ERDC/CERL Final Report

Construction Engineering Research Laboratory

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Workshop to Improve Inter-Agency Cooperation and Collaboration for Managing Sustainable Populations of Mohave Ground Squirrels

Final Report for Project # 11-121. Submitted to the DoD Legacy Program

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1. BACKGROUND

The Mohave ground squirrel (MGS; *Xerospermophilus mohavensis*) is a small herbivorous endemic rodent found in desert-scrub habitat of the western Mojave Desert. This species is believed to have the smallest geographic range of any California ground squirrels, about 2 million hectares, of which approximately 34.5% is on DoD lands (i.e., Naval Air Weapons Station (NAWS) at China Lake, National Training Center on Fort Irwin, Edwards Air Force Base [EAFB]). The remaining MGS range is managed by the Bureau of Land Management (BLM; ~31.8%), private land owners (~31.0%), and within state and federal protected lands (~2.7%; Stewart 2005). The historic range of the MGS is confined to the northwestern corner of the Mojave Desert; bounded by the San Gabriel, Tehachapi, and Sierra Nevada Mountains to the south and west, and by Owens Lake and various small mountain ranges to the north (Fig. 1; Leitner 2008). The MGS is currently listed as threatened under the California Endangered Species Act and is a Priority 1 Species-At-Risk candidate within the Army. The primary threats to the MGS are habitat loss, fragmentation, and degradation from urbanization, agricultural development, military activities, energy development, roads, off-highway vehicle use, and livestock grazing. Natural factors, such as drought, may impact MGS breeding behavior and could affect this species' ability to persist in areas with extended periods of drought from global climate change. It is important that facilitated workshops is conducted to help identify the most effective methods for detecting and monitoring MGS populations throughout its range. Improvements in conservation protocols for this species are needed in order to evaluate the effectiveness of management and regulatory actions.

Objectives

The objectives of this workshop were to: 1) improve inter-agency cooperation, collaboration, and understanding of various management and regulatory actions; 2) review and summarize the current literature for MGS and similar ground squirrel species; 3) bring together recognized experts on MGS and similar species and on relevant topic areas so there could be an exchange of ideas; 4) increase the standardization and quality of field data collection so more informed, adaptive management, and regulatory decisions can be made; 5) seek the input of workshop participants on how to enhance conservation efforts for MGS through improvements in field methodologies, protocols, and management strategies and to map a course to implement these ideas through a conservation strategy; 6) distribute information from the workshop to natural resource managers and regulatory personnel and other interested parties involved in the conservation of MGS through

website posting(s) (e.g., Mojave Desert Ecosystem Program [MDEP], Desert Manager's Group [DMG]); 7) provide a base from which other future discussions, meetings, and information exchanges will happen; and 8) develop a technical report that discusses the viewpoints of workshop participants on how best to standardize field protocols to survey and detect MGS and to monitor population trends, and a number of other topic areas.

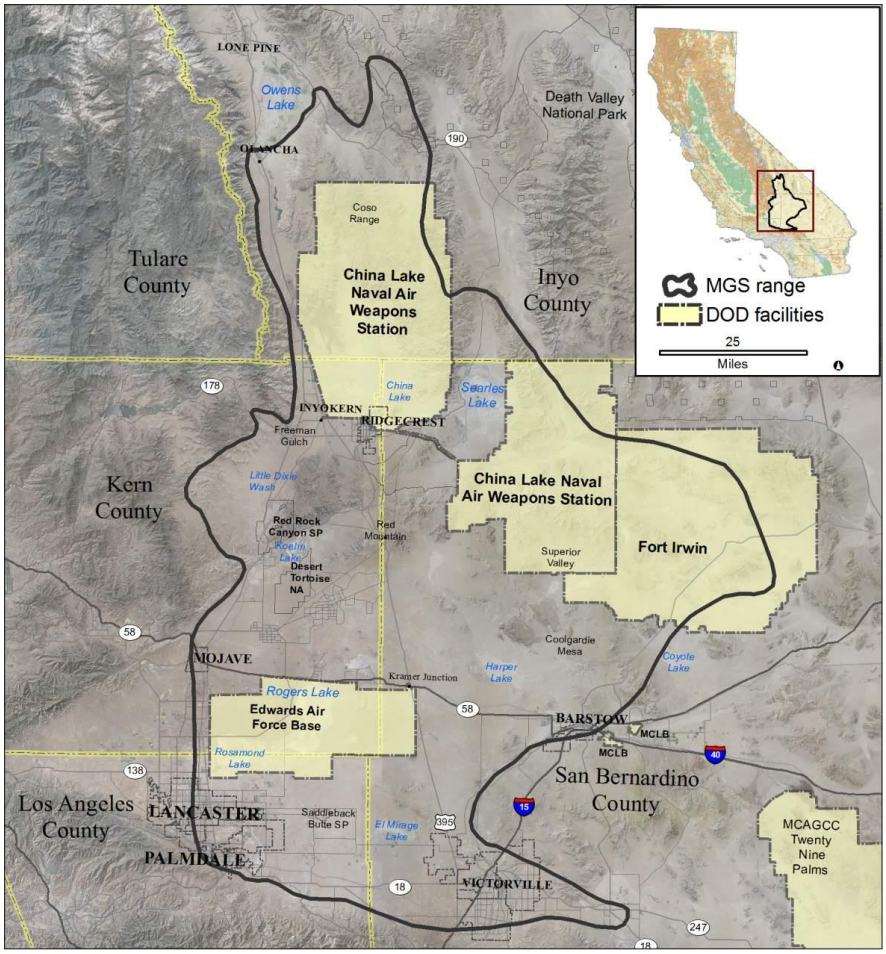

Figure 1. Map showing the boundary of the Mohave ground squirrel's range within the western Mojave Desert (ESRP 2010).

2. DAY 1

The Mohave ground squirrel workshop was held at the Mojave National Preserve Office in Barstow, CA on July 24-27, 2012. The first half day of the MGS workshop provided workshop participants with background material on MGS, Washington ground squirrel (WGS), and southern Idaho ground squirrel (SIGS) as a way to provide everyone with a good base of knowledge for our upcoming discussions during the workshop. Dr. Leitner, from California State University, Stanislaus and the Endangered Species Recovery Program, started the workshop with two presentations that provided background information on MGS life history, home range, distribution, and geographic connectivity. Mr. Mach (with the Oregon Military Department), a Natural Resource Specialist working on the Naval Weapon Systems Training Center, Boardman in Oregon, followed by providing an overview of the Washington ground squirrel's (WGS; (*Urocitellus washingtoni*) life history traits that showed some similarities to MGS, and providing insight into WGS issues they are dealing with on base. Dr. Yensen, from the College of Idaho, spoke about his work on southern Idaho ground squirrels (SIGS; *Urocitellus brunneus endemicus*) and compared the life history of SIGS with MGS. Dr. Matocq, from the University of Nevada, Reno, spoke next about her work with genetic variation in MGS. Her research showed patterns of connectivity between MGS populations, and identifies three genetic groups (north, central, and south) within the MGS range, based on strong separation in MtDNA. Ms. Hogan, who works for the U.S. Fish and Wildlife Service and works closely with the Desert Renewable Energy Conservation Plan (DRECP) Renewable Energy Action Team (REAT), provided an update on the DRECP alternatives, which will affect future renewable energy development projects and conservation within the western Mojave Desert. The final presentation of the day was given by Mr. Scofield, who works for the Bureau of Land Management and is the Co-Chair and Department of the Interior Representative of the Desert Manager's Group. He provided information on the political landscape affecting MGS.

