Mohave Ground Squirrel

Draft Conservation Strategy

California Department of Fish and Wildlife
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For MGS conservation strategy technical review – Do not distribute

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

Contents

List of Acronyms

ACEC	Area of Environmental Concern
BLM	Bureau of Land Management
BMP	Best Management Practices
CAPP	Conceptual Area Protection Plan
CBI	Conservation Biology Institute
CCR	California Code of Regulations
CDCA	California Desert Conservation Area
CDFA	California Department of Food and Agriculture
CDFG	California Department of Fish and Game
CDFW	California Department of Fish and Wildlife
CDPR	California Department of Parks and Recreation
CEC	California Energy Commission
CEQA	California Environmental Quality Act
CESA	California Endangered Species Act
CFGC	California Fish and Game Commission
CHU	Critical Habitat Unit
CNDDB	California Natural Diversity Database
CO_2	Carbon dioxide
CROS	California Roadkill Observation System
CWHR	California Wildlife Habitat Relationships
DFA	Development Focus Area
DMG	Desert Managers Group
DNA	Deoxyribonucleic acid
DOD	Department of Defense
DRECP	Desert Renewable Energy Conservation Plan
DTNA	Desert Tortoise Natural Area
DWMA	Desert Wildlife Management Area
EAFB	Edwards Air Force Base
EIS	Environmental Impact Statement
ER	Ecological Reserve
ESA	Endangered Species Act
FGC	Fish and Game Code
FLPMA	Federal Land Policy and Management Act
FR	Federal Register
GIS	Geographic Information Systems
HA	Hectare
HCP	Habitat Conservation Plan
HQA	Habitat Quality Analysis
INRMP	Integrated Natural Resources Management Plan
ITP	Incidental Take Permit
KGRA	Known Geothermal Resource Area
LAE	Land Acquisition Evaluation
LUPA	Land Use Plan Amendment

MCP	Minimum convex polygon
MGS	Mohave ground squirrel
MGSCA	Mohave Ground Squirrel Conservation Area
MGSTAG	Mohave Ground Squirrel Technical Advisory Group
MGSWG	Mohave Ground Squirrel Working Group
MOU	Memorandum of Understanding
MW	Megawatt
NAWS	Naval Air Weapons Station
NCCP	Natural Community Conservation Plan
NEPA	National Environmental Policy Act
NRD	Natural Resources Division
O&M	Operations and maintenance
OHMVR	Off-Highway Motor Vehicle Recreation
OHV	Off-highway vehicle
PACT	Planning Alternative Corridors for Transmission
PIER	Public Interest Energy Research
PIRA	Precision Impact Range Area
PV	Photovoltaic
REAT	Renewable Energy Action Team
REPG	Renewable Energy Policy Group
RTGS	Round-tailed ground squirrel
SEA	Significant Ecological Area
SFEIS	Supplemental Final Environmental Impact Statement
SPEIS	Solar Programmatic Environmental Impact Statement
SR	State Route
UC	University of California
UCLA	University of California, Los Angeles
US	United States
USFWS	United States Fish and Wildlife Service
WCB	Wildlife Conservation Board
WEA	Western Expansion Area
WEMO	West Mojave

Preface

In 2006, members of the California Desert Managers Group (DMG) Mohave Ground Squirrel Work Group (MGSWG) and the California Department of Fish and Game (CDFG) prepared a draft Mohave ground squirrel Conservation Strategy in cooperation with the Mohave ground squirrel Technical Advisory Group (MGSTAG). In 2010, the DMG continued the effort by drafting preliminary goals, objectives, and conservation measures. The MGSTAG recommended conservation priorities in the same year, some of which were incorporated into the DMG effort. No further development on the conservation strategy was conducted until the CDFG reinitiated work on the draft in 2012, updating information based on the newest available science. CDFG, now the California Department of Fish and Wildlife (CDFW), continued working on the strategy through 2014 with technical and stakeholder review.

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Executive Summary

The Mohave ground squirrel (MGS) is listed as "vulnerable" by the World Conservation Union (http://www.iucnredlist.org/details/20474/0) and as "Threatened" by the state of California (Cal. Code Regs., tit. 14, § 670.5, subd. (b)(6)(A).). The goal of the Conservation Strategy is to recover the species from its vulnerable and Threatened status. Steps that can be taken to achieve this goal are to: 1) assess the most current understanding of the state of the MGS; 2) formulate achievable objectives that will ensure the continued existence of the species; and 3) provide conservation measures that may realistically be implemented in order to achieve the objectives, including measures that anticipate future impacts resulting from climate change.

Habitat loss and degradation, ultimately leading to curtailment of the species' range and barriers to movement across the landscape, are the largest known causes of the species' decline (Gustafson, 1993). Other threats are analyzed in this strategy, but sufficient research has not been conducted to determine the extent of these stressors on the persistence of the species; thus, managing these other threats alone may not confer long-term conservation and resiliency of the MGS. During years of drought, the MGS will fail to reproduce (Leitner and Leitner, 1998), and it could shift its distribution to find and exploit high-quality food resources. Lack of forage associated with habitat loss could further reduce reproduction rates and could cause local extirpations. Where lack of rainfall may cause local extirpation, destruction of suitable habitat could prevent recolonization in better years. Loss of foraging habitat could also lead to decreases in the stored energy required to sustain individual squirrels during periods of aestivation and hibernation, resulting in decreased survival and fitness. Therefore, it is important to conserve contiguous, viable habitat throughout the MGS range.

Much of the MGS range has not been sufficiently surveyed to determine the exact locations and stability of potential populations, and in some of these areas, MGS may already be extirpated (Gustafson, 1993). While some portions of the range have been adequately surveyed, additional surveys in areas with gaps of information would help to determine the overall population status and distribution (See Appendix C). To recover the species, high-quality habitat must be available for potential colonization, to support existing populations, and to maintain genetic connectivity. Along with the threats of destruction and degradation of habitat posed by urban growth, recreation and other human activity, and renewable energy development throughout its range, climate change scenarios will undoubtedly place additional pressures on the stability of the MGS, potentially causing further reduction of habitat and necessitating additional shifts in its distribution and range.

The management needed to conserve MGS and its habitat includes a range of actions: acquisition of undisturbed, contiguous habitat from willing sellers; management of public land for the protection of MGS; conservation of suitable habitat for future needs under climatic stress; design and implementation of an adaptive management and monitoring program; public education; and funding of research and monitoring efforts to better understand and manage for the needs of MGS. Habitat conservation needs to focus on areas that support existing population centers, with five miles of habitat extending from each population center for dispersal, and linkages or corridors for connectivity (See Appendix C). Land managers and jurisdictional agencies working together on conservation mechanisms and planning will also help to protect MGS. Such mechanisms include avoiding impacts to MGS when siting development projects, minimizing impacts, and conducting education and outreach. Through an Adaptive Management process, conservation decisions need to be driven by research that assesses current trends of population dynamics and distribution, genetic exchange, effects of climate change, threats to the species' survival, and ecological requirements. Direct recovery actions, such as translocation or captive breeding programs should be assessed as rapid responses to severe threats.

Photo: David Delaney (Delaney, 2009)

Introduction

The Mohave ground squirrel (*Xerospermophilus mohavensis*) (MGS) is endemic to the western part of the Mojave Desert, in portions of Inyo, Kern, Los Angeles, and San Bernardino Counties, California. It has one of the smallest ranges of any species of ground squirrel in North America (Hoyt, 1972), and its response to annual variation in rainfall makes it extremely vulnerable to local extirpations (Leitner and Leitner, 1998). Patterns of extirpation and recolonization following rainfall patterns make it difficult to efficiently survey for the species, and the MGS' movement across its range to exploit different habitat types also makes it difficult to identify stable populations in specific locations. However, compilations of both regional and project-related survey data have inferred that the western, eastern, and southern edges of the MGS range are contracting (Leitner, 2008, 2013; Leitner, pers. comm.).

Brooks and Matchett (2002) summarized information from all known MGS trapping studies from 1918 to 2001 (19 studies). They concluded there was "an especially strong decline in trapping success from 1980 through 2000" across most of the MGS range. Though declines in trapping success could have been attributed to variations in trapping methods and annual rainfall patterns, declines in trapping success in the 1990s did not correlate with these factors. Leitner (2008) summarized information from trapping studies conducted from 1998 – 2007, including project-driven surveys, regional field studies, and incidental sightings. The southern portion of the range was the most intensely sampled by these surveys, yet surveys between 1998 and 2011 yielded less than five detections outside of Edwards Air Force Base (Leitner, 2013), while historic data from the California Natural Diversity Database (CNDDB) indicated dozens of detections in the same areas. Some range maps excluded the west Antelope Valley and Lucerne Valley regions from the MGS range (Gustafson, 1993; Leitner, 2008). Gustafson (1993) attributed the lack of occurrence data in the western and southern portions of the range to loss of habitat coupled with drought. Loss of habitat caused by development and agriculture has likely caused MGS to move out of the Apple and Lucerne Valley areas in search of suitable foraging. Round-tailed ground squirrels (*X. tereticaudus*) and California ground squirrels (*Otospermophilus beecheyi*) have been found in these areas instead of MGS, undoubtedly due to their close associations with agriculturally disturbed land (Krzysik, 1994). It is not known if MGS has been displaced by competition or had already moved out of these areas before the other species moved in. Extirpations observed in the southern part of the range could be expected in other portions of the range if the human populations increase and development and loss of habitat continue.

The Coso Range within the China Lake Naval Air Weapons Station (China Lake) has been one of the most consistently surveyed MGS locations, with studies spanning over a period of about thirty years. While data from all years are not available, the annual fluctuation in numbers of individuals captured between 1988 and 1996 was quite apparent (Leitner and Leitner, 1998). It is important to note that this area has had little to no disturbance, and sites with no recruitment were associated with seasons of low rainfall (Leitner and Leitner, 1998). Local rainfall variation was the most likely factor in the differences seen between sites with no observations and sites with high detection rates.

Throughout the historic range of the MGS, there are a few areas where thriving populations have been found. Leitner (2008) identified some geographic locations of known populations, including the four population centers with the highest levels of persistence and detection rates listed below (Leitner 2008) (See Appendix C):

1. East side of Edwards Air Force Base
2. Little Dixie Wash – The broad valley extending from Southern Indian Wells Valley to Red Rock Canyon State Park
3. Coso/Olancha - Western section of the Coso Range within the China Lake Naval Air Weapons Station (NAWS) and adjacent areas to the northwest, from the town of Olancha to Rose Valley
4. Coolgardie Mesa/Superior Valley - North of Barstow from Coolgardie Mesa toward Superior Valley on a 3,000 ft. elevation plateau, stretching north across the Goldstone Deep Space Tracking Station in Fort Irwin onto the Mojave B Range of China Lake Naval Air Weapons Station, and south to the Calico Mountains.

In addition to the persistent population centers, Leitner (2008, 2013) identified other populations of MGS north of State Highway 58. The annual persistence or density of these populations is unknown. There are recent records indicating populations exist in and around the periphery of the Desert Tortoise Natural Area (DTNA); Pilot Knob near Cuddeback Lake; north of Edwards Air Force Base, from east of U.S. 395 to the Hyundai test track; west and south of Harper Lake; north Searles Valley; and from the Fremont Valley west of Johannesburg to the east and north into the Spangler Hills Open (OHV) Area. Leitner (2013) described a detection rate of 86% in Fremont Valley after four years of adequate rainfall, following decades of no detection data. This illustrates how annual rainfall could influence the local extirpation and colonization patterns of the MGS throughout its range.

Populations discovered only after years of sufficient rainfall, and populations with persistent detection rates in years of less than sufficient rainfall, indicate that viable habitat in any given year could support a population even if MGS is not present in a particular survey. Only persistent surveying over multiple years with negative detection data can infer MGS would not occupy an area, as in the case of west Antelope Valley. Therefore, protecting habitat throughout the species' range will create a better opportunity for MGS recolonization and movement across the landscape in response to naturally occurring stressors.

I. Species Description

The MGS is a medium-sized squirrel about 22 cm (9 inches) long, including a tail length of about 6.2 cm (2.4 inches) (Grinnell and Dixon, 1918; Ingles, 1965), with relatively short legs. The upper body pelage has been described as grayish-brown with tinges of pinkish cinnamon, and the ventral surface is creamy white, including the underside of the tail (Merriam, 1889; Ingles, 1965). Juveniles have been observed with cinnamon-colored pelage, molting to gray as they mature into adults (Recht pers. comm., as cited in Gustafson, 1993). Recht (1977) observed that MGS 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, and the ears are small relative to other ground squirrel species in California.

A. Taxonomy

The MGS is a distinct monotypic species recognized by the International Committee of Zoological Nomenclature Code as *Xerospermophilus mohavensis*. It was discovered by F. Stephens in June 1886 (Merriam, 1889), and formally described by Merriam as *Spermophilus mohavensis* - a distinct species, unlike previous descriptions. The type locality described by Grinnell and Dixon (1918) is restricted to near Rabbit Springs, about 24 km (15 miles) east of Hesperia in Lucerne Valley, San Bernardino County. Helgen *et al*. (2009) proposed that the MGS' genus *Spermophilus* be split into eight genera, including what was previously the subgenus *Xerospermophilus.* This newly formed genus, *Xerospermophilus*, contained MGS and the round-tailed ground squirrel (RTGS). The relationship between these 2 species was studied by Hafner and Yates (1983), Hafner (1992), Bell, *et al*. (2009), and Bell and Matocq (2011) who demonstrated a degree of chromosomal, genetic, and morphological differentiation between MGS and RTGS. Their supporting evidence included:

1. The MGS has a diploid chromosome number of 38 while that of the round-tailed ground squirrel is 36;
2. 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
3. Morphometric analysis of 20 cranial characters showed significant differences ($p < 0.0001$), with the MGS being larger in all but two characters.

Hafner (1992) and Bell (2009) suggested divergence and speciation between the two species occurred as far back as the late Pliocene or Pleistocene Periods.

The MGS and RTGS were originally considered peripatric (Gustafson, 1993), until Hafner (1992) described a narrow contact zone where the ranges overlapped. Due to recent westward expansion, the RTGS range now overlaps the MGS range in Lucerne Valley, along the Mojave River near Barstow, along Highway 58 west of Barstow near Hinkley, and in the National Training Center at Fort Irwin (Fort Irwin) (Zeiner *et al.*, 1990; Leitner, 2008). Surveys in 2012 indicated additional westward expansion of RTGS into the MGS range to about 10 miles east of Kramer Junction (Leitner, pers. comm.). Hafner (1992) found that the two species within the contact zone were not highly competitive and that there was no genetic introgression from hybridization, identifying the contact zone as neutral. Additional research is needed to verify Hafner's observations in newly created contact zones from the recent westward expansion of the RTGS.

Differences in species habitat selection, such as the MGS' preference for sandy soils mixed with gravel and undisturbed desert scrub communities, and the RTGS's preference for soft windblown sand and use of agriculturally disturbed land (Ingles, 1965; Wessman, 1977; Zeiner *et al.*, 1990; Krzysik, 1994), may serve as a prereproductive isolating mechanism between the two ground squirrels (Hafner and Yates, 1983; Hafner, 1992; Wessman, 1977). However, Wessman (1977), Hafner and Yates (1983), and Hafner (1992) all identified the

Mojave River Valley as a complex contact zone where differences in habitat preference did not factor into separating the two species. The MGS and RTGS may be isolated behaviorally as well. For example, the MGS is a solitary species while the RTGS is generally colonial, which may reduce contact and potential cross breeding (Recht, 1992 comment letter *in* Gustafson, 1993, Appendix E). Hafner (1992) suggested that habitat preference alone did not keep either species from crossing into each other's range beyond the neutral contact zone, since preferred habitat types for both species occurred beyond the boundary of each squirrel species' distribution. Hafner suggested that low vagility (extremely slow range expansion) of both species, due to limited annual above-ground activity, may have played a substantial role in preventing introgression and competition between the two species.

Although MGS has distinct species status, evidence of hybridization was found by Hafner (1992) in the Mojave River Valley about 2.1 miles northwest of Helendale, and on Hodge Road about 6.2 miles northwest of Lenwood. Hafner and Yates (1983) collected two hybrid specimens near Helendale, adjacent to agricultural fields, and suggested the artificially elevated food supply in these fields may have broken down ecological prereproductive isolating mechanisms that normally prevent hybridization. They concluded that retention of full species status for the MGS was warranted. Hafner (1992) also collected two hybrid specimens from near Coyote Dry Lake, about 18 miles northeast of Barstow, where Wessman (1977) described a gradation between loose, sandy soils preferred by RTGS and gravelly soils associated with MGS. Since Hafner's observations, another hybrid was discovered in Fort Irwin, and another possibly backcrossed specimen was found near Hinkley (Bell and Matocq, 2011). Although these sites did not contain the complexity of the Helendale site, variable habitat conditions supported the occurrence of both species.

Though hybridization has occurred within contact zones, recent examination of mitochondrial, morphological, allozyme, and chromosome data show no evidence of broad introgression of alleles between the two species (fertility of hybrids) (Bell *et al*., 2009; Bell and Matocq, 2011), which supports the retention of full species status for the MGS.

B. Range and Distribution

1. Range

The MGS has the smallest range among all of the ground squirrel species found in the United States (Hoyt, 1972). The historic range of the MGS published by Leitner (2008), second map in Appendix A, is bounded on the south by the San Gabriel and San Bernardino Mountains, and to the west by State Route (SR)-14 from Palmdale to Mojave, the Tehachapi Mountains, and the Sierra Nevada Mountains. On the north and east, the range is bounded by Owens Lake and a series of small mountain ranges, including the Argus, Panamint, and Quail ranges, and extends to the east edges of the Granite and Avawatz ranges. The southeast edge of the range follows the Mojave River south of Barstow and includes the west edge of Lucerne Valley, about three miles from the type locality. While the present Mojave River generally defines the extreme southeastern boundary of the MGS range, the species historically occurred east of the river in Lucerne Valley (see list of specimens examined by Hafner, 1992).

Though some historic range maps did not include the Antelope Valley west of the cities of Palmdale, Lancaster, Rosamond, and Mojave, due to an apparent lack of detection data in the area (Gustafson, 1993), Zeiner, *et al.* (1990) included the area based on the historic range depicted by Grinnell and Dixon (1918). Grinnell and Dixon (1918) and Howell (1938) included West Antelope Valley without reference to specific specimens collected; however, Gustafson (1993) indicated that the in-tact habitat in this region may have historically supported MGS. The range of the MGS depicted by the California Wildlife Habitat Relationships System (CWHR) (CDFG and CA Interagency Wildlife Task Group, 2005), first map in Appendix A, reflected professional knowledge and all occurrences reported to CDFG. The 2005 map includes the extreme southwestern portion of the Antelope Valley, west of the cities of Palmdale, Lancaster, Rosamond, and Mojave (roughly 1,037 km^2 or 400 mi^2). Although this area apparently contained suitable habitat prior to the extensive agricultural development and urbanization of recent decades and some amount of habitat still remains, the reported occurrences in that area remain unconfirmed (Leitner, 2008). Gustafson (1993) stated the MGS may no longer exist in the Victorville to Lucerne Valley portion of its range, because most of the habitat there has been fragmented or lost due to rural and urban development. However, this region was retained in the Leitner (2008) range map because of historic records and 3 detections near Adelanto (western outskirts of Victorville). In 2011, a protocol survey confirmed an additional sighting west of the City of Adelanto, but no MGS had been detected east of Victorville (Leitner, 2013).

The U.S. Fish and Wildlife Service (USFWS) (2011) (76 FR 62214), third map in Appendix A, estimated the current geographic range of the MGS to be about 21,525 km^2 (8,311 mi^2), including the Antelope Valley west of the cities of Palmdale, Lancaster, Rosamond, and Mojave, and the southeastern edge of the range from the City of Victorville to western Lucerne Valley.

2. Distribution

Even within seemingly suitable habitat, the distribution of the MGS is very patchy (Gustafson, 1993). Thus, suitable habitat throughout its range is unoccupied. This is probably due to both naturally and anthropogenically induced local extirpations and failure to repopulate vacated areas.

SR-58 bisects the MGS range between the cities of Mojave and Barstow. Extensive trapping efforts in some areas south of this highway conducted between 1998 and 2012 indicate that the only known significant population of MGS in this part of the range is one 1200-km^2 region in the south central and eastern portion of Edwards Air Force Base (EAFB) (Leitner, 2008; 2013). The species appears to be absent from portions of its rangein the Antelope Valley, city of Lancaster, city of Palmdale, and east of the city of Victorville (Hoyt, 1972; Leitner, 2008; 2013). Gustafson's (1993) conclusion that the persistence of the species in the highly developed areas between Antelope Valley and Lucerne Valley was questionable is supported by the paucity of detection data between 1998 and 2012. Except for a possible remnant population near the city of Adelanto (Leitner, 2013) and reported recent sightings in Saddleback Butte State Park (CDPR NRD, 2004 Table 5; Swolgaard, pers. comm.), surveys throughout the MGS range since 1998 indicate that the MGS is absent from most of its range south of SR-58 (Leitner, 2008; 2013). This indicates that approximately 25-30% of the historic range may not be occupied.

North of SR-58, there are additional areas where MGS have not been recently detected. Except for a few incidental sightings, the area west of California City has not had positive MGS detection data since 1993 (Leitner, 2008; 2013); although, a regional survey effort in this area is lacking (See Appencix C). Between 2009 and 2012, surveys in and immediately surrounding the city of Ridgecrest no longer yielded MGS detections that had occurred prior to 2008, and surveys in 2010 and 2011 yielded no detections in good habitat southwest of Ridgecrest (Leitner, 2013). Leitner (pers. comm) indicated that some areas of agriculture and low habitat suitability may act as barriers to connectivity within the north and central portions of the MGS range (*e.g.*, the Cantil area). Consequently, the habitat in these sections of the range is fragmented. In the eastern edge of the MGS range, survey efforts in Fort Irwin indicated declining detection rates and MGS range (Krzysik, 1994), and Krzysik described the Fort Irwin populations as patchily distributed and low density. Surveys conducted as recently as 2013 show no MGS detections in the eastern edge of the MGS range in Fort Irwin (Leitner, 2013); however, round-tailed ground squirrels were observed in that area.

Bell and Matocq (2011) described the MGS distribution as three genetically distinct regions: southern, northern, and mid-western/central, with the southern and northern regions containing a higher proportion of distinct ("private") alleles, and the mid-western/central region showing a higher amount of heterozygosity. Evidence from Bell and Matocq's (2011) DNA studies show that some genetic exchange has occurred throughout the range, from concentrated populations in the Olancha area in the north to EAFB in the south (see Appendix C, Important Areas). The most concentrated area of genetic exchange is near the town of Johannesburg (Bell and Matocq, 2011), between the central populations found in the Little Dixie Wash area, Fremont Valley, DTNA, north Searles Valley, and Pilot Knob. South central populations are also connected to this genetic hub, such as the area between DTNA and EAFB, and the populations at Harper Lake and Coolgardie Mesa/Superior Valley.

Some recently reported detections suggest that MGS may have occurred, or could possibly still occur, outside of the ranges depicted in Appendix A. For example, a 2005 detection south of Barstow (Leitner, 2008; California Natural Diversity Database (CNDDB) occurrence #343), and a 2000 detection in Panamint Valley (CNDDB occurrence #448) imply possible distribution beyond the published range maps. There have also been two possible recent detections of the MGS in southern Lucerne Valley, east of the Leitner (2008) range (Jones, pers. comm.).

Inman *et al.* (2013) developed a model predicting the current and future distribution of the MGS relative to physiographic topography and current and anticipated disturbances, including climate change (Appendix B). While the distribution model mostly aligns with the range published by Leitner (2008), high detection probability north of Owens Lake is predicted for the future, indicating a general distribution shift to the north.

C. Habitat Requirements

MGS have been observed throughout the range, exploiting a variety of vegetation and soil types (Best, 1995). Although this species generally inhabits flat to moderate terrain and avoids steep slopes and rocky terrain (Zembal and Gall, 1980; Brylski *et al*., 1994; Krzysik, 1994), juveniles can apparently traverse steep terrain during dispersal (Zembal and Gall, 1980; Leitner *et al.*, 1991; Harris and Leitner, 2005). MGS exhibit a preference for gravelly as opposed to soft sandy soils (Hafner and Yates, 1983), but have been found in loose sandy soils or in sand mixed with gravel (Burt, 1936; Brylski *et al*., 1994; Krzysik, 1994). The species is not known to occupy areas of desert pavement (Aardahl and Roush, 1985) or to cross dry lakes or playas (Harris and Leitner, 2005). Aardahl and Roush's (1985) studies indicated low abundance of MGS in areas with high abundance of surface rock or shallow soils with rapid drainage.

Essential habitat features consist of adequate 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, MGS populations may fail to persist in low quality habitat. High quality drought refugia, defined by the availability of preferred food sources (winterfat, *Krascheninnikovia lanata,* and spiny hopsage, *Grayia spinosa*, in the Coso Range), are necessary to maintain overall populations and act as a source for recolonization of surrounding habitat (Leitner and Leitner, 1998). The combination of shrub vegetation quality and winter rainfall may explain spatial and temporal variation in MGS presence and absence (Leitner, 2012).

Gustafson (1993) described different studies that reported MGS occurrences in many of the broad desert community types of Munz and Keck (1959) and Vasek and Barbour (1988), including Shadscale Scrub, Creosote Bush Scrub, Alkali Sink/Saltbush Scrub, Blackbush Scrub, and Joshua Tree Woodland, as well as some of Holland's (1986) more narrowly defined communities for the California Natural Diversity Database (CNDDB). These habitats are described by Holland (1986) as Mojave Creosote Bush Scrub, dominated by creosote bush (*Larrea tridentata*) and burrobush (*Ambrosia dumosa*); Desert Saltbush Scrub, dominated by various species of saltbush (*Atriplex sp.*); Desert Sink Scrub, which is similar in composition to Desert Saltbush Scrub, but is sparser and grows on poorly drained soils with extremely high alkalinity; Desert Greasewood Scrub, similar in composition to Desert Saltbush Scrub, but with sparse succulent vegetation and generally located on valley bottoms; and Shadscale Scrub, which is dominated by *A. confertifolia* and *Artemisia spinescens*.

Blackbush Scrub in the West Mojave is described by Vasek and Barbour (1988) as dominated by low dark shrubs, similar but not necessarily equivalent to the "blackbrush" (*Coleogyne*) species found in southern Nevada, interspersed with Joshua trees (*Yucca* *brevifolia*). Joshua Tree Woodland includes Joshua trees widely scattered over a variety of shrub and perennial herb species (Vasek and Barbour, 1988). These habitat types occur throughout the range of the MGS.

In the northern portion of the range, MGS was also found by Leitner and Leitner (1998) in Mojave Mixed Woody Scrub, described as habitat typically occurring on hilly terrain and composed of a variety of shrub species (Holland, 1986). Leitner (2007, 2009) also found in the Fort Irwin Western Expansion Area (WEA), which is in the central portion of the range, occurrences were mostly associated with Mojave Creosote Bush Scrub, Desert Saltbush Scrub, and Mojave Mixed Steppe. Mojave Mixed Steppe contains many of the same shrub species as Mojave Mixed Woody Scrub, but the understory is dominated by grasses (Holland, 1986). Some of the dominant species associated with Leitner's 2006-2009 detections were shadscale, Cooper's boxthorn (*Lycium cooperi*), burrobush, spinescale saltbrush (*A. spinifera*), and creosote bush.

Creosote Bush Scrub is the most wide-spread of the broad community types within the range of the MGS, and also tends to have high production of annual plants (Holland, 1986). This community type is where MGS is often observed (Gustafson, 1993). Although records of occurrences indicate MGS have been found in a variety of habitat types throughout their range, some detection locations may not be indicative of sustained or persistent MGS populations (Leitner, pers. comm.). Change of habitat quality due to low winter rainfall and annual plant production, as well as human-related activities, may fragment, destroy, or modify otherwise suitable habitat (Stewart, 2005). MGS occupying an area may move out as a result of low rainfall and plant production and/or human disturbance.

Some of the community types occupied by MGS differ considerably in vegetative composition; and different species of shrubs or annuals may be used within a single year, depending on environmental conditions such as rainfall (see Food Habits). Harris (pers. comm., as cited in Stewart, 2005) indicated very few historic MGS locations completely lacked winterfat and spiny hopsage. His assertion was supported by the presence of these plant species in occupied sites used for home range and dispersal studies (Harris and Leitner, 2004; Harris and Leitner, 2005). Since much of the creosote scrub habitat in the Mojave Desert does not include these shrub species, it may not constitute optimal habitat for MGS (Stewart, 2005). Other plant communities may provide suitable habitat after only one or two years of adequate rainfall, when populations are expanding, but they will not be consistently occupied after multiple years of inadequate rainfall. When precipitation levels are suboptimal, these habitats may become population sinks. Additionally, juveniles can travel considerable distances (see Home Range and Movements), and may appear in habitats that are not permanently occupied. Therefore, it is possible that some of the historic records may be from sites that were occupied only on a transient basis (Stewart, 2005).

