Draft

Mohave Ground Squirrel

Conservation Strategy

Executive Summary

Preface

Members of the Desert Managers Mohave Ground Squirrel Work Group (MGSWG) have prepared Mohave Ground Squirrel Conservation Strategy, in cooperation with the Mohave Ground Squirrel Technical Advisory Group. The following members of the MGSWG participated in writing and discussion until a consensus was reached:

Agency MGSWG and MGSTAG

California Department of Fish and Game ....John, Gustafson, Scott Harris Rebecca Jones, Steven Juarez, Tonya Moore, Denyse Racine, Annette Tenneboe, Julie Vance
California Department of Transportation………Tom Dayak
California State Parks, Lancaster .... Carrie Bemis
California State University………………………Phil Leitner, Tony Recht
County of Kern……………………………………Lorelie Oviatt
County of San Bernardino……………………….Randy Scott
Defenders of Wildlife……………………………..Cynthia Wilkerson
Department of Defense………………………… Clarence Everly
U.S. Air Force……………………………………Shannon Collis, Bob Wood
U.S. Army Fort Irwin... Mickey Quillman, Brian Shomo
U.S. Bureau of Land Management .... Shelly Ellis, Larry LaPre, Bob Parker, Charles Sullivan
U.S. Fish and Wildlife Service, Ventura..............Robert McMorran
U.S. Marine Corps Air Logistics Base ....Carmela Gonzalez, Mannyl Joia
U.S. Naval Air Weapons Station .... Tom Campbell, John O'Gara

Cover photo: Mohave Ground Squirrel in Kern County. Courtesy of Phil Leitner

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Overview

Species Description

The Mohave ground squirrel (*Spermophilus mohavensis*) is a medium-sized squirrel about 23 cm (9 inches) long, including a tail length of about 6.4 cm (2.5 inches) (Grinnell and Dixon 1918, Ingles 1965) and relatively short legs. The upper body pelage has been described as grayish-brown, pinkish-gray, cinnamon-gray, and pinkish cinnamon (Gustafson 1993). M. Recht (cf. Gustafson 1993) has observed that juveniles have cinnamon-colored pelage and molt to gray as they mature into adults. He further states that Mohave ground squirrel dorsal hair tips are multi-banded and the skin is darkly pigmented. Both of these characteristics assist in thermoregulation. The eyes are fairly large and set high in the head.

Taxonomy
The Mohave ground squirrel is a distinct full species, with no subspecies. It was discovered by F. Stephens in early June 1886 (Gustafson 1993) and formally described as a distinct, monotypic species by Merriam (1889). Best (1995) gives a full account of the taxonomy including changes in generic names. The type locality is near Rabbit Springs, about 24 km (15 miles) east of Hesperia in Lucerne Valley. The Mohave ground squirrel's closest genetic relative, the round tailed ground squirrel (*Spermophilus tereticaudus*), has a contiguous, but non-overlapping geographic (i.e., parapatric) range. This has lead to some controversy as to whether the two taxa are full biological species (Gustafson 1993). However, the studies of Hafner and Yates (1983) and Hafner (1992) demonstrated a degree of chromosomal, genetic, and morphological differentiation consistent with distinct species recognition. Supporting evidence includes: the Mohave ground squirrel has a diploid chromosome number of 38 while that of the round-tailed ground squirrel is 36; electrophoretic analysis of 24 gene loci coding for 16 proteins revealed a moderate level of genetic differentiation between the taxa (Rogers genetic similarity $S = 0.78$); and morphometric analysis of 20 cranial characters showed significant differences ($p < 0.0001$), with the Mohave ground squirrel being larger in all but two characters. Ecological factors, such as the Mohave ground squirrel's preference for gravelly soils and the round-tailed ground squirrels' preference for sandy soils, may serve as a prereproductive isolating mechanism (Hafner and Yates 1983, Hafner 1992) between the two ground squirrels. The species are likely to be isolated behaviorally as well. For example, the Mohave ground squirrel is a solitary species while the round-tailed squirrel is colonial (Recht cf. Gustafson 1993). It is plausible that additional prereproductive isolating mechanisms exist.

In spite of support for distinct species status, evidence of hybridization was found in three specimens, one from about 1.5 miles northwest of Helendale and two from near Coyote Dry Lake about 21 km (13 miles) northeast of Barstow (Hafner 1992). Significantly, Helendale is an extremely disturbed site, ecologically dissimilar from the other study localities with no evidence of hybridization. The specimens collected near Helendale were found adjacent to agricultural fields and nowhere else. The artificially elevated food supply in these fields may have broken down ecological prereproductive isolating mechanisms that normally prevent hybridization (Hafner and Yates 1983) and the authors conclude that retention of full species status for the Mohave ground squirrel is warranted. [need to insert update from Kayce Bell here].

Hafner (1992) interpreted the existing data to indicate a zone of parapatry in which there is neutral secondary contact, i.e. no significant competition or intergradation between the species following vicariance and differentiation. The vicariance event thought to initiate the speciation is the Wisconsinan full pluvial which created a network of rivers and lakes near the end of the Pleistocene Period (Hafner 1992).

Distribution
The presumed historic range of the Mohave ground squirrel is shown in Figure 1 [probably best to get the

current DFG range maps] as delineated by the California Department of Fish and Game (1980). Confined to the northwestern corner of the Mojave Desert, it is bounded on the south and west by the San Gabriel, Tehachapi, and Sierra Nevada Mountains. On the northeast, it is bounded by Owens Lake and a series of small mountain ranges, including the Coso, Argus, Slate, Quail, Granite, and Avawatz Mountains. On the southeast, the range of the Mohave ground squirrel abuts a portion of the range of the closely related round-tailed ground squirrel (*Spermophilus tereticaudis*). The 232 km (144 mile) zone of parapatry of these two species closely follows the network of ancient lakes and rivers that existed in the late Pleistocene Period until about 10,000 years ago (Hafner 1992). While the present Mojave River generally defines the extreme southeastern boundary of the Mohave ground squirrel's range, the species historically occurred east of the river in Lucerne Valley (see list of specimens examined by Hafner 1992).

The current range of the Mohave ground squirrel is shown in Figure 2 [again, get updated map if available] as delineated in Gustafson (1993). The boundaries illustrated here include all known occurrences of the species and of native vegetation types used by the species in the vicinity of known occurrences. Mountain ranges on the periphery of the range are excluded. Also excluded from this revised map is the extreme southwestern toe of the presumed historic range (roughly 1,037 km^2 or 400 mi^2), which is that portion of the Antelope Valley west of Palmdale, Lancaster, Rosamond, and Mojave. Although this area apparently contained squirrel habitat prior to the extensive agricultural development and urbanization of recent decades, and a small amount of habitat still remains, the new boundary reflects the lack of definite records of the squirrel's occurrence here. The squirrel may now be almost completely extirpated from the Victorville to Lucerne Valley portion of its historic range because most of the habitat here has been fragmented or lost due to agriculture and urbanization. However, this region has been retained in the current range because historic records and two recent documented occurrences (R. Jones, personal observation).

As delineated above, the current geographic range of the Mohave ground squirrel includes about 19,800 km^2 (7,640 mi^2) in the western portion of the Mojave Desert in California. This is the smallest range among the ground squirrel species found in the United States. Only the San Joaquin antelope ground squirrel (*Ammospermophilus nelsoni*) in California and the Idaho ground squirrel (*Spermophilus brunneus*) have comparably small ranges (Hall 1981). Also, it is important to note that, even within apparently suitable habitat, the distribution of the Mohave ground squirrel is very patchy. Thus, much of the potential habitat is unoccupied. In part, this probably is due to both naturally and anthropogenically induced local extirpations, and failure to repopulate these vacated sites, as discussed below under threats due to habitat fragmentation.

State Highway 58 bisects the Mohave ground squirrel range between Mojave and Barstow. Extensive trapping efforts in a number of areas south of this highway for the past 5-10 years (P. Leitner, personal communication) reveal that the only significant population of Mohave ground squirrels in this part of their historic range is in one region of about 15 x 20 km in the eastern portion of Edwards Air Force Base. The species appears to be absent from extensive portions of its range in the Antelope Valley, Lancaster, and Palmdale regions (P. Leitner, personal communication). This supports Gustafson's (1993) conclusion that the persistence of the species in the highly developed area between Palmdale and Lucerne Valley is in question. The apparent absence from most portions of the Mohave ground squirrel range south of SR-58 constitutes elimination across 25-30% of the historic range. This is based on surveys throughout the Mohave ground squirrel range from 2002-2004 (Leitner 2005; Figure 3).