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3. DAY 2

The second day of the MGS Workshop started with two presentations by Dr. Reinke, a biologist with the Natural Resources Program on EAFB. Dr. Reinke described the installation's "soft footprint" approach for the development of large-scale solar energy on EAFB. He followed with descriptions of the ongoing Small Business Innovation Research (SBIR) Program-funded projects that are on the base. The installation has been very successful in getting SBIR grants awarded.

State/Federal Agency Discussion: Data Gaps and Agency Needs

State and Federal personnel made a number of suggestions/comments in relation to data gaps and agency needs during a round robin discussion:

1) How well do habitat models reflect animal distribution, abundance, occupancy rates, important linkages (i.e., USGS model, but also Penrod et al. {2012} for discussion on linkage network for California Deserts) between suitable habitat areas, quality versus marginal habitat, etc?
2) What constitutes good habitat and where is it located within the MGS range?
3) What size buffers are adequate/appropriate to protect MGS habitat? Are there areas that should be protected from any disturbance, that are in essence are unmitigable?
4) Need to outline what the ultimate goal is for habitat conservation.
5) What amount and location of preserve or other natural habitat needed to preserve the species for the long-term (including effects of climate change)?
6) Need to assess habitat quality from a squirrel's point of view based on important biologically meaningful variables.
7) What are the pluses and minuses to acquiring mitigation lands?
8) Why is the range of MGS so restricted and their population size limited, given the high dispersal rate, relatively low competition with other squirrels, and its generalist-type nature?
9) There is a need to better understand MGS nutrition. What are their food preferences and how does nutrition influence MGS dormancy?
10) Need for robust statistically-based survey approaches/protocols.
11) Long-term data are needed on range wide distribution and population trend data for MGS populations.
12) Importance of connectivity between populations of MGS; need for better understanding of how many linkages are necessary, where should linkages be located, how large should linkages be to be effective?
13) What linkage areas are crucial to the species for its long-term survival?
14) What constitutes a viable MGS population?
15) Need to define what constitutes a core MGS population with boundaries that are acceptable to the MGS community. How many core populations are needed to recover the species?
16) What are the limiting factors impacting MGS population growth and sustainability?
17) Need density estimates on MGS populations throughout their range.
18) Need to know where populations are located and at what density.
19) Need to better understand of the relationship of MGS population density across different habitat types.
20) Are invasive species an issue for MGS?

21) Need to share information.
22) Need to collaborate/cooperate more effectively.
23) Need for greater resolution on genetics.
24) Need more information on mortality factors versus reproductive effects.
25) Policy and land planning decisions are being made ahead of the science.
26) How does development around military installations affect MGS populations on base?
27) Information is needed on how to conduct a demographic study on MGS, and understand how demographics are tied to habitat use.
28) Need for more work on MGS burrows, especially through an improved understanding of burrow configuration, artificial burrow construction, and burrow use.
29) Need to look into alternative funding opportunities to conduct MGS work on military lands.

Participant List of Prioritized Needs

Workshop participants then rated the different topic areas of data gaps based on what they thought was the most important to least important as listed below.

1) Range wide distribution/population trend data for specific areas throughout the MGS range.
2) Demographic data
3) Identification of habitat characteristics associated with MGS density.
4) Statistically robust survey protocols based on needs
5) Amount and type/configuration of habitat needed for the long-term sustainability of MGS populations
6) Resolution of MGS genetics
7) Nutrition/diet studies to help define habitat requirements
8) Clarification of factors limiting the growth of MGS populations
9) Identification of what constitutes a viable or core MGS population
10) Clear, valid models that represent the reality on the landscape
11) How to address data calls when there is limited information
12) Focus efforts on geographic gap areas
13) Population viability study

Field Surveys Techniques and Protocols

The purpose of this session was to provide workshop participants an overview and real-world examples of the types of field techniques/technology and protocols being used to survey for MGS. Dr. Leitner provided an overview of MGS live-trapping in the western Mojave Desert, as well as examples from his long-term survey work in the Coso Range. Mr. Delaney followed with an overview of the direct-funded U.S. Army CERL project that he and Dr. Leitner worked on that compared the effectiveness of live-trapping with camera trapping within the Western Expansion Area on Fort Irwin in 2009-2010. He continued by describing their current follow-on camera trap project funded in 2011-2012 by Fort Irwin and the California Department of Fish and Wildlife (CDFW), in which they are surveying for MGS using camera traps at random sites ranging from Ridgecrest to Lucerne Valley.

Mary Kotschwar, from the Desert Tortoise Preserve Committee, presented some recent data her organization collected at the Desert Tortoise Research Natural Area near California City, while surveying for MGS using direct and auditory observation. She also described some preliminary estimates on occupancy and detection probability based on their work.

CDFW Survey Protocol: overview and discussion of possible ways to revise

Scott Osborn, the statewide Coordinator for small mammal conservation for the California Department of Fish and Wildlife, presented an overview on the state's MGS survey protocol. The purpose of the CDFW MGS live-trapping protocol is to determine if the MGS is present in a proposed project area. The CDFW issues permits to trained biologists to conduct pre-project surveys for projects that would remove or degrade habitat.. The standard protocol covers projects up to 180 ac in area and linear projects up to 5 mi long (larger projects require case-specific survey protocols). Biologists need to be permitted to handle MGS. The current established CDFW MGS protocol specifies: 1) conduct visual surveys between Mar 15 – Apr 15 prior to live-trapping; 2) use 100 traps in either a 4 x 25 or 10 x 10 grid pattern, with 35 m spacing between traps; 3) traps should be placed within the best habitat on-site; 4) survey reports are reviewed by CDFW staff; 5) during diurnal hours traps will have shade covers and biologists should avoid putting out traps during inclement weather and when temperatures are too high; 6) three trapping sessions of 5 days each should be held per season, or until the 1st MGS detection - Session 1: between Mar 15 to Apr 15; Session 2 - at least 2 weeks later, between May 1-31; and Session 3: at least 2 weeks later, Jun 15 to July 15.

There are a number of limitations with the current CDFW trapping protocol, namely: 1) negative survey data is only valid for 1 year. This can be problematic for developers, but does provide important year-to-year variation in presence data; 2) the expense of conducting live-trapping surveys may encourage project proponents to assume MGS presence and go straight into permit application and associated MGS mitigation, which reduces the amount of data being collected on MGS distribution; 3) results are not statistically based, therefore it is not possible to conduct a detection probability analysis on the results; 4) data need to be updated on a regular basis, which can prove difficult if funding/willingness is not there; 5) currently there is no provision for the use of camera traps within the CDFW trapping protocol, but this technology/technique could be used on a case-by-case basis; and 6) there is an assumption that all sites within the MGS' range are occupied and thus require surveys.

