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A Conservation Strategy for the MOHAVE GROUND SQUIRREL

Xerospermophilus mohavensis

CONTENTS

LIST OF ACRONYMS AND ABBREVIATIONS

ACEC	Area of Critical Environmental Concern
BLM	Bureau of Land Management
BMP	Best Management Practices
CalWEA	California Wind Energy Association
CBI	Conservation Biology Institute
CDCA	California Desert Conservation Area
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
CMA	Conservation and Management Actions
CNDDB	California Natural Diversity Database
CO_2	Carbon Dioxide
CPA	MGS Core Population Area
CROS	California Roadkill Observation System
DFA	Development Focus Area
DOD	Department of Defense
DRECP	Desert Renewable Energy Conservation Plan
DTRNA	Desert Tortoise Research Natural Area (DTNA)
DWMA	Desert Wildlife Management Area
EA	Environmental Assessment
EAFB	Edwards Air Force Base
EIS	Environmental Impact Statement
ER	Ecological Reserve
ESA	Endangered Species Act
GIS	Geographic Information Systems
HQA	Habitat Quality Analysis
INRMP	Integrated Natural Resources Management Plan
IFS	Individual Focus Species
ITP	Incidental Take Permit

KGRA	Known Geothermal Resource Area
LUPA	Land Use Plan Amendment
MCP	Minimum Convex Polygon
MGS	Mohave Ground Squirrel
MGSCA	Mohave Ground Squirrel Conservation Area
MGS TAG	Mohave Ground Squirrel Technical Advisory Group
MOU	Memorandum of Understanding
NAWS	Naval Air Weapons Station
NEPA	National Environmental Policy Act
NRD	Natural Resources Division
NSO	No Surface Occupancy
NTC	National Training Center
OHMVRD	Off-Highway Motor Vehicle Recreation Division
OHV	Off-Highway Vehicle
PIER	Public Interest Energy Research
PIRA	Precision Impact Range Area
PPA	MGS Peripheral Population Area
PV	Photovoltaic
REAT	Renewable Energy Action Team
RMP	Resource Management Plan
ROD	Record of Decision
RTGS	Round-tailed ground squirrel
SEA	Significant Ecological Area
SDM	Species Distribution Model
SR	State Route
SVRA	State Vehicular Recreation Area
T14, CCR	Title 14, California Code of Regulations
US	United States
USFWS	United States Fish and Wildlife Service
VPL	Variance Process Lands
WEA	Western Expansion Area
WTA	Western Training Area
WEMO	West Mojave
WMRNP	West Mojave Route Network Project

Photos by David Delaney

Photos by David Delaney

FROM THE DIRECTOR

After many years, the Department of Fish and Wildlife is pleased to present a comprehensive, scientifically based conservation strategy that lays the foundation for conservation and recovery of Mohave ground squirrel in California.

Deserts are known for their seemingly harsh, dry, desolate landscapes, and wide climatic variability. These characteristics also make them places of astounding beauty – fragile habitats inhabited by some of the most uniquely adapted species on Earth. The Mojave Desert is no exception. As one of the hottest and driest deserts in North America, it is also incredibly diverse. With elevations ranging from 282 feet below sea level in Death Valley to over 11,000 feet above sea level in the Panamint Mountains, the California portion of the Mojave Desert supports an incredible variety of species and habitats.

When thinking about the Mojave Desert, species like the Joshua tree, desert bighorn sheep, red-tailed hawk, and desert tortoise may readily come to mind, but sometimes, the elusive ones are just as emblematic. Such is the case for the Mohave ground squirrel, a small day-active ground squirrel that has adapted to this particularly harsh environment by spending much of the year underground in dormancy. Originally listed as Rare by the State of California in 1971, the Mohave ground squirrel was reclassified as threatened under the California Endangered Species Act in 1985. Initial efforts to develop a conservation strategy began in the 1990s and were reinitiated multiple times since. This latest effort involved broad participation and dedicated effort of more than 35 organizations, including state, federal, and local agencies, academia, consulting firms, and non-governmental organizations.

In 2018, the Legislature passed Senate Bill 473, which, among other changes, amended the California Endangered Species Act to authorize the Department of Fish and Wildlife to develop and implement non-regulatory recovery plans for the conservation and survival of threatened and endangered species. This conservation strategy serves as an important first step in achieving that goal by outlining a multifaceted approach to conservation and recovery of the species.

Desert species, like the Mohave ground squirrel, face many challenges, including climate change and ongoing habitat loss, but it is through efforts such as these, that we can help ensure all Californians have the opportunity to experience the full beauty and richness of our desert ecosystems for generations to come.

Charlton H. Bonham

Director, California Department of Fish and Wildlife

PREFACE

In 2006, members of the California Desert Managers Group[1] and the California Department of Fish and Game prepared a draft Mohave ground squirrel (MGS) Conservation Strategy in cooperation with the Mohave Ground Squirrel Technical Advisory Group. In 2010, the California Desert Managers Group continued the effort by drafting preliminary goals, objectives, and conservation measures and the Mohave Ground Squirrel Technical Advisory Group recommended conservation priorities. California Department of Fish and Game reinitiated work on the draft in 2012, incorporating the latest scientific information. California Department of Fish and Game, now the California Department of Fish and Wildlife, continued working on the strategy through 2014 with technical and stakeholder review. The resulting draft was reviewed by the California Department of Fish and Wildlife executive team for policy consistency and by the Mohave Ground Squirrel Technical Advisory Group for technical accuracy. This final Conservation Strategy incorporates changes based on those reviews and additional species information developed since 2014.

EXECUTIVE SUMMARY

The Mohave ground squirrel (MGS) occurs in the western Mojave Desert of California. This small day-active ground squirrel is active primarily in the early spring and summer. It spends much of the remainder of the year underground in dormancy (hibernation or aestivation). The species is listed as "vulnerable" by the World Conservation Union[2] and as "Threatened" by the State of California (§670.5(b)(6)(A), T14, CCR).

The goals of the MGS Conservation Strategy are to provide guidance on the conservation of MGS and ultimately recover it from its vulnerable and Threatened status. To help achieve these goals, the MGC Conservation Strategy:

1. Assesses the conservation status of the MGS;
2. Identifies achievable objectives intended to ensure the continued existence of the species; and
3. Provides conservation measures that may realistically be implemented to achieve the objectives

The greatest known cause of the MGS's decline is habitat loss, which has led to a reduction of the species' range and a decrease in dispersal opportunities (Gustafson, 1993). Habitat loss can result from urban and rural development, agriculture, military operations, energy development, transportation infrastructure, and mining. Other major threats to MGS include habitat degradation and habitat fragmentation. Off highway vehicle use, grazing, commercial filming, recreational activity and pesticide and herbicide use can cause degradation of habitat (United States Fish and Wildlife Service 2011, Fed. Reg. 76:62214). Lack of contiguous, suitable habitat decreases the species' ability to persist during periods of drought. In drought years, the MGS may forgo reproduction to conserve energy due to the lack of food supply (Leitner and Leitner, 1998). Lack of forage opportunities and habitat loss can further reduce reproduction rates and cause local extirpations. Loss of linkages between suitable habitat patches can prevent recolonization in years of better rainfall. Loss of foraging habitat can also lead to decreases in stored energy required to sustain individual squirrels during periods of aestivation, resulting in decreased survival. Therefore, it is important to conserve suitable 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, on-going monitoring would help to determine the overall population status and distribution (See Figure 1). To recover the species, high-quality habitat must be available to support existing populations, allow for population expansion during years favorable for reproduction, and maintain genetic linkages between subpopulations.

Along with continued threats from habitat loss and degradation throughout its range, climatic changes will likely place additional stress on the species, by causing further reduction of suitable habitat and necessitating shifts in its distribution and range. Climate change impacts may also exacerbate other threats to the species such as habitat loss and degradation from disturbance, invasive species and disease, and drought. Although the exact trajectory of climate change is unknown, timely implementation of conservation actions to ameliorate habitat loss threats are necessary.

The management necessary to conserve MGS and its habitat includes a range of actions: acquisition, protection, and restoration of undisturbed, contiguous habitat; protection of MGS on public lands; identification and implementation of climate adaptation measures; design and implementation of an adaptive management and monitoring program; public education; and funding of research and monitoring efforts. For maximum effectiveness, habitat conservation efforts should focus on areas that support existing core population areas (Figure 1), additional habitat should be preserved for dispersal and linkage between population areas (linkages), as well as for population expansion (peripheral population areas). Land managers and jurisdictional agencies working together on conservation mechanisms and planning can also help to protect MGS. Such mechanisms include avoiding impacts to MGS when siting development projects, minimizing impacts, and conducting education and outreach. Investment in research and monitoring that assesses population trends, distribution, genetic exchange, climate change impacts, threats to the species' survival, and ecological requirements supports informed decision-making. Direct recovery actions, such as translocation or captive breeding programs, should be considered for rapid response to severe threats.

INTRODUCTION

The Mohave ground squirrel (*Xerospermophilus mohavensis*) (MGS) occurs only within the western part of the Mojave Desert in portions of Inyo, Kern, Los Angeles, and San Bernardino counties, California. Its geographic range is one of the smallest of any species of ground squirrel in North America (Hoyt, 1972). Its response to annual variation in rainfall makes it extremely vulnerable to local extirpations (Leitner and Leitner, 1998), which, when coupled with habitat loss and fragmentation, makes it inherently susceptible to overall population declines. Due to these issues, MGS is listed as "vulnerable" by the World Conservation Union[3] and as "Threatened" by the State of California (§670.5(b)(6)(A), T14, CCR).

Regional and project-related survey data indicate MGS occupancy has retracted in the southern, eastern, and western portions of its geographic range (Leitner, 2008a, 2013b; P. Leitner, pers. comm. 9/14/12). Major threats to MGS recovery are drought, habitat loss, habitat fragmentation, and habitat degradation (Gustafson, 1993). During particularly dry years, reproduction does not occur, with successive drought years leading to population decline. These factors, and others, suggest that a new approach to MGS conservation is needed.

The California Department of Fish and Wildlife (CDFW) has developed this Conservation Strategy as a feasible approach to conservation of the MGS.

Work on a conservation strategy for the Mohave ground squirrel began in the 1990s and continued intermittently for several years. In 2012, California Department of Fish and Game (later California Department of Fish and Wildlife) reinitiated work on the document in coordination with efforts to develop the Desert Renewable Energy Conservation Plan. This final Conservation Strategy incorporates changes to a 2014 draft based on previous policy-level and technical reviews and additional species information developed since 2014.

CONSERVATION STRATEGY PURPOSE

The purpose of the Conservation Strategy is to provide guidance and policies for the conservation of the MGS, with the goal of recovering the species from its vulnerable and threatened status. The Conservation Strategy includes goals, objectives, and measures based on current scientific information and is organized in three main sections:

- Part One outlines conservation goals, objectives, and measures addressing four major topics related to MGS conservation: A) Habitat Protection and Management, B) Conservation Planning, C) Monitoring and Research, and D) Outreach and Education.
- Part Two summarizes the current state of knowledge of MGS ecology and conservation issues.
- Part Three summarizes current MGS policies of land and wildlife management agencies within the species' geographic range.

The CDFW developed the Conservation Strategy in its role as the state trustee agency for wildlife conservation, as defined by the California Environmental Quality Act (PRC §21000 et seq.) and the California Environmental Quality Act Guidelines (§15386 et seq., T14, CCR). In total, the Conservation Strategy is CDFW's current policy and guidance regarding MGS conservation and recovery and lays the foundation for comprehensive and scientifically based conservation and recovery of Mohave ground squirrel in California. Implementation of the conservation goals, objectives, and measures outlined here requires CDFW to work with partners at other state, federal, and local agencies, as well as in collaboration with academic institutions and non-governmental organizations.

The Conservation Strategy is not a recovery plan for MGS. It does not list conservation objectives or targets, which, if achieved, would assure the long-term persistence of the species. Such recovery planning is an important early step in the conservation measures outlined in Part One and should be among the highest priority actions for CDFW and its partners. Recovery planning, including development of quantifiable objectives for MGS recovery, is a fundamental step, along with the other conservation measures described in this document, towards achieving the Conservation Strategy goals.

Implementation of the Conservation Strategy requires the leadership of the CDFW working with agency partners such as the Bureau of Land Management and the Department of Defense, California Department of Parks and Recreation, and others, as well as private land managers, consultants, and non-governmental organizations. The Mohave Ground Squirrel Technical Advisory Group (MGS TAG) brings together all these stakeholders and serves an important advisory role in setting priorities, identifying resources, engaging partners, and establishing timelines for the conservation actions outlined in the strategy.

Photo by Ed LaRue

PART ONE:

CONSERVATION STRATEGY GOALS, OBJECTIVES, AND MEASURES

INTRODUCTION

The following goals, objectives, and conservation measures have been developed as guidance to help achieve the overall conservation goals of long-term protection of MGS habitat and viability of the species. The measures include a wide variety of actions. Some of these are solely the responsibility of the CDFW, while others will be carried out by other agencies, researchers, or project proponents. Some conservation measures, such as recovery planning and research studies, not tied to specific development projects should be prioritized by CDFW in consultation with the MGS TAG. Due to recent legislative changes, CDFW may also develop and implement non-regulatory recovery plans for CESA-listed species. While funding for such an effort would need to be secured, the MGS TAG provides a forum to identify key participants and outline the MGS recovery plan process.

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 evaluation of the effectiveness of these measures. Individual implementation of many actions will require environmental analysis under National Environmental Policy Act (NEPA) or the California Environmental Quality Act (CEQA). The goals, objectives, and measures are divided into four categories: A) Habitat Protection and Management, B) Conservation Planning, C) Monitoring and Research, and D) Outreach and Education.

A. Habitat Protection and Management

GOAL: Implement on-the-ground protection of MGS habitat areas necessary to ensure the long-term viability of the species

» Objective: Identify and prioritize habitat protection and restoration areas

- Measure: Identify and delineate MGS Core Population Areas (CPAs), Peripheral Population Areas (PPAs), and Linkages as shown in Part Two of this document
- Measure: Emphasize the critical conservation importance of habitat protection and restoration in CPAs, PPAs, and Linkages in planning and compliance documents
- Measure: Develop Conceptual Area Protection Plans and other land/easement acquisition plans to prioritize habitat protection efforts
- Measure: Identify areas within or adjacent to CPAs, PPAs, and Linkages in need of, and available for, habitat restoration projects

» Objective: Protect habitat in currently known CPAs, PPAs, and Linkages

- Measure: Designate public lands for long-term conservation of MGS habitat within CPAs, PPAs, and Linkages
- Measure: For private lands within CPAs, PPAs, and Linkages, work with willing landowners and partner agencies, such as the Wildlife Conservation Board, to secure protection of MGS habitat, either through conservation easement or purchase
- Measure: Implement habitat restoration projects in high priority sites within CPAs, PPAs, and Linkages

» Objective: Protect habitat in PPAs, Linkages, and areas where remnant populations may exist to ensure unique genotypes are conserved and opportunities for genetic exchange occur throughout the MGS geographic range

- Measure: Protect MGS habitat parcels, where feasible, in areas where MGS may now be largely absent due to habitat loss, especially in the southern part of the MGS geographic range
- Measure: Manage public lands in the periphery of the MGS range where MGS currently occur, may occur, or could be re-introduced, to provide habitat to support PPAs
- Measure: Identify and prioritize important locations along transportation corridors to maintain or enhance wildlife crossing opportunities to ensure connectivity between CPAs, PPAs, and Linkages; working with local and state transportation agencies, design and implement such opportunities using wildlife friendly fencing and appropriately designed under- or overcrossings

GOAL: Minimize threats to MGS associated with development and other land uses

» Objective: Mitigate impacts to MGS habitat quality for ground-disturbing projects

- Measure: Encourage participation in local and regional planning projects that include measures benefitting MGS conservation; programs or projects may include Regional Conservation Investment Strategies, Habitat Conservation Plans, Natural Community Conservation Plans, and Safe Harbor Agreements
- Measure: Establish guidelines for off-site mitigation, including mitigation ratios and management and monitoring recommendations
- Measure: Establish off-site mitigation through conservation banks or other mechanisms
- Measure: Develop guidelines for on-site restoration of MGS habitat after temporary disturbance

» Objective: Reduce the impact of agriculture on MGS and MGS habitat

- Measure: Encourage participation of agricultural landowners in conservation easements, Safe Harbor Agreements, or Voluntary Local Programs to encourage MGS conservation actions while providing regulatory certainty to landowners
- Measure: Work with Bureau of Land Management (BLM) to review grazing allotments within the MGS range and adjust grazing practices (duration, intensity, and timing) to minimize or avoid impacts to MGS food resources
- Measure: Develop recommendations for reducing MGS exposure to agricultural pesticides, including aerially-applied chemicals and rodenticides

» Objective: Monitor and minimize impacts of recreational activities to MGS and its habitat

- Measure: Monitor recreational activities in the MGS range to identify activities that may impact MGS populations
- Measure: Minimize unauthorized off-highway travel in protected areas and control access in areas with unauthorized use
- Measure: Restore MGS habitat in closed off-highway vehicle (OHV) areas
- Measure: Develop and implement best practices with agencies and jurisdictions to reduce litter, dumping, and food subsidies for ravens and other predators

Photo by Dr. Philip Leitner

B. Conservation Planning

GOAL: Develop and implement a Recovery Plan for the MGS

» Objective: Develop a recovery plan for MGS that includes recovery goals or targets that, if achieved, would help ensure the long-term viability of the species

- Measure: Identify a recovery team comprised of agency, academic, and non-governmental organization staff
- Measure: Secure funding for work of the recovery team
- Measure: Use the best available science and other information necessary to develop conservation actions and mechanisms
- Measure: Set quantifiable recovery goals for MGS based on currently accepted methods for recovery planning

» Objective: Implement the MGS recovery plan

- Measure: Secure funding to implement the recovery plan
- Measure: Identify and work with recovery partners to implement the recovery plan

GOAL: Identify and implement conservation actions for MGS at the local, state, and federal levels

» Objective: Integrate protection and enhancement of MGS habitat into land use planning decisions

- Measure: Develop guidance for integrating MGS habitat protection into local, state, or federal land use plans, regional range-wide conservation plans (such as the Desert Renewable Energy Conservation Plan (DRECP)), local conservation plans (Habitat Conservation Plans, Natural Community Conservation Plans), and mitigation lands
- Measure: Develop land use policies that include habitat acquisition and restoration priorities
- Measure: As needed, develop disturbance caps in habitat areas important to MGS conservation

» Objective: Develop and implement standard practices and measures during the environmental review and implementation of CEQA and NEPA projects that may impact MGS

- Measure: Review and revise California Department of Fish and Wildlife's (CDFW) MGS Survey Guidelines to incorporate recent information on survey methods
- Measure: Develop standard methods for habitat assessment and assessment of MGS presence on proposed project sites that will inform estimates of take of the species
- Measure: Develop best management practices (BMPs) to minimize take of MGS during all phases of project implementation, especially during ground disturbance phases

» Objective: Encourage development to occur in areas where habitat value is already substantially diminished

- Measure: Incentivize new projects to occur on lapsed agricultural land not suitable for MGS.
- Measure: Incentivize clustering of development, except where new projects would impact a CPA or reduce the effectiveness of a Linkage

GOAL: Identify and reduce (or plan for) climate change impacts to MGS populations

» Objective: Assess potential effects of climate change on MGS

- Measure: Use multiple scenario modeling to project vegetation and bioclimatic shifts in MGS habitat suitability
- Measure: Investigate potential impacts of migrating species, invasive species, non-native predators and competitors, and disease vector proliferation
- Measure: Model future fire regimes in the Mojave Desert to determine if these may pose a threat to MGS
- Measure: Model future changes in precipitation patterns to determine if flash flood frequency or intensity poses a threat to MGS

» Objective: Plan and implement climate adaptation strategies to minimize the impacts to MGS

- Measure: Establish protections for areas projected to remain suitable and/or become suitable for MGS in the future; several such areas are discussed in the Climate Change Impacts section of Part Two
- Measure: Develop monitoring and management strategies for threats identified from modeling or contemporary observations, including new predators and competitors, disease, and altered fire or flash flood regimes

GOAL: Integrate best available science into MGS conservation and management decision-making

» Objective: Evaluate MGS population trends for decisions in conservation planning and habitat protection

- Measure: Update MGS distribution maps at least every five years to indicate occurrence shifts
- Measure: Incorporate area-specific population trend information into land-use and habitat conservation decisions

» Objective: Where trends suggest population decline, evaluate and adjust conservation actions

- Measure: Review and evaluate effectiveness of BMPs and impact minimization measures; work with permitting agencies to adjust measures where appropriate
- Measure: Analyze trend data in areas with various land uses and management prescriptions to determine compatibility with MGS conservation; for example: areas subject to grazing; areas affected by pesticides; closed OHV areas; areas with recreational activity, including OHV open areas; and various levels of disturbance

» Objective: Evaluate and improve reporting process for CEQA and NEPA projects

- Measure: Standardize procedures to simplify and streamline reporting
- Measure: Establish central repositories for reports and data obtained by different agencies and jurisdictions consistent with CDFW policies regarding data stewardship
- Measure: Establish a feedback process for integrating information into future management decisions

» Objective: Use information from captive propagation, reintroduction, and translocation pilot programs to inform management decisions

- Measure: Evaluate the feasibility of such programs and implement as a last resort, if feasible

C. Monitoring and Research

GOAL: Monitor MGS populations to determine trends in occupancy and population size throughout the MGS geographic range

» Objective: Establish a long-term MGS population monitoring program at CPAs and other areas of interest

- Measure: Include sites where existing long-term or repeated monitoring has occurred, such as Coso-Olancha, Little Dixie Wash, Coolgardie Mesa-Superior Valley, and Edwards Air Force Base (EAFB)
- Measure: Consider incorporating mitigation lands, which may have monitoring requirements, as well as lands with habitat restoration projects, in the monitoring program
- Measure: Incorporate methods to maximize detection (e.g., camera trapping) as well as methods to obtain genetic, reproductive condition, and diet samples (e.g., live-trapping)
- Measure: Ensure monitoring occurs with sufficient frequency to capture population changes through cycles of rain and drought
- Measure: Develop a (or modify an existing) database to serve as a central repository for monitoring data consistent with CDFW Data Stewardship Policy

Photo by Dr. Philip Leitner and David Delaney

GOAL: Develop an MGS research program that informs conservation and management of the species

» Objective: Support research that addresses important conservation issues

- Measure: Continue research to determine the effect of round-tailed ground squirrel (RTGS) geographic range expansion into the eastern portions of the MGS geographic range; such research should include the topic areas listed in Appendix 2
- Measure: Support research that improves our understanding of MGS population dynamics, including population size, range, distribution, threats and environmental effects; such research should include the topic areas listed in Appendix 2
- Measure: Support research that improves understanding of MGS ecological requirements to inform improved conservation measures
- Measure: Prioritize research on anthropogenic derived threats to MGS conservation based on urgency, feasibility, and availability of funding
- Measure: Identify opportunities during development projects to research MGS response to and use of disturbance areas and features designed for MGS conservation
- Measure: Evaluate the feasibility and effectiveness of translocation, captive propagation, and reintroduction of MGS as a conservation tool

D. Outreach and Education

GOAL: Develop and implement education and outreach programs to inform residents, workers, and tourists about MGS

» Objective: Develop an MGS educational program for the public, including outdoor recreationists

- Measure: Integrate MGS into existing endangered species education programs, at federal, state, and county recreation sites
- Measure: Work with California Department of Parks and Recreation (CDPR) OHV associations and municipalities (e.g., California City) to educate OHV users on the importance of staying on existing roads and trails and avoiding closed areas
- Measure: Develop MGS educational materials for K-12 classrooms

» Objective: Develop an educational program for construction workers and miners

- Measure: Collate existing programs used by consultants for worker briefings; update and revise as necessary
- Measure: Include worker briefings as a requirement for biological monitors designated in Incidental Take Permits (ITPs) for construction projects

» Objective: Develop an educational program for ranchers and farm workers

- Measure: Work with the Farm Bureau, Natural Resources Conservation Service, and other agriculture industry and government organizations to disseminate information to landowners and workers about MGS conservation

Photo by Dr. Philip Leitner

Photo by Ed LaRue

PART TWO:

BACKGROUND INFORMATION ON MOHAVE GROUND SQUIRREL ECOLOGY AND CONSERVATION

This section of the Conservation Strategy provides information on the ecology and conservation status of the MGS. The biology and life history of the squirrel provides essential context for its conservation status, including the threats to its persistence and recovery.

1. ECOLOGY OF THE MOHAVE GROUND SQUIRREL

Description

The MGS is a medium-sized ground squirrel about 9 inches (22 cm) long, including a tail length of about 2.4 inches (6.2 cm) (Grinnell and Dixon, 1918; Ingles, 1965), with relatively short legs. The upper body pelage is 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 (T. Recht pers. comm., as cited in Gustafson, 1993). Recht (1977) observed MGS dorsal hair tips are multi-banded and the skin is darkly pigmented. Both characteristics assist in thermoregulation. The eyes are large and set high in the head, and the ears are small relative to other ground squirrel species in California.

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*. Helgen et al. (2009) revised the genus Spermophilus by splitting it into eight genera. The newly formed genus, *Xerospermophilus*, includes MGS and the RTGS (*Xerospermophilus tereticaudus*). RTGS ranges throughout much of the American Southwest and the western edge of its geographic range abuts the eastern edge of the MGS range. The two species are distinct based on morphological, chromosomal, and genetic characteristics (Hafner and Yates, 1983; Hafner, 1992; Bell et al., 2009; Bell and Matocq, 2011; and Leitner et al., 2017); however, occasional hybridization occurs in contact zones between MGS and RTGS.

Photo by David Delaney

Bell et al. (2010) suggested the two species diverged between 1 and 3 million years ago. The MGS was formerly viewed as distributed on the periphery of the large RTGS geographic range, until Hafner (1992) described a narrow contact zone where the ranges overlapped (see discussion in Gustafson, 1993). 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, and in the National Training Center (NTC) Fort Irwin (see Figure 1) (Zeiner et al., 1990; Leitner, 2008a). Surveys in 2012 indicated additional westward expansion of RTGS into the MGS range to about 10 miles (16 km) east of Kramer Junction (P. Leitner, pers. comm. 9/14/12). Camera surveys in 2018 at NTC Fort Irwin indicated additional areas of RTGS incursion into the eastern portion of the MGS geographic range. Together, these areas of range incursion by RTGS represent a substantial fraction of the overall MGS geographic range.