North of State Highway 58 are additional areas where Mohave ground squirrels have failed to be detected in recent trapping surveys. Dr. Leitner's research (P. Leitner, personal communication) indicates a number of areas where human-caused or natural habitat degradation and low habitat suitability present barriers within the north and central portions of the Mohave ground squirrel range. As a result, the population in these sections of the range may be significantly fragmented. Recent surveys also indicate no evidence of the Mohave ground squirrel over a wide area on the eastern edge of their range. In 2004, this consisted of 15 sites trapped from the El Mirage OHV Area to Fort Irwin. No Mohave ground squirrels were captured. (Leitner, Handout from February 2004 Mohave Ground Squirrel Technical Advisory Group meeting).

In the portions of their range where Mohave ground squirrels have been reliably found (the "core areas" as shown in Figure 5), habitat continues to be developed and lost. Without dedication to maintaining intact habitat in these core population areas and connectivity between them, the trend of local extinction seen in the more developed southern portion of the Mohave ground squirrel range is expected to continue throughout the range.

Habitat Requirements
The Mohave ground squirrel has been reported from all of the broad community types of Munz and Keck (1959) and Vasek and Barbour (1988), and all but three of Holland's (1986) more narrowly defined communities (Gustafson 1993). It has been observed in habitats described by Holland (1986) as Mojave Creosote Scrub, dominated by creosote bush (*Larrea tridentate*) 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 (Gustafson 1993). These habitat types occur throughout the range of the Mohave ground squirrel. In the northern portion of the range, this species is also found in Mojave Mixed Woody Scrub, typically occurring on hilly terrain and composed of a variety of shrub species (Holland 1986).

Creosote Bush Scrub is the most wide-spread of the broad community types within the range of the Mohave ground squirrel, and also tends to have the greatest production of annual plants. Therefore, it is not surprising that this is the community type in which the Mohave ground squirrel is most often found. This species inhabits flat to moderate terrain and generally avoids steep slopes and rocky terrain (Leitner 1980, Leitner and Leitner 1989). However, juveniles can apparently traverse steep terrain during dispersal (Leitner, personal communication). Mohave ground squirrels exhibit a preference for gravelly as opposed to sandy soils (Hafner 1982), but have been found in sandy and, occasionally, rocky soils (Wessman 1977, Zembal and Gall 1980, Best 1995). The species is not known to occupy areas of desert pavement (Aardahl and Roush 1985).

Essential habitat features consist of 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 (Leitner and Leitner 1998). During drought episodes, Mohave ground squirrel populations may fail to persist in low quality habitat. High quality drought refugia, defined by the availability of preferred food sources (winterfat and spiny hopsage in the Coso Range), are necessary to maintain overall populations and act as a source for recolonization of surrounding habitat. As such, the combination of shrub vegetation quality and winter rainfall may explain spatial and temporal variation in Mohave ground squirrel presence and absence.

Although records of Mohave ground squirrel occurrences have been found in a variety of habitat types throughout their range (as stated above), these locations may not be indicative of sustained or persistent Mohave ground squirrel populations because of variability of habitat quality due to natural events (i.e., winter rainfall and annual plant reproduction) and human-related activities which fragment, destroy, or modify otherwise suitable habitat. For example, many of the community types in which the squirrel has been found differ considerably in vegetative composition throughout the range and may not include shrubs or annuals even in years of adequate rainfall (see discussion under food habits). Harris (personal communication) indicates that hardly any historical Mohave ground squirrel locations completely lack winterfat and spiny hopsage and this is supported by the dated presented below under "food habits" from unpublished data referenced in Leitner (2004). Since much of the creosote scrub habitat in the Mojave

Desert does not include these shrub species, it may not constitute optimal habitat for the species. Other plant community may provide suitable habitat only after one or two years of adequate rainfall when populations are expanding, but they will not be consistently occupied after years of less rainfall. These habitats may become population sinks when precipitation levels are suboptimal. Additionally, juveniles can travel considerable distances (see next section), and may appear in habitats that are not permanently occupied. Therefore, it is possible that some of the historical records may be from sites that were occupied only on a transient basis.

Home Range and Movements
Adult home ranges vary between years and throughout a season, presumably as a result of variation in quantity and quality of food resources. Harris and Leitner (2004) studied home ranges and movements of 32 adult female and 16 adult male Mohave ground squirrels with radio-telemetry on the Coso Range in 1990 and 1994-1997. For adult females, home ranges were largest in a year of extreme drought (1990) and during two years when rainfall was ample enough to support reproduction. During a severe drought in 1990, individual movements between 200-400 m a day were recorded by Leitner and Leitner (1998). Harris and Leitner (2004) suggest that the extreme drought necessitated larger movements in order to find scarcer food resources. In the productive years, greater overall resources were necessary to support reproduction, also increasing the size of the home range. In years of moderate drought and no reproduction, the Mohave ground squirrels appeared to gather enough resources in a smaller area to support early aestivation.

Leitner et al. (1991) determined that the mean home range of 12 radio equipped Mohave ground squirrels was 1.9 ha (4.7 acres), calculated using the minimum convex polygon (MCP) method. However, the burrows in which individual squirrels spent the night often were 183 – 366 (200-400 yards) from the areas where they foraged during the day. Harris and Leitner (2004) report home range sizes separately by sex and for the mating and postmating season. Postmating home ranges of females ranged from 0.29-1.9 ha (median value, MCP method) with an average of 1.2 ha (Harris and Leitner 1999), while those for males ranged from 0.38 to 2.96 ha (J. Harris, personal communication) and averaged 1.24 ha (Harris and Leitner 1999). During the 1997 mating season, (mid-February to mid-March), the median MCP home range for males was 6.73 ha while that for females was much smaller at 0.74 ha (Harris and Leitner 2004).

The maximum distance moved within-days, as reported by Harris and Leitner (2004), was greater for males during the mating season (median 391 m, range 274 – 1,491 m) than during the postmating season (median 130 m, range 46-427 m). The same figure for females did not differ between the mating (median 138 m, range 96-213 m) and postmating seasons (median 205 m, range 24-371). The maximum within-days distance moved was significantly greater for males than females only during the mating season. Additionally, Harris and Leitner (2004) report that 40.2% of male squirrel within-days movements were greater than 200 m during the mating season. This is significantly more ($p<0.05$) than that for the postmating season (13.8%). Females hardly ever moved greater than 200 m within a day. This occurred 1.5% of the time in the mating season and 6.1% of the time in the postmating season, although the difference was not significant. Overall, the percentage of within-day movements greater than 200 m was significantly greater for males than females only during the mating season ($p<0.001$). Female home ranges may be separated by a distance greater than the diameter of their typical home range (Harris and Leitner 2004), thus necessitating larger male movements during the mating season in order to maximize the number of mating opportunities.

Individuals may maintain several home burrows that are used at night, as well as accessory burrows that are used for temperature regulation 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).

Mohave ground squirrels exhibit male-biased natal dispersal with many males moving at least one km from their home burrows (max 6.2 km) while most females settle within 200-300 m (Leitner and Leitner 1998;

Harris and Leitner 2005). Natal dispersal begins with exploratory movements of several hundred meters during the day, with the squirrel returning to the natal burrow at night (Brylski et al. 1994, Leitner and Leitner 1998). Aardahl and Roush (1985) also noted that juveniles had larger home ranges than adults, although their work was not designed to estimate home range. Adult females appear to display strong site fidelity. Leitner and Harris (2004) found that all females located in multiple years demonstrated some amount of overlap with their previous year's home range (mean 41% +/- 16%) and four females demonstrated complete overlap.

Food Habits

Recht (1977) characterized the Mohave ground squirrel as a facultative specialist, concentrating for short periods of time on particular food sources, but changing from one source to another throughout the active season. He believed that squirrels sampled various foods periodically in order to recognize better forage, and that the two properties that caused them to select a particular plant species over others available at a given time were higher water content and greater abundance. Leitner and Leitner (1989) found great variation among individual squirrels, even on the same study site, suggesting that individuals may concentrate on their own preferred foods. These observations are not mutually exclusive, of course, and the general finding is that the Mohave ground squirrel is quite flexible in exploiting high quality food resources (Leitner and Leitner 1992). In their syntheses of nearly a decade of data from the Coso Range, Leitner and Leitner (1998) confirm that these squirrels continuously sample available foods, but only concentrate on one or two items at a time.