During discussion, workshop participants suggested the following ways to improve the CAFW trapping protocol_____: 1) make requirements specific to geographic areas where the data were collected; 2) standardize mitigation; 3) require more trapping beyond 1st MGS detection to improve our base knowledge on MGS distribution and population trend data; 4) understand the significance of an impact and if it can be fully mitigated (for example,*the* quality of mitigation land may not be good enough to account for a loss, or do not know the importance of the loss, both in terms of habitat and number of MGS); 5) incorporate camera trapping into survey protocol trapping, either partially or fully depending on the location (camera trap use is limited by the threat of theft or vandalism in areas with high human use); 6) allow negative results to be good for 2 years or more during drought years; 7) trapping results should be driven by weather/drought, such that there must be adequate precipitation during biologically important times of the year (*i.e.*, winter) for there to be valid data, otherwise development cannot occur or would automatically require full mitigation; 8) assess habitat impact, treat models as hypotheses that needs to be validated through intensive surveying; 9) ensure grid design (*i.e.*, grid size and trap spacing and configuration) has a strong statistical basis for validation; 10) change purpose of protocol trapping from just detection to significance of population; 11) base protocol trapping on female home range; 12) specify most effective trap type (Tomahawk versus Sherman); may need to systematically compare trap types to determine this; 13) specify the most efficient bait type; may need to systematically test different types of bait first to determine this; 14) specify that taking tissue samples is required when live-trapping; 15) consider requiring the collection of demographic and habitat data to better assess project impacts; 16) consider collecting the types of data listed in Brooks and Matchett (2002); and 17) include negative data in the MGS database on survey location data.

Survey Efforts on Fort Irwin

Ms. Liana Aker, the lead wildlife biologist on Fort Irwin, provided an overview of their current and future MGS survey program. She stressed that they do not have a fully structured survey and monitoring program for MGS, but are using existing data and reestablishing species presence on the installation. She mentioned that they are using camera traps to document the presence of a number of species of interest on base, and are interested in expanding the work. The USGS recently donated some professional grade weather stations that they will use in conjuction with their trapping efforts. Both U.S. Army CERL and California State University, Stanislaus are assisting Fort Irwin with their MGS program.

Occupancy Models

Dr. Roemer, a professor at New Mexico State University, provided an overview of occupancy modeling. He emphasized the importance of incorporating covariate analysis in occupancy models to better understand factors that affect animal presence at each site. He provided some examples (Fig. 2) of covariates and subcategories within each covariate that might be important for understanding detection probability, occupancy rates, and demographic information. Important covariates can include weather (temperature, annual rain fall, wind), soils (e.g., structure, depth, rock, slope), vegetation (e.g., structure, seed bank, species composition, annual vs. perennial), time (e.g., time of day, season, phenology).

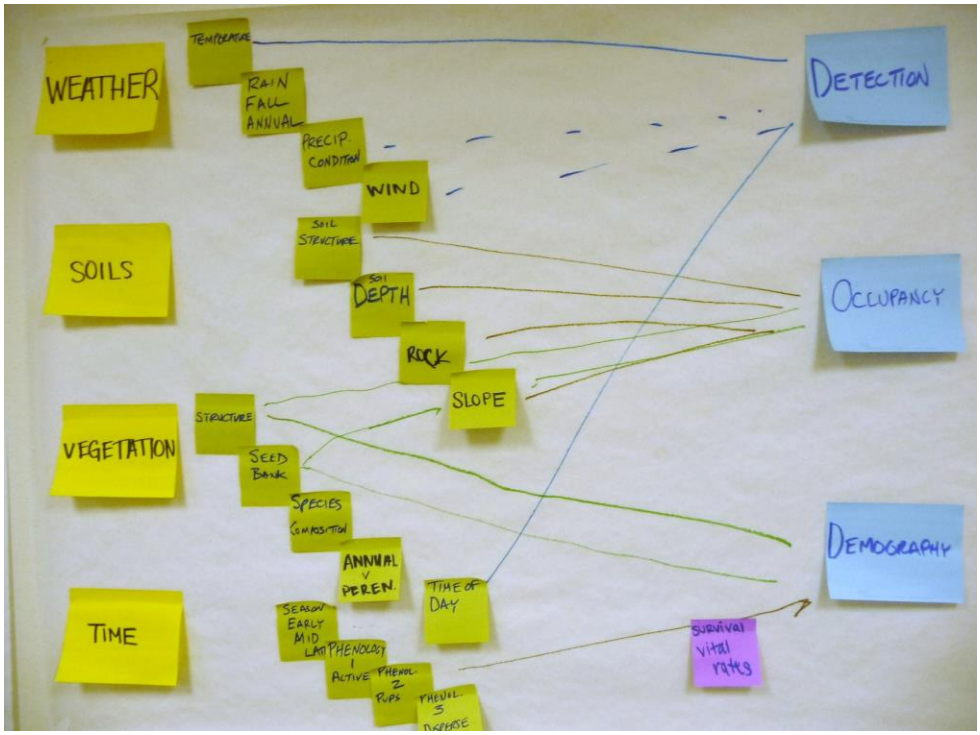

Figure 2. Examples of covariates and subcategories of variables that could be used in occupancy models.

Kit Fox Study

Dr. Roemer presented some of his work on kit fox on White Sands National Monument, NM from 2011-2012. He was studying kit fox occupancy, population dynamics, distribution, and abundance. His group addressed occupancy before investigating population dynamics. They also studied the general mesocarnivore community to assess the impact of carnivores on the ecosystem and the ecological role of carnivores. The study objectives were to document carnivore distribution patterns and measure ecological covariates. Some of the main covariates they investigated were prey abundance (e.g., rabbits), predator distribution (e.g., coyotes, which can kill foxes), environmental temperatures (kit foxes adapt to extreme temperature regimes better than coyotes), and bait type. They subdivided the study area into different habitat types and located random camera sites based on the proportion of habitat types and home range of kit foxes. Cameras were moved for different sampling sessions.

Matrix of MGS Survey Techniques

A number of different tools/techniques have been used to survey and monitor for the presence of MGS (Table 1). It is important for resource managers/researchers to understand the potential benefits and limitations of these survey techniques before deciding which technique is best for the land they manage or their research project. Table 1 provides a list of important distinguishing factors that people should consider as they decide which survey method(s) to use for their specific need/application. The ratings and the importance of the variables listed in Table 1 are subjective, and depend greatly on a number of factors, such as research/management question, funding level, experience, permit status, etc.

Determination of Rangewide Distribution

Discussion on this topic was primarily based on detection for distribution purposes. Participants discussed the importance of having the appropriate grid size, sample size, and sample technique based on the specific research question being asked. A range-wide sampling framework was suggested that would be made up of 10 x 10 km sampling units. Participants stressed the importance of prioritizing or randomizing within such a range-wide sampling grid, while taking into account where and when areas had already been sampled. It is not only important to fill in data gaps for areas that have never been sampled, but to collect information in areas that have not been sampled recently.

Participants agreed that it is important to do occupancy analysis on the existing presence data that have been collected (i.e., Edwards AFB and the Delaney and Leitner camera data). It was also pointed out that habitat modeling and occupancy estimates may help to identify those areas that should be sampled using more detailed demographic protocols. Edwards AFB has very detailed MGS presence data, and is interested in collecting demographic data on its MGS population.

