
CURRENT STATUS OF THE MOHAVE GROUND SQUIRREL (*XEROSPERMOPHILUS MOHAVENSIS*): A FIVE-YEAR UPDATE (2008–2012)

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Abstract.—The Mohave Ground Squirrel (*Xerospermophilus mohavensis*) is endemic to the western Mojave Desert of California and is listed as Threatened by the State of California. Its current conservation status is of great interest because of the large-scale development of renewable energy resources in the California desert. To document its current distribution and status, I assembled a comprehensive database covering unpublished field studies and surveys conducted during the five-year period from 2008–2012, updating a publication covering the preceding 10 y (Leitner 2008). These data confirm that Mohave Ground Squirrels are still present in all areas known to be occupied during the period 1998–2007. Recent surveys have documented new occurrences in additional areas, especially in the central part of the range. Although the southern portion of the range was most intensively sampled during 2008–2012, the only positive records were from Edwards Air Force Base, with an additional detection in Victor Valley. This suggests that local extirpations may have occurred in recent decades throughout much of the southern part of the historic range. Systematic surveys are recommended for large areas in the central and northern portions of the range where occurrence data are lacking. In particular, the status of the species on the China Lake Naval Air Weapons Station and Fort Irwin should be better documented. The possible expansion of the closely-related Round-tailed Ground Squirrel (*Xerospermophilus tereticaudus*) along the eastern edge of the Mohave Ground Squirrel range may have serious impacts and should be carefully monitored.

Key Words.—conservation; distribution; geographic range; Mojave Desert; renewable energy; *Xerospermophilus tereticaudus*

The Mohave Ground Squirrel (*Xerospermophilus mohavensis*) is listed as a Threatened species under the California Endangered Species Act. It is restricted to a small geographic area in the western Mojave Desert of California. Although the species was originally listed because of low numbers throughout its range with the cause unknown, it is currently of intense conservation interest because of recent proposals for renewable energy development within its range. Several state and federal agencies are currently in the process of planning for the conservation of desert species and ecosystems while facilitating the appropriate development of utility-scale renewable energy in the California deserts. To support these planning efforts, it is important to document the current geographic distribution of the Mohave Ground Squirrel, as well as existing data on its status throughout the historic range. I have previously presented all available information on the status of the Mohave Ground Squirrel for the period 1998–2007 (Leitner 2008).

In this study, I have updated that analysis, bringing together information from unpublished field surveys conducted during the five-year period from 2008 through 2012. I obtained reports for all sponsored research efforts and received the results of protocol trapping surveys from consulting biologists. The data I present here include both positive records documenting Mohave Ground Squirrel occurrence and negative records from field surveys in which the species was not detected. The overall purpose of this review is to document current known geographic occurrences of the Mohave Ground Squirrel, to identify areas in which the species no longer appears to be present, and to recommend additional field studies and other management actions where needed. I have also

included some recent occurrence records for the closely-related Round-tailed Ground Squirrel (*Xerospermophilus tereticaudus*) to better define its current contact zone with the Mohave Ground Squirrel. The Round-tailed Ground Squirrel is widely distributed throughout the eastern Mojave Desert of California and there is increasing evidence that it is expanding westward, replacing the Mohave Ground Squirrel in certain areas.

METHODS

I used several sources of information regarding the distribution and occurrence of the Mohave Ground Squirrel from 2008–2012: the California Natural Diversity Database (CNDDDB), regional field studies, protocol trapping at proposed development sites, and incidental observations reported by field biologists. The CNDDDB is a state-wide program managed by the California Department of Fish and Wildlife (CDFW) that maintains an inventory of the status and locations of rare species and natural communities. This program only lists positive occurrences and is not designed to provide a systematic survey. The CNDDDB contained 399 occurrence records for the Mohave Ground Squirrel as of June 2013. There were 28 occurrences at new locations submitted from 2008–2012 plus eight new records at previously known locations for the species. A number of regional field studies using live-trapping were conducted from 2008–2012, many of them funded by state and federal agencies. I have reviewed unpublished reports that describe the results of such trapping surveys and have also obtained data from several biologists whose surveys have not been documented in formal reports. These studies provide positive records of

Mohave Ground Squirrel occurrence, as well as negative results where trapping efforts failed to detect the species.

David Delaney and I conducted a large-scale field investigation using trail cameras in 2011 and 2012 at 123 sites widely distributed within and adjacent to the historic range (Leitner and Delaney 2014). These camera sites were randomly located on public lands within 12 large study areas that stretched from Lucerne Valley in the south to Searles Valley in Inyo County. Additional data on Mohave Ground Squirrel distribution was derived from the protocol trapping surveys carried out at proposed development sites as required under CDFW guidelines (California Department of Fish and Game 2010). To collect records of protocol trapping surveys for the period 2008–2012, I contacted all biologists who possessed a CDFW Memorandum of Understanding authorizing take of Mohave Ground Squirrels. All biologists who were actively conducting surveys during that period provided their records, including dates of trapping sessions, locations of trapping grids, number of trap-days of sampling effort, and whether or not Mohave Ground Squirrels were detected.

I have classified as incidental observations all records reported by biologists who observed or captured Mohave Ground Squirrels incidental to other field studies. This category includes visual and auditory detections, captures made while trapping for other species, and highway mortalities. I list the number of records obtained for this review from regional trapping and camera surveys, protocol trapping, and incidental observations (Table 1). For regional and protocol surveys, a record is defined as a single trapping session (usually five days) at a specific grid location. If no Mohave Ground Squirrels were detected, such records were considered negative, while a positive record was a trapping session in which > one Mohave Ground Squirrels were captured. For regional camera surveys, a positive record indicates that there was > one Mohave Ground Squirrel detection at a particular study site. For incidental observations, all records were positive. The sampling effort for regional and protocol surveys is calculated as the number of traps operated per day times the number of days per trapping session, summed over all trapping sessions.

I entered data from all sources into Excel spreadsheets. I developed a series of base maps covering the geographic range of the Mohave Ground Squirrel using GIS techniques. I plotted all records, both positive and

negative, on these digital maps for visual analysis. In this way, the distribution of Mohave Ground Squirrel occurrences over the five year period from 2008–2012 could be visualized in relation to the distribution of sampling effort (with blank areas denoting no sampling).

RESULTS

General distribution.—Sampling efforts during 2008–2012 covered approximately 70% of the geographic range of the Mohave Ground Squirrel (Fig. 1). Overall, the regional and protocol trapping surveys plus the camera surveys resulted in 868 negative records, as compared to only 141 sessions in which at least one Mohave Ground Squirrel was detected. Although the regional trapping studies involved only 22.2% of the total trapping effort, they accounted for 89.7% of the positive trapping records. On the other hand, the protocol surveys made up 77.8% of trapping effort, but contributed only 10.3% of Mohave Ground Squirrel trapping detections. I recorded Mohave Ground Squirrels at 73 of the 123 camera trapping sites.

There was very little survey activity in Inyo County, the northern part of the range. However, I regularly detected the species by live-trapping at two long-term study sites in the Coso Range on China Lake Naval Air Weapons Station (NAWS; Leitner 2010, 2011, 2012). There were also several positive records in northern Searles Valley based upon camera trapping, live-trapping, and visual observations. The only other occurrences reported for Inyo County were four incidental observations in the Indian Wells Valley area of China Lake NAWS.

In the central part of the range, from Ridgecrest south to State Route 58, there was extensive survey activity during 2008–2012 with a large number of Mohave Ground Squirrel detections noted. As in the period 1998–2007, positive records confirmed the continued presence of Mohave Ground Squirrels in Little Dixie Wash southwest of Inyokern, around the Desert Tortoise Research Natural Area (DTRNA), and in Superior Valley on Fort Irwin (Leitner 2008). The camera study carried out in 2011–2012 sampled the central part of the range from Ridgecrest south to Kramer Junction and east to Hinkley. I detected Mohave Ground Squirrels at 71% of camera sites in this region.

The southern part of the Mohave Ground Squirrel range, south of State Route 58, was sampled extensively

TABLE 1. A summary of the data sources used for this review of the Mohave Ground Squirrel (*Xerospermophilus mohavensis*), indicating the total number of records of each type, the number of positive records, and the sampling effort for trapping surveys as measured by the number of trap-days.