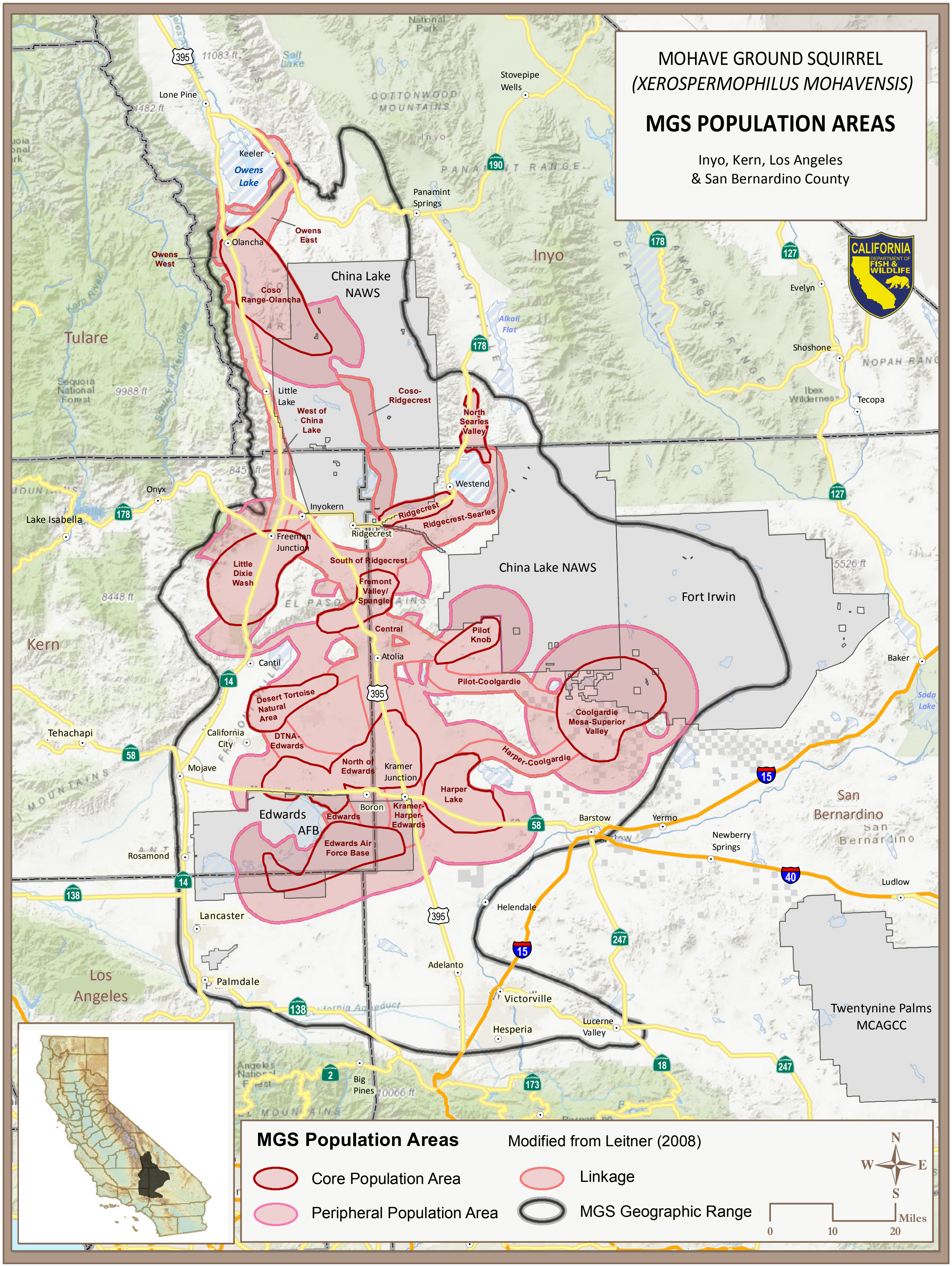

Figure 1. MGS population areas (Source: Modified from Leitner, 2008a)

Differences in habitat selection may reproductively isolate the two species from each other (Wessman, 1977; Hafner and Yates, 1983; Hafner, 1992). MGS prefers sandy soils mixed with gravel and undisturbed desert scrub vegetation, while RTGS prefers soft windblown sand and can subsist in disturbed land (Ingles, 1965; Wessman, 1977; Zeiner et al., 1990; Krzysik, 1994). 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 have not resulted in separation of the two species. Hafner (1992) suggested habitat preference alone did not keep either species from crossing into each other's range beyond the contact zone, since preferred habitat types for both species occurred beyond the boundary of each species' distribution. Behavioral differences may tend to isolate MGS and RTGS from each other. For example, the MGS is a solitary species while the RTGS is generally colonial, which may reduce contact and potential for cross breeding (Recht, 1992 comment letter in Gustafson, 1993).

Although MGS has distinct species status, evidence of hybridization with RTGS was found by Hafner and Yates (1983), who collected two hybrid specimens southeast of Barstow[4] adjacent to agricultural fields and suggested the artificially elevated food supply in these fields may have broken down ecological reproductive isolating mechanisms that normally prevent cross-breeding. Hafner (1992) also collected two hybrid specimens northeast of Barstow[5] 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 NTC Fort Irwin, and an offspring from a mating of a hybrid and pure MGS parents was found near Hinkley (Bell and Matocq, 2011). Additional evidence of occasional cross-breeding has since been found in the contact zones between the species (Matocq, pers. comm., 9/25/2018).

Leitner et al. (2017) collected 55 MGS genetic samples from a study area in Hinkley Valley and desert habitats approximately 6 miles (10 km) west of Hinkley. These samples were added to an additional 72 specimens

previously analyzed by Bell and Matocq (2011) to increase the sample size of the study (n=127). Most specimens analyzed were considered genetically "pure", which means their genomic composition was at least 90% from one species or the other. However, two individuals were identified as second-generation hybrids and three other individuals were identified as backcross MGSs indicating there was some RTGS genetic contribution through ancestry. These results confirm: 1) pure MGS and pure RTGS are living near one another, 2) hybridization does occur, 3) some hybrids are fertile, and 4) backcrossing occurs in both species. Leitner et al.'s (2017) study conveys the importance of continued field surveys combined with genetic analysis. Matocq is currently using new genetic analysis methods to look at larger sections of the MGS genome. In her recent research, she analyzed genetic sections from 608 MGS and discovered six potential hybrid squirrels (Matocq, 2018).

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 (Bell et al., 2009; Bell and Matocq, 2011), indicating hybridization is a rare occurrence and further supporting the retention of full species designation for MGS.

Geographic Range

The MGS has one of the smallest geographic range areas of North American ground squirrels (Hoyt, 1972). Although understanding of the species' geographic range has evolved over time, CDFW currently defines the range as shown in Figure 1[6]. The area within the CDFW geographic range of the MGS as described here and depicted in Figure 1 encompasses approximately 5,136,596 acres (2,078,707 hectares). This depiction of the MGS geographic range includes some areas only sparsely occupied by the species in recent years and excludes the western Antelope Valley (west of State Route (SR)-14) that some authors include within the

range, but which has no confirmed record of MGS occurrence (California Department of Fish and Game (CDFG)1980, Zeiner et al., 1990, Gustafson 1993)[7].

In recent years, extensive live-trapping and camera-trapping surveys were conducted in the southern portion of the MGS range but did not result in detections of MGS. Suitable habitat exists in this area, so it is possible the species persists at some locations within this portion of the range. This may also apply to the Victorville-Lucerne Valley portion of the range, which Gustafson (1993) previously determined was likely not occupied by MGS due to fragmented and converted habitat. There were three detections near Adelanto (west of Victorville; see Figure 1) in the 1998-2008 period (Leitner, 2008a) and an additional detection west of Adelanto in 2011 (Leitner 2013a), but no MGS has been recently detected east of Victorville (Leitner, 2013b).

Distribution

The distribution of MGS within its geographic range is patchy, even within seemingly suitable habitat (Gustafson, 1993). MGS CPAs (Figure 1) have been identified where MGS seem to persist even during years unfavorable for reproduction. Other apparently suitable habitat may be unoccupied due to local extinctions for periods of one to many years before recolonization. Other areas may remain unoccupied indefinitely due to unknown factors reducing habitat suitability or accessibility to dispersing MGS.

Photo by Erica Orcutt

SR-58 bisects the MGS range between the cities of Mojave and Barstow. Extensive trapping efforts between 1998 and 2012 in some areas south of this highway indicate the only known significant population of MGS in this part of the range is a 463 mi^2 (1200-km^2) region in the south central and eastern portion of EAFB (Leitner, 2008a; 2013a). The species appears to be absent in developed portions within and near Lancaster and Palmdale, and east of Victorville (Hoyt, 1972; Leitner, 2008a; 2013a). The paucity of detections between 1998 and 2012 supports Gustafson's (1993) conclusion that the species does not likely persist in the highly developed areas between Antelope Valley and Lucerne Valley. In addition, surveys conducted between 2014 and 2016 at eight Los Angeles County parks only detected MGS at the northernmost park, the Phacelia Wildlife Sanctuary (LaRue, 2016). Except for a possible remnant population near Adelanto (Leitner, 2013b) and reported sightings in Saddleback Butte State Park (California Department of Parks and Recreation (CDPR) Natural Resources Division (NRD), 2004 Table 5; C. Swolgaard, pers. comm. 3/5/2013), surveys throughout the MGS range since 1998 indicate the MGS is absent from most of its range south of SR-58 (Leitner, 2008a;

2013a). This indicates approximately 25-30% of the historical range maybe sparsely occupied by small isolated populations in remnant patches of habitat. If extant in such patches, MGS individuals in these areas would be especially important from a conservation perspective because populations on the periphery of species' range may have different genetic, behavioral, or physiological adaptations than core populations.

North of SR-58, there are additional areas where MGS had not been recently detected prior to more intensive surveys conducted starting in 2016. One area of interest is known as the "Bowling Alley", which is north of EAFB along U.S. Route 395. This area is incorporated in the "North of Edwards" CPA in this document. In an unpublished report by LaRue (2016), 13 MGS, including both adults and juveniles, were captured in the Bowling Alley during a five-day study. Except for a few incidental sightings, the area west of California City has not had MGS detections since 1993 (Leitner, 2008a; 2013a). Between 2009 and 2012, surveys in and around Ridgecrest in areas that had previously showed MGS did not result in any detections. Surveys in 2010 and 2011 yielded no detections in suitable habitat southwest of Ridgecrest (Leitner, 2005; 2013b), indicating some areas of agriculture and low habitat suitability may act as barriers to connectivity within the north and central portions of the MGS range. Consequently, the habitat in these sections of the range is fragmented. In the eastern edge of the MGS range, survey efforts at NTC Fort Irwin indicated declining detection rates and reductions in occupancy (Krzysik, 1994). Krzysik described the NTC Fort Irwin populations as patchily distributed and low density. Surveys conducted in 2013 and 2018 had no MGS detection in the eastern edge of the MGS range in NTC Fort Irwin (Leitner, 2013b; Garlinger, pers. comm., 2/4/2019); however, RTGSs were observed in that area.

Bell and Matocq (2011) described the MGS distribution as consisting of three genetically differentiated 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) studies show genetic exchange occurs throughout the range. 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, Desert Tortoise Research Natural Area (DTRNA), north Searles Valley, and Pilot Knob. South central populations also connect to this genetic hub, such as the area between DTRNA and EAFB, and the populations at Harper Lake and Coolgardie Mesa/Superior Valley (see Figure 1).

Some recently reported detections suggest MGS may have occurred, or could possibly still occur, outside the geographic range currently recognized by CDFW (see Figure 2). For example, a 2005 detection south of Barstow (Leitner, 2008a; California Natural Diversity Database (CNDDB[8]) occurrence #343), and a 2000 detection in Panamint Valley (CNDDB occurrence #448) suggest possible distribution beyond the published range maps. In 2007, an MGS was observed west of the range boundary in Cane Canyon. There has also been a detection in southern Lucerne Valley, east of the range boundary depicted by Leitner (2008a) range (B. Jones, pers. comm. 9/27/12).

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 (the model's depiction of current suitability is shown in Figure 3). While the distribution model mostly aligns with the range published by Leitner (2008a), high detection probability north of Owens Lake is projected for the future, suggesting future climate conditions may be more favorable for the species north of its current geographic range.

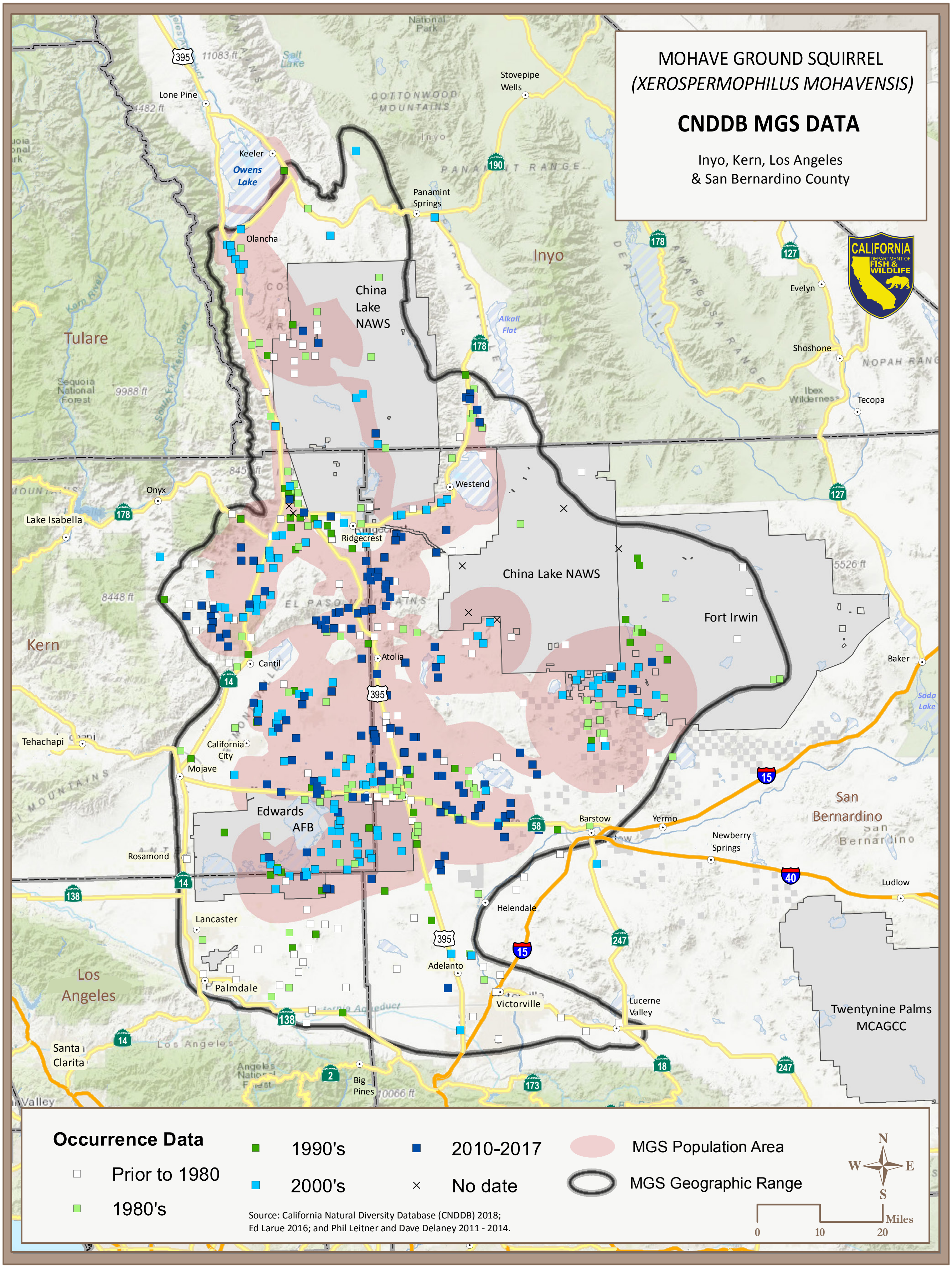

Figure 2. CNDDB occurrence data (Source: California National Diversity Database, 2018 https://www.wildlife.ca.gov/data/cnddb)

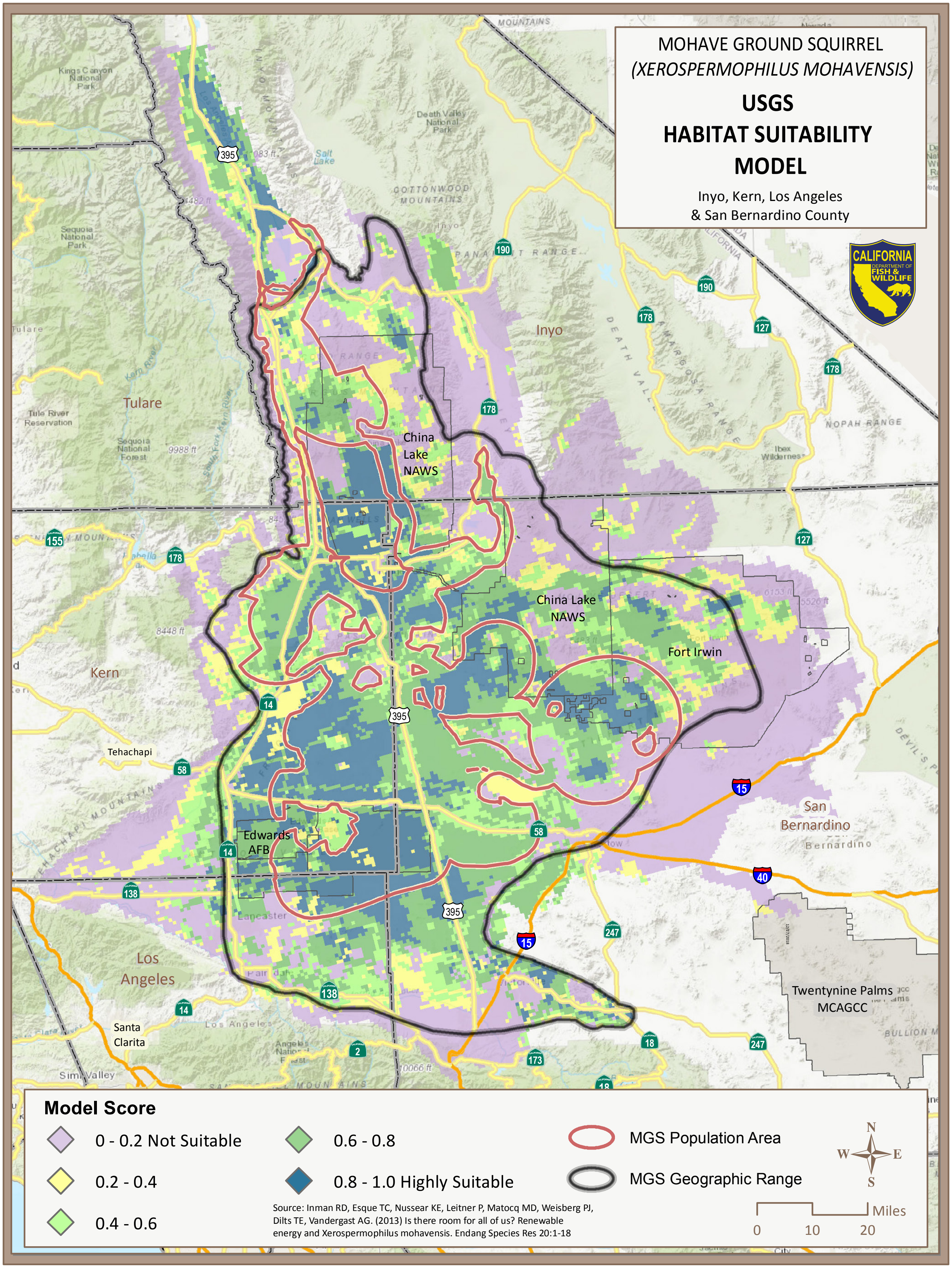

Figure 3. MGS USGS habitat suitability model (Source: Inman R.D. et al., 2013)

Habitat Requirements

Essential habitat features for MGS include adequate food resources and soils with appropriate composition for burrow construction. MGS has been observed exploiting a variety of vegetation and soil types (Best, 1995). Although the 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 substrates as opposed to soft sandy substrates (Hafner and Yates, 1983); however, they have been found in loose sandy substrates and in sand-gravel mixes (Burt, 1936; Brylski et al., 1994; Krzysik, 1994). The species is not known to occupy areas of desert pavement[9] (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 where surface rocks predominate or with shallow soils.

Gustafson (1993) reviewed several studies that provided descriptions of vegetation communities in which MGS had been found. Although a variety of vegetation classification schemes had been used, the overall conclusion was that "it has been demonstrated that the squirrel has been found to occur in all Mojave Desert scrub communities described by Munz and Keck (1959) and Vasek and Barbour (1988), and most of those described by Holland (1986)." Table 1 lists the vegetation communities in which MGS occurs or is suspected to occur (Gustafson 1993).

Munz and Keck (1959)	**Vasek and Barbour (1988)**	**Holland (1986)**
Alkali Sink	Saltbush Scrub	*Desert Sink Scrub*
		Desert Saltbush Scrub
		Desert Greasewood Scrub
Creosote Bush Scrub	Creosote Bush Scrub	Mojave Creosote Bush Scrub
		Mojave Wash Scrub
Shadscale Scrub	Shadscale Scrub	Shadscale Scrub
Sagebrush Scrub	Sagebrush Scrub	
	Blackbush Scrub	Blackbush Scrub
Joshua Tree Woodland	Joshua Tree Woodland	Joshua Tree Woodland
		Mojave Mixed Woody Scrub

Table 1. Vegetation communities in which MGS are known or suspected to occur (Gustafson 1993). Italics indicate subcommunities of Holland (1986) where no specific MGS observations have been reported but where the species likely occurs.

While MGS appear to be habitat generalists, the presence of shrubs that provide reliable forage during drought years may be critical for population persistence (Leitner and Leitner, 1998; Figure 4). During droughts, MGS populations may be extirpated from low quality habitat areas, while higher quality habitat areas act as drought refugia. These areas are distinguished by the availability of preferred food sources (such as winterfat, *Krascheninnikovia lanata*, and spiny hopsage, *Grayia spinosa*) and are necessary to maintain the total MGS population by providing source subpopulations for recolonization of surrounding habitat (Leitner and Leitner, 1998). A combination of shrub vegetation quality and winter rainfall explains much of the spatial and temporal variation in MGS presence and absence (Leitner, 2012).

Figure 4. Prime habitat in Little Dixie Wash and Fremont Valley population centers
(Source Photos: Randi Logsdon)

Inman et al. (2013) used abiotic factors to model habitat suitability for MGS. Species occurrence data were related to landscape characteristics, such as surface texture, topographic position, summer albedo, winter precipitation, air temperature, and winter climatic water deficit (Figure 3). The model showed greater daily fluctuation in the surface temperature of rocks indicates substrate that is sandy or contains small particle sizes (e.g., alluvium) and represents more suitable habitat than solid bedrock with consistent surface temperatures (Kahle, 1987; Inman et al., 2013). However, neither this type of model nor 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, are important factors to consider in combination to determine the quality of MGS habitat.

Home Range and Movements

Adult home ranges and daily movement distances vary annually and through the active season depending on whether it is a reproductive year, as well as on variation in food resources and time in the annual cycle. Harris and Leitner (2004) studied home ranges and movements of 32 adult females and 16 adult males using radio-telemetry in the Coso Range in 1990 and 1994-1997. Adult female home ranges were the largest in a year of extreme drought and no reproduction (1990), and in two years (1995 and 1997) when rainfall was sufficient to support reproduction. During a severe drought in 1990, individual movements between 219-437 yards (200-400 m) per day were recorded by Leitner and Leitner (1998). Harris and Leitner (2004) suggested the extreme drought necessitated larger movements and expanded home range sizes to find scarcer food resources. In reproductive years, such as 1995 and 1997, females' high energetic needs required them to forage over large areas. In reproductive years males cover larger areas than females in the spring to gain access to multiple females. In years of moderate drought and no reproduction, Harris and Leitner (2004) concluded MGS were able to gather enough food in smaller home ranges to support an early entry into the dormant period (aestivation).[10]

Adult male MGS tend to travel greater distances each day during the mating season (February – March) compared to males during the post-mating season or to females throughout the year. Adult females tend to move similar distances throughout the active season (Harris and Leitner, 2004)[11].

Individual squirrels may maintain several home burrows for use at night (Leitner et al., 1991), as well as accessory burrows used as cool temperature refuges and for predator avoidance during the day (Recht, 1977). MGS dig aestivation and hibernation burrows specifically for use during the summer and winter periods of dormancy (Best, 1995). Burrows are often constructed beneath large shrubs, such as *Lycium cooperi, Grayia spinosa* (Leitner et al., 1991), desert willows (*Chilopsis linearis*) (Elliot, 1904, as cited by Best, 1995), or creosote bush (*Larrea tridentata*).

MGS exhibit male-biased juvenile dispersal, with males tending to move much farther from their natal burrows than females[12]. 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 juveniles had larger home ranges than adults. Leitner and Harris (2004) reported all females demonstrate some degree of overlap with their previous year home ranges (mean 41% +/- 16%), with some females showing complete overlap in areas between years, indicating high site fidelity by adult females.

Food Habits

There are few published studies of the MGS diet and feeding behavior. Understanding the food requirements of MGS is critically important to characterize the species' habitat requirements, as well as to guide habitat restoration projects. Two early studies by Recht (1977) and Zembal and Gall (1980) reported visual observations of MGS foraging, providing detailed descriptions of various food items consumed. Recht (1977) observed eight individual MGS feeding on 11 plant taxa. He noted they periodically sampled various foods, presumably to determine best available forage, and basing plant species selection on water content and adequate nutrition. Zembal and Gall (1980) observed MGS feeding on the fruit and seeds of Joshua trees (*Yucca brevifolia*).

Leitner and Leitner (2017) completed an extensive dietary analysis of fecal samples collected during a nine-year ecological investigation of MGS. The study site was in and around the Coso Range in the northern portion of the MGS geographic range. During the study, 754 fecal samples were collected and analyzed using microhistological techniques. Seventy-seven distinct food items were identified in the analysis, which included over 50 plant taxa in 24 families and included other non-plant material (e.g. fungus, bones, and arthropod fragments). However, even with a large array of food items identified, foliage dominated the MGS diet with a relative density of 76.4%. Leaves and stems of shrubs comprised the largest component of plant matter, detected in 75% of all samples, and accounting for 40% relative density. Leaves from forbs comprised the second largest component, with 34.1% relative density and detected in 88% of all samples. The third component consisted of plant reproductive parts (e.g. flowers, pollen, and seeds), which made up 20.3% relative density and detected in 53.2% of all samples. Despite the large number of distinct food items discovered, 71% of the plant portion of the dietary analysis consisted of only eight plant taxa. Of this 71%, more than a third (37%) were three chenopod shrubs: winterfat (*Krascheninnikovia lanata*), spiny hopsage (*Grayia spinosa*) and saltbush (Atriplex spp.). The perennial forb, freckled milkvetch (*Astragalus lentiginosus*), contributed 12.6% of the mean relative density of the diet.

The MGS diet is influenced by season and rainfall (Leitner and Leitner, 2017). During spring, MGS diet predominantly consisted of a few species of shrubs and forbs. However, the proportions of shrubs and forbs consumed during spring varied based on the amount of rainfall over winter. During spring of dry years, MGS relied primarily on the leaves of the three chenopod shrubs mentioned above, comprising more than 66% of the diet; forbs contributed little to the diet. During spring of wet years, MGS diet consisted of 23.6% leaves of the three chenopod shrubs and 50.1% composition of four forb taxa (perennial freckled milkvetch; annuals *Gilia/Linanthus, Lupinus odoratus, Eriogonum* spp.), with freckled milkvetch accounting for 25% of the forb component. During summer, plant matter still comprised more than 50% of the diet, with winterfat contributing 24.6% of the relative density. As in the spring, summer proportions varied based on the amount of rainfall during the preceding winter. During summers after dry winters, more than 50% of the diet was composed of herbaceous leaf material, primarily forbs (42.6%) and a smaller portion made up of shrubs (15.3%). During summers of wet years, 20.7% of the diet was composed of herbaceous leaf material, with winterfat having the highest contributing relative density (29.6%). Flowers and seeds from shrubs and forbs comprised 28.1% of the diet.

Photo by Erica Orcutt

The amount of available food resources has been strongly correlated with reproduction in MGS. MGS reproduction is closely dependent on annual herbaceous plant production (Leitner and Leitner, 2017). One factor strongly influencing the productivity of annual herbaceous plants is the amount of rainfall during winter. MGS reproduction in the Coso Range only occurred when winter precipitation was at least 3.1 inches (80 mm), resulting in greater than 89 lbs/acre (100 $kg \cdot ha^{-1}$) annual herbaceous plants (Leitner and Leitner, 2017). When less than 3.1 inches (80 mm) of rain fell during winter, MGS failed to reproduce in this region.

As mentioned, the extensive diet study completed by Leitner and Leitner (2017) relied upon samples collected in the Coso Range in the northern portion of the MGS geographic range. The more southerly portions of the MGS range were surveyed from 2002-2010 with 68 trapping grids spread out over the south and southwest region (P. Leitner, unpublished data). Shrub density was sampled at all 68 grids. Thirty-one of the 68 grids measured a combined density of greater than 121 plants/acre ($\geq$300 plants ha^{-1}) of winterfat and spiny hopsage. MGS were captured at 77% of these sites with higher winterfat and spiny hopsage density (24/31), compared to captures at only 16% of the lower density sites (6/37). These results suggest abundance of these two shrub species positively relates to the presence of MGS throughout the geographic range of the species.