Population Estimates and Habitat Quality

Workshop participants suggested the following ways to improve population estimates and habitat quality data, namely: 1) multi-year studies need to follow detection studies; 2) data need to be collected through a series of wet and dry years; 3) determine what factors (e.g., weather, vegetation, predation, etc.) drive distribution patterns (i.e., why are MGS found in some areas, but not others); 4) for demographic data, separate 5-day grid trapping sessions by 2 weeks throughout the active season to get all offspring and family lineage information; 5) collect more genetic information to better understand how MGS populations are linked; 6) need to conduct population viability analysis using grid-based mark-recapture study timed just before aestivation; 7) need to collect survival rate data by marking immigrants and emigrants within populations; 8) estimate population density using a closed-population model, e.g., estimate how many total marked individuals there are based on recaptures; 9) use individual fecundity estimates to estimate reproduction in a population; and 10) use survival and fertility rates to investigate population dynamics. A number of additional variables were identified as important when investigating population dynamics, such as: a) survival and fertility; b) use of a 2-stage model which measures the number of juveniles and adults at time t; c) measure of fecundity by calculating female annual survivorship x mean number of pups/litter; d) the annual survival of juveniles and adults determined by using a matrix; e) population size estimated at t + 1; and f) parameters factored in that are important for MGS survival, such as precipitation, vegetation, etc. A grid size of 500 x 500 m with 25 m spacing was suggested for population estimation and to assess habitat quality, though subdividing to subgrids to get the best data for parameter estimates was also suggested.

Table 1. Qualitative and quantitative matrix of variables for different surveying methods used for monitoring the presence of Mohave ground squirrels in the Mojave Desert, CA.

Variables	**Live trapping**	**Camera trapping**	**Audio surveillance**	**Visual surveillance**	**Track plates**
Quantity of data	Limited	Very large	Moderate	Low-moderate	Low-moderate
Quality of data	Very high	Very high	Moderate	Very high	Fair-poor
Possible number of MGS detections per day	Low-moderate	Low-high	Low-moderate	Low-moderate	Low-moderate
Chance that earlier data are compromised by more recent data	No	No	Unlikely, but possible masking by other sounds at the time of recording	No	Possible
Permits required	Yes	No	No	No	No
Environmental impacts on trapping success	High	Limited	Limited	Limited	Possible
Potential impact on MGS health/behavior	Moderate/high	Minor	Minor	Minor/moderate	Minor
Potential for disease transmission	High	None	None	None	None
Ability to individually identify squirrels	Yes	Limited	Limited	Limited	Limited
Data adequate to establish density estimates	Possible	Possible	Possible	Possible	Unlikely
Data adequate to establish occupancy rates	Possible	Possible	Possible	Possible	Unlikely
Time to setup/monitor/operate equipment	Fast-slow	Moderate	Moderate	Fast	Moderate
Time to reduce data	Fast	Moderate-long	Moderate-long	Fast	Moderate
Repeatability of results	Likely	Likely	Likely	Likely	Unknown
Ability to collect genetic samples	Yes	No	No	No	No

Table 1. cont.

Detection of non-target species/ social interactions	Likely/very limited	High/high	High/possible	High/possible	Likely/very limited
Threat of theft/vandalism	Possible	Possible	Possible	Possible	Unlikely
Cost	Expensive	Moderate	Expensive	Low-moderate	Moderate
Data collection in areas with reduced access	Limited	Few restrictions	Few restrictions	Limited	Limited
Consistency of data output	Moderate-high	High	Moderate-high	Moderate-high	Low
Ability to determine exact timing and duration of detections	Limited	High	High	High	Limited
Ability to document morphometric data	High	Not possible	Not possible	Limited	Limited
Confidence in target species identification	High	High	Moderate	High	Limited
Ability to draw in potential predators	Yes	Yes	Unlikely	Unlikely	Yes
Habituation of target animals to detection method possible	Yes	Yes	Not likely	Not likely	Yes
Distinguishes animal species	Yes	Yes	Likely	Yes	Possible
Technique requires specialized training/knowledge	Yes	No	Yes	No	Yes

4. DAY 3

Best Methods for MGS Detection

A number of different field techniques were discussed to detect MGS presence, including live-trapping, camera traps, auditory and visual surveys, track plates, and pit fall traps. Workshop participants discussed benefits and limitations for some of the more common field techniques that have been used in recent years (Table 1). Few studies have attempted to compare the detection rates between different techniques, though Delaney and Leitner (Delaney 2009, Leitner 2009) have collected some preliminary data comparing live-trapping with camera traps as part of a study within the Western Expansion Area on Fort Irwin in 2009-2010. These data suggest that camera traps are at least as effective as live-traps (Delaney 2009, Leitner 2009), but further analysis is needed before firm conclusions can be reached. The participants' discussion analyzed the different field techniques as follows:

Live-traps – Live-trapping is the predominant method for surveying MGS and other ground squirrel species in the western Mojave Desert. This method is known to be effective in detecting MGS presence, and is the only viable way to collect detailed morphometric and genetic data, but live-trapping can be costly and requires state permits. A variety of live-traps have been used for ground squirrels, including Tomahawk, Pymatuning, and Sherman traps. It does not appear that trapping success varies based on the trap type used, but there has not been a study done to specifically address this question relative to MGS survey use.

Camera traps - Workshop participants agreed that camera trap technology appears to be an effective, non-invasive method for detecting ground squirrel presence. In addition to randomly placing camera traps on the landscape to detect MGS presence, it was suggested that camera traps could be used to monitor animal behavior and collect demographic data at natal burrows. Further investigation is needed to determine what the optimal number of camera traps/grid is and what the best placement configuration is for this technology. Camera traps should be effective for determining occupancy rates.

Auditory/Visual Surveys – Auditory and visual surveys have been shown to be effective in detecting MGS and other ground squirrel species. These techniques can be cost effective for surveying small to moderate sized areas, although cryptic behavior of MGS sometimes makes auditory or visual detection problematic.

Track plates – Track plates have been used to a limited degree to detect MGS. There is a question as to the overall accuracy and consistency of this technique for identifying ground squirrels, especially between different species and age classes (but see Table 1 for more details). There does not appear to be any interest across land management agencies for the wide use of this technique.

Use of canines – The use of canines to detect MGS and other ground squirrels has had limited use (Leitner 2009). Canines can be trained to detect MGS presence, but at times it can be difficult to interpret their signals. In particular, it can be uncertain as to how long ago the target animal was present. This technique could possibly be used as an initial screening tool to locate areas that may be occupied by MGS, followed by use of live-trapping or cameras as confirmation. Researchers might want to also consider placing acoustic and/or video recording equipment on search dogs. Canine detectors could possibly be used to find MGS scat for genetic analysis, as it has for other desert species like desert tortoise (Clark and Heaton 2006), but more testing needs to be done, especially because of concern that canines may attract potential predators.