Type of Data	Total Records	Positive Records	Trap-days
Regional Trapping Surveys	172	61	98,155
Regional Camera Surveys	123	73	15,200
Protocol Surveys	714	7	344,665
Incidental Observations	99	99	---
Totals	1,108	240	458,020

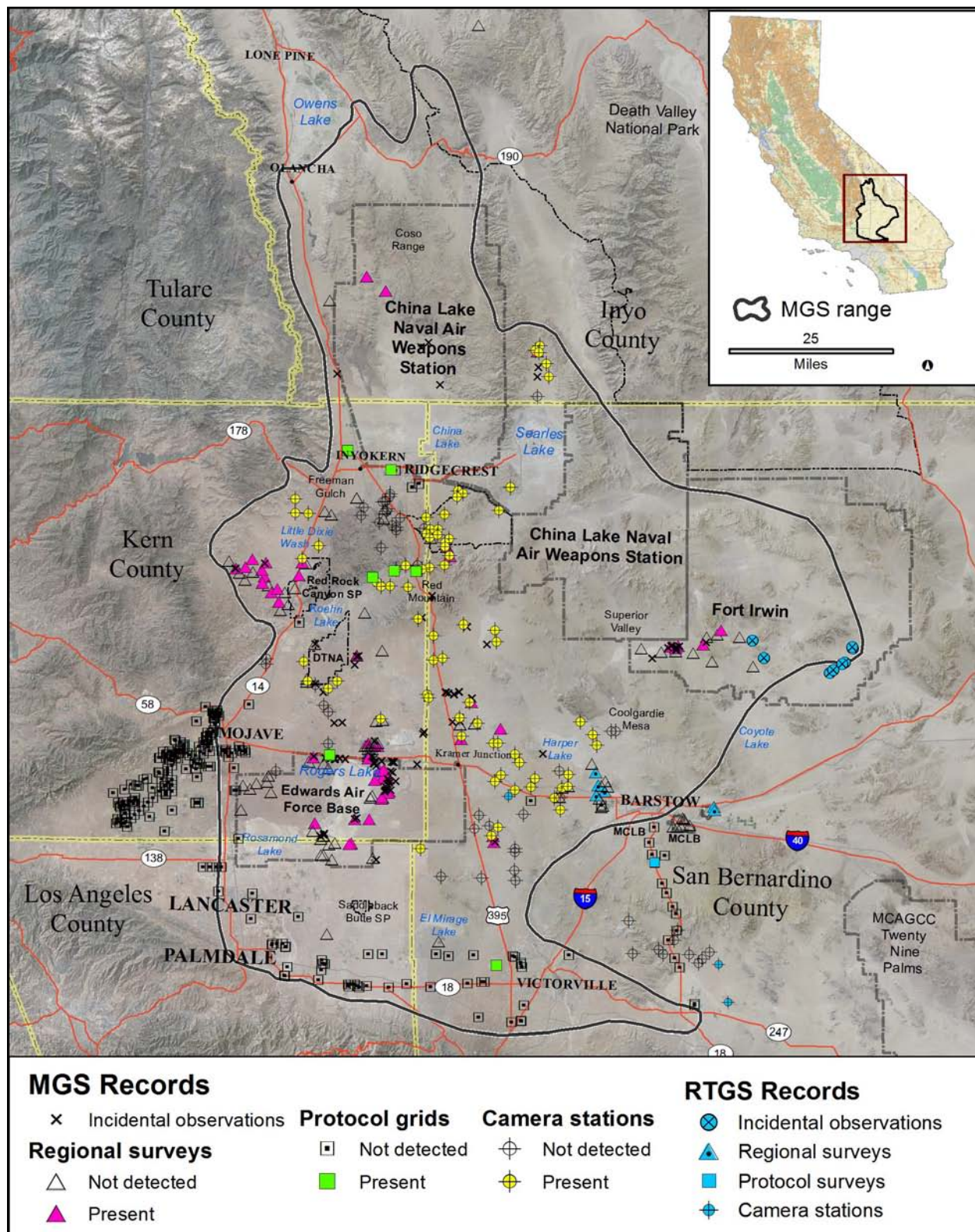


FIGURE 1. The geographic distribution of all Mohave Ground Squirrel (*Xerospermophilus mohavensis*) records for the period 2008–2012. Occurrences of the Round-tailed Ground Squirrel (*Xerospermophilus tereticaudus*) in the contact zone between the two species are also shown.

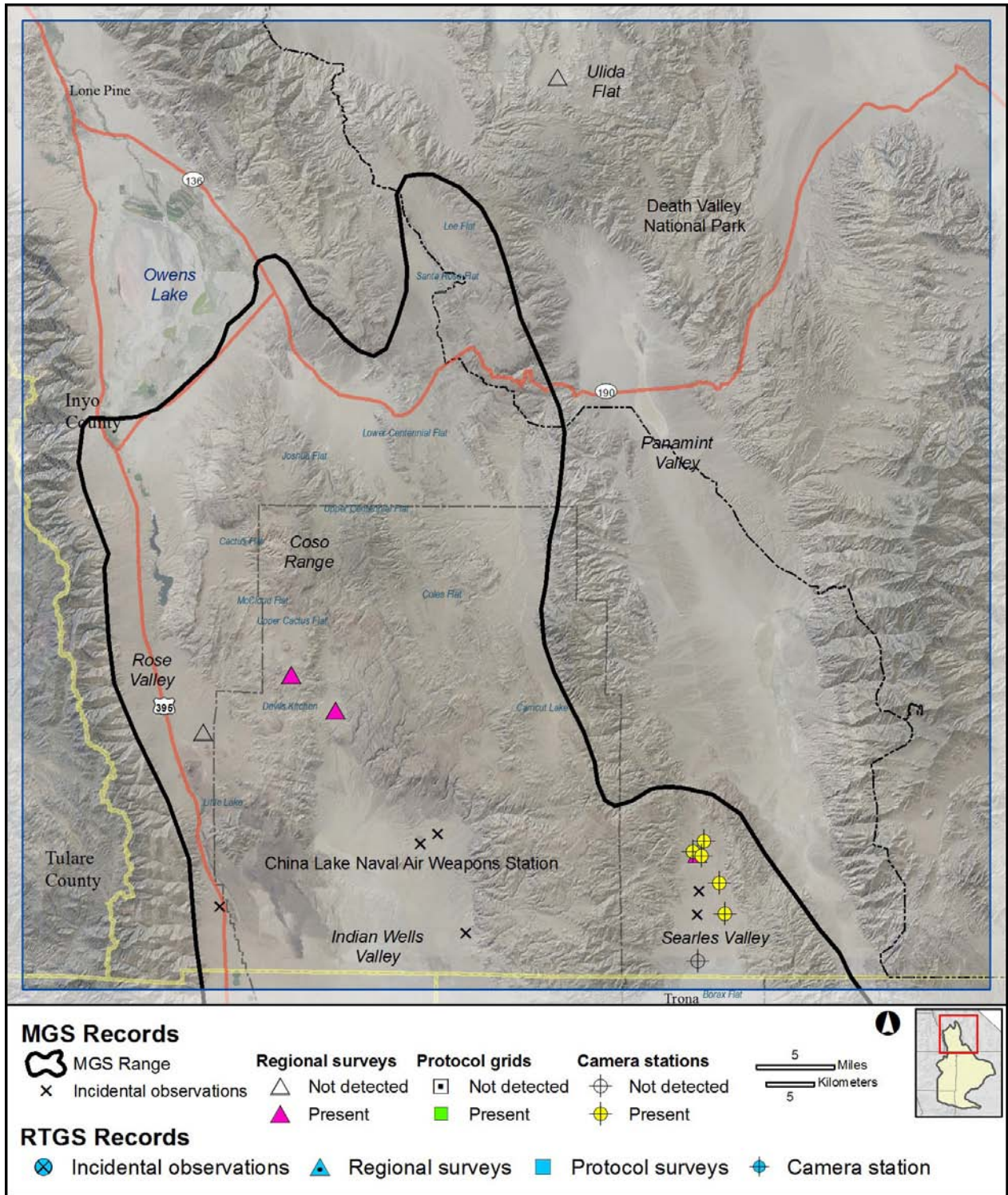


FIGURE 2. Mohave Ground Squirrel (*Xerospermophilus mohavensis*) range within Inyo County, California. Symbols indicate locations of 2008–2012 Mohave Ground Squirrel records, both positive and negative.

during 2008–2012. Regional studies on Edwards Air Force Base (EAFB) confirmed the continued presence of the species throughout the central portion of the installation. I also detected Mohave Ground Squirrels at three of 12 camera sites south of State Route 58 and east of EAFB. From 2008–2012, there were only 48 protocol surveys in the southern portion of the range as compared

to 247 during the previous 10 y (Leitner 2008). Although these protocol sites were well-distributed from Lancaster and Palmdale east to Victorville, the sole detection was a juvenile Mohave Ground Squirrel captured at a site in Adelanto in 2011.