In an ongoing study, Orcutt et al. (2019) modeled the probability of MGS occupancy at sites where camera surveys were conducted in 2011 and 2012. The camera study sites encompassed non-military lands throughout most of the geographic range of the species, from Searles Valley in the north, south to Lucerne Valley. Vegetation plots at the sites quantified the herbaceous and shrub species present, which were then used to explore the relationship between plant species and likelihood of MGS occupancy. A weak positive association of MGS with woolystar (*Eriastrum* sp.) and desert dandelion (*Malacothrix* sp.) was found. MGS were also more likely to be found where *Schismus* sp. (Mediterranean grass) was less abundant. Schismus is an invasive non-native species that tends to crowd out native herbaceous plants where it occurs. In terms of shrub cover, MGS were more likely to occupy sites as total percent shrub cover increased, and as creosote bush cover decreased. Together, these two relationships suggest that increased shrub cover diversity might improve habitat conditions for MGS; however, this was not a significant model in the analysis.

Seasonal and Daily Activity

The MGS active season is generally five to six months a year. During the active season they reproduce, forage, and prepare for about six or seven months of inactivity (Bartholomew and Hudson, 1960; 1961). During the inactive season, MGS are 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) described the summer period of torpor as aestivation and the winter period as hibernation, with slight differences in body temperature between the two seasons. However, the differences were so small that Best (1995) defined the entire period of torpid inactivity as aestivation. This behavior is an adaptation to food and water scarcity and the energetic demands of 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 eastern 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 February, while 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

Photo by Dr. Philip Leitner and David Delaney

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

MGS are diurnal and may be active only a few hours or throughout the day (Ingles, 1965; Best, 1995). 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 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 occurred only in the morning and afternoon. Recht observed MGS digging shallow depressions in the shade and lying prone in them, allowing excess body heat to transfer into the soil through conduction. Conversely, during periods of cool ambient temperatures, MGS were observed basking in the sun, warming body temperatures by erecting hairs to expose darkly pigmented skin to the sun (Recht, 1977).

Social Behavior

Recht (pers. comm., as cited in Gustafson, 1993) found males defended territories against other males during the mating season, but not against females. Up to four females were observed entering and occupying burrows within the territory of a single 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 Wilkerson and Stewart, 2005) found evidence that males stake out the hibernation sites of females so they can mate with them when they emerge. In Recht's (1977) study, dispersing juveniles established larger, lower quality home ranges than those of adults. Adults kept juveniles out of their home ranges through agonistic behavior. Juvenile home ranges clustered around those of adults and when 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 solitary, with little overlap of their home ranges outside of the breeding season (Burt, 1936; Bartholomew and Hudson, 1960). Recht (1977) found that nine 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 another MGS individual 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 temporal and/or spatial avoidance may occur between them.

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 typically extends from February to mid-March (Best, 1995; Harris and Leitner, 2004). Gestation lasts 29 or 30 days and litter size generally ranges between four and nine pups (Best, 1995). Pregnancy and lactation may continue through mid-May (Pengelley, 1966, as cited in Wilkerson and 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; Aardahl, pers. comm. 7/13/2015). Throughout their nine-year study in the Coso Range, Leitner and Leitner (1998) found females of all age classes produced young, while males generally did not mate until two years or more of age.

MGS reproductive success depends on the amount of fall and winter rainfall (see Food Habits). Evidence exists 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 2.6 to 3.1 inches [65 - 80 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 the timing of winter rainfall is also important. In years where less than 1.2 inches (30 mm) of winter rain had fallen before the end of January, reproduction did not occur. Leitner and Leitner (1992) found 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 (Leitner and Leitner, 1992). In the spring of 1994, following a winter with 2.7 inches (68 mm) of rainfall, there was no evidence of MGS reproduction recorded at the study sites in the Coso Range (Leitner et al., 1995). In NTC Fort Irwin Western Expansion Area (WEA), trapping data in 2006 and 2007 confirmed no reproduction occurred after two very dry winters between 2005 and 2006 (0.89 inches and 0.31 inches [22.6 mm and 7.9 mm]) (Leitner, 2007). However, in 2009, evidence of reproduction was confirmed after two winters of rainfall higher than 2.9 inches (74 mm), likely an adequate amount for forb production (Leitner, 2009).

Photo by David Delaney

Figure 5 illustrates the relationship between MGS numbers and winter rainfall at one of Leitner's study sites over a 9-year period.

Reproductive failure may cause local extirpations in dry years, which may be followed by recolonization after wet years. Annual rainfall less than 2.6-3.1 inches (65 – 80 mm) could result in reproductive failure throughout the MGS range (Leitner and Leitner, 1998). For example, a small reproductive population of MGS has been detected previously in Rose Valley, but after a severe drought from 1988-1991 the population disappeared for five years. After two years of adequate rainfall, MGS moved onto the site and reproduced (P. Leitner pers. comm. 6/27/18).

Interaction with other Ground Squirrel Species

INTERACTION OF MGS AND RTGS

The range of the RTGS encroaches upon the eastern edge of the MGS range (Zeiner et al., 1990). The phylogenetic relationship between the MGS and RTGS is discussed above in the Taxonomy section. Although RTGS range expansion increases overlap with the MGS range, documented occurrences of hybridization are few. Differences in the species' biology may limit interactions.

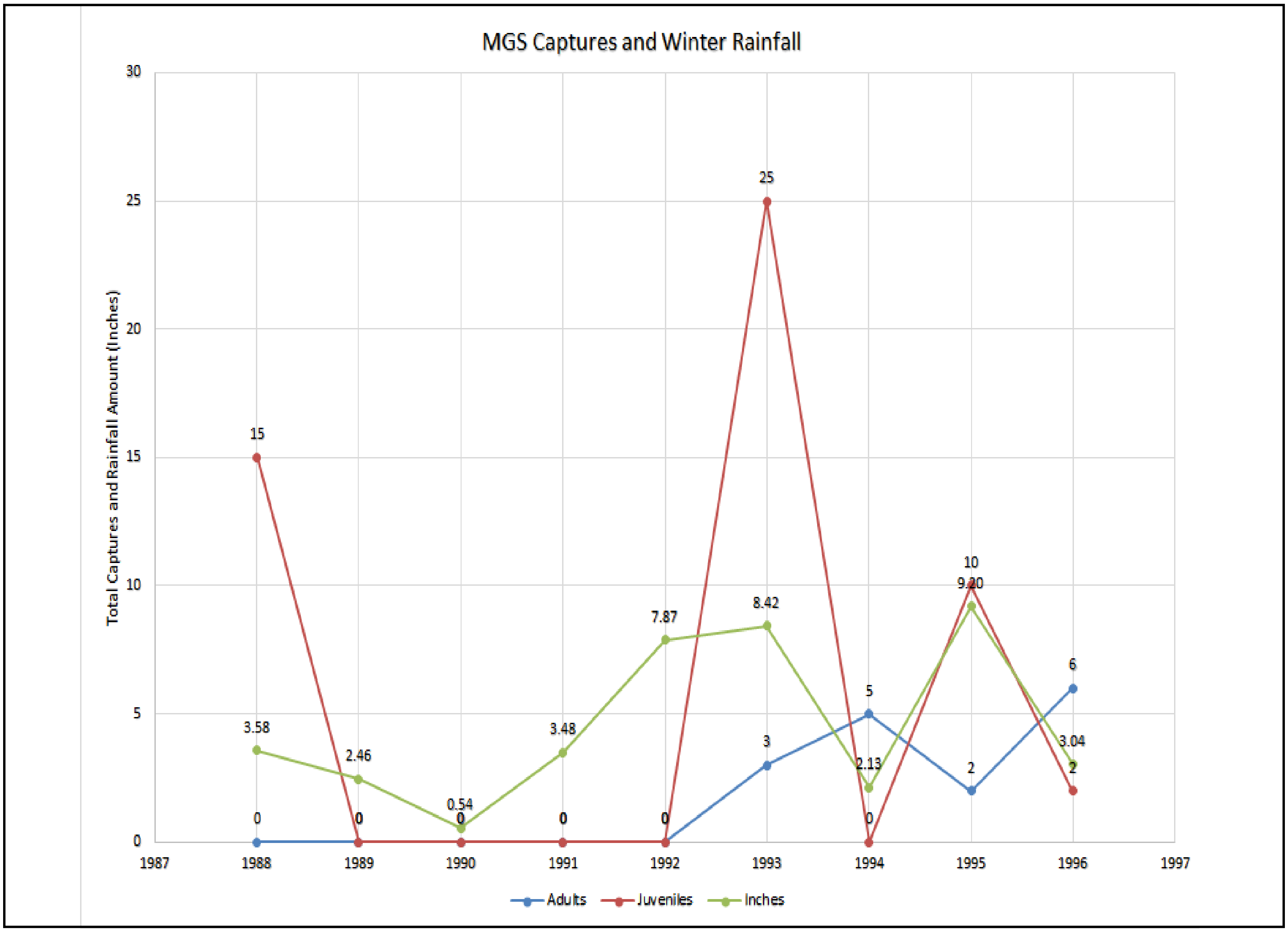

Figure 5. Total MGS captures (adults and juveniles) at the Coso 1 study site in Rose Valley compared to preceding winter rainfall totals (Source: Leitner, pers. comm., 2018).

Hafner (1992) suggested 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). Differences in habitat preference may be a reason MGS moved out of certain areas and RTGS moved in (Krzysik, 1994); however, it is unknown whether the two species occupy different habitat niches in areas where their ranges overlap. Where the two species overlap, little is known about their interactions; however, MGS generally acts aggressively in encounters with other ground squirrel species (Krzysik, 1994).

INTERACTION OF MGS AND WHITE-TAILED ANTELOPE SQUIRREL

The geographic range of the MGS lies completely within the range of the white-tailed antelope squirrel (*Ammospermophilus leucurus*, antelope squirrel) (Zeiner, et al., 1990). While the species are roughly similar in size (Howell, 1938) and food habits (Leitner and Leitner, 1989, 1992), apparently little competition exists between them (Delaney, 2012; Leitner, 2012). Leitner and Leitner (1989) found the 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 predominating and forb foliage lesser in importance. Arthropods comprised about 21% of the antelope squirrel's diet, as opposed to less than 10% of 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). Antelope squirrels' diet of predominantly seeds, a food resource that remains available long after maturation (Leitner and Leitner, 1990), as well as a remarkably high thermal neutral zone (Bartholomew and Hudson, 1961), allows antelope squirrel activity to occur all year without aestivation. MGS torpor effectively eliminates contact between the two species for more than half of the year (see Seasonal and Daily Activity above).

Observation of interspecific interactions indicate MGS individuals appear dominant and displace antelope squirrels (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) similarly observed MGS's dominant behavior at camera bait stations where the two species interacted. While the antelope squirrel is far more common and widespread with a much larger geographic range than the MGS (Zeiner, et. al., 1990), the antelope squirrel does not appear to outcompete or displace MGS.

INTERACTION OF MGS AND CALIFORNIA GROUND SQUIRREL

Less is known about interactions between the MGS and California ground squirrel (*Otospermophilus beecheyi*). Wessman (1977) stated California ground squirrels stayed close to haystacks and agricultural fields and generally did not extend into natural habitats. Similar to RTGS, the MGS's 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 more aggressive (Wessman, 1977; Krzysik, 1994).

Predators

Little information exists on predators of MGS. 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. A single predation event by a prairie falcon of an MGS was recently documented at a baited camera station at EAFB (Zimmerman, 2018).

Harris (pers. comm., as cited in Wilkerson and Stewart, 2005) noted MGS could be vulnerable to common raven (*Corvus corax*) predation. Raven populations increased over 15 times in the western Mojave Desert between 1968 and 1988 (Boarman, 1993) and continued to increase dramatically over the decades that followed (Boarman et al., 2005; Fleischer et al., 2008). The increase in raven populations directly relates to increases in human occupation and subsidized food resources for ravens (Boarman et al., 2005, Fleischer et al., 2008;). Leitner (2005) reported ravens may capture and take MGS, since they are known to prey on other species of ground squirrels. There are 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[13]. Harris (pers. comm., as cited in Wilkerson and Stewart, 2005) found empty MGS radio-collars (sometimes with blood and hair present) on or under Joshua trees that commonly served as perching and nesting sites for ravens.

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). Defenders of Wildlife also identified the gopher snake (*Pituophis catenifer*) and desert kit fox (*Vulpes macrotis arsipus*) as likely predators (Wilkerson and Stewart, 2005).

Population Size and Trends

Currently, no estimate of total MGS population size exists, nor was population size estimated for state and federal status reviews of the species (Gustafson, 1993; United States Fish and Wildlife Service (USFWS) 2011, Fed. Reg. 76:62214). The challenge of monitoring the abundance and distribution of MGS stems from difficulty in detecting the species during most of the year. MGS avoid harsh conditions in their environment, including intense summer heat, cold winters, lack of water, and low primary productivity, by hibernating in the winter and aestivating during much of the summer and fall. During particularly dry years, the squirrels do not reproduce, further reducing aboveground activity during the spring and summer.

Although estimates of population size and density are problematic, some conclusions regarding population trends and regional occupancy can be made from live-trapping data. 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 (Brooks and Matchett, 2002). Declines in trapping success in the 1990s did not correlate with either variations in trapping methods or annual rainfall patterns (Leitner, 2008a). Leitner (2008a) summarized information from multiple trapping studies conducted from 1998 – 2007, including project-driven surveys, regional field studies, and incidental sightings. Although the most intensely sampled, the southern portion of the range yielded fewer than five detections outside of EAFB (Leitner, 2013b), while data from the CNDDB indicated dozens of detections before 1998 in the same areas (Figure 2).

The Coso Range within the Naval Air Weapons Station China Lake (NAWS China Lake) has been one of the most consistently surveyed MGS locations, with studies spanning over a period of 30 years. While data from all years are not available, large fluctuation in numbers of individuals captured between 1988 and 1996 is apparent (Leitner and Leitner, 1998). It is important to note this area has had little to no disturbance, and sites with no recruitment were associated with seasons of low rainfall (Leitner and Leitner, 1998).

Throughout the geographic range of the MGS, there are a few areas where populations have consistently been found. Leitner (2008a) identified geographic areas of known populations, including four CPAs with the highest levels of persistence and detection rates, listed below (Leitner 2008a) (See Figure 1):

1. Edwards Air Force Base – The southeastern portion of EAFB from south of Rogers Dry Lake to the southern and eastern borders of the base, approximately 76,814 acres (31,086 ha)

2. Little Dixie Wash – The broad valley extending from southern Indian Wells Valley to Red Rock Canyon State Park, approximately 97,231 acres (39,348 ha)

3. Coso/Olancha – The western section of the Coso Range within the NAWS China Lake and adjacent areas to the northwest, from the town of Olancha to Rose Valley, approximately 111,762 acres (45,228 ha)

4. Coolgardie Mesa/Superior Valley – The area north of Barstow from Coolgardie Mesa toward Superior Valley on a 3,000-foot (914 m) elevation plateau, stretching north across the Goldstone Deep Space Tracking Station in NTC Fort Irwin onto the Mojave B Range of NAWS China Lake, and south to the Calico Mountains, approximately 127,552 acres (51,618 ha)

In addition to these persistent population areas, Leitner (2008a, 2013a) identified other CPAs of MGS north of State Highway 58.

1. Desert Tortoise Research Natural Area – This area includes the DTRNA itself, as well as land immediately adjacent to the west, south, and east along Randsburg-Mojave Road, approximately 42,072 acres (17,026 ha)

2. North of Edwards Air Force Base (including the area colloquially referred to as "The Bowling Alley") – The area lies generally north of EAFB and Kramer Junction along SR-58, including Boron and the Borax Mine area, covering approximately 5 miles (8 km) to the east and 20 miles (32 km) to the west of U.S. 395, and about 12 miles (19 km) north of Kramer Junction on the east and about 7 miles (11 km) north of Rogers Dry Lake on the west (south of the developed portion of California City), approximately 123,756 acres (50,082 ha).

3. Pilot Knob – This area extends approximately 15 miles (24 km) southwest from the NAWS China Lake Mojave B Range to the north end of Cuddeback Dry Lake, approximately 25,339 acres (10,254 ha)

4. Ridgecrest - The valley between Ridgecrest and Searles Dry Lake, in and outside of the southeastern border of NAWS China Lake, along SR 178, approximately 19,442 acres (7,868 ha)

5. North Searles Valley – This area extends approximately 10 miles (16 km) north of Searles Dry Lake, approximately 17,430 acres (7,054 ha)

6. Harper Lake – This area is located west of Hinkley, along Highway 58 from Harper Lake to 5 miles (8 km) east of Kramer Junction, extending to approximately 15 miles (24 km) east of the junction, approximately 68,061 acres (27,543 ha)

7. Fremont Valley/Spangler – This area extends from east Fremont Valley to just southwest of Spangler Hills and Teagle Wash, approximately 40,236 acres (16,283 ha)

Based on available data, these eleven CPAs appear to support persistent MGS populations; however, the population size or trend has not been characterized for any of them. Because the preceding winter's rain dramatically affects rate of population growth or decline, surveys over multiple years would be needed to characterize population size.

Based on the continued loss of habitat throughout the species' range and loss of MGS occupancy in large portions of southern and eastern portions of the range, CDFW concludes the MGS population overall is likely smaller now than historically, and smaller than when the species was originally listed in 1971. In addition, although the current population trend for MGS cannot be quantified with available data, information from recent camera- and live-trapping studies suggest MGS population densities areare historically low in much of the undeveloped areas of the geographic range. Multiple threats to the species, described in the follow section, contribute to these historical and current trends.

2. THREATS

Major threats to MGS recovery are range contraction, habitat loss, habitat degradation, habitat fragmentation, and climate change, including increased severity and persistence of drought. Loss of occupancy within the MGS geographic range due to loss of suitable habitat is the biggest cause of MGS decline. Reduced areas of contiguous suitable habitat leave the species vulnerable to other major stressors, such as drought-induced local extirpation (Gustafson, 1993). Habitat loss can result from urban and rural development, agriculture, military operations, energy development, transportation infrastructure, and mining.

Habitat quality is an important factor for a healthy, sustainable MGS population. Habitat fragmentation and degradation can reduce habitat quality, resulting in population-level impacts. OHV use, grazing, commercial filming, recreational activity, or the use of pesticides and herbicides can fragment or degrade habitat (USFWS 2011, Fed. Reg. 76:62214).

Climate change also poses a threat to MGS. Projected impacts from climate change include reductions in suitable habitat, constraints on activity due to physiological limits of temperature and water availability, and decreased reproduction during severe and extended periods of drought (USFWS 2011, Fed. Reg. 76:62214). Indirect effects of climate change could include proliferation of invasive species or disease vectors; increased competition or predation from shifts in distribution of other species; and catastrophic natural events, such as fire or flash floods.

Among the most obvious aspects of climate change affecting MGS is increased frequency and severity of drought. With most of the Mojave Desert's annual precipitation falling during the winter, weather patterns that block or shunt winter storms away from southern California reduce vegetation growth important for MGS reproduction. Persistent drought, as occurred during the period 2011 through 2017, also affects survival of long-lived desert shrubs and reduces the seed bank of annual plants, slowing recovery of desert vegetation after the end of the drought period.

Lastly, direct mortality from other human activities, predation, disease, and competition with other species can decrease MGS population size.

Each of these potential threats is discussed in greater detail below. Though one single threat may not severely impact the habitat or the species, the cumulative impacts of multiple stressors could result in jeopardy to the species' existence. The possibility exists that single stressing events or impacts could irreversibly affect a significant portion of the species' range. For example, large-scale development within a single MGS CPA could reduce the viability of the local population, which could in turn significantly reduce the species' overall viability. Therefore, land managers should consider both individual and cumulative impacts to MGS conservation, at both local and range-wide scales, when evaluating and implementing conservation and management actions.

Range Contraction

Restricted distribution and regional extirpations pose risks to MGS (Hoyt, 1972; Brylski et al., 1994). As detailed above under Distribution, MGS appears absent from a large portion of its historical 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 NTC Fort Irwin (P. Leitner, pers. comm. 10/18/13).

Except for the existing population at EAFB, the species was absent from nearly all areas surveyed south of SR-58 for a period of about 15 years (Leitner 2008a; 2013a). In 2005, Defenders of Wildlife calculated the extent of this area at over 1 million acres (400,000 ha), more than 20% of the species' historical range (Wilkerson and Stewart, 2005). Recent studies and incidental sightings have determined remnant populations, or at least dispersing juveniles, may still exist in the southern part of the range (CDPR, 2004; Leitner, 2013b). 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). It is difficult to determine the actual extent of range contraction in the southern region because development projects have largely driven the survey effort and may not fully represent the extent of available habitat (Leitner, 2008a; USFWS 2011, Fed. Reg. 76:62214).

Due to ground disturbing military operations, MGS occurrences in NTC Fort Irwin decreased substantially by the 1990s (Krzysik, 1994; Recht, 1995). Additional surveys since that time suggest MGS no longer occurs in the eastern extent of its range (P. Leitner, pers. comm. 10/18/13). However, the cause of range contraction and regional extirpation, whether habitat disturbance or other factors, is unclear.

Habitat Loss

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 and more of the range was expected to be lost in the future, mostly adjacent to existing urban or suburban areas in the southern portion of the range (USFWS 2011, Fed. Reg. 76:62214). See Figure 6 and Table 2 depicting land use throughout MGS geographic range. USFWS (2011) determined unincorporated areas are likely to have a relatively small loss of habitat to development due to lack of existing infrastructure. Unincorporated areas comprise most of the central and northern portion of the MGS range. Under the highest impact scenario presented by USFWS, all incorporated land within the range of MGS (about 8.9 %) would be developed; however, the USFWS considered this complete build-out unlikely (USFWS 2011, Fed. Reg. 76:62214). Inman et al. (2013) calculated impacts to 16% of the historical range have occurred because of urban development. However, by summing the Inman et al. (2013) and USFWS estimates it appears up to 25% of the MGS range could be threatened by development.

The federal government owns 62% of the MGS range, little of which is subject to development (USFWS 2011, Fed. Reg. 76:62214). Most of this federal land is managed by the BLM and the Department of Defense (DOD). Nearly all lands within the NAWS China Lake and NTC Fort Irwin are lands used by the DOD and unavailable for other public use. The BLM's 2006 West Mojave (WEMO) Plan, 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, which has a 1% disturbance cap (such as building public facilities in recreation areas). About 1.7 million acres (687,966 ha) of important MGS habitat included in BLM conservation lands 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 due to residential and commercial development, golf courses, airports, landfills, wastewater treatment facilities, prisons, flood management structures, and other facilities (USFWS

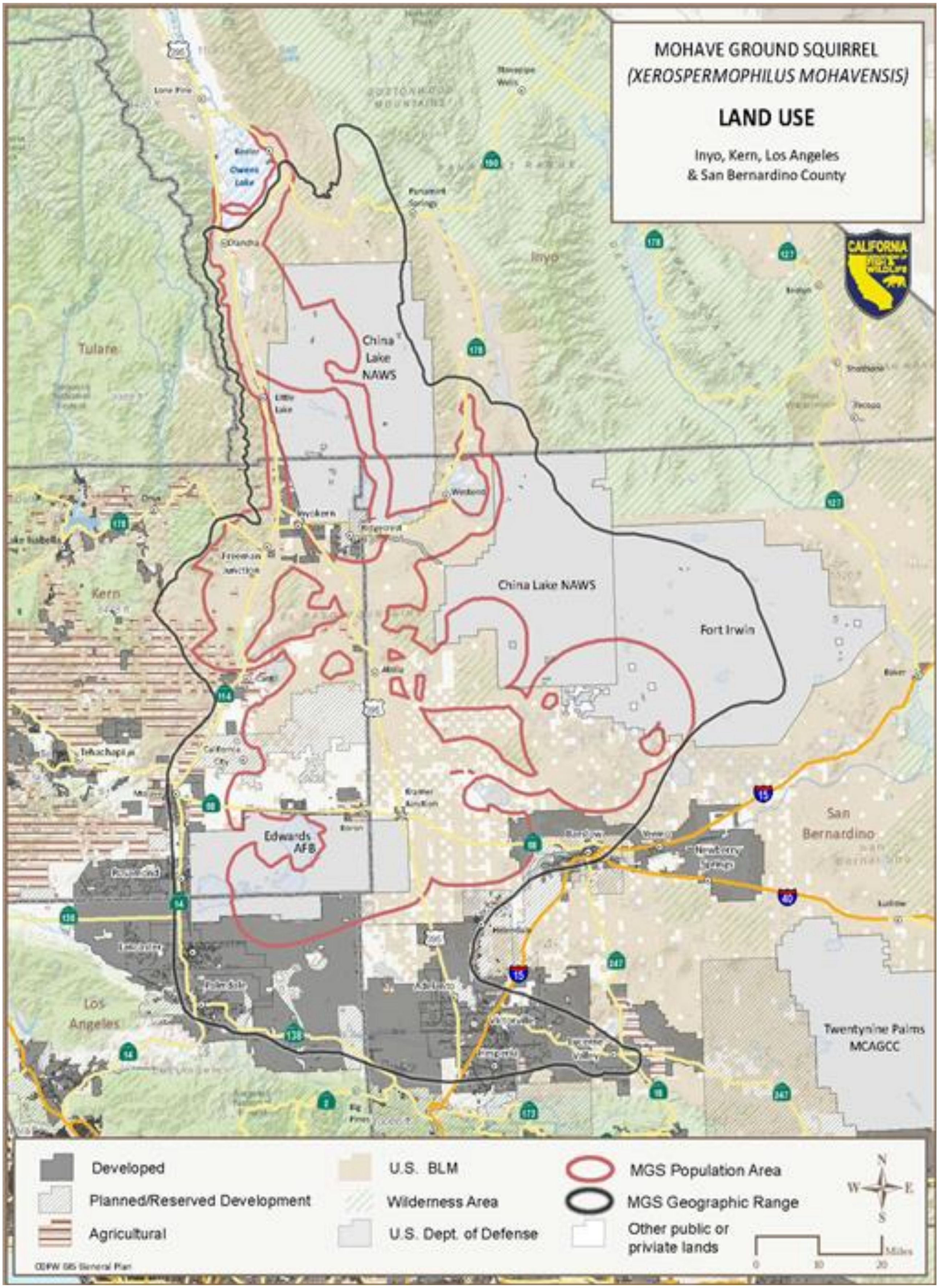

Figure 6. Land use throughout MGS geographic range and population areas (Source: CDFW GIS General Plan https://www.wildlife.ca.gov/Conservation/Planning/Data-and-Tools)

Land Use	Area within MGS Geographic Range (Acres)	Area within MGS Population Areas (Acres)
Developed	781,211.4	95,950.4
Planned/Reserved Dev.	257,887.9	108,160.5
Agricultural	69,467.6	25,240.2
BLM - General	1,643,408.9	968,707.5
BLM - Wilderness	325,148.6	124,317.6
DOD	1,803,767.8	588,898.3

Table 2. Land use throughout MGS geographic range and population areas (Source: CDFW GIS General Plan https://www.wildlife.ca.gov/Conservation/Planning/Data-and-Tools)

2011, Fed. Reg. 76:62214). Most development occurred in valleys, flats, and gently sloping areas, 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, Lucerne Valley, Pinon Hills, and to a lesser extent Trona and Argus. Defenders of Wildlife's geographic information systems (GIS) analysis in 2005 indicated urban development has occurred on more than 108,000 acres (44,000 ha), roughly 2.1 % of the total MGS geographic range, and rural development occurred on more than 28,000 acres (11,000 ha), roughly 0.5 % of the total MGS geographic range (Wilkerson and Stewart, 2005).