Because of the variability in the vegetation used by MGS discussed above and potential changes in vegetation due to climatic variables, it is difficult to predict where suitable habitat may occur based on vegetation data alone. Inman *et al.* (2013) created a species distribution model that related species occurrence data to the probability of finding suitable habitat based on abiotic landscape characteristics, such as surface texture, topographic position, summer albedo, winter precipitation, air temperature, and winter climatic water deficit (Appendix B). For example, the model shows that greater daily fluctuation in the surface temperature of rocks indicates substrate that is sandy or contains small particle sizes (*e.g.*, alluvium), representing more suitable habitat than solid bedrock with consistent surface temperatures (Kahle, 1987; Inman *et al.*, 2013). However, neither this type of model or vegetation data alone can accurately describe or predict MGS habitat. Changing conditions based on biotic and abiotic factors, along with varying levels of ground disturbance, all need to be analyzed when determining the quality and quantity of required habitat.

Photos: Randi Logsdon

Figure I.C-1 – Prime habitat in Little Dixie Wash and Fremont Valley population centers.

D. 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, and whether or not MGS is actively breeding. Harris and Leitner (2004) studied home ranges and movements of 32 adult females and 16 adult males using radio-telemetry on the Coso Range in 1990 and 1994-1997. Adult female home ranges were the largest in 1) a year of extreme drought and no reproduction (1990), and 2) during two years (1995 and 1997) when rainfall was ample enough to support reproduction. During a severe drought in 1990, individual movements between 200-400 m per day were recorded by Leitner and Leitner (1998). Harris and Leitner (2004) suggested that the extreme drought necessitated larger movements and expanded home range sizes in order to find scarcer food resources. In reproductive years, females' increased energetic needs required them to forage over larger areas. In years of moderate drought and no reproduction, Harris and Leitner (2004) concluded the MGS was able to gather enough food resources in a smaller home range to support early aestivation.

Leitner *et al*. (1991) determined that the mean home range of 12 radio-equipped MGS in the Coso Range of Inyo County was 1.9 hectares (ha) (4.7 acres), calculated using the minimum convex polygon (MCP) method. Notably, the burrows in which individual squirrels spent the night were often between 200 – 250 m (219 - 273 yards) from the areas where they foraged during the day. Harris and Leitner (2004) reported home range sizes in the Coso Range separately by sex and for the mating and post-mating seasons. Post-mating home ranges of females ranged from 0.29-1.9 ha (MCP method), with an average of 1.2 ha (Harris and Leitner, 2004). Post-mating home ranges for males did not significantly differ from females, except in 1997 when they were slightly larger, ranging from 0.38 to 2.96 ha (J. Harris, pers. comm., as cited in Stewart, 2005). During the 1997 MGS mating season (mid-February to mid-March), the median MCP home range for males was 6.73 ha (maximum 40 ha), while for females, the median was much smaller at 0.74 ha (Harris and Leitner, 2004). In a more recent study at Inyokern-Fremont Junction near Ridgecrest, Leitner (pers. comm.) reported larger home range sizes during the mating season for males, with MCPs ranging from 17 to 90 ha, and smaller home ranges (less than 1 ha) closer to the aestivation period. The larger areas covered by males in the spring represented distances traveled to gain access to females, rather than the home range typically used by animals for foraging.

The maximum long-distance movement by dispersing juveniles reported by Harris and Leitner (2005) was 6,230 m for males and 3,862 m for females. Leitner (pers. comm.) described the largest movement by a male juvenile as 8 km (about 5 miles). Harris and Leitner (2004) reported that within a day, dispersal distance was greater for males during the mating season (median 391 m, range 274–1,491 m) than during the post-mating season (median 130 m, range 46-427 m). The within-day dispersal distance for females did not differ between the mating (median 138 m, range 96-213 m) and post-mating seasons (median 205 m, range 24-371). The maximum within-day distance moved was significantly greater for males than females only during the mating season. Additionally, Harris and Leitner (2004) reported that 40.2% of within-day movements by males were greater than 200 m during the mating season. This is significantly more than the post-mating season (13.8%). Females rarely moved distances 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 post-mating season, although the difference was not considered significant. Overall, the percentage of within-day movements greater than 200 m was significantly greater for males than females only during the mating season. 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 movements by males during the mating season in order to maximize the number of mating opportunities.

Individuals may maintain several home burrows that are used at night (Leitner *et al*., 1991), as well as accessory burrows that are used for temperature regulation and predator avoidance during the day (Recht, 1977). Aestivation burrows are dug specifically for use during the summer and winter periods of dormancy (Best, 1995). Burrows are often constructed beneath large shrubs, such as *Lycium* and *Grayia sp*. or desert willows (*Chilopsis linearis*) (Leitner *et al*., 1991; Best, 1995).

MGS exhibited male-biased natal dispersal, with many males moving at least 500 m from their home burrows (average 2.9 km in 2005, maximum 6.2 km), while on average, females settled between 200-750 m (maximum 3.8 km) (Leitner and Leitner, 1998; Harris and Leitner, 2005). Natal dispersal begins with exploratory movements of several hundred meters during the day, with the squirrel often returning to the natal burrow at night (Leitner and Leitner, 1998). Aardahl and Roush (1985) noted that juveniles had larger home ranges than adults. Leitner and Harris (2004) reported that in a multi-year study, all females demonstrated some degree of overlap with their previous year home ranges (mean 41% +/- 16%), and four females demonstrated complete overlap. This indicates adult females are likely to display strong site fidelity.

E. Food Habits

MGS is known to eat a wide variety of foods, including: 1) leaves of forbs, shrubs, and grasses; 2) fruits and flowers of forbs; 3) seeds of forbs, grasses, shrubs, and Joshua trees; 4) fruits of Joshua trees; 5) fungi; and 6) arthropods (Leitner and Leitner, 1989, 1992; Best, 1995). Recht (1977) characterized the MGS 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.

In Los Angeles County, Recht observed that MGS periodically sampled various foods in order to recognize better forage, and that plant species selection was based on water content and abundance. The MGS chose four major food resources, which Recht (1977) identified as having higher water content than other plants present (*Lycium, Coreopsis, Amsinckia,* and *Salsola sp*.). Each of these plant species were consumed at different times of the year, based on the seasonal variation of abundance and succulence between them.

In the Coso Range, Leitner and Leitner (1998) also concluded that MGS intermittently exploited available food sources, and found great variation in food habits among individual squirrels. Even within a study site, individuals concentrated on their own preferred foods. These observations, as well as Recht's (1977) observations, indicate that the MGS is quite flexible in exploiting high quality resources. Leitner and Leitner (1992) noted that the larvae of several species of Lepidoptera were present in exceptional numbers within the study area in the spring of 1991, and that three MGS females preferentially selected them, as well as cactus (*Opuntia*) seeds, even though the leaves and seeds of forbs were also abundant. Leitner and Leitner (1992) suggested the arthropods and cactus seeds provided the highest nutritional value available. In their synthesis of nearly a decade of data (1988-1996) from the Coso Range, Leitner and Leitner (1998) confirmed that MGS sampled a variety of foods as they become available, but only concentrated on one or two items at a time. Best (1995) described variation in diet based on the location within the MGS range.

Of particular importance to the Mojave ground squirrel diet are annual, native forbs. In poor rainfall years production of these forbs may be reduced, which can lead to MGS reproductive failure (Leitner *et al*., 1995; Leitner and Leitner, 1998). In Leitner and Leitner's 1988 Coso Range study, native forbs were clearly the most important food category, comprising one-half or more of MGS diet in all of the study sites (Leitner and Leitner, 1989). In 1989, 1990, and 1994, shrub leaves constituted the majority of the diet (Leitner and Leitner, 1998), and lack of MGS reproduction was correlated with low precipitation and production of forbs.

Leitner and Leitner (1998) found that forbs comprised approximately 42% of the MGS diet, and non-native grasses were rarely consumed. Analyses of feces described by Best (1995) indicated that forbs comprised up to 85% of the MGS diet, with a single plant species dominating most of the samples analyzed, similar to results reported by Leitner and Leitner (1989). Between 1988 and 1996, Leitner and Leitner (1998) found that shrub foliage averaged over 45% of all fecal samples. These samples were representative of early, middle, and late active seasons, during both wet and dry years. They concluded that shrubs, especially the leaves, were the mainstay both early and late in the active season (when forbs are not available or are dried out) and are critical in drought years when they may be the only food source available. The leaves of three shrubs (winterfat, spiny hopsage, and saltbushes) made up 60% or more of the MGS shrub diet, indicating that these three shrubs are generally a mainstay food source for MGS when forbs are not available (Leitner *et al.*, 1995; Leitner and Leitner, 1998).

Leitner (2012) confirmed that winterfat and spiny hopsage are the preferred shrub foliage. These species are relied upon for sustaining MGS populations when winter rainfall and annual plant production limit or preclude reproduction and dispersal into unoccupied or underutilized habitats. Creosote bush can comprise up to 45% of an individual's diet (Best, 1995); however, Leitner (pers. comm., as cited in Stewart, 2005) hypothesized that creosote bush communities lacking significant amounts of winterfat or spiny hopsage are not necessarily optimal foraging habitat.

In the WEA of Fort Irwin, Leitner (2007; 2009) found that only one of three sites trapped had persistent MGS detections both in 2006 and 2009. Of the three sites, this site had the highest density of winterfat and spiny hopsage. Additionally, Harris and Leitner (2004) stated that spiny hopsage and winterfat were important shrub species for MGS at the Coso Range sites. Harris (pers. comm., as cited in Stewart, 2005) found very little winterfat or spiny hopsage at sites with the lowest MGS captures; captures were mostly concentrated in areas with a high density of these brush species. Leitner (2008a) found similar results (no detections where these shrub species were absent) in the Spangler Hills Open Area and western Rand Mountains, on sites with evidence of livestock grazing and heavy OHV use (Goodlet and Goodlet, 1991; BLM, 2008).

F. Seasonal and Daily Activity

The MGS active season is generally five to six months a year. During this time they reproduce, forage, and prepare for about six or seven months of inactivity (Bartholomew and Hudson, 1960, 1961). During the inactive season, MGS is secluded in their burrows and exist in a state of torpor for much of the time. This reduced metabolic rate conserves energy and water, allowing them to live off stores of body fat. Bartholomew and Hudson (1960) established that the summer period of torpor is aestivation, and the winter period is hibernation, with slight differences in body temperature between the two seasons; however, the differences were so small, Best (1995) defined the entire period of torpor as aestivation. This behavior appears to be an adaptation to food scarcity and temperature extremes (Bartholomew and Hudson, 1961).

The length of the active season for individual MGS varies by age, sex, reproductive status, and the availability of food resources. Bartholomew and Hudson (1960) found MGS in Antelope Valley to be active from early March to August. Harris and Leitner (2004) and Leitner and Leitner (1998) observed emergence from hibernation as early as Februarywhile Best (1995) reported emergence as early as January. Aestivation generally begins in July or August (Bartholomew and Hudson, 1960, 1961; Leitner and Leitner, 1998), but Leitner *et al*. (1995) observed aestivation as early as April in a non-reproductive year. Generally, MGS emerge from hibernation with low body weights and fatten substantially during the active season to prepare for dormancy (Bartholomew and Hudson, 1961; Leitner and Leitner, 1998). In a poor food year, it takes longer for an individual to add the amount of fat necessary to carry it through the long period of inactivity (Leitner and Leitner, 1998).

Adults tend to enter aestivation earlier than juveniles because energy is not required for growth, and adults usually have home ranges with better food resources (Recht, 1977). In a poor food production year, juveniles may remain active as late as August or September (Recht pers. comm., as cited in Gustafson, 1993). Males tend to enter aestivation earlier than females and they typically emerge from hibernation up to two weeks earlier than females (Best, 1995), possibly because they do not have to put energy into milk production before they begin to store fat (Leitner and Leitner, 1990).

MGS is diurnal and active throughout the day (Best, 1995) or may be active only a few hours during the day (Ingles, 1965). During the early part of the active season, they forage above ground throughout the day (Recht, 1977). However, as temperatures increased in the spring, Recht observed that MGS spent more time in the shade of shrubs, sometimes retreating briefly to burrows to escape the heat of the sun, usually around noon. By mid-summer, activity peaks were only in the morning and afternoon. To dissipate excess body heat, Recht observed MGS digging shallow depressions in the shade and laying prone in them, allowing heat to be transferred into the soil through conduction. Conversely, when ambient temperatures were cool, MGS was observed basking in the sun, warming body temperature by erecting hairs to expose darkly pigmented skin to the sun (Recht, 1977).

G. Social Behavior

Recht (pers. comm., as cited in Gustafson, 1993) found that males defended territories against other males during the mating season, but not against females. Up to four females were observed entering the territory of a single male, and occupying burrows close to the male. Recht observed each female individually entering the male’s burrow, presumably to copulate, then leaving after about a day to establish her own home range. In contrast, Harris (pers. comm., as cited in Stewart, 2005) found evidence that males stake out the hibernation sites of females so that they can mate with them when they emerge. In Recht's (1977) study, dispersing juveniles established home ranges that were larger and of lesser quality than adult home ranges. Adults kept juveniles out of their home ranges through agonistic behavior. Juvenile home ranges were clustered around those of adults, and when the adults entered aestivation, the juveniles took over the adults' home ranges until they too entered aestivation.

MGS is described as territorial in nature (Adest, 1972), and both juveniles and adults appear to be solitary, with little overlap of their home ranges outside of the breeding season (Burt, 1936; Bartholomew and Hudson, 1960). Recht (1977) found that 9 MGS maintained separate home ranges with minimal overlap before the end of June, and territorial behavior was observed where overlap did occur. Invasion of a territory by a conspecific triggered fighting, particularly in the case of juveniles dispersing into adult territories or increasing overlap with exploratory movements. This extreme intraspecific aggression was demonstrated in Adest's (1972) laboratory studies and is consistent with Recht's observations, as well as the observations of Bartholomew and Hudson (1960). In his laboratory study, Adest (1972) found social behavior between captive MGS to be almost entirely agonistic for both males and females. Bartholomew and Hudson (1960) stated that conspecific aggression required MGS in captivity to be housed separately.

During the mating season, however, Harris and Leitner (2004) found considerable overlap in male home ranges, though the males did seem to avoid each other. Spring camera trapping studies found very little interaction between adult MGS (Delaney, 2012), which suggests there may be temporal and/or spatial avoidance between them.

H. Reproduction

MGS mate soon after emergence from hibernation, with pregnant females generally observed in March (Burt, 1936; Ingles, 1965; Recht unpublished, as cited in Leitner *et al*., 1991). The mating season is typically from February to mid-March (Best, 1995; Harris and Leitner, 2004). Gestation lasts 29-30 days, and litter size is generally between four and nine (Best, 1995). Pregnancy and lactation may continue through mid-May (Pengelley, 1966, as cited in Stewart, 2005) and juveniles most likely emerge from natal burrows within four to six weeks of birth (Best, 1995). Mortality is high during the first year (Brylski *et al*., 1994) and apparently skewed towards males, resulting in high adult female to male ratios in both juvenile and adult populations (as high as 7:1 for adults) (Leitner and Leitner, 1998). Throughout their nine-year study in the Coso Range, Leitner and Leitner (1998) found that females of all age classes produced young, while males generally did not mate until two years or more of age.

MGS reproductive success is dependent on the amount of fall and winter rainfall (see Food Habits above). There is evidence of a positive correlation between fall and winter precipitation and fecundity rates the following year (Leitner and Leitner, 1998; Leitner, 2009). In the spring following low rainfall (less than 65 mm) winters, herbaceous plants are not readily available as a food source, and the species may forego breeding entirely (Leitner and Leitner, 1998). Harris and Leitner (2004) found that the timing of winter rainfall is also important. In years where less than 30 mm of winter rain had fallen before the end of January, reproduction did not occur. Leitner and Leitner (1992) found that high rainfall in the late fall and early winter stimulated growth of annual grasses. However, in years with only late winter rain, reproduction may still be successful after late germination of shrub and perennial species, as observed by Leitner and Leitner (1992).

Reproductive failure may periodically cause local extirpations in dry years and recolonization in wet years. Annual rainfall less than 65 – 80 mm could result in reproductive failure throughout the MGS range (Leitner and Leitner, 1998). In the spring of 1994, following a winter with 68.6 mm of rainfall, there was no evidence of MGS reproduction recorded at the study sites in the Coso Range (Leitner *et al*., 1995). In Fort Irwin WEA, trapping data in 2006 and 2007 confirmed that no reproduction occurred after two very dry winters between 2005 and 2007 (22.6 mm and 7.9 mm, respectively) (Leitner, 2007). However, in 2009 evidence of reproduction was confirmed after two winters of rainfall higher than 74 mm, which was likely an adequate amount for forb production (Leitner, 2009).

In 2011 and 2012, high abundance and a wide distribution of MGS detections followed four winters of at least 65 mm of rainfall. Prior to these relatively wet years in Fremont Valley, there had been no records of detections in over 20 years; but in 2012, this area yielded a high detection rate (Leitner, 2013; Leitner and Delaney, 2013). This implies that Fremont Valley had been recolonized after being unoccupied.

I. Interaction of MGS and White-tailed Antelope Squirrels

The geographic range of the MGS completely overlaps the range of the white-tailed antelope squirrel (*Ammospermophilus leucurus*) (antelope squirrel) (Zeiner, *et al.*, 1990). While these species are roughly similar in size (Howell, 1938) and food habits (Leitner and Leitner, 1989, 1992), there apparently is little competition between them (Delaney, 2012; Leitner, 2012). Leitner and Leitner (1989) found that these two species differ in the relative proportions of foliage and seeds eaten. The predominant food of MGS was foliage of forbs and shrubs, with seeds of forbs and shrubs the next most important. The opposite was true for the antelope squirrel, with seeds being predominant and forb foliage of lesser importance. Arthropods were about 21% of the antelope squirrel’s diet, as opposed to less than 10% in the MGS diet.

MGS and antelope squirrels also differ in other aspects of their biology that may reduce interaction between them. For example, while MGS is solitary and defends territories (Bartholomew and Hudson, 1960; Adest, 1972; Recht, 1977), the antelope squirrel lives within a social hierarchy and exhibits group behavior (Adest, 1972; Fisler, 1976; Zembal and Gall, 1980). By virtue of its ability to predominantly utilize seeds, a food resource that remains available long after it has been produced (Leitner and Leitner, 1990), as well as a remarkably high thermal neutral zone (Bartholomew and Hudson, 1961), the antelope squirrel remains active all year instead of aestivating and hibernating like the MGS. It is possible MGS torpor eliminates interspecific contact for more than half of the year (see Seasonal and Daily Activity above).

When interspecific interactions were observed, MGS appeared dominant and displaced the antelope squirrel (Adest, 1972; Zembal and Gall, 1980). Bartholomew and Hudson (1961) stated that in comparison with the antelope squirrel, the MGS is "bigger and fatter and has a temperament that goes with its more generous proportions." Delaney (2009) and Leitner (2012) observed the dominant behavior at camera bait stations where the two species interacted. Though it is recognized that the antelope squirrel is far more ubiquitous with a much larger range than the MGS (Zeiner, *et. al.*, 1990), there is no indication of the antelope squirrel outcompeting or displacing MGS.

Photo: David Delaney (Delaney, 2009)

Figure I.H-1. Juvenile MGS and antelope squirrel at feeding station.

J. Interaction of MGS and Other Ground Squirrels

The ranges of the round-tailed ground squirrel (RTGS) and the California ground squirrel overlap the MGS range (Zeiner *et al.*, 1990). The relationship between the MGS and RTGS was discussed above in the Taxonomy section. RTGS range expansion is increasingly resulting in overlap with the MGS range; however, documented occurrences of hybridization are minimal. Differences in the species' biology have been documented, but more information on the species' interaction is needed.

Hafner (1992) suggested that divergence between the two species greatly reduced competitive interactions and interbreeding, as evidenced by both cranial and genetic data (Hafner, 1992; Bell and Matocq, 2011). It has been suggested that the difference in habitat preference could be a reason MGS moved out of certain areas and RTGS moved in (Krzysik, 1994); however, it is unknown if the two species occupy different habitat niches in areas where their ranges overlap. Where there are encounters between the two species, little is known about their interactions; however, MGS generally acts aggressively in encounters with other species (Krzysik, 1994). Though it appears the RTGS and MGS may occupy neutral zones with minimum competition, additional research is needed to understand MGS and RTGS interactions, particularly as the RTGS western expansion increases into occupied MGS habitat.

Even less is known about interactions between the MGS and California ground squirrel. Wessman (1977) stated that California ground squirrels stayed close to haystacks and agricultural fields, and generally did not extend into natural habitats. Similar to RTGS, the MGS' preference for natural habitats would presumably reduce the number of areas where interaction with California ground squirrels would occur. However, if habitat overlap does result in interaction, the California ground squirrel is larger (Howell, 1938; Ingles, 1965) and aggressive (Wessman, 1977; Krzysik, 1994). Additional research is required in the contact areas between the two species to assess the effect of California ground squirrel interactions with MGS.

K. Predators

There is little information on MGS' natural predators. Leitner *et al*. (1991) found circumstantial evidence of predation by the prairie falcon (*Falco mexicanus*) and coyote (*Canis latrans*). Recht (pers. comm., as cited in Gustafson, 1993) found similar evidence of predation by the Mojave rattlesnake (*Crotalus scutulatus*), and identified rattlesnakes as predators.

Harris (pers. comm., as cited in Stewart, 2005) noted that MGS could be vulnerable to common raven (*Corvus corax*) (raven) predation. Raven populations increased over 1500% in the western Mojave desert between 1968 and 1988 (Boarman, 1993) and have continued to increase dramatically over the decades that followed (Boarman *et al*., 2005; Fleischer *et al*., 2008). The increase in raven populations is directly related to increases in human occupation and subsidization (Fleischer *et al*., 2008; Boarman *et al*., 2005). Leitner (2005) reported that ravens may capture and take MGS, since they are known to predate on other species of ground squirrels. There have been at least three documented accounts of ravens preying on ground squirrels (Boarman, 1993) and a video account of a raven hunting near ground squirrel burrows in the Ukraine (http://www.youtube.com/watch?v=HawgNqdfS-4). Harris (pers. comm., as cited in Stewart, 2005) found empty MGS radio-collars (sometimes with blood and hair present) on or under Joshua trees where ravens were commonly seen perching and nesting.

Other predators likely include the golden eagle (*Aquila chrysaetos*), red-tailed hawk (*Buteo jamaicensis*), American badger (*Taxidea taxus*), and bobcat (*Lynx rufus*), as well as domestic or feral cats (Gustafson, 1993) and dogs (LaBerteaux, 1992 comment letter *in* Gustafson, 1993). The gopher snake (*Pituophis catenifer*) and desert kit fox (*Vulpes macrotis arsipus*) were also identified by Defenders of Wildlife as likely predators (Stewart, 2005). Since only circumstantial evidence and inferences exist for predation on MGS, focused research is necessary to identify its actual predators.

II. Threats

Major threats to MGS recovery are drought, habitat loss, habitat fragmentation, and habitat degradation (Gustafson, 1993). Habitat loss is the biggest cause of MGS decline, as curtailment of suitable habitat has resulted in contraction of the MGS range. The small amount of contiguous suitable habitat remaining leaves the species vulnerable to other major stressors, such as drought-induced local extirpation (Gustafson, 1993).

Habitat can be lost due to urban and rural development, agriculture, military operations, energy development, transportation infrastructure, and mining. Habitat can be fragmented or degraded by OHV use, livestock and wild ungulate grazing, commercial filming, recreational activity, or the use of pesticides and herbicides (76 FR 62214). Climate change is also a recognized threat, with the strongest impact being reduced availability and distribution of foraging and breeding habitat (76 FR 62214). Indirect effects of climate change could include proliferation of invasive species or disease vectors; increased competition or predation from displaced fauna; and catastrophic natural events, such as fire or flash floods. Lastly, direct mortality from causes such as anthropogenic activities and predation could decrease recruitment and population sizes.

Each of these potential threats are discussed and analyzed in greater detail below. Though one single threat may not severely impact the habitat or the species as a whole, the cumulative impacts of multiple stressors could result in jeopardy to the species' existence. Therefore, each of the potential threats should be managed and minimized to lessen the cumulative impacts.

A. Drought

Results from the studies described under Reproduction in the Species Description above imply that years with low winter precipitation correlate with low rates of reproduction throughout the MGS range. This may have a direct impact on the overall population size if drought events increase (see Climate Change Impacts below). In drought years, when there is not sufficient forage to meet increased energy demands of reproduction or for offspring to survive, MGS adapts by foregoing reproduction and entering aestivation earlier in the season (Leitner and Leitner, 1998).

In drought years, annual forbs and grasses are not available, thus necessitating reliance on certain shrub species to provide nutrition and water (See Habitat Requirements and Food Habits sections in Species Description above). Lack of important shrub species that provide sufficient forage for non-reproductive individuals during drought years could increase mortality rates during torpor. Over time, MGS have survived prolonged periods of drought through persistent populations in locations that provide consistently sufficient habitat (Leitner, 2008). These persistent populations become sources for extirpated areas in years of higher rainfall. Habitat loss in areas that support these persistent populations, and activities that sever movement corridors between source populations and areas suitable for recolonization, impede and potentially prevent survival of the species.

Additionally, the MGS is not as physiologically adapted to drought conditions as antelope squirrels are (Bartholomew and Hudson, 1961), and therefore relies on the vegetation and soil structure of its habitat to behaviorally adapt (Recht, 1977). Increased drought conditions coupled with a decrease in suitable habitat could force MGS into longer periods of torpor with fewer opportunities to meet energy demands.

The extent of the threat of drought is directly tied to the extent of habitat loss, fragmentation, and degradation. Preservation of existing habitat is a critical component to off-set the negative impacts caused by drought. Increased drought events in the future may render some of the existing habitat inhospitable, requiring additional conservation of areas predicted to support MGS under these conditions (see Climate Change Impacts below).

B. Range Contraction

The recovery of MGS is already at risk due to the species' restricted distribution relative to other ground squirrels, and the uncertainty of how vulnerable it is to regional extirpations (Hoyt, 1972; Brylski *et al*., 1994). As detailed above under Distribution in Species Description, MGS already appears to be absent from a large percentage of its historic range (Gustafson, 1993). Habitat loss has been associated with range contraction at the western and southern edges of the MGS range (Gustafson, 1993), and habitat disturbance may be implicated in contraction of the eastern edge of the range in Fort Irwin (Leitner, pers. comm.).

Except for the existing population in Edward's Air Force Base (EAFB), the species was absent from nearly all areas surveyed south of SR-58 for a period of about 15 years (Leitner 2008; 2013). In 2005, Defenders of Wildlife calculated the extent of this area as over 400,000 ha (over 1 million acres), which amounts to over 20% of the species' historic range (Stewart, 2005). Recent studies and incidental sightings have indicated that remnant populations, or at least dispersing juveniles, may still exist in the southern part of the range (CDPR, 2004; Leitner, 2013)). However, camera studies conducted between 2010 and 2012 confirmed detections only adjacent to EAFB and just south of the Kramer Hills (Leitner and Delaney, 2013). The lack of detection data could be biased as a result of focused development-driven surveys rather than randomly selected scientific study areas, an insufficient protocol, and/or temporal factors (Leitner, 2008; 76 FR 62214). Therefore, it will be difficult to determine the actual extent of the range contraction in the southern region unless the existing habitat is fully and adequately surveyed.

Due to ground disturbing military operations, MGS occurrences in Fort Irwin decreased substantially by the 1990s (Krzysik, 1994; Recht, 1995). Additional survey efforts since that time have inferred determined MGS no longer occurs in the eastern extent of its range (Leitner, pers. comm.). However, it is not clear if the range is contracting due to habitat disturbance or if other factors are causing regional extirpation.

To understand the actual level of range contraction due to habitat curtailment, and to project trends of continuing contraction, sufficient research and monitoring studies need to be conducted in the far western, southern, eastern, and northern portions of the MGS range. In addition, habitat outside the range—particularly where there have been reports of MGS detections—needs to be surveyed to analyze the extent of contraction relative to potential shifts in distribution or range extensions.

C. Habitat Loss

1. Urban, Suburban, and Rural Development

In 2011, the USFWS calculated about 2.6% of the range of the MGS had been lost to urban, suburban, and rural development (development), and more of the range was expected to be lost in the future, most likely adjacent to existing urban or suburban areas in the southern portion of the range (76 FR 62214). USFWS determined unincorporated areas not adjacent to existing cities are likely to have a smaller loss of habitat to development due to lack of existing infrastructure. Fortunately, unincorporated areas comprise most of the central and northern portion of the MGS range. The worst-case scenario presented by USFWS was that all incorporated land within the range of MGS (about 8.9 %) would be developed; however, the USFWS considered this complete build-out unlikely (76 FR 62214). Inman *et al.* (2013) calculated 16% of the historic range has already been impacted by urban development. Considering this estimate, up to 25% of the MGS range could be threatened by development.

