INVESTIGATIONS INTO THE CONTROL OF COYOTE AND FERAL BURRO POPULATIONS ON THE NATIONAL TRAINING CENTER FORT IRWIN, CALIFORNIA

ANNUAL PROGRESS REPORT
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INVESTIGATIONS INTO CONTROL OF COYOTE POPULATIONS

A. Description of Project

We investigated a population of coyotes (*Canis latrans*) residing on the National Training Center (NTC) Fort Irwin, CA to assess how anthropogenic subsidies may alter coyote behavior and disease incidence and to develop strategies to mitigate human-coyote conflict. Prior to 2008, the coyotes on the garrison behaved similarly to other urban coyotes, utilizing the garrison for resources during nocturnal hours and then returning to the surrounding desert during daybreak (L. Aker, *pers. comm*). However, coyotes have recently taken up residence within the garrison and are visible at all times of day (L. Aker and C. Everly, *pers. comm*); many of these individuals are infected with sarcoptic mange. The prevalence of sarcoptic mange appears to have increased within the population, inciting public health concerns among the residents. Coyotes have also been observed foraging on garbage, receiving handouts, and sheltering in anthropogenic structures. Further, coyotes have become bolder, appearing indifferent to the presence of humans and even approaching residents for food (L. Aker and C. Everly, *pers. comm*). These traits are signs of coyote habituation to people and could result in increased aggression and potential transfer of wildlife parasites (Timm et al. 2004).

To preclude human-coyote conflicts, the managers of NTC seek the most effective management practices to reduce resource use of the garrison by coyotes and to mitigate the prevalence of mange in the resident coyote population. The purpose of our study is to identify the demographic composition of the coyote population; verify the factors that may contribute to the establishment of a resident, urban population; determine the factors contributing to the high prevalence of mange in the population; and propose management actions to reduce coyote use of the garrison and minimize the spread of mange to conspecifics, domestic commensals, and other sensitive species, such as the kit fox (*Vulpes macrotis*).

Study Area

The NTC is a U.S. military training facility encompassing 3055 km^2 in San Bernardino County, California. The garrison or developed area of the base is 18.3 km^2 (7.05 mi^2), with a population of 8,845 and density of 484.2 people/km^2 (1,254.1 people/mi^2). The elevation is 748 m (2,454 ft.) above sea level and the surrounding land cover is dominated by creosote (*Larrea tridentata*) and white bursage (*Ambrosia dumosa*; Turner et al. 1984). Summers are hot and dry, with a mean daily high of 38°C (100°F), whereas winters are cool with a mean low of 6°C (42°F; Housman 2013). Precipitation is highly variable across years with an average annual precipitation of 5.2 cm ± 3.84 (2.06 in ± 1.51); 80% of the rainfall occurs between November and March with 20% during summer convection storms from July to September (Housman 2013).

The study area was partitioned into 3 regions: urban, exurban, and wildland-interface, based on perceived resource use and interaction rates among coyotes. The urban region consists solely of the developed sections of the garrison where subsidized resources would be most prevalent. Buffers for exurban/wildland-interface regions are based on the largest radius of an exurban coyote's home range (assuming a circular home range) under similar environmental conditions (Grinder and Krausman 2001). A 4.36 km buffer was applied to define the exurban region, or area surrounding the garrison where use of subsidized resources by coyotes was still expected. The wildland-interface region was denoted by a final 4.36 km buffer extending from the exurban region and defined as an area inhabited by coyotes that do not

rely heavily on garrison resources, but instead, are more focused on natural resources including wild prey. Land-cover beyond the wildland-interface region was considered wildland; coyotes within this extensive area were considered to have no access to urban subsidies and a low probability of encountering an urban/exurban coyote.

B. Preliminary Data Collected

Coyote Trapping

Coyotes have been captured since 05/21/15 and a variety of methods have been employed, including: large cage traps provided by the Directorate of Public Works (DPW), smaller cage traps provided by New Mexico State University (NMSU), Collarum® neck snares, trail snares, and Belisle® foot snares. Baits utilized for trapping have included commissary meat scraps, road-killed black-tailed jackrabbits (*Lepus californicus*), frozen rodents, Burger King® meat patties, commercial dog food, commercial cat food, Hawbawkers Canine Bait, Collarum® Canine Bait, and Mark June's Widowmaker Bait. Cage traps were prebaited for at least 10 days to acclimatize coyotes to fully entering the trap. Snare traps were only operational when temperatures were <27°C (80°F) and checked every 6 hours. All trapping and handling methods met the guidelines suggested by the American Society of Mammalogists (Sikes and Gannon 2011) and were approved by the New Mexico State University Institutional Animal Care and Use Committee (IACUC Protocol #2015-001).