Sampling Design

The participants discussed an interest in establishing a range-wide sampling design that has consistent protocols across the range. The size of the sampling frame would depend on the areas of interest. Large sampling frames (e.g., 10 x 10 km) could be used to survey larger areas. The sampling frames could be based on UTM coordinates to make it easier to randomly subdivide larger sampling blocks into smaller areas. An advantage of this method is that it would allow for a comparison of detection data across the range and would make it easier to monitor ongoing/future survey work on MGS based on the same grid pattern. Use of a universal grid pattern would assist land managers/ researchers in identifying priority areas for sampling or for possible development, or where survey work has not been done, while also possibly helping to prioritize potentially suitable habitat. To date, most of the live-trap sampling for MGS presence has occurred in relation to project clearance surveys. Management/ research based sampling for MGS has occurred on Edwards AFB (Dan Reinke, pers. comm.), Fort Irwin (Liana Aker, pers. comm.; Delaney {2009}, Leitner {2009}), within the Coso Range (Leitner 1980), and at a number of random locations throughout the western Mojave Desert (Delaney and Leitner, pers. comm.). It is important to also resample areas with historic MGS records to update the status of the species in these areas.

Model Covariates

The United States Geological Survey (USGS) developed a habitat suitablility model based on occurrence data from 440 data points, all these occurances since 1975. The workshop participants were very interested in this model, particularly when it would be available to the public, and what variables were used in creaing the model. No one from the USGS that worked on the model was present, but Dr. Leitner, who collaborated on the project, provided some background material. The USGS used multiple Maxent models with custom layers for 14 environmental variables to model the data. Some of the model variables used in the USGS model included surface texture, surface albedo, precipitation, and winter climatic water deficit. Winter climatic water deficit was found to be the biggest predictor of MGS habitat suitability, while vegetation was not used because it could not project habitat suitability into the future under climate change scenarios. It was pointed out that the vegetation layers that were available for use by the USGS are not fine-scale or up-to-date. Todd Keeler-Wolfe, and others from the CDFW, are working on collecting additional vegetation plot data which should help to improve habitat information within much of the MGS range.

Workshop participants discussed model covariates that could influence detection, occupancy, demography, and habitat suitability for predicting MGS presence. They identified a number of variables that can impact the detection rate of MGS, including timing during the active season and time of day. Identifying the seasonal period and time of day when detection probability is the highest should be helpful in making future surveys more effective. Other important variables are weather (temperature, rain, wind, etc.), soil temperature, presence of predators (e.g., ravens, kit fox, badgers), bait type, and trap type. For determining occupancy rates, factors such as soil depth and texture, surface texture (e.g., rock, sandy soil, etc.), slope, and seed bank, could greatly influence model predictive power.

Capture and Survival Probability

Dr. Roemer presented some of his work on the banner-tailed kangaroo rat in the Chihuahuan Desert of New Mexico from 2004-2007. The study objective was to evaluate whether environmental drivers affect the survival of the banner-tailed kangaroo rat. They examined 15 environmental variables as possible drivers of kangaroo rat survival (e.g., precipitation, land surface temperature, vegetation, dew point, density, percent scrub cover, habitat saturation). They found that summer, diurnal land surface temperatures were the most important driver, and was negatively correlated with

banner-tailed kangaroo rat survival. The point of the study was to use models of factors influencing survival to determine probability of survival, and thus probability of recapture.

Statistical Analysis

Participants briefly discussed the importance of sample size, sample timing, and sample period when it comes to documenting variation in MGS populations across years. For example, factors such as weather and fecundity will greatly influence how stable populations are, and how long they can persist in a specific area or across a larger region. It was pointed out that few land managers within the western Mojave Desert have a good understanding of where MGS occur on their lands. However, EAFB does have good information on the spatial occurance of MGS populations on base. This installation is well-positioned to investigate habitat associations with MGS presence/occupancy data by comparing areas with and without MGS presence.

Conservation Strategies

Workshop participants started by listing some other conservation strategy examples, such as the Flat-tailed Horned Lizard Management Strategy for minimizing habitat loss and the BLM conservation strategy which was incorporated into the West Mojave Plan. The Desert Managers Group has sponsored the development of an MGS Conservation Strategy Plan. Previous editions of this conservation plan were incorporated into the most recent version. It is important that this Conservation Strategy Plan be incorporated into the Desert Renewable Energy Conservation Plan (DRECP). The BLM is also working on a set of rules for maintaining, altering, or expanding conservation allocations across the western Mojave Desert. It is important that any conservation strategy incorporative adaptive management of the resource and identify areas that are critical for MGS recovery. Participants discussed the function of a conservation strategy and how it compared with a recovery plan. An effective conservation strategy should provide adequate conservation measures so that federal listing of a species is not necessary. There was interest from the group in reestablishment of the MGS Working Group and associated information resources. The group determined it is important that the conservation strategy be updated as more information becomes available, in order to be effective long-term.

Participants discussed the importance of developing recovery goals for the MGS that would remove this species from listing under the California Endangered Species Act (CESA) list and preclude federal listing as well. Participants raised several questions associated with recovery goals

for the MGS, namely: 1) what conservation measures would meet both goals of removing the species from CESA and precluding federal listing; 2) what should the delisting criteria be for this species; 3) how many core populations are necessary to recover this species and where are they located; 4) how stable is the population, which expresses the need for population trend data; 5) what actions are necessary to sustain the population; 6) how best to monitor the species and determine the population trend/trajectory over time; 7) what are the opportunities for conservation; 8) how best to restore MGS habitat; and 9) how best to conserve what remains.

Participants discussed the process of adopting a conservation strategy, namely: getting people involved that are interested, folding in the MGS Technical Advisory Group, and securing agency involvement for input, effective implementation, and development of conservation priorities. It is important that future research inform land management actions to benefit the MGS. A key component of conserving this species is identifying core areas and linkage areas and maintaining the connectivity between them. To provide for the long-term survival of the MGS, and to preclude the need for federal listing, there needs to be more research across a variety of life history topic areas for the species. The USFWS makes its listing determinations on the best available scientific information, but there are limitations on what is available. There is an important need for functional and effective groups working on the conservation strategy for this species and the need for tools to help focus needed research and improve ways to find new funding sources. Ms. Logsdon announced CDFW's plan to lead the update and completion of the current draft Conservation Strategy to fold into the DRECP, with the participation of the Desert Management Group, and an interagency working team was developed during the course of the workshop.

Map Review

Workshop participants reviewed maps showing MGS distribution and discussed which areas they thought were critical to conserve the species, which areas were desirable to conserve, and which areas need more research due to a lack of information on MGS occurance. The discussion included the terminology of "core area" where MGS are know to persist and "corridors" which represent occupied linkages where MGS may be moving currently and in the future, especially in response to climate change. The map also provided for discussions of known MGS populations, known areas of MGS concentration, and of MGS populations thought to be genetically connected. Participants discussed the effects of topography on occurrence and what factors that may create barriers for MGS movement. Areas were identified where participants thought more information was needed on MGS

populations (e.g., South of EAFB to El Mirage Valley, NAWS at China Lake, Fort Irwin, California City area north of EAFB, and the Kramer-Fremont Desert Wildlife Management Areas. It was suggested that the USGS habitat suitability model should be utilized to review prospective areas for MGS presence to help focus research questions and prioritize where work should be done.