From 2008–2012, 186 survey sites were sampled in two areas outside the generally accepted boundaries of

the Mohave Ground Squirrel geographic range. During this five-year period, 66% of all protocol trapping sites were located southwest of the town of Mojave, an area of large-scale wind energy development. No Mohave Ground Squirrels were detected here despite this intensive sampling effort. In the region from Barstow south to Lucerne Valley, protocol trapping and camera surveys were conducted at 27 locations. There were no Mohave Ground Squirrel occurrences, but Round-tailed Ground Squirrels were found at three of these sites.

Regional analysis.—Inyo County.—The Mohave Ground Squirrel range in Inyo County is almost entirely made up of federal lands (Fig. 2.). These include China Lake NAWS as well as public lands administered by US Bureau of Land Management (BLM). No protocol trapping was carried out in Inyo County from 2008–2012. Regional surveys conducted annually at two long-term monitoring sites in the Coso Range yielded 241 captures over this 5-y period. However, trapping at a nearby site in Rose Valley in 2010 produced negative results. Four incidental observations in Indian Wells Valley between the Coso Range and Ridgecrest are significant as they suggest that this area is occupied by Mohave Ground Squirrels. Finally, eight occurrences were documented

in northern Searles Valley, including camera detections, live-trap captures, and incidental sightings.

Ridgecrest area and Little Dixie Wash, Kern County.—During 2008–2012, consulting biologists conducted trapping at five protocol grids in the vicinity of Ridgecrest and Inyokern (Fig. 3). Mohave Ground Squirrels were captured at two of these sites, confirming the continued presence of the species in this partially urbanized area. A number of Mohave Ground Squirrel records were reported in the Little Dixie Wash region, which stretches southwest from Inyokern to Red Rock Canyon State Park. These included 12 regional survey sites in and near Red Rock Canyon at which the species was captured (Biosearch Associates 2012). In addition, I detected Mohave Ground Squirrels at all five of the camera study sites in this region. The El Paso Wash area to the southwest of Ridgecrest was intensively sampled with 14 camera sites in 2011 and 2012 (Leitner and Delaney 2014). The results were entirely negative, with no Mohave Ground Squirrel detections recorded in either year. This was consistent with negative results in 2011 from two regional trapping grids in this same area. Camera trapping yielded entirely different results in 2012 at 26 sites to the south and southeast of Ridgecrest (Leitner and Delaney 2014). I detected Mohave Ground Squirrels

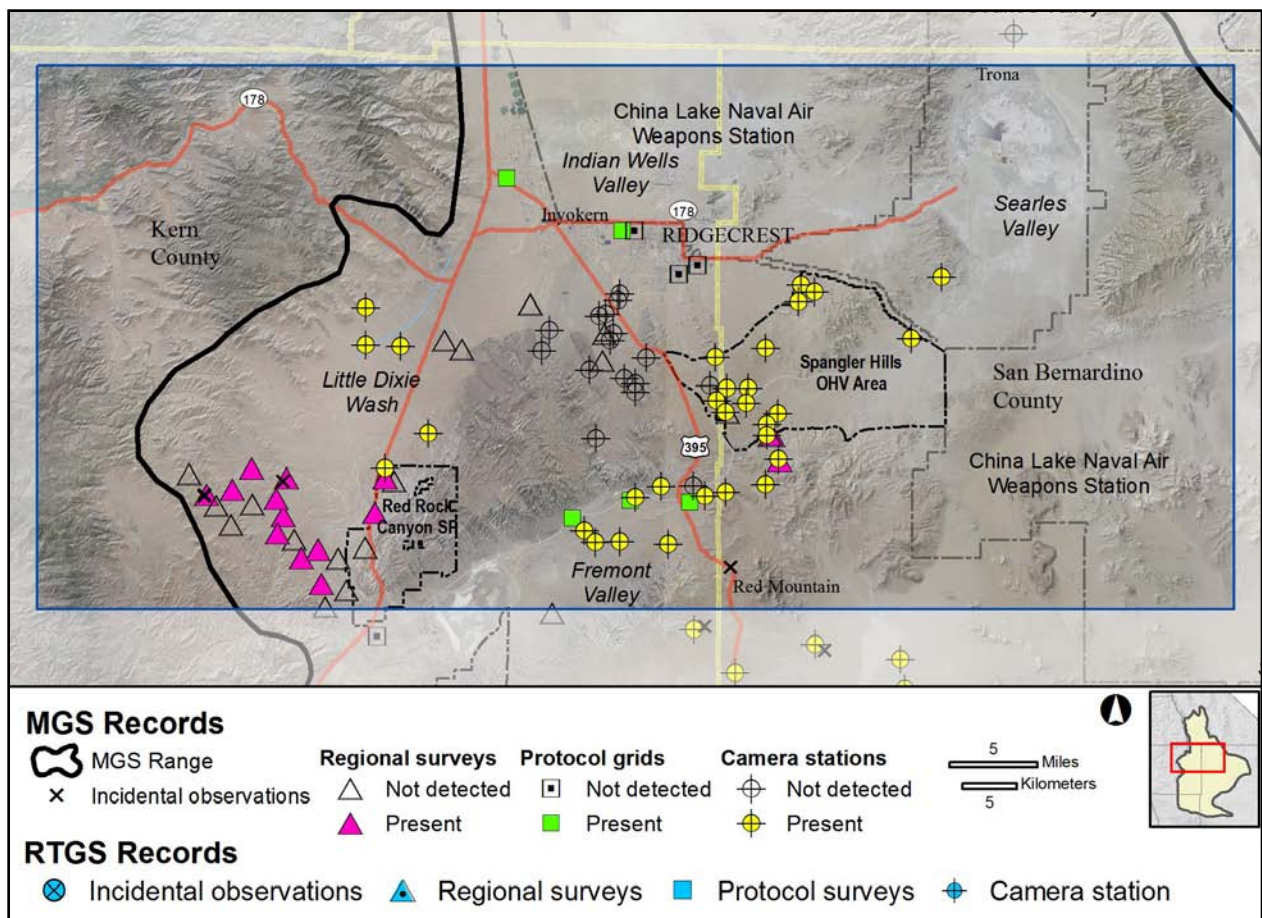


FIGURE 3. Mohave Ground Squirrel (*Xerospermophilus mohavensis*) range in the vicinity of Ridgecrest and in the Little Dixie Wash region. Symbols indicate locations of 2008–2012 Mohave Ground Squirrel records, both positive and negative.