Within the MGS range, populations of larger cities (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 Wilkerson and Stewart, 2005; AnySite Online as cited in Wilkerson and Stewart, 2005; U.S. Bureau of the Census, 2011[14]). If this growth continues, human population increase will continue to exert development pressure on MGS habitat.

MGS has been detected in habitat near urban areas and populations near such areas could be directly affected by further development. Though MGS have been observed in or within a few miles of urban areas, it is unlikely they would establish residency in such proximity without access to adjacent undeveloped habitat.

Based on its status review in 2011 (USFWS 2011, Fed. Reg. 76:62214), 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 combined impacts of all large and small development projects could result in regional extirpation of the species, such as possibly occurred in the area east of the City of Victorville.

AGRICULTURAL DEVELOPMENT

Agricultural development results in the conversion of native desert habitat to croplands and orchards (CDFG, 2005a). Habitat loss from agricultural activities has occurred over many decades at several locations within the MGS range. Aardahl and Roush (1985) stated that urban and agricultural development resulted in "significant loss of habitat" for the species. By the early 1990s, more than 39,000 acres (15,700 ha), 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 (USFWS 2011, Fed. Reg. 76:62214).

Agricultural production increased in the Antelope Valley after the mid-1990s due to increased production of fruit and vegetable crops (mainly onions and carrots) (University of California Cooperative Extension, Los Angeles County[15]. The 2006 WEMO Plan (LaRue, 1998, unpublished data, as cited in BLM, 2005, Appendix M) reported that about 4% of historical MGS records originate from what are now agricultural areas. In 2005, Defenders of Wildlife estimated over 92,000 acres (37,000 ha) of MGS habitat—equal to 1.9% of the total habitat–were converted to agriculture (Wilkerson and Stewart, 2005). Agricultural developments in the western Mojave Desert are not always sustainable in the long-term. 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 USFWS 2011, Fed. Reg. 76:62214). Many abandoned agricultural lands within the range of MGS remain fallow in a weedy condition not suitable for MGS (P. Leitner, pers. comm. 3/13/13). An example is a large expanse of fallowed land between Little Dixie Wash and the DTRNA in Kern County that likely precludes dispersal (P. Leitner, pers. comm. 3/13/13). Pistachio orchard development starting in the early 2010s is evident north of Inyokern, where very little intact habitat remains (Logsdon, personal observation, Figure 7).

Figure 7. Agriculture development in MGS range (Photo: Randi Logsdon)

Many MGS CPAs within Kern County were partially zoned by the 2009 County Plan for extensive agriculture (Kern County, 2009). However, USFWS found local agriculture agencies in the west Mojave Desert are not predicting future increases in agriculture development (USFWS 2011, Fed. Reg. 76:62214). If land use designations are changed, much of this land could possibly remain as open space.

In Los Angeles County, abandoned agricultural land is being converted for residential and commercial development (Los Angeles County Cooperative Extension, 2009, as cited in USFWS 2011, Fed. Reg. 76:62214). To the extent abandoned agricultural land is converted for development projects, impacts to intact habitat could averted by focusing development on land already unsuitable for MGS.

MILITARY OPERATIONS

The DOD manages about one-third of the area within the MGS geographic range (See Table 3 and Table 4). These include three major military bases, NAWS China Lake, NTC Fort Irwin, and EAFB. Within the MGS geographic range, NAWS China Lake consists of two units in the north and northeast, EAFB is in the west, and NTC Fort Irwin is on the eastern border (Figure 8). Loss or degradation of MGS habitat at NTC Fort Irwin occurs from ground force training activities in natural areas. These military bases contain cantonment areas, which generally contain offices, housing, shops, restaurants, utilities, and recreational facilities such as golf courses. These developed areas result in similar impacts to those described above under Urban, Suburban, and Rural Development. Analysis in Google Earth shows cantonment areas in NTC Fort Irwin, EAFB, and NAWS China Lake cover approximately 3 square miles (7.8 km2) each (CDFW unpublished analysis). These areas are equal to or larger in size than the developed areas of many small towns and unincorporated communities described in the Development section. Airstrips and related facilities at EAFB and NAWS China Lake exceed the size of airports associated with small communities not on DOD land. The overall development footprint within DOD land, however, is smaller than the total area impacted by the towns, cities, communities, and airports not on DOD land.

Photo by Dr. Philip Leitner and David Delaney

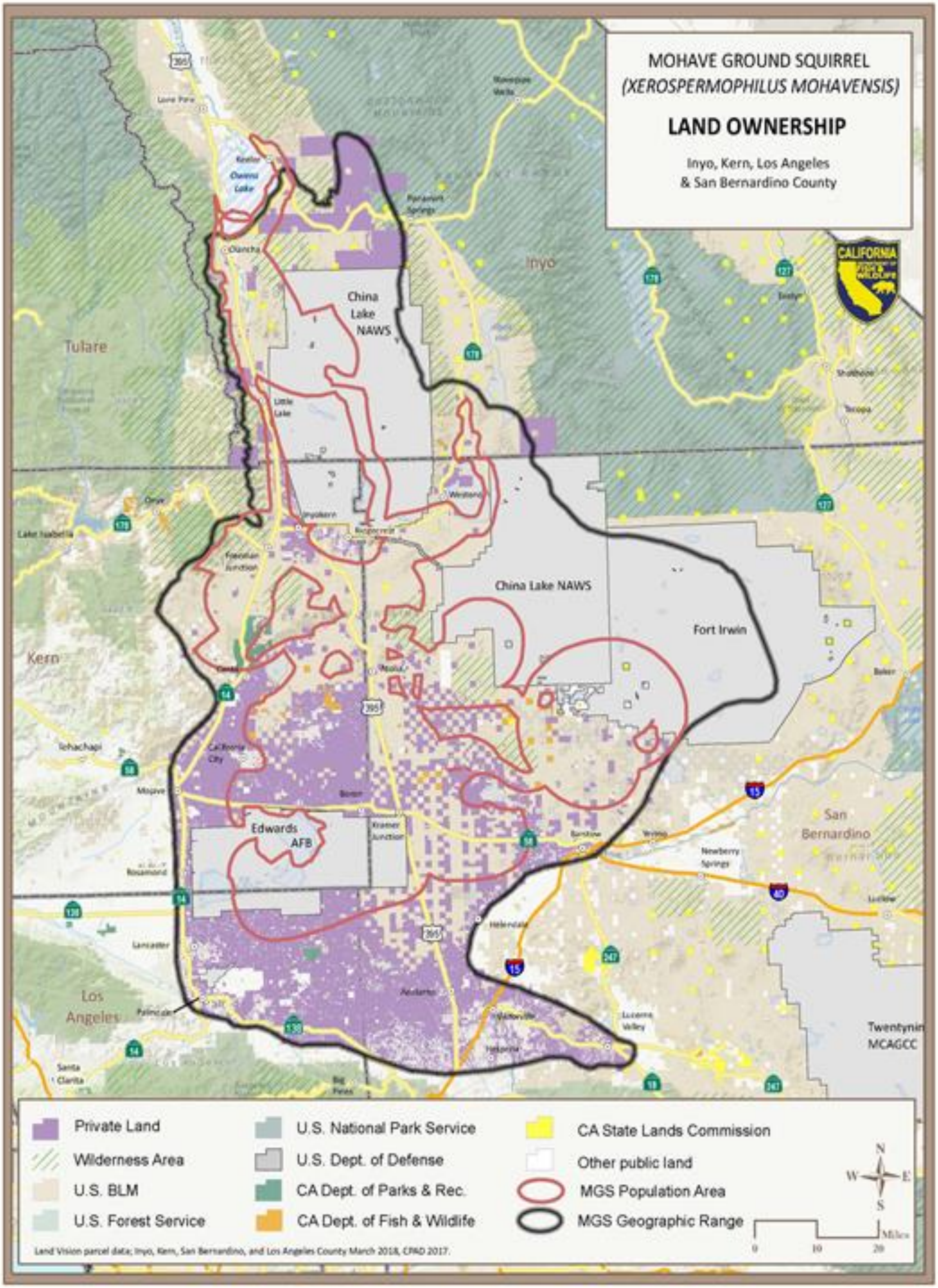

Figure 8. Land ownership throughout MGS geographic range and population areas (Source: California Protected Areas Data Portal (CPAD), 2018 https://www.calands.org/)

Land Ownership	Area within MGS Population Areas (Acres)	Percentage of Area within MGS Population Areas
Private Land	501,464.9	23.2%
US BLM	968,707.5	44.9%
DOD	588,898.3	27.3%
All other public categories	96,372.3	4.5%
Total	2,155,443.0	

Table 3. Simplified land ownership within MGS population areas (Source: Land Vision parcel data; Inyo, Kern, San Bernardino, and Los Angeles counties March 2018, CPAD 2017)

Description	Area within MGS Geographic Range (Acres)	Area within MGS Population Areas (Acres)
Total Area	5,136,596	2,155,443
Land Ownership		
Private	1,442,869	501,465
BLM (incl. Wilderness)	1,643,409	968,708
USFS	22,969	4,081
NPS	43,945	0
DOD	1,803,768	588,898
CDPR	22,083	12,974
CDFW	27,002	21,734
CSLC	22,340	11,364
Other public lands (local, municipality and unknown status)	108,212	46,220

Table 4. Land ownership throughout MGS geographic range and population areas (Source: California Protected Areas Data Portal (CPAD), 2018 https://www.calands.org/)

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 remove MGS habitat within the project area. Military solar facilities could produce up to 7 gigawatts (GW) of power, impacting up to 23,400 acres (9,470 ha) (Kwartin et al., 2012). For example, NTC Fort Irwin could develop up to 17,848 acres (7,223 ha) of habitat inside and outside of cantonment areas for solar power. NAWS China Lake could develop up to 5,315 acres (2,151 ha) of habitat for solar power (Kwartin et al., 2012).

NTC Fort Irwin, including the training grounds on the western margin of NTC Fort Irwin known as the WEA, constitutes approximately 8.2% of MGS range, and ground forces training within the installation impact MGS habitat (USFWS 2011, Fed. Reg. 76:62214). However, ground forces training does not impact all the habitat area within the base. Defenders of Wildlife determined that training at NTC Fort Irwin encompassed about 360,500 acres (146,000 ha) of MGS habitat, which amounts to 7.4% of the total range (Wilkerson and 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 NTC Fort Irwin sites, and found a significant reduction of numbers of MGS captured in 1994 compared to 1993. For example, the Goldstone Unit training site previously had persistent detections of MGS, however Recht (1995) found no evidence of MGS presence in his study.

The USFWS (USFWS 2011, Fed. Reg. 76:62214) determined that use of vehicles during NTC Fort Irwin ground operations would be like the effects of 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 fine grained, creating a less suitable substrate for MGS burrow construction (CDFG, 2005b). Ground operations confined to roads or other denuded areas would reduce impacts on MGS. However, when maneuvers occur on otherwise undisturbed land, tanks and other military vehicles can severely impact habitat quality.

The WEA includes 75,300 acres (30,500 ha) of habitat near the eastern portion of the MGS range (Wilkerson and Stewart, 2005), and contains part of the persistent population described by Leitner (2008a) as Coolgardie Mesa/Superior Valley. The purpose of the WEA was to expand areas for training maneuvers at NTC Fort Irwin. Wilkerson and Stewart (2005) stated 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 Wilkerson and Stewart, 2005; P. Leitner, pers. comm. 11/2/12). The comment letter referenced by Wilkerson and Stewart (2005) stated, "[t]he potential expansion likely represents the single largest threat to the viability of the squirrel." Of concern was the loss of linkage 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 Wilkerson and Stewart, 2005). The 2005 Supplemental Final Environmental Impact Statement (EIS) for the WEA described about 45,000 acres (18,211 ha) of significant impact to MGS habitat (CALIBRE et. al., 2005).

Leitner (2007) concluded from 2006 surveys MGS were widely distributed throughout the WEA and suggested 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. To the extent DOD manages the WEA for conservation, the threat to MGS could be minimized.

Other locations on DOD land, such as the Goldstone Deep Space Communications Complex in NTC Fort Irwin and most of EAFB and NAWS China Lake (more than 1,745,000 acres (706,180 ha), are undeveloped and receive little to no surface impacts from military operations (USFWS 2011, Fed. Reg. 76:62214). In addition, EAFB conducts MGS research and actively implements management practices to reduce threats to its MGS populations (412th Test Wing, 2017; Delaney, 2012; D. Reinke, pers. comm.7/24/12-7/27/12).

DOD maintains buffer areas around its test facilities for safety and security reasons. These buffer areas and the undisturbed land in EAFB and NAWS China Lake, estimated by the USFWS to be 27% of the MGS range, provide de facto conservation for MGS habitat (USFWS 2011, Fed. Reg. 76:62214). 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 Memorandum of Understanding (MOU), 2011). In the case of a national emergency, important population and linkage habitat could be impacted to an unknown degree. To the extent weapons impact the ground, and development of airports, energy facilities, and cantonment areas occurs, NAWS China Lake and EAFB operations could pose a moderate threat to MGS habitat. However, where conservation does not conflict with military readiness, the DOD maintains Integrated Natural Resources Management Plans (INRMP) to protect natural resources including MGS and has agreed to participate in conservation planning with state and federal agencies (REAT DOD MOU, 2011) The status of DOD facility INRMPs is discussed in Part Three.

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, construction of 22 power plants within or near the range of the MGS had occurred (USFWS 2011, Fed. Reg. 76:62214). Several proposals to generate energy using renewable sources within the MGS range (USFWS 2011, Fed. Reg. 76:62214) could have larger impacts on MGS habitat. Proposed renewable energy projects could include geothermal, solar, or wind, or cogeneration projects that combine solar, wind, and/or natural gas.

Federal and state mandates and incentives to reduce carbon emissions and develop renewable energy sources prompted several recent applications to federal, state, and local agencies for 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 like 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 because of renewable energy development.

Geothermal Energy

Some areas that support populations of MGS also have high geothermal development potential. Leitner (1979) discussed the impacts of geothermal energy production, stating it would be very difficult to carry out geothermal exploration and development activities without causing some adverse impacts on MGS habitat. Geothermal energy project construction and operation may also have adverse impacts on MGS habitat (USFWS 2011, Fed. Reg. 76:62214). These impacts include crushing burrows; grading habitat used for foraging, cover, and reproduction; introduction of non-native or 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 (USFWS 2011, Fed. Reg. 76:62214). Although geothermal project sites may be large overall, entire project areas are typically not cleared of vegetation, and patches of habitat remain between disturbed sites.

Geothermal energy projects are restricted to specific areas where geothermal energy is sufficient and near the surface. Two locations in the range of the MGS are Known Geothermal Resource Areas (KGRAs): the Coso Hot Springs KGRA (Coso) on both NAWS 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 acres (42,897 ha) which account for about 2% of the MGS range (USFWS 2011, Fed. Reg. 76:62214). Leitner and Leitner (1989) identified 1,000 acres (405 ha) of impacted habitat in the Coso project area. In 1988, BLM, NAWS China Lake, and CDFG developed a Stipulation for Mitigation of Impacts to the MGS at the Coso KGRA. The Mitigation Plan required the establishment of a 43,448-acre (17,583 ha) Coso Grazing Exclosure Mitigation Program (BLM, 2008). The program includes MGS trapping within the exclosure and evaluations of the MGS populations and MGS habitat every five years for the life of the Project. The Mitigation Plan allows surface disturbance within the Coso KGRA of up to 2,193 acres (887 ha) (BLM, 2008). The surface disturbance calculations are reported annually to the California Energy Commission (CEC). In 2009, completion of the Hay Ranch Water Pipeline allowed for greater latitude in development of geothermal resources into the existing Coso geothermal projects. The entire project is located within approximately 55 acres (22 ha) of land. Other than Coso, no geothermal plants have been developed within the MGS range. However, the BLM is evaluating a geothermal lease for exploration and development at the Haiwee Geothermal Leasing Area in Inyo County[16].

After the Coso geothermal plants were developed, Leitner and his colleagues conducted annual baseline and monitoring studies for nine years within the Coso KGRA. They evaluated the 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.

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. The development footprint of a natural gas facility may be similar to that of a geothermal facility described above, and the nature and magnitude of impacts to MGS habitat could be similar. CDFW is not aware of any studies conducted on natural gas development within the MGS range. However, natural gas facilities 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 built or proposed in the MGS range would impact highly suitable habitat. Figure 9 depicts sites where solar energy facilities are planned or built in or near the MGS geographic range. Solar energy projects include a variety of technologies including solar thermal (power towers, solar trough) and solar photovoltaic (PV) systems. Habitat loss occurs during 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 also operate or are under construction in the West Mojave Desert. Individual utility-scale

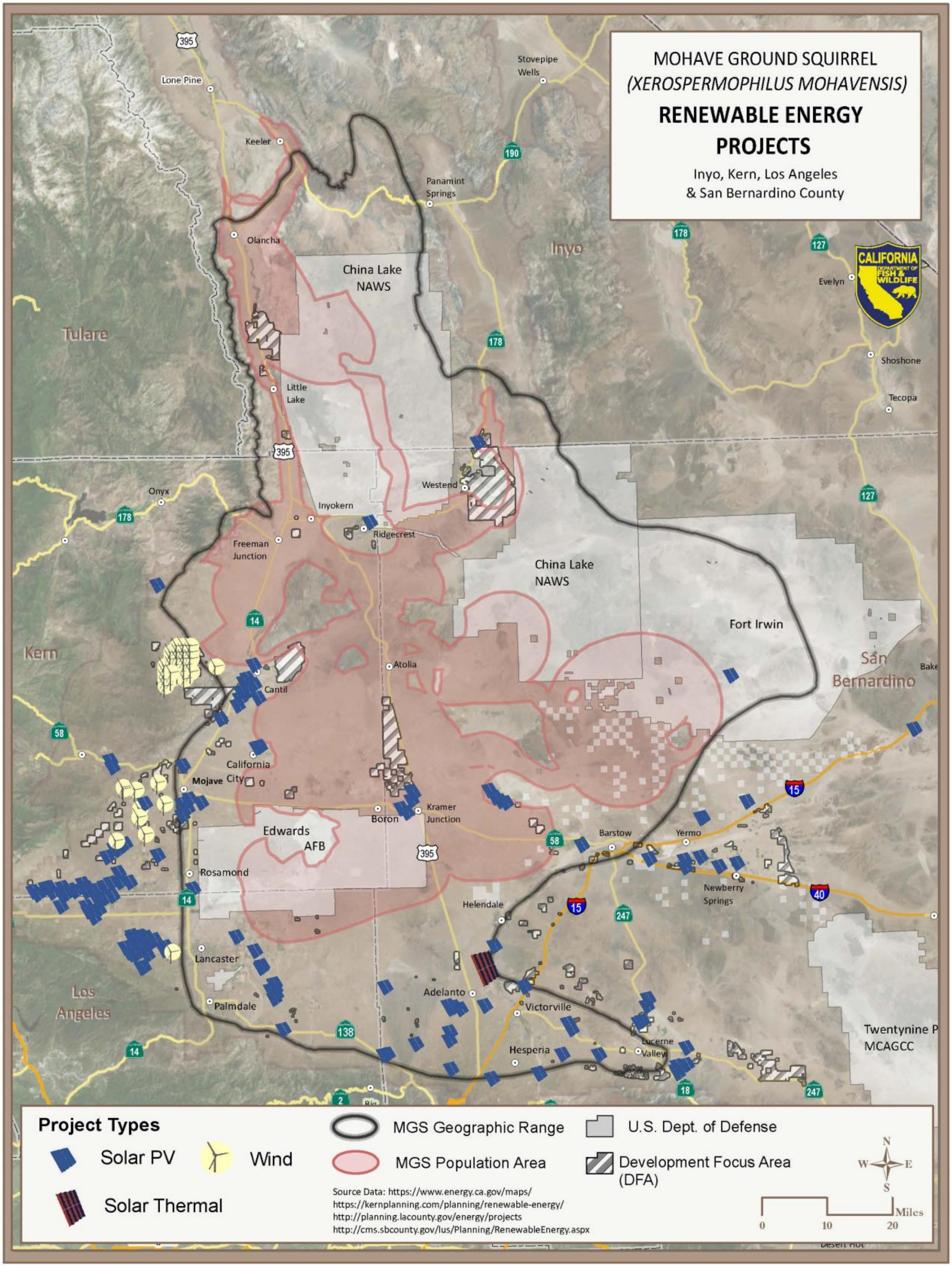

Figure 9. Current and planned renewable energy facilities within DRECP Development Focus Areas (DFA) and MGS geographic range (Source: https://www.energy.ca.gov/maps/, https://kernplanning.com/planning/renewable-energy/, http://planning.lacounty.gov/energy/projects, http://cms.sbcounty.gov/lus/Planning/RenewableEnergy.aspx)

solar projects may occupy 1,000 acres (405 ha) or more of cleared vegetation (USFWS 2011, Fed. Reg. 76:62214). PV arrays have the potential to change surface heat balance and temperature and affect regional weather patterns (Millstein and Menon, 2011), which may affect desert species (Sinervo, 2014). Large-scale development of solar panels generates a substantial urban heat island effect in adjacent desert habitat, raising maximum daily temperatures by between 0.7 °F and 1.4 °F (0.4 – 0.75 °C) (Sinervo, 2014). In another study, the heat island effect over a PV plant created temperatures that were regularly 5 °F to 7 °F (3 – 4 °C) warmer than wildlands at night (Barron-Gafford et al., 2016). This increase in temperature, coupled with increasing temperatures due to climate change, may limit activity during extreme heat events and result in detrimental effects on food availability and habitat quality. Infrastructure projects (e.g., transmission lines, pipelines, substations, new access roads) create additional impacts to the MGS habitat (USFWS 2011, Fed. Reg. 76:62214[17]).

Adverse habitat impacts from construction and operation of solar plants are similar to those described above for construction of geothermal facilities (USFWS 2011, Fed. Reg. 76:62214). However, construction of solar projects typically requires clearing all vegetation 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 (near Kramer Junction and near Harper Dry Lake) occupy a combined 3,600 acres (1,457 ha), or 0.07% of the MGS range (USFWS 2011, Fed. Reg. 76:62214) (Figure 10). The Kramer Junction project converted 1,003 acres (406 ha) of spiny saltbush and creosote scrub, both important species for MGS foraging and cover (ERT, Inc., 1987). Both project sites occur in areas with MGS detections (Leitner, 2013b) and both diminish and fragment contiguous habitat within CPAs. Proposed solar development facilities south of California City (such as the Borax Solar Project), if approved, would further fragment the habitat supporting MGS populations (Kern County, 2012).

In 2014, the Abengoa Mojave Solar Project near Harper Dry Lake in San Bernardino County became operational. The project is located halfway between Barstow and Kramer Junction on 1,765 acres within the MGS

Figure 10. Kramer Junction solar facility (Photo: Alan Radecki)

geographic range[18]. CDFW issued an ITP for the facility requiring mitigation for resulting impacts to MGS (ITP No. 2081-2011-055-06). Currently, Kern County and San Bernardino County are reviewing additional solar facility proposals that could result in impacts to MGS habitat.

The large-scale solar energy production proposed in NTC Fort Irwin and EAFB, described in the Military Operations section above, could result in a much greater loss of MGS habitat than CEC-approved projects. To address these impacts, DOD is conducting research at EAFB to determine whether 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 (D. Reinke, pers. comm.7/24/12-7/27/12). Depending on results of the study, impacts of solar development on MGS habitat in EAFB could be reduced.

Under the DRECP (see Renewable Energy Action Team (REAT) section under Summary of Management Actions below), solar energy development within the MGS range, outside of DOD installations, is restricted to development focus areas (DFAs) (Renewable Energy Policy Group, 2012A).

Wind Energy

Wind energy is like geothermal energy in that habitat between wind turbines may be available for the MGS. Although wind farms may occupy hundreds of thousands of acres, access roads and tower bases (pads) are the only areas where vegetation is completely cleared (USFWS 2011, Fed. Reg. 76:62214). Still, pads can be large (half acre or more), and construction of the wind plant, roads, and ancillary facilities could affect habitat. Ancillary facilities include meteorological towers, substations, 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 (USFWS 2011, Fed. Reg. 76:62214). 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) but could provide some benefits in the long term.

Wind energy facilities are not typically constructed on the flat terrain preferred by MGS. However, some wind energy sites were permitted within the MGS range on flat land south and west of Mojave, in Antelope Valley (Kern County, 2012; CDFG, 2012b). Figure 9 depicts locations of wind energy facilities built, or planned within or near, the MGS geographic range. 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 (see Figures 11 and 12; Table 5). The California Wind Energy Association (CalWEA) identified good wind energy resource areas[19] throughout the MGS geographic range. CalWEA proposed wind energy sites within the MGS population centers at North of EAFB, Little Dixie Wash, Fremont Valley/Spangler and North Searles Valley (Rader and Morrison, 2012; Richmond and Morrison, 2012).

Not all wind power development applications are approved. For example, proposed sites that could also interfere with military radar systems would likely be rejected due to DOD guidance on types and locations of

DRECP (excludes DOD lands)	Area within MGS Geographic Range (Acres)	Area within MGS Population Areas (Acres)
ACEC area	1,611,843.3	1,037,790.8
DFA area	91,136.9	51,075.6

Table 5. DRECP Areas of Critical Environmental Concern (ACEC) and Development Focus Areas (DFA) within MGS geographic range and population areas (Source: DRECP, 2016 https://www.drecp.org/)

renewable energy projects. The DOD evaluated the proposed DFAs in the DRECP and provided feedback on the areas that compromise national security and would not be allowable[20]. However, the DOD proposes to construct its own wind energy projects that may affect MGS habitat; for example, a 49-acre (20-ha) project in NTC Fort Irwin (USFWS 2011, Fed. Reg. 76:62214).

Wind power plants within the MGS range have not been analyzed for impacts to MGS habitat, except through requirements under California Endangered Species Act (CESA) and CEQA or NEPA. The USFWS (USFWS 2011, Fed. Reg. 76:62214) assessed the threat as low relative to other energy development, due to the uncertainties discussed above.

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 intensive vehicular use may also pose a behavioral barrier to movement, thus further fragmenting MGS habitat. Although observations of radio-collared MGS traversing 4-lane divided highways occur, these crossings pose considerable mortality risk (P. Leitner, pers. comm., as cited in Wilkerson and Stewart, 2005). A 1998 vegetation survey conducted in the West Mojave Desert (BLM, 2005) described disturbance along 310 transects studied throughout the range of MGS. The transects were 0.75 miles (1.2 km) in length, totaling 232.5 miles (374 km) of transects. Roads bisected 37 percent of these transects in one or more places.

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 2.5 miles (4 km) from the road (impact zone), depending on the volume of traffic. Dispersed camping, allowed along roads on BLM lands, can also cause disturbance to habitat. CDFW estimated existing paved roads and highways, including both the road surface and disturbed road shoulders, encompass about 313,000 acres (126,667 ha) of MGS habitat, equal to 6.1% of the species' range (CDFW GIS analysis, 2019). However, some studies suggest roads and their impact zones result in minimal to negligible negative effects on small mammals and that roads can result in neutral or positive effects on some species of ground squirrels (Garland and Bradley, 1984; Forman and Alexander, 1998; Fahrig and Rytwinski, 2009). Recent and historical MGS records in spatial occurrence data obtained by CDFW from various sources for the DRECP (CDFG unpublished data, 2012) show linear detection patterns along U.S. Highway 395 (US-395), SR-58, and SR-178. Garland and Bradley (1984) found 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 antelope squirrels.

Garland and Bradley (1984) and Forman and Alexander (1998) suggested 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 on upper hill slopes could have a negative impact on hydrology, causing excessive soil erosion (Forman and Alexander, 1998). Roads can also disturb habitat conditions allowing non-native weedy plant species to spread (Frenkel, 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 .6 miles (1 km). 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 and 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 cotton rats and prairie voles avoided road crossings. Evidence of gene flow between populations throughout the MGS range, particularly north to south (Bell and Matocq, 2011), suggest existing roads currently do not present a movement barrier for genetic exchange (USFWS 2011, Fed. Reg. 76:62214).