Mohave ground squirrels are known to eat a wide variety of foods including: leaves of forbs, shrubs, and grasses; fruits and flowers of forbs; seeds of forbs, grasses, shrubs, and Joshua trees; fungi; and arthropods (Gustafson 1993). Leitner and Leitner (1992) noted that the larvae of several species of Lepidoptera were present in exceptional numbers in the spring of 1991 and that the squirrels selected them even though the leaves and seeds of forbs also were abundant. More generally, Leitner and Leitner (1998) conclude that Mohave ground squirrels exploit intermittently available food sources. Of particular importance to the Mojave ground squirrel diet are annual forbs, insufficient production of which in poor rainfall years may lead to reproductive failure (Leitner and Leitner 1990).

In their 1998 study, which summarized data collected from 1988-1996 at the Coso Range, Leitner and Leitner found that forbs comprised approximately 42% of the Mohave ground squirrel diet. Shrub material, especially foliage, made up about 45% (of all fecal samples, which included early, middle, and late active season during both wet and dry years) and is critical both early and late in the active season (when forbs are not available or are dried out) and in drought years when it may be the only food source available. The leaves of three shrubs (winterfat, *Krascheninnikovia lanata*; spiny hopsage, *Grayia spinosa*; and saltbush, *Atriplex* sp.) made up 60% of the Mohave ground squirrel shrub diet (i.e., 24% of their overall diet), indicating that these three species are the mainstay food for Mohave ground squirrel when forbs are not available (early and late in the season and in drought years). Based on these data, Leitner (personal communication) maintains that winterfat and spiny hopsage are habitat elements essential for sustaining Mohave ground squirrel populations when winter rainfall and annual plant production limit or preclude Mohave ground squirrel reproduction and dispersal into unoccupied or underutilized habitats. Leitner (personal communication) further hypothesizes that large areas of creosote bush habitat within the Mohave ground squirrel range lacking significant amounts of these two shrubs are not optimal habitat. Evidence supporting these hypotheses is derived from data of forty individual Mohave ground squirrels captured in field studies in 2002. Thirty-nine Mohave ground squirrels were captured at ten grids (sampling arrays) with combined winterfat and spiny hopsage densities equal to or greater than 300 per hectare, while only one was trapped at four grids where densities of the two shrubs were less than 300 per hectare (Leitner, unpublished data referenced in Leitner 2004). Additionally, the John Harris notes that differences in Mohave ground squirrel abundance and persistence through drought at the 4 Coso sites are related to the density of shrubs (J. Harris, personal communication). At Coso site 1, there is very little winterfat or spiny hopsage. At that site, adult numbers are lowest of all four sites and there have been years when the species disappeared. At site 2 (Coso Basin), adult captures have been concentrated in the corner of the grid that has a high density of winterfat and spiny hopsage. The site with the highest desity of these shrubs, site 3 (Cactus Peak) has had the highest density of squirrels over the length of thes study.

Importantly, the Leitner and Leitner 1998 study documented a dietary overlap between livestock and the Mohave ground squirrel for winterfat, a plant that is relatively uncommon. The cattle diet consisted of 24% winterfat and 13% saltbush. The domestic sheep diet was comprised primarily of forbs and grasses (83%) in a wet year (1995) and 50% winterfat in a dry year (1996).

Seasonal and Daily Activity

The activity season of the Mohave ground squirrel is very short (Bartholomew and Hudson 1960; Tomich 1982). Adults generally are active for only about five months a year (usually February to July), during which time they reproduce, forage, and prepare for about six months of inactivity (usually August through January). During the inactive season, the squirrels are secluded in their burrows and exist in a state of torpor for much of the time. The reduced metabolic rate of the torpid squirrels conserves energy and water, permitting them to be maintained on their stores of body fat. The summer period of inactivity is specifically called aestivation and the winter period is called hibernation. This behavior appears designed to avoid that part of the year when food is scarce and temperatures may be extreme.

The length of the activity season for individual Mohave ground squirrels varies depending on age, sex, and the availability of food resources. Aestivation generally begins between July and September in reproductive years, but may start as early as April or May in non-reproductive years (Leitner, et al. 1995). Generally, Mohave ground squirrels emerge from hibernation with low body weights and fatten substantially during the active period (Leitner and Leitner 1998). In a poor food year, it takes longer for an individual to acquire the amount of fat necessary to carry it through the long period of inactivity. Adults tend to enter aestivation earlier than juveniles because they do not have to put energy into growing before beginning to store fat, and they usually have home ranges with better food resources (Recht 1977). Juveniles may remain active as late as August or September (Recht cf. Gustafson 1993). Males tend to enter aestivation earlier than females because they typically emerge from hibernation earlier (Recht cf. Gustafson 1993) and do not have to put energy into milk production and the feeding of young before they begin to store fat (Leitner and Leitner 1992). Males also typically emerge up to two weeks prior to females (Best, 1995).

During the early part of the active season, Mohave ground squirrels are above ground throughout the day (Recht 1977). However, as temperatures increase later in the spring, the squirrels spend more and more time in the shade of shrubs and sometimes retreat briefly to burrows. This behavior reduces their heat load from the sun's radiation. To dissipate excess body heat, a squirrel often will dig a shallow depression in a shady spot and lay prone in it for a short time, allowing heat to be conducted efficiently from its body into the soil. Conversely, when ambient temperatures are cool, a squirrel may bask in the sun to warm its body. The rate of warming probably is increased by erection of the body hairs on the side facing the sun, which exposes the darkly pigmented skin.

Social Behavior

Recht (cf. Gustafson 1993) found that males tended to be territorial during the mating period. Females entered the territory of a given male one at a time and remained for a day or two, apparently copulating in the male's burrow. Thereafter, the females established their own home ranges. In contrast, Harris (personal communication) has evidence that males stake out the hibernation sites of females so that they can mate with them when they emerge. After weaning, juveniles in Recht's (1977) study established home ranges that were larger and of poorer quality than those of adults. Adults kept juveniles out of their home ranges by antagonistic behavior. Juvenile home ranges were clustered around those of adults, and when the adults entered aestivation, the juveniles took over the adults' home ranges.

Although usually not defending a territory in the strict sense, both juvenile and adult Mohave ground squirrels tend to be solitary with little overlap of their home ranges. This probably is the result of each squirrel maintaining a spatiotemporal territory about 2 m in diameter, the invasion of which by a conspecific triggers fighting (Recht cf. Gustafson 1993). The extreme intraspecific aggression demonstrated in Adest's (1972) laboratory studies is consistent with such an interpretation. However, Harris and Leitner (2004) found considerable overlap in male home ranges during the mating season, though they do seem to stay away from each other on a smaller scale.

Reproduction

Mohave ground squirrels mate soon after emergence from hibernation (Burt 1936; Leitner et al. 1991; Recht cf. Gustafson 1993) from mid-February to mid-March (Harris and Leitner 2004). Gestation lasts 29-30 days and litter size is between four and nine (Best 1995). Lactation continues through mid-May (Pengelley 1966) and juveniles most likely emerge from natal burrows within three to six weeks. Mortality is high during the first year (Brylski et al. 1994) and apparently skewed towards males, resulting in a high adult female to male ratio (between 7:1 and 1.3:1 in Leitner and Leitner 1998). Females will breed at one year of age if environmental conditions are favorable, while males sometimes do not mate until two years of age (Leitner and Leitner 1998).

Mohave ground squirrel reproductive success is dependent on the amount of fall and winter rainfall. A positive correlation between fall and winter precipitation and recruitment of juveniles the following year exists (Leitner and Leitner 1998). Following low rainfall (less than 65 mm) winters, annual herbaceous plants are not readily available, and the species may forego breeding entirely (Leitner and Leitner 1998). Harris and Leitner (2004) found that timing of rainfall is also important as reproduction did not occur in years with less than 30 mm of winter precipitation by the end of January. Due to the small geographic range of the species, a low rainfall year could result in reproductive failure throughout the Mohave ground squirrel range (Harris, personal communication). Indeed, in the spring of 1994, following a winter with low rainfall, there was no evidence of Mohave ground squirrel reproduction recorded at a number of survey sites throughout the northern and central portions of the species' range (Leitner, personal communication). This indicates that range-wide, synchronized reproductive failure occurs periodically. Although this is a natural phenomenon, it increases the vulnerability of the species to the effects of anthropogenic habitat loss, fragmentation, and degradation.