Sixty-two percent of the MGS range is federally owned, little of which is subject to development (76 FR 62214). The majority of federal land is owned by the Bureau of Land Management (BLM) and the Department of Defense (DOD). The BLM's 2006 West Mojave (WEMO) Plan, which was adopted as an amendment to the California Desert Conservation Area (CDCA) plan, does not allow development on conservation lands, unless it is associated with an allowable use (such as building public facilities in recreation areas). About 1.7 million acres of important MGS habitat is included in BLM conservation lands that are restricted from development. On DOD land, a small amount of development occurs primarily in cantonment areas discussed in Military Operations below.

Loss of MGS habitat has occurred from residential and commercial development, golf courses, airports, landfills, wastewater treatment facilities, prisons, flood management structures, and other facilities (76 FR 62214). Most development has occurred in valleys, flats, and gently sloping areas, which are the same types of landscapes most often used by MGS. The greatest losses of MGS habitat have occurred in and adjacent to cities, including Palmdale, Lancaster, Victorville, Adelanto, Hesperia, Apple Valley, Barstow, and Ridgecrest. Smaller areas of habitat have been lost in and near towns such as Hinkley, Boron, North Edwards, California City, Mojave, Rosamond, Inyokern, and Littlerock, and unincorporated communities such as Pearblossom, Phelan, Desert Lake, Lake Los Angeles, Trona, Argus, Lucerne Valley, and Pinon Hills. Defenders of Wildlife's GIS analysis in 2005 indicated that urban development accounted for over 44,000 ha (108,000 acres), and rural development spanned over 11,000 ha (28,000 acres) (Stewart, 2005)

The larger cities within the MGS range (Adelanto, Apple Valley, California City, Hesperia, Lancaster, Palmdale, Ridgecrest, and Victorville) grew an average of 85% between 1990 and 2010 (Alfred Gobar Associates as cited in BLM, 2005, Table 3-38; U.S. Bureau of the Census, 2000 as cited in Stewart, 2005; AnySite Online as cited in

Stewart, 2005; U.S. Bureau of the Census, 2011, as cited in http://www.cubitplanning.com/state/25-california-census-2010-population). If this growth continues, population increases will continue to increase development pressure on MGS habitat.

MGS has been detected in habitat near urban areas, and could be directly affected by urban expansion. For example, an individual was observed south of State Route 18, about 5 miles from Pinon Hills (CNDDB occurrence #257) in 1992, as well as near a U.S. Air Force industrial plant adjacent to Palmdale in 1934 (CNDDB occurrence #45). Historic records indicate MGS was found about 2 miles from Inyokern (CNDDB occurrence #78, #114, #149) and 1 mile from the golf course at China Lake (CNDDB occurrence #42). Between 1997 and 2008, observations were made in the vicinities of Ridgecrest, Olancha, and around the Borax mine, about 2 miles north of the town of Boron (Leitner, 2008). Some more recent surveys detected individuals on the edge of Adelanto, and about 2 miles from the towns of Hinkley and California City (Leitner and Delaney, 2013). Dispersing individuals were seen on paved parking lots and in small parcels in the middle of housing developments (Campbell, pers. comm.). Though MGS have been observed in or within a few miles of urban areas, it is unlikely they would establish residency there without access to adjacent undeveloped habitat.

Based on its status review in 2011 (76 FR 62214), the USFWS determined that urban, suburban, and rural development did not pose a substantial threat relative to the overall effects on habitat destruction and degradation. Part of that finding was based on existing conservation from BLM's 2006 WEMO Plan. Gustafson (1993) noted that while no single development project threatens the existence of MGS in a region, unless it destroys the last population, the total impact of all large development projects combined with the impact of smaller projects can result in the regional extirpation of the species. Gustafson stated further that this is what likely occurred in the western triangle of Antelope Valley, to the west of SR-14, and in the area east of the City of Victorville.

2. Agricultural Development

Agricultural development results in the conversion of native desert habitat to croplands and orchards (CDFG, 2005). Habitat loss from agricultural activities has occurred at several locations within the range of the MGS. Aardahl and Roush (1985) stated that urban and agricultural development resulted in "[s]ignificant loss of habitat" for the species. By the early 1990s, more than 15,700 ha (39,000 ac), or 0.7 % of the range, had been lost to agriculture, including areas in the Antelope Valley and Mojave River Basin (Gustafson, 1993). Krzysik (1994) reported that the spread of alfalfa fields throughout the species' southern range in the Mojave River area had destroyed prime MGS habitat and fragmented populations. Wessman (1977) concluded MGS was no longer found in the Lucerne Valley, Apple Valley, or Victorville areas, which were dominated by agriculture and are estimated by the USFWS to constitute about 2.4 % of the species' range (76 FR 62214). The extent of local extirpations due to the threat of agriculture is unknown, but could be determined by surveying how much of the land used for agriculture remains fallow and impermeable to MGS occupancy or movement.

Agricultural production increased in the Antelope Valley after the mid-1990s due to increased production of fruit and vegetable crops (mainly onions and carrots) (UC Cooperative Extension, Los Angeles County, http://celosangeles.ucanr.edu/Agriculture/). The 2006 WEMO Plan (LaRue, 1998, unpublished data, as cited in BLM, 2005, Appendix M) reported that about 4% of the historic MGS records were found in what are now agricultural areas. In 2005, Defenders of Wildlife estimated that over 37,000 ha (92,000 acres) of MGS habitat—equal to 1.9% of the total habitat–were converted to agriculture (Stewart, 2005). However, by 2009 Kern County agricultural production had decreased by over 10%, and carrot production alone decreased by about 8% (CDFA, 2011). In Los Angeles County, decreases in West Mojave Desert agriculture occurred due to rising costs of ground water pumping for irrigation (Los Angeles County Cooperative Extension, 2009, as cited in 76 FR 62214). Many of the existing agricultural lands within the range of MGS have been abandoned, remain fallow, and appear to not support MGS occupancy (Leitner, pers. comm.). An example of this is a large expanse of fallowed land between Little Dixie Wash and the DTNA in Kern County (Cantil to Koehn Lake) that likely precludes dispersal (Leitner, pers. comm.). Agriculture for pistachios in 2013 was evident north of Inyokern, where very little intact habitat remains (Logsdon, personal observation, Figure C2-1).

Many of the MGS population centers within Kern County were partially zoned by the 2009 County Plan for extensive agriculture (Kern County, 2009). However, USFWS found that local agriculture agencies in the west Mojave Desert are not predicting an increase in agriculture development for the future (76 FR 62214). It is possible that if land use designations are changed, much of this land could remain as open space.

Depending on the amount of land converted to agricultural uses, the overall impact of agriculture on MGS habitat may increase or decrease in the future. In Los Angeles County, abandoned agricultural land is being converted for residential and commercial development (Los Angeles County Cooperative Extension, 2009, as cited in 76 FR 62214). To the extent abandoned agricultural land is converted for development projects, impacts to in-tact habitat could decrease.

Photo: Randi Logsdon

Figure II.C.2-1. Agricultural habitat conversion north of Inyokern.

3. Military Operations

The Department of Defense (DOD) manages about one-third of the range of the MGS. Within the species' range, there are three major military bases, The National Training Center at Fort Irwin, Edwards Air Force Base (EAFB), and China Lake Naval Air Weapons Station (China Lake). MGS habitat has been lost to military operations primarily from ground forces training. Cantonment areas, which generally contain offices, housing, shops, restaurants, utilities, and recreational facilities such as golf courses, have the same impact described above under Urban, Suburban, and Rural Development. Analysis in Google Earth shows that cantonment areas in Fort Irwin, EAFB, and China Lake cover approximately three square miles each, equal to or larger than the development impacts from many of the small towns and unincorporated communities described in the section above. EAFB and China Lake also have airstrips and related facilities, larger than the airports associated with the small communities outside of DOD land. The overall development footprint within DOD land, however, is smaller than the cumulative impacts of the towns, cities, communities, and airports outside of DOD land.

Some DOD installations have developed or are proposing to develop both solar and wind energy generation facilities. Solar energy development has the potential to fully convert and impact MGS habitat. Military solar facilities could produce up to 7 gigawatts (GW) of power, impacting up to 23.4 thousand acres (Kwartin *et al.*, 2012). For example, Fort Irwin could develop up to 17,848 acres of habitat inside and outside of cantonment areas. China Lake could develop up to 5,315 acres of habitat for solar power (Kwartin *et al.*, 2012).

Fort Irwin, including the Western Expansion Area (WEA), constitutes approximately 8.2% of the MGS range, and ground forces training within the installation impacts MGS habitat (76 FR 62214). Fort Irwin is on the eastern edge of the MGS range, and not all of the area within Fort Irwin is impacted by ground forces training. Defenders of Wildlife determined that training at Fort Irwin encompassed about 146,000 ha (360,500 acres) of MGS habitat, which amounts to 7.4% of the total range (Stewart, 2005). Krzysik (1994) noted heavy shrub losses and disturbance to habitat due to military operations, including the use of tanks and other tracked vehicles destroying biologically valuable cryptobiotic soil crust. Recht (1995) surveyed six Fort Irwin sites, and found a significant reduction of numbers of MGS captured in 1994 compared to 1993. At a site where MGS was no longer present, Recht found evidence of training that had occurred since 1993. The site with persistent detections was in the Goldstone Unit, where ground training operations do not occur.

The USFWS (76 FR 62214) determined that use of vehicles during Fort Irwin ground operations would be similar to the effects of off-highway vehicle (OHV) use, where flat and low-sloping terrain used by MGS would be preferred. Ground-based military maneuvers can 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 finely grained, creating a less suitable substrate for MGS burrow construction (CDFG, 2005). If ground operations are confined to roads or other areas that are already denuded, impacts on MGS would be reduced. However, when maneuvers occur in otherwise undisturbed land, tanks and other military vehicles could have more intense impacts on the MGS habitat than recreational OHV use.

The WEA includes 30,500 ha (75,300 acres) of habitat near the eastern portion of the MGS range (Stewart, 2005), and contains part of the persistent population described by Leitner (2008) as Coolgardie Mesa/Superior Valley. The purpose of the WEA was to expand areas for training maneuvers at Fort Irwin. Stewart (2005) stated that the approved expansion would represent a significant loss (up to 1.5%) of what was considered to be “probably excellent” or “prime” MGS habitat (CDFG, 2004, as cited in Stewart, 2005; Leitner, pers. comm., as cited in Stewart, 2005). The comment letter referenced by Stewart (2005) stated, “[t]he potential expansion likely represents the single largest threat to the viability of the squirrel.” Of particular concern was the loss of connectivity habitat between known populations, potentially isolating the Goldstone area from source populations in the south (CALIBRE *et al*., 2005; CDFG comment letter dated December, 22, 2003, as cited in Stewart, 2005). The 2005 Supplemental Final Environmental Impact Statement (SFEIS) for the WEA described about 45,000 acres of significant impact to MGS habitat (CALIBRE *et. al.*, 2005).

Leitner (2007) concluded from 2006 surveys that MGS was widespread throughout the WEA, and suggested that the western and northern portions of the WEA were the most important for conservation. Delaney (2009) followed up with camera studies and found comparable or even greater numbers of MGS detections in the same study areas. These studies informed DOD resource managers on how to manage training maneuvers consistent with conservation of MGS habitat. To the extent DOD manages the WEA for conservation, the threat could be minimized.

Other locations on DOD land, such as the Goldstone Deep Space Communications Complex in Fort Irwin and most of EAFB and China Lake (more than 1,745,000 acres (706,180 ha)), are undeveloped and receive little to no surface impacts from military operations (76 FR 62214). In addition, EAFB conducts MGS research and implements good management practices to reduce threats to its important MGS populations (EAFB, 2008; Delaney, 2012; Reinke, pers. comm.).

DOD maintains buffer areas around its test facilities for safety and security reasons. These buffer areas and the undisturbed land in EAFB and China Lake, estimated by the USFWS to be 27% of the MGS range, provide *de facto* conservation for MGS habitat (76 FR 62214). However, DOD does not guarantee conservation of habitat in perpetuity if such conservation is inconsistent with or impedes the DOD's ability to maintain a ready military force (REAT DOD MOU, 2011). In the case of a national emergency, important population and linkage habitat could become impacted to an unknown degree. To the extent weapons impact the ground, and airports, energy facilities, and cantonment areas are developed, China Lake and EAFB operations could pose a moderate threat to the MGS' habitat. However, where conservation does not conflict with military readiness, the DOD maintains Integrated Resource Management Plans (INRMPs) to protect natural resources including MGS, and has agreed to participate in conservation planning with state and federal agencies (REAT DOD MOU, 2011).

4. Energy Production

Energy development includes two components: energy generation within power plants, and energy transportation to customers via transmission lines and related facilities (*e.g.*, substations). Generation and ancillary facilities (such as pipelines, transmission lines, and roads) require ongoing maintenance after construction. In the western Mojave Desert, power plants currently generate energy using both non-renewable sources (*e.g.*, natural gas) and renewable sources (*e.g.*, solar, wind, and geothermal).

Prior to 2011, a total of 22 power plants had been constructed within or near the range of the MGS (76 FR 62214). No new non-renewable energy projects had been proposed as of 2011 within the MGS range (76 FR 62214); however, the Kern County and San Bernardino County general plans indicated goals for natural gas development (Kern County, 2009 (Chapter 5); URS, 2012). If these plans result in development in MGS habitat, non-renewable energy sources could have an impact. There have been several proposals, however, to generate energy using renewable sources within the MGS range (76 FR 62214), which could have larger impacts on habitat. Proposed renewable energy projects could be geothermal, solar, or wind, or cogeneration projects that combine solar, wind, and/or natural gas.

Federal and state mandates and incentives regarding carbon emission reduction and renewable energy sources prompted several recent applications to federal, state, and local agencies for the construction and operation of new renewable energy projects on both private and public land, as well as for the expansion of existing renewable energy facilities. Impacts to MGS associated with construction and operation of energy facilities and infrastructure are similar to those described above for urban and suburban development, causing both habitat loss and degradation. Inman *et al.*, (2013) estimated that at least a 24% loss of current habitat could occur as a result of renewable energy development.

Geothermal Energy

Leitner (1979) discussed the impacts of geothermal energy production, stating that it would be very difficult to carry out geothermal exploration and development activities without causing some adverse impacts on MGS habitat. Some areas that support populations of MGS also have high geothermal development potential. Geothermal energy projects are restricted to specific areas where geothermal energy is sufficient and near the surface. There are two locations in the range of the MGS that are Known Geothermal Resource Areas (KGRAs): the Coso Hot Springs KGRA (Coso), on both China Lake and BLM land in the northern portion of the range; and the Randsburg KGRA, mostly or entirely on managed BLM land near Randsburg in the central part of the range (BLM, 2005, Appendix P-2). The Coso geothermal plant, developed in 1987, has four power plants and more than 120 wells. It occupies 106,000 ac (42,897 ha) (2% of the range of the MGS) (76 FR 62214). Leitner and Leitner (1989) identified 405 ha (1,000 acres) of habitat impacted. Other than Coso, no geothermal plants have been developed within the MGS range, but the BLM is evaluating a geothermal lease for exploration and development at the Haiwee Geothermal Leasing Area in Inyo County (see http://www.blm.gov/ca/st/en/fo/ridgecrest/haiwee_geothermal/announcements.html).

Geothermal energy project construction and operation may have adverse impacts on MGS habitat (CDFG, 1988). These impacts include crushing burrows; grading habitat used for foraging, cover, and reproduction; introduction of non-native/invasive plants, especially along pipelines, transmission lines, and roads; and altering habitat upslope and downslope, which could cause hydrologic and erosion effects that alter the soil and vegetation (76 FR 62214). Although the overall geothermal project site may be large, the entire project area is not cleared of vegetation, and patches of habitat are left between the disturbed sites.

After the Coso geothermal plants were developed, Leitner and his colleagues conducted annual baseline and monitoring studies for 9 years within the Coso KGRA. They evaluated a mitigation plan developed to offset the effects of habitat loss from the geothermal plants. MGS was widespread and abundant enough for the researchers to collect substantial ecological data using marking techniques (Leitner and Leitner, 1989). During these studies, no correlation was made between abundance of MGS and distance to geothermal plant disturbance.

For future geothermal development, BLM requires analysis of the effects on MGS habitat, and management practices that minimize or mitigate these effects. While it is clear there is at least some threat to the habitat posed by geothermal exploration and development, there is no evidence that the extent of the threat impacts the persistence of MGS populations.

Natural Gas

Natural gas facilities may be constructed to offset deficiencies in wind or solar energy generation, as part of cogeneration plants, or as stand-alone facilities. Construction and drilling could involve hydraulic fracturing (known as fracking). The development footprint of a natural gas facility may be similar to that of a geothermal facility described above, and impacts to MGS habitat could be relatively the same. The effects of fracking—such as ground water or soil contamination, water consumption, and air quality—on MGS habitat are unknown, and we are not aware of any studies conducted on natural gas development within the MGS range.

Though Kern County and San Bernardino County have natural gas energy development in their general plans, there are no natural gas resource areas or gas fields within the MGS range (see http://energyalmanac.ca.gov/naturalgas/interstate_pipelines.html; http://energyalmanac.ca.gov/petroleum/documents/MAP_OIL_GAS_GEOTHERMAL.PDF). Natural gas pipelines, however, do cross the western Mojave Desert, and further construction and maintenance of pipelines, as proposed by Kern County (Kern County, 2009), could have erosion impacts and cause long-term loss of MGS habitat (Wilshire, 1992).

Solar Energy

Optimal insolation levels for solar energy production overlap terrain preferred by MGS (Inman *et al*., 2013), and some solar energy projects proposed in the MGS range would impact highly suitable habitat. Solar energy projects include a variety of technologies; for example, solar thermal (power towers, solar trough), or solar photovoltaic (PV) systems. Habitat loss always results from the construction of a solar facility.

PV is currently the most likely type of solar energy development to occur within the MGS range, although solar thermal projects are also operating or are under construction in the West Mojave Desert. Utility scale solar projects may occupy 1,000 acres or more of cleared vegetation (76 FR 62214). Solar project site requirements (flat terrain, high insolation) match the habitat preferences of MGS. Infrastructure projects (*e.g.*, transmission lines, pipelines, substations, new access roads) create additional impacts to the MGS habitat (76 FR 62214; http://www.nrel.gov/docs/legosti/fy98/22589.pdf).

Adverse habitat effects from construction and operation of solar plants are similar to effects described above for construction of geothermal facilities (76 FR 62214). However, construction of solar projects requires all vegetation be cleared from the site. Large blocks of converted habitat can fragment contiguous MGS habitat, and could potentially block important habitat linkages between populations.

Two existing solar power plants (one near Kramer Junction and the second near Harper Dry Lake) combined occupy an estimated 3,600 acres (1,457 ha), or 0.07% of the MGS range (76 FR 62214). The Kramer Junction project converted 1,003 acres of spiny saltbrush and creosote scrub, both of which are important species for MGS foraging and cover (ERT, Inc., 1987). Both project sites occur in areas with MGS detections (Leitner, 2013) and fragment contiguous habitat within population centers. Proposed solar development facilities south of California City (such as the Borax Solar Project), if approved, would further fragment habitat supporting MGS populations (Kern County, 2012).

Photo: Alan Radecki

Figure II.C.4-1. Kramer Junction solar facility

In 2012 there were 19 complete solar project applications within the MGS range in Kern County and in Antelope Valley (Kern County, 2012), which is not included in the Leitner (2008) range and does not support MGS. Of the proposed projects in Kern County outside of Antelope Valley, only one project was approved by the CEC, which would have likely been developed on habitat that is already unviable for MGS. If some of the other applications had been approved, substantial habitat loss could have occurred. For example, The CEC approved a 563-MW hybrid solar-natural gas project in Victorville (http://www.energy.ca.gov/siting/solar/). If constructed, this project would impact suitable habitat near a possible remnant MGS population to the west. However, solar energy development projects can be canceled for various reasons, including analysis of impacts on natural resources such as MGS habitat.

The large-scale solar energy production proposed in Fort Irwin and EAFB, described in the Military Operations section above, could have a much greater impact on loss of MGS habitat than CEC-approved projects. To address these impacts, DOD is conducting research at EAFB to determine whether or not certain configurations of solar arrays could be developed that are compatible with MGS use and/or movement throughout the facility; for example, raised and rotating solar panels that provide shade and allow for the growth of forbs (Reinke, pers. comm.). Depending on the results of the study, the impacts of solar development on MGS habitat in EAFB could be reduced.

Under the Desert Renewable Energy Conservation Plan (DRECP) (see REAT section under Summary of Management Actions below), solar energy development within the MGS range, outside of DOD installations, would be restricted to development focus areas (DFAs) (REPG, 2012). The DFAs are designed to site projects within disturbed lands or lands that do not support MGS populations. However, some of the alternatives to be analyzed under the National Environmental Policy Act (NEPA) include DFAs for solar development that overlap important MGS population centers and linkages and prime contiguous habitat. If some of these DFAs are actually developed to their fullest extent, the impact on important MGS habitat would be severe. For example, an area under analysis for a DFA just north of Kramer Junction and west of U.S. 395 would sever a viable north-south linkage between populations, as well as east-west connectivity between populations in the central part of the range. Another area under analysis would potentially isolate the Little Dixie Wash population, which provides a persistent source for MGS recolonization in other population centers throughout the range. Under the same alternative, a proposed DFA overlaps an important population center in the DTNA. Even under the proposed alternative, DFAs overlap an important breeding population just north of EAFB.

Only a portion of each DFA would need to be developed to meet energy output targets, (REPG, 2012), and DRECP conservation measures would likely limit development impacts within important habitat. Land set aside by BLM for the purpose of solar development (See Summary of Current Research and Management Actions below, BLM section) called variances, also overlap some of the important MGS populations and linkages described above; however, they are smaller than DFAs and some may not be developed at all due to lack of feasibility for substantial energy production and conflicts with resource protection under the DRECP (REPG, 2012, Section 2; BLM, 2012). In these cases, renewable energy projects within DFAs and variances would need to avoid these populations and linkages; otherwise, the loss of habitat and its effect on MGS recovery would be irreversible.

<u>Wind Energy</u>

Wind energy is similar to geothermal energy in that habitat between wind turbines may be available for the MGS. Although wind farms may occupy hundreds of thousands of acres, the access roads and tower bases (pads) are the only areas where vegetation is completely cleared (76 FR 62214). Still, pads can be large (up to 40 or more square feet), and construction of the wind plant, roads, and ancillary facilities could have a serious impact on the habitat. Ancillary facilities include meteorological towers, substations and electrical collection systems of buried cables, electrical transmission lines and associated tower structures, and “switching stations” that connect the electrical components associated from the wind turbines to transmission lines (76 FR 62214). Construction of the turbines, ancillary facilities, and access roads generally result in temporary habitat impacts. Restoration of temporarily impacted desert habitat is not effective for short-term conservation due to the extremely slow pace of ecological succession and recovery (Randall, *et al.*, 2010). Instead, habitat acquisition would be needed to compensate for the habitat destroyed.

Wind energy sites do not typically occupy the same flat terrain preferred by MGS, and wind energy sites permitted for construction on flat land are south and west of Mojave, in Antelope Valley (Kern County, 2012; CDFW, 2012b). However, at least 20 applications for wind energy projects within the MGS range were received by BLM between 2010 and 2011, covering about 194,000 acres (78,509 ha) (76 FR 62214). DFAs under some of the DRECP alternatives would allow wind energy development within occupied MGS habitat in north Searles Valley and in linkages in the northern part of the range and expansion habitat around EAFB (CDFW Renewable Energy Program data) (See Appendix C). Notwithstanding implementation of the DRECP, the California Wind Energy Association (CalWEA) identified good wind energy resource areas throughout important occupied habitat and linkages from the California City area to the El Paso Range. CalWEA proposed wind energy sites within the North of EAFB population center; the central north-south linkage from Kramer Junction to Ridgecrest, including the genetic hub at Johannesburg; the Little Dixie Wash population center; and in North Searles Valley (Rader and Morrison, 2012; Richmond and Morrison, 2012). The proposed areas were based on an industry standard of wind speeds greater than 5 meters per second, which was considered commercially viable for wind energy; however, future technology may lower the standard, causing additional impacts to MGS habitat.

Not all applications are approved, and proposed wind power sites that could impact occupied MGS habitat could also interfere with military radar systems, and would likely be rejected due to DOD guidance on the types and locations of renewable energy projects that conflict with military missions (Renewable Energy Policy Group, 2012, 2012b; REAT DOD MOU, 2011; also see http://www.pe.com/local-news/topics/topics-environment-headlines/20120520-mojave-desert-military-wants-to-limit-wind-development.ece). However, the DOD is proposing to construct its own wind energy projects that impact MGS habitat; for example, a 49-acre (20-ha) project in Fort Irwin (76 FR 62214).

In 2012, Kern County listed 13 wind projects in the MGS range delineated by USFWS (2011) as either approved for construction or ready to begin the approval process; however, all of these projects would be in the Tehachapi foothills or Antelope Valley and would not impact habitat used by MGS. Additional build-out in Kern County will only occur based on available transmission, about 4,200 MW anticipated in the near future (Oviatt, pers. comm.). It is not known if any of these future projects would impact occupied MGS habitat.

Wind power plants that exist within the MGS range have not been analyzed in terms of impacts to MGS habitat, other than through requirements under the California Endangered Species Act (CESA) and California Environmental Quality Act (CEQA) or NEPA. The uncertainty of the acreage of habitat affected, as well as the quantity of wind projects that will actually be constructed where MGS occur, makes it difficult to assess the extent of the threat. The USFWS (76 FR 62214) assessed the threat as low relative to other energy development, due to the reasons discussed above.

5. Transportation Infrastructure

An extensive network of roads and highways lies within the MGS range (Gustafson, 1993). Paved routes themselves render habitat unusable by MGS for burrowing or foraging. Routes with extensive vehicular use may also pose a behavioral barrier to movement, thus further fragmenting high-quality MGS habitat. Although radio-collared MGS have been observed traversing 4-lane divided highways, these crossings are made at considerable mortality risk (Leitner, pers. comm., as cited in Stewart, 2005). A 1998 vegetation survey conducted in the West Mojave Desert (BLM, 2003) described disturbances along 310 transects studied throughout the range of MGS. Thirty-seven percent of these transects were bisected by roads.

In a desert tortoise study, von Seckendorff-Hoff and Marlow (2002) found degradation of creosote scrub community habitat along roads, and a reduction of desert tortoise sign up to 4 km from the road (impact zone), depending on the volume of traffic. Dispersed camping, which is allowed along roads on BLM lands, can also cause disturbance to habitat. The MGS Technical Advisory Group calculated that existing highways could affect up to 66,000 ha (163,000 acres) of MGS habitat, equal to 3.3% of the species' range (76 FR 62214). However, some studies suggest that roads and their impact zones have minimal to negligible negative effects on small mammals and that roads can have neutral or positive effects on ground squirrels (Garland and Bradley, 1984; Forman and Alexander, 1998; Fahrig and Rytwinski, 2009). Recent and historic MGS records in spatial occurrence data obtained by the CDFW from various sources for the DRECP (DRECP MGS data, 2012) show linear detection patterns along U.S. Highway 395 (US-395), SR-58, and SR-178. Garland and Bradley (1984) found that the disturbed roadside in a Mojave Desert creosote bush community in Nevada altered desert pavement (hard and extremely compacted soil) to a softer texture, providing more suitable habitat for the antelope ground squirrel. Garland and Bradley (1984) and Forman and Alexander (1998) suggested that altered soil conditions and excess water from runoff caused by road contouring provide abundant green forb vegetation, which ground squirrels could use while dispersing or moving within their home ranges.

Roads can also provide deterrents to larger mammal predators such as foxes and badgers (Fahrig and Rytwinski, 2009). Fahrig and Rytwinski (2009) suggested that small mammals may have low road mortality due to the ability to avoid vehicle strikes, relative to larger mammals, and that small mammal abundance does not change due to road proximity. The prediction that small mammal road mortality is lower than mortality of medium-size or large-size mammals is supported by data in the California Roadkill Observation System (CROS) (http://www.wildlifecrossing.net/california/observations/roadkill); however, the data also confirm a number of white-tailed antelope squirrel and round-tailed ground squirrel road-kill observations in or near Death Valley, just east and north of the MGS range.

Roads on upper hill slopes could have a negative impact on hydrology, causing excessive soil erosion (Forman and Alexander, 1998). Roads can also provide a vector for non-native species and lower species diversity (Frankel, 1970). In the Mojave Desert, non-native grasses can displace native forbs exploited by MGS (Brooks, 2000). However, Forman and Alexander (1998) did not find documentation that the spread of non-native species caused by roads exceeded 1 kilometer. In some cases, roadside vegetation management includes introduced species control as well as preservation and enhancement of native plant species compatible with special-status wildlife habitat needs (Jones & Stokes, 1992).