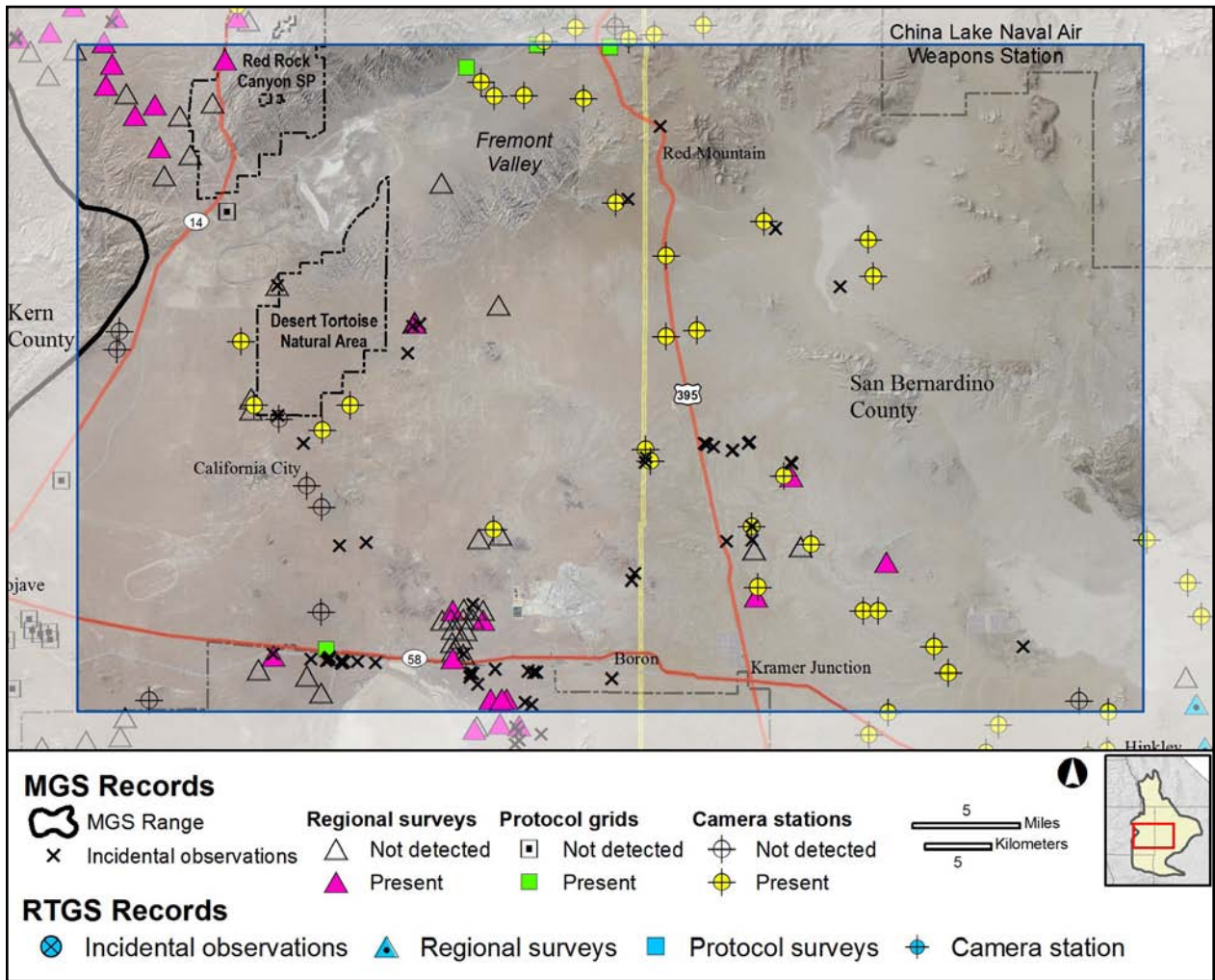


FIGURE 4. Mohave Ground Squirrel range (*Xerospermophilus mohavensis*) extending from Fremont Valley to Edwards Air Force Base. Symbols indicate locations of 2008–2012 Mohave Ground Squirrel records, both positive and negative.

at 24 of these 26 locations, which extended over a span of about 50 km (30 mi). Because the Spangler Hills OHV Open Area is heavily impacted by off-road vehicles, it is particularly noteworthy that 14 of 15 camera sites there were occupied by Mohave Ground Squirrels. I also confirmed that the species was present in the upper portion of Fremont Valley, where it was found at six camera sites and three protocol trapping grids. From 1998–2007 there were almost no data available for the Spangler Hills Open Area or Fremont Valley with the exception of several unsuccessful trapping attempts in 2002 and 2003 (Leitner 2008).

Fremont Valley to Edwards Air Force Base, Kern County.—A number of Mohave Ground Squirrel detections were documented in the region from Fremont Valley south to EAFB (Fig. 4). There was intensive sampling in several locations along State Route 58 from Boron west for about 25 km (16 mi). Regional surveys, incidental observations, and a single protocol grid yielded Mohave Ground Squirrel records at more than 25 sites adjacent to State Route 58. The species was also documented at four camera sites and a regional survey trapping grid

around the western, southern, and eastern boundaries of the DTRNA. Staff of the Desert Tortoise Preserve Committee, Inc., which manages the DTRNA in collaboration with the BLM, made visual and trail camera detections of Mohave Ground Squirrels in and adjacent to the preserve both in 2011 and 2012 (Mary Logan, pers. comm.). The occurrence of Mohave Ground Squirrels at the DTRNA was reported in Leitner (2008) and these records confirm the persistence of the species in this area. There were also three Mohave Ground Squirrel occurrence records between the DTRNA and EAFB, providing evidence that this area is occupied by the species. Leitner (2008) suggested that Mohave Ground Squirrels might be present in the region extending northward from Kramer Junction to Red Mountain roughly parallel to US 395. Field studies from 2008–2012 have shown that this region is in fact occupied and can provide genetic and demographic continuity across a distance of more than 40 km (25 mi). The evidence includes detections at 15 camera stations and several regional survey sites plus numerous visual observations across this region. Taken together with the recent documentation of Mohave Ground Squirrel occurrences

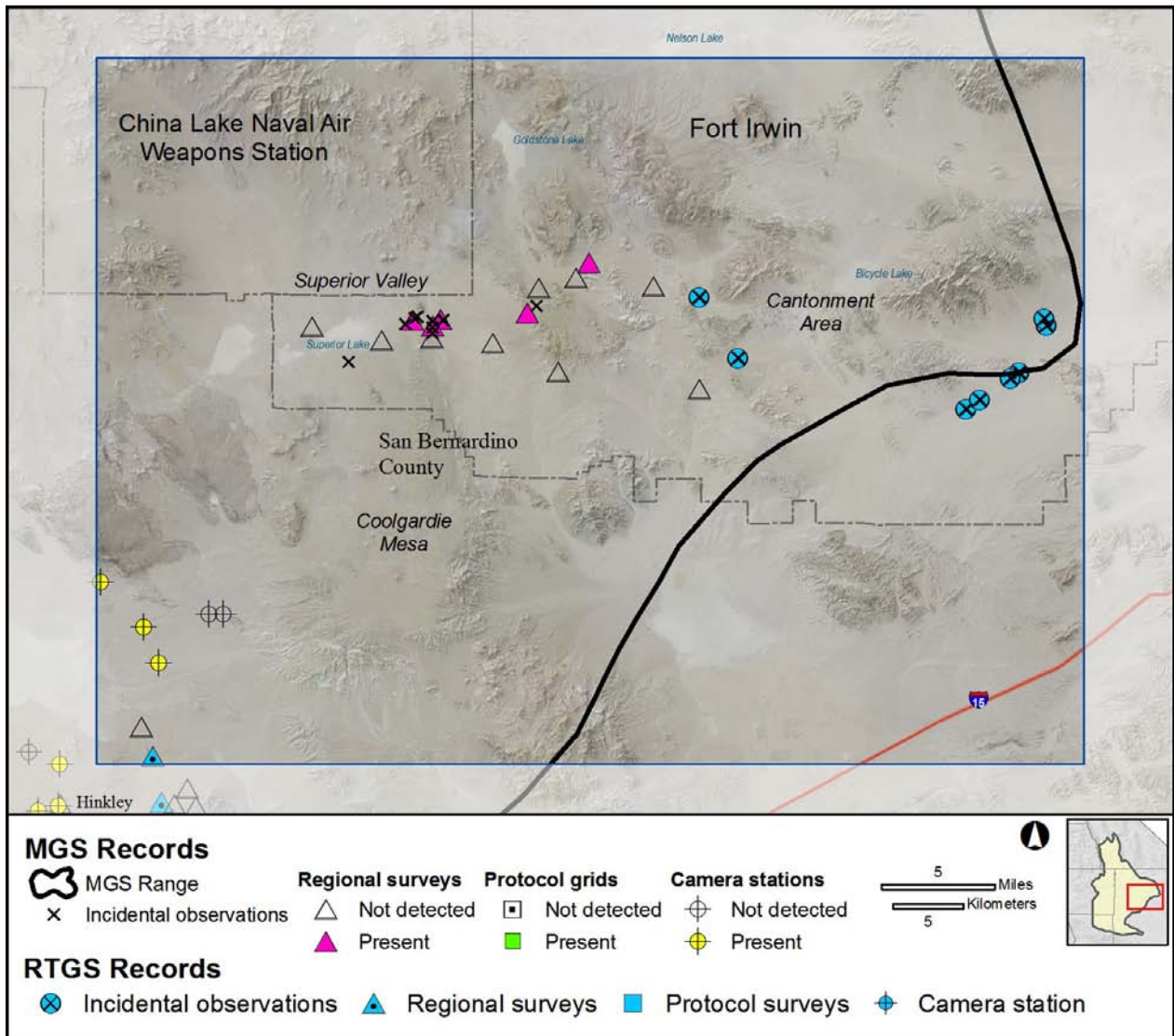


FIGURE 5. Mohave Ground Squirrel (*Xeromorphophilus mohavensis*) range on Coolgardie Mesa and Superior Valley and east onto Fort Irwin. Symbols indicate locations of 2008–2012 Mohave Ground Squirrel records, both positive and negative. Round-tailed Ground Squirrel (*Xeromorphophilus tereticaudus*) records are also shown.

south from Ridgecrest toward Red Mountain, it appears that a continuous belt of occupied habitat connects EAFB with the Ridgecrest area.