We captured 36 individual coyotes (22 males, 14 females) and had 3 recaptures over 1178 trap nights. Trap sites were distributed throughout the garrison in an effort to sample both urban and exurban coyotes. The highest trap success occurred near the landfill and water treatment areas on the eastern side of the garrison (n = 29). Of the new captures, 18 were classified as juvenile (<12 months of age), 7 as yearlings (between 1 and 2 years), and 11 as adults (>2 years). The average weight for adults and yearlings (n = 18) was 10.85 ± 1.86 kg whereas the average weight for juveniles was 8.41 ± 1.85 kg (n = 12). It should be noted, however, that coyotes are reproductively active in their first breeding season when they are less than 1 year-old. Visible manifestations of sarcoptic mange were observed in 24 individuals (Pence et al. 1983); 8 were diagnosed with class I mange (active lesions apparent on <5% of their body surface), 6 as class II (infection covering between 5 to 50% of an individual's body), and 10 as class III (infections with > 50% of the body covered).

Table 1. The number of traps deployed to capture coyotes from 02/22/15 to 6/19/16 at NTC Fort Irwin.

Trap Type	No. Deployed	Trap Nights	Coyote Captures	Trap Success
DPW Cage Trap	5	375	10	2.7%
NMSU Cage Trap	3	188	5	2.7%
Collarum Neck Snare	5	561	23	4.1%
Trail Neck Snare	2	22	0	0.0%
Belisle Foot Snare	3	32	1	3.1%
Total	18	1178	39	3.3%

Table 2. The characteristics and fate of coyotes captured from 02/22/15 to 6/19/16 at NTC Fort Irwin (*n* = 36). Note that coyotes that are listed as 'Alive' are still being monitored.

Coyote ID	Date of Capture	Sex	Age	Weight (kg)	Mange Class	Fate
VHF Collar (*n* = 15)						
77	05/25/15	F	Adult	9.6	3	Mortality
80	05/31/15	M	Adult	11.6	3	Mortality
82	06/11/15	F	Adult	11.3	3	Mortality
83	07/09/15	M	Yearling	12.5	0	Alive
91	10/20/15	M	Yearling	10.0	2	Mortality
92	10/20/15	F	Adult	9.2	2	Mortality
93	11/03/15	M	Yearling	10.4	0	Alive
95	11/18/15	M	Juvenile	8.2	0	Alive
97	11/19/15	M	Juvenile	9.5	0	Alive
98	11/21/15	M	Juvenile	9.2	0	Mortality
102	02/10/16	M	Juvenile	10.3	1	Alive
103	02/10/16	F	Juvenile	9.7	1	Alive
106	03/15/16	F	Juvenile	9.0	0	Alive
107	03/22/16	F	Juvenile	9.1	2	Alive
108	04/07/16	F	Juvenile	9.0	2	Alive
GPS Collar (*n* = 12)						
78	05/26/15	F	Adult	10.2	3	Mortality
79	05/26/15	F	Adult	10.0	3	Mortality
90	10/04/15	M	Yearling	12.0	0	Alive
94	11/07/15	M	Adult	12.7	3	Collar Dropped
96	11/18/15	M	Adult	14.1	3	Mortality
100	01/16/16	M	Adult	11.2	1	Alive
101	02/09/16	M	Juvenile	11.0	1	Alive
104	02/28/16	F	Juvenile	10.8	2	Alive
105	03/02/16	M	Juvenile	10.7	2	Mortality
109	04/26/16	F	Adult	10.5	1	Alive
110	04/27/16	M	Yearling	12.5	3	Alive
111	04/27/16	M	Yearling	10.5	1	Alive
Ear Tag Transmitter (*n* = 5)						
85	09/08/15	M	Juvenile	6.2	1	Mortality
86	09/10/15	M	Juvenile	7.2	0	Missing
87	09/17/15	M	Juvenile	7.2	0	Tag Dropped
88	09/18/15	F	Juvenile	7.0	0	Alive
99	12/18/15	F	Juvenile	6.3	0	Mortality
No Transmitter (*n* = 4)						
76	05/24/15	M	Yearling	5.6	3	Mortality
81	06/02/15	F	Adult	9.0	3	Mortality
84	09/04/15	M	Juvenile	6.0	0	Unknown
89	09/19.15	M	Juvenile	4.9	1	Unknown