Roads may also act as physical barriers to movement, causing fragmentation of habitat (Forman and Alexander, 1998; Fahrig and Rytwinski, 2009). Swihart and Slade (1984) found that cotton rats and prairie voles significantly avoided road crossings. Evidence of gene flow between populations throughout the MGS range, particularly north to south (Bell and Matocq, 2011), suggest it is not likely that existing roads currently impact enough habitat to present a movement barrier for genetic exchange (76 FR 62214). However, mortality and abundance studies are needed to understand the MGS' actual response to roads on a more localized scale.

The proposed 63-mi (101.4-km) High Desert Transportation Corridor would connect SR-14 in Palmdale with US-395 (Adelanto) and Interstate 15 (I-15) (Victorville), and would terminate on the southeast side of Apple Valley at SR-18. The corridor would contain a freeway/expressway and possibly a high-speed rail line (http://www.sbcounty.gov/dpw/transportation/high_desert_corridor.asp). Most impacts to habitat would occur during construction. However, conservation actions (*e.g.,* habitat acquisition) could offset some loss of habitat. The corridor would transverse the southernmost portion of the MGS range, which has had as few as 5 confirmed detections within the last 20 years (CNDDB; Leitner, 2008; 2013). MGS surveys conducted in 2011 for this project resulted in no detections (Brylski, 2011; Mitchell, 2011). Additionally, the corridor includes some areas already developed for urban and rural use and agriculture, which would decrease the amount of habitat lost.

Construction on sections of US-395 and SR-58 is being proposed. Starting in 2015, areas of US-395 may be realigned and also widened from the southern terminus at I-15 to north of Kramer Junction, (http://www.highdeserteconomy.com/index.php?post=141). The US-395 projects would occur mostly in the southern portion of the MGS range, but would overlap the North of EAFB population center, described by Leitner (2008) as Boron/Kramer Junction, by about 2 miles. The southern widening phase would include areas south of Adelanto that have already been developed. However, the northern realignment phase could impact important linkage habitat between the Harper Lake, North of EAFB, and EAFB population centers. The SR-58 widening, expected to begin in 2014 would extend from Hidden River Road to Lenwood Road, east of Kramer Junction (http://www.dot.ca.gov/dist8/projects/san_bernardino/sr58/hinkley/index.htm).

Another proposed project involves a 13-mile segment of expressway starting at the Kern/San Bernardino county line to about 12.9 miles to the east (http://www.dot.ca.gov/dist8/projects/san_bernardino/sr58/kramerjunction/index.htm). Both SR-58 projects would bisect the Harper Lake population center described by Leitner and Delaney (2013); however, most of the habitat east of Hidden River Road is already disturbed.

All of the projects combined could add up to about 13,253 ac (5,363 ha), including already disturbed areas (76 FR 62214). The widening and expressway projects are still in the planning phase; therefore, project descriptions are not final, and the projects may not go forward as initially proposed. This uncertainty makes it difficult to estimate the extent of the threat, but if the projects move forward, habitat loss would occur in two population centers.

6. Mining

Some mining occurs within the MGS range, including mineral, sand, and gravel extraction (76 FR 62214). Mining can result in the loss of MGS habitat through removal of vegetation used for forage and cover, and removal or erosion of soils used for burrows. Off-road travel and drilling associated with mining exploration, and the construction of roads to access the mine site during production, can also result in impacts on habitat (Boarman, 2002). Minerals are usually extracted via addits (a type of horizontal shaft), shafts, and/or pits. The unused material may include overburden, waste ore, and tailings, which are deposited near the mine site. A mining operation may also require office space, storage facilities, and power plants at the mine site (76 FR 62214), and construction and maintenance of these facilities can also impact habitat. Construction and maintenance of worker housing (*e.g.*, in Randsburg) have the same impacts on MGS habitat as urban/suburban and rural development (Boarman, 2002).

Mining operations range from less than a few acres for recreational mining and exploration to large commercial mines covering several square miles; however, most mines in the western Mojave Desert are small with localized impacts (76 FR 62214). The largest open-pit mine in the state of California, the U.S. borax boron mine located north of Boron, is in the MGS range (http://clui.org/ludb/site/us-borax-boron-mine). CDFW permitted the Borax mine to expand its land operations, resulting in an estimated 5,566 acres of additional loss of MGS habitat; however, this loss was offset by approximately 6,000 acres of habitat compensation in the form of conservation easements (CDFW ITP tracking database). Habitat surrounding the U.S. Borax Mine, including the conservation easement to the north, supports a viable population of MGS described by Leitner (2008, 2013).

The demand for sand, gravel, cement, and other mineral commodities used as construction materials is expected to increase as human populations in the western Mojave Desert increase (BLM, 2005, Appendix P). As sand and gravel mining sites become depleted, it is likely that proposals for expanded operations will be submitted to permitting agencies. Mine expansion in the MGS range would result in the loss of additional habitat, but this loss was estimated to be less than 0.01 percent of the range

(76 FR 62214). Furthermore, small existing or proposed gold and silver mines are in the Mojave-Rosamond and Randsburg areas, and these mines are located on rocky buttes that are not the MGS' preferred habitat (76 FR 62214).

Although some mine expansion does not appear to pose a major threat with regard to habitat loss, the Rand Mine may expand into areas where MGS could be present (R. Jones, pers. comm.), posing a toxic hazard threat. Many of the mines in the Randsburg mine complex have been in operation from the time when arsenic and mercury were used for gold processing. Residual arsenic and mercury may be carried by rain or streamflow into lower elevations (see http://www.blm.gov/ca/st/en/prog/aml/project_page/randsburg.html). BLM designated the area as an Abandoned Mine Land site under the Comprehensive Environmental Response, Compensation, and Liability Act. Results of sampling water, sediment, and biota indicated elevated arsenic and mercury levels exist in the floodplain sediments that discharge into the Fremont Valley population center. Health analyses of ill desert tortoises near the Randsburg mines showed elevated levels of both arsenic and mercury in their systems (R. Jones, pers. comm.). It is unknown if the same toxicity occurs in MGS.

Mining does not occur on DOD lands, which are about one-third of the MGS range, but it can occur on conservation lands administered by BLM (76 FR 62214) or on county lands designated as "open space" (Los Angeles County, 1980; Kern County, 2012(b); Inyo County, 2001; URS, 2012). The overall mining footprint throughout the range appears to be low, except for the U.S. Borax Mine. Most mining locations are likely in elevations higher than those occupied by MGS, and those in lower elevations do not appear to correlate with a lack of MGS detections. However, future mining development and site expansions could impact MGS habitat, depending on location and size of the operation.

D. Habitat Degradation and Fragmentation

Habitat fragmentation occurs when blocks of habitat become separated or discontinuous by loss or degradation (reduction in quality) of intervening habitat. Populations of animals could become separated, and gene flow would no longer occur between individuals in the separated blocks of habitat. Large-scale blocks of fragmentation, such as tens of thousands of acres, can result in smaller size, isolated populations, putting them at risk for extirpation due to reduced genetic variation and ability to respond to fluctuations in environmental conditions (Soulé, 1986, as cited in Gustafson, 1993). Reduced genetic exchange throughout the range would lower the resilience of the species as a whole. Even if habitat is separated by smaller blocks of fragmentation, it is still unlikely that MGS would cross the intervening space (Gustafson, 1993). For example, up to 425 meters of unoccupied habitat could separate home ranges within a population (Leitner, 1999). Fragmentation in widely spread populations with low density would impact intrapopulation dynamics as well as connectivity between populations.

Habitat fragmentation could also prevent other critical metapopulation dynamics, such as recolonization of population areas that are abandoned during years of drought. During prolonged years of low rainfall, MGS fail to persist in low-quality habitat, and populations only remain viable in high-quality drought refugia (Leitner and Leitner, 1998) (see Food Habits in the Species Description above). When rainfall returns to a level that can produce better forage in lower-quality habitat, the populations in the drought refugia provide a source for recolonization. Loss and degradation of habitat between drought refugia and temporarily unoccupied habitat could prevent recolonization, which could pose a cumulative threat to the species.

Since Gustafson (1993) identified habitat fragmentation as a cause of MGS decline, habitat has become increasingly more fragmented throughout the range, and the potential is high for further fragmentation. All of the impacts discussed above for Habitat Loss have the potential to degrade or fragment habitat in areas where habitat is not completely converted. In addition, OHV use, sheep and cattle grazing, drought, pesticide/ herbicide use, commercial filming, and recreational activities could all fragment or degrade the quality of MGS habitat, and are discussed further below.

1. OHV Use

Bury *et al*. (1977) studied OHV effects on terrestrial vertebrates in the Western Mojave Desert at four sites south of Barstow, and concluded that OHV use detrimentally affects Creosote Bush Scrub habitat in the Mojave Desert. OHVs can degrade habitat by collapsing burrows (Bury *et al.*, 1977), damaging shrubs that provide cover, and compacting soil (76 FR 62214).

Brooks (1998, as cited in BLM, 2003) and Frenkel (1970) found that roads may serve as dispersal corridors for non-native plant species, and that non-native species are higher in density in areas with high road densities. Non-native species can out-compete and suppress the growth of native forbs used by MGS (Brooks, 2000), resulting in degradation of MGS habitat. The 1998 vegetation study cited in BLM (2003) indicates that 47% of the 310 transects studied were bisected by some type of OHV track. Bury *et al.*, (1977) discussed the potential of noise from OHV use to disrupt desert wildlife's establishment and defense of territories. Furthermore, OHV noise can impair hearing and disrupt physiological or behavioral characteristics of small mammals such as kangaroo rats (Lovich and Bainbridge, 1999; Schubert and Smith, 2000).

There are four open OHV areas managed by BLM within the MGS range: Jawbone Canyon, Dove Springs, El Mirage, and Spangler Hills (Open Areas). In Open Areas, OHV use is not restricted to designated roads and trails. Outside of the range, the Stoddard Valley Open Area, just south of Barstow, is near the site of a MGS detection in 2005 (CNDDB occurrence #343; Leitner, 2008). Designated open routes outside of the Open Areas are also used by OHVs, and there may be impacts associated with illegal use of routes designated as closed and illegal creation of new routes.

BLM (2003) reported that within the four Open Areas and the heavily used California City/Rand Mountains area, 274 mi^2 (70,966 ha) were affected by wide OHV trails, and

324 mi^2 (83,916 ha) were impacted by more narrow OHV tracks. Impacts to MGS habitat are greatest in Open Areas and high-OHV-use areas (*e.g.*, staging areas for OHV events, camping areas), and less in areas where activities are confined to existing roads and trails (76 FR 62214). Stewart (2005) estimated that nearly 3,000 ha of MGS habitat were impacted by legal OHV use, with considerably more affected by illegal OHV use. Though cross-country OHV use is restricted to the Open Areas, the occurrence of off-route OHV use tends to extend or "spill over" into areas immediately adjacent to the Open Areas (BLM, 2005, Chapter 3). The USFWS (76 FR 62214) calculated that the Open Areas plus the "spill-over zones" constitute about 4.6% of the range of MGS.

Additional enforcement and road closures by BLM could reduce impacts to the habitat, particularly if BLM reaches the target of reducing the number of designated routes in the Rand Mountains area by 90% (BLM, 2005, Chapter 3). The 2006 WEMO Plan and its Record of Decision revised the designated OHV route network (BLM, 2006) to reduce impacts to desert habitats. Under a U.S. District Court order, additional revisions to the OHV route network will further minimize impacts to species' habitat by 2014 (U.S. District Court, 2011).

MGS has been observed in some OHV-use areas, but not others. For example, from 2010 to 2012 there were no detections in the El Paso Wash area southwest of Ridgecrest, which has an extensive OHV-use network (http://www.blm.gov/ca/st/en/fo/cdd/west_mojave__wemo/wemo_maps.html); however, to the south and southeast of Ridgecrest, MGS were observed with a 93% detection rate in the Spangler Hills Open Area (Leitner, 2013). It was not established that OHV use in the El Paso Wash explained the lack of detections. There have also been recent detections in the Dove Springs Open Area (CNDDB occurrences #191, #396); land used heavily by OHVs in Fremont Valley and areas east of California City (BLM, 2008; Leitner, 2008b; 2013b; Leitner and Delaney, 2013); and along U.S. 395 from Kramer Junction to Red Mountain (Leitner, 2013). Whether or not MGS reside in or move through OHV-use areas could be related to the location of populations and limits of dispersal, especially as these factors relate to rainfall patterns and habitat availability.

As OHV route designations are currently under revision by BLM, it is not clear how much the new designations will reduce impacts to MGS habitat. The extent to which OHV use is a limiting factor of dispersal or occupancy is not known; however, population centers overlapping the Spangler Hills and Dove Springs Open Areas, as well as surrounding networks of used routes, implies the extent of degradation or fragmentation caused by OHV use does not prevent MGS occupancy (see Appendix C and http://www.blm.gov/ca/st/en/fo/ridgecrest/dovesprings_ohv_area.html and http://www.blm.gov/pgdata/etc/medialib//blm/ca/pdf/pdfs/ridgecrest_pdfs.Par.5014eea3.File.pdf/SpanglerMap.pdf) (Leitner and Delaney, 2013).

2. Grazing

Livestock grazing has the potential to degrade MGS habitat through changes in soil and vegetative structure, accelerated erosion, and collapsing of burrows (Laabs, 2006).

Campbell (1988) stated that vegetation in the desert tortoise range had undergone significant changes because of a century of livestock grazing, and that non-native annual grasses had partially replaced the once dominant perennial native grasses. Aardahl and Roush (1985) found that grazing by sheep and cattle had the potential to influence the long-term population of MGS, if such grazing would diminish the amount of annual forbs and grasses available for forage.

Leitner and Leitner (1998) documented a dietary overlap in relatively uncommon but important forage between livestock and the MGS. Winterfat foliage made up 24% of the cattle diet, and saltbush leaf, 13%. In a wet year, sheep ate mainly forbs and grasses (83%); while in a dry year, winterfat was 50% of the sheep diet, even though this forage species was rare. In addition to livestock grazing pressures, other small mammals such as the black-tailed jackrabbit consume winterfat and many of the same forb species as the MGS (Leitner and Leitner, 1989). Considering the strong relationship between MGS habitat quality and the availability of these preferred forage species, particularly during drought, livestock grazing could decrease the habitat quality needed to support MGS populations.

In non-drought years, cattle consumed more non-native grasses, such as *Poa*, *Bromus* and *Schismus* species, than native forbs (Leitner and Leitner, 1989, 1992). Managing the timing of livestock grazing and intensity on native plants, and focusing grazing on areas disturbed by non-native grasses, could lessen the impacts of grazing on MGS habitat. In drought years, grazing would need to be managed to reduce impacts on winterfat and spiny hopsage.

Cattle, sheep, and horse grazing occurs throughout the MGS range, on both public and private lands. As of 2005, the total area authorized for grazing within the range of the MGS was about 2.4 million acres (982 ha) (calculated from BLM, 2005, Table 3-45). Additionally, grazing was allowed in some federally designated wilderness areas, including the El Paso and Golden Valley wilderness areas (Stewart, 2005). USFWS (76 FR 62214) calculated (WEMO Plan data) that about 1.7 million acres (695,530 ha) of grazing was authorized by BLM within MGS habitat (about 23% of the range), not including private grazing lands. However, not all land designated for grazing overlaps MGS habitat, as some of the allotments occur in hilly or mountainous terrain or utilize anthropogenically disturbed land. Furthermore, all allotments are not actively grazed. Cattle grazing no longer occurs in China Lake or EAFB (BLM, 2005, Chapter 4; EAFB, 2008), and grazing is not allowed within the DTNA (Campbell, 1988). The Pilot Knob allotment, which is about 45,619 ac (38,994 ha) of habitat overlapping a MGS population center described by Leitner (2008), is no longer used to graze cattle.

Although grazing may result in the degradation of soils and vegetation, USFWS (76 FR 62214) could not demonstrate it results in complete loss of habitat. Leitner and Leitner (1998) completed a nine-year study in the Coso region evaluating habitat improvements as a result of removing livestock grazing. Of four sites studied, two were within the Coso Grazing Exclosure, and two were outside of the exclosure. The study concluded that variation in rainfall determined MGS presence and abundance on all four study sites. No correlation between grazing and habitat quality was found. The only direct effect of grazing discussed was the removal of critical shrub species such as winterfat and annual herbaceous production, mostly by sheep.

MGS habitat can also be degraded by burros and feral (wild) horses, mostly in the northern portion of the species' range (Abella, 2008 Figure 1; 76 FR 62214). Wild horses and burros are widespread throughout China Lake (NAWS China Lake, 2000, Figure 2.1.2.7b). Impacts to MGS habitat from feral burros and wild horses are similar to those of livestock grazing; however, the extent of these impacts is not known. For example, feral burro impacts to Mojave Desert plant communities are influenced by many factors, such as population density, topography and soils, resident plant groups affected by the burros' seasonal grazing patterns, the long-term effects of historical grazing, fire disturbances, climatic variation, and the grazing animals' behavior (Abella, 2008). Leitner and Leitner (1989) reported the burro diet was 90% annual grasses, with *Bromus*, *Schismus*, and *Poa* species making up most of the diet. This observation infers very little overlap with the food preferences of the MGS; however, burro food utilization can vary, including selection of shrubs such as *A. dumosa* and *L. Tridentata* (Abella, 2008) in drier years. Similar to cattle, wild horses mostly consume grasses, but will forage selectively on forbs and shrubs where grass is unavailable, including winterfat and spiny hopsage (Krysl *et al.*, 1994).

Under the Wild Horse and Burro Protection Act, BLM was able to establish an ongoing burro and wild horse removal program that reduced the impact of burros on their lands (BLM, 2005, chapter 2). Since 1981, China Lake has had an ongoing program to capture and remove burros and wild horses from its land, and has a long-term management goal to completely eliminate burros and maintain a high-quality herd of approximately 168 horses (NAWS China Lake, 2000).

The extent to which wild burro and horse grazing is controlled and livestock allotments are managed or closed will determine the overall impact of degradation of the MGS habitat. While grazing by itself may not create a severe impact to the habitat, heavy or long-term grazing in combination with other stressors could accelerate habitat degradation.

3. Commercial Filming

Commercial filming occurs on private and BLM lands in the western Mojave Desert, with particular spots favored for viewsheds. Activities associated with creating motion pictures, television shows, music videos, and commercials may require driving off-road or cross-country (76 FR 62214), with similar impacts described above for OHV use. Sets may be constructed and left on the site for repeated use, presenting some of the same impacts as small-scale development, or temporary impacts could result from setting up equipment. Areas could be cleared of vegetation for the purpose of filming. The presence and activities of large groups of people involved in the productions could cause crushing of burrows or vegetation, or attraction of predators. Trained or domestic animals (such as dogs, cattle, or horses) may also be brought onto production sites, potentially causing additional impacts on the habitat through crushing of burrows or vegetation, or grazing. These activities could render MGS habitat less suitable for occupancy, even after the production is completed.

The extent to which commercial filming uses have already disturbed MGS habitat is unknown, and repeated use of the same impacted areas would likely prevent further impacts on pristine habitat. For example, automobile commercials or other commercial filming is permitted by BLM on the El Mirage lakebed (http://www.blm.gov/ca/st/en/fo/barstow/mirage.html), an area that would not be used by the MGS (Harris and Leitner, 2005). At least five commercial films were shot near developed areas (Barstow, Lancaster, and Victorville) or on DOD land (Delfino *et al*., 2007), and at least one film was produced in Trona. The Antelope Valley Film Office tracked over 220 productions from 2002 to 2003 (Delfino et. al., 2007). Many of these filming sites were in the southern portion of the MGS range, where suitable habitat is already patchy and may no longer be occupied (CDPR, 2004; Leitner, 2008; 2013).

No studies have been conducted to assess the level of habitat disturbance filming activities cause, making it difficult to analyze the extent of the threat. Outreach or education programs for people using MGS habitat for filming could help to minimize degradation of the habitat. USFWS (76 FR 62214) found no data indicating that filming activities are a major source of habitat degradation. Filming projects in the desert are subject to NEPA, county permits and/or CEQA, which may require minimization of impacts to natural resources. However, where filming impacts are identified, additional guidelines need to be established to avoid unnecessary degradation of MGS habitat.

4. Recreational Activities

Delfino *et al*. (2007) stated the Mojave Desert is one of the top outdoor recreation locations in the United States. Recreational activities (in addition to OHV use discussed above) may occur throughout the MGS range, inside or outside of OHV Open Areas. Vegetation may be cleared to provide camping accommodations or picnic areas, shooting ranges, competitive racing events, or trails for hiking or running, horseback riding, or dirt bikes. Recreationists may conduct these activities off of designated trails and roads. Wildlife viewing (such as birding) and nature photography are also popular recreational uses of the Mojave Desert (Delfino *et al*., 2007). Campers on BLM lands may use any site off the side of the road instead of being confined to designated campgrounds. People and domestic animals such as dogs or horses could cause impacts by crushing burrows or vegetation, or by grazing. Recreationists may also clear vegetation for campfires or events. Litter (trash, debris, and food items) could attract predators or competitors that drive MGS out of the area.

Large amounts of vegetation could be destroyed by the careless setting of wildfires. Wildfires in the desert are infrequent, so large fires have the potential to destabilize MGS habitat. Native desert vegetation is poorly adapted to fire and is slow to recover following disturbance (Brooks, 2004).

About 22,000 acres (8,900 ha) of land within the MGS range are managed by the California Department of Parks and Recreation (CDPR), and 15,000 acres (6,070 ha) are managed by CDFW (76 FR 62214). Some of this acreage provides public access and recreational opportunities. BLM manages most of the federal land that is used for public recreation within the MGS range, which supports over a million visits per year for the recreational activities described above (Delfino *et al*., 2007).

No studies have been conducted on the level of disturbance recreational activities cause, making it difficult to analyze the extent of the threat. USFWS (76 FR 62214) found that OHV use and development of golf courses had the most impact on habitat. Impacts of other forms of recreation, however, need to be assessed. Where impacts from recreation are identified, land management practices or guidelines need to be adjusted to prevent unnecessary degradation of MGS habitat.

5. Pesticide and Herbicide Use

Agriculture occurs in the MGS range, mostly in the southern portion. Pesticides and herbicides used during agricultural activities, including rodenticides, could expose MGS and its habitat to toxicity (Hoyt, 1972). Because MGS eats plants and arthropods, its habitat could be adversely affected by the loss or reduction of forage from the use of insecticides and herbicides (76 FR 62214). The risk of secondary poisoning from ingesting treated plants or arthropods could also render the habitat less suitable. In addition, drift of pesticides and herbicides from agricultural fields into adjacent habitat could degrade the quality of the habitat (76 FR 62214).

Pesticides and herbicides may also be used by private homeowners or landowners in the MGS range. Commercial development and road construction projects may need to clear vegetation, and the potential exists for project related application of pesticides and herbicides to impact nearby habitat (http://www.dot.ca.gov/hq/maint/manual/chc2(final).pdf).

USFWS (76 FR 62214) could not establish that use of pesticides or herbicides adversely affects MGS habitat, either from reduction of forage or contamination of treated vegetation or arthropods. Furthermore, herbicides are often used to target non-native species, and such application would not likely have an effect on vegetation used by MGS (Otahal, pers. comm.). Agricultural areas are mostly confined to those portions of the range where MGS is no longer being detected (see Distribution above); however, there may be some areas of active agriculture in the central portion of the range, and pistachio fields are becoming established in the northern portion of the MGS range (Logsdon, personal observation). Residential areas, particularly small towns and rural communities, occur throughout the MGS range within and near occupied population centers; however, it is not clear if private landowners' use of pesticides or herbicides affect surrounding habitat.

Although USFWS could not establish the use of pesticides and herbicides as a threat to MGS, there have been no focused studies on the health of MGS populations near areas that are treated. Bioaccumulation studies would need to be conducted on plants and animals in habitat adjacent to residential, agricultural, or project sites where pesticides or herbicides are in use. Additional occupancy studies would need to be conducted to determine whether or not MGS have historically used or currently use the habitat adjacent to the affected areas, and whether or not they occur in reproductive populations. If any impacts of herbicide or pesticide use are found on the survival and persistence of local MGS populations, land use management decisions would need to be evaluated to minimize the impacts to MGS habitat.

6. Invasive Species

The MGS prefers native forbs as forage, and non-native grasses are rarely consumed (Recht, 1977; Leitner and Leitner, 1998). Anthropogenic activities that disturb the ground and vegetation, including the construction of roads, transmission lines, pipelines, or other linear features; shifts in climate patterns; and other biotic or abiotic factors can serve as vectors for the invasion of alien annual grasses (Frankel, 1970; Resources Legacy Fund, 2012). By the late 1990s, alien annual grasses (*Bromus* and *Schismus)* were widespread and abundant in the Mojave Desert (Brooks, 2000). Brooks (2000) found evidence of competition between the native flora and invasive grasses, with a significant correlation between thinning of the invasive annuals and the density and biomass of native forbs.

Increased anthropogenic disturbance coupled with climate change could provide a competitive advantage for annual grasses to displace native forbs critical to the MGS diet. Lack of available quality forage could increase foraging distances (*i.e.*, larger home ranges). Foraging over greater distances could increase energetic needs, potentially resulting in failed reproductive attempts, retarded growth, individual mortality, and a corresponding decline in populations (Recht, 1977; Leitner and Leitner, 1998). Non-native grasses such as cheatgrass could also increase the potential for the spread of wildfires, which could destroy important brush species. Recovery of most of the Mojave Desert brush species could be extremely slow, up to 100 years of succession for some species such as blackbrush (Brooks, 2004).

Restoration plans and management prescriptions should include measures to control annual grasses and foster the growth of native forbs. The threat of invasive plant species to MGS habitat could be substantial, particularly as climate changes.

E. Competition

The threat of competition from the antelope squirrel is considered to be low. Although there is significant range overlap, differences in food preference, seasonal and daily behaviors, and social behavior separate the two species. The antelope squirrel consumes mostly seeds and arthropods (Leitner and Leitner, 1989; 1992), as opposed to leaves and flowers of forbs and brush species that make up the majority of the MGS diet. There may be competition for forage during drought years when antelope squirrels consume a higher percentage of shrubs and forb leaves (Leitner *et al.*, 1995). When the species interact at a commonly preferred resource, MGS has been observed as having the competitive advantage due to aggressive behavior (Adest, 1972; Zembal and Gall, 1980; Delaney, 2009). This aggression likely reduces competition for breeding territories and burrow selection as well.

Leitner *et al.* (1989, 1992, 1995) observed food habits of the black-tailed jackrabbit to assess the potential threat of competition for MGS resources. Winterfat and *Grayia spp.* were the prominent shrub components of the jackrabbit's diet, particularly when other preferred food was not available; however, relative density in food types preferred by the jackrabbit differed more from MGS preferences than the food types preferred by the antelope squirrel (Leitner and Leitner, 1992; Leitner *et al.*, 1995). In most cases, introduced grasses such as bluegrass and Arabian schismus were more important to the jackrabbit's diet than shrubs or forbs. The diversity in diet selection exhibited by the jackrabbit as well as MGS could also lower the instances of direct competition.

The competitive threat posed by the California ground squirrel is not known. In places where their ranges overlap, the California ground squirrel is perceived as a larger, aggressive competitor (Krzysik, 1994). Wessman (1977) observed California ground squirrels in landscapes dominated by agriculture. These observations were made mostly in sites where MGS and RTGS were not present, in the Mojave River, Lucerne, and Apple valleys. It is not known if the California ground squirrel occupied areas within the MGS range after the habitat was altered and MGS moved out, or if competitive interactions displaced MGS. Wessman (1977) observed both species in alfalfa fields south of Helendale, as well as California ground squirrels in natural MGS habitat. Krzysik (1994) suggested the California ground squirrel could have been a factor in the MGS range contraction in the south; however, there is not enough specific data to confirm whether or not that is the case. If agricultural development increases throughout the MGS range, the threat of competition with the California ground squirrel could also increase.

The scientific community is concerned with the western expansion of the round-tailed ground squirrel (RTGS) range. Expansion of the RTGS range increases the number of potential contact zones with MGS, and RTGS may compete for similar food resources (Leitner, pers. comm.). The RTGS expansion within the last two decades implies that the two species are not parapatric with narrow zones of contact as originally thought. Between 1997 and 2007, RTGS were found to be abundant in areas where MGS was no longer detected, particularly east of Hinkley (Leitner, 2008). Recent studies in Fort Irwin infer that MGS may no longer be present east of the cantonment area where RTGS was commonly found, and in 2013 RTGS was observed west of the cantonment, where MGS also appears to be missing (Leitner, 2013). Surveys in 2012 confirmed the westernmost detection of RTGS in occupied MGS habitat, between Hinkley and Kramer Junction (Leitner and Delaney, 2014). The data indicate the RTGS range is expanding as the MGS range contracts; however, it is unknown if RTGS is contributing to MGS range contraction or utilizing the habitat after MGS move from disturbed areas. Eastern Fort Irwin habitat may be more disturbed than other areas within the installation, and some of the RTGS detections in the Hinkley area occurred in disturbed sites.

