1993). Conversion of habitat results in the isolation of populations from one another, which leads to reduced gene flow. Small, isolated populations are subjected to the loss of genetic variation, which may ultimately lead to a reduction in fecundity, growth and survivorship (Meffe, et al. 1997). Small populations face a greater probability of extirpation, resulting from either environmental variation, fluctuations in abundance, or genetic factors such as inbreeding depression and genetic drift (Noss and Cooperrider, 1994). Moreover, if the habitat is

isolated from other blocks of habitat, natural re-colonization of the habitat can not take place.

Degradation of native habitats is another cause of the decline of the Mohave ground squirrel (Gustafson, 1993). Activities associated with increased human occupation include garbage dumping, off-highway vehicle use, and livestock grazing. Food resources available to Mohave ground squirrels occupying degraded habitat will be reduced, resulting in smaller litter size and lowered population levels. Off-highway vehicle use is prevalent in many areas within the range of the Mohave ground squirrel, in both designated and undesignated areas. Off-highway vehicles result in the mortality of individuals, collapsing of burrows, removal of shrubs used for cover, decrease in annual species used as forage, and changes in soil structure (Bury, et al., 1977). Grazing by cattle and sheep occurs throughout the range of the Mohave ground squirrel, and has been taking place for more than a century. Grazing by livestock may affect Mohave ground squirrels through changes in soil and vegetative structure, accelerated erosion, and collapsing of burrows. Persistent grazing pressure has resulted in the replacement of perennial grasses by annual grasses throughout much of the western Mojave Desert. At the Coso study area, overlap in the forage consumed by Mohave ground squirrels with that consumed by both sheep and cattle has been demonstrated (Leinter and Leitner, 1998). Competition for certain shrubs could be exacerbated during times of drought because alternative sources of food are not available. Shrub cover required by the Mohave ground squirrel for thermoregulation and protection from predators can be reduced by grazing pressure (Gustafson, 1993).

The effects of drought are another threat to the Mohave ground squirrel (Gustafson, 1993). Low rainfall leads to reduced productivity of annual plants. This, in turn, can cause Mohave ground squirrels to forego breeding, and can reduce the survivorship of adults. If drought events are prolonged, extirpation of Mohave ground squirrels from an area can result. In itself, drought events would not threaten the species, since it has adapted to these conditions. However, habitat fragmentation and degradation can prevent natural recolonization of habitat from which local populations have been extirpated.

Biological Standards:

Given the temporal and spatial variation in Mohave ground squirrel abundance, protection of large areas of native habitat is likely needed to ensure long-term survival. The size and location of preserve areas should be based on biological, demographic and genetic considerations. Mohave ground squirrel abundance is known to fluctuate widely in response to rainfall patterns. Moreover, during extended droughts, lower quality habitat may not be capable of supporting the species, and local extirpation can occur. However, these areas can be re-colonized by dispersing individuals when conditions favoring reproduction return. Therefore, core preserve areas must be large enough to support sufficient numbers of individuals to account for natural fluctuations in abundance. Further, it is critical that core reserves are situated in high quality habitats in which the species can persist during drought conditions. These "drought refugia" provide sources from which populations may expand under better conditions.

To determine appropriate preserve area size and localities, accurate data regarding demographics and habitat requirements are necessary. The most comprehensive research concerning population dynamics, food habits and habitat requirements of the Mohave ground squirrel has been gathered at a long-term study site in the Coso Range of Inyo County (Leitner and Leitner, 1998). A major result of this study is that certain shrub species appear to be important in providing forage during years when annual forb growth is low. These shrub species may be critical to the persistence of populations through years of drought. However, data gathered at Coso is primarily from a habitat (Mojave Mixed Woody Scrub) that is somewhat atypical of the bulk of the range of the species. Research into food habits and critical habitat features in creosote bush scrub and saltbush scrub habitats more typical of the southern part of the range is necessary to identify critical habitat features. A minimum preserve size of 60,000 acres of suitable habitat has been calculated (Gustafson, 1993).

Smaller preserve areas are not preferable due to consequences that arise from small population size. In general, small, isolated populations are at higher risk of local extirpation resulting from demographic and environmental stochastic events as well as from the genetic consequences of small population size, including loss of genetic variability, genetic drift and inbreeding depression. Smaller areas are also more susceptible edge effects and disturbance from surrounding non-compatible land use (Meffe, et al., 1997).

Connectivity between preserve areas is critical to ensure that populations inhabiting reserves are not isolated and that gene flow between populations is maintained. The width of such corridors between preserves should be based on demographic considerations including home range size and average dispersal distances.

As with all rare species, it is important to preserve naturally occurring genetic variability to the greatest degree possible (Meffe, et al., 1997). Data regarding genetic variation between populations of Mohave ground squirrels are currently lacking. Areas that show genetic differentiation from other populations, if there are such, should be prioritized for protection in order to preserve genetic variability of the species as a whole. Research investigating genetic hierarchies among populations of the Mohave ground squirrel is necessary to address this concern.

Human activities within preserve areas and corridors need to be assessed, managed and monitored. Certain activities are incompatible with maintaining optimal habitat for Mohave ground squirrels and should be eliminated. Other activities may be compatible at lower levels. Grazing by domestic livestock in Mohave ground squirrel habitat may reduce the availability of annual herbaceous plants and perennial forage species that are important to Mohave ground squirrels. Therefore, grazing in designated Mohave ground squirrel preserve areas should be carefully controlled or eliminated. Off-highway vehicle activity can negatively affect the frequency of shrubs critical to Mohave ground squirrel foraging and burrowing and have other direct and indirect effects. Such activities should be controlled or eliminated in Mohave ground squirrel preserve areas.

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