Coolgardie Mesa and Superior Valley, San Bernardino County.—This extensive plateau area north of Barstow has yielded many Mohave Ground Squirrel records dating back to 1977 (Wessman 1977). From 2008–2012 regional surveys were carried out at 14 sites in this region, all within the boundaries of Fort Irwin (Fig. 5). Mohave Ground Squirrels were trapped at five of these locations and there were a number of visual detections as well. However, trapping at the two easternmost sites failed to capture Mohave Ground Squirrels and there were two incidental observations of Round-tailed Ground Squirrels nearby. In addition, I observed Round-tailed Ground Squirrels at six sites to the east of the Fort Irwin cantonment area, where earlier records had reported Mohave Ground Squirrels. These findings raise questions con-

cerning the present location of the contact zone between these two closely related species on Fort Irwin.

Wind resource area southwest of Mojave, Kern County.—The major wind resource area to the southwest of the town of Mojave has been the site of extensive energy development in recent years. Although most of this area is outside the generally accepted boundaries of the Mohave Ground Squirrel range, there is much apparently suitable desert scrub habitat (pers. obs.). From 2008–2012 protocol trapping surveys were carried out at 159 sites here (Fig. 6). In spite of this extensive sampling effort, there have been no visual detections or captures of Mohave Ground Squirrels. This is entirely consistent with the lack of detections at 26 protocol sites trapped here prior to 2008 (Leitner 2008).

Edwards Air Force Base, Kern County.—Edwards Air Force Base (EAFB) has continued a Mohave Ground Squirrel monitoring program, with regional surveys car-

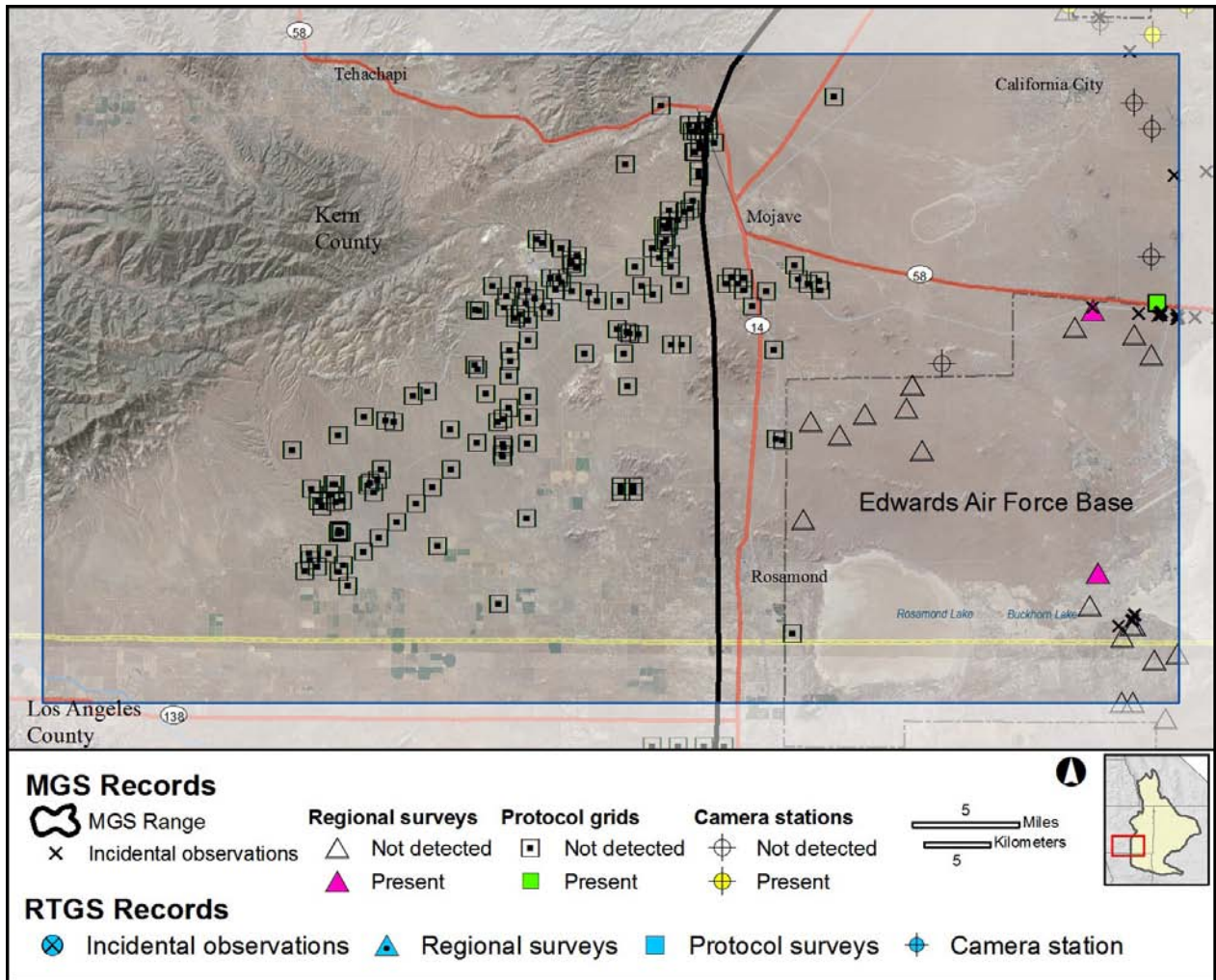


FIGURE 6. Mohave Ground Squirrel range (*Xerospermophilus mohavensis*) in the vicinity of the town of Mojave. Symbols indicate locations of 2008–2012 Mohave Ground Squirrel records, both positive and negative.

ried out during several recent years (United States Air Force 2010a, 2010b, 2011). The distribution of Mohave Ground Squirrel occurrences was generally similar to that reported in Leitner (2008) for 1998–2007 (Fig. 7). Regional trapping surveys at seven sites in the far western section of EAFB yielded no detections, which is consistent with the lack of occurrences there from 2003–2007. More than 30 captures and incidental observations were reported in areas to the south and east of Rogers Dry Lake, a pattern noted in earlier studies (Leitner 2008). However, recent surveys have documented nine new Mohave Ground Squirrel records to the north-west and northeast of Rogers Dry Lake in areas not surveyed intensively for many years. Two detections were reported just beyond the southern boundary of EAFB, one an incidental sighting in northeastern Los Angeles County and the other at a camera site west of US 395 in San Bernardino County.

Kramer Junction to Barstow, San Bernardino County.—I sampled the region to the east of Kramer Junction extensively by camera trapping in 2012 (Fig. 8). I found Mohave Ground Squirrels at 23 out of 33 randomly located camera sites in this region. The geograph-

ic pattern of detections indicates that Mohave Ground Squirrels are widely distributed over the broad expanse of low hills and plains east of Kramer Junction. From 1998–2007 there was almost no sampling in this region (Leitner 2008), but there are a number of CNDDDB records of the species here from 1988 and earlier. Several Mohave Ground Squirrel occurrences were also documented in a small area south of the Kramer Hills and east of US 395, the first record of Mohave Ground Squirrels here since 1994 (Scarry et al. 1996). Regional surveys in the agricultural area around Hinkley have confirmed the presence of Round-tailed Ground Squirrels (Vanherweg 2012). Based upon data presented in Leitner (2008), the contact zone between these two closely related species was thought to be just west of Hinkley. However, I detected both species in 2012 at a camera site 11 km (7 mi) west of the previous western-most Round-tailed Ground Squirrel record.

Los Angeles County.—Protocol trapping efforts in northeastern Los Angeles County from 2008–2012 (Fig. 9) have failed to find the species. Just as in the previous 10-y period, the only positive records were at several sites within or very close to EAFB. Regional trapping

surveys in Los Angeles County at several locations on EAFB and at two county parks were unsuccessful.

Victor Valley, San Bernardino County.—Because of the depressed local economy, there has been little housing or commercial development in the Victor Valley and consequently a much reduced level of protocol trapping from 2008–2012 (Fig. 10). However, a juvenile female Mohave Ground Squirrel was captured by a consultant in 2011 at a solar project site near Adelanto, suggesting that a relict population is still extant in this region.

Mojave River to Lucerne Valley, San Bernardino County.—The area east of the Mojave River was sampled by extensive protocol trapping along State Route 247 from Barstow south to Lucerne Valley (Fig. 10). This trapping survey yielded no Mohave Ground Squirrel detections, but a Round-tailed Ground Squirrel was captured about 8 km (5 mi) south of Barstow. In 2011, I recorded Round-tailed Ground Squirrels at two camera survey sites in Lucerne Valley. There has been no evidence of Mohave Ground Squirrels east of the Mojave River between Victorville and Lucerne Valley since a capture reported by Wessman (1977).