Genetic examination of a RTGS specimen collected in 2004 implies that RTGS has been occupying MGS habitat just east of EAFB for nearly a decade (Leitner, pers. comm.).

Hafner (1992) described evidence of minimal competition or interbreeding between the two species; however, research is required to determine whether or not RTGS is expanding at the expense of MGS or if the two species are occupying separate niches in a neutral zone with minimal hybridization.

There is no documentation of MGS competing with other species for resources, other than competition from domestic or wild ungulate grazers discussed in Grazing above. Interspecific aggression exhibited by MGS may reduce competition with RTGS and other ground squirrels. Differences in soil preferences and food habits may also reduce competition between MGS and other ground squirrels for territories with suitable habitat characteristics. Focused research needs to be conducted to determine the extent competition, particularly with California ground squirrels and RTGS, influences MGS range contraction.

F. Direct Mortality

Any of the habitat impacts discussed above could cause direct harm or mortality to MGS. For example, direct mortality can occur from the crushing of occupied burrows, vehicle strikes (Gustafson, 1993; Bury *et al*., 1977), exposure to pesticides or rodenticides and bioaccumulation of chemicals from contaminated forage (76 FR 62214); starvation; predation; disease; entrapment; and other harm caused by construction or other anthropogenic activities. Direct killing, such as for ground squirrel control or sport, could also negatively affect MGS survival rates. These potential threats are discussed in detail below.

1. Vehicle Strikes

MGS have been observed being struck or crushed by vehicles (Gustafson, 1993; BLM, 2003; Stewart, 2005; 76 FR 62214; CNDDB). Three percent of MGS detections in CNDDB were road kills, and about 20 of the CNDDB records identified vehicle strikes or OHV use as a threat at the detection site (http://www.dfg.ca.gov/biogeodata/cnddb/). Direct mortality by vehicle strikes is likely to affect male juvenile MGS disproportionately because they are more likely to travel longer distances during natal dispersal than adults or female juveniles (Leitner and Leitner, 1998; Harris and Leitner, 2005). CROS data suggest that the majority of small mammals struck by vehicles statewide are squirrels (various species) (http://www.wildlifecrossing.net/california/observations/roadkill?tid=5), and a large number of road-killed antelope squirrels were observed near Death Valley, Panamint Valley, and north of China Lake, not far from the MGS range (http://www.wildlifecrossing.net/california/map/roadkill/species?field_taxon_ref_nid=531). Therefore, some undocumented ground squirrel strikes likely have occurred within MGS range, posing a mortality threat to MGS.

BLM (2003) stated that the "spill-over" effect from the OHV Open Areas (see OHV Use above) caused higher incidents of vehicle impacts, such as strikes on MGS, in land adjacent to the Open Areas than in non-adjacent sites. Specifically referenced were areas adjacent to Jawbone and Spangler Hills, and both of these Open Areas overlap or are close to MGS population centers. OHV impacts may also occur in areas not adjacent to or within the Open Areas (BLM, 2003). Areas with authorized routes or illegal off-road use in Fremont Valley, California City, Dove Springs, and east of U.S. 395 could impose vehicular strike impacts to MGS in the Little Dixie Wash, North of EAFB, Fremont Valley-Spangler, Harper Lake, Boron-Kramer Junction, and Coolgardie Mesa-Superior Valley population centers. BLM's route closures based on the WEMO Plan, as well as additional closures resulting from litigation, could reduce some potential vehicle strikes associated with OHVs. Road closure combined with increased enforcement could be effective in decreasing injury and mortality of MGS.

Construction of new freeways or widening of highways, with an associated increase in traffic, could increase the level of vehicular impacts; however, this increase may occur mostly near the developed areas in the southern portion of the MGS range, and may be offset by fencing. Along SR-58 near Kramer Junction, Boarman and Sazaki (1996) observed a significant decrease of small vertebrate mortality where fencing offset vehicle strikes. Storm-drain culverts could better provide reduced mortality from MGS road crossings, without the effect fencing would have on fragmenting the habitat. Boarman and Sazaki (1996) observed antelope ground squirrels using culverts along SR-58, as well as other small mammals and reptiles. Further studies need to be conducted to determine how MGS specifically respond to culverts or fencing to avoid road crossings.

Within DOD land, particularly Fort Irwin, ground training maneuvers occur in MGS habitat. Tanks and other tracked vehicles could strike and kill individual squirrels. .In Recht's 1994 study, it was not clear whether the decline in detections after a year of ground operations was a result of direct mortality, destruction of habitat, or lack of sufficient rainfall. Focused studies would be required on military training grounds, as well as throughout the MGS range where vehicular impacts occur, to determine the extent and demographics of vehicle-caused mortality and resulting effects on populations.

2. Pesticide and Herbicide Use

Poisons frequently are used around agricultural fields, golf courses, earthen dams and canal levees to control rodents (Stewart, 2005). It is not known whether or not MGS forage in agricultural fields, but they were observed in desert plant communities adjacent to planted fields (Hoyt 1972, Hafner and Yates 1983) and could therefore be exposed to the effects of pesticide drift. Round-tailed ground squirrels frequent alfalfa fields and other agricultural lands, making MGS potentially susceptible to control of round-tailed ground squirrels in those areas where their ranges and foraging habits overlap, such as in the contact zone near Helendale described by Hafner and Yates (1983). Hoyt (1972) observed MGS in alfalfa fields and concluded they "could be easily exterminated by the State Rodent Program." Statewide ground squirrel control was historically common and could have resulted in the poisoning of MGS. In the 1800s and early 1900s, the California State Commission of Horticulture launched a massive campaign to kill all species of ground squirrels using poisoned grains throughout California, including in natural areas, affecting 12,299 acres in Kern County alone (Jacobsen and Christierson, 1918). Large-scale ground squirrel control programs continued through the 1970s; however, *O. beecheyi* and similar species known to depredate crops or transmit disease were directly targeted (Dana, 1962).

Currently, control of ground squirrels is not species-wide, and is only legal when squirrels are found damaging crops, gardens, or personal property (Fish & G. Code, § 4152); or are considered to be harmful (Fish & G. Code § 4153), such as potentially carrying or transmitting disease to humans. Control of squirrels for the purpose of eradicating a potential epidemic may be carried out on a large geographic scale by public agencies; however, these efforts would not target MGS or its habitat since it has never been known to carry disease (see Disease section below). Squirrels can be legally taken by homeowners or property owners in residential communities in developed, rural, or semi-rural areas under Fish and Game Code section 4152, and some species of squirrels can be hunted (*e.g.*, fox squirrels). MGS have been seen in developed areas, such as backyards and parking lots (Campbell, pers. comm.), and could be mistaken for other common ground squirrels and lethally taken. However, most squirrel control guidelines are specific to *O. beecheyi*, and some educate the public on the differences between depredating squirrels and protected squirrels (see http://www.ipm.ucdavis.edu/PMG/PESTNOTES/pn7438.html). Similar to the threat of vehicle strikes, MGS found in non-natural areas would most likely be dispersing juveniles, making them more susceptible to this threat than adults.

Drift of insecticides, herbicides, or rodenticides from fields adjacent to occupied habitat, or bioaccumulation of these chemicals from contaminated forage and insects, could have direct effects on MGS health or survival in addition to the impacts on habitat discussed above. However, USFWS (76 FR 62214) found no information that the use of pesticides adversely affects the MGS from direct exposure or bioaccumulation from consuming treated vegetation or insects, and there have been no studies identifying or quantifying these impacts. To determine the extent of the threat, monitoring of populations near sites using pesticides or herbicides would need to be conducted, along with specific toxicity and necropsy studies.

3. Starvation

Starvation may be the most common cause of direct mortality of MGS, particularly during torpor when the previous active season did not provide enough forage for adequate fat stores (Gustafson, 1993). This is most likely to occur when juveniles are excluded by adults from better home ranges, and need to expend more energy traveling through larger home ranges to find quality food (Recht, 1977). Adults may adapt behaviorally to a lack of adequate food supply; for example, foregoing reproduction and entering aestivation earlier than they would in a year with adequate plant production (Leitner and Leitner, 1998). The survival of MGS during drought years largely depends on available forage; for example, where shrubs such as winterfat or spiny hopsage are available, survival during torpor is more likely (see Food Habits section in the Species Description above). Leitner and Leitner (1998) suggested preservation of these important plant species could minimize drought-induced starvation, which could be a threat to MGS populations if it affects breeding adults or reduces recruitment.

Human and changing climate impacts could increase drought events and the decline of quality food. Such impacts could exacerbate naturally caused starvation. Reduction of human impacts to in-tact habitat would help increase resiliency in MGS populations faced with a shortage of resources, allowing them to disperse to or recolonize areas with a more adequate food supply.

4. Predation

Potential MGS predators were discussed in the Species Description - Predators section above. Much of this predation occurs naturally; however, anthropogenic disturbance (*e.g.*, litter, road kill) can increase predation pressure by attracting predators not otherwise present (76 FR 62214). Boarman (1993, 2002) discussed the impact of raven predation on desert tortoise as a result of raven population increases that are subsidized by human activity. While raven predation on MGS has only been circumstantially observed (see Predators section above), the improper disposal of trash, debris, and food waste undoubtedly attracts ravens and other potential predators. This extends beyond the developed or residential areas associated with human activity; for example, recreationists in Open Areas can attract predators through careless littering of natural habitats. Windblown trash can also create problems a good distance away from areas that are populated or visited by humans. Artificial water sources, intentional feeding of birds, and food left out for domestic pets potentially attract ravens or other predators. Vertical structures such as transmission lines and telephone poles provide artificial nesting opportunities for ravens and other birds of prey. Increasing areas where ravens and other predators come into contact with MGS could potentially cause additional predation events. Boarman (1993) noted that ravens are known to prey on small mammals including ground squirrels, though the species of ground squirrels were not specified. The actual effect of ravens or other subsidized predators on MGS is unknown.

Overall, only a limited amount of predation events have been recorded by the literature. Of 36 MGS radio-collared in 1995 and 1997, 12 (33%) had at least circumstantial evidence of loss to predation (Harris and Leitner, 2005). Stewart (2005) thought increasing coyote populations within the west Mojave Desert could further increase predation risk to MGS; however, USFWS (76 FR 62214) found no recorded observations of coyotes preying on MGS or fecal analysis of coyote scat that contained remains of MGS. The impacts of predation on the MGS is not yet understood; however, USFWS (76 FR 62214) speculated that rodents are important prey items for many of the desert predators identified in the Species Description – Predators section above.

Some concern was expressed in the literature about predation from domestic or free-roaming pets such as cats and dogs (Gustafson, 1993; Stewart, 2005). Harrison (1992) established that even well-fed house cats are notorious for their predation on small mammals and birds, and 64% of the prey in a one-year study on 77 cats was small mammals. Dunford (1977) listed house cats as a major predator of the round-tailed ground squirrel. Domestic and especially feral cats increase as human populations increase; however, there has been no documentation found on the impact of cats preying on MGS (Leitner, 2005). Domestic and feral dogs are commonly observed digging up rodent burrows (Stewart, 2005) and have been identified as potential predators (LaBerteaux, 1992 comment letter *in* Gustafson, 1993 Appendix E). BLM (2005) and USFWS (76 FR 62214) did not consider feral dogs to have been documented as a significant threat. The threat of predation by cats and dogs is expected to be localized near urban development (BLM, 2005, Chapter 3; Stewart, 2005); however, recreationists or residents in rural areas may bring or even release domestic pets into wild habitat as well.

MGS can escape predators by dashing into burrows or hiding in vegetation, and are cryptic in nature making them difficult to detect (Recht, 1977). The removal of vegetation and continued anthropogenic attraction of predators could have implications regarding the effects of predation on MGS survival rates. The extent of this threat is thought by scientists to be relatively low, but specific studies are necessary to verify this assumption.

5. Disease

Information on diseases affecting MGS is limited; however, California ground squirrels are subject to sylvatic plague (Zeiner *et al.*, 1990; Leitner, 2005; Foley *et al.* 2007; CA Dept. Public Health, 2012). In the early 20th century, ground squirrels in California were infected by the bubonic plague (Jacobsen and Christierson, 1918), resulting in massive panic and eradication efforts. In 2012, California ground squirrels were still being discovered with plague infections in Riverside and San Diego Counties (see http://www.huffingtonpost.com/2012/10/10/squirrel-bubonic-plague-california-tests-positive_n_1954502.html and http://www.nctimes.com/news/local/sdcounty/health-bubonic-plague-found-in-squirrels-on-palomar-mountain/article_4f77f1d3-002c-59ad-9ace-9eb5bff9d545.html) and in northern Inyo County (CA Dept. Public Health, 2012). Coyotes and domestic cats have also tested positive for plague; however, most of the infected mammals have been found in forested environments and not in the desert (CA Dept. Public Health, 2012), and would not likely come into contact with the MGS. No studies are known to have been conducted on the prevalence of disease or parasites in MGS populations (Leitner, 2005), and there is no evidence of the plague in MGS or antelope squirrels reported by the California Department of Public Health within the last five years.

USFWS (76 FR 62214), in consultation with CDFW and Leitner (2005), found no research or observational evidence that documents or suggests that disease is affecting the MGS. The actual threat is unknown, but given the most available data, is thought to be low. The extent to which the California ground squirrel range overlaps with the MGS range, now or in the future, could affect the possibility of disease transmission; however, MGS ectoparasites (flea species) and possible resistance factors would need to be researched before the threat could be assessed.

6. Other Anthropogenic Impacts

Other potential anthropogenic impacts on the mortality of MGS include direct killing by shooting (*e.g.*, for sport); exposure to dumped garbage and toxic substances (LaBerteaux, 1992 comment letter *in* Gustafson, 1993 Appendix E); incidental harm during construction, research, educational, or recreational activities; and agricultural activities.

Shooting and Recreation

There is no evidence direct shooting of MGS occurs, but shooting of wild animals in general, such as desert tortoise, is a problem in the west Mojave Desert (Gustafson, 1993). MGS is likely less of a target than other wild animals, due to its cryptic coloring, quick movements, and hiding behavior (Gustafson, 1993). However, recreational shooting is allowed on BLM land, in Open Areas and motorized access zones (BLM, 2003; http://www.blm.gov/ca/st/en/fo/barstow/recshoot.html), or anywhere within the MGS range where the shooting of game species is legal. It is plausible that individual MGS could be accidentally or intentionally shot, particularly with the use of shotguns. In San Bernardino County, for example, shotguns are allowed throughout most of the west Mojave Desert, with the exception of the El Mirage Open Area north of El Mirage Lake (http://www.specialdistricts.org/2/FishandGame/)

Recreationists and their domestic pets may also potentially go off of roads and trails (see Recreation section above) for their activities, and may crush or excavate occupied burrows, expose MGS to predation, strike MGS with vehicles or bikes, or set fires that kill individuals. Most recreation and shooting activities that are a threat to MGS could be off-set with adequate public education programs and signage within breeding population centers.

Littering and Toxic Waste

Littering was discussed above relative to subsidizing predators; however, large dumped items can decrease forage opportunity as well as crush or block openings to occupied burrows. Abandoned vehicles, appliances, equipment, ammunition or explosives, animal or human waste, coal, ashes, oil, grease, gas, paint, medical waste, insulation, batteries, and other items that generally require safe disposal could contaminate the environment used by MGS. Little is understood about how MGS is affected by contamination and waste. The Environmental Protection Agency identifies about 18 contaminated sites (superfund, hazardous waste, landfills, and an abandoned mine) within the range of the MGS (http://www.epa.gov/oswercpa/mapping_tool.htm), and MGS occur on at least five of the sites (EAFB and Harper Lake populations).

Avoidance measures are recommended for evaporation ponds at construction sites for wildlife in general because of the potential threat of toxic exposure (REAT, 2009). Disposal of hazardous waste could also occur from mining operations or ruptured pipelines. Waste from mining is regulated by the State Water Quality Resources Board, which issues waste discharge requirements to keep hazardous materials out of the environment. To the extent the discharge orders are effective, MGS could be protected from exposure to mining waste. However, in 2006 and 2008, several MGS were detected in close proximity to the Borax mine, and in some cases very close to the waste disposal borrow pit (CNDDB). Comments from the surveyor indicated that the MGS found were threatened by a boric acid pond under construction, as well as by overburden in the mine expansion area. Vanherweg (2000) reported a healthy breeding MGS population of up to 100 individuals in EAFB near an Open Burn/Open Detonation site containing fragments of an exploded ordinance. The report was supporting documentation for an application to the California Department of Toxic Substances Control.

It appears that at least two healthy MGS populations thrive around sites with hazardous waste. However, ongoing monitoring of these populations, as well as specific necropsies or toxicity tests, would be required to determine whether or not the hazardous substances are causing harm or mortality to the individual ground squirrels.

Incidental Harm From Construction Activities

Incidental harm to individual MGS or their burrows could occur from construction or other ground-breaking projects. For example, construction workers could crush MGS with grading equipment or create hazardous situations (*e.g.*, entrapment, vehicular strikes, predator attraction) (CDFW ITP language). Construction activities could crush and collapse occupied burrows; particularly in project sites where MGS had not been detected by pre-construction surveys, or when construction occurs during the dormant season. Since MGS burrows are indistinguishable from other animal burrows (such as the antelope squirrel), it is impossible for biologists to flag and buffer active MGS burrows prior to construction activities without visually detecting the squirrels (Hacker, pers. comm.). For some projects, developers may choose to assume MGS is present and fully mitigate for potentially harmed individuals through the acquisition and conservation of off-site habitat (FGC 2081). Only minimization and avoidance measures required by CESA, CEQA, or NEPA are aimed to prevent direct harm. Such measures may include biologists educating construction workers on how to avoid impacts to MGS, posted speed limits, restricting vehicles to existing roads, removal of litter, and closure of pits or holes that could cause entrapment (CDFW ITP language).

Biologists are often required by CESA permits to monitor the site during all phases of construction for the presence of MGS (CDFW ITP language). If MGS is seen on the construction site during project activities, biologists may be required to move them out of harm's way (CDFW ITP language); however, effective relocation protocols have not yet been developed for this. Biologists may have difficulty trapping and capturing MGS present on the site within the time frame needed (Hacker, pers. comm.). Since relocation of MGS does not generally occur and translocation attempts have failed (Bailey, pers. comm.; discussion at MGS workshop, Barstow, CA, 2012), there is no information regarding good relocation sites, artificial burrow construction, or the subsequent survival of relocated individuals.

Incidental Harm from Capturing and Handling

Biologists are required by CDFW to survey for MGS before the start of any construction activity. Where visual surveys do not provide detections, live trapping is required (CDFG, 2003). Researchers also use live traps to study MGS populations and to get baseline data before projects are approved. Setting live traps for MGS could potentially cause mortality of an individual through inappropriate handling or marking, imposing excessive physiological stress; sustained entrapment causing overheating, chilling, dehydration, or starvation; or creating an opportunity for predation. CDFW special permit conditions and qualification screening of scientists handling MGS help to minimize the potential for these activities to cause harm. Biologists are required to report incidental injuries or mortalities and to consult with CDFW to apply corrective measures to prevent further harm before resuming trapping (CDFW Memorandum of Understanding language). At least five years of CDFW permit reports indicate no known direct harm to MGS from research (Logsdon, personal observation).

Biologists, educators, animal control staff, or the general public setting traps for other small mammals within its range could also inadvertently capture and harm MGS. Biologists or educators trapping small mammals under a CDFW permit also adhere to strict conditions that help to minimize injury or mortality, and they are required to report MGS captures and any incidental harm (CDFW Scientific Collecting Permit language). It is not known how many MGS are incidentally captured, handled, and harmed by individuals without CDFW handling permits. However, incidental harm from the general public or individuals other than permitted biologists handling MGS is unlikely.

G. Climate Change Impacts

Climate change is the least understood but perhaps the most serious threat to the overall persistence of the MGS. Scientists can make predictions through the use of models on how the climatic environment and MGS habitat may change, but there is no certainty regarding the extent of these potential threats, and how the MGS may adapt evolutionarily or behaviorally (Resources Legacy Fund, 2012). The following are some potential scenarios resulting from climate change that could have adverse effects on the survival of the species (Resources Legacy Fund, 2012):

1. Loss of suitable habitat.
2. Habitat distribution shifts.
3. Proliferation of invasive species or disease.
4. Increased natural catastrophic events or increased severity/frequency of natural events (*e.g.,* changes of fire regime).

1. Loss of Suitable Habitat

Data collected from the Mojave Desert region indicate that mean, maximum, and minimum temperatures have been steadily increasing since 1890 (http://www.wrcc.dri.edu/monitor/cal-mon/frames_version.html). The UCLA Institute of the Environment and Sustainability projected that mean temperatures in Lancaster/Palmdale will increase by about 5 degrees Fahrenheit (^{o}F) from baseline temperatures (1981-2000) to the middle of the 21st century (2041-2060) (Hall *et al*., 2012, Figure 15). The number of extremely hot days per year (over 95^{o}F) in the Lancaster area is projected to triple, particularly in summer (Hall *et al*., 2012), and winter freezes in the west Mojave Desert are projected to decrease (Smith *et al*., 2009; CBI, 2013). Conservation Biology Institute (CBI) (2013) models predict a maximum temperature increase of up to 14 ^{o}F in certain parts of the west Mojave Desert by 2069.

Vegetation composition studies within the Mojave Desert show changes in the vegetation over time, due to increasing temperatures, drought, and fire (Thomas *et al*., 2004). For example, some *Atriplex* and *Coleogyne* species alliances disappeared in dryer years or after fire, particularly when non-native grasses were present, leaving only annual herbs (Thomas *et al*., 2004). More drought-tolerant species may take the place of less drought-tolerant species. For example, *L. Tridentata* may die after prolonged periods of drought and will only resprout when moisture returns (Thomas *et al*., 2004). Models project decreasing precipitation in the Mojave Desert over time, along with greater run-off from high-intensity storms, which, along with temperature increases, will directly impact desert vegetation (Archer and Predick, 2008; CBI, 2013).

Shrubs and forbs that are good habitat components for MGS could disappear as interannual changes in precipitation affect the growth and viability of the species. Other global change components, such as nitrification, increased carbon dioxide, and large pulses of rainfall could cause lower Sonoran Desert vegetation and invasive grasses such as *Bromus* to migrate into the Mojave Desert, changing the composition of the flora in MGS habitat (Smith *et al*., 2009).

The effects on MGS of drought coupled with lack of suitable habitat were discussed in the Drought section above. If overall temperatures continue to rise and warmer conditions increase throughout the day or year, such changes would affect the MGS' thermoregulation behavior, creating a situation in which individual squirrels spend increasingly more time underground than actively seeking forage. If increased drought conditions decrease the quality of habitat, the energy and time required to seek out high-quality food resources in larger home ranges will increase (Recht, 1977; Harris and Leitner, 2004). Higher energetic demands with decreased opportunity for sufficient forage, compounded by low reproduction rates, would likely increase local extirpations. The extent of the threat of habitat loss as a result of climate change could be lessened by persistent populations in areas with drought-tolerant habitat, allowing dispersal to newly created or lesser affected habitat. Therefore, anthropogenic impacts to habitat prior to or during changing climate conditions could substantially increase the cumulative impacts on the species' survival.

2. Species Distribution Shifts

In the event of climatic changes, distribution of habitat would likely occur over time as vegetation evolutionarily adapts or shifts in response to changing patterns of sunlight, shade, and rainfall (Resources Legacy Fund, 2012). In addition, USFWS, *et al.* (2012) projected changes in plant communities in the desert regions, affected by increasing carbon dioxide (CO_2) in the atmosphere. For example, some plants may experience increased productivity with higher CO_2 levels, such as the invasive red brome, while others may diminish due to increased fire risk (Archer and Predick, 2008; USFWS, *et al.*, 2012). Even slight changes in temperature, precipitation, or the frequency and magnitude of extreme climatic events can substantially alter the distribution and composition of natural plant communities in arid regions (Archer and Predick, 2008). In the Mojave Desert, a moderate prediction of temperature increase and precipitation decrease correlated with nearly a 66% loss of suitable habitat for the desert tortoise, as well as a shift of habitat distribution to 222 meters higher in elevation (Barrows, 2011).

As climatic variables such as temperature and precipitation change, native plant and animal species are likely to experience shifts in distribution. Data suggest increased atmospheric CO_2 without a severe increase in fire could expand the distribution of Joshua trees (Archer and Predick, 2008). Other Sonoran Desert species may migrate north into the Mojave Desert as the physiogeographic boundaries of the desert systems change. Such changes may provide suitable habitat for a concurrent migration of native wildlife; some of which may compete with MGS and may have better physiological capabilities for the changing climatic conditions.

Under the assumption of increased drought and decreased precipitation, scientists predict that the MGS will move to the west and north in response to the changing environment, likely seeking drought refugia provided by foothills of the Sierra Nevada mountain ranges (Delaney, 2012(b); Leitner, pers. comm.). Inman *et al.*, (2013) also predicted the northern portion of the range as suitable habitat over the time scale of projected climate change scenarios, using non-vegetation variables such as surface texture and climatic water deficit. For example, northern China Lake and Owens Valley in Inyo County were projected to be potentially suitable for MGS over time. CBI models also show cooler temperatures and lower water deficits for northern and northwestern edges of the Mojave Desert (CBI, 2013).

The majority of the in-tact MGS habitat lies in the central and eastern portion of the range—in flat, dry areas that are predicted to heat up substantially more than in the cooler and wetter regimes of higher elevations. Since MGS and desert tortoise share similar habitat alliances and natural communities, the decreased area and elevation shift seen in Barrows' (2011) niche model for desert tortoise could also apply to MGS. Habitat in the western portion of the range, south of Fremont Valley, is already impacted by disturbances. Since the MGS habitat may shift to higher elevations as well as to the north and the west, Sierra Nevada foothills west of the Little Dixie Wash population are potentially a target for a shift in the species' distribution (Leitner, pers.

comm.), particularly with some existing detection data in this area outside of the published range (DRECP data).

Genetic studies suggest that the MGS can make large movements across the landscape to occupy available habitat (Bell and Matocq, 2011). Unless remaining MGS habitat in all portions of its range is effectively conserved, such movement through the landscape could be blocked, preventing shifts to more suitable or newly available habitat following climatic events. To the extent the MGS adapt to surviving in higher temperatures or higher elevations, the species could find enough suitable habitat to avoid extinction within the next century. Conserving drought-sufficient forage throughout the range, as well as preserving habitat in and linkages to areas predicted to be refugia from climatic extremes, will be key to the species' persistence (Resources Legacy Fund, 2012).

3. Invasive species and disease

As climatic changes alter the vegetation structure of the west Mojave Desert, it is plausible that invasive plant species—particularly those more adapted to the changing environment—would displace native species (Resources Legacy Fund, 2012). Migrating species may not provide the required water content and nutrients needed for MGS survival. The predicted proliferation of grasses such as red brome could perpetuate itself through increased fires, from which natural desert scrub communities are slow to recover. A change in the vegetation communities could also cause a corresponding change in fauna within the MGS range, possibly adding competition and predation pressure, as well as disease vectors that do not exist in the MGS' habitat today (Resources Legacy Fund, 2012). These additional stressors could further exacerbate other climate change scenario threats described above.

USFWS (2012 Chapter 2) projects that extreme drought events will increase plants' susceptibility to disease in the desert ecosystem. Changing conditions could cause insect outbreaks, possibly affecting the health of both plant and animal species. Such susceptibility could further reduce availability of quality habitat elements for the MGS.

4. Natural Catastrophic Events

Other natural catastrophic events, besides extreme drought, could result from climate change. Rainfall events could be less frequent and more intense (IPCC, 2007; Resources Legacy Fund, 2012), causing flash flooding, destruction of biological crust and soil texture, or pluvial inundation of lake valleys that support MGS populations. Such events could isolate populations genetically (Hafner, 1992; Bell and Matocq, 2011), causing divergence or population extirpations. During the late Pleistocene, the MGS' northern populations were isolated by the full pluvial, but subsequent climatic shifts allowed dispersal into newly available habitat in other parts of the species' range, allowing the limited genetic flow to continue between north and south (Bell and Matocq, 2011). To the extent habitat is available to provide refugia and connectivity to the refugia, and to the extent the refugia is large enough to support metapopulation dynamics, the MGS may be able to adapt to stochastic events. However, habitat must also remain available for the species to recolonize portions of the range previously cut off by these events in order to prevent complete genetic isolation of populations.

Increased fire events could also result from climate change, particularly with the increase of invasive grasses, causing additional stress on MGS habitat (Resources Legacy Fund, 2012). Fire is likely to drive shifts in the ranges of important forb species and/or introduce novel ecological systems not suitable for the MGS. Conversion or extinction of currently existing plant species can result from changes in frequency, size, and intensity of fires, affected by diminishing moisture conditions (Resources Legacy Fund, 2012) and the slow recovery of desert vegetation. Fire prevention regimes within the West Mojave Desert may need to change to prevent or reduce sources and intensity of wildfires, with rapid responses to red brome proliferation.