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 connection, a bikeway and green energy element[21]. Most impacts to habitat would occur during construction. The corridor would transverse the southernmost portion of the MGS range, which has had very few MGS detections within the last 20 years (CNDDB; Leitner, 2008a; 2013). MGS surveys conducted in 2011 for this project resulted in no MGS detection (ECORP, 2011). CEQA and NEPA clearances for the project were completed and certified in June 2016, with construction set to start soon.

Construction on multiple sections of US-395 and SR-58 are currently being planned or implemented. Areas of US-395 may be realigned and widened from the southern terminus at I-15 to north of Kramer Junction[22]. 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 already developed. However, the northern realignment phase could impact important linkage habitat between the Harper Lake, North of EAFB, and EAFB population areas. The SR-58 widening would extend from Hidden River Road to Lenwood Road, east of Kramer Junction[23].

Construction began on a project in late 2017 that involves a 13-mile (21 km) segment of expressway starting at the Kern/San Bernardino county line to about 12.9 miles (20.8 km) to the east[24]. 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 the projects combined could total about 13,253 acres (5,363 ha), including already disturbed areas (USFWS 2011, Fed. Reg. 76:62214). Some of the widening and expressway projects in the planning phases, awaiting final project descriptions that may differ from those 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 at least two CPAs.

Agencies and partners should work with transportation agencies to identify and plan for small animal under-crossings or large multi-species crossings with wildlife friendly fencing to maintain or enhance connectivity for CPAs, PPAs and Linkages.

MINING

Some mining occurs within the MGS range, including mineral, sand, borates, and gravel extraction (USFWS 2011, Fed. Reg. 76:62214; see Figure 11 and Table 6). Mining can result in the loss of MGS habitat through removal of vegetation and removal or erosion of soils used for burrows. Off-road travel, drilling associated with mining exploration, and access road construction can also result in impacts to habitat (Boarman, 2002). Minerals are usually extracted via adits (a type of horizontal shaft), shafts, or from open pits. The unused material may include overburden, waste ore, and tailings deposited near the mine site. A mining operation may also require office space, storage facilities, and power plants at the mine site (USFWS 2011, Fed. Reg. 76:62214), and construction and maintenance of these facilities may also impact habitat. Construction and maintenance of worker housing (e.g., in Randsburg) pose the same impacts on MGS habitat as urban/suburban and rural development (Boarman, 2002).

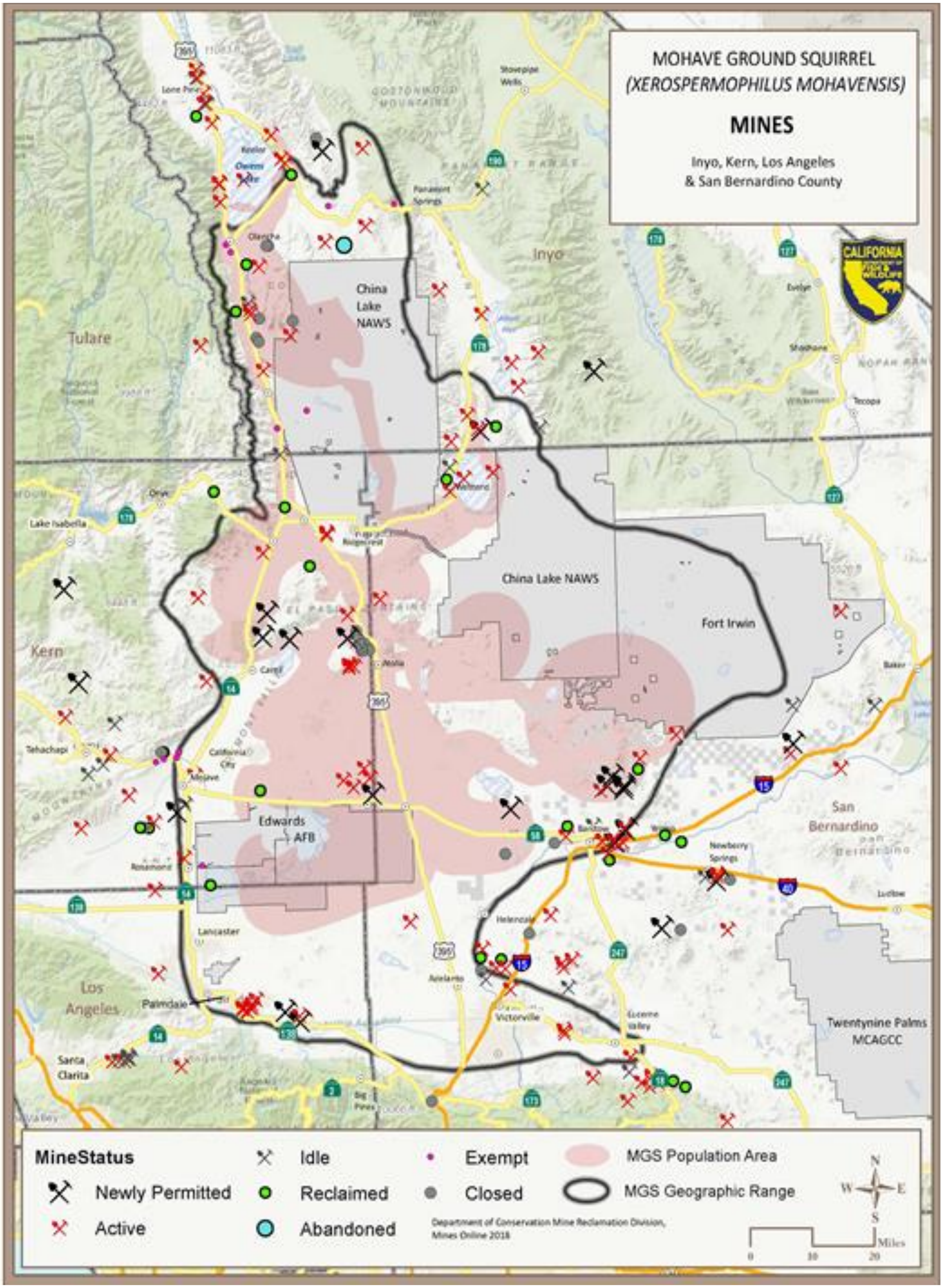

Figure 11. Mine disturbance throughout MGS geographic range and population areas (Source: Department of Conservation Mine Reclamation Division, 2018 http://maps.conservation.ca.gov/mol/index.html)

Mine Area of Disturbance	Area within MGS Geographic Range (Acres)	Area within MGS Population Areas (Acres)
Newly Permitted and Active	66	30
Idle	8	4
Reclaimed	11	7
Abandoned	1	0.0
Exempt	9	3
Closed	15	13

Table 6. Mine disturbance throughout MGS geographic range and population areas (Source: Department of Conservation Mine Reclamation Division, Mines Online 2018 http://maps.conservation.ca.gov/mol/index.html)

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 (USFWS 2011, Fed. Reg. 76:62214) and impacts to MGS habitat are usually required to be offset by protection of other lands prior to permitting. Two active gravel/crushed stone mines are located on the MGS linkage west of NAWS China Lake. The largest open-pit mine in the state of California, the U.S. Borax boron mine located north of Boron, is located in the MGS range[25]. When the Borax mine was approved for expansion, it resulted in an estimated 5,566 acres (2,252 ha) of MGS habitat loss. Habitat surrounding the U.S. Borax Mine, including the conservation easement to the north, supports a viable population of MGS described by Leitner (2008a, 2013a).

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 existing sand and gravel mining sites become depleted, it is likely the mining companies may propose expanding operations. Mine expansion in the MGS range would result in the loss of additional habitat, but USFWS (2011, Fed. Reg. 76:62214) estimated this loss at less than 0.01% of the range (USFWS 2011, Fed. Reg. 76:62214). Small existing or proposed gold and silver mines in the Mojave-Rosamond and Randsburg areas are located on rocky buttes, not preferred MGS habitat (USFWS 2011, Fed. Reg. 76:62214).

Although some mine expansion does not appear to pose a major threat to MGS habitat, the Rand Mine may expand into areas where MGS could be present (R. Jones, pers. comm. 8/21/13), posing a toxic hazard threat. Many of the mines in the Randsburg mine complex have operated since arsenic and mercury were used for gold processing. Residual arsenic and mercury may be carried by rain or streamflow into lower elevations[26]. 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. 8/21/13). It is unknown if the same toxicity occurs in MGS.

Photo by Dr. Philip Leitner and David Delaney

There are no active mines on DOD lands, which comprise about one-third of the MGS range, but mining can occur on conservation lands administered by BLM (USFWS 2011, Fed. Reg. 76:62214) or on county lands designated as "open space" (Los Angeles County, 1980[27]; Kern County, 2012; Inyo County, 2001; URS, 2012). The overall mining footprint throughout the range appears low, except for the U.S. Borax Mine. Most mines are 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, BLM requires mitigation for any new mines planned in the MGS Conservation Area (MGSCA) to help offset potential impacts on MGS.

Habitat Degradation and Fragmentation

Habitat fragmentation occurs when blocks of habitat become disconnected by loss or degradation (reduction in quality) of intervening habitat. This can separate populations of animals and reduce gene flow between individuals. Large-scale fragmentation, such as that occurring over tens of thousands of acres, can result in smaller, 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 can lower the resilience of the species. Even habitat separations resulting from small areas of fragmentation are still unlikely to be crossed by MGS (Gustafson, 1993). For example, a length of 465 yards (425 m) of unoccupied habitat could separate home ranges within a population (Leitner, 1999).

Habitat fragmentation could also prevent other critical metapopulation dynamics, such as recolonization of population areas 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). When rainfall returns to a level that can produce better forage in lower-quality habitat, squirrels may recolonize the lower quality habitat areas. Loss and degradation of habitat between such areas could prevent recolonization, which could pose a cumulative threat to the species.

 

Photos by Ed LaRue

Since Gustafson (1993) identified habitat fragmentation as a cause of MGS decline, habitat has become increasingly fragmented throughout the range and the potential is high for further fragmentation. All the impacts discussed in the Habitat Loss section above 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.

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 OHV use detrimentally affects Creosote Bush Scrub habitat, which is the most ubiquitous and frequently used vegetation community by MGS in the Mojave Desert. OHVs can degrade habitat by collapsing burrows (Bury et al., 1977), damaging shrubs that provide cover, and compacting soil (USFWS 2011, Fed. Reg. 76:62214).

Brooks (1998, as cited in BLM, 2003) and Frenkel (1970) found roads may serve as dispersal corridors for non-native plant species and that non-native plant species are higher in density in areas with high road densities. Non-native vegetation can outcompete 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).

Four open OHV areas managed by BLM exist within the MGS range: Jawbone Canyon, Dove Springs, El Mirage, and Spangler Hills (Open Areas) (Figure 12 and Table 7). In Open Areas, OHV use is not restricted to designated roads and trails. Designated open routes outside of the Open Areas used by OHVs potentially impact MGS. In addition, illegal use of closed routes and the illegal creation of new routes may result in impacts.

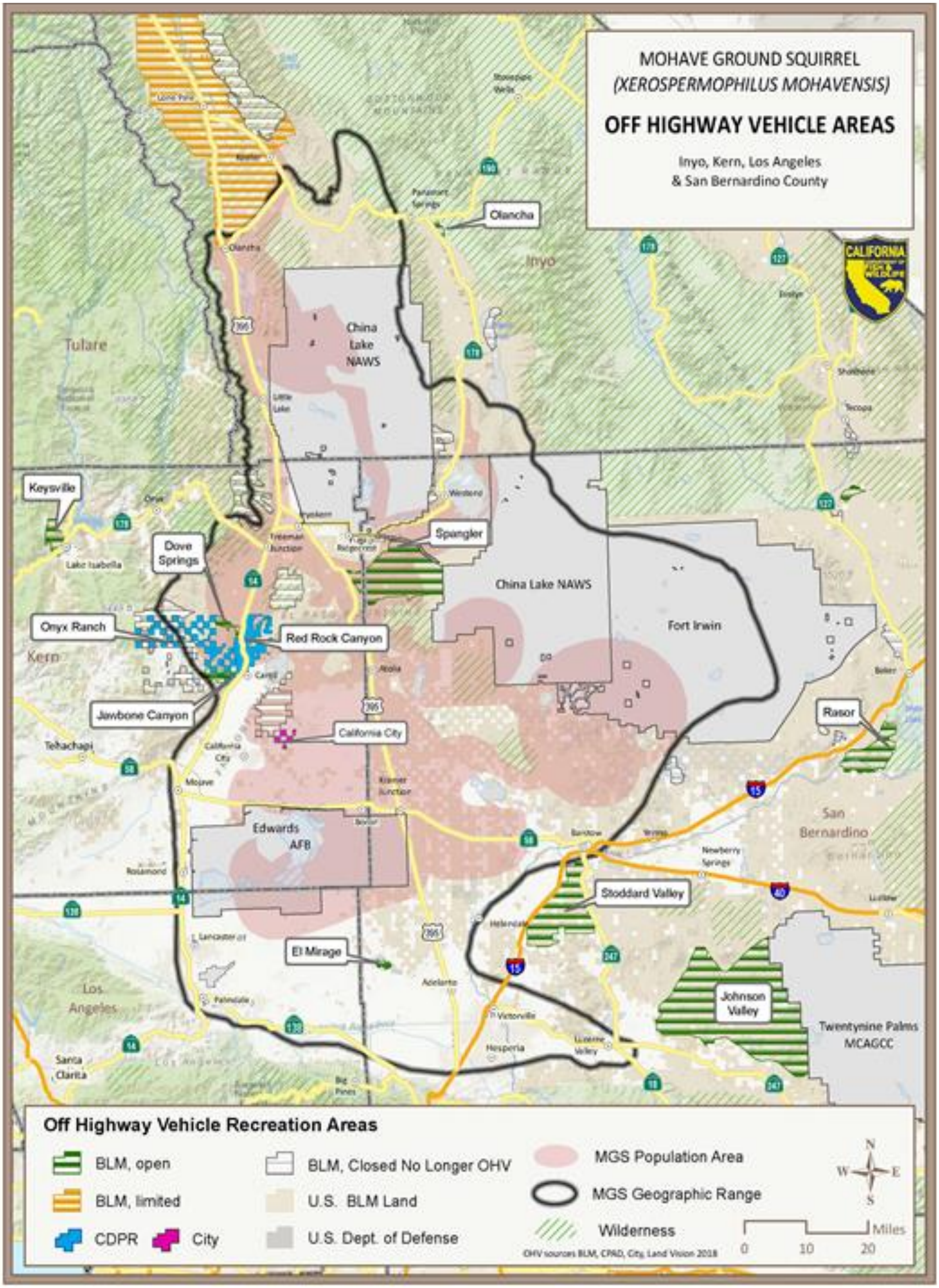

Figure 12. Off-highway vehicle use areas throughout MGS geographic range and population areas (Source: BLM, CPAD, City, Land Vision 2018)

OHV Areas	Area within MGS Geographic Range (Acres)	Area within MGS Population Areas (Acres)
BLM - Open	106,535.6	78,514.6
BLM - Limited	11,775.4	11,686.0
BLM - Closed	100,151.9	35,228.4
CDPR	36,220.2	19,847.2
City	2,471.8	2,471.8

Table 7. Off-highway vehicle use areas throughout MGS geographic range and population areas (Source: BLM, CPAD, City, Land Vision 2018)

BLM (2003) reported that habitats/lands 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 (USFWS 2011, Fed. Reg. 76:62214). Wilkerson and Stewart (2005) estimated nearly 7,400 acres (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 (USFWS 2011, Fed. Reg. 76:62214) calculated the Open Areas plus the "spill-over zones" constitute about 4.6% of the range of MGS.

BLM (2003) stated the spill-over effect from OHV Open Areas caused higher incidents of vehicle impacts, such as strikes on MGS, in land adjacent to the Open Areas than in non-adjacent sites. For example, vehicle strikes may be more likely areas adjacent to the Jawbone and Spangler Hills OHV areas. 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 could result in vehicular strike impacts to MGS.

The 2006 BLM WEMO Plan and its Record of Decision (ROD) revised the designated OHV route network (BLM, 2006) to reduce impacts to desert habitats. A U.S. District Court order required additional revisions to the OHV route network were to further minimize impacts to species' habitat (U.S. District Court, 2011). Currently BLM is evaluating an amendment to the WEMO, called the West Mojave Route Network Project (WMRNP) (See BLM section below).

MGS has been observed in some OHV-use areas, but not others. For example, from 2010 to 2012 no detections were documented in the El Paso Wash area southwest of Ridgecrest, which has an extensive OHV-use network[28]. However, to the south and southeast of Ridgecrest, MGS were observed with a 93% detection rate in the Spangler Hills Open Area (Leitner, 2013b). Recent detections have been documented 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, 2013b). Whether or not MGS reside in or move through OHV-use areas could relate to the location of populations and limits of dispersal, especially as these factors relate to rainfall patterns and habitat availability.

As BLM revises OHV route designations, it is unclear how much the new designations will reduce impacts to MGS habitat. The extent to which OHV use is a limiting factor for 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, suggests habitat degradation caused by OHV use does not prevent MGS occupancy (Leitner and Delaney, 2013).

In 2013, BLM established the WEMO OHV Monitoring Protocol (Doc. 332-3) to document the ongoing extent, usage, and locations of all existing incursions in the WEMO Planning Area (BLM, 2016). The protocol requires BLM to complete field inspections and collect data on field sample routes, using ground observations and aerial monitoring. The Outdoor Recreation Planner and the Field Managers from BLM evaluate the compliance to the OHV route designation and recommend actions to protect the area from unnecessary disturbance[29]. Quarterly reports and a yearly monitoring status memorandum help monitor changes in OHV routes (BLM, 2017). The September 2018 quarterly report indicates implemented actions resulted in restored vegetation and fewer incursions on previously distributed habitat, thus indicating potential for improved management for this type of impact.

In summary, OHV use within the MGS geographic range likely substantially impacts MGS, primarily through habitat degradation. Minimizing development of new OHV areas and maintaining enforcement of resource protection rules at existing OHV areas may prevent further degradation of MGS habitat.

OTHER RECREATIONAL ACTIVITIES

Delfino et al. (2007) stated the Mojave Desert is one of the top outdoor recreation locations in the United States (US). Recreational activities (in addition to OHV use discussed above) may occur throughout the MGS range, inside or outside of OHV Open Areas (Figure 13). Vegetation removal to provide camping accommodations or picnic areas, shooting ranges, competitive racing events, or trails for hiking or running, horseback riding, or dirt bikes may occur. Wildlife viewing (such as birding) and nature photography are also popular recreational uses of the Mojave Desert (Delfino et al., 2007).

The CDPR manages about 22,083 acres (8,937 ha) of land within the MGS range, and CDFW manages 27,000 acres (10,926 ha) (USFWS 2011, Fed. Reg. 76:62214 and CDFW GIS analysis). Portions of these areas provide public access and recreational opportunities. BLM manages most of the federal land 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).

Campers on BLM lands may use any site adjacent to roads and are not restricted 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 events or defensive space around campfires for safety reasons, and may conduct activities off designated trails or roads. Litter (trash, debris, and food items) could attract predators or competitors that drive MGS out of the area.

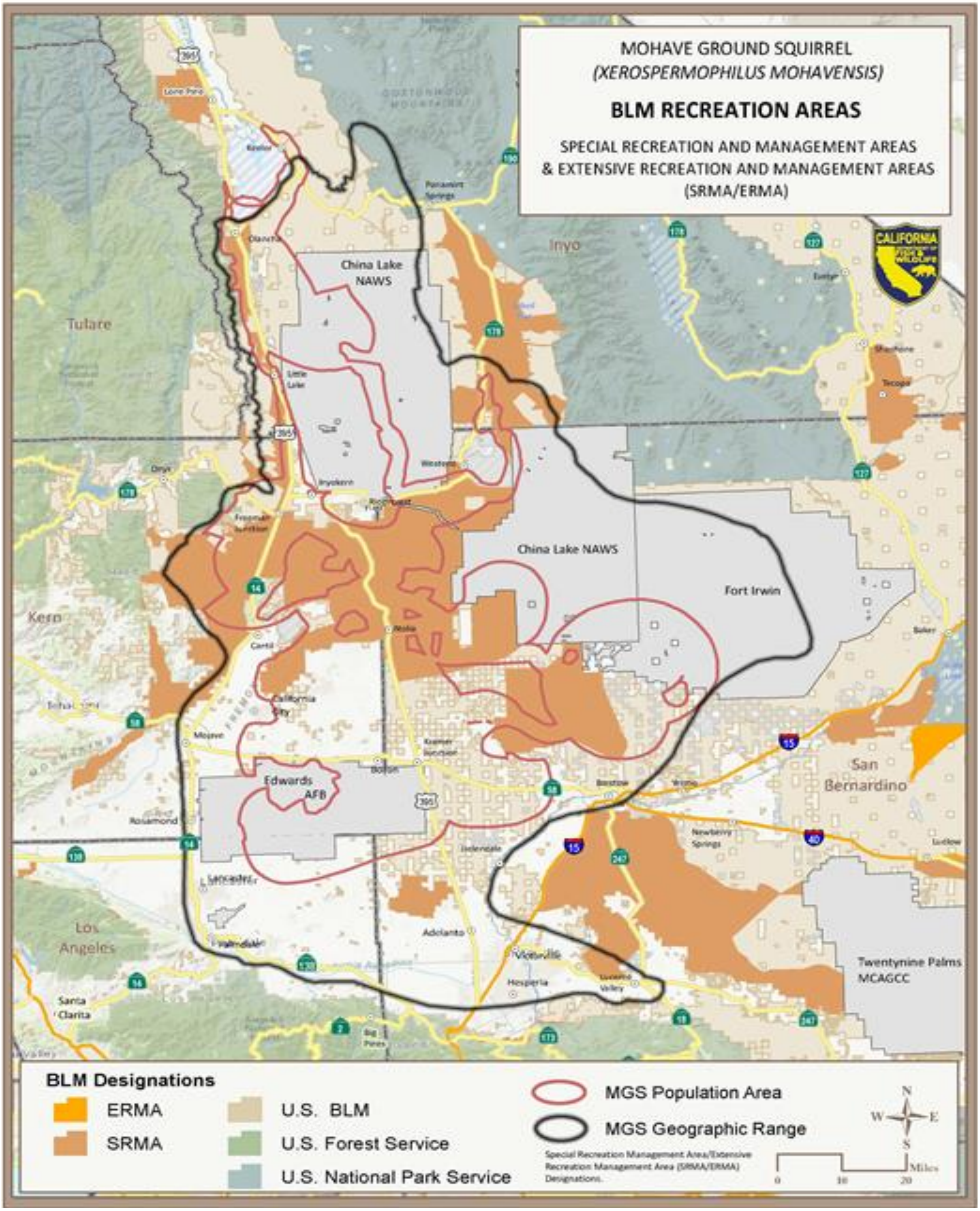

Figure 13. BLM recreation areas within MGS geographic range (Source: DRECP, 2016)

Recreational activities can result in accidental wildfires, which can destroy vegetation. Because wildfires in the desert are infrequent, 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).

GRAZING

Livestock grazing can degrade MGS habitat through changes in soil and vegetative structure, accelerated erosion, and collapsing of burrows (Laabs, 2006). Campbell (1988) stated significant changes in vegetation in the desert tortoise range resulted from a century of livestock grazing and non-native annual grasses partially replacing once dominant perennial native grasses. Aardahl and Roush (1985) found the potential for grazing by sheep and cattle to influence the long-term population of MGS, if such grazing diminishes 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 non-drought years, cattle consumed more non-native grasses, such as *Poa*, *Bromus* and *Schismus* species, than native forbs (Leitner and Leitner, 1989, 1992). 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. Managing the timing of livestock grazing and intensity on native plants, as well as focusing grazing on areas occupied by non-native grasses, could lessen the impacts of grazing on MGS habitat.

Cattle, sheep, and horse grazing occurs throughout the MGS range, on both public and private lands (Figure 14). As of 2005, the total area authorized for grazing (Table 8) within the range of the MGS was about 2.4 million acres (971,245 ha) (calculated from BLM, 2005, Table 3-45). However, livestock grazing operations have decreased overall within the MGS range, with about one million acres (404,685 ha) used for grazing (BLM, 2018). Grazing was allowed in some federally designated wilderness areas, including the El Paso and Golden Valley wilderness areas (Wilkerson and Stewart, 2005). USFWS (USFWS 2011, Fed. Reg. 76:62214), using WEMO Plan data, calculated about 1.7 million acres (687,966 ha) of grazing 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 previously disturbed land. Furthermore, not all allotments are actively grazed. Cattle grazing no longer occurs in NAWS China Lake or EAFB (BLM, 2005, Chapter 4; 412th Test Wing, 2017), and grazing is not allowed within the DTRNA (Campbell, 1988). The Pilot Knob allotment, consisting of about 45,619 acres (38,994 ha) of habitat overlapping a MGS population center described by Leitner (2008a), is no longer used to graze cattle.

Although grazing may result in the degradation of soils and vegetation, the USFWS concluded grazing does not make habitat completely unsuitable for MGS (USFWS 2011, Fed. Reg. 76:62214). Leitner and Leitner (1998) completed a nine-year study in the Coso region evaluating habitat improvements following elimination of livestock grazing. Of four sites studied, two within grazing exclosures and two without grazing exclosures, the study concluded variation in rainfall determined MGS presence and abundance on all four study sites. The study found no correlation between grazing and habitat quality. The study discussed removal of critical shrub species such as winterfat and annual herbs, mostly by sheep, as the only direct effect of grazing.

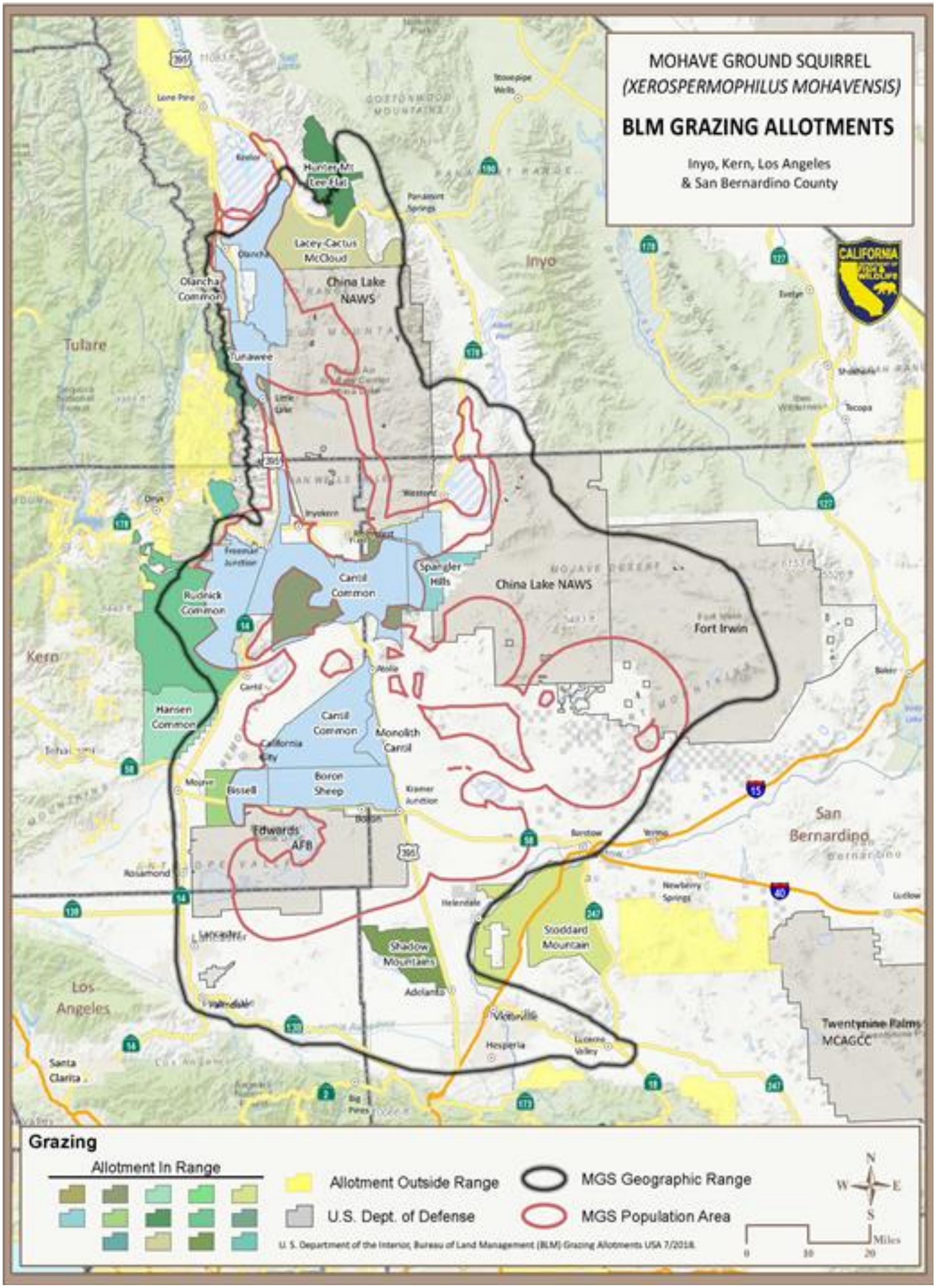

Figure 14. Grazing allotments in MGS geographic range and population areas (Source: BLM, 2018)

	Area within MGS Geographic Range (Acres)	Area within MGS Population Areas (Acres)
Grazing Allotments	1,006,840.5	628,210.0

Table 8. Grazing allotments within MGS geographic range and population areas (Source: U. S. Department of the Interior, Bureau of Land Management (BLM) Grazing Allotments USA 7/2018)

Burros and feral (wild) horses, mostly in the northern portion of the species' range, can also degrade MGS habitat (Abella, 2008, Figure 8; USFWS 2011, Fed. Reg. 76:62214). Wild horses and burros are widespread throughout NAWS China Lake (NAWS China Lake, 2000). Impacts to MGS habitat from feral burros and wild horses are like those of livestock grazing; however, the extent of these impacts is not known. For example, several factors influence feral burro impacts to Mojave Desert plant communities, 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 annual grasses comprise 90% of the burro diet, with Bromus, Schismus, and Poa species making up most of the diet. This observation suggests 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. Like 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., 1984).