Coyote Mortalities

Carcasses both study and non-study animals were collected and frozen and then sent to either Dr. Janet Foley of the Department of Medicine and Epidemiology, School of Veterinary Medicine, University of California, Davis or to Dr. Deanna Clifford, Wildlife Investigations Lab, California Department of Fish and Wildlife (DFW). Collared individuals were monitored for mortality signals during standard telemetry sampling or >2 times a week during periods of limited telemetry sampling. Non-collared individuals were collected opportunistically when observed by NMSU or DPW affiliated personnel. Coyotes captured by DPW and affiliates for euthanasia, due to either injury or substantially poor health, were also collected and processed before being euthanized.

There were a total of 27 mortalities recorded during this reporting period, including 14 study and 13 non-study animals (see Table 3). Of the 27 mortalities, 16 were suspected to have died from mange-related complications, 4 were struck by vehicles, 2 were euthanized, and 4 died of unknown causes. Of the unknown, 3 were carcasses provided by the Fort Irwin Vet Clinic to DFW personnel. The final mortality whose cause of death was unknown was collared coyote 98, whose head and collar were found cached ~2 km southeast of the garrison. The animal appeared healthy when captured. The missing carcass of the individual could have been a result of a predation mortality or due to another form of mortality (i.e., vehicular collision) followed by scavenging.

Seasonal survival rates were calculated using the Kaplan-Meier staggered entry design (Pollock et al. 1989). Survivorship estimates were calculated only for the 2015/2016 Wet Season due to inadequate sample sizes during the 2015 Dry Season. Cumulative survival of coyotes over 26 weeks was 0.44 (SE = 0.07) with 8 confirmed mortalities and 2 censored individuals due to dropped collars. The majority of mortalities (n = 6) occurred during December. Seven of the mortalities were suspected of being exposure related, with 5 of the individuals diagnosed as having at least class II mange during capture and the remaining 2 individuals in poor health with possible class I mange.

Table 3. Recorded mortalities of study and non-study coyotes at NTC Fort Irwin from 02/22/15 to 06/19/16. All carcasses due to be necropsied by CA Department of Fish and Wildlife (DFW) personnel at the Wildlife Investigations Lab in Rancho Cordova.

ID	Date	Mange	Mortality Cause	Comments
Study animal mortalities (*n* =14)				
76	05/23/15	3	Unknown (Pending Necropsy)	Poor reaction to anesthesia.
82	06/13/15	3	Unknown (Pending Necropsy)	Poor reaction to anesthesia.
81	08/10/15	3	Unknown (Pending Necropsy)	Suspected mange related.
*78	08/19/15	3	Unknown (Pending Necropsy)	Suspected mange related.
77	10/18/15	3	Unknown (Pending Necropsy)	Suspected mange related.
80	12/02/15	3	Unknown (Pending Necropsy)	Suspected mange/exposure related
85	12/08/15	1	Unknown (Pending Necropsy)	Suspected exposure.
92	12/09/15	3	Unknown (Pending Necropsy)	Suspected mange/exposure related.
96	12/17/15	3	Unknown (Pending Necropsy)	Suspected mange/exposure related
79	12/19/15	3	Unknown (Pending Necropsy)	Suspected mange/exposure related
98	12/30/15	0	Unknown	Head found cached S of the garrison. Possible predation/scavenging.
91	01/04/16	2	Unknown (Pending Necropsy)	Suspected mange/exposure related
99	02/17/16	1	Unknown (Pending Necropsy)	Suspected exposure related.
105	06/14/16	3	Unknown (Pending Necropsy)	Suspected mange/exposure related
Non-study animal mortalities (*n* = 13)				
M01	05/29/15	3	Unknown (Pending Necropsy)	Suspected mange related.
M02	05/31/15	0	Vehicular collision	
M03	06.16/15	2	Unknown (Pending Necropsy)	Suspected mange related.
M04	08/05/15	0	Vehicular collision	Euthanized due to compound fracture in R hind limb.
M06	11/17/15	2	Euthanized	Poor health.
M07	12/16/15	0	Vehicular collision	
**M08	12/22/15	0	Unknown (Pending Necropsy)	
**M09	12/22/15	0	Unknown (Pending Necropsy)	
**M10	12/22/15	0	Unknown (Pending Necropsy)	
M11	01/07/16	3	Euthanized	Debilitated individual trapped in shipping container.
M12	05/18/16	3	Unknown (Pending Necropsy)	Suspected mange related.
M13	05/31/16	2	Vehicular collision	
M14	05/31/16	3	Vehicular collision	