DISCUSSION

Geographic range. — The generally-recognized boundary of the Mohave Ground Squirrel geographic range has been basically unchanged since the publication of a map in Gustafson (1993). The range map featured in Leitner (2008) was based on that 1993 map, but showed a minor extension to the north in Inyo County to include two confirmed records at Lee Flat in 1993 and 2007 (CNDDDB Occurrence No. 327). Leitner (2008) also discussed two incidental observations outside of the generally accepted boundary. These records were approximately 8 km (5 mi) beyond the mapped range limits, but within the dispersal range of juvenile Mohave Ground Squirrels (Harris and Leitner 2005). There have been no subsequent detections in either area and no evidence of resident populations there. Two other incidental observations were reported to the southwest of the town of Mojave in 2006, but these supposed records were apparently based on mistaken identification and have been withdrawn from the CNDDDB. The US Fish and Wildlife Service (2011) recently suggested that the western por-

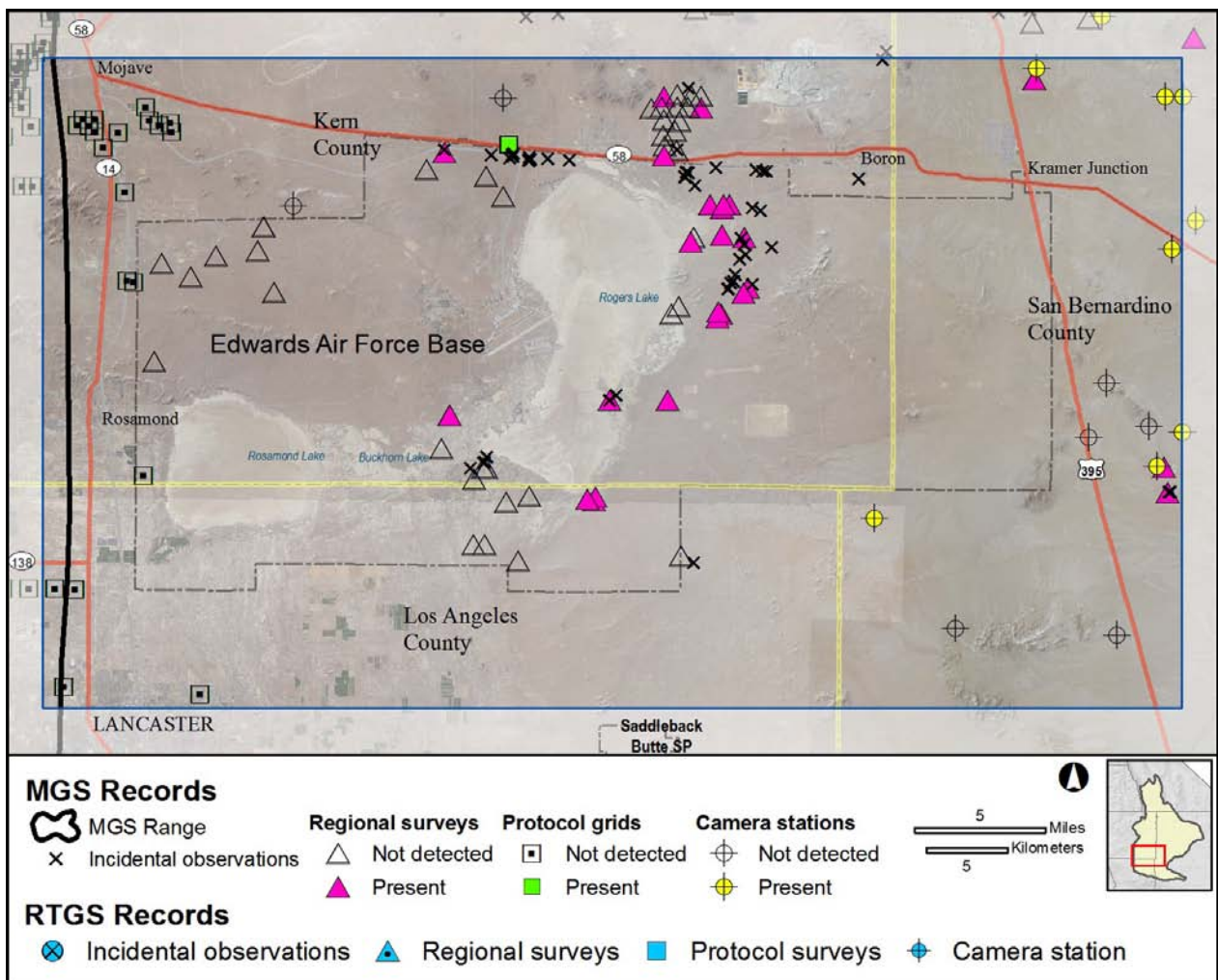


FIGURE 7. Mohave Ground Squirrel (*Xerospermophilus mohavensis*) range on Edwards Air Force Base and vicinity. Symbols indicate locations of 2008–2012 Mohave Ground Squirrel records, both positive and negative.

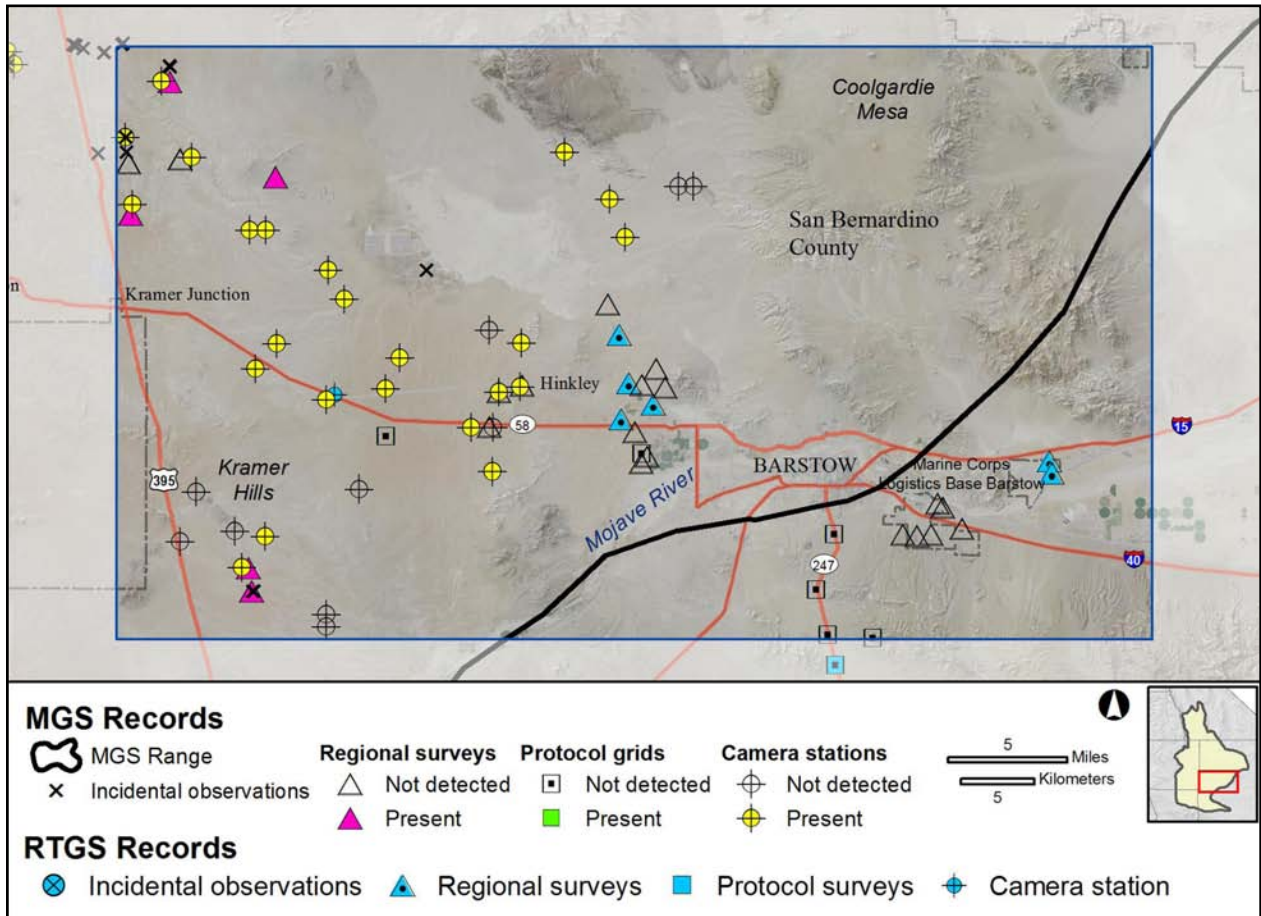


FIGURE 8. Mohave Ground Squirrel (*Xerospermophilus mohavensis*) range from Kramer Junction east to Barstow. Symbols indicate locations of 2008–2012 Mohave Ground Squirrel records, both positive and negative. Round-tailed Ground Squirrel (*Xerospermophilus tereticaudus*) records are also shown.

tion of the Antelope Valley be included within the range of the Mohave Ground Squirrel. This does not seem justified as there has never been any record of the species to the west of State Route 14 between Mojave and Palmdale, in spite of extensive protocol trapping over much of this area.