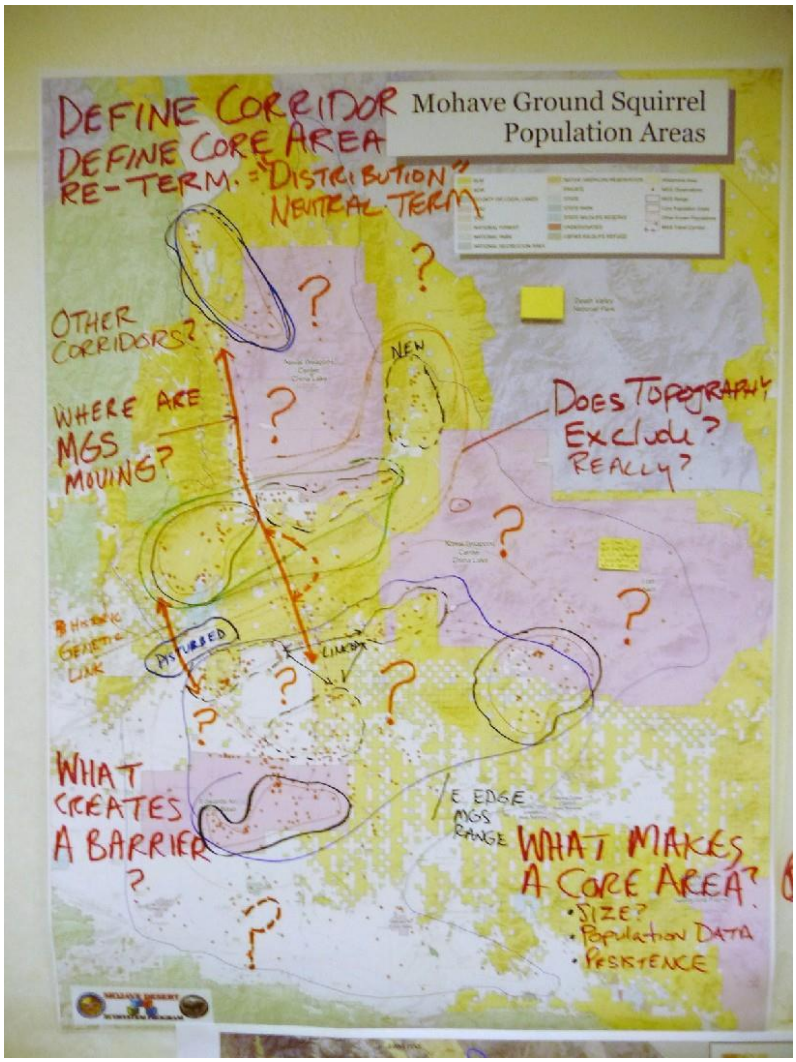

Figure 3. Distribution map of the Mohave ground squirrel. Participants used the map to discuss topics such as core area, corridors, and possible changes in distribution relative to climate change.

DRECP Maps

Ms. Hogan attended the DRECP REAT meeting in Ontario, CA the same week as the MGS workshop. She presented maps to workshop participants showing alternative locations (which will be analyzed under the California Environmental Quality Act) that might be reserved for the siting of renewable energy projects across the landscape of the western Mojave Desert development focus areas (DFA). It was explained that in addition to DFAs, the DRECP alternatives provide potential arrangements for a reserve design, with conservation priorities based on the level of biological sensitivity. The participants discussed that conservation of MGS should not be driven by potential development scenarios, but by the biology of the species. See http://www.drecp.org/ for more information.

Southern Idaho Ground Squirrel

Dr. Yensen presented overview material on northern Great Basin ecology, including how human use and ecological impacts have changed the landscape. He followed with a discussion of the life history of the southern subspecies of Idaho ground squirrel and identified the species as an important component of the local ecosystem. He then provided some detailed examples of his team's research, including studies of reproduction, survival, food abundance, burrow configuration and use, and population growth as components of a population viability model for the southern Idaho ground squirrel. He discussed how his work related to MGS diet studies and suggested that a similar population viability model could also be applied to MGS. He recommended trying to determine the historical conditions of the West Mojave Desert to better determine how MGS have adapted to changes on the landscape.

Climate Change

Participants discussed how climate predictions appear to show that the Mojave Desert will get hotter and drier in the future. The University of California, Los Angeles Climate Study Center is projecting that the number of "extreme heat events" in southern California will increase by 30-40% by mid-century (Hall et al. 2012). Some studies indicate that vegetation composition within the MGS range appear to be changing over time due to increasing temperatures. The group expressed concern that increasing temperature and decreasing precipitation in the Mojave Desert will particularly affect the growth and viability of certain plant species with Great Basin affinities, many of which are important MGS forage species. The MGS does not appear to be physiologically well-adapted to its

desert existence, but uses behavioral mechanisms as its primary adaptation. If overall temperatures rise and warmer conditions expand during the year, such changes could cause MGS to shift their daily and seasonal activity patterns. Based on their postulated climate envelope, it is likely that MGS will move to north in response to climate change.

5. DAY 4

Terminology Discussion

The group discussed the concept of "core areas" and its variety of definitions and criteria associated with it depending on the species being discussed. The concept of core areas is sound, but there appears to issues with its use, how it is applied, and the semantics of the phase. The use of certain terminology (e.g., core area, core population, and corridors) can cause difficulties in communication between resource managers/researchers and other stakeholder groups (*e.g.*, general public, contractors, business community, County Supervisors, etc.). It important that resource managers/researchers are aware that other stakeholder groups may have different perspectives on what specific terms mean and that this can lead to misinterpretation or confusion of the message that resource managers/researchers are trying to convey to the other groups. Two prime examples of terms for which there has been some confusion, include "core population/area" and "corridors". The concern about the use of these terms has to do with the restrictive use that some stakeholders have put on these terms based on their own impressions/biases. Some stakeholder groups have the impression that the terms core area and corridor only refer to specific areas on the landscape, and that the land areas covered by these terms do not change over time (*e.g.*, expansion or contraction) due to possible extrinsic or intrinsic factors such as drought, anthropogenic effects, climate change, etc.

Several participants at the MGS workshop expressed caution in the use of these terms when communicating with stakeholders because some stakeholder groups assume that the protection of some initial core areas identified by Leitner (2008) will be adequate to sustain MGS populations over the long-term. Leitner (2008) did not suggest that the core areas that were identified in his paper were the only such areas within the historic range of the MGS, but that those were the areas that met his definition at that time based on the available distribution data. Resource managers look to expert opinion and empirical data to help them identify important animal populations, but it important to understand that such information is not static, and that it should be considered more dynamic in

nature. It is important to identify and describe areas that will allow populations to expand, remain, and persist over time.

The group also expressed concerns that there is increasing pressure to identify important population areas and migration pathways that MGS use relative to the siting of renewable energy DFAs within the western Mojave Desert. It is important that all stakeholders groups recognize that additional "core" areas may be identified as new information on MGS distribution becomes available. There has been a substantial increase in the amount of data on MGS distribution since Leitner (2008) was published. Work is being done to update the historic/known distribution of MGS using newly available survey data (Leitner, pers. comm.). His definition of MGS core area was based on three factors that were generated from historic/current live-trapping data. It is important that resource managers, researchers, and others convene to discuss what the definition of "core area" means for the MGS and to agree on the criteria used to define such areas.