The evidence that extended periods of abnormally low winter precipitation apparently cause high rates of Mohave ground squirrel mortality in most areas within its range unless sufficient key shrub species are available in core areas has important implications for Mohave ground squirrel conservation. The result is that habitat loss in core areas and activities that sever dispersal and/ or movement corridors between these core areas will impede and potentially prohibit conservation.

Interaction of Mohave and Antelope Ground Squirrels

The geographic range of the Mohave ground squirrel is overlapped completely by the range of the white-tailed antelope ground squirrel (*Ammospermophilus leucurus*). While these species are roughly similar in size (the Mohave is somewhat larger) and food habits, there apparently is little competition between them. Leitner and Leitner (1989) found that they differ in the relative proportions of foliage and seeds eaten. The predominant food of the Mohave ground squirrel was the foliage of forbs and shrubs, with seeds of forbs and shrubs the next most important food category. The opposite was true for the antelope ground squirrel, with seeds being predominant, forb foliage of lesser importance, and insects making up about 25% of their diet.

Mohave and antelope ground squirrels also differ in other aspects of their biology. For example, while the Mohave ground squirrel is solitary, the antelope ground squirrel is colonial (Bartholomew and Hudson 1960). In encounters between individuals of the two species, the Mohave ground squirrel is dominant and displaces the antelope squirrel (Adest 1972, Zembal et al. 1979). Finally, by virtue of its ability to utilize seeds, a food resource that remains available long after it has been produced (Leitner and Leitner 1990), the antelope ground squirrel remains active all year long instead of aestivating and hibernating like the Mohave ground squirrel (Bartholomew and Hudson 1960).

Predators
There is little documentation of the Mohave ground squirrel's natural predators. Leitner et al. (1991) found circumstantial evidence of predation by the prairie falcon and coyote. Recht (see Stewart 1993) found similar evidence of predation by the Mohave rattlesnake. Leitner (2005b), has seen high numbers of ravens in Mohave ground squirrel habitat. Raven populations have increased over 1000% in the California desert throughout the past 30 years (Boarman 2002) and are known to prey on small mammals. John Harris (personal communication) has found empty Mohave ground squirrel radio-collars (sometimes with blood and hair present) on or under Joshua trees on several occasions. Ravens were commonly seen perching and nesting on Joshua trees at these sites. Harris further notes (personal communication) that juvenile Mohave ground squirrels could be particularly vulnerable to raven predation. Other likely predators include the red-tailed hawk, badger, kit fox, bobcat, and gopher snake.

Threats

The Mohave ground squirrel is threatened by loss of habitat and degradation of habitat due to urban, suburban, and rural development, agriculture, military activities, energy development, livestock grazing, and OHV use (California Department of Fish and Game, 2005).

A. Curtailment of Range
The persistence of the Mohave ground squirrel is inherently threatened due to its relatively small range (WEMO HCP, Appendix MGS-3). As detailed above under "distribution," the Mohave ground squirrel appears to be absent from a large percentage of this historic range. Except for the existing population in the eastern portion of Edward's Air Force Base, the species has been absent from almost all surveys conducted south of State Highway 58 for the past 10 years (Leitner 2004). A recent GIS analysis has calculated the extent of this curtailed area as over 400,000 ha (over 1 million acres), which amounts to over 20% of the species' range (Wilkerson and Stewart, 2005).

B. Habitat Destruction
Throughout the remaining portion of its range, Mohave ground squirrel habitat incurs present and threatened destruction due to urban and rural development, agricultural practices, military operations, energy production, and transportation infrastructure.

Urban, Suburban and Rural Development
Large scale habitat destruction occurs in urban areas with the development of subdivisions, shopping malls, golf courses, aircraft runways, landfills, sewage disposal facilities, prisons, dikes and levees, etc. The greatest losses to urbanization have been in and adjacent to the cities of Palmdale/Lancaster, Victorville/Adelanto/Hesperia/Apple Valley, and Ridgecrest. Smaller areas of urbanization include the towns of Kramer Junction, Boron, North Edwards, California City, Mojave, Rosamond, Inyokern, and Little Rock. Additional urbanization has occurred at the headquarters and outlying areas of the three major military bases: Edwards Air Force Base, the National Training Center and Fort Irwin, and China Lake Naval Air Weapons Station. Gustafson (1993) notes that while no single development threatens the existence of Mohave ground squirrel in a region unless it destroys the last population, "the total impact of all large developments, combined with the impact of smaller developments, can result in the regional extirpation of the species." Gustafson goes on to hypothesize that this is what occurred in the western triangle of Antelope Valley, to the west of SR-14, and in the area east of Victorville.

Since the 1993 analysis of Mohave ground squirrel range, cities within the Mohave ground squirrel range (Adelanto, Apple Valley, California City, Hesperia, Lancaster, Palmdale, Ridgecrest, and Victorville) grew by an average of 38.8% between 1990 and 2000 (calculated from WEMO HCP, Table 3-38, which cites

Alfred Gobar Associates; U.S. Bureau of the Census; AnySite Online). A recent GIS analysis (Wilkerson and Stewart, 2005) indicates that urban development now accounts for over 44,000 ha (108,000 acres) and rural development spans over 11,000 ha (28,000 acres). In total, these lands in a developed state account for 2.8% of the Mohave ground squirrel range.

The current version of the West Mojave Plan HCP and California Desert Conservation Area Plan Amendment ("WEMO Plan") allows development throughout one-third of the Mohave Ground Squirrel range. WEMO justifies this by conserving 35% of the range in a Mohave ground squirrel Conservation Area. Within the Mohave ground squirrel Conservation Area itself, 6,975 ha (17,235 acres) of habitat would be allowed to be taken. The mitigation provided under WEMO is 5:1 for lands within the Conservation Area. Importantly, the West Mojave Plan does not protect known Mohave ground squirrel core habitat areas from future development and some of these core areas are currently impacted by livestock grazing and other uses. Outside of identified conservation areas, the mitigation ratio is either 1:1 or 0.5:1 depending on the designated quality of the habitat for the desert tortoise. Current observations indicate that desert tortoise habitat quality does not necessarily equate with Mohave ground squirrel habitat quality (P. Leitner, personal communication). There are extensive areas within Mohave ground squirrel range that appear to support good desert tortoise populations but are absent of Mohave ground squirrels. Additionally, current mitigation for Mohave ground squirrel impacts has been much higher than this 1:1 ratio (generally between 3:1 and 5:1 with the lowest recorded ratio of 2.3:1 for the Hyundai HCP). Unlike current permits, the WEMO mitigation does not include additional enhancement and endowment funds, thus decreasing the conservation value of the mitigation considerably.

Mohave ground squirrels are not completely absent from all urban areas. Mohave ground squirrels were observed south of Highway 138, near Pinyon Hills as well as near an aesopace industrial complex located adjacent to Palmdale in 2002. Both cases involved some available undeveloped habitat. Observations have also occurred in residential backyards in Inyokern and on the golf course at China Lake.

Agricultural Development

Agriculture causes conversion of Mohave ground squirrel habitat, and exposure to pesticides, herbicides and rodenticides (California Department of Fish and Game 2005). Hoyt (1972) noted that agricultural fields had been established in former habitat of the Mohave ground squirrel and Aardahl and Roush (1985) state that urban and agricultural development has resulted in "[s]ignificant loss of habitat" for the species. One hundred and fifty-eight square kilometers (61 square miles) of Mohave ground squirrel habitat had been lost to agriculture by the early 1990s (Gustafson 1993). No updated data are available to quantify the extent or intensity of this threat at the present time. The WEMO HCP (Appendix M) reports that about 4% of the historic Mohave ground squirrel occurrences are found in agricultural areas. Current estimates are that over 37,000 ha (92,000 acres) of current Mohave ground squirrel habitat - equal to 1.9% of the total – is in agriculture (Wilkerson and Stewart 2005).