Thus, there is no solid evidence that the generally accepted boundaries of the Mohave Ground Squirrel geographic range should be expanded. However, a review of the 1998–2012 distributional data suggests that the species may no longer be present in six distinct regions within its currently mapped range. First, there have been no Mohave Ground Squirrel records in the Fremont Valley west of California City since 2002. Second, no Mohave Ground Squirrels have been trapped or observed in the western portion of EAFB since a single record in 1994, in spite of regional trapping surveys at 22 randomly selected sites. Third, there have been very few recent Mohave Ground Squirrel detections in the northeastern portion of Los Angeles County where it was commonly reported from 1920 until 1989. The only sites in Los Angeles County where the species has been trapped or observed since 1991 are on or very close to EAFB where the species is known to be widespread. The fourth area of concern is east of the Mojave River in the area from

Victorville to Lucerne Valley where there have been no Mohave Ground Squirrel records since 1977. The fifth region where Mohave Ground Squirrels seem to be absent is around Barstow and west to Hinkley Valley. The Round-tailed Ground Squirrel appears to be widely distributed here and may well be extending its range to the west along the State Route 58 corridor. The only Mohave Ground Squirrel report east of the Mojave River since 1998 was a single visual detection south of Barstow in 2006 (Leitner 2008). Finally, the current range boundary as mapped includes much of Fort Irwin, but the only recent records here are in the extreme western part of the installation. There are recent Round-tailed Ground Squirrel occurrences in areas of Fort Irwin where Mohave Ground Squirrels were reported in earlier decades (Wessman 1977; Krzysik 1994).

Distribution of survey efforts.—Protocol trapping surveys are almost always undertaken to determine the potential of proposed projects to impact the Mohave Ground Squirrel (California Department of Fish and Game 2010) and may be sponsored by private developers or by public agencies such as California Department of Transportation. These surveys are usually located on private property, although in the case of linear projects

such as highways, pipelines, or communication infrastructure there may be trapping sites on public land as well. During the 10-y period from 1998–2007, the great majority of protocol surveys were located in the southern portion of the Mohave Ground Squirrel range (Leitner 2008). This pattern was even more pronounced from 2008–2012, with only 10 of 240 protocol sites located in the central portion of the range and none in the northern area.

Regional trapping studies tend to be focused on military and public lands and are often funded by state and federal agencies. From 2008–2012, the majority of regional trapping surveys were conducted on military installations, including EAFB, Fort Irwin, China Lake NAWS, and Marine Corps Logistics Base Barstow. Surveys took place at 24 sites in and adjoining Red Rock Canyon State Park, as well as on conservation lands man-

aged by CDFW and by Rio Tinto Borax. In comparison to 1998–2007, there were fewer regional trapping sites on BLM land (Leitner 2008).

For the first time, David Delaney and I used trail cameras for large-scale surveys in 2011 and 2012 on public lands managed by BLM, CDFW, and California State Parks (Leitner and Delaney 2014). We sampled 123 randomly selected sites during this survey effort, covering a significant portion of the Mohave Ground Squirrel geographic range plus a large region outside the range to the east of the Mojave River near Lucerne Valley. This has provided positive occurrence data for a number of areas that had not been surveyed adequately, from Searles Valley in the north, from Ridgecrest south to Kramer Junction, and then east toward Barstow.

Significant portions of the Mohave Ground Squirrel range were not adequately sampled from 2008–2012.

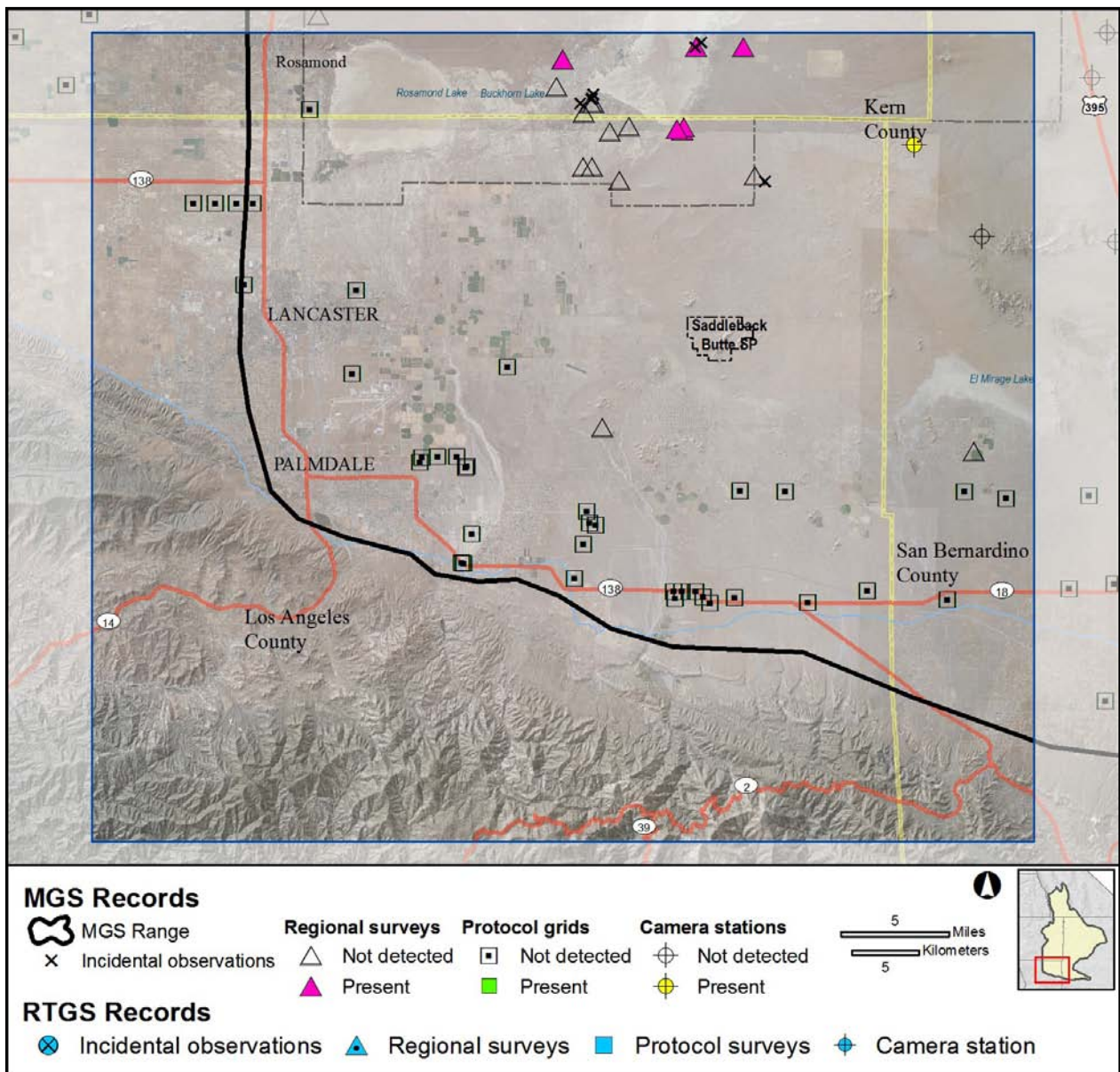


FIGURE 9. Mohave Ground Squirrel (*Xerospermophilus mohavensis*) range in Los Angeles County, California. Symbols indicate locations of 2008–2012 Mohave Ground Squirrel records, both positive and negative.