Experts cannot predict the exact nature of how the Mojave Desert biota will change in response to climate change over the next 40 to 50 years, nor can they predict the extent of the effects these changes will have on the MGS (Resources Legacy Fund, 2012). They do, however, recommend that scientists and stakeholders work together to predict what events could likely occur as a result of climate change, and to begin conservation efforts in anticipation of these changes as quickly as possible (Cohen, 2012). Adaptive management—adjusting land management regimes in response to climatic and environmental changes already starting to occur—will be crucial to protect many species, including the MGS (Resources Legacy Fund, 2012). Reducing other current and future threats and stressors will help to keep the populations resilient.

III. Listing History

The MGS is listed by the state of California as Threatened under CESA (Cal. Code Regs., tit. 14, § 670.5, subd. (b)(6)(A).). In 1971 the species was listed as “rare,” and in 1985 it was reclassified as Threatened under CESA, meaning the species is likely to become endangered in the foreseeable future in the absence of special protection and management efforts (Fish & G. Code, § 2067.). In 1991, Kern County petitioned the California Fish and Game Commission (CFGC) to delist the MGS, stating there was insufficient data presented to the CFGC in 1971 to warrant the listing (Gustafson, 1993, Appendix A). The CFGC accepted the petition for consideration, and CDFW prepared a report to the CFGC in response to the petition (Gustafson, 1993). The report concluded that the petition failed to provide accurate substantive information to warrant delisting, and recommended the species remain listed as Threatened (Gustafson, 1993). Notwithstanding the report and numerous comment letters from the public and scientific community supporting CDFW’s recommendation (Gustafson, 1993, Appendix E), the CFGC acted to remove the MGS from Threatened status. In response to a subsequent petition to overturn the CFGC’s decision, judicial review by the California Supreme Court in 1997 determined the action was in violation of CEQA, and the species remained listed as Threatened (Frost, 2012). No subsequent petitions have been received by CFGC to delist the MGS.

In 1985, USFWS published a proposed rule designating the MGS as a category 2 candidate for listing as a Threatened or Endangered species under the federal Endangered Species Act (ESA).

The category 2 candidate designation was based on the assessment that sufficient information on biological vulnerability and threats were not currently available to indicate that listing the MGS as Endangered or Threatened was warranted. In 1994, USFWS published a proposed rule that reviewed the candidates for listing, and MGS remained as a category 2 candidate (59 FR 58982). In response to a 1993 petition to list the MGS as Threatened, USFWS published a 90-day finding in 1995, which determined that the petition did not present substantial information indicating that the listing was warranted (60 FR 46569). After the finding, increased research efforts raised concerns that the MGS was still declining (Brooks and Matchett, 2002; CDFG, 2005). In 2005, Defenders of Wildlife petitioned the USFWS to list the MGS as Endangered due to increased loss and degradation of habitat and increased threats (Stewart, 2005). In 2010, the USFWS made its 90-day finding (75 FR 22063), concluding that the petition presented substantial scientific or commercial information to indicate that listing the MGS may be warranted, and started a 12-month status review. In October 2011, as a result of the 12-month status review, the USFWS published its finding that the MGS was not in danger of extinction, nor likely to become endangered within the foreseeable future throughout all or a significant portion of its range. Therefore, listing the MGS as Endangered or Threatened under ESA was not considered warranted at that time (76 FR 62214). No subsequent petitions have been received by the U.S. Department of the Interior to list the MGS.

IV. Summary of Management Actions

State, federal, and local agencies managing the MGS and its habitat have been supporting ongoing research and conservation management. These research and management efforts are detailed below, but generally focus on reassessing and protecting the key population centers and linkages established by Leitner (2008, 2013).

A. Renewable Energy Action Team (REAT)

In response to federal and state initiatives and mandates to assist with reaching renewable energy development targets, and the several applications for permits for renewable energy projects within the Mojave and Colorado deserts, the Renewable Energy Action Team (REAT) was formed. Its core members include CEC, CDFW, BLM, and USFWS. Agreements were signed between REAT agencies and other participating agencies to develop the Desert Renewable Energy Conservation Plan (DRECP), a joint state Natural Communities Conservation Plan (NCCP), federal Habitat Conservation Plan (HCP), and BLM Land Use Plan Amendment (LUPA) (http://www.drecp.org/participants/). When completed, the DRECP intends to conserve and manage natural biological diversity within the plan area while allowing for commercial-scale renewable energy development (http://www.drecp.org). The REAT is developing a network of lands set aside for conservation within the DRECP boundaries, which includes most of the MGS population centers, expansion habitat, and linkages. Renewable energy development projects under the DRECP would be restricted to DFAs, which are designed to provide incentives through permit streamlining and "no-surprise" assurances for developers to site projects in areas with the least amount of impacts on important MGS habitat (REPG, 2012). BLM's LUPA will also provide land use designations compatible with protection of MGS within its system of conservation units.

While the DRECP draft Environmental Impact Report/Environmental Impact Statement (EIR/EIS) is still in process (http://www.drecp.org/), the REAT is tracking all renewable energy projects—from application through construction—and working closely with jurisdictional agency staff to keep projects from undermining conservation of the MGS that would be provided under the DRECP. Until the DRECP is implemented, jurisdictional agency staff will continue environmental analysis and permitting of renewable energy on a project-by-project basis. State and federal laws and regulations, including CESA, CEQA, NEPA, Lake and Streambed Alteration Agreements, and other environmental statutes require that impacts to MGS are mitigated and minimized, and that no project activity would result in jeopardizing the continued existence of the species (Fish & G. Code, § 2081). The DRECP would be governed by statutes under the NCCP Act that provide for the protection of the species and habitat on a landscape or ecosystem level (Fish & G. Code § 2820 et seq.), and would thus likely provide a greater amount of habitat protection than laws such as CESA. However, projects not related to renewable energy would not be covered by the DRECP and are not being monitored by the REAT.

B. California Department of Fish and Wildlife (CDFW)

In 2012, CDFW purchased MGS habitat as part of the advance mitigation/in-lieu fee program required by Senate Bill 34 (http://www.dfg.ca.gov/Climate_and_Energy/Renewable_Energy/Fee_Trust_Fund.aspx). A total of 3,451 acres were purchased in the Fremont-Kramer and Superior-Cronese Desert Wildlife Management Areas (DWMAs) on BLM land. The acquisitions are comprised of 126 parcels ranging from 1.25 to 160 acres, scattered throughout the area between Cuddeback Lake and Harper Lake. Most of these parcels appear to be suitable MGS habitat, except for a few that include dry lake beds or are on steep, rocky mountain ridges (*e.g.,* Fremont Peak and Gravel Hills). All but 136 of these acres were used as desert tortoise mitigation for the Ivanpah Solar Project, which is being built outside of the MGS range.

Mitigation requirements in CESA Incidental Take Permits (ITPs) have protected a substantial amount of MGS habitat. From 1998 to 2012, CDFW issued nearly 200 ITPs requiring a total of 50,633 acres of compensatory habitat mitigation (referred to as "Habitat Management Lands" in ITPs). As of 2013, 17,425 acres had been transferred to public ownership and/or had conservation easements recorded (CDFW ITP tracking database).

Prior to 2006, CDFW spent about $800,000 to fund studies that provided information on genetics, diet, dispersal, and locations of MGS. In addition, approximately $100,000 had been collected from ITPs that were targeted for MGS trapping conducted by the Desert Tortoise Preserve Committee. In 2012, under the USFWS State Wildlife Grant program, CDFW funded $240,000 for Dr. Leitner's research utilizing camera trapping to determine locations and persistence of MGS populations (CDFW Agreement #P1196001). In 2013, $37,000 of CDFW funding was provided for Dr. Leitner to conduct surveys in public and private parcels east and south of California City and to continue long-term studies in the Coso Range-Olancha area (Leitner, 2013a). Under the USFWS Section 6 Grant program, CDFW awarded $59,700 for continuing data gap studies in Kern and Los Angeles Counties in 2014 (CDFW Agreement #P1382014). Cumulatively, the funding amounts to about a million dollars for MGS research.

CDFW also manages 18,152 acres of potentially suitable habitat within the West Mojave Desert Creek Ecological Reserve (ER) in San Bernardino County (http://www.dfg.ca.gov/lands/er/region6/westmojave.html) and 1,090 acres in the Fremont Valley ER in Kern County (http://www.dfg.ca.gov/lands/er/region4/fremont.html). A limited amount of recreational activities (hiking and wildlife viewing) as well as quail hunting is allowed in the West Mojave Desert Creek ER, and only wildlife viewing is allowed in the Fremont Valley ER. The Fremont Valley ER supports prime MGS habitat adjacent to the Desert Tortoise Natural Area (DTNA), with a detection as recent as 2013 just south of its boundary (Heitkotter, pers. comm.).

C. Mojave Desert State Parks

CDPR is working on purchasing 28,500 acres of land in eastern Kern County, between Red Rock Canyon State Park and the Piute Mountains, for off-highway vehicle use (CDPR OHMVR, 2012). Approximately 20,000 of those acres, between Red Rock Canyon and Kelso Valley, are within the MGS range. Habitat appears variable across this area, and distribution and abundance of MGS is unknown. The proposed acquisition area adjoins BLM land in the Little Dixie Wash population center described by Leitner (2008), and is within potential expansion habitat for that population. Detections as recent as 2004 are just east of some of the proposed parcels (CNDDB occurrences #191, #395-396) and historic detections are within or adjacent to the proposed acquired land (CNDDB occurrences in Dove Spring, 1974).

Suitable habitat within the MGS range occurs in a few existing State Parks, in which the land is protected from uses other than recreation:

- Saddleback Butte State Park contains approximately 1,500 acres of flat land that is potentially suitable habitat for MGS. Recht (1977) conducted MGS research in Blue Rock Butte, less than 2 miles northwest of the Park, and historic MGS detections were reported in the Park (CDPR, 2004; CNDDB occurrence #227). CDPR personnel reported observations of MGS in the Park's east side as recently as 2004 (CDPR NRD, 2004 Table 5; Swolgaard, pers. comm.). Researchers are currently pursuing funding opportunities to conduct surveys in the Park as well as nearby County parks to determine whether or not the area supports a MGS population.

- The Antelope Valley Indian Museum, less than 2 miles southwest of Saddleback Butte State Park, contains 390 acres of flat land, including approximately 200 acres of potentially suitable habitat for MGS. No studies of small mammals have been conducted within this park's boundary or are currently planned, State Parks personnel recorded an uncertain observation of MGS within the park (CDPR NRD, 2004 Table

5; Swolgaard, pers. comm.), and there is at least one historic record from 1991 near the park (CNDDB occurrence #226). The park's land is available for day-use recreation and ceremonial purposes only (http://www.parks.ca.gov/?page_id=632).

- Red Rock Canyon State Park contains 25,456 acres of land, and one-third of the park may contain suitable habitat for MGS. A small trapping survey (10 acres) for small mammals was conducted in 1991 and 1992, and a single juvenile MGS was captured (CNDDB occurrence #186). Leitner (2008) identified at least three positive detections plus incidental sightings in the northern portion of the Park between 1998 and 2007. OHV use is allowed within the road system of the Park (http://www.parks.ca.gov/?page_id=631).

D. Edwards Air Force Base (EAFB)

EAFB has actively monitored its MGS populations since 1988, including its persistent population described by Leitner (2008), and has actively engaged in good management practices such as strictly regulating OHV use and roads (Reinke, pers. comm.; EAFB, 2008). Since 2003, at least 45% of the EAFB has been surveyed. EAFB has completed at least five years of inventories for the presence of MGS, and 82% of its 60 Habitat Quality Analysis (HQA) plots had been surveyed as of 2006 (EAFB, 2008). Survey efforts continued in 2008, with inventories planned annually or in accordance with available funding, to survey all 60 HQA plots (EAFB, 2008), continuing through 2011 (ECORP, 2011). Currently, EAFB has funding for implementation of sophisticated data collection systems to use for further inventories (Reinke, pers. comm.). The Natural Resources Program is researching a proposed soft-footprint approach to a solar facility within EAFB's boundaries (Delaney, 2012b). The results of this research will determine if raised solar panels would avoid destruction of vegetation and natural communities (Reinke, pers. comm.), which would lessen the impacts on MGS.

A persistent MGS population appears to be located in the Precision Impact Range Area (PIRA), east, southeast, and south of Rogers Dry Lake. The PIRA is a controlled bombing range that is mostly undeveloped; 60,800 acres of designated Critical Habitat established by USFWS for the desert tortoise is located within the PIRA boundary. The PIRA will continue to be managed under its current land use as part of the test and training mission.

The following conservation measures for the MGS are in EAFB's 2008 Integrated Natural Resources Management Plan (INRMP) (EAFB, 2008), which is currently under a 5-year revision (Mull, pers. comm.):

a. Develop and implement education awareness in concert with the Desert Tortoise Awareness Program.
b. Continue to conserve habitat through road closure projects.
c. Decrease habitat fragmentation through well-planned habitat restoration projects in areas suitable for MGS.
d. Evaluate effectiveness of revegetation efforts in MGS habitat.
e. Complete baseline surveys at all HQA plots and record incidental sightings.

f. Monitor populations and enter data into the EAFB GIS and Ecosystem Model.
g. Use survey and monitoring data to develop a Predictive Habitat Model; verify model through ground truthing surveys.
h. Use all inventory and incidental observations to map known populations.
i. Share technical knowledge with the resource agencies and scientists.
j. Consider for implementation the objectives in the WEMO Plan that do not conflict with the military mission of the Air Force.
k. Attend and participate in conservation working groups to further the survival of the species.

EAFB representatives have also participated in discussions with REAT agencies responsible for the development of the DRECP. EAFB provides guidance on topics such as maintaining habitat corridors between MGS populations on the installation and the reserve off of the base, and certain restrictions on renewable energy development along the borders of the installation (CDFW, 2012).

E. National Training Center (NTC) and Fort Irwin

NTC and Fort Irwin funded or otherwise supported trapping studies for the MGS in 1977 and 1983-1991, establishing a good amount of occurrence data (Krzysik, 1994) which was followed by Recht's studies in 1993-1994 (Recht, 1995). Studies described by Krzysik (1994) and Recht (1995) indicate a general decline in the number of captures over time; although, the Goldstone Lake population in 1993 was more abundant after a season of higher rainfall than in 1994. Fort Irwin established three conservation areas for Lane Mountain milk-vetch (USFWS, 2008), which also partially serve to conserve habitat for the MGS.

Delaney (2009) and Leitner (2009) conducted camera and traditional trapping surveys within Fort Irwin's WEA, including vegetation studies, to evaluate video and audio surveillance techniques as well as to provide data for Fort Irwin's understanding of MGS population trends, density, distribution, and habitat associations. Leitner's survey results in 2009 showed a decline in detections from his earlier study in 2007 (Leitner, 2007). Fort Irwin personnel started a MGS camera study in 2013, and found no detections in the northern sites where Recht (1995) had documented occurrences (Aker, pers. comm.). Round-tailed ground squirrels were found instead. Fort Irwin staff will continue to systematically survey the northern part of the installation (Aker, pers. comm.).

NTC and Fort Irwin have an INRMP currently in preparation. The goals and objectives of the INRMP are to more effectively manage, protect, and sustain natural resources, including threatened and endangered species such as MGS (http://www.irwin.army.mil/Community/Environment/Pages/NEPA.aspx). Review of the INRMP and assessment of environmental risks associated with implementation of the plan is currently underway.

F. China Lake

China Lake provided logistical support for annual surveys and ecological studies conducted by Leitner *et al*. between 1988 and 1996, both inside and outside of the grazing exclosure areas (Leitner and Leitner, 1998); however China Lake did not provide funding for these studies.

China Lake's 2000-2004 INRMP, currently under revision, managed sensitive species primarily through the minimization of impacts (NAWS China Lake, 2000). Projects within China Lake, such as the China Lake Joint Venture's Navy 2 Geothermal Project in 1988, have generally been authorized under consultation with CDFW to ensure there are no significant impacts to MGS or that any impacts are fully mitigated (http://powerplanting.homestead.com/files/Coso.htm). The INRMP's objectives for MGS were to maintain viable populations through protecting habitat to the greatest extent practical and to document occurrence and distribution through surveys. Additionally, the INRMP provided support for staff to participate in regional natural resource and recovery planning (NAWS China Lake, 2000). China Lake will continue to support (with briefings, badging, staff (when available), and logistics) trapping efforts at the Coso Known Geothermal Resource Area, conducted either by Dr. Leitner's team or other approved research teams (Woods, pers. comm.).

G. Bureau of Land Management (BLM)

Approximately one-third of the MGS range is within federal land managed by BLM. BLM's 2006 WEMO Plan stated that 1.7 million acres for a MGS conservation area (MGSCA) would be established for the long-term survival and protection of the species (BLM, 2005, Chapter 2). The MGSCA incorporated most of the MGS population centers described by Leitner (2008), and provided connectivity between these populations (BLM, 2005, Chapter 2, Map 2-1; Leitner (2008) Figure 1) (see Appendix A). The WEMO Plan provided that only 1% of the MGSCA could be developed, and at a 5:1 habitat acquisition mitigation ratio (BLM, 2005). The WEMO Plan went through ten years of public input (LaPre, pers. comm.), and was adopted in 2006 with a few modifications (BLM Record of Decision, 2006). In 2011, BLM announced preparation of an amendment to the WEMO Plan to modify OHV management in response to the U.S. District court remedy order (http://www.blm.gov/ca/st/en/fo/cdd/west_mojave__wemo.html; U.S. District Court, 2011); however, the modifications affect the MGSCA only through changes in OHV route designations.

BLM is also working on a LUPA that addresses the conservation and renewable energy requirements of the DRECP and that may further modify the CDCA and WEMO Plans, including proposed changes to Areas of Critical Environmental Concern (ACECs) (REPG, 2012, Appendix D). LUPA alternatives will be analyzed as part of the joint EIR/EIS for the DRECP. In the preferred alternative of the LUPA (proposed LUPA), the MGSCA mostly overlaps existing and proposed ACECs and DWMAs, each of which has its own conservation measures and development cap. The proposed LUPA designates a separate MGS unit as an ACEC to conserve portions of the MGSCA that do not overlap other conservation units (REPG, 2012, Chapter 3; Woods, pers. comm.). The proposed LUPA protects the majority of habitat needed for the conservation of MGS, except no protection is given to habitat on BLM lands west of U.S. 395 in the California City area between the Rand Mountains and Fremont-Kramer Junction, or in those areas described in the Climate Change Impacts section above, which would potentially provide refugia under extreme drought conditions (west of Little Dixie Wash and Owens Valley). The designated conservation units would be managed for uses that are compatible with the resources being protected. These uses could include grazing, mineral extraction, recreational activities, paleontological digs, filming, and in some cases rights of way for linear development projects (such as transmission lines and roads) and projects that would be evaluated in each case to determine the impacts on MGS habitat. Renewable energy development would not be considered a compatible use. Until the LUPA Record of Decision is final, the land uses and designations in place under the WEMO Plan remain in effect. In the future, other land use changes that modify the WEMO Plan or DRECP LUPA could lessen or strengthen the conservation requirements for MGS.

The CDCA Plan was modified by the Solar Programmatic EIS plan (SPEIS) (BLM, 2012) through the introduction of variance lands available for solar energy development. Based on expert opinion and recent trapping and camera studies (Leitner and Delaney, 2013), BLM's Ridgecrest Field Office identified important linkage habitat that overlaps with variance lands designated by the SPEIS (Woods, pers. comm.). The SPEIS allows BLM to evaluate variance land applications on a case-by-case basis, including identifying areas of development that are suitable for other plans such as the DRECP and to avoid conflicts with conservation of natural resources (BLM, 2012, Appendix B). The DRECP identifies the linkage habitat as critical for genetic exchange between MGS populations (REPG, 2012, Appendix E), and detection data indicate that MGS occur in most of these linkages (Leitner, 2013). BLM staff will consider conflicts in the following linkages (see Appendix C and figure G-1) when reviewing variance land applications (Woods, pers. comm.):

- The area just east of California City and north of SR-58, connecting the EAFB population to the DTNA to the north.
- Along US-395 from Kramer Junction, heading north towards Little Dixie Wash and the Spangler Hills.
- East of Kramer Junction, north of SR-58, as far east as the boundary of the Black Mountain Wilderness Area.

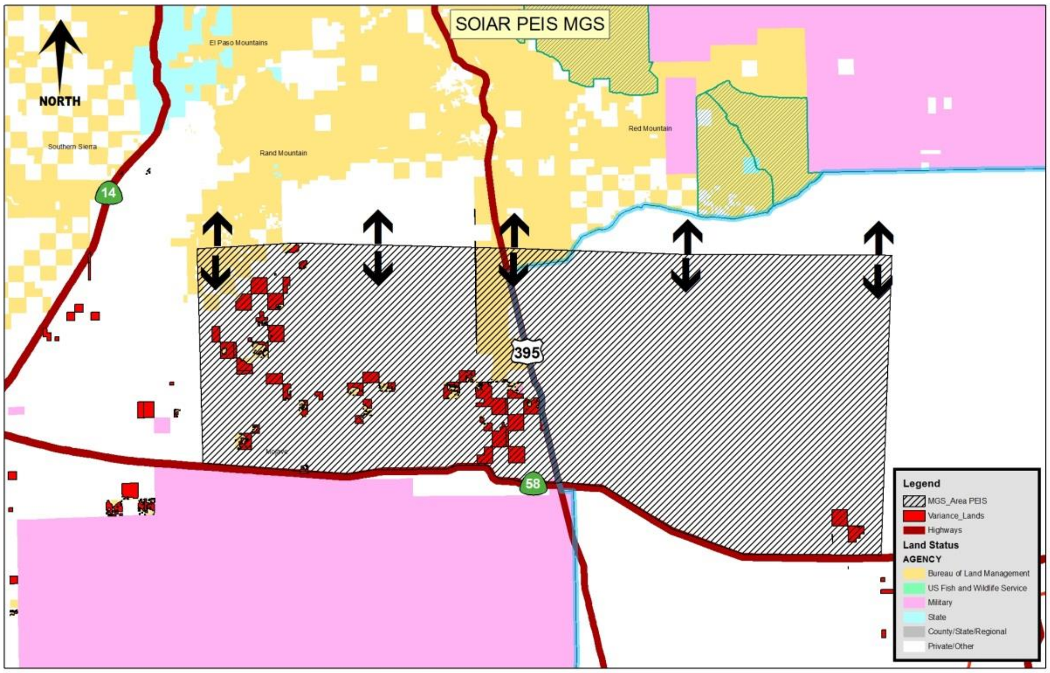

Figure IV.G-1. BLM Ridgecrest Field Office depiction of variance and linkage conflicts. Red blocks are variance lands that are subject to application denial. Overlap with important population and linkage areas is depicted by the black hatches. The arrows indicate potential north-south movement between populations.

In addition to land use planning, the BLM Ridgecrest Field Office (Field Office) identified the following conservation priorities for MGS (Woods, pers. comm., Otahal, pers. comm.):

1. Protect persistent population centers identified by Leitner (2008). Continue to take MGS into consideration when designating routes in the west Mojave Desert, completing NEPA for proposed actions, and consulting with CDFW on projects, including findings on impacts and appropriate mitigation measures.

2. Focus research in the DTNA. Help to establish a protected connection from the DTNA and Desert Tortoise Preserve Committee acquired lands to MGS populations in the Pilot Knob area. Acquire suitable private land interspersed among existing blocks of BLM land to help connect populations from Kramer Junction to Ridgecrest.

3. Incorporate MGS awareness outreach anytime the Field Office conducts Desert Tortoise Awareness outreach/training.

4. Support research. Geographic areas within the Field Office's jurisdiction that need further study include:
   - Northeastern corner of Los Angeles County.
   - North-south corridor along US 395 between Ridgecrest and Kramer Junction.
   - North and east of Searles Dry Lake.
   - Both sides of Highway 14 between Highway 58 and Red Rock Canyon vicinity.

5. Identify development sites on BLM land with minimal impact on MGS habitat; for example, within DRECP DFAs.

6. Identify lands not suitable for MGS as the areas most appropriate for new development; for example, abandoned agricultural fields, and develop policies that would provide incentives for development in such areas.

H. California Energy Commission (CEC)

The CEC has funded research projects for MGS, relative to managing renewable energy development in the West Mojave Desert. For example, the CEC provided funding for the following projects:

- MGS exploratory trapping study in 1989 and 1999, intended to increase the understanding of the ecology and habitat requirements of the MGS throughout a large portion of its range (Leitner, 1999).

- Field research in 2011, to refine the known distribution and to validate locations of population centers and corridors, for the Planning Alternative Corridors for Transmission (PACT) study under the Public Interest Energy Research (PIER) program (Condon *et al.*, 2012).

- Development of the USGS MGS species distribution model, under the PIER program (Inman *et al.*, 2013).

The CEC may continue to fund research needs under its PIER program, depending on what solicitations are available and proposals selected (http://www.energy.ca.gov/contracts/index.html). The CEC has proposed awards to various counties for updating their general plans relative to renewable energy, and such awards may benefit the conservation needs of MGS (http://www.energy.ca.gov/contracts/PON-12-403_NOPA.pdf).

I. U.S. Fish and Wildlife Service (USFWS)

The MGS is not federally listed; however, some of its habitat overlaps habitat for the desert tortoise. USFWS designated Critical Habitat Units (CHUs) for the desert tortoise, which occur within the Western Mojave Recovery Unit (recovery unit) (USFWS, 2012). The recovery unit contains a good portion of MGS habitat with Mojave saltbush (*Atriplex* spp.) and blackbrush scrub communities, and includes the Fremont-Kramer and Superior-Cronese CHUs, which contain important population centers and linkages for MGS. The recovery unit also includes critical habitat for MGS in the DTNA, Fort Irwin, China Lake, and EAFB. The CHUs within the recovery unit are areas which USFWS has identified as essential for recovery of the desert tortoise, and that may require special management considerations and conservation actions to provide sufficient space for desert tortoise populations and movement corridors (USFWS, 2012). The CHUs in aggregate are intended to protect the variability that occurs across the desert tortoise's range. Any protection that meets the requirements to recover the desert tortoise could also have substantial benefit to the conservation of the MGS.

Similarly, the MGS could benefit from USFWS protection of Lane Mountain milk-vetch. CHUs for this federally listed species include MGS habitat within Fort Irwin, where ground-disturbing military operations could otherwise take place. The Critical Habitat designation in Coolgardie-Mesa potentially provides protection on BLM land to one of the persistent population centers described by Leitner (2008). For example, USFWS works with BLM to prevent unauthorized OHV use in the area (76 FR 29108).

J. County Parks and Zoning

Some county parks also potentially protect suitable MGS habitat from public use impacts. For example, Los Angeles County maintains the Butte Valley Wildflower Sanctuary (approximately 351 acres); Alpine Butte (320 acres) and Carl O. Gehardy (547 acres) Wildlife Sanctuaries, and some smaller parks within the MGS range, such as Big Rock Wash and the Jackrabbit Flat, Phacelia, Theodore Payne, and Mescal wildlife sanctuaries (http://parks.lacounty.gov/wps/portal/dpr/Parks/). It is unknown if any of the habitat protected by these county parks currently support MGS; although, some historic detections occurred near the parks (for example, CNDDB occurrences #257, #23), and at least two historic detections occurred within the Butte Valley Wildflower Sanctuary during Recht's studies in 1976 and 1977 (CNDDB occurrences #228, #190). Further studies are needed to determine whether or not the MGS is completely extirpated from this portion of its range.

In addition to its parks, Los Angeles County has designated Significant Ecological Areas (SEAs) throughout the Antelope Valley and within its portion of EAFB. Part of the Antelope Valley SEA surrounds some of the state and county parks discussed above, where there have been historic detections of MGS and where habitat still remains (Los Angeles County, 1980, Appendix E). In 2011, Los Angeles County proposed additional SEAs connecting the existing SEAs to provide corridors and linkages for all of the wildlife species within the vicinity (http://planning.lacounty.gov/sea/). The intent of the proposed SEA regulations is not to completely preclude development, but to allow controlled development without jeopardizing the biotic diversity of the area, and to require review of development proposals by a technical committee (http://planning.lacounty.gov/sea/). If the Plan is amended as proposed, possible remnant MGS populations south of EAFB could be provided essential connectivity to the EAFB population through this designation (see map: http://planning.lacounty.gov/assets/upl/project/gp_2035_FIG_6-2_significant_ecological_areas.pdf).