Under the Wild Horse and Burro Protection Act, BLM established an ongoing burro and wild horse removal program that reduced the impact of burros on their lands (BLM, 2005, Chapter 2). Since 1981, NAWS China Lake's ongoing program to capture and remove burros and wild horses from its land works toward a long-term management goal to 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 alone may not create a severe impact to the habitat, heavy or long-term grazing in combination with other stressors could accelerate habitat fragmentation and degradation.

COMMERCIAL FILMING

Commercial filming occurs on private and BLM lands in the western Mojave Desert, with particular spots favored for their scenic views. Activities associated with creating motion pictures, television shows, music videos, and commercials may require driving off-road or cross-country (USFWS 2011, Fed. Reg. 76:62214), 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 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) brought onto production sites could potentially cause additional impacts to the habitat through crushing of burrows or vegetation, or grazing. These activities could render MGS habitat less suitable for occupancy, even after production ceases.

The extent to which commercial filming uses have disturbed MGS habitat is unknown, and repeated use of previously impacted areas would likely prevent further impacts on suitable habitat. For example, BLM issues permits for automobile commercials or other commercial filming on the El Mirage lakebed, an area not suitable for MGS (Harris and Leitner, 2005). Previous projects include at least five commercial films shot near developed areas (Barstow, Lancaster, and Victorville) or on DOD land (Delfino et al., 2007), and at least one film produced in Trona. The Antelope Valley Film Office tracked over 220 productions from 2002 to 2003 (Delfino et. al., 2007). Many of these productions were sited in the southern portion of the MGS range, where suitable habitat is patchy and may no longer be occupied (CDPR, 2004; Leitner, 2008a; 2013a).

No study has assessed the level of habitat disturbance filming activities cause, making it difficult to analyze the extent of the threat. USFWS (USFWS 2011, Fed. Reg. 76:62214) found no data indicating filming activities are a major source of habitat degradation. Filming projects in the desert are often subject to NEPA, CEQA, public land, and/or county permits, which may help minimize impacts to MGS habitat.

PESTICIDE AND HERBICIDE USE

Agriculture occurs mostly in the southern portion of the MGS range. Pesticides and herbicides used during agricultural activities, including rodenticides, could expose MGS and its habitat to toxins (Hoyt, 1972). Because MGS eats plants and arthropods, adverse effects to its habitat could result from the loss or reduction of forage due to use of insecticides and herbicides (USFWS 2011, Fed. Reg. 76:62214). The risk of secondary poisoning from ingesting treated plants or arthropods could also harm MGS. In addition, drift of pesticides and herbicides from agricultural fields into adjacent habitat could degrade the quality of the habitat (USFWS 2011, Fed. Reg. 76:62214). Drift of insecticides and herbicides from fields adjacent to occupied habitat, or bioaccumulation of these chemicals from contaminated forage and insects, could have direct and/or indirect effects on MGS health or survival in addition to the impacts on habitat discussed above.

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.

USFWS (USFWS 2011, Fed. Reg. 76:62214) 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. Application of herbicides typically used to target non-native species would not likely impact vegetation used by MGS (C. Otahal, pers. comm. 10/31/12). Agricultural areas are mostly confined to those portions of the range where MGS is no longer detected (see Distribution above); however, some areas of active agriculture in the central and northern portions of the range may exist. Residential areas, particularly small towns and rural communities, occur throughout the MGS range within and near occupied CPAs; however, it is unclear whether private landowners' use of pesticides or herbicides affect surrounding habitat.

INVASIVE SPECIES

The MGS prefers native forbs as forage, as non-native forbs are rarely consumed (Recht, 1977; Leitner and Leitner, 1998). Human 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, such as livestock grazing, can facilitate the invasion of non-native annual grasses (Frenkel, 1970; Resources Legacy Fund, 2012). Non-native species displacing native vegetation and disrupting ecological processes are considered invasive species. By the late 1990s, non-native annual grasses (Bromus and Schismus) were widespread and abundant in the Mojave Desert (Brooks, 2000). Brooks (2000) found evidence of competition between the native forbs and invasive grasses, with a significant correlation between thinning of the invasive annuals and an increase in the density and biomass of native annuals.

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 (*Bromus tectorum*) could also increase the potential for the spread of wildfires, which could destroy important brush species.

Climate Change Impacts

Scientific understanding of the potential threat of climate change to MGS persistence is still limited. However, current analyses suggest it is perhaps the most serious threat to the persistence of the species. Projections of future climate effects on MGS can be modeled, but additional information on the extent or intensity of these effects and how MGS may adapt evolutionarily or behaviorally is needed (Resources Legacy Fund, 2012). Potential scenarios resulting from climate change with potential to adversely affect survival of the species follow (Resources Legacy Fund, 2012):

LOSS OF SUITABLE HABITAT

Data collected in the Mojave Desert region indicate steady increases in mean, maximum, and minimum temperatures since 1890[30]. The University of California, Los Angeles Institute of the Environment and Sustainability projected mean temperatures in Lancaster/Palmdale will increase by about 5 degrees Fahrenheit (°F) (2.8 °C) from baseline temperatures (1981-2000) by the middle of the 21st Century (2041-2060) (Hall et al., 2012). The number of extremely hot days per year (over 95 °F [35 °C]) in the Lancaster area is projected to triple (Hall et al., 2012), and winter freezes in the west Mojave Desert are projected to decrease (Smith et al., 2009; Conservation Biology Institute (CBI), 2013). CBI (2013) models project a maximum temperature increase of up to 14 °F (7.8 °C) 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 (saltbrush and blackbrush) species alliances disappeared in drier 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* (creosote bush) may die after prolonged periods of drought and will only re-sprout 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 forb habitat components suitable for MGS could disappear as changes in precipitation affect the growth and viability of the species. Other related changes, such as nitrification, increased atmospheric carbon dioxide (CO_2), and the timing and intensity of precipitation could cause lower Sonoran Desert vegetation and invasive grasses such as *Bromus tectorum* (cheatgrass) to migrate into the Mojave Desert, changing the composition and availability of suitable flora in MGS habitat (Smith et al., 2009).

The Drought section of this document presents the effects of drought on MGS coupled with lack of suitable habitat. If overall temperatures continue to rise and warmer conditions increase throughout the day or year, such changes could reduce the time available for squirrels to spend aboveground foraging and for other essential behaviors. 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 impacts of climate change likely would combine and interact with ongoing human impacts to habitat quality and population persistence to create a cumulative impact to the species greater than the effects to the species seen to date.

Several areas have been described that may provide suitable habitat for MGS in the face of future climate change (Inman et al., 2016). These include two spatially-explicit areas and two generalized descriptions of areas that likely would be suitable in the future:

- Habitat in Owens Valley north of Owens Lake, including modeled habitat at 0.7 suitability value or higher (Inman et al., 2016), and habitat east and west of Owens Lake that could be used as a corridor from the Olancha-Coso Range population;
- 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; and
- Habitat with an abundance of perennial shrubs, such as winterfat and spiny hopsage, to provide forage during droughts and plants with high water content and shade value.

SPECIES DISTRIBUTION SHIFTS

As climate changes, the distribution of habitat is expected to change as vegetation adapts or shifts in response to changing patterns of sunlight, shade, and rainfall (Resources Legacy Fund, 2012). In addition, USFWS (2012) projected changes in plant communities in the desert regions resulting from increased CO_2 in the atmosphere. For example, some plants may experience increased productivity with higher CO_2 levels, such as the invasive red brome (*Bromus rubens*), while others may diminish due to increased fire frequency or severity (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 temperature increase and precipitation decrease was projected to decrease suitable habitat for the desert tortoise by nearly 66%, and raise the lower elevation of suitable habitat by 728 feet (222 m) 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). On the other hand, bioclimatic modeling studies of Joshua tree distribution project future Joshua tree habitat suitability could significantly decrease in future climates, with a general retraction of its geographic range to the north and to higher elevations (Cole et al., 2011; Barrows et al., 2014). Sonoran Desert plant species may migrate north into the Mojave Desert. Such changes may provide suitable habitat for a concurrent migration of native wildlife, some of which may compete with MGS and may better adapt to changing climatic conditions.

Under the assumption of increased drought and decreased precipitation, scientists predict MGS will move to the north and northwest in response to the changing environment, likely seeking drought refugia provided by foothills of the Sierra Nevada mountain ranges (Delaney, 2012; P. Leitner, pers. comm. 11/2/12). 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 remain suitable for MGS over time (see Figure 3). CBI models also show cooler temperatures and lower water deficits for northern and northwestern edges of the Mojave Desert (CBI, 2013).

Most intact MGS habitat lies in the central and eastern portion of the range—in flat, dry areas projected to heat up substantially more than the cooler and wetter regimes of higher elevations. Because 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 loss already impacts the western portion of the range, south of Fremont Valley. Because MGS habitat may shift to higher elevations as well as to the north and the west, the Sierra Nevada foothills west of the Little Dixie Wash population are potentially a target for a shift in the species' distribution (P. Leitner, pers. comm. 11/2/12), particularly with existing detection data in this area outside of the published range (DRECP data).

Genetic studies suggest MGS can move long distances across the landscape to occupy available habitat (Bell and Matocq, 2011). However, adequate habitat corridors are necessary to facilitate this type of movement as climatic conditions shift. To the extent the MGS adapt to surviving in higher temperatures or higher elevations, the species could find enough suitable habitat to avoid extinction over the next century.

Species distribution models (SDMs) are used to estimate habitat suitability under future climate scenarios. Many studies modeling climate change suggest reduction, alteration, or elimination of plant and animal distributions if trends continue (Pearson et al., 2014). Inman et al. (2016) used a previously developed SDM (Inman et al., 2013) (Figure 3) that incorporated partial dispersal models from field data on juvenile MGS dispersal to project the impact of climate change and energy development on the species. See Table 9 detailing the habitat suitability within MGS geographic range and population areas based on the USGS MGS Habitat Suitability Model (Inman et al., 2013). The environmental covariates used in this model and selected from a previous model developed by Inman et al. (2013) include: surface texture, surface albedo, mean winter climatic water deficit, and precipitation. Future energy development was also incorporated in the model: scale factors were assigned to reduce habitat suitability where energy development may occur. Two greenhouse gas emission scenarios, A2 and B1, were projected annually from 2015 to 2080. Two MGS dispersal scenarios were incorporated into each climate scenario. The first pattern included dispersal and used a data informed pattern, which historically shows long-term gene flow due to juvenile dispersal. The second pattern used a no-dispersal pattern, assuming that MGS dispersal may be limited due to the inability to shift its range in response to climate change.

USGS MGS Habitat Suitability Model	Area within MGS Geographic Range (Acres)	Area within MGS Population Areas (Acres)
Model Score 0.0 - 0.2	1,282,702.8	200,464.6
Model Score 0.2 - 0.4	531,353.4	126,715.2
Model Score 0.4 - 0.6	765,441.3	332,664.9
Model Score 0.6 - 0.8	1,446,784.5	797,995.6
Model Score 0.8 - 1.0	1,099,310.3	697,681.7

Table 9. USGS MGS habitat suitability acres within MGS geographic range and population areas (Source: Inman R.D. et al., 2013)

Under the A2 and B1 emission scenarios without dispersal, the study projected losses of 11.0% and 10.8% (respectively) of current habitat by 2030. Under the same emission scenarios, but with dispersal, the study projected 38.7% and 38.3% more habitat beyond current habitat availability by 2030. Factoring in dispersal uncertainty may result in an offset in the increase of habitat availability by 6.3% and 8.5%. By 2080, under the no-dispersal pattern, using the same emission scenarios (A2 and B1), the study projects losses of 52.7% and 64.0% of viable habitat. Using a dispersal pattern under the same scenarios resulted in a gain of 37.0% and 49.8% viable habitat by 2080. Factoring in dispersal uncertainty may result in an offset in the increase of habitat availability by 6.0% and 2.5%.

The two emission scenarios resulted in a significant overlap of predicted habitat between the two, with 5968 mi^2 (15,456 km^2) (90.8%) of common habitat in 2030. This large overlap suggests high congruence between the two scenarios. By 2080, the overlap decreased to 3,314 mi^2 (8,584 km^2) (65.7%), with predicted overlapping common habitat constrained to the Owens Valley.

The footprint of renewable energy did not vary through time, however, the total area and configuration did. This resulted in differing impacts for each of the time periods. By 2030, energy development with no dispersal resulted in a habitat loss of 168 mi^2 (436 $km^{2)}$ (A2) and 163 mi^2 (423 $km^{2)}$ (B1). Combining these results with the results from the climate scenarios, the loss of habitat is projected to be 707 mi^2 (1,830 km^2) and 692 mi^2 (1,793 km^2). When dispersal was factored in, the results were a gain of 1,818 mi^2 (4,708 km^2) and 1,797 mi^2 (4,655 km^2). By 2080, a similar pattern occurred, with a reduction of 175 mi^2 (453 km^2) under A2 and a reduction of 128 mi^2 (332 km^2) under B1.

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). Climate immigrant 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 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 MGS habitat today (Resources Legacy Fund, 2012). These additional stressors could further exacerbate other climate change threats described above.

USFWS (2012 Chapter 2) projects extreme drought events to 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.

NATURAL CATASTROPHIC EVENTS

Other natural catastrophic events, besides extreme drought, could result from climate change. Less frequent and more intense rainfall events could result (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, and the limited genetic flow to continue between north and south (Bell and Matocq, 2011). To the extent available habitat can support adequately sized refugia and linkages for support of metapopulation dynamics, potential for MGS to adapt to stochastic events may exist. However, habitat must also remain available for the species to recolonize portions of the range previously cut off by these events 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 of communities or extinction of 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.

DROUGHT

Results from the studies described under Reproduction in the Species Description above indicate years with low winter precipitation correlate with low rates of reproduction throughout the MGS range. This may directly impact the overall population size if drought events increase (see Climate Change Impacts below). In drought years, without 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).

Drought years, when annual forbs and grasses are not available, necessitate reliance on certain shrub species for nutrition and water (See Habitat Requirements and Food Habits sections above). Lack of suitable forage from shrub species for non-reproductive individuals during drought years likely increases MGS mortality during torpor. Over time, MGS populations persisted in some areas during drought and these populations later serve as sources for recolonization of areas where local extinctions occurred (Leitner, 2008a). Habitat loss in areas supporting these persistent populations, and activities or landscape conditions preventing movement between source populations and areas suitable for recolonization impede and potentially prevent survival of the species.

Additionally, the MGS is less physiologically adapted to drought conditions than antelope squirrels (Bartholomew and Hudson, 1961), and therefore relies on the vegetation and soil structure of its habitat to behaviorally avoid heat and water stress (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 threat posed by drought is directly tied to habitat loss and degradation. Increased drought events may render some existing habitat areas inhospitable and insufficient to support viable MGS populations. Because drought affects the ability of the species to reproduce in a given year, it also directly and severely impacts population trend.

Competition

Competition is a normal ecological interaction between species. As discussed above in the Interactions with other Ground Squirrels section, MGS shares portions or all its range with three other ground squirrel species (RTGS, white-tailed antelope squirrel, and California ground squirrel), which are nearest to MGS in their ecological niches and thus could pose the greatest competitive threat to the species. Little evidence suggests competition with any of the other ground squirrels, alone, threatens the viability of MGS populations. However, in combination with other threats, such as habitat degradation or increased drought frequency, other ground squirrel species could potentially gain a competitive advantage over MGS. See the Interactions section for more detail on MGS competition with these ground squirrels.

Photo Dr. Philip Leitner and David Delaney

Other mammalian herbivores may also compete with MGS for food resources. Leitner et al. (1989, 1992, and 1995) observed food habits of the black-tailed jackrabbit to assess the potential threat of competition for MGS resources. Winterfat and *Grayia spinosa* constitute 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 (*Schismus arabian*) 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 reduce instances of direct competition.

No documentation exists of MGS competing with other species for resources, other than competition from domestic or wild ungulate grazers discussed in Grazing above.

Direct Mortality

Direct mortality of MGS may occur from vehicle strikes, exposure to pesticides, starvation, predation, disease and other anthropogenic activities (Gustafson, 1993; Bury et al., 1977, and USFWS 2011, Fed. Reg. 76:62214). These potential threats are discussed in detail below.

VEHICLE STRIKES

Fahrig and Rytwinski (2009) suggested small mammals may experience low road mortality due to their greater ability to avoid vehicle strikes relative to larger mammals; they further suggested small mammal abundance does not change due to road proximity. Data in the California Roadkill Observation System (CROS) supports the prediction that small mammal road mortality is lower than mortality of medium-size or large-size mammals. However, the data also confirm a number of white-tailed antelope squirrel road-kill observations in or near Death Valley, just east and north of the MGS range.

MGS have been observed being struck or crushed by vehicles (Gustafson, 1993; BLM, 2003; Wilkerson and Stewart, 2005; USFWS 2011, Fed. Reg. 76:62214; CNDDB). About 3 percent of the more than 400 MGS records 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[31]. 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 most small mammals struck by vehicles statewide are various species of squirrels[32] and many road-killed antelope squirrels were observed near Death Valley, Panamint Valley, and north of NAWS China Lake, not far from the MGS range[33]. Therefore, some undocumented ground squirrel strikes likely have occurred within MGS range, posing a mortality threat to MGS of unknown magnitude.

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 minimized by fencing. Along SR-58 near Kramer Junction, Boarman and Sazaki (1996) observed a significant decrease in small vertebrate mortality where fencing was used to block access to roadways. Use of storm-drain culverts could also reduce mortality risk from MGS road crossings, without the effect fencing may have on fragmenting the habitat. Boarman and Sazaki (1996) observed antelope ground squirrels, as well as other small mammals and reptiles, using culverts along SR-58. Further studies need to be conducted to determine how MGS specifically respond to culverts or fencing to avoid road crossings.

Within DOD land, particularly NTC 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.

INCIDENTAL HARM FROM CONSTRUCTION ACTIVITIES

Incidental harm to individual MGS or their burrows could occur from construction or other ground-disturbing projects. For example, construction can result in MGS mortalities associated with grading equipment or create hazardous situations (e.g., entrapment, vehicular strikes, and predator attraction). Construction activities could also collapse occupied burrows; particularly in project sites where pre-construction surveys do not detect MGS, or when construction occurs during the dormant season.

GROUND SQUIRREL CONTROL METHODS

In the 1800s and early 1900s, the California State Commission of Horticulture launched a statewide campaign to kill all species of ground squirrels using poisoned grains, including in natural areas, affecting 12,299 acres (4,977 ha) in Kern County alone (Jacobsen and Christierson, 1918). Hoyt (1972) observed MGS in alfalfa fields and concluded they "could be easily exterminated by the State Rodent Program." Historically common, ground squirrel control was a common practice historically and could have resulted in the poisoning of MGS. Large-scale ground squirrel control programs continued through the 1970s and directly targeted the California ground squirrel, *Otospermophilus beecheyi*, and similar species known to depredate crops or transmit disease (Dana, 1962).

Currently, ground squirrel control is only legal when squirrels are found damaging crops, gardens, or personal property (Fish & G. Code, §4152); or are harmful (Fish & G. Code §4153), such as potentially carrying or transmitting disease to humans. Control of squirrels for eradicating a potential epidemic may be carried out on a large geographic scale by public agencies; however, these efforts would not target MGS since it has never been known to carry disease (see Disease section). Squirrels may be taken legally 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 tree squirrels can be hunted (e.g., fox squirrels). MGS have been seen in developed areas, such as backyards and parking lots (W. Campbell, pers. comm. 10/26/12), and could be mistaken for other common ground squirrels and lethally taken. However, most squirrel control guidelines are specific to the California ground squirrel and some educate the public on the differences between pest squirrels and other squirrels[34]. As with the threat of vehicle strikes, MGS found in developed areas would most likely be dispersing juveniles, making them more susceptible to this threat than adults.

Although no evidence of illegal shooting of MGS exists, the illegal shooting of wild animals in general, such as desert tortoise, has been documented in the west Mojave Desert (Gustafson, 1993). The cryptic coloring, quick movements, and hiding behavior (Gustafson, 1993) of MGS makes it a less likely target than other wild animals. However, BLM allows hunting and recreational target shooting in Open Areas and motorized access zones (BLM, 2003), or anywhere within the MGS range where shooting is legal, making accidental take of MGS a possibility.

STARVATION

Starvation may be the most common cause of direct mortality of MGS, particularly during torpor if the previous active season does not provide enough forage for adequate fat stores (Gustafson, 1993). This is most likely to occur due to exclusion of juveniles by adults from better home ranges and greater expenditure of energy traveling through larger home ranges to find quality food (Recht, 1977). Adults may respond behaviorally to a lack of adequate food supply; for example, foregoing reproduction and entering aestivation earlier than they would in a year with greater plant production (Leitner and Leitner, 1998). The survival of MGS during drought years largely depends on available forage. For example, where fresh growth on shrubs such as winterfat or spiny hopsage is available, survival during torpor is more likely (see Food Habits section). Leitner and Leitner (1998) suggested preservation of these important plant species on the landscape could minimize drought-induced starvation.

Increasing frequency of severe droughts likely would lead to a decline in the quality of available forage for MGS. Such impacts could exacerbate naturally caused starvation.

PREDATION

The impact of predation on MGS populations is not yet fully known; however, USFWS (USFWS 2011, Fed. Reg. 76:62214) indicated rodents are important prey items for many of the desert predators identified in the Predators section above. The literature documents only a limited number of predation events. Of 36 MGS radio-collared in 1995 and 1997, 12 (33%) showed at least circumstantial evidence of loss to predation (Harris and Leitner, 2005).

Much of the predation on MGS likely occurs naturally; however, anthropogenic disturbance (e.g., litter, road kill) can increase predation pressure by attracting or subsidizing predators (USFWS 2011, Fed. Reg. 76:62214). Boarman (1993, 2002) discussed the impact of raven predation on desert tortoise because of raven population increases subsidized by human activity. While raven predation on MGS has only been circumstantially

observed (see Predators section above), improper disposal of trash, debris, and food waste can attract ravens and other potential predators. This extends beyond developed or residential areas associated with human activity; for example, recreationists in Open Areas can attract predators through littering or unsecured trash disposal. Windblown trash can also create problems at a distance away from areas populated or visited by humans. Artificial water sources, intentional feeding of birds, and food left out for domestic pets may attract ravens or other predators. Vertical structures such as transmission lines and telephone poles provide artificial perching and nesting sites for ravens and raptors. Boarman (1993) noted ravens are known to prey on small mammals including ground squirrels, though the species of ground squirrels were not specified.

Wilkerson and Stewart (2005) thought increasing coyote populations within the west Mojave Desert could further increase predation risk to MGS. However, USFWS (USFWS 2011, Fed. Reg. 76:62214) found no recorded observation or other evidence of coyotes preying on MGS.

Predation by domestic pets and feral animals such as cats and dogs may also be a concern (Gustafson, 1993; Wilkerson and Stewart, 2005). Harrison (1992) demonstrated well-fed house cats prey heavily 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 RTGS. Domestic and feral cats increase as human populations increase; however, no documentation exists on the impact of cats preying on MGS (Leitner, 2005). Domestic and feral dogs are commonly observed digging up rodent burrows (Wilkerson and Stewart, 2005) and have been identified as potential predators (LaBerteaux, 1992 comment letter in Gustafson, 1993 Appendix E). BLM (2005) and USFWS (USFWS 2011, Fed. Reg. 76:62214) did not consider feral dogs to be a significant threat to the species. The threat of predation by cats and dogs is expected to be localized near urban development (BLM, 2005, Chapter 3; Wilkerson and Stewart, 2005); however, recreationists or residents in rural areas may bring or even release domestic pets into natural habitats as well.

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

DISEASE

Information on diseases affecting MGS is limited and more research is needed. However, disease information from other squirrels in California provides context for future work. Sylvatic plague affects California ground squirrels (Zeiner et al., 1990; Leitner, 2005; Foley et al. 2007; CA Dept. Public Health, 2016). The bacterium *Yersinia pestis*, the same pathogen that causes bubonic plague and pneumonic plague in humans, causes the disease. In the early 20th century, infection of ground squirrels in California by sylvatic plague (Jacobsen and Christierson, 1918), provided additional impetus to California ground squirrel eradication efforts. In 2016, California ground squirrels were still being discovered with plague infections in Riverside County (CA Dept. Public Health, 2016). No studies are known on the prevalence of disease or parasites in MGS populations (Leitner, 2005), nor does evidence exist of plague in MGS or antelope squirrels as of 2014[35].

Small mammals such as tree squirrels serve as important hosts for tick-borne pathogens, including Lyme disease and anaplasmosis, while other common rodents such as deer mice (*Peromyscus maniculatus*) can act as reservoirs (McDonald et al., 2018). No evidence exists of tick-borne pathogens in MGS, however ticks have been observed on MGS, indicating the potential for the species to be a disease host or reservoir exists.

USFWS (USFWS 2011, Fed. Reg. 76:62214), in consultation with CDFW and Leitner (2005), found no research or observational evidence that documents or suggests disease is affecting the MGS. The actual threat is unknown, and considered to be low, given the information available.

LITTERING AND TOXIC WASTE

Littering, as discussed above, subsidizes predators. In addition, large items dumped in MGS habitat 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 generally requiring safe disposal could contaminate the environment used by MGS. Little is known 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[36] and MGS occur on at least five of the sites (EAFB and Harper Lake populations).

Evaporation ponds at construction sites can pose a threat for wildlife in general because of the potential for toxic exposure (REAT, 2010). Disposal of hazardous waste could also occur from mining operations or ruptured pipelines. To minimize the threat, the State Water Resources Control Board regulates mining waste, issuing waste discharge requirements to keep hazardous materials out of the environment. However, in 2006 and 2008, several MGS were detected near the Borax mine and in some cases very close to the waste disposal borrow pit (CNDDB).