Military Operations

Military maneuvers directly kill Mohave ground squirrels, damage vegetation, compact soils, change soil texture, and create fugitive dust. As a result, the habitat is largely denuded, the composition, abundance and distribution of the vegetation is altered, and the soil becomes finer grained. Finer textured soils do not provide a suitable habitat substrate for ground squirrel burrow construction (California Department of Fish and Game 2005). Tanks and other military vehicles have impacts similar to, and perhaps more intense than, the impacts of off-highway vehicles on the Mohave ground squirrel. As detailed below, Bury et al. (1977) found these direct and indirect impacts (including running over individual animals, collapsing their burrows, destruction of shrubs, disturbance of soils, and reduction in the number of spring annuals) to be detrimental to wildlife and Creosote Scrub habitat in the Mojave Desert. Current training at Fort Irwin encompasses about 146,000 ha (360,500 acres) of Mohave ground squirrel habitat (Wilkerson and Stewart 2005). This amounts to 7.4% of the total range. Krzysik (1991) noted heavy shrub losses and disturbance to this habitat due to military operations at Fort Irwin.

The recently approved expansion of Fort Irwin affects over 30,500 ha (75,300 acres) within the Mohave ground squirrel range and represents a significant loss of Mohave ground squirrel habitat (1.5%). California Department of Fish and Game biologists term this as “probably excellent habitat” for Mohave ground squirrels (CDFG 2004) and P. Leitner describes it as being in the “middle of prime Mohave ground squirrel habitat (personal communication).” Further, the same CDFG biologists conclude that “[t]he potential expansion likely represents the single largest threat to the viability of the [Mohave ground] squirrel (CDFG 2004).” At a January 7, 2004 Mohave Ground Squirrel Technical Advisory Group (“TAG,” headed by the California Department of Fish and Game) there was broad acknowledgement amongst the TAG participants that this expansion would jeopardize the existence of the Mohave ground squirrel.

In addition to impacting up to 30,000 ha of prime Mohave ground squirrel habitat, the expansion of military training on Fort Irwin would fragment one of only four known thriving populations of the species. Eventually this region will represent a dispersal barrier between the remaining habitat to the north on the Goldstone Tracking Station and in the Mojave B range of China Lake Naval Air Weapons Station and that at Coolgardie Mesa to the south. The California Department of Fish and Game acknowledged this habitat fragmentation concern in their comments on the West Mojave HCP (DFG comment letter dated December, 22, 2003): “the [Fort Irwin expansion] isolates the relatively-intact Goldstone area, at which there is evidence of good squirrel populations.” Because Mohave ground squirrels rely on continuous habitat to survive low rainfall years, even that habitat not directly destroyed by the expansion will be less capable of sustaining Mohave ground squirrels.

The Supplemental Draft Environmental Impact Statement (SDEIS) for the Fort Irwin expansion indicates that the impacts of this project on the Mohave ground squirrel are significant (Charis 2004, p. 4-21). Unfortunately, there is no mitigation targeted at reducing the significant impact to the Mohave ground squirrel. The Biological Assessment concludes that this is “[b]ecause the Mojave ground squirrel is not listed federally (Charis 2003, p. 4-39).” Instead, the SDEIS document claims that “[c]reation of conservation areas and purchase of mitigation lands for desert tortoise and Lane Mountain milk-vetch will also benefit the Mojave ground squirrel, where the ranges overlap (Charis 2004, p. 4-26).” As the compensation lands have not been identified, it is impossible to quantify or rely on the fact that the amount of overlap between the compensation lands and the Mohave ground squirrel will be sufficient. Further, recent Mohave ground squirrel monitoring indicates that much of the Desert Wildlife Management Areas (DWMAs) where desert tortoise compensation lands will be directed do not have Mohave ground squirrel populations (P. Leitner, personal communication). This lack of overlap is particularly apparent in the Ord-Rodman DWMA, the entirety of which is southeast of Barstow and outside the known Mohave ground squirrel range.

Energy Production

Leitner (1980) discusses the impacts of geothermal energy production, remarking that “it will be very difficult to carry out geothermal exploration and development activities [in the Coso Geothermal Study Area] without causing some adverse impacts [to Mohave Ground Squirrels].” According to Leitner and Leitner (1989), the production of geothermal resources at the Coso Known Geothermal Resource Area (KGRA) resulted in the loss of up to 405 hectares (1,000 acres) of desert scrub habitat. The areas with the highest geothermal development potential also supported populations of Mohave ground squirrel (Leitner 1980). In addition to geothermal development, there also exist solar energy development plants within the range of the Mohave ground squirrel. Although the associated acreages and impacts have not been quantified, one can assume such development may degrade the functional value of Mohave ground squirrel habitat.

Transportation

An extensive network of roads and highways lies within the range of the Mohave ground squirrel and they are known to be run over by vehicles (Gustafson 1993). Paved routes themselves render habitat completely unusable by the Mohave ground squirrel for burrowing or forage production. Extensive vehicular routes may also pose a behavioral barrier to some movement, thus further fragmenting otherwise quality Mohave ground squirrel habitat. Although radio-collared Mohave ground squirrels have readily traversed 4-lane divided highways, these crossing are made at considerable mortality risk (Leitner, personal communication). A 1998 survey reported in the Western Mojave Desert Off-Road Vehicle Designation Project Environmental Assessment and Draft CDCA Plan Amendment ("WEMO Route Designation") described the number and types of human disturbances along 310 transects throughout the range of the Mohave ground squirrel. Thirty-seven percent of these transects were bisected by roads. Currently, camping is allowed up to 91.5 m (300 feet) from existing roads on all BLM lands. Additionally, there is evidence of disturbance to vegetation along roadsides up to 400 m out. Minimum tortoise depression zone along highways edges for the desert tortoise are well discussed in the literature (Boarman 2002; Nicholson 1978, Berry and Turner 1987, LaRue 1993, Boarman and Sazaki 1996, von Seckendorff Hoff and Marlow 1997, cf. Baepler et al. 1994). Thus, the impact zone reaches beyond the roadbed itself. A recent analysis based on a 400 m road impact zone (as conservatively established from Hoff and Marlow 2002 and consultation with the Mohave Ground Squirrel Technical Advisory Group), indicates that the threat of highways affects over 66,000 ha (163,000 acres) of Mohave ground squirrel habitat, equal to 3.3% of the species range.

C. Habitat Degradation

Off-highway vehicle (OHV) use, grazing by sheep and cattle, drought, habitat fragmentation, domestic animal predation, and rodenticides all degrade the quality of Mohave ground squirrel habitat.

Off-highway vehicle use

Bury et al. (1977) studied the effects of off-highway vehicles on terrestrial vertebrates in the Western Mojave Desert at four sites south of Barstow. Direct effects include running over individual animals, collapsing their burrows, and breaking shrubs which provide cover. LaRue (WEMO Route Designation, p. 30) crushed a juvenile male Mohave ground squirrel on a dirt road as it attempted to cross in front of his truck near Water Valley. Direct mortality by OHVs is likely to affect male juvenile Mohave ground squirrel disproportionately because they are more likely to travel longer distances during natal dispersal than adults or female juveniles. Indirect effects, deemed more significant, include disturbance of soils and destruction of shrubs, both of which combine to reduce the number of spring annuals. Bury et al. (1977) concluded that off-highway vehicles detrimentally affect wildlife and Creosote Bush Scrub habitat in the Mojave Desert. Brooks (1999a, 2000 from WEMO Route designation) found roads serve as dispersal corridors for non-native species and that non-native species are more common along roadsides. The displacement of native species on which Mohave ground squirrel persistence depends greatly reduces the habitat quality surrounding both paved and dirt roads and routes.