Other county land use designations may be prescribed for intrinsic natural resource value, with allowable uses that may be compatible with MGS habitat conservation; for example, Inyo County's "natural resources" designation (Inyo County, 2001), or "open space" in the other counties (Los Angeles County, 1980; Kern County, 2012(b); URS, 2012). Most of these designations allow limited resource extraction (*e.g.*, mining) and recreational activity. There have been no studies on the effects these land use designations have on fragmentation or degradation of MGS habitat, and zoning requirements may change over time. Additionally, isolated parcels of open space surrounded by habitat disturbances would not provide the contiguous habitat blocks needed for MGS conservation. Acquisition of habitat within such zoned parcels could ensure better conservation of contiguous habitat, particularly if they are in-holdings surrounded by protected land.

K. Private Conservation Areas and Reserves

Scattered throughout the MGS range are parcels of land that are protected through private foundations, trusts, and/or non-profit organizations. Some of these lands are acquired and managed through the CESA mitigation process and the CDFW Renewable Energy Resources Fee Trust Fund (See CDFW section above), or through other grants and public funding. For example, the Desert Tortoise Preserve Committee has acquired much of the 42,000 acres within and adjacent to the DTNA (http://www.tortoise-tracks.org/wptortoisetracks/dfgd/establishing-desert-tortoise-preserves/). Other examples are the Mojave Desert Land Trust (http://www.mojavedesertlandtrust.org/), Transition Habitat Conservancy (http://www.transitionhabitat.org/), Mojave Desert Resource Conservation District (http://www.mojavedesertrcd.org/), the Wildlands Conservancy (http://www.wildlandsconservancy.org/), and the Antelope Valley Conservancy (http://www.avconservancy.org/). In addition, some private landowners choose to manage their properties for the preservation of natural resources in cooperation with conservation organizations. Though these parcels are managed for conservation, similarly to open space parcels, they would need to cover expansive blocks of contiguous MGS habitat to effectively conserve the species.

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Photo: Phil Leitner (camera study, 2011)

Conservation Strategy

Introduction

The following goals, objectives, and conservation measures have been developed for participating agencies to ensure that the overall conservation goal of long-term protection of MGS habitat and viability of the species is achieved. It is understood that implementation of these actions is subject to availability of funds and compliance with all applicable laws and 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. Individual implementation of many actions will require environmental analysis under NEPA and/or CEQA. The goals, objective, and measures are divided into five categories: A) Habitat Protection, B) Conservation Mechanisms and Habitat Management, C) Research Needs, D) Climate Change Impacts, and E) Monitoring and Adaptive Management.

I. Goals, Objectives and Measures

A. HABITAT PROTECTION

Goal A Using the best available scientific information, develop and implement on-the-ground protection of MGS habitat most needed to conserve the long-term viability of the species.

Objective A1 Maintain functional habitat connections (linkages) and corridors for movement between known populations through land acquisition and land use designations.

Measures

A1.1 Identify and secure acquisition of private lands (*e.g.*, fee title acquisition, conservation easements) or designation of public lands for long-term conservation of habitat within linkages or corridors. Known linkages and corridors at the time of this document's finalization are listed below and are mapped in Appendix C.

- Owens West/Owens East - North Owens Valley to the Coso Range-Olancha population center, on the east and west edges of Owens Lake (49,061 acres)
- West of China Lake - Coso Range-Olancha to the Little Dixie Wash population center, along U.S. 395, from the western edge of China Lake to the Sierra Nevada Range (61,488 acres)
- Coso-Ridgecrest - Coso Range-Olancha to Ridgecrest through China Lake NAWS, China Lake (dry lake) on the west and the Argus Range on the east (43,241 acres)

- South of Ridgecrest - Little Dixie Wash to the Fremont Valley/Spangler and Ridgecrest population centers, from the El Paso range on the west to Randsburg Wash Road on the east. (69,855 acres)
- Ridgecrest-Searles – From Randsburg Wash Road on the west to the southern and eastern edges of Searles Dry Lake (54,074 acres)
- Central - Fremont Valley/Spangler to DTNA, Pilot Knob, and Boron/Kramer Junction population centers, along U.S. 395 with linkages extending east through the Almond Cove/Cuddeback Lake area and west to the DTNA (97,315 acres)
- DTNA-Edwards - Contiguous habitat between the northwestern edge of the North of Edwards population and the southwestern edge of the DTNA population, extending to the Borax mine on the east. (23,534 acres)
- Edwards – North-south linkage from the North of Edwards population center to the EAFB population center (7,277 acres)
- Pilot-Coolgardie - Pilot Knob to the Coolgardie Mesa-Superior Valley population center, south of China Lake (43,611 acres)
- Harper-Coolgardie - Harper Lake population center to Coolgardie Mesa-Superior Valley through habitat north of Harper Lake and south of the Black Hills (35,071 acres)
- Kramer-Harper-Edwards - EAFB to Boron/Kramer Junction and Harper Lake, through northeastern EAFB and along the northeast border of EAFB (29,382 acres)

Objective A2 Protect currently known population centers through land acquisition and land use designations.

Measures

A2.1 Identify and secure acquisition of private lands (*e.g.*, fee title acquisition, conservation easements) or designation of public lands for long-term conservation of habitat within population centers. Known population centers at the time of this document's finalization are listed below and are mapped in Appendix C.

- Coso Range-Olancha, at least 111,762 acres
- Little Dixie Wash, at least 97,231 acres
- Coolgardie Mesa-Superior Valley, at least 127,552 acres
- DTNA - Including land immediately adjacent to the west, south, and east along Randsburg-Mojave Road, at least 42,072 acres

- North of Edwards – North, east, and west of Kramer Junction along SR-58, including Boron and the Borax Mine area, covering approximately 5 miles to the east and 20 miles to the west of U.S. 395, and about 12 miles north of Kramer Junction on the east and about 7 miles north of Rogers Dry Lake on the west (south of the developed portion of California City), at least 123,756 acres
- Pilot Knob - Extending approximately 15 miles southwest from the Naval Air Weapons Station (NAWS) China Lake Mojave B Range to the north end of Cuddeback Dry Lake, at least 25,339 acres
- Ridgecrest - The valley between the towns of Ridgecrest/China Lake and Searles Dry Lake, in and outside of southeastern China Lake, along SR 178, at least 19,442 acres
- North Searles Valley - Extending approximately 10 miles north of Searles Dry Lake, at least 17,430 acres
- Harper Lake - West of Hinkley, along Highway 58 from Harper Lake to 5 miles east of Kramer Junction, extending to approximately 15 miles east of the junction, at least 68,061 acres
- Fremont Valley/Spangler - Extending from east Fremont Valley to just southwest of Spangler Hills and Teagle Wash, at least 40,236 acres
- Edwards Air Force Base – Southeastern portion from south of Rogers Dry Lake to the southern and eastern borders of the base, at least 76,814 acres

A2.2 Define and delineate the population centers to include both the known population center habitat and suitable habitat extending out five miles from the population center, for juvenile dispersal and additional connectivity (approximately 527,251 total acres).

Objective A3 Identify the best parcels for acquisition.

Measures

A3.1 Develop Conceptual Area Protection Plans (CAPPs) and Land Acquisition Evaluations (LAEs) for critical MGS habitat acquisition target areas to support habitat acquisition funding requests to the WCB and conservation organizations. Submit habitat acquisition funding requests to WCB and the conservation organization for specific parcels identified in the CAPPs and LAEs.

A3.2 Conserve habitat that is contiguous with already protected habitat through oversight of mitigation acquisition and selection of conservation easements.

B. CONSERVATION MECHANISMS AND HABITAT MANAGEMENT

Goal B1 Identify conservation mechanisms at the local, state, and federal levels that can be implemented to effectively conserve the MGS now and in the future.

Objective B1.1 Under existing laws and regulations and in consultation with regulatory authorities, work collaboratively at the local, state, and federal levels to develop and implement standardized methodologies, processes, and requirements that will help conserve the MGS.

Measures

B1.1.1 Consult with the jurisdictional wildlife agency(ies) to develop best management practices (BMPs) that would be included in authorizations for surface disturbance activities at the local, state, and federal levels, to guide project proponents to avoid and minimize take of MGS from all phases of surface disturbance projects. Examples of BMPs are in Appendix E.

B1.1.2 Develop survey protocol requirements consistent with CESA or NCCP/HCP laws, best suited for the conservation of MGS. Create standards for:

- Qualifying biologists to conduct protocol surveys.
- Setting requirements on when and where protocol surveys shall be conducted before ground-disturbing activities.
- Setting the standard of when a full occupancy study should be conducted before ground-disturbing activities.

B1.1.3 Develop the most effective project impact minimization measures, such as pre-construction surveys, construction monitoring, burrow excavation, and/or relocation.

B1.1.4 Develop disturbance caps in habitat important to MGS conservation, described in Section A above.

Objective B1.2 Develop habitat management prescriptions and other protective measures for MGS on public and private land

Measures

B1.2.1 Develop restoration, enforcement, and monitoring requirements, zoning or use requirements, or other land management prescriptions required to protect occupied habitat.

B1.2.2 Manage grazing regimes (*e.g.*, length of grazing, seasons) or retire grazing to minimize impacts on MGS populations and important MGS forage (*e.g.*, winterfat, spiny hopsage, saltbush).

B1.2.3 Manage land uses to reduce potential threats and stressors to MGS, including:

- Develop requirements to reduce pollution and attraction of potential predators.

- Develop buffer requirements to reduce MGS exposure to agricultural hazards such as rodenticides or other chemical hazards.
- Implement road closures and increase enforcement of illegal off-road travel.
- Monitor recreational activity such as target shooting, hiking, or camping to place restrictions on activities and/or locations where high impacts are occurring.

Objective B1.3 Develop and implement an interagency education and outreach program to inform residents of and visitors to the West Mojave Desert about the needs of the MGS; local, state, and federal requirements; and how the public can help conserve the MGS.

Measures

B1.3.1 Develop educational materials and programs for construction workers or users of public or private land (*e.g.*, recreationists, miners, ranchers, farmers, film crews, researchers) that will reduce harm or mortality of MGS individuals during anthropogenic activities, including:

- Signage in recreation areas that overlap with population centers and active burrows, or docents to give presentations in public access areas.
- Requirements for biologists to educate construction workers on avoiding and minimizing harm to MGS during construction activities.
- School programs that teach children about MGS conservation.
- Outreach program for fire prevention in recreation or work areas.
- Educational pamphlets on identification and life history requirements of MGS and how to avoid impacts.
- Work with residents and farmers to reduce harm or mortality caused by the use of chemicals, rodenticides, pesticides, or herbicides.

B1.3.2 Integrate MGS into existing endangered species education programs (*e.g.*, Desert Tortoise Information and Youth Education Program).

B.1.3.3 Work with OHV associations and municipalities (such as California City) to train OHV users to self-govern and to volunteer actions that help conserve MGS (for example, staying on existing roads, tracks, or trails; posting signage; flagging active burrows).

Objective B1.4 Identify development zones with low impacts to MGS habitat

Measures

B1.4.1 Identify lands not suitable or marginally suitable for MGS as the areas most appropriate for new development, considering lands previously converted for agriculture, mining, or other human development. Employ appropriate land use planning processes to delineate specific areas appropriate for development while identifying MGS habitat conservation areas not appropriate for development.

B1.4.2 Develop policies that would provide incentives for development in appropriate areas and dissuade development in areas needed for MGS conservation (described in Section A above).

B1.4.3 Integrate identified lands for development into existing or developing local or range-wide conservation plans (such as the DRECP).

<u>Goal B2</u> Use restoration and enhancement to increase the quality of MGS habitat.

Objective B2.1 Develop an effective restoration plan to remove barriers to MGS movement in potential corridors.

Measures

B2.1.1 Work with local, state, and federal agency technical staff and a desert restoration specialist to identify disturbed areas within known MGS corridors that are feasible for restoration.

B2.1.2 Establish an implementation strategy based on a restoration plan developed by a desert restoration specialist for effectively removing barriers to MGS movement in the identified areas.

B2.1.3 Establish effective guidelines and principles for developers or lead agencies who are conducting restoration as mitigation for temporary disturbance of linkage habitat.

Objective B2.2 Revegetate closed roads.

Measures

B2.2.1 Work with the jurisdictional agency to fence or otherwise block closed roads to potential traffic.

B2.2.2 Remove blacktop (asphalt) or any other road building material from the closed road.

B2.2.3 Work with a restoration specialist to improve the condition of the soil and to facilitate the growth of native vegetation through invasive species removal and/or planting of native species.

Objective B2.3 Evaluate the effectiveness of a long-term restoration plan to convert disturbed land into suitable MGS habitat.

Measures

B2.3.1 Work with local, state, and federal agency technical staff and a desert restoration specialist to identify disturbed areas within MGS population centers that are feasible for restoration.

B2.3.2 Establish an implementation strategy based on a restoration plan developed by a desert restoration specialist for effectively restoring disturbed land into habitat suitable for MGS movement and colonization.

B2.3.3 Establish effective guidelines and principles for developers or lead agencies who are conducting restoration as mitigation for temporary disturbance of suitable habitat.

C. RESEARCH NEEDS

Goal C1 Determine MGS baseline data in suitable habitat with known populations as well as habitat that could support unknown populations.

Objective C1.1 Establish, in consultation with MGS experts, a monitoring program to set a baseline for population trends.

Measures

C1.1.1 Complete sampling in the Coso Range-Olancha population center to document a baseline after the whole cycle of winter rainfall variation, from the three years of steady precipitation (2008-2011) through the end of the subsequent drought.

C.1.1.2 Conduct sampling during the breeding season after at least three years of sufficient rainfall in the Little Dixie Wash, Coolgardie-Mesa, and EAFB population centers to set a baseline for monitoring population trends.

Objective C1.2 Conduct effective surveys in areas with recent detections or sightings but with no regional surveys since 1993 (last 20 years), to determine if breeding populations or occupied linkages exist (data gap areas).

Measures

C1.2.1 **Surveys in data gap areas** - Conduct camera trapping and live trapping studies in data gap areas during the second breeding season after a year of sufficient winter rainfall. Data gap areas at the time of this document's finalization are listed below (see Appendix C).

- West of California City - Undeveloped habitat west of the developed portion of California City, extending from the City of Mojave on the west to about 10 miles east; from the northwestern border of EAFB on the south to about 10 miles north of Mojave, extending west to the southern Sierra foothills in the north.

- South of Edwards AFB - Contiguous habitat south of Edwards Air Force Base from Jackrabbit Flat County Park on the west to the Los Angeles County line on the east, and south to Highway 138, including Mescal County Park.
- North China Lake - Indian Wells Valley and Coso Basin in Kern County, extending east to the Argus Range in San Bernardino County.
- West China Lake – Habitat in the western portion of China Lake, including Christmas Canyon and extending to the western edge of Pilot Knob Valley.
- Superior Valley – from the Pilot Knob to Coolgardie Mesa-Superior Valley population centers, including all of Superior Valley, China Lake Mojave B Range.
- South of Helendale – from Shadow Mountain Road south to Colusa Road.
- Fort Irwin/China Lake - From Eagle Crags (China Lake Mojave B Range) east to the Granite Mountains, and south to the Tiefort Mountains. Continue surveys in Fort Irwin where previous MGS detections were made.

C1.2.2 Work with local, state, and federal agencies to create and maintain a central database with standard formats for MGS occurrence and distribution data.

Goal C2 Develop a MGS research strategy that will enhance conservation and contribute to recovery.

Objective C2.1 Support research projects that address important conservation issues now and in the future.

Measures

C2.1.1 Continue genetic research to determine the extent of the eastern boundary of the MGS range and interaction/hybridization with round-tailed ground squirrels (RTGS). Components of this research should include:

- Understanding the extent of the RTGS distribution within the MGS range
- Determining the habitat niche occupied by RTGS and whether or not the contact areas present the threat of competition
- Reproduction and dispersal patterns of RTGS in habitat occupied by MGS
- Genetic evidence of interbreeding

C2.1.2 Support research projects that improve scientific knowledge of population dynamics. Examples of such research include:

- Estimate the overall population size, both during cycles of drought and cycles of adequate rainfall.

- Investigate genetic variation and historic and current migration rates between population centers throughout the species' range.
- Determine trends of extirpation/recolonization of populations over multiple drought and rainfall cycles.
- Use radio telemetry to collect data on dispersal, mortality, and recruitment rates.
- Conduct necropsies or compile observations that infer causes of mortality, to determine the extent of threats to MGS survival.

C2.1.3 Support research projects that improve scientific knowledge of MGS ecological requirements; for example, conduct studies on MGS requirements for:

- Food/nutrition
- Vegetation cover
- Burrow characteristics
- Water
- Reproduction
- Dispersal
- Physiological and behavioral adaptations
- Avoiding predators
- Disease resistance

Objective C2.2 Survey potential areas of range extensions or range shifts where MGS is not known to occur.

Measures

C.2.2.1 **Surveys in research areas** - Survey good habitat with some detections but not sufficient regional surveys, and which could provide potential range extensions:

- South of Barstow – About five miles south of Barstow between I-15 and I-40
- Lower Centennial/Lee Flat - Lower Centennial Flat, northeast to Lee Flat, Inyo County
- Panamint Valley – northern Panamint Valley, Inyo County

Objective C2.3 Identify potential stressors and threats and study how they affect MGS.

Measures

C2.3.1 Identify MGS responses to linear disturbance features, such as roads and transmission lines.

C2.3.2 Identify the key predators of MGS. Study actual predation effects beyond circumstantial evidence.

C2.3.3 Study how shifts in forage distribution affect dietary requirements.

C2.3.4 Determine potential physiological impacts to MGS due to projected changes in temperature and precipitation; *i.e.*, study how increased temperature may stress the species' thermal tolerances.

C2.3.5 Conduct studies on the effects of pollution, chemical usage, and usage of pesticides, herbicides, and rodenticides in residential/agricultural areas adjacent to occupied MGS habitat.

C2.3.6 Conduct studies on the interactions and possible competition and hybridization between MGS and other ground squirrels with overlapping ranges (*e.g.*, round-tailed ground squirrel, antelope squirrel, California ground squirrel).

C2.3.7 Conduct studies on the effects of road density within MGS habitat and vehicle strikes on local MGS populations.

C2.3.8 Conduct studies on the effects of recreation and commercial filming on MGS behavior and habitat loss.

C2.3.9 Conduct studies to determine the effects of grazing on MGS habitat and foraging requirements.

C2.3.10 Study the effects of mining operations on MGS habitat, such as fragmentation or destruction, and population dynamics.

C2.3.11 Study the potential threat of disease transmission from other ground squirrel species or other sources by performing health assessments on captured individuals and/or necropsies on salvaged carcasses.

Objective C2.4 Research MGS response to and/or use of disturbance areas and features designed for increased compatibility between development and MGS persistence.

Measures

C2.4.1 Conduct research on the compatibility of various solar panel/array designs and installation methods with forb growth, MGS occupancy, or MGS movement.

C2.4.2 Conduct research on the compatibility of linear array configurations for renewable energy or other facilities with MGS movement.

C2.4.3 Conduct research on the compatibility of small-footprint (under 100 acres) geothermal wells and towers, wind turbine pads and access roads, O&M facilities, and other structures or facilities with MGS occupancy or movement.

C2.4.4 Design and research the effectiveness of exclusion fencing specific for keeping MGS out of construction areas and other sites posing immediate threats to MGS.

C2.4.5 Study burrow depths and determine the effect of shallow-level land grading during the dormant season.

C2.4.6 Conduct studies to understand the effects of various levels of OHV use on MGS habitat and populations.

C2.4.7 Conduct telemetry studies to understand MGS' use of corridors that do not contain good habitat.

D. CLIMATE CHANGE IMPACTS

Goal D1 Identify and reduce, where possible, potential stressors and threats to MGS as a result of climate change.

Objective D1 Establish multiple scenario projections through modeling the potential effects of climate change on MGS, and develop management strategies to address the impacts.

Measures

D1.1 Identify potential shifts in vegetation communities and conserve newly available habitat containing sufficient forage species.

D1.2 Determine simulated impacts of migrating species, invasive species, and disease vector proliferation, and develop an early detection rapid response such as a control protocol for the impact(s).

D1.3 Determine simulated impacts of introduced predators or competitors, and develop an early detection rapid response for each of these impacts.

D1.4 Determine modeled impacts of increased fire and begin early fire prevention programs to educate the public and to place fire restrictions during extremely dry seasons.

D.1.5 Determine modeled impacts of flood events and begin early flood prevention programs.

Objective D2 Establish conservation targets based on modeled refugia.

Measures

D2.1 Use the most updated scientific models to determine conservation of habitat that will potentially be available as refugia from increased temperatures or other climatic variables (such as flood or fire), and conservation of linkages that facilitate movement to the refugia. Examples of such areas include:

- At least 78,000 acres of habitat in Owens Valley north of Owens Lake, including modeled habitat at 0.7 suitability value or higher (see Appendix B), and habitat east and west of Owens Lake that could be used as a corridor from the Olancha-Coso Range population.
- At least 73,000 acres of potential habitat west of the Little Dixie Wash population, including low foothills, valleys, and modeled suitable habitat at 0.7 or higher.
- Other low-elevation foothills, passes, and/or valleys that are predicted to support growth of forbs under drought or extreme heat conditions, or are shadowed by larger mountain ranges.
- Habitat with an abundance of perennial shrubs to provide forage during droughts, such as winterfat and spiny hopsage, and plants with high water content and shade value.

D2.2 Under the guidance of desert restoration experts, restore, enhance, or create habitat with sufficient microclimate structure (*e.g.*, sufficient canopy for shade or soil substrate for burrows).

E. MONITORING AND ADAPTIVE MANAGEMENT

Goal E1 Make and adjust conservation and management decisions based on the best available science and most recent information.

Objective E1.1 Evaluate population trends for long-term conservation and habitat protection decisions.

Measures

E1.1.1 Monitor population centers where baselines were established, each season after a cycle of three years of sufficient rainfall, and infer range-wide and local population trends based on the results of the monitoring. Include data gap areas that have population centers discovered through baseline studies.

E1.1.2 Monitor protected linkages and corridors, using the most recent survey detection data, genetic research, and habitat distribution models to focus the monitoring locations.

E1.1.3 Monitor and evaluate modeled habitat refugia and linkages protected in anticipation of climate change impacts during seasons following at least three years of drought.

E1.1.4 Establish an adaptive management plan that restricts disturbance in suitable habitat where monitoring indicates stable or increasing population trends.

E1.1.5 Support the publishing of updated range and distribution maps at least every five years to reflect the most current information on distribution changes and range extensions or curtailment.

Objective E1.2 Evaluate compliance and reporting requirements for development and other land use activities under local, state, and federal laws.

Measures

E1.2.1 Establish a feedback mechanism for management decision makers to access compliance reports from permitting agencies.

E.1.2.2 Establish a central location for reports and information obtained from the permitting agencies.

Objective E1.3 Where trends infer population decline, evaluate conservation mechanisms at the local, state, and federal levels for effectiveness in conserving MGS, and adjust conservation actions for better protection.

Measures

E1.3.1 Review mortality data reports and evaluate BMPs, survey protocol requirements, and impact minimization measures. Work with permitting agencies to adjust measures where mortality is high and causality is inferred.

E1.3.2 Analyze monitoring data over time in areas with various land use management prescriptions on public and private land, and evaluate areas for effectiveness in managing potential threats; for example:

- Areas with managed grazing regimes
- Areas that buffer agricultural or other activities that potentially expose MGS habitat to chemical hazards
- Areas with active road closures and enforcement preventing illegal off-road vehicle use
- Areas managing recreational activity, including OHV open areas, through education and outreach, seasonal closures, and other conservation actions
- Areas where varying levels of disturbance caps are enforced (from 1% to no cap)

E1.3.3 In areas where monitoring data are not available or sufficient, modify the trend monitoring design to include areas that contain the different land use management prescriptions.

Objective E1.4 Evaluate focused development zones by analyzing population trends in surrounding occupied habitat.

Measures

E1.4.1 Analyze monitoring data in occupied habitat and population centers adjacent to development zones or add these areas to the trend monitoring plan.

E1.4.2 Where trends show local populations declining near development zones, re-evaluate the development zones with the jurisdictional agencies in order to focus project activity in areas with the least amount of impact on nearby populations.

Objective E1.5 Monitor MGS use of areas with restored or enhanced habitat in linkages or other important ecological areas (such as population centers or expansion habitat).

Measures

E1.5.1 Design a monitoring plan with MGS experts or analyze existing monitoring data to determine whether or not MGS reside and breed in these areas.

Objective E1.6 Monitor MGS use of areas acquired as mitigation land.

Measures

E1.6.1 Design a monitoring plan with MGS experts or analyze existing monitoring data to determine whether or not MGS reside and breed in these areas.

Goal E2 Evaluate applied research objectives and methods, as new information becomes available.

Objective E2.1 Evaluate areas of research, as new information becomes available.

Measures

E2.1.1 Identify and prioritize data gaps and research areas at least once every five years or as new detection data becomes available.

E2.1.2 Identify and prioritize studies on threats and stressors, as new information identifies actual threats to MGS survival.

Objective E2.2 Evaluate and improve protocols for baseline surveys, trend monitoring, and occupancy studies.

Measures

E2.2.1 Evaluate and improve currently used camera and/or live trapping techniques to determine whether or not they are sufficient for discovering new population centers and increasing detection probability.

E2.2.2 Ensure baseline studies include adequate methods for obtaining accurate demographic information (*e.g.*, age class, sex, reproductive status).

E2.2.3 Adopt into the survey protocol and occupancy studies newly discovered techniques that are considered by the scientific community to be effective for detecting MGS.

Goal E3 Determine the effectiveness of recovery techniques and adapt research objectives and management decisions to include the most effective techniques.

Objective E3.1 Evaluate the effectiveness of translocation methods.

Measures

E3.1.1 Work with local, state, and federal agencies, and the scientific community, to evaluate the effectiveness and conservation value of translocation to salvage individuals during ground-disturbing projects, for population augmentation or reintroductions, or for accelerating range expansion/shifts as habitat changes in response to climate change.

E3.1.2 Develop studies that determine the viability of MGS survival and reproduction in destination locations, including the effects of territory defense where other MGS occur.

E3.1.3 If translocation is found to be feasible and effective, then develop guidance on translocation methods and applications based on the results of studies discussed in the measures above.

Objective E3.2 Evaluate the effectiveness of captive breeding and reintroduction for MGS conservation.

Measures

E3.2.1 Work with experts nationwide or worldwide to understand captive breeding programs that were successful for species similar to MGS.

E3.2.2 Work with experts to develop a captive breeding/reintroduction pilot program for MGS. Obtain partnerships with facilities (such as zoos) that have successfully reared in captivity other threatened or endangered species similar to MGS.

E3.2.3 Evaluate the effectiveness of the pilot program to determine if a potential captive breeding protocol with local, state, and federal agencies and species experts should be developed.

E3.2.4 For potential reintroduction protocols, study the viability of MGS survival and reproduction in destination locations, including the effects of territory defense where MGS occur.

E3.2.5 Implement effective captive breeding and reintroduction programs based on the information obtained and the developed protocol, or determine if the technique should be removed from consideration.

II. Summary of Recommended Management Actions

- Conserve habitat supporting MGS population centers, expansion and dispersal areas extending from population centers, and connectivity linkages or corridors (important areas) through acquiring private land parcels to be managed as conservation easements or habitat management land, or other conserved land, in perpetuity.

- Manage public land within MGS important areas (such as BLM, California State Parks, National Park Service, or County Park lands) to be compatible with conservation of habitat. Multiple uses of these areas should include uses that are not destructive to habitat or important vegetation used by the MGS.
- Conserve habitat that is predicted through scientific models to potentially protect MGS in the future from extreme climate variables and events resulting from climate change, through management actions described above. Ensure conservation of habitat that can be used as linkages to these areas from existing populations.
- Conserve habitat by working with private developers and public land management agencies to strategically site development projects on land with the least amount of impacts on the MGS, and integrate development strategies into NCCP/HCP planning.
- Work with jurisdictional agencies to establish conservation mechanisms best suited for the protection of the MGS, consistent with NCCP/HCP and CESA laws.
- Support research on the status of MGS, population dynamics and distribution, genetics, effects of climate change, causes of decline or mortality, and ecological requirements.
- Support research on the potential threats to MGS persistence other than habitat loss, and work with jurisdictional agencies to develop management plans for each of the threats that are inferred to be negatively affecting populations, movement, or survival of the species.
- Support studies on the effectiveness of translocation and captive breeding programs.
- Develop educational and outreach programs that would reduce the impacts of anthropogenic activities on MGS habitat and populations.
- Develop an Adaptive Management strategy to monitor the effects of conservation strategy actions through monitoring population trends, analyzing results, and changing the strategy as new information becomes available.

APPENDIX A – Range Maps

California Wildlife Habitat Relationships System

California Department of Fish and Game

California Interagency Wildlife Task Group

Range maps are based on available occurrence data and professional knowledge. They represent current, but not historic or potential, range. Unless otherwise noted above, maps were originally published in Zeiner, D.C., W.F. Laudenslayer, Jr., K.E. Mayer, and M. White, eds. 1988-1990. California's Wildlife. Vol. I-III. California Depart. of Fish and Game, Sacramento, California. Updates are noted in maps that have been added or edited since original publication.