On the other hand, 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 provided supporting documentation for an application to the California Department of Toxic Substances Control. It also appears 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 necessary to determine whether the hazardous substances cause harm or mortality to individual ground squirrels.

INCIDENTAL HARM FROM SCIENTIFIC RESEARCH AND MONITORING

CDFW requires proponents of development projects to assess the project site for presence of MGS during the environmental review process. This may include live-trapping surveys (CDFG, 2010). Researchers also use live traps to study MGS ecology and population status. Setting live traps for MGS could result in death of individual squirrels through inappropriate handling, excessive heat or cold stress; dehydration, or starvation; or creating an opportunity for predation.

CDFW issues MOUs for MGS research pursuant to §783.1(a), T14, CCR, and Fish and Game Code §2081(a). Fish and Game Code §2081(a) authorizes CDFW to issue memorandums of understanding to public agencies, universities, zoological gardens, and scientific or educational institutions, to import, export, take, or possess any endangered species, threatened species, or candidate species for scientific, educational, or management purposes. Permittees authorized to trap MGS under a CDFW MOU must adhere to strict conditions intended to minimize injury or mortality. More than 10 years of CDFW annual reports indicate no known direct mortality or serious injury to MGS from research (CDFW records).

Photo by Dr. Philip Leitner and David Delaney

PART THREE:

LISTING HISTORY AND MANAGEMENT ACTIONS

Part Three of the Conservation Strategy provides an account of the CESA and federal Endangered Species Act (ESA) listing processes relative to MGS, as well as information on the state and federal agencies managing lands within the range of MGS.

1. LISTING HISTORY

In 1971, MGS was listed by the State of California as Rare, a designation removed by legislation passed in 1985. In the same legislation, the MGS listing status was reclassified under CESA as Threatened §670.5(b)(6)(A), T14, CCR). Under CESA, a Threatened status means the species is likely to become endangered in the foreseeable future in the absence of special protection and management efforts (Fish & Game Code, §2067). In 1991, Kern County petitioned the California Fish and Game Commission (CFGC) to delist the MGS, stating insufficient information in 1971 to warrant the listing (Gustafson, 1993, Appendix A). CFGC accepted the delisting petition for consideration and CDFG prepared a status review report for the CFGC (Gustafson, 1993). CDFG's report concluded the petition failed to provide sufficient information to indicate delisting was warranted and CDFG recommended the species remain listed as Threatened (Gustafson, 1993). The CFGC voted to remove the MGS from the State's list of Threatened and Endangered species. In response to a subsequent petition to overturn the CFGC's decision, judicial review by the California Supreme Court in 1997 determined the initial action to delist was in violation of CEQA and the species remained listed as Threatened (Frost, 2012). No subsequent petitions have been received by CFGC to delist or up list (to Endangered) MGS.

In 1985, USFWS proposed designating the MGS as a Category 2 Candidate for listing as Threatened or Endangered under the federal ESA. Although no longer used, the designation Category 2 Candidate indicated conservation concern for the species, but available data were insufficient to justify a listing proposal. MGS remained a Category 2 Candidate after a subsequent review (USFWS 1994, Fed. Reg. 59:58983). In response to a petition by Stewart (1993) to list the MGS as Threatened, USFWS published a 90-day finding in 1995 of its determination the petition did not present substantial information warranting listing (USFWS 1995, Fed. Reg. 60:46569). 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 (Wilkerson and Stewart, 2005). In 2010, the USFWS made its 90-day finding (USFWS 2010, Fed. Reg. 75:22063), concluding the petition presented enough information to indicate listing may be warranted and started a 12-month status review. In October 2011, after the status review, the USFWS published its finding the MGS was not in danger of extinction, nor likely to become endangered within the foreseeable future and therefore did not warrant listing (USFWS 2011, Fed. Reg. 76:62214). The U.S. Department of the Interior has not received any subsequent petitions to list the MGS.

2. SUMMARY OF MANAGEMENT ACTIONS

State, federal, and local agencies managing the MGS and its habitat support ongoing research and conservation management. These research and management efforts detailed below generally focus on reassessing and protecting the CPAs and linkages established by Leitner (2008a, 2013a).

Bureau of Land Management

BLM's mission is to sustain the health, diversity, and productivity of public lands for the use and enjoyment of present and future generations[37]. Approximately one-third of the MGS range is land managed by the BLM. BLM's 2006 WEMO Amendment to the CDCA Plan stated 1.7 million acres (687,966 ha) for a 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 CPAs described by Leitner (2008a), and provided potential linkages between these populations (BLM, 2005, Chapter 2, Map 2-1). The WEMO Amendment allows for the development of up to 1% of the undeveloped/disturbed lands within the MGSCA. Only portions of the MGSCA overlapping with Desert Wildlife Management Areas (DWMA) designations could receive mitigation, which would be congruent with mitigation for the federally-listed threatened desert tortoise (BLM, 2005). The WEMO Amendment went through a 15-year public planning process and BLM adopted it in 2006 with a few modifications (BLM ROD, 2006).

In 2011, BLM announced preparation of an amendment to the CDCA to modify OHV management within the WEMO Planning Area in response to the U.S. District court remedy order (U.S. District Court, 2011). This amendment, known as the WMRNP, will provide transportation management areas, adopt transportation and travel management strategies, and designate routes on public lands in the WEMO Planning Area (BLM 2018, Fed. Reg. 83:11785). The WMRNP project area consists of approximately 16,000 miles (25,750 km) of OHV or primitive routes within the WEMO planning area (BLM, 2012). The WMRNP specifically amends the decisions to CDCA within WEMO regarding the planning and resource management of a transportation network, as well as livestock grazing, on public lands within the Planning Area. The BLM developed potential resource-specific minimization mitigation measures to help minimize impacts in the designation of routes (BLM, 2012). The potential mitigation measures proposed in the draft supplemental EIS to help decrease the impact on MGS core areas are (BLM, 2012):

- Construct wildlife bypass;
- Install Wildlife Safety Zone signs;
- Modify access to a less impacting designation; Limit the route to lower intensity use or prohibit Special Recreation Permitted use;
- Install access type restrictor;
- Re-align route to avoid designated area;
- Restrict stopping/parking/camping;
- Add parking/camping area;
- Install barriers and maintain or upgrade existing barriers;
- Remove attractants;
- Construct or install educational information such as signs;
- Install fencing;
- Narrow route;
- Monitor the route for signs of increasing impacts to a sensitive resource;
- Route closure; and
- Determine that no additional minimization and mitigation measure is needed based on site evaluation

Approximately 179,619 acres (72,689 ha) of MGS core area have been identified within the WMRNP Planning Area. Threats to MGS would not change from the previous 2005 WEMO Final EIS (BLM, 2005) such as habitat disturbance and potential mortality due to OHVs. Once review of the WMRNP is complete, BLM will adopt a proposed plan amendment decision and prepare the ROD. When completed, the ROD will provide comprehensive long-range decisions for (1) managing transportation and travel management resources in the WEMO Planning Area and (2) identifying allowable livestock grazing management uses on BLM-administered public lands[38].

Renewable Energy Action Team

In response to federal and state initiatives and mandates to reach renewable energy development targets, and several applications for renewable energy project permits within the Mojave and Colorado deserts, the REAT was formed. Its core members include CEC, CDFW, BLM, and USFWS. Agreements were signed between REAT agencies and other participating agencies to oversee the implementation of the DRECP, a joint state Natural Community Conservation Plan, federal Habitat Conservation Plan, and BLM Land Use Plan Amendment (LUPA)[39].

DRECP OVERVIEW

The DRECP, an interagency plan established in September 2016, encompasses approximately 22,585,000 acres (9,139,825 ha), which includes the Mojave Desert and the Colorado/Sonoran Desert ecoregion in California (BLM, 2016) (See Figure 15). The DRECP was designed to protect and conserve important desert ecosystems, while also facilitating the development of renewable energy projects in the plan area. The DRECP is broken into two phases. Phase 1 consists of the BLM LUPA covering over 10 million acres (4,046,856 ha) of BLM-managed lands. For Phase 1, the LUPA allocates public land for renewable energy, conservation, and recreation. It includes goals and objectives for land management. The DRECP also includes the California Desert Conservation Area Resource Management Plan (RMP), the Bishop RMP, and Bakersfield RMP. Phase 2 of the DRECP focuses on further aligning local, state, and federal renewable energy development, and conservation plans, policies, and goals.

The LUPA includes the following land designations: DFAs, Variance Process Lands (VPLs), General Public Lands, BLM Conservation Areas, and Recreation Management Areas. In addition, Conservation and Management Actions (CMAs), established in the DRECP, cover various portions of the LUPA. These CMAs are identified at different levels within the LUPA to provide a broad plan and a land-use specific management plan for MGS. The first level of CMAs covers the entirety of the LUPA. The next level of CMAs is specific to the land designations. DFAs are the areas where renewable energy development is allowed and could be streamlined for approval. VPLs are areas where renewable energy development is allowed, but without streamlined approval. General Public Lands are areas managed by BLM that do not have specified land allocations or other designations. This land is available for renewable energy development, but without streamlining of the approval process. BLM Conservation and Recreation Areas are not available for renewable energy development. The BLM Conservation area is land designated as National Conservation Lands, Areas of Critical Environmental Concern, wildlife allocations, and National Scenic and Historic Trail management corridors. The approved LUPA does not detail project-specific plans or decisions; rather, implementation relies upon later analysis of proposed projects. The BLM has the authority to deny renewable energy development based on site-specific issues and concerns, even in areas identified as DFAs.

DRECP MGS MANAGEMENT

The established DRECP area includes approximately 961,000 acres (388,903 ha) of land identified as Area of Critical Environmental Concern (ACECs) and has designated MGS management as a priority. ACECs are closed to geothermal leasing and development unless they overlap with a DFA. Where overlap occurs, ACECs are open to geothermal development with a No Surface Occupancy (NSO) stipulation. NSO stipulation prohibits building or disturbance on the surface, although exploration of fluid minerals may occur through directional drilling. 198,500 acres (80,330 ha) of ACEC are BLM managed lands, in addition to the MGS management area previously established in the WEMO Plan (Figure 16). MGS ACEC units established in

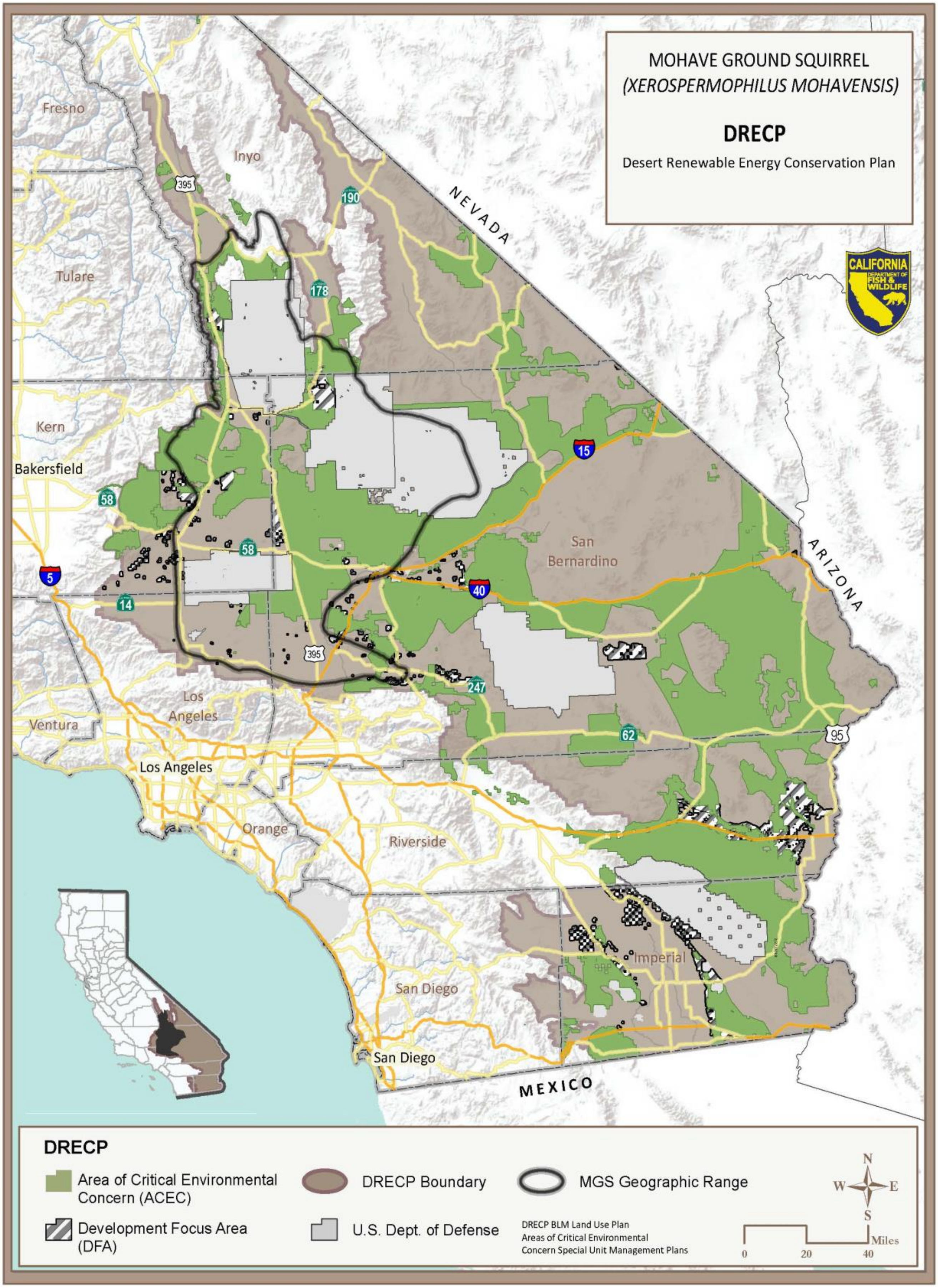

Figure 15. DRECP Areas of Critical Environmental Concern (ACEC) and Development Focus Areas (DFA) (Source: DRECP, 2016 https://www.drecp.org/)

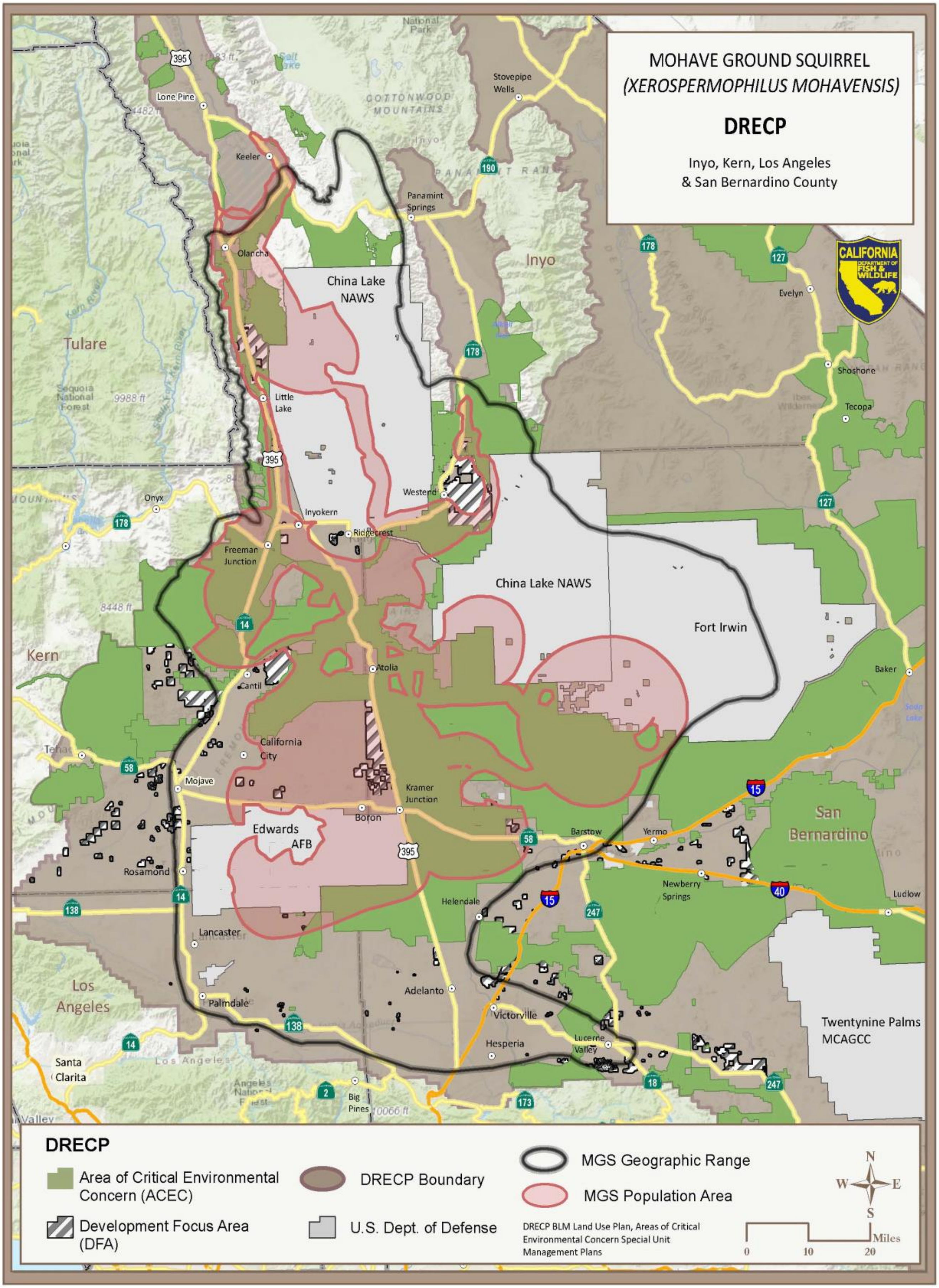

Figure 16. DRECP Areas of Critical Environmental Concern (ACEC) and Development Focus Areas (DFA) within MGS geographic range and population areas (Source: DRECP, 2016)

the DRECP are located in three sub-regions: Basin and Range, Mojave and Silurian Valley, and West Desert and Eastern Slopes.

Within the DRECP, special unit management plans were created for ACECs. The special unit management plans detail objectives, allowable uses, and management actions for the resources within the ACECs. The MGS ACEC special unit management plan caps disturbance at one percent, meaning that within the MGS ACEC a maximum one percent of the area may be disturbed by anthropogenic sources. The area contains 11 MGS CPAs and between these areas, habitat linkages provide vital genetic flow to maintain species diversity.

The special unit management plan for the MGS ACEC outlines desired future outcomes for the following resources: soil, water, air, vegetation, fish and wildlife, climate change and adaptation, trails and travel management, recreation, land tenure, rights of way, renewable energy, minerals, and livestock grazing. Table 10 describes the special unit management plan as described in Appendix B of the DRECP.

Resource & Objective	Management Action
Soil, Water & Air: Restrict construction when soils are at heightened risk of erosion	Ensure soils meet or exceed the Soil Standard of Rangeland Health
Vegetation: Maintain intact vegetation communities and prevent fragmentation	Rehabilitate disturbed areas, remove invasive plants, ensure MGS plant food species are maintained, and ensure diverse vegetation
Fish and Wildlife: Protect habitat to maintain populations of special status species to ensure persistence	Designate MGS as priority species for management and protection and maintain stable or increasing populations of special status species
Climate Change and Adaptation: 1) Protect biodiversity and manage for resilience 2) Maintain/enhance ecosystem processes and prepare/respond to significant environmental disturbances	1) Prioritize habitat with highest resiliency potential for enhancement, consider actions that enhance productivity of climate refugia and maintain migration corridors by minimizing obstructions, disturbances and fragmentation 2) Reduce impacts to vegetation and soil structure/biota and use disturbance events to assess climate adaptation actions
Trails and Travel Management: Protect significant values of area, while allowing public access	Sign/manage designated routes, use minimization criteria for routes in MGS habitat, rehab/restore un-authorized routes, limit vehicles by signing/fencing/barriers, increase public awareness of ACEC, increase patrols, and SRPs limited to OHV open areas (if within MGS ACEC, SRPs only allowed September 1st-February 28th)
Recreation: Provide opportunities for use of ACEC attributes	Increase public awareness of ACEC value, maintain signs/barriers/kiosks, work with volunteers to clean-up parking/camping areas, and increase compliance with resource protection
Land Tenure: Consolidate through tenure adjustment	Acquire inholdings, edgeholdings, and other interests from willing sellers
Rights of Way: Protect resource values of ACEC	Land use proposals analyzed on a case-by-case basis to assess if compatible with ACEC goals
Renewable Energy: Not an allowable use	ACECs are closed to development unless they overlap with DFA. Where there is overlap, ACECs are open with an NSO stipulation
Minerals: Support the need for minerals, while protecting sensitive resources	Proposals analyzed on a case-by-case basis to assess if compatible with ACEC goals
Livestock Grazing: Provide opportunities for livestock grazing, while limiting impacts on ACECs	Adjust livestock use where needed to meet resource objectives

Table 10. MGS ACEC special management plan. As described in Appendix B of the DRECP (Source: DRECP, 2016)

The DRECP LUPA outlines goals and objectives of BLM-managed lands within the DRECP area. The goals and objectives add to those identified in the CDCA Plan, and Bishop and Bakersfield RMPs. Goals of the LUPA encompass the following categories: biological resources; comprehensive trails and travel management; cultural resources and tribal interests; lands and realty; minerals; national scenic and historical trails; national recreation trails; paleontology; recreation and visitor services; soil resources; water resources; water-dependent resources; special vegetation features; visual resources management; wild horses and burros; and wilderness characteristics. Each category includes a description and objectives for the land use goal.

In the DRECP LUPA, MGS CMAs appear under multiple land use allocations. As noted above, first level CMAs, or "LUPA-wide CMA", describe standard practices for ensuring appropriate biological conservation and management. The LUPA-wide CMA has subcategories for Individual Focus Species (IFS), including MGS, and includes species-specific conservation management actions. The MGS IFS CMAs are:

1. Protocol surveys are required for activities in MGS CPA. The survey data collected must be provided to BLM and CDFW.

2. Projects within MGS CPAs requiring an EIS must assess effects of proposed activities on the long-term function of the affected CPA. Projects must be designed to reduce any impacts to the long-term function of the affected CPA to less than significant under NEPA.

3. Authorized projects and management activities in CPA will be developed in previously disturbed areas and/or areas of low habitat quality to the maximum extent practicable.

4. For projects requiring an Environmental Assessment (EA) or EIS due to potential impacts to MGS habitat within a CPA and linkages between CPAs, ground disturbance activities shall be avoided during the MGS dormant season (August 1-February 28) unless absence is supported by survey or other available data during previous active season.

5. During the MGS active season (February 1-August 31) clearance surveys throughout the site are required immediately prior to conducting any ground disturbance activities. Ground disturbance is only allowed within cleared areas and those areas must be monitored while the activities are conducted for any MGS that may enter the cleared area. If MGS are detected, then the area must be flagged and avoided, at a minimum of 50 feet, until MGS moves out of harm's way. A designated biologist may move MGS.

6. Under NEPA proposed projects in a linkage area must analyze potential effects on MGS connectivity. Activities must be designed to maintain the function of linkage during and after construction. The assessment must consider pre and post activity of area to support resident MGS and provide for dispersal of offspring to CPA outside the linkage area and dispersal through the linkage between CPAs. Activities in linkages must be configured and located in a way that does not reduce the existing MGS populations in linkage area.

7. Use of rodenticide in the project area is not allowed except in buildings.

If biological resources are impacted by activities in their habitat, compensation may be required. The standard biological resource compensation ratio is 1:1. MGS is an exception to this standard with a compensation ratio of 2:1. Compensation acreage requirements can be fulfilled through non-acquisition (restoration and enhancement), land acquisition, or a combination of these options. However, as of July 24, 2018, the Department of the Interior policy prohibits the BLM from requiring any compensatory mitigation.

In addition to the LUPA CMAs, the Ecological and Cultural Conservation CMA category also applies to MGS. This category refers to areas within the BLM Conservation Land Allocations area (California Desert National Conservation Lands, ACECs, and Wildlife Allocation). The CMAs are:

1. Long-term vegetation removal in CPAs and linkages, requiring EA or EIS, is not allowed unless activity is compatible with MGS conservation and management.

2. To the maximum extent practicable, establish and maintain fencing to prevent grazers from accessing the MGS and from important foraging habitat, including winterfat and spiny hopsage.

CMAs were also created for DFAs and VPLs. MGS was one of the IFS for this category. The CMAs are:

1. DFAs and VPLs within MGS range must configure solar panel and wind turbines to allow areas of native vegetation growth that will allow MGS movement through site. (e.g., raised/rotating solar panels or open space between rows of panels or turbines). Fences must allow MGS through.

2. Clearance surveys are required in some DFA areas.

3. Protocol surveys are required in some CPAs and linkages.

4. There is no required setback[40] for MGS on DFAs

5. The DFA in the North of Edwards MGS CPA (aka "The Bowling Alley") is closed to renewable energy applications until further evaluation can be completed on the MGS conservation requirements for the area.

6. Once the reevaluation of North of Edwards MGS population occurs, the DFA can either be eliminated and the land converted to General Public Lands or it can be opened to applications for renewable energy infrastructure.

The identified DFAs in the MGS range are located in the ecoregion subareas known as West Desert and Eastern Slopes, the Mojave and Silurian Valley, and the Basin and Range area of the DRECP. The BLM LUPA allocates 49,000 acres (19,830 ha) of land of the Basin and Range region, 52,000 acres (21,044 ha) of land of the West Desert and Eastern Slopes region, and 3,000 acres (1,214 ha) of land of the Mojave and Silurian Valley region for renewable energy development. DFAs within the above-mentioned subareas are located in the following MGS population areas[41]: Coso Range-Olancha, West China Lake Linkage, North Searles Valley, Ridgecrest-Searles Linkage, Little Dixie Wash, West of Dixie Climate Change Extension, DTNRA, Central Linkage, and North of Edwards.

If some of the DFAs are developed to their fullest extent, the impact on important MGS habitat could be severe. For example, significant development in the DFA just north of Kramer Junction and west of U.S. 395 (known as the "Bowling Alley") could severely impact a core population center for the MGS and sever a viable north-south linkage between populations, as well as an east-west linkage between populations in the central part of the range. LaRue (2016) detected MGS throughout the Bowling Alley, providing a good indicator of the habitat quality and the general ecological health and importance of this area.

STATUS OF THE DRECP

On March 28, 2017, Executive Order 13783 (Executive Office of the President 2017, Fed. Reg. 82:16093) was released, directing federal agencies to review all actions that could potentially burden the development or use of domestically produced energy resources. On January 8, 2018, Executive Order 13821 (Executive Office of the President 2018, Fed. Reg. 83:1507) directed federal agencies to reduce barriers to capital investment, remove obstacles to broadband service and more efficiently employ Government resources to foster rural broadband infrastructure. Because of the above mentioned executive orders, BLM published a notice of intent (BLM 2018, Fed. Reg. 83:4921) in February 2018, to amend the three DRECP land use plans and initiated public scoping process. Specifically, BLM seeks input on the potential impacts on commercial-scale renewable energy projects from the LUPA as well as input on opportunities for expanding multiple uses on public lands. Based on the information collected during the scoping, the BLM may propose to amend the LUPA.

U.S. Fish and Wildlife Service

USFWS's mission is to work with others to conserve, protect and enhance fish, wildlife and plants and their habitats for the continuing benefit of the American people.[42] Although the MGS is not federally listed, some of its habitat overlaps the ESA-listed Threatened desert tortoise (*Gopherus agassizii*) habitat. 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.), Creosote bush scrub, and blackbrush scrub communities. Specifically, the Fremont-Kramer and Superior-Cronese CHUs contain important CPAs and linkages for MGS. The recovery unit also includes habitat for MGS in portions of the DTRNA Fort Irwin, China Lake, and EAFB CPAs. The CHUs within the recovery unit are areas identified by USFWS 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 linkages (USFWS, 2012). The CHUs in aggregate are intended to protect the varying habitat that occurs across the desert tortoise's range. Any actions contributing to recovery of the desert tortoise could also have substantial benefit to the conservation of the MGS.