* Not necropsied due to miscommunication with NTC Vet Clinic staff.
** Carcasses provided by NTC Vet Clinic during transport to DFW Wildlife Investigations Lab.

Table 4. Cumulative survival estimates for coyotes tracked during the 2015/2016 Wet Season (11/01/15 to 04/30/16) at NTC Fort Irwin (*n* = 27).

Week	Start Date	No. at Risk	No. of Deaths	No. Censored	No. Added	Survival $\hat{S}(t)$	95% Confidence Interval Lower	Upper
1	11/01/15	9	0	0	2	1.0000	1.0000	1.0000
2	11/08/15	11	0	0	0	1.0000	1.0000	1.0000
3	11/15/15	11	0	0	4	1.0000	1.0000	1.0000
4	11/22/15	15	0	1	0	1.0000	1.0000	1.0000
5	11/29/15	14	1	0	0	0.9286	0.7937	1.0635
6	12/06/15	13	2	1	0	0.7857	0.5937	0.9777
7	12/13/15	10	2	0	1	0.6286	0.4305	0.8266
8	12/20/15	9	0	0	0	0.6286	0.4334	0.8238
9	12/27/15	9	1	0	0	0.5587	0.3722	0.7452
10	01/03/16	8	1	0	0	0.4889	0.3153	0.6624
11	01/10/16	7	0	0	0	0.4889	0.3170	0.6608
12	01/17/16	7	0	0	1	0.4889	0.3187	0.6591
13	01/24/16	8	0	0	0	0.4889	0.3203	0.6575
14	01/31/16	8	0	0	0	0.4889	0.3219	0.6559
15	02/07/16	8	0	0	3	0.4889	0.3234	0.6544
16	02/14/16	11	1	0	0	0.4444	0.2890	0.5999
17	02/21/16	10	0	0	0	0.4444	0.2903	0.5986
18	02/28/16	10	0	0	2	0.4444	0.2915	0.5974
19	03/06/16	12	0	0	0	0.4444	0.2927	0.5962
20	03/13/16	12	0	0	1	0.4444	0.2939	0.5950
21	03/20/16	13	0	0	1	0.4444	0.2950	0.5939
22	03/27/16	14	0	0	0	0.4444	0.2961	0.5927
23	04/03/16	14	0	0	1	0.4444	0.2973	0.5916
24	04/10/16	15	0	0	0	0.4444	0.2983	0.5905
25	04/17/16	15	0	0	0	0.4444	0.2994	0.5895
26	04/24/16	15	0	0	3	0.4444	0.3005	0.5884

Monitoring of Telemetry Tagged Coyotes

Coyotes were tracked via traditional radio telemetry using triangulation and homing techniques. We used a Communication Specialists telemetry receiver (Model R1000) coupled to a handheld 3-element Yagi antenna. Locations consisted of ≥ 3 compass bearings with intersecting angles between 20° and 160° collected in < 15 minutes to compensate for animal movement (White and Garrott 1990). Locations were calculated using Locate III (Truro Computing, Nova Scotia, Canada) and only locations with error ellipses < 0.25 ha and an azimuth standard deviation < 5° were recorded (White and Garrott 1990). We obtained locations by following a sequential tracking method that encompassed a complete 24-hour cycle (Laundré and Keller 1984, Gese et al. 1990). The 24-hour cycle was partitioned into six 4-hour tracking blocks to ensure locations were temporally distributed throughout the diel cycle. Observers attempted to collect ≥ 3 locations during a tracking block, with an hour of separation between locations for VHF animals, and only a single location each block for GPS-collared animals. GPS collars were programmed to collect Quick Fix Psuedoranging (QFP) locations exclusively to maximize transmitter battery life and obtain a greater number of locations. The schedules were set to obtain a single location every hour from 0600 – 1759 and 2 locations every hour from 1800 – 0559 for a total of 36 locations over a 24-hour cycle.