The WEMO Route Designation report of the 1998 vegetation studies indicates that 47% of the 310 transects studied were bisected by some type of OHV track. Within the Mohave ground squirrel range, there exist four authorized off-highway areas operated by the BLM (Jawbone Canyon, Dove Springs, El Mirage, and Spangler Hills), constituting over 417 square kilometers (161 mi^2). The WEMO Route Designation reports the number of square miles of trials and tracks in the Spangler, El Mirage, Jawbone/Dove, and California City/Rands OHV access areas. Cumulatively these areas contain 710 km^2 (274 mi^2) affected by above average trails, and 840 km^2 (324 mi^2) impacted by tracks. If El Mirage is subtracted, because it falls in the portion of the range that is apparently unoccupied, this leaves an impact area of 661 km^2 (255 mi^2) for above average trails and 790 km^2 (305 mi^2) for tracks. In addition to the direct impacts, the indirect impacts, including those of habitat fragmentation, render this habitat severely degraded for Mohave ground squirrels. It appears that Mohave ground squirrels may occur and disperse through some open areas, but not others. The reasons for this are unknown. However, it is important to note that, while there is some evidence that Mohave ground squirrels are known to occur and/or move through Dove Springs Open Area, the same is not true for Spangler Hills (P. Leitner, unpublished data). It would appear that this is related to the location of Mohave ground squirrel core populations and the limits of dispersal, especially as these factors relate to rainfall patterns and habitat availability.

The WEMO Route Designation states that data support a "spill-over" effect from open areas, with higher incidences of vehicle impacts in adjacent areas than non-adjacent areas. The document specifically admits that "areas adjacent to Jawbone and Spangler Hills [,] remain susceptible to open area-related impacts" (p. 32). The document goes on to say that vehicle impacts may also be prevalent in areas not adjacent to open areas. Within the proposed Mohave ground squirrel Conservation Area, this includes "lands within the Rand Mountains, west of Silver Lakes, within Kramer Hills, north of Hinkley, and southwest of Fort Irwin." East and northeast of Fremont Peak, Fremont Valley, Iron Mountains north of Silver Lakes, Superior Valley (one 10.4 km^2 region), and southeast of Harper Lake are also mentioned as areas with possible vehicular impacts.

An estimated calculation indicates that nearly 3,000 ha (7,300 acres) of additional Mohave ground squirrel habitat are impacted by legal ORV use (Wilkerson and Stewart 2005). This figure, amounting to 0.1% of Mohave ground squirrel habitat, does not include areas where ORVs illegally trespass and destroy and degrade habitat, figures that are likely to be considerable.

Livestock Grazing

Livestock grazing has the potential to degrade Mohave ground squirrel habitat through changes in soil and vegetative structure, accelerated erosion, and collapsing of burrows (Laabs 2002). Campbell (1988) wrote that desert vegetation in the range of the desert tortoise has undergone significant changes as a result of a century or more of livestock grazing. Annual grasses, often nonnative species, have partially replaced the once dominant perennial grasses and shrubs have increased (Campbell 1988). Aardahl and Roush (1985) wrote that "grazing by sheep and cattle[,] have the potential of influencing the long-term population [viability] of the Mohave ground squirrel." Leitner and Leitner (1998) documented a dietary overlap in relatively uncommon forage between livestock and the Mohave ground squirrels. Winterfat foliage made up 24% of the cattle diet and saltbush leaf constituted 13%. In a wet year, sheep ate mainly forbs and grasses, while in a dry year winterfat was 50% of the sheep diet, even though this forage species was rare. Considering the strong relationship between habitat quality and the availability of these preferred forage species, livestock grazing significantly decreases the habitat quality for the Mohave ground squirrel.

Grazing by cattle and sheep occurs throughout the range of the Mohave ground squirrel, including Hunter Mountain, Lacey Cactus McCloud, Olancha, Walker Pass, Harper Dry Lake, Cantil Common, Spangler Hills, Lava Mountains, Monolith Cantil, Bissell, Boron, Shadow Mountains, Stoddard Mountain Middle Unit, Buckhorn Canyon, Boron, Lava Mountains, Stoddard Mountain West Unit, Tunawee, Rudnick, and Hansen. These livestock grazing allotments constitute just under 2,000 km^2 (771 mi^2) of the Mohave ground squirrel range as calculated from CDCA Plan 1980. Additionally, grazing was allowed under the CDCA in some federally designated wilderness areas including the El Paso and Golden Valley wilderness areas. In fact, visual inspection of the WEMO Plan maps show an estimated 5,443 km^2 (2100 mi^2) of sheep, cattle, or sheep/cattle allotments within the current Mohave ground squirrel range (excluding the area south of Highway 58) that will be available under the plan. The WEMO HCP (Appendix M) reports that a total of 6,143 km^2 (614,276 ha or 1,517,262 acres) of BLM sheep allotments are being actively grazed within the known range of the Mohave ground squirrel. (This includes BLM and private lands.) The WEMO Plan indicates that this figure is likely to be an underestimation because of an additional potential to graze in areas not associated with BLM allotments.

Recent estimate of BLM grazing allotments in the Mohave ground squirrel range are as follows: 302,000 ha (746,000 acres) sheep grazing; 179,000 ha (443,000 acres) cattle grazing; and 52,000 ha (129,000 acres) sheep and cattle grazing. In total, this amounts to over 500,000 ha (1,300,000 acres) of Mohave ground squirrel habitat – 27% of the species' range (Wilkerson and Stewart 2005).

Habitat Fragmentation

Habitat fragmentation occurs when areas of habitat become separated or discontinuous by destruction or degradation of intervening habitat. Populations of animals thus become separated, and gene flow no longer occurs between individuals in the separated habitats. If habitat blocks are separated by significant distances or anthropogenic barriers, it is unlikely that Mohave ground squirrels will cross the intervening space (Gustafson 1993). This effectively lowers the population size in each separate occurrence, putting the subpopulation at risk for extirpation due to natural fluctuations in environmental conditions (Soule 1986), thus lowering the resilience of the species as a whole.

During prolonged years of low rainfall, Mohave ground squirrels fail to persist in low quality habitat and only remain viable in high quality drought refugia (Leitner and Leitner 1998). When rainfall returns to a level that can produce Mohave ground squirrel forage on lower quality habitats, the populations at the drought refugia provide a source for recolonization. Habitat fragmentation, loss and degradation between these drought refugia prevent recolonization of these temporarily unoccupied habitats, thus posing a cumulative threat to the species.

The 1993 status review of the Mohave ground squirrel (Gustafson 1993) indicates that habitat fragmentation is a cause of decline of the Mohave ground squirrel. Since 1993, there has been increased development and fragmentation throughout the range of the species, and this remains a significant threat in the future. As discussed previously, the Fort Irwin expansion will fragment one of the last remaining thriving Mohave ground squirrel populations, partially isolating the Goldstone and Mojave B Range populations. The West Mojave HCP also fails to maintain habitat connectivity through the Mohave ground squirrel Conservation Area. This plan will allow significant gaps in the habitat between the Edwards Air Force Base population and the Desert Tortoise Natural Area, within the region just south of Ridgecrest, and reinforce the barrier effect of State Highway 58.

Domestic Animal Predation
Harrison (1992) established that even well-fed house cats are notorious for their predation on small mammals and birds. Domestic dogs commonly dig up rodent burrows. The threat associated with this mortality and habitat destruction is expected to be localized near rural and urban development.

Rodenticides/ Pesticides
Poisons frequently are used around agricultural fields, golf courses, earthen dams and canal levees to control rodents. It is not known whether Mohave ground squirrel will forage in agricultural fields, but they do live in desert plant communities adjacent to planted fields (Hoyt 1972, Hafner and Yates 1983) and are therefore exposed to the effects of pesticides. Hoyt (1972) stated that because Mohave ground squirrels appear dependent on alfalfa fields in some areas they “could be easily exterminated by the State Rodent Program.” In a letter included in Appendix E of Gustafson (1993), J.B. Aardahl of the BLM wrote that in fact “[i]n the early part of this century, ground squirrels were systematically eliminated with poison grain by the Los Angeles Agricultural Commission office in the Antelope Valley.”

Listing History

The Mohave ground squirrel has been listed as threatened under the California State Endangered Species Act since 1971 due to the degradation and loss of habitat in its limited range. The Mohave ground squirrel is a category 2 candidate (Federal Register: May 4, 2004 (Volume 69, Number 86, p. Page 24875-24904) and was first identified as such on September 18, 1985. Category 2 includes taxa for which sufficient information on biological vulnerability and threats is not currently available to indicate that listing as endangered or threatened is warranted. In 1995 the U.S. Fish and Wildlife Service, in response to a petition to list the Mohave ground squirrel, denied the request to list the Mohave ground squirrel under the Federal Endangered Species Act due to lack of information regarding the threats to the species. Since that time, increased research efforts have raised concerns that the Mohave ground squirrel is still declining (BLM 2003, Brooks and Pyle 2002). In 2005, Defenders of Wildlife petitioned the U.S. Fish and Wildlife Service to list the Mohave ground squirrel as endangered due to increase in loss and degradation of habitat and increased threats (Wilkerson and Stewart 2005). The U.S. Fish and Wildlife Service is currently processing that listing request and Defenders of Wildlife is working with the Desert Managers Group to develop and implement an effective rangewide conservation strategy that will ensure protection of the Mohave ground squirrel on the ground.