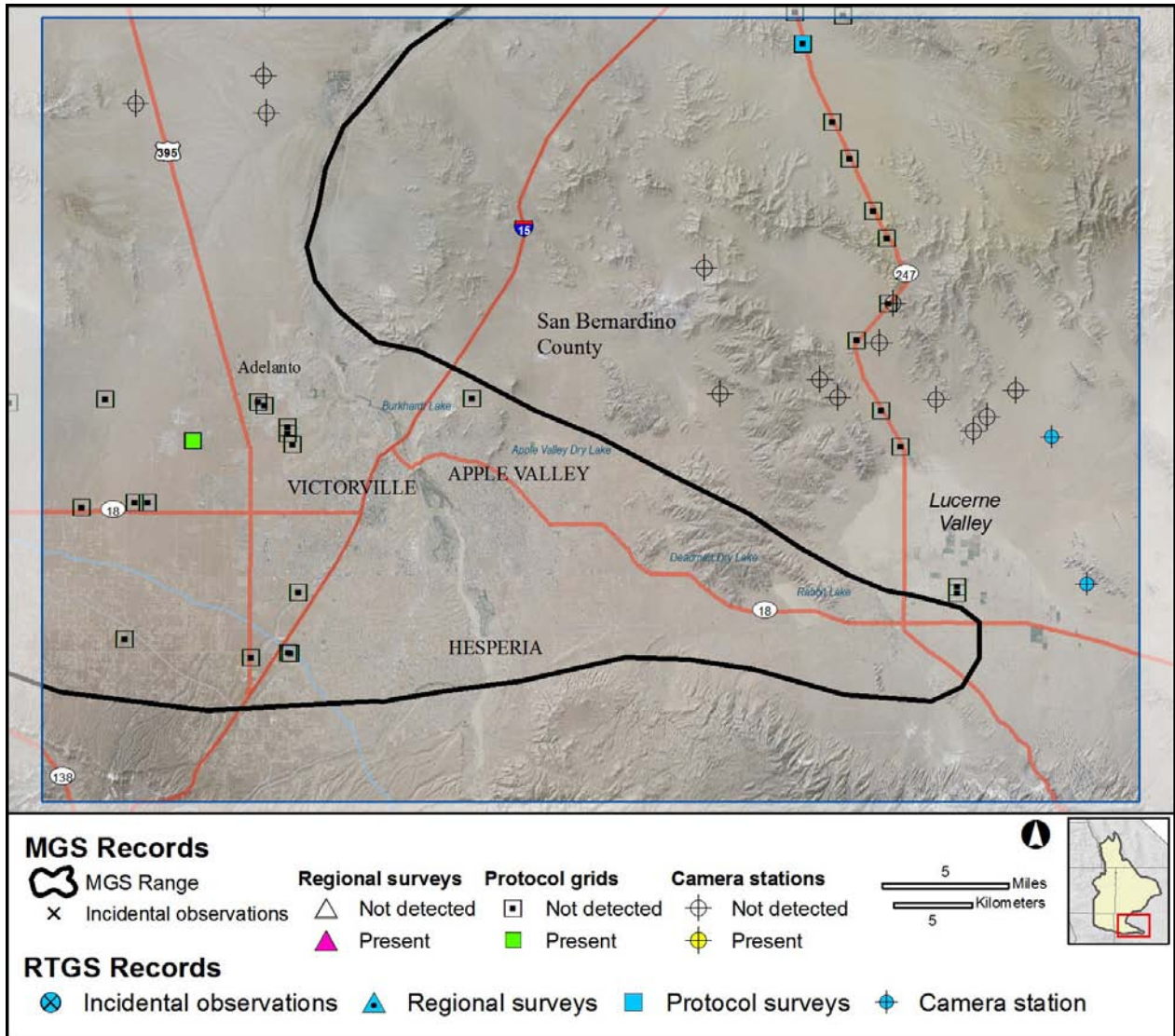


FIGURE 10. Mohave Ground Squirrel range (*Xerotherophilus mohavensis*) from the vicinity of Victorville east to Lucerne Valley. Symbols indicate locations of 2008–2012 Mohave Ground Squirrel records, both positive and negative. Round-tailed Ground Squirrel (*Xerotherophilus tereticaudus*) records are also shown.

With the exception of the Coso area and northern Searles Valley, there were no surveys in Inyo County. As was the case from 1998–2007 as well (Leitner 2008), there was very little sampling effort from 2008–2012 on China Lake NAWS and on much of Fort Irwin. These military lands represent the largest remaining areas for which we have inadequate data on Mohave Ground Squirrel distribution and abundance.

MANAGEMENT RECOMMENDATIONS

Mohave Ground Squirrel database.—Leitner (2008) recommended that the 1998–2007 database of Mohave Ground Squirrel records be maintained by a public agency and made available to interested parties. In response, the CDFW has incorporated several Mohave Ground Squirrel datasets into the Biogeographic Information & Observation System (BIOS), which allows users to visualize these data online using a GIS platform. The datas-

ets available include maps from Leitner (2008) that show the boundaries of the historic range and the locations of Mohave Ground Squirrel occurrences. All data for 1998–2007 covering protocol trapping, regional surveys, and incidental observations are now entered into BIOS. It is recommended that CDFW put in place a permanent system to collect annually all Mohave Ground Squirrel data, including unsuccessful survey efforts, from biologists, consultants, and agency staff.

Needed regional surveys.—Leitner (2008) pointed out the lack of current data on the status of the Mohave Ground Squirrel in certain areas in the northern and central parts of its range. Extensive camera surveys in 2011–2012 from EAFB north to Ridgecrest have demonstrated that the species is present throughout this region (Leitner and Delaney 2014). Additional field data have also clarified the distribution of Mohave and Round-tailed Ground Squirrels on the southern part of Fort Irwin. Neverthe-

less, there have been no systematic surveys on China Lake NAWS or on much of Fort Irwin. Well-designed comprehensive field surveys on these installations are strongly recommended, as they make up much of the total range of the species.

The status of the Mohave Ground Squirrel in the southern portion of its range between Lancaster and Victorville is poorly understood. Since 2008, there have been a number of protocol surveys in this area, but only one Mohave Ground Squirrel occurrence has been documented. This occurrence was recorded near Adelanto, in an area that is known to support a relict population. Additional surveys are urgently needed in the southern part of the range, especially in northeastern Los Angeles County where state and county parks may have the potential to support Mohave Ground Squirrel populations.

Wind energy special survey area.—The West Mojave Plan (US Bureau of Land Management 2003) recommended that the region southwest of the town of Mojave be surveyed to determine if it might support a previously undocumented Mohave Ground Squirrel population. Because of extensive wind energy development here, protocol trapping was required at 159 sites from 2008–2012. There have been no Mohave Ground Squirrel detections here and it seems clear that no further surveys are needed.

Interactions with Round-tailed Ground Squirrel.—Recent surveys have confirmed that Round-tailed Ground Squirrels are widely distributed in Hinkley Valley west of Barstow (Leitner 2008; Vanherweg 2012). In 2012, I detected Round-tailed Ground Squirrels at a camera site approximately 20 km (12 mi) to the west of Hinkley. The same study documented Mohave Ground Squirrels at a number of sites just to the west and north of Hinkley. These observations suggest that this region is an active contact zone between the two species and that Round-tailed Ground Squirrels may be extending their range westward here. Survey data since 2008 indicates that there may be an extensive contact zone on Fort Irwin as well, with Round-tailed Ground Squirrels shifting westward there as well. Recent habitat modeling studies using climate change scenarios project that by 2030 there could be significant loss of suitable habitat for the Mohave Ground Squirrel in the region west of Hinkley and on Fort Irwin (Esque et al. 2013). If the Round-tailed Ground Squirrel is better adapted to projected hotter and drier conditions, this species may already be expanding its range in response to climate change. Comprehensive field studies are urgently needed to monitor changes in the distribution of these two ground squirrel species. Comparative data on competitive interactions between Mohave and Round-tailed Ground Squirrels are also needed including information on diet, dispersal capabilities, annual cycle, and reproductive performance in relation to rainfall.

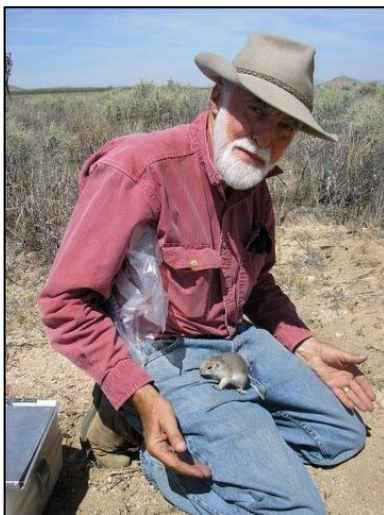
Use of trail cameras for ground squirrel studies.—Delaney (2009) and Leitner (2009) explored the use of trail cameras to detect Mohave Ground Squirrels in the Western Expansion Area of Fort Irwin. Trail cameras used with bait readily attracted Mohave Ground Squirrels and were found to be at least as effective as live traps in confirming their presence. Based upon this finding, David Delaney and I successfully carried out a large-scale survey using trail cameras in 2011 and 2012. It is recommended that the results of this survey be used as a baseline for future monitoring efforts. Although camera surveys cannot be used to estimate population density or abundance, the results of the 2011–2012 camera study can serve to identify future changes in the distribution and status of the species through the use of occupancy analysis (MacKenzie et al. 2006).

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