Concept of "Core Areas"

Participants thought that the concept of core area/population was sound, but that they are issues with how people use the term and a general lack of consistency with its use. It was suggested that the term "known" precede the word "core" so people do not emphasize core areas as the only areas that need protection. The group thought that persistence of a population over time and across one or more drought cycles was a good indictor of a core population. The group agreed that more areas need to be surveyed to better understand where populations occur across the landscape. It was suggested that populations that are genetically linked could be defined as a "core" area or "population center", without defining blocks of habitat. It is important to understand that populations expand when habitat is healthy, and can contract when habitat degrades. There need to be good descriptions of habitats where MGS populations have been found to expand, remain, and persist over time. The relationship between habitat characteristics and MGS presence, density, and reproductive fitness needs to be much better understood. With the growth of human population centers and activities within the western Mojave Desert, it is crucial that we are able to identify currently occupied areas that MGS populations may be capable of expanding into, especially when considering the effects of climate change on the MGS. It was suggested that instead of core populations that the term "source population" could be used. Associated with the earlier group discussion of climate change, it is anticipated, based on USGS and University of Nevada, Reno modeling efforts, that MGS will move in a more northerly direction in future years. The group brought up the question of how to address areas

without data, and how to determine additonal "source" areas, if new populations are detected after non-drought years (i.e, recolonization).

Concept of "Corridors"

As with "core population", the participants were also concerned about how the term "corridor" has been misused as well. It was suggested that a better term might be linkage. Regardless of the term, the participants agreed that the concept and importance of conserving land for MGS to move between important population areas is crucial to the long-term survival and sustainability of this species. The group noted that there are different types of corridors depending on the linkage being discussed, such as genetic or demographic linkages. Detailed vegetation and habitat suitability models could indicate where demographic linkages could exist. The University of Nevada, Reno is working on a connectivity model for MGS based on the USGS habitat suitability model. The UNR model takes into account potential barriers (e.g., fallowed agriculture land in Fremont Valley, or developed areas in Indian Wells Valley), but it is not clear how permeable these barriers are to MGS movement. It is important to determine the best paths across the landscape for MGS in different parts of the range. Research on genetic linkages will be very helpful in identifying these important areas. The collaboration between volunteer trappers and researchers has provided tissue samples from MGS that will help ground-truth the UNR connectivity model and help with questions concerning potential hybridization between MGS and the closely-related round-tailed ground squirrels (*Xerospermophilus tereticaudus*). The BLM, South Coast Wildlands, and Northern Arizona University are also working on the topic of linkages, and have developed a linkage network for the California deserts (Penrod et al. 2012). It was pointed out that a modeled corridor is a planning mechanism, not a design. The model can show how landscape patterns affect species movements, which can be used for land use planning. However, whether or not a "corridor" is used as a linkage depends largely on habitat, and the discussion pointed out that habitat models need to be validated before a "corridor" model can be relied upon.

Translocation/Captive Breeding

Workshop participants discussed the concept and application of translocation/captive breeding programs in relation to MGS. There was agreement that in most cases the use of translocation/captive breeding programs should be a last resort, and not a substitute for real recovery actions. The majority of ground squirrel translocations have failed (E. Yensen, pers. comm.), emphasizing the need for

careful planning prior to any such attempt. The participants stressed the importance of having detailed information (sink/source population, territorialism of species of interest, habitat, genetics, etc.) about the potential translocation site prior to any action. They also discussed the importance of having detailed data on the receiving population and other important biological factors, such as predation pressure. Animals with a strong homing response have been documented to travel many miles in search of their original home territory, which exposes them to increased risk from predation and anthropogenic impacts outside of the project activity. Prior to any translocations, it is essential to clearly define how it will be determined if the translocation was successful and what data will be collected to evaluate success? It was pointed out that ground squirrels in general have not been propagated in captivity on a large scale. Some ground squirrels have been propagated for research purposes, but not for the purpose of recovering a population. More investigation is needed to determine what other ground squirrel species have been raised in captive breeding programs and how successful those programs were. It is important to take into account differences in life history characteristics between ground squirrel species when developing a captive breeding/release program. The participants agreed that it is important to collect information on existing translocation/captive breeding programs in case of catastrophic events that could force resource managers to consider such actions. Information on the success and failures from zoos would be helpful in developing a proof of concept MGS program. One major concern of captive breeding/release programs is the effect that these reintroduced animals have on the receiving population and the surrounding resources.

Improved Communication/Cooperation

The group discussed recent examples of cooperation within the MGS community, such as volunteer live-trapping surveys to collect genetic tissue samples for ongoing speciation research between MGS and round-tailed ground squirrels. Participants discussed the importance of collecting, analyzing, and reporting MGS data in a more uniform manner. The group discussed ways to improve communication within the MGS community, as well as how to distribute information to other groups using MGS web sites (DMG, MDEP, MGS Working Group, etc.). The discussion identified the importance of establishing ways to improve communication and more readily include other interested groups in the MGS community.

Post-Workshop Plan to Move Forward

Participants listed a number of actions they were interested in taking to move forward with the information discussed at the workshop, namely: 1) use information and discussion from the workshop as a springboard for future meetings/discussions; 2) establish additional working groups to address specific topic areas; 3) re-invigorate the Desert Manager's Group by reaching out to other groups/organizations (i.e., non-governmental organizations, consultants, biologists, academic scientists, etc.); 4) move forward with the parties involved in developing the MGS conservation strategy; 5) invent new pathways to get information out to other interested parties and get them more involved; and 6) establish new ways to improve and foster ongoing communication/collaboration among groups/individuals.

Post-Workshop Follow Up Topics

There were a number of topics/issues that participants were interested in following up on after the workshop:

1) Develop a draft summary report of the MGS workshop.
2) Submit a draft report to the DoD Legacy Program for their review (12/31/12).
3) Secure additional funds to analyze existing data MGS data (e.g., occupancy data analysis).
4) Work with desert counties to advocate the use of "soft foot prints" for energy/human development projects, MGS monitoring plans, BMPs, and CDFW policy.
5) Revise the MGS protocol trapping procedures (CDFW).
6) Invite the USGS authors of the MGS Habitat Suitability Model to the next MGS Technical Advisory Group meeting to present their work, as well as a CEC research briefing.
7) Develop a demographic protocol based on the best survey methodology to collect MGS demographic data. There is interest across multiple agencies, but EAFB is in position to mobilize data collection on this topic.
8) Develop the concept of "core area" and distributed to the group for input by 12/31/12.
9) Complete an update to the Leitner (2008) paper by 12/31/12.
10) Continue the process of organizing and coordinating the MGS conservation strategy efforts.
11) Learn about captive breeding program for MGS;
12) Educate the public through new exhibit on MGS at regional zoos.
12) Learn more about the CDFW's policy direction associated with MGS.