Summary of Current Management Actions

Department of Fish and Game

Over the past several years the Department has spent about $800,000 funding studies which include information on genetics, diet, dispersal, and location of MGS. In addition, approximately $100,000 has been collected from 2081 permit that has or will going into MGS trapping that is being administered by the Desert Tortoise Preserve Committee. Habitat and management fees ave also been acquired through the 2081 process.

Mojave Desert State Parks

Habitat for Mohave ground squirrel may be present in three state parks:
Saddleback Butte State Park – approximately 1,500 acres of relatively flat land that is potentially suitable habitat for Mohave ground squirrel. Tony Recht conducted Mohave ground squirrels research in the Park several decades ago and several were reported from a survey for desert tortoise in October 2004 (Woodward 2004).

Antelope Valley Indian Museum - contains 390 acres of similar habitats, including approximately 200 acres of potentially suitable habitat for Mohave ground squirrel. No studies of small mammals have been conducted and no records of Mohave ground squirrel are known. No studies are planned.

Red RockCanyon State Park - contains 25,456 acres and one-third of the park may contain suitable habitat for Mohave ground squirrel. A small trapping survey (10 acres) for small mammals was conducted in 1991 and 1992, and a single juvenile Mohave ground squirrel was captured (Callahan-Compton 1992). Two past records of Mohave ground squirrel found in a northern area of the park are in DPR records. No studies are planned.

Edwards Air Force Base

Edwards Air Force Base has completed three years of inventories for the presence of Mohave ground squirrels in conjunction with the monitoring of sixty Habit Quality Analysis plots. Approximately

45 percent of the Base has been surveyed since 2003 and funds are programmed for Mohave ground squirrel inventories through 2013.

Highest populations appear to be located on the Precision Impact Range. This area is a controlled bombing range that is undeveloped and sits within critical habitat established for the desert tortoise. This area will continue to be managed under its current land use as part of the test and training mission.

Edwards has also submitted several Legacy projects to complete feasibility studies on the acquisition of land around the Base in conjunction with specific flight corridors. Once these studies are complete Edwards plans to submit proposals to enter into private conservation agreements, for long-term protection of our range against encroachment, under the Readiness and Environmental Protection Initiative (REPI) Funding Program, Section 2811 of the National Defense Authorization Act (10 USC 2684a).

Fort Irwin

1. The NTC & Fort Irwin has a total of 445,241 acres of (8.87 %) of the Mohave Ground Squirrel (MGS) habitat. The areas on Fort Irwin with MGS habitat include: Goldstone DSCS (33,905 acres); The Western Expansion Area (70,198 acres); the Leach lake Bombing Range (34,261 acres); and the pre-expansion Fort Irwin (306,877 acres).

2. The NTC & Fort Irwin has fund trapping studies for the MGS in 1977, 1985, and 1993-1994. In 1977, 11 MGS were trapped at 7 locations out of 9 areas (total of trapped. In 1985, 3 locations (a total of 22 grids) were trapped and 9 MGS were trapped at 2 of the locations. In 93/94, 5 locations (17 grids) were trapped with 14 MGS trapped at 2 locations.

3. The NTC & Fort Irwin has established three conservation areas for Lane Mountain milk-vetch *(Astragalus agassizii*) which will work well for conservation for the Mohave Ground Squirrel. Under an agreement with the California Department of Fish and Game, the Paradise Conservation Area will be enhanced for Mohave Ground Squirrel by planting the preferred food plants for the MGS.

Marine Corp Logistic Base – Barstow

Will be doing trapping at the base to determine if MGS are present.

BLM ?
China Lake?

Conservation Strategy

Overview and Purpose

Behavioral and demographic characteristics of the Mohave ground squirrel's biology make it difficult to determine the exact population status of this species. Annual variation in the period of surface activity, sensitivity of population size to rainfall, and a discontinuous distribution (Gustafson 1993) all challenge the ability to accurately estimate the overall population size. Nevertheless, recent review of trapping success and monitoring data reveals that this species is in decline.

Brooks and Matchett (2002) summarized information from all known Mohave ground squirrel trapping studies from 1918 to 2001 (19 in total). After combining clustered sites, they analyzed 178 raw data points which were pooled after determining no statistical bias from such pooling. Trends in trapping success were evaluated using Spearman rank-order correlations. They conclude that "[t]here was an especially strong decline in trapping success from 1980 through 2000 (rs = -0.60, n =29)" across most of the Mohave ground squirrel range. Further, "the recent decline in trapping success does not seem to have been associated with systematic changes in the trapping methods." This decline was not correlated with winter rainfall which generally increased between 1984 and 1998 (Brooks and Matchett 2002).

As mentioned in the above discussion on Mohave ground squirrel distribution, there exists evidence that Mohave ground squirrels are now virtually absent from much of the historic range south of State Highway 58. A recent field study by Dr. Leitner (2004) found no Mohave ground squirrels at six trapping grids between US Highway 395 and the Mojave River in the southern portion of its range. He also states that very few previous records exist in this region and that no occurrences have been documented during the past 10 years. This absence may be related to poor forage availability. Leitner (2004) reported that spiny hopsage was present at only three of six grids, and only at very low densities (</= to 24/ha). Winterfat was detected on five of the grids, but was only present at densities greater than 100/ha on two. As mentioned in the food habits section above, 2002 surveys throughout the Mohave ground squirrel range indicate that combined densities of winterfat and spiny hopsage greater than 250 – 300 per ha are associated with occupancy of Mohave ground squirrels. Results from available Mohave ground squirrel surveys between 2002 and 2005 (Leitner 2005b) are mapped in Figure 3 and demonstrate the apparent absence throughout much of the Mohave ground squirrel range south of State Highway 58.

The Coso Range within the China Lake Naval Air Weapons Station (NAWS) has been one of the most consistently surveyed Mohave ground squirrel locations over the past thirty years. Figure 4 shows the number of adult Mohave ground squirrel captures at two trapping sites in the Coso Range between 1990 and 2005 as presented by Dr. Leitner at the 2005 Mohave ground squirrel Technical Advisory Committee meeting (Leitner 2005a). While data from all years are not available, the annual fluctuation in number of individuals captured is quite apparent. It is important to note that no reproduction occurred at either site in 1990 or in 1994, presumably due to low rainfall. Local rainfall variation could explain the differences seen between sites 2 and 3 (Leitner 2005a). Of critical importance is the apparent drop in number of Mohave ground squirrels from the 1993-1996 period to the 2001-2005 period.

Throughout the historic range of the Mohave ground squirrel, there are very few areas where thriving populations can be found. P. Leitner's extensive research has identified only four such core areas. These are: 1) a small area on the east side of Edwards Air Force Base, 2) the east-central portion of Kern County in and around Freeman Gulch and near the Jawbone-Butterbredt Area of Critical Environmental Concern, 3) the Coso Range within the China Lake Naval Air Weapons Station and adjacent areas to the northwest, and 4) north of Barstow from Coolgarde Mesa toward Superior Valley on a 3,000 ft. elevation plateau, stretching north across the Goldstone Deep Space Tracking Station onto the Mojave B Range of China Lake Naval Air Weapons Station (Figure 5; Leitner 2005b). In 2002, Leitner successfully trapped Mohave ground squirrel on all four grids in this Superior Valley/ Coolgardie Mesa region. Outside of these regions, populations of Mohave ground squirrel north of State Highway 58 are scattered, fragmented, or unknown. There are recent scattered records in the Desert Tortoise Research Natural Area, Pilot Knob, Cuddeback Lake, at the site of the Hyundai automotive test track in California City, and at the translocation site for the Hyundai project (M. Connor, personal communication) which is located south of the Randsburg-Mojave Road and directly west of the California Department of Fish and Game West Mojave Desert Ecological Reserve. Dr. Leitner has summarized and mapped the current status of the Mohave ground squirrel throughout its range according to the best available data (Figure 5). Figure 5 indicates the four identified core populations, other habitat that may potentially sustain Mohave ground squirrels, the area of "virtual absence" south of State Highway 58, and habitat that may be unsuitable or a potential barrier. The status categories are based on results of a six-grid trapping array as follows:

"virtually absent" category =	0 captures on 0 grids
"present, low density" =	4-6 captures on 2-3 grids
"core area" =	18-20 captures on 5-6 grids

Please note that the colored areas on Figure 4 are meant to be approximate and do not represent hard boundaries or even necessarily proportional areas inhabited by Mohave ground squirrels. For example, please remember that, as noted above, the population on Edwards Air Force Base exists in a very small area (ca. 15 x 20 m), making its long-term sustainability questionable.