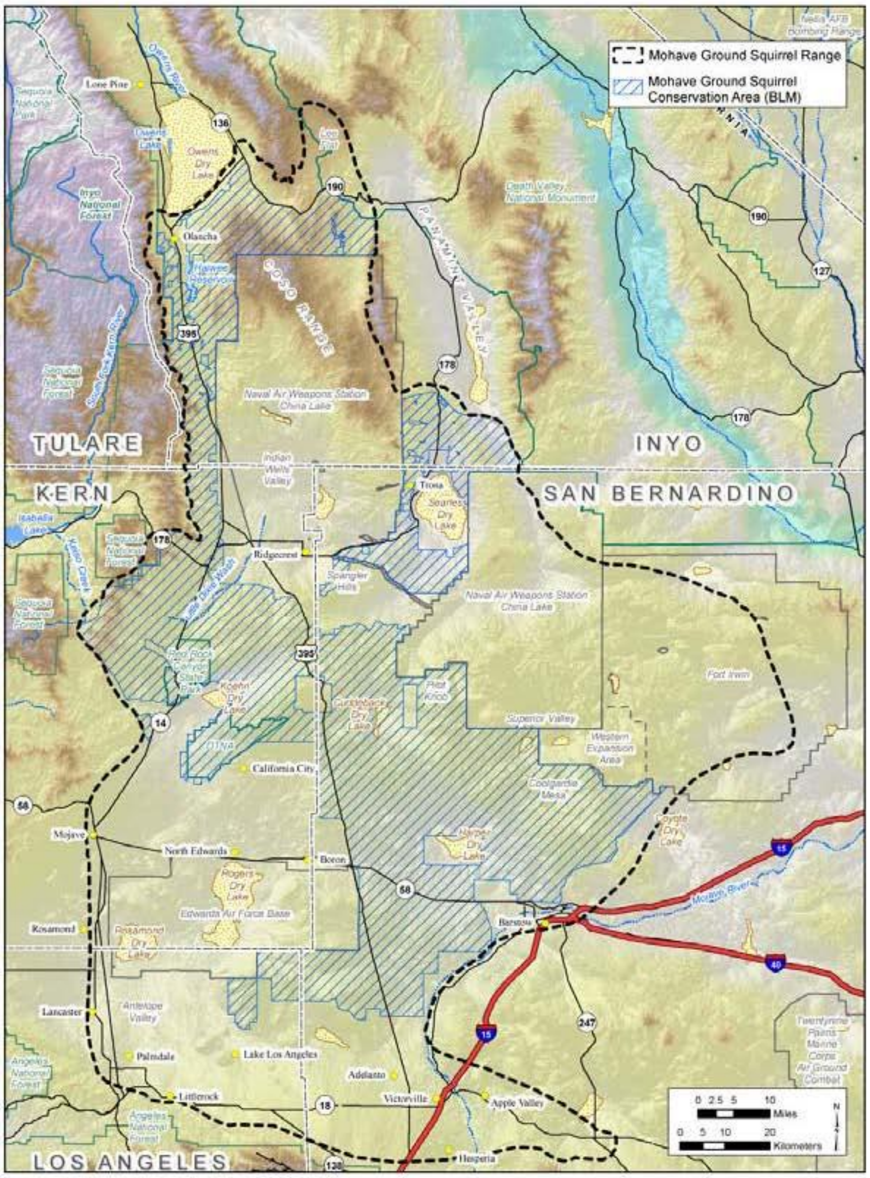
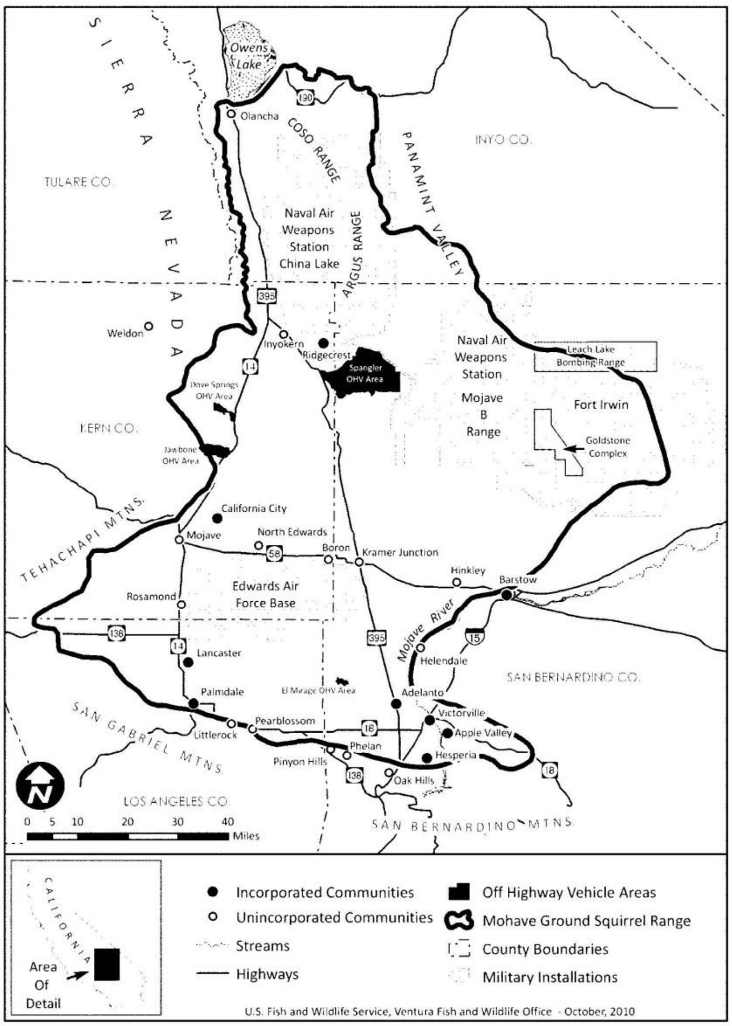


Figure 1. The historic range of the Mohave ground squirrel in the western Mojave Desert of California, with important place names indicated. The Mohave Ground Squirrel Conservation Area is shown as established in the West Mojave Plan (U.S. Bureau of Land Management (2005).

Map 1. Place names, major roads, military bases, and off-highway vehicle areas in the range of the Mohave ground squirrel (calculated by the Service).



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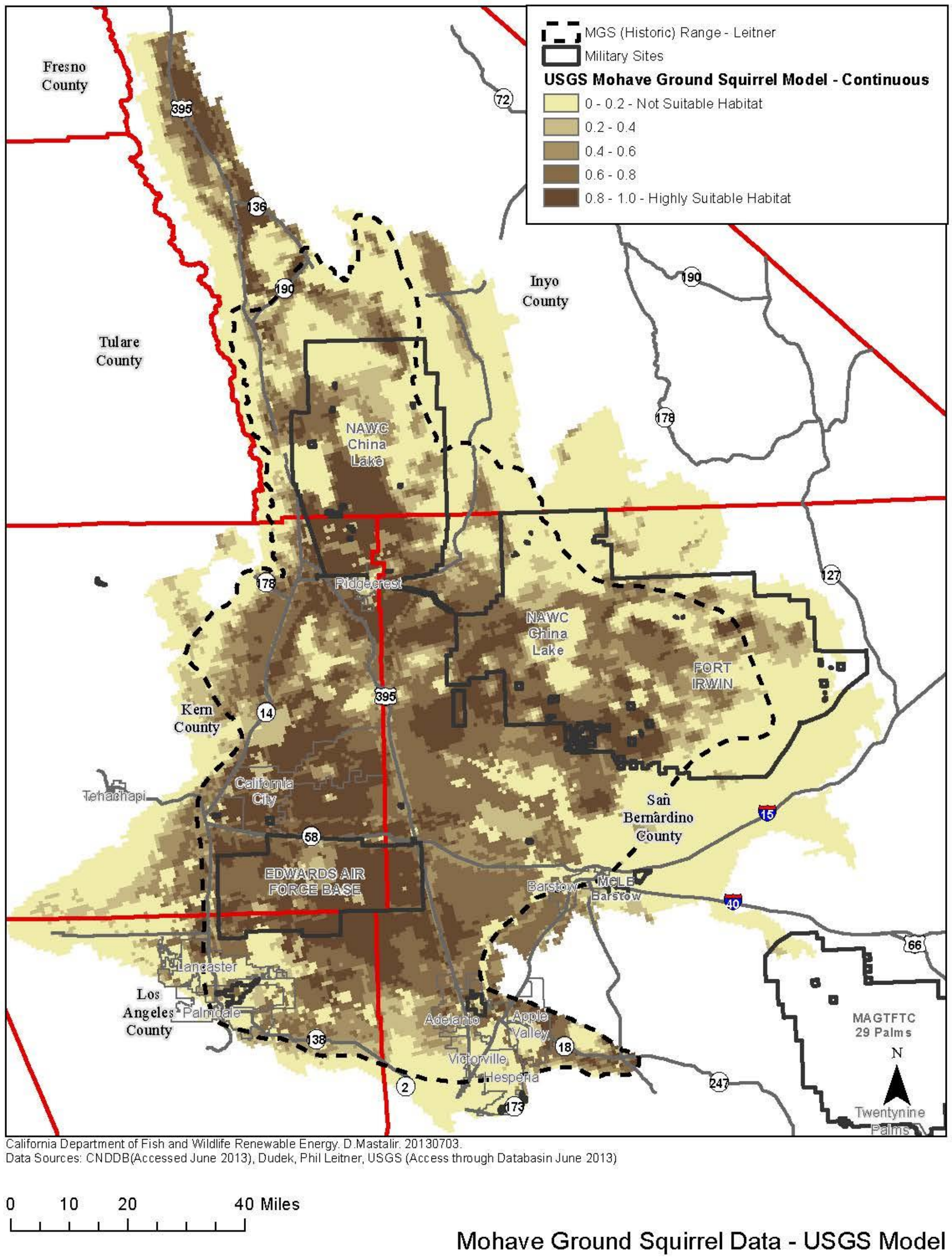
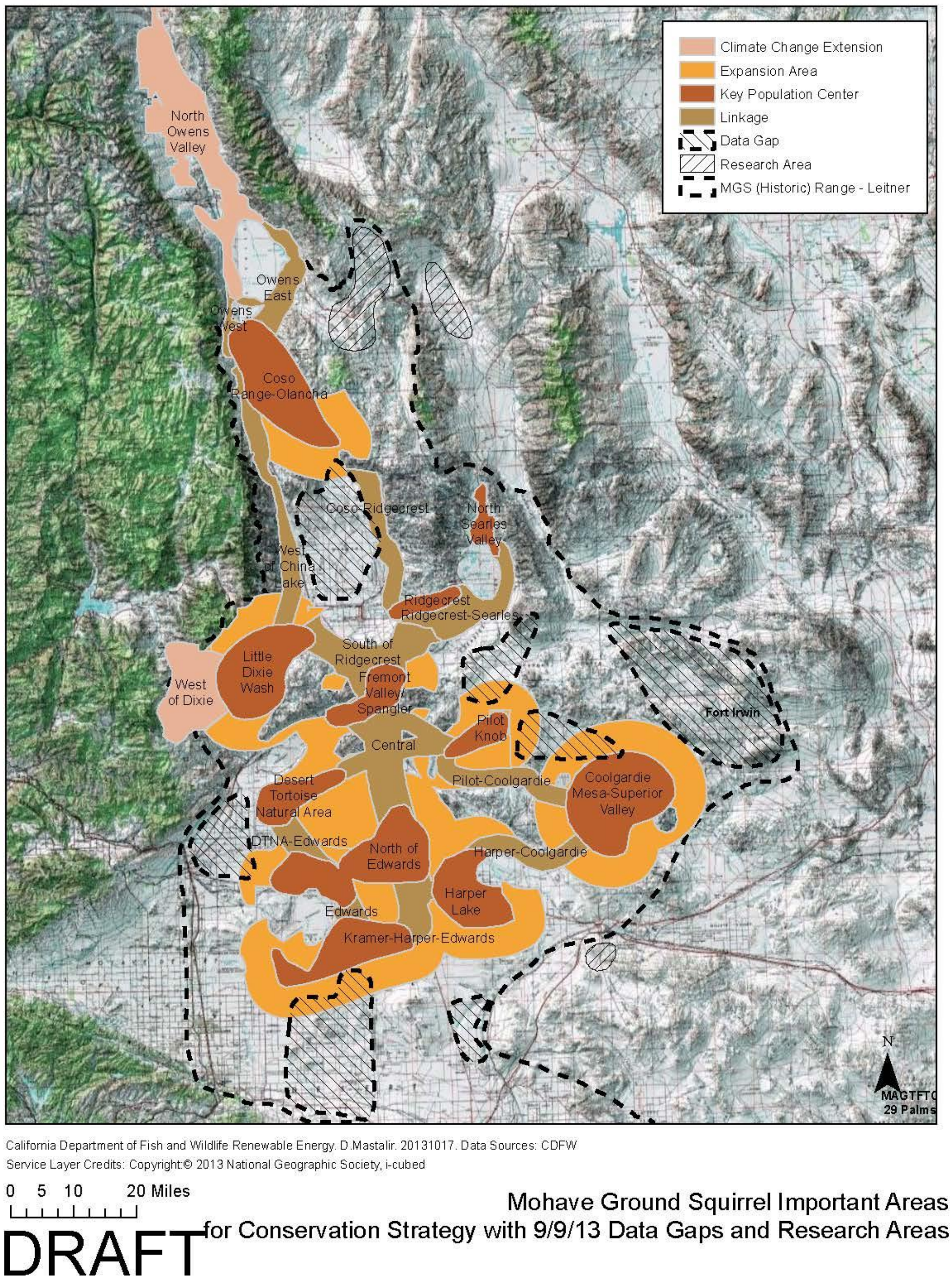
APPENDIX B – USGS Habitat Suitability Model

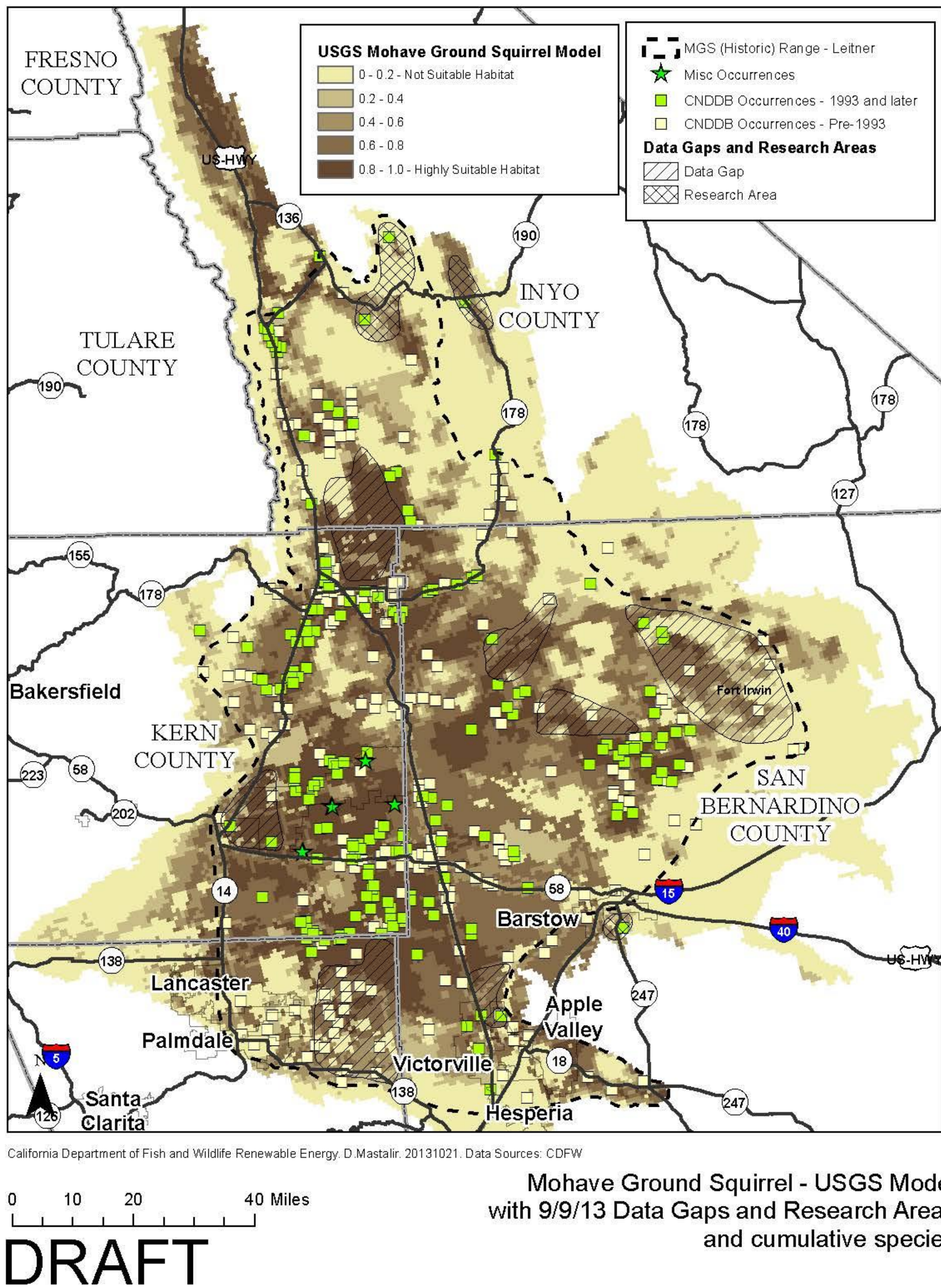


California Department of Fish and Wildlife Renewable Energy. D.Mastalir. 20130703.
Data Sources: CNDDB(Accessed June 2013), Dudek, Phil Leitner, USGS (Access through Databasin June 2013)

Mohave Ground Squirrel Data - USGS Model

APPENDIX C – Important Areas and Data Gaps





Mohave Ground Squirrel - USGS Model
with 9/9/13 Data Gaps and Research Areas
and cumulative species

APPENDIX D - CDFG MGS Survey Guidelines 2010

CALIFORNIA DEPARTMENT OF FISH AND GAME

MOHAVE GROUND SQUIRREL SURVEY GUIDELINES
(January 2003; minor process and contact changes in July 2010)

Unless a certain circumstance[1] applies, the Department of Fish and Game (Department) requires a survey to be undertaken for the Mohave ground squirrel (*Xerospermophilus mohavensis*) on a project site if the proposed site has potential habitat of this species and the presence of the species on the project site is unknown. Potential habitat is land supporting desert shrub vegetation[2] within or adjacent to the geographic range[3] of the species. A project is an action that results in temporary or permanent removal or degradation of potential habitat. The Department considers a project site to be an area of land controlled by the project proponent, including but not limited to the portion proposed for removal or degradation of potential habitat. The Department considers a project site to be occupied by the Mohave ground squirrel, if an individual of this species is observed, or is captured on any sampling grid, on the project site.

The Department intends for these survey guidelines to apply to projects that would negatively affect ≤180 acres or to linear projects ≤ 5 miles in length. For projects of larger scale, the Department requires special survey protocol(s) to be developed through its consultation with either the project proponent or the local lead agency (if appropriate) or both entities.

For projects of the appropriate scale, each survey shall adhere to the following conditions:

1. Studies that include trapping for the Mohave ground squirrel shall be authorized by a Memorandum of Understanding (MOU) or Letter Permit issued by the Wildlife Branch of the Department, or by other permit as determined by the Department, and shall be undertaken only by a qualified biologist. A qualified biologist is a biologist who has demonstrated pertinent field experience in capturing and handling ground squirrels or other small mammals in desert/arid communities and who has been permitted by the Department to work without supervision. Each biologist setting traps, opening traps containing captured animals, or handling captured animals must be named in the MOU or Letter Permit as an authorized person, whether qualified or not to work without supervision.

2. Visual surveys to determine Mohave ground squirrel activity and habitat quality shall be undertaken during the period of 15 March through 15 April. All potential habitat

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1 A survey is not necessary in the circumstance that the project proponent prefers to assume that the Mohave ground squirrel is present on the project site and applies for a California Endangered Species Act incidental-take permit (Fish and Game Code Section 2081b) requiring mitigation and compensation.

2 Examples of desert shrub vegetation that is known to provide habitat for the Mohave ground squirrel include (but are not limited to) Mojave Creosote Bush Scrub, Mojave Mixed Woody Scrub, and Desert Saltbush Scrub as described in Holland 1986.

3 Because the limits of the geographic range are not known precisely, surveys may be required in areas up to five miles from currently-documented boundaries.

on a project site shall be visually surveyed during daylight hours by a biologist who can readily identify the Mohave ground squirrel and the white-tailed antelope squirrel (*Ammospermophilus leucurus*).

3. If visual surveys do not reveal presence of the Mohave ground squirrel on the project site, standard small-mammal trapping grids shall be established in potential Mohave ground squirrel habitat. The number of grids will depend on the amount of potential habitat on the project site, as determined by the guidelines presented in paragraphs 4 and 5 of these guidelines.

4. For linear projects (for example, highways, pipelines, or electric transmission lines), each sampling grid shall consist of 100 Sherman live-traps (or equivalent; the minimum length of any trap is 12 inches) arranged in a rectangular pattern, 4 traps wide by 25 traps long, with traps spaced 35 meters apart along each of the four trap lines. At a minimum, one sampling grid of this type shall be established in each linear mile, or fraction thereof, of potential Mohave ground squirrel habitat along the project corridor.

5. For all other types of projects, one sampling grid consisting of 100 Sherman live-traps (or equivalent; the minimum length of any trap is 12 inches) shall be established for each 80 acres, or fraction thereof, of potential Mohave ground squirrel habitat on the project site. The traps shall be arranged in a 10 x 10 grid, with 35-meter spacing between traps.

6. Each sampling grid shall be trapped for a minimum five consecutive days, unless a Mohave ground squirrel is captured before the end of the five-day term on the grid or on another grid on the project site. If no Mohave ground squirrel is captured on a sampling grid on the project site in the first five-consecutive-day term, each sampling grid shall be sampled for a SECOND five-consecutive-day term. Trapping may be stopped before the end of the second term if a Mohave ground squirrel is captured on any sampling grid on the project site. If no Mohave ground squirrel is captured during the second five-consecutive-day term, each sampling grid shall be sampled for a THIRD five-consecutive-day term. The FIRST trapping term shall begin and be completed in the period of 15 March through 30 April. If a SECOND term is required, it shall begin at least two weeks after the end of the first term, but shall begin no earlier than 01 May, and shall be completed by 31 May. If a THIRD term is required, it shall begin at least two weeks after the end of the second term, but shall begin no earlier than 15 June, and shall be completed by 15 July. All trapping shall be conducted during appropriate weather conditions, avoiding periods of high wind, precipitation, and low temperatures (<50°F or 10°C).

7. For projects requiring two or more sampling grids, capture of a Mohave ground squirrel on any grid will establish presence of the species on the project site. Trapping may be stopped on all grids on the project site at that time. For linear projects, very large project sites, project sites characterized by fragmented or

highly-heterogeneous habitats, or in other special circumstances, continued trapping may be necessary.

8. A maximum 100 traps shall be operated by each qualified biologist. Each trap shall be covered with a cardboard A-frame or equivalent non-metal shelter to provide shade. Trap and shelter orientation shall be on a north-south axis. All traps shall be opened within one hour of sunrise and may be closed beginning one hour before sunset. Traps shall be checked at least once every four hours to minimize heat stress to captured animals. When traps are open, temperature shall be measured at a location within the sampling grid, in the shade, and one foot (approx. 0.3 meters) above the ground at least once every hour. Traps shall be closed when the ambient air temperature at one foot above the ground in the shade exceeds 90°F (32°C). Trapping shall resume on the same day after the ambient temperature at one foot (approx. 0.3 meters) above the ground in the shade falls to 90°F (32°C) and shall continue until one hour before sunset. Suggested baits are mixed grains, rolled oats, or bird seed, with a small amount of peanut butter.

9. A qualified biologist shall complete the Survey and Trapping Form, which is found on the last page of these guidelines. This biologist, or the lead agency for the project, shall submit the completed form to the appropriate Department office (see page 4) with the biological report on the project site.

10. The Department may allow variation on these guidelines, with the advance written approval of the appropriate regional habitat conservation planning office (see page 4). Such variations could include biologically-appropriate modification of the trapping dates or changes in grid configuration that would enhance the probability of detecting Mohave ground squirrels. Any variation which concerns trapping or marking methods must be incorporated into the MOU or permit that authorizes the work.

11. If a survey conducted according to these guidelines results in no capture or observation of the Mohave ground squirrel on a project site, this is not necessarily evidence that the Mohave ground squirrel does not exist on the site or that the site is not actual or potential habitat of the species. However, in the circumstance of such a negative result, the Department will stipulate that the project site harbors no Mohave ground squirrels. This stipulation will expire one year from the ending date of the last trapping on the project site conducted according to these guidelines.

<u>Literature Cited</u>

Holland, R. F. 1986. Preliminary descriptions of the terrestrial natural communities of California. Nongame Heritage Program report. California Department of Fish and Game (Sacramento), 156 pages.

CONTACTS

A. For information on obtaining an MOU or on the type of experience that a qualified biologist must have, contact the following:

Scott D. Osborn
Wildlife Branch, Nongame Wildlife Program
Department of Fish and Game
1812 Ninth Street
Sacramento, CA 95811

voice: (916) 324-3564
fax: (916) 445--4048
e-mail: sosborn@dfg.ca.gov

B. For information on project review and conservation planning by the Department, as these activities regard the Mohave ground squirrel, contact the following:

(for Kern County)
Habitat Conservation Planning
San Joaquin Valley and Southern Sierra Region
Department of Fish and Game
1234 E. Shaw Avenue
Fresno, California 93710
telephone: (559) 243-4005

(for Los Angeles County)
Habitat Conservation Planning
South Coast Region
Department of Fish and Game
4949 View Ridge Avenue
San Diego, California 92123
telephone: (858) 467-4201

(for Inyo and San Bernardino counties)
Habitat Conservation Planning
Eastern Sierra and Inland Deserts Region
Department of Fish and Game
407 West Line Street
Bishop, California 93514
telephone: (760) 872-1171

Mohave Ground Squirrel (MGS) Survey and Trapping Form (photocopy as needed)

PART I - PROJECT INFORMATION (use a separate form for each sampling grid)

Project name: ______________________________ Property owner: ____________________

Location: Township __________; Range __________; Section __________ ; ¼ Section ________

Quad map/series: ______________________ UTM coordinates: ________________________
GPS coordinates of trapping-grid corners

Acreage of Project Site: ______________ Acreage of potential MGS habitat on site: __________

Total acreage visually surveyed on project site: ____________ Date(s): __________________
visual surveys

Visual surveys conducted by: ____
names of all persons by date (use back of form, if needed)

Total acres trapped: ______________ Number of sampling grids: __________________

Trapping conducted by: ____
names of all persons by sampling term and sampling grid (use back of form, if needed)

Dates of sampling term(s): FIRST__________ SECOND __________ THIRD ____________
if required if required

PART II - GENERAL HABITAT DESCRIPTION (use back of form, if needed)

Vegetation: dominant perennials: ____
other perennials: ____
dominant annuals: ____
____
other annuals: ____
____

Land forms (mesa, bajada, wash): ____

Soils description: ____

Elevation: ____________________________ Slope: ________________________

PART III - WEATHER (report measurements in the following categories for each day of visual survey and each day of trapping; using 24-hour clock, indicate time of day that each measurement was made; use a separate blank sheet for each day)

Temperature: AIR minimum and maximum; SOIL minimum and maximum; Cloud Cover: % in AM and % in PM; Wind Speed: in AM and in PM

APPENDIX E - Examples of Best Management Practices

1. Pre-construction surveys 30 days prior to breaking ground.
2. Burrows marked or surrounded by fencing.
3. Minimization of road construction and use (*i.e.*, existing roads used only within the project site).
4. Posted speed limits within project sites.
5. Open hole and trench inspections for trapped animals. Open holes and trenches closed when not in use.
6. Trash removal, and removal of items that would attract potential predators (such as ravens).
7. Removal of vertical features no longer used, to eliminate potential predator perching or nesting sites.
8. Rodenticide use prohibited on project sites.
9. Herbicide use only on targeted invasive grasses in MGS habitat.
10. Monitoring during project activities by qualified biologist(s) or trained site workers.
11. Buffering project activities away from detection sites.
12. Relocation of squirrels detected during project activities under a translocation protocol approved by the jurisdictional wildlife agency(ies).
13. Use of evaporation ponds restricted, drained when not in use.
14. Removing trash, rocks, gravel, and/or debris that cause shading or other disturbance to vegetation.
15. Clearing non-native vegetation or species brought in accidentally by the project activities.
16. Education of project workers by a qualified biologist on how to identify and avoid harm to MGS.
17. Restrictions on bringing domestic pets to project sites.
18. Fire prevention guidelines for all project activities.