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APPENDIX A

Workshop Participants/Facilitation Team

Participant	Organization
Judy Hohman*	U.S. Fish and Wildlife Service
Bronwyn Hogan*	U.S. Fish and Wildlife Service
Scott Osborn*	California Department of Fish and Wildlife
Randi Logsdon	California Department of Fish and Wildlife
Becky Jones*	California Department of Fish and Wildlife
Lisa Gymer	California Department of Fish and Wildlife
Eric Weiss	California Department of Fish and Wildlife
Clarence Everly	Fort Irwin
Liana Aker*	Fort Irwin
David Delaney*	U.S. Army CERL
Danny Reinke	Edwards Air Force Base
Thomas Mull	Edwards Air Force Base
Fon Allan Duke*	MDEP, DoD Coordinator for DMG
Russell Scofield*	BLM, DoI Coordinator for DMG
Larry LaPre	Bureau of Land Management
Jeff Mach	Oregon Army National Guard/Military Department
William Vagt	Oregon Army National Guard/Military Department
Philip Leitner*	California State University at Stanislaus, ESRP
Eric Yensen	The College of Idaho
Jeff Aardahl	Defenders of Wildlife
Mary Logan	Desert Tortoise Preserve Committee
Marjorie Matocq	University of Nevada, Reno
Gary Roemer	New Mexico State University
Debra Hughson	National Park Service, Mojave National Preserve
Jim Nelson*	Nelson Facilitation
Soren Nelson	Workshop assistant
Julia Gonzales	Workshop assistant (CDFW)

* Planning Committee Members

Figure 1. Photograph of the participants of the DoD Legacy funded Mohave Ground Squirrel Workshop held at the Mojave National Preserve Office in Barstow, CA 24-27 July 2012.

APPENDIX B

Summary of Workshop Evaluation
Mohave Ground Squirrel Working Group
July 24-27, 2012

1. . Please tell us who you represent:
   Total evaluations: 21
   Military: 5
   Federal Agency: 6
   State Agency: 5
   Other: 5
      -Desert Tortoise Preserve Committee
      -NGO
      -Academia x3

2. In general the meeting was:
   Great: 14
   Very Good: 7
   Good: 0
   Fair: 0
   Poor: 0

3. Something I liked about this meeting was...
   - Facilitator kept on track and moving
   - Good discussion, density and distribution discussion
   - Participation of outside researchers. Presentations on new techniques – camera trapping.
   - Bringing in people from outside the MGS world, bringing in academia
   - Interest in data, models, and natural history
   - Weaving of non-MGS topics into the agenda. Good presentations by Eric, Gary and others – helped inspire the MGS-centric discussions
   - Learn what is happening in other states – ideas on how to improve protocols – modeling
   - The opportunity to coordinate and learn and feel confident about moving forward with being part of the group that conserves and recovers MGS
   - The wealth of knowledge out there and willing to share research work, genetic results, conservation thoughts – all very useful.
   - The length of time which stressed the focus to the species w/o being distracted w/ daily grind
   - Everyone's willingness to share so much information the facilitation that kept the meeting running so well and the extensive reading list sent out before the meeting
   - Outstanding facilitator and impressive participation by leading experts. Key was devoting time for active participation by all.
   - Collaboration and dedication by the participants, good people, good meeting
   - Participation
   - Energy, interaction, data sharing, new ideas. Facilitation!
   - The collection of attendees I thought was nearly perfect. I would have loved a bit more background and current approaches for WA ground squirrel but Eric Yensen was awesome w/ Idaho g.s.

- Very good folks – the right folks – the non-MGS folk helped – generated good life for new projects
- Expansion of knowledge related to professionals dedicated to MGS conservation. Ability to see future projects for EAFB.
- Participation by all members of the workshop.
- Great contributions from everyone – discussions provided ideas for future work
- Very interactive; passionate ecologists and land managers

4. Something that I think could have been improved is...
- More lunches in
- Too cold
- Fewer acronyms. Less emphasis on DRECP
- Temperature of the room. After first day not going around room asking what they got out of the day's discussion
- Integration into planning
- I wish I had done more of the pre-meeting reading, and that DFG generally was better prepared. How can you ensure prior preparation?
- More on future needs for climate change
- Not much – very well facilitated – got everything I had hoped for.
- Keep room temp more moderate! In summer 75 lowest
- Still need to keep the focus tight (although it was VERY good/tight) still might have resulted in more deliverables.
- I think a little more time could have been spent developing the list of study covariates affecting detection and occupancy, but I appreciate the facilitator keeping things moving to cover all the topics.
- None!
- Hard to improve upon.
- More goals to be set.
- Well if I HAD to complain, things we couldn't do anything about: the presentation screen could have been bigger and the climate in the room w/ fluctuating temperature hot/cold.
- Well done – not really.
- Having CD available w/ data before meeting on presentations
- Seasonal timing to afford a field trip
- More info about fund – (just kidding!)
- The meeting was very smooth – I don't think anything needed to be changed

5a. Do you see this workshop being a catalyst for future MGS meetings/discussions? If so, in what ways (in person, e-meetings, regular comm., etc.)? Involving what specific topics?
- Yes – DMG
- Communication down to the Technical Advisory Group. Use of camera trapping.
- Yes.
- Yes – e-meeting – regular communication
- I hope this will be a catalyst for MGS and basic biology of MGS, which is sorely needed to inform conservation decisions.
- Yes, e-meeting mostly. Conservation strategies, trapping protocols.
- Yes – helped launch conservation strategy

- Yes. As new info comes in would love to discuss results and implications.
- Certainly I think it will be a variety at forums. Processing existing data – modeling, policy reform etc.
- Yes! I foresee a lot of telephone and email conversations about data analysis and study design with several of the people here.
- Yes, mix of telecom/webex and occasionally in person as needed to allow for personal interactions
- Meetings like this are always beneficial.
- Yes, web and in person. Modeling and data analysis.
- Yes! In form appropriate to the need!
- I think the most important role of this meeting was to be a catalyst for participation and collaboration in general, in any form – be it future meetings and conference calls.
- Yes – in person cooperation
- Yes – following modeling / validation, demographic studies
- Yes. In all possible way. All pertinent topics
- Yes – good opportunities for future communications thru DMG and MGS TAG
- Yes; all of the above. Another meeting would be prudent after another round of data analysis.

5b. How often should a workshop such as this take place, if at all, in the future?

- Within the next year
- Every couple of years
- ~2 years
- After some demographic input
- This scale 1st every 2 years
- As needed, and it almost certainly will be needed again at some point
- 1 a year or as needed
- Every year or two
- Every 2 years or so
- Every other year
- Another year or so – maybe smaller groups on specific topics (i.e DFG survey protocol)
- Every few years we should all try to meet again
- If a stronger research and conservation effort can be started, the once per 5 yrs would be a good interval
- Once /year
- Perhaps in 5 yrs to see where we are. Future sooner workshops would focus on a particular topic.
- Every 5 years

6. Other comments:

- Really enjoyed Dave's organizing dinner together
- It would be good to have a group like this meet every four years to review how we are doing in our progress to conserve the species and recommendations on how to improve what we are doing
- I appreciate having a facilitator w/ a science background
- Would love to have a meeting that allows a field trip to see MGS
- Enjoyed your style of facilitation, Jim. I hope we meet again.

- Very good presentation provided new way for EAFB to more towards MGS conservation
- Far exceeded my expectations
- Thanks! A+ kudos to Dave for organizing the workshop and Jim's outstanding facilitation.
- Thanks for inviting me and allowing me to participate and contribute ideas.
- Thanks so much for everything
- Great info. Great ideas. Great discussions. Great facilitation.
- Sorry I missed the 2 middle days
- Still very hard to integrate military conservation with conservation on other federal lands and private lands.