Currently the Mohave ground squirrel is listed as "vulnerable" by the World Conservation Union (IUCN VU B1+3d; IUCN 2003). This specific vulnerable designation is used for species with a geographic range that is estimated to be less than 20,000 km^2, and estimates indicating at least two of the following: 1) severely fragmented or known to exist in no more than ten locations; 2) continuing decline, observed, or inferred, or projected in any of the following: extent of occurrence; area of occupancy; area, extent and/or quality of habitat; number of locations or subpopulations; number of mature individuals; and 3) extreme fluctuations in any of the following: extent of occurrence; area of occupancy; number of location or subpopulations; number of mature individuals. There is no legal protection provided by this IUCN status.

Overall goal

The goal of this conservation strategy is to ensure long-term protection of MGS habitat and viability of species.

Conservation Objectives

Objective 1) Foster communication and coordination among participants and other interested parties to identify opportunities for collaborative action to further species recovery and the acquisition, protection, restoration and management of MGS habitat.

Objective 2)   Determine the extent of the MGS range

Objective 3)   Determine ecological requirements

Objective 4)   Develop and implement effective conservation measures to sustain long term viability of the species

Objective 5)   Develop and Implement an Adaptive management plan

Conservation Measures

The following Conservation Measures have been developed for participating agencies to ensure that the goal of long-term protection of MGS habitat and viability of species is achieved. It is understood that implementation of these actions is subject to availability of funds and compliance with all applicable regulations. It is anticipated that specific actions may be modified based on information obtained from future monitoring, research, and evaluations of the effectiveness of this strategy.

Habitat Management

1. Limit loss of habitat and effects on MGS through effective conservation measures and when applicable through mitigation and compensation

   a) Avoid/minimize impacts to MGS and its habitat
      i. Limit land use authorizations that would cause surface disturbance
      ii. Limit route proliferation
      iii. No pesticide treatments shall be applied within MAs. Use of specifically targeted, hand-applied herbicides (e.g. for tamarisk eradication projects) is allowed.

   b) Restore/enhance habitat - Methods to be used may include, but are not limited to, a) ripping or scarifying compacted soils, b)recontouring the surface, c) pitting or imprinting the surface, d) seeding with nativeplants, e) planting seedlings, f) irrigating, and g) barricading.

2. Secure and/or manage sufficient core habitat and corridors to maintain self sustaining populations

   a) Establish and maintain a prioritized list of parcels or screening criteria for acquisition within management areas (MAs) and habitat corridor.
   b) Seek funding to acquire key parcels within MAs.
   c) Using compensation and other funds, acquire land within MAs in accordance with established priorities and/or criteria.
   d) Participate in exchanges where opportunities arise to acquire key parcels within MAs.

Mitigation

1) Prior to project initiation, an individual shall be designated as a field contact representative. The field contact representative shall have the authority to ensure compliance with protective measures for the MGS and will be the primary agency contact dealing with these measures. The field contact representative shall have the authority and responsibility to halt activities that are in violation of these terms and conditions.

2. All project work areas shall be clearly flagged or similarly marked at the outer boundaries to define the limit of work activities. All construction and restoration workers shall restrict their activities and vehicles to areas that have been flagged to eliminate adverse impacts to the MGS and its habitat. All workers shall be instructed that their activities are restricted to flagged and cleared areas.

3. Within MGS habitat, the area of disturbance of vegetation and soils shall be the minimum required for the project. Clearing of vegetation and grading shall be minimized. Wherever possible, rather than clearing vegetation and grading the ROW, equipment and vehicles shall use existing surfaces or previously disturbed areas. Where grading is necessary, surface soils shall be stockpiled and replaced following construction to facilitate habitat restoration. To the extent possible, disturbance of shrubs and surface soils due to stockpiling shall be minimized.

4. Existing roads shall be used for travel and equipment storage whenever possible.

5. A biological monitor shall be present in each area of active surface disturbance throughout the work day from initial clearing through habitat restoration, except where the project is completely fenced and cleared of MGSs by a biologist. The monitor(s) shall perform the following functions:

a) Develop and implement a worker education program. Wallet-cards summarizing this information shall be provided to all construction and maintenance personnel. The education program shall include the following aspects at a minimum:

biology and status of the MGS,
protection measures designed to reduce potential impacts to the species,
function of flagging designating authorized work areas,
reporting procedures to be used if a MGS is encountered in the field, and

b) Ensure that all project-related activities comply with these measures. The biological monitor shall have the authority and responsibility to halt activities that are in violation of these terms and conditions.

c) All hazardous sites (e.g., open pipeline trenches, holes, or other deep excavations) shall be inspected for the presence of MGSs prior to backfilling.

d) Work with the project supervisor to take steps, as necessary, to avoid disturbance to MGSs and their habitat. If avoiding disturbance to a MGS is not possible or if a MGS is found trapped in an excavation, the affected animal shall be captured by hand and relocated.

6. The project proponent shall develop a project-specific habitat restoration plan under approval by the lead agency. The plan shall consider and include as appropriate the following methods: replacement of topsoil, seedbed preparation, fertilization, seeding of species native to the project area, noxious weed control, and additional erosion control Generally, the restoration objective shall be to return the disturbed area to a condition that will perpetuate previous land use.The project proponent shall conduct periodic inspection of the restored area. Restoration shall include eliminating any hazards to MGSs created by construction, such as holes and trenches in which animals might become entrapped. Disturbance of existing perennial shrubs during restoration shall be minimized, even if such shrubs have been crushed by construction activities.

Compensation

If adverse effects remain after the project proponent has taken all reasonable on-site mitigation measures, a project proponent must compensate for on-site effects. To evaluate whether it is appropriate to collect compensation, biologists must consider whether the impacted area can potentially support MGSs based on habitat factors favorable to MGSs. If biologists determine that the project area can potentially support MGSs, then compensation shall be required. Negative MGS survey results in the project area shall be irrelevant in the determination of whether to charge compensation because MGSs can reoccupy the suitable MGS habitat in the future, or MGSs were present but not detected due to their cryptic nature.

The goal of compensation is to prevent the net loss of MGS habitat and make the net effect of a project neutral or positive to MGSs by maintaining a habitat base for the species. Compensation ratios can range from 1:1 to 5:1 depending upon:

a) Species known to be present on site
b) Habitat condition
c) Proximity of known disturbances
d) Vegetation type

Fees for management and restoration of the habit are also needed. Currently a PAR analysis is being used to determine the fee per acre for lands going to the Department.

Monitoring Program

1) Determine the extent of the MGS range
    a) Prioritize areas for survey/monitoring
    b) Update current map
    c) Determine the most efficient and statistically valid method of locating MGS
    d) Conduct surveys

2) Determine ecological requirements
    a) Determine environmental parameters and limiting factors
    b) Determine habitat elements of population sources, sinks and corridors

3) Maintain genetic variation through out the range

Restorative Measures

Adaptive management

Develop and implement an adaptive management plan which would include the following:
1) Long term monitoring for status trends
2) Population estimates and baseline population data
3) Continue to support research that promotes conservation of MGS
    a) locate core populations
    b) Determine important corridors between core areas
    c) Determine barriers to movement and id measure to minimize barriers
    d) Document genetic variation through out the range
4) Create/maintain central data base
5) Standardize data collection
6) Investigate potential for translocation/reintroduction of MGS
7) Assess need for and develop education materials as necessary
8) Effectiveness monitoring of measures and make changes in implementation if needed.

Literature Cited

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