We began monitoring coyotes in June 2015 but suspended monitoring efforts from October 2015 to mid-January 2016 due to having to focus on trapping more coyotes to place more collars and thus increase the number of coyotes we could track; the need to trap and place radio telemetry collars on burros; place cameras to survey the distribution of coyotes for an occupancy modeling study; and to sample habitat. During the reporting period we collected 950 VHF locations and 10,548 QFP locations from 31 individuals. Individuals were designated broadly as either resident or transient based on their perceived spatial patterns (Gese et al. 1996). Residents inhabit a well-defined area of use where the individual spends the majority of its time. Transients refer to individuals that utilize an area for a limited time, then usually move a distance to another section of the installation. Because of this behavior, transient individuals were opportunistically relocated when we were downrange of the garrison or they were located when the animal was utilizing the study area adjacent to the garrison.

Seasonal minimum convex polygons (100% MCPs) were calculated using the Geospatial Modeling Environment and the Home Range Tools (HRT) extension (Rodgers et al. 2007) for ArcGIS 10.3.1 (ESRI, Redlands, California, USA). MCPs were calculated for coyotes with ≥12 locations to provide a general visual representation of the animal's home range because some of these individuals moved great distances from their point of capture limiting the number of locations that could be collected. In the future, home range estimates will be made only using an adequate sample of locations that results in describing a stable seasonal home range (e.g., Roemer et al. 2001). The 2016 Wet Season data have been combined with the early 2016 Dry Season data for the purpose of this report due to the low sample sizes obtained thus far.

Table 5. The size of the home ranges of coyotes monitored from 05/21/15 to 06/19/16 at NTC Fort Irwin.

ID	Collar	No. of Locations	Region	Status	100% MCP (km^2)	
					2015 Dry Season	2016 Wet/Dry Season
Coyotes currently being monitored (*n* = 17)						
83	VHF	133	Exurban	Resident	7.63	90.44
88	EAR	26	Urban	Transient	N/A	0.92
90	GPS	13	Wildland	Transient	N/A	104.93
93	VHF	12	Wildland	Transient	N/A	8.22
95	VHF	61	Wildland	Transient	N/A	260.22
97	VHF	74	Exurban	Resident	N/A	26.97
100	GPS	14	Urban	Transient	N/A	220.91
101	GPS	16	Urban	Transient	N/A	21.12
102	VHF	104	Urban	Resident	N/A	31.70
103	VHF	111	Urban	Resident	N/A	18.03
104	GPS	37	Urban	Resident	N/A	3.73
106	VHF	21	Wildland	Transient	N/A	53.24
107	VHF	55	Urban	Transient	N/A	164.36
108	VJF	49	Urban	Transient	N/A	42.03
109	GPS	8	N/A	N/A	N/A	N/A
110	GPS	8	N/A	N/A	N/A	N/A
111	GPS	6	N/A	N/A	N/A	N/A
Coyotes no longer being monitored (*n* = 15)						
77	VHF	79	Urban	Resident	12.69	N/A
78	GPS	2593	Urban	Resident	89.53	N/A
79	GPS	6374	Urban	Resident	366.52	83.92
80	VHF	75	Urban	Resident	7.48	N/A
*82	VHF	0	N/A	N/A	N/A	N/A
85	EAR	4	N/A	N/A	N/A	N/A
**86	EAR	1	N/A	N/A	N/A	N/A
87	VHF	1	N/A	N/A	N/A	N/A
91	VHF	1	N/A	N/A	N/A	N/A
92	VHF	1	N/A	N/A	N/A	N/A
94	GPS	663	Urban	Resident	N/A	27.54
96	GPS	918	Urban	Resident	N/A	19.11
98	VHF	1	N/A	N/A	N/A	N/A
99	EAR	3	Urban	Resident	N/A	N/A
105	GPS	22	Urban	Resident	N/A	16.51

*Expired 48 hours after capture.
** Missing one week after capture; possible transmitter failure.