Similarly, the MGS could benefit from USFWS protection of ESA-listed Lane Mountain milk-vetch. CHUs for this species include MGS habitat within Fort Irwin, where ground-disturbing military operations could otherwise take place. The Critical Habitat designation in Coolgardie-Mesa provides additional protection on BLM land to the persistent MGS CPA at Coolgardie Mesa-Superior Valley. For example, USFWS works with BLM to prevent unauthorized OHV use in the area (USFWS 2011, 76:29108).

Department of Defense

EDWARDS AIR FORCE BASE

EAFB is a United States Air Force installation, 308,180 acres (124,716 ha) in size, located 22 miles (35 km) northeast of Lancaster. EAFB has actively monitored its MGS populations since 1988, including the core population described by Leitner (2008a). EAFB actively manages for MGS by restricting OHV use and new roads, and minimizing new ground disturbance (412th Test Wing, 2017). EAFB has completed at least seven years of inventories for the presence of MGS and surveyed 58% of its 60 Habitat Quality Analysis (HQA) plots as of 2011 (EAFB GIS).

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 mostly undeveloped controlled bombing range; 60,800 acres (24,605 ha) 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, therefore the MGS population will continue to be managed.

The following conservation measures for the MGS are in EAFB's 2017 INRMP (412th Test Wing, 2017):

- Develop and implement education awareness in concert with the Desert Tortoise Awareness Program.
- Measure impacts to known populations during project monitoring activities.
- Conserve and manage MGS.
- Monitor population at 5-year intervals to determine long-term trends.
- Evaluate threat of round tailed ground squirrels to MGS.
- Continue to conserve habitat through road closure projects.
- Evaluate effectiveness of revegetation efforts in MGS habitat.
- Complete baseline surveys at all HQA plots and record incidental sightings.
- Monitor populations and enter data into the EAFB GIS.
- Use survey and monitoring data to develop a Predictive Habitat Model; verify model through ground truthing surveys.
- Use all inventory and incidental observations to map known populations.
- Share technical knowledge with the resource agencies and scientists.
- Consider for implementation the objectives in the WEMO Plan that do not conflict with the military mission of the Air Force.
- 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 linkages between EAFB MGS populations, and certain restrictions on renewable energy development along the borders of the installation (CDFG, 2012a). In 2018, EAFB conducted presence-absence surveys, using camera live-trapping, to determine MGS presence in areas where positive results occurred previously on the base. Preliminary results confirm MGS presence at most of these sites. Additional live-trapping surveys are planned for 2019 to collect tissue samples and research whether RTGS have expanded into EAFB and/or hybridizing with the MGS population.

NATIONAL TRAINING CENTER AT FORT IRWIN

Fort Irwin and the National Training Center are a major training center for the US Military, located 37 miles (60 km) northeast of Barstow. Large portions of Fort Irwin and the NTC are prime MGS habitat. Fort Irwin and the NTC conducted 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 showed greater abundance 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.

Photo by Dr. Philip Leitner and David Delaney

Delaney and Leitner (2009) conducted camera and live-trapping surveys within Fort Irwin's WEA, including vegetation studies, to evaluate video and audio surveillance techniques and provide data on MGS population trends, density, distribution, and habitat associations. The surveys showed a decline in detections from Leitner's earlier study in 2007 (Leitner, 2007). The results showed that audio-video surveillance is a valuable tool to monitor MGS populations when used in conjunction with live-trapping. In 2013, Fort Irwin personnel started an MGS camera study and found no detections in the northern sites where Recht (1995) had documented occurrences (L. Aker, pers. comm. 6/13/13); however, RTGSs were detected.

Fort Irwin staff continues to systematically survey the northern part of the installation (L. Aker, pers. comm. 6/13/13). The Fort Irwin's WTA (formerly, Western Expansion Area) consists of high quality habitat presently supporting a large portion of the MGS CPA in this part of its range. Camera surveys on a small scale (generally, eight to sixteen cameras each year) continue to document MGS throughout the WTA. Camera transects installed early in the season remain in place until mid to late June to document reproduction (L. Aker, pers. comm. 6/21/2018). The Army continues to retain ownership of the WTA and intends to pursue military training objectives in the area as outlined in the Supplemental Final (Calibre, 2005).

NTC and Fort Irwin are currently preparing an INRMP. 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[43]. Review of the INRMP and assessment of environmental risks associated with implementation of the plan is currently underway.

NAVAL AIR WEAPONS STATION - CHINA LAKE

NAWS China Lake comprises 1.1 million acres in Inyo, Kern, and San Bernardino Counties, California[44]. NAWS China Lake's mission is to operate and maintain the installation facilities and provide support services, including airfields, for the assigned tenants of the installation. Tenants include the China Lake Joint Venture's Navy 2 Geothermal Project. The project was authorized in consultation with CDFW to ensure that impacts to MGS are fully mitigated[45]. In fulfillment of the Sikes Act (as amended). As the chief custodian to the lands, NAWS China Lake prepares and implements an INRMP. The NAWS China Lake INRMP is coordinated with the CDFW and USFWS on a five-year cycle, with the next update scheduled in 2019.

The current INRMP (Tierra Data, 2014) guides management of natural resources with an emphasis on federally threatened or endangered species and their critical habitat. While MGS is not federally listed, the INRMP includes a strategy to "continue to support efforts to study and monitor the MGS" (Tierra Data, 2014). The INRMP also includes an objective to maintain a large and healthy MGS population, in part through habitat management in conjunction with Mojave Desert tortoise critical habitat.

NAWS China Lake has provided logistical support for annual surveys and ecological studies conducted by Leitner et al. between 1988 and 2018. NAWS China Lake will continue to support (with briefings, badging, staff (when available), and logistics) trapping efforts at the Geothermal Project. In 2019, NAWS China Lake will also fund an installation-wide survey effort to determine distribution limits for MGS. Through implementation of the INRMP, NAWS China Lake will continue to coordinate with Federal, State, and Local partners on the conservation and management of MGS.

California Department of Fish and Wildlife

The Mission of CDFW is to "manage California's diverse fish, wildlife, and plant resources, and the habitats upon which they depend, for their ecological values and for their use and enjoyment by the public". CDFW works with local and federal agencies and stakeholders to conserve MGS. CDFW accomplishes its mission as California's trustee agency for wildlife through a broad range of activities, ranging from ecological and population studies of the state's wildlife, fish, and plant species; habitat management and restoration projects; acquisition of fee title and conservation easements on lands important for wildlife conservation; issuance of a variety of permits and licenses to control the consumptive and other uses of wildlife; development of policies and guidance, both for CDFW and other stakeholders; and review of proposed legislation and regulations for their effects on the state's wildlife. Development of this Conservation Strategy is a component of CDFW's policy and guidance regarding species at risk.

Habitat acquisition is a key factor in listed species conservation and recovery. To offset and mitigate habitat lost to development, ITPs issued by CDFW under the authority of Fish & Game Code §2081(b) often require purchase and set-aside of habitat that could otherwise be available for future development. This may occur on a project-by-project basis or in a programmatic fashion. For example, in 2012 CDFW purchased MGS habitat using funds provided by renewable energy developers as part of an advance mitigation fee program required by Senate Bill 34[46]. A total of 3,451 acres (1,397 ha) were purchased in the Fremont-Kramer and Superior-Cronese DWMAs. The acquisitions are comprised of 126 parcels ranging from 1.25 to 160 acres (0.50 to 65 ha), scattered throughout the area between Cuddeback Lake and Harper Lake.

Mitigation requirements in CESA ITPs for individual development projects have protected a substantial amount of MGS habitat. From 1998 to 2015, CDFW issued 323 ITPs requiring a total of 108,828 acres (44,041 ha) of compensatory habitat mitigation (referred to as "Habitat Management Lands" in ITPs). As of 2015, 31,495 acres (12,746 ha) had been transferred to public ownership and/or had conservation easements recorded (CDFW unpublished data).

Conducting or supporting basic research on the ecology and conservation status of species at risk is essential to their conservation. 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 of additional CDFW funds 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 research using camera trapping to determine locations and persistence of MGS populations. In 2013 and 2018, CDFW provided funds totaling $45,800 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. Under the USFWS Section 6 Grant program, CDFW awarded $59,700 for continuing data gap studies in Kern and Los Angeles Counties in 2014. Cumulatively, the funding amounts to approximately $1,250,000 for MGS research.

Management of CDFW lands (Ecological Reserves (ER) and Wildlife Areas) provides essential habitat for a variety of biological resources, including both common and imperiled wildlife. CDFW manages 18,152 acres (7346 ha) of potentially suitable habitat, which occurs in many non-contiguous blocks of 640 acres (259 ha) or less in area, within the West Mojave Desert ER in San Bernardino County[47] and 1,090 acres (441 ha) in the Fremont Valley ER in Kern County[48]. A limited amount of recreational activities (hiking and wildlife viewing) as well as quail hunting are allowed in the West Mojave Desert ER, and only wildlife viewing is allowed in the Fremont Valley ER. The Fremont Valley ER supports prime MGS habitat adjacent to the DTRNA, with a detection as recent as 2013 just south of its boundary (S. Heitkotter, pers. comm. 6/13/13).

CDFW leads the MGS TAG[49], a multi-stakeholder group of scientists and managers from public agencies, DOD installations, academia, and private consulting firms. The MGS TAG provides a forum for exchange of information on MGS status, scientific research, and to discuss conservation priorities and actions. The TAG generally meets twice each year and provides an expert peer review function for CDFW's policies and guidance on matters related to MGS.

California Energy Commission

The CEC is the state's primary energy policy and planning agency for a clean energy future[50]. 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 CPAs and linkages, for the Planning Alternative Corridors for Transmission study under the Public Interest Energy Research (PIER) program (Condon et al., 2012).
- Development of the USGS MGS SDM, under the PIER program (Inman et al., 2013).

The CEC may continue to fund research needs under its PIER program, depending on available solicitations and proposals selected[51]. The CEC has proposed awards to various counties to updating their general plans relative to renewable energy, and such awards may benefit the conservation needs of MGS[52].

California Department of Parks and Recreation

The mission of CDPR is to "provide for the health, inspiration and education of the people of California by helping to preserve the state's extraordinary biological diversity, protecting its most valued natural and cultural resources, and creating opportunities for high-quality outdoor recreation." [53] California has 280 state parks, with a few located within the MGS range. Some of the state parks are designated as State Vehicle Recreation Areas (SVRA), which offer trails, tracks, and other OHV recreation opportunities.

In 2014, CDPR designated the Eastern Kern County Onyx Ranch SVRA on 50 parcels of land encompassing approximately 25,000 acres (10,117 ha) in eastern Kern County west of Red Rock Canyon State Park for OHV use (CDPR Off-Highway Motor Vehicle Recreation Division [OHMVRD], 2015). Approximately 20,000 of those acres (8,094 ha), between Red Rock Canyon and Kelso Valley, are within the MGS range. Management Measures were implemented under CDPR's Wildlife Habitat Protection Program and Habitat Monitoring System to protect sensitive biological resources from potential effects of existing uses (CDPR, 2013). The OHMVRD found the project management activities, which included the implementation of these measures, would not adversely impact special-status species, such as the MGS. Therefore, no changes or alterations to the project were required to mitigate or avoid significant effects on the environment[54].

MGS habitat in the Onyx Ranch SVRA varies across the area and the distribution and abundance of MGS there is unknown. A camera trapping protocol is being developed to survey for MGS in the area and should begin in 2019 (T. Farmer, pers. comm. 4/5/2018). The acquisition area is interspersed in checkerboard fashion with BLM land in the Little Dixie Wash population center described by Leitner (2008a) and is within potential expansion habitat (PPA) for that population. Detections as recent as 2004 are located just east of some of the acquired parcels (CNDDB occurrences #191, #395-396) and historical detections are within or adjacent to the acquired land (CNDDB occurrences in Dove Spring, 1974).

Suitable habitat within the MGS range occurs in a few other existing State Parks:

- Saddleback Butte State Park contains approximately 1,500 acres (607 ha) of flat land that is potentially suitable habitat for MGS. Recht (1977) conducted MGS research in Blue Rock Butte, less than 2 miles (3.2 km) northwest of the Park, and historical 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; C. Swolgaard, pers. comm. 3/6/13). However, a 2014 survey (LaRue) in the adjacent Butte Valley Wildflower Sanctuary did not detect any MGS.

- The Antelope Valley Indian Museum State Historic Park less than 2 miles (3.2 km) southwest of Saddleback Butte State Park, contains approximately 200 acres (81 ha) of potentially suitable habitat for MGS. No studies of small mammals have been conducted or are currently planned within the property boundary. State Parks personnel recorded an unconfirmed observation of MGS within the property (CDPR NRD), 2004 Table 5; C. Swolgaard, pers. comm.3/6/13). At least one historical record exists from 1991 near the museum property (CNDDB occurrence #226). The museum is available for day-use recreation and ceremonial purposes only[55].

- Red Rock Canyon State Park contains 25,456 acres (10,302 ha) of land; one-third of the park may contain suitable habitat for MGS. A small trapping survey (10 acres [4 ha]) for small mammals was conducted in 1991 and 1992, and a single juvenile MGS was captured (CNDDB occurrence #186). Leitner (2008b) 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[56].

County Parks and Zoning

Some county parks also protect suitable MGS habitat from public use impacts. For example, Los Angeles County maintains the Butte Valley Wildflower Sanctuary (approximately 351 acres (142 ha)); Alpine Butte (320 acres (129 ha)) and Carl O. Gehardy (547 acres (221 ha)) 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[57]. It is unknown if any of the habitat protected by these county parks currently support MGS, although there are historical detections near the parks (for example, CNDDB occurrences #257, #23), and at least two historical detections occurred within the Butte Valley Wildflower Sanctuary during Recht's studies in 1976 and 1977 (CNDDB occurrences #228, #190). During a study conducted by LaRue, no MGSs were captured during a trapping effort within the Butte Valley Wildflower Sanctuary (LaRue, 2015). However, LaRue live-trapped five MGS at Phacelia Wildlife Sanctuary. Six other LA County parks had no MGS captures during LaRue's work (LaRue, 2015).

In addition to its parks, Los Angeles County has designated Significant Ecological Areas (SEAs) throughout 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 historical detections of MGS occurred and where habitat 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 the wildlife species within the vicinity[58]. 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[59]. If the Plan is amended as proposed, possible remnant MGS populations south of EAFB could retain essential connectivity to the EAFB population[60]. As of February 2019, the proposed additional SEAs of Antelope Valley are being evaluated.

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[61]), or "open space" in the other counties (Los Angeles County, 1980; Kern County, 2012; URS, 2012). Most of these designations allow limited resource extraction (e.g., mining) and recreational activity.

Private Conservation Areas and Reserves

Scattered throughout the MGS range are parcels of land 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 assisted with the establishment of the DTRNA, which encompasses 25,280 acres (10,230 ha) of prime habitat for the desert tortoise. The Committee, along with The Wildlands Conservancy, also acquired Blackwater Well Ranch, which includes the grazing rights for 49,000 acres (19,830 ha) of potential desert tortoise habitat.[62] Other examples are: Mojave Desert Land Trust[63], Transition Habitat Conservancy[64], Mojave Desert Resource Conservation District[65], Wildlands Conservancy[66] and Antelope Valley Conservancy[67]. In addition, some private landowners choose to manage their properties for the preservation of natural resources in cooperation with conservation organizations. While acquired and managed for other species, the conservation of habitats may provide important ancillary benefits for MGS conservation.

Conclusion

Conservation and recovery of the MGS should be achievable goals, despite the many threats to the species. As described in the foregoing sections, CESA prohibits "take" of MGS without authorization. Such authorizations, when provided by CDFW to project developers, are accompanied by requirements to minimize and fully mitigate the project's impacts to MGS. Minimization and mitigation requirements ultimately help secure habitat for the species and, if effectively planned, may result in a network of lands designed to ensure the species' survival. Other local and regional conservation planning tools, such as conservation easements, Natural Community Conservation Plans, Safe Harbor Agreements, and Regional Conservation Investment Strategies, also provide mechanisms by which conservation of at-risk species may be achieved while allowing development to occur.

All the state and federal agencies mentioned above, including the DOD installations, have among their primary or secondary mandates the protection of natural resources, including listed species. All have procedures and policies aimed at ensuring needs of imperiled species are addressed in management decisions. Non-governmental conservation organizations contribute to MGS conservation by working between and among public and private landowners to facilitate resource protection that benefits the squirrel. Scientists continue to gather data on the ecology and conservation needs of MGS. The MGS TAG provides a forum for sharing of information among these agencies and groups to facilitate informed decision-making.

MGS recovery is achievable through the implementation of the conservation goals, objectives, and measures outlined in this document. With renewed focus and commitment, building upon the foundation of existing work, we can help ensure the MGS, a species emblematic of California's southern desert and uniquely adapted to survive its harsh summers and bitter winters, can persist and even thrive for generations to come.

Photo by Dr. Philip Leitner and David Delaney

ENDNOTES

1. http://www.dmg.gov/

2. http://www.iucnredlist.org/details/20474/0

3. http://www.iucnredlist.org/details/20474/0

4. Near the town of Helendale.

5. Near Coyote Dry Lake

6. In geographic terms, the MGS range is in the western Mojave Desert, bounded on the north and east by Owens Lake and several small mountain ranges of the western Great Basin, including the Argus, Panamint, and Quail ranges, and extending to the eastern edges of the Granite and Avawatz ranges. The southeast edge of the range follows the Mojave River south of Barstow and includes the western edge of Lucerne Valley. In the south, the species ranges to the bases of the northern foothills of the San Gabriel and San Bernardino mountains. In the west, the eastern base of the southern Sierra Nevada (including the Scodie and Piute mountains) bound the range in the north. CDFW defines the western boundary of the range south of the Sierra Nevada as along a roughly north-south line near SR-14 from Mojave south to Palmdale.

7. Some authors include the western Antelope Valley within the MGS geographic range. This area is the western-most extent of the Mojave Desert. It lies west of SR-14 and is bounded on the north by the Tehachapi Mountains and on the south by the San Gabriel Mountains (Figure 1). Based on climate, soils, and the native vegetation that existed prior to European-American settlement, there is no known reason why MGS should not occur in the western Antelope Valley. However, there is no historical record in mammal collections of MGS from this area. The online compilation of museum collections VertNet Portal includes several records of MGS with location descriptions that could not be precisely georeferenced. One of these was an MGS collected by W.B. Richardson, then of the Museum of Vertebrate Zoology, in 1933 at a site called "West Antelope Valley, Sears Cattle Camp". A search for additional field note information related to this collection trip has to date been unsuccessful. Other early scientific trips to the western Antelope Valley (primarily in the Fairmont area) by Joseph Grinnell (in 1904), Nokes (in 1916), and Cantwell (in 1932) collected both nocturnal and diurnal (antelope squirrel) rodent species, but no MGS. Why MGS were not collected in western Antelope Valley by early naturalists is not clear, but the area already had a long history of European-American occupancy by the start of the 20th century. Spanish-American settlement of California depended on travel and trade along El Camino Viejo, the main inland route connecting the settlements in coastal southern California with the Central Valley and Bay Area settlements. Cattle ranches were developed along the route through western Antelope Valley starting in the 18th century and it is likely that native desert vegetation was already highly impacted by the time of the 20th century scientific expeditions to the area. Therefore, while the area may have supported MGS prior to European-American settlement, at this time there is no historical evidence to support this and CDFW does not consider the area to be part of the geographic range of MGS. Even if the area is considered historically occupied by MGS, surveys from 1998 through 2012 have not detected the species (Leitner, 2008a, 2013a), supporting the conclusion it is not currently occupied.

8. The California Natural Diversity Database (CNDDB) is an inventory of the status and locations of rare plants and animals in California. https://www.wildlife.ca.gov/Data/CNDDB

9. A natural desert soil type consisting of a closely-packed, interlocking surface of pebbles or cobbles with sand and fines filling the interstices. Plant cover is minimal or absent.

10. Post-mating home ranges of females ranged from 0.72 to 4.7 acres (0.29-1.9 ha) (Minimum Convex Polygon [MCP] method), with an average of 2.9 acres (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 0.94-7.3 acres (0.38-2.96 ha) (J. Harris, pers. comm., as cited in Wilkerson and Stewart, 2005). During the 1997 MGS mating season (mid-February to mid-March), the median MCP home range for males was 16.6 acres (6.73 ha) (maximum 98.8 acres (40 ha)), while for females the median was much smaller at 1.8 acres (0.74 ha) (Harris and Leitner, 2004). In a more recent study near Inyokern, (P. Leitner, pers. comm. 9/14/12) larger home range sizes were estimated during the mating season for males, with MCPs ranging from 42 to 222 acres (17 to 90 ha), and smaller home ranges (less than 2.5 acres (1 ha)) closer to the aestivation period.

11. Harris and Leitner (2004) reported that within a day, movement distance was greater for males during the mating season (median 428 yards (391 m), range 300-1631 yards (274–1,491 m)) than during the post-mating season (median 142 yards (130 m), range 50-467 yards (46-427 m)). The within-day movement distance for females did not differ between the mating (median 151 yards (138 m), range 105-233 yards (96-213 m)) and post-mating seasons (median 224 yards (205 m), range 26-406 yards (24-371 m)). 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 219 yards (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 statistically significant. Overall, the percentage of within-day movements greater than 219 yards (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 to maximize the possible number of mating opportunities.

12. Young males were reported to disperse at least 547 yards (500 m) from their home burrows (average 1.8 miles (2.9 km), maximum 3.9 miles (6.2 km)), while on average, young females settled between 219-820 yards (200-750 m) (maximum 2.4 miles (3.8 km)) (Leitner and Leitner, 1998; Harris and Leitner, 2005). The maximum long-distance movement by dispersing juveniles reported by Harris and Leitner (2005) was 6830 yards (6,230 m) for males and 4224 yards (3,862 m) for females. Leitner (pers. comm. 9/14/12) described the largest movement by a male juvenile as 8747 yards (8,000 m).

13. http://www.youtube.com/watch?v=HawgNqdfS-4

14. http://www.cubitplanning.com/state/25-california-census-2010-population

15. http://celosangeles.ucanr.edu/Agriculture/

16. https://eplanning.blm.gov/eplfrontoffice/projects/nepa/68429/87853/105200/Haiwee_DEIS_April_2012.pdf

17. http://www.nrel.gov/docs/legosti/fy98/22589.pdf

18. http://www.energy.ca.gov/sitingcases/abengoa/index.html

19. Areas with persistent wind speeds greater than 5 meters per second, considered commercially viable for wind energy.

20. http://www.drecp.org/finaldrecp/lupa/Appendix_E_DOD_Conflict_Maps.pdf

21. http://cms.sbcounty.gov/dpw/Transportation/HighDesertCorridor.aspx

22. http://dot.ca.gov/dist8/documents/us395/US-395%20and%20US-58%20REVISION%208-2014%20rev007.pdf

23. http://www.dot.ca.gov/dist8/Project-SR-58-Hinkley.html

24. http://www.dot.ca.gov/dist8/Project-SR-58-Kramer-Junction-Expressway.html

25. http://clui.org/ludb/site/us-borax-boron-mine

26. https://www.blm.gov/programs/abandoned-mine-lands/california/rand-historic-mining-complex

27. http://planning.lacounty.gov/assets/upl/project/gp_web80-conservation-and-open-space.pdf

28. https://www.blm.gov/ca/pdfs/cdd_pdfs/wemo_pdfs/plan/wemo/Vol-1-Chapter2_Bookmarks.pdf

29. https://www.blm.gov/programs/planning-and-nepa/plans-in-development/california/west-mojave-route-network-plan/court-documents

30. http://www.wrcc.dri.edu/monitor/cal-mon/frames_version.html

31. http://www.dfg.ca.gov/biogeodata/cnddb/

32. http://www.wildlifecrossing.net/california/observations/roadkill?tid=5

33. http://www.wildlifecrossing.net/california/map/roadkill/species?field_taxon_ref_nid=531

34. http://www.ipm.ucdavis.edu/PMG/PESTNOTES/pn7438.html

35. https://www.cdph.ca.gov/Programs/CID/DCDC/Pages/Plague.aspx

36. http://www.epa.gov/oswercpa/mapping_tool.htm

37. https://www.blm.gov/about/our-mission

38. https://eplanning.blm.gov/eplfrontoffice/projects/nepa/93521/137935/169703/West_Mojave_Route_Network_Project_Draft_Supplement l_Environmental_Impact_Statement_508.pdf

39. http://www.drecp.org/participants/

40. Setback: A defined distance from a resource within which an activity would not occur; otherwise often referred to as a buffer.

41. Composed of CPAs, linkages and projected climate change extensions

42. https://www.fws.gov/help/about_us.html

43. http://www.dodnaturalresources.net/INRMP-INDEX.html

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APPENDIX 1 – SURVEY GUIDELINES

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

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^{o}F or 10^{o}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.

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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 2

MGS Research Topics

The following research topics are not presented in priority order. It is recommended the MGS TAG work with CDFW to prioritize these topics. Additional topics for MGS research are listed in Conservation Strategy Part One, Topic C (Research and Monitoring)

Interactions of MGS with RTGS: Continue research to determine the effect of RTGS geographic range expansion into the eastern portions of the MGS geographic range; such research should include:

1) Determine the trending extent of RTGS distribution in the MGS range
2) Determine the ecological niche occupied by RTGS and whether competition between the two species is a threat to MGS populations
3) Assess reproduction and dispersal patterns of RTGS in habitat occupied by MGS
4) Determine the frequency and spatial distribution of hybridization

MGS Population Dynamics: Support research that improves our understanding of MGS population dynamics, including population size, range, distribution, threats and environmental effects:

1) Determine the feasibility of estimating the overall MGS population size, during cycles of drought and rainfall; if feasible, implement such methods as part of the population monitoring program
2) Investigate genetic variation and historical and current movement rates between population areas throughout the MGS range
3) Determine trends of extirpation/recolonization of populations over multiple drought and rainfall cycles
4) Use radio telemetry to add to existing data on dispersal, mortality, and recruitment rates in a variety of sites and habitat conditions
5) Conduct necropsies or compile observations to determine causes of mortality

MGS Conservation Threats. Prioritize research on the following conservation threats to MGS based on urgency, feasibility, and availability of funding:

1) Determine how linear features, such as roads, transmission lines, and pipelines, affect MGS dispersal
2) Study the effects of road density on local MGS populations, including both paved and non-paved roads
3) Identify the key predators of MGS and quantify predation effects on MGS vital rates; determine whether the large population increase of common ravens in the Mojave Desert is affecting MGS
4) Determine physiological and behavioral resiliency of MGS to projected changes in temperature and precipitation

5) Study the effects of recreation and other human activity on MGS behavior and habitat quality

6) Synthesize existing information on grazing impacts to MGS; determine if additional work is needed

7) Study the effects of mining operations on MGS habitat, such as habitat loss and fragmentation

8) Study the potential threat of disease by performing health assessments and disease exposure testing of live-trapped individuals, as well as necropsies on salvaged carcasses

9) Study the potential threat of localized increases in temperature from solar projects on MGS

Development-related Research Opportunities. Identify opportunities during development projects to research MGS response to and/or use of disturbance areas and features designed for MGS conservation; topics may include:

1) The compatibility of various renewable energy facility and infrastructure designs with forb growth, MGS occupancy, and MGS movement

2) The compatibility of small-footprint (under 100 acres [40 ha]) geothermal wells and towers, wind turbine pads and access roads, operations and maintenance facilities, and other structures or facilities with MGS occupancy and movement

3) The effectiveness of exclusion fencing to keep MGS out of construction areas and other sites where MGS could be harmed

4) Burrow depths to determine the effect of shallow grading and compaction during the dormant season

5) The effects of OHV use on MGS habitat and populations in existing permitted OHV areas

6) Telemetry studies to understand MGS use of landscape habitat linkages that do not contain good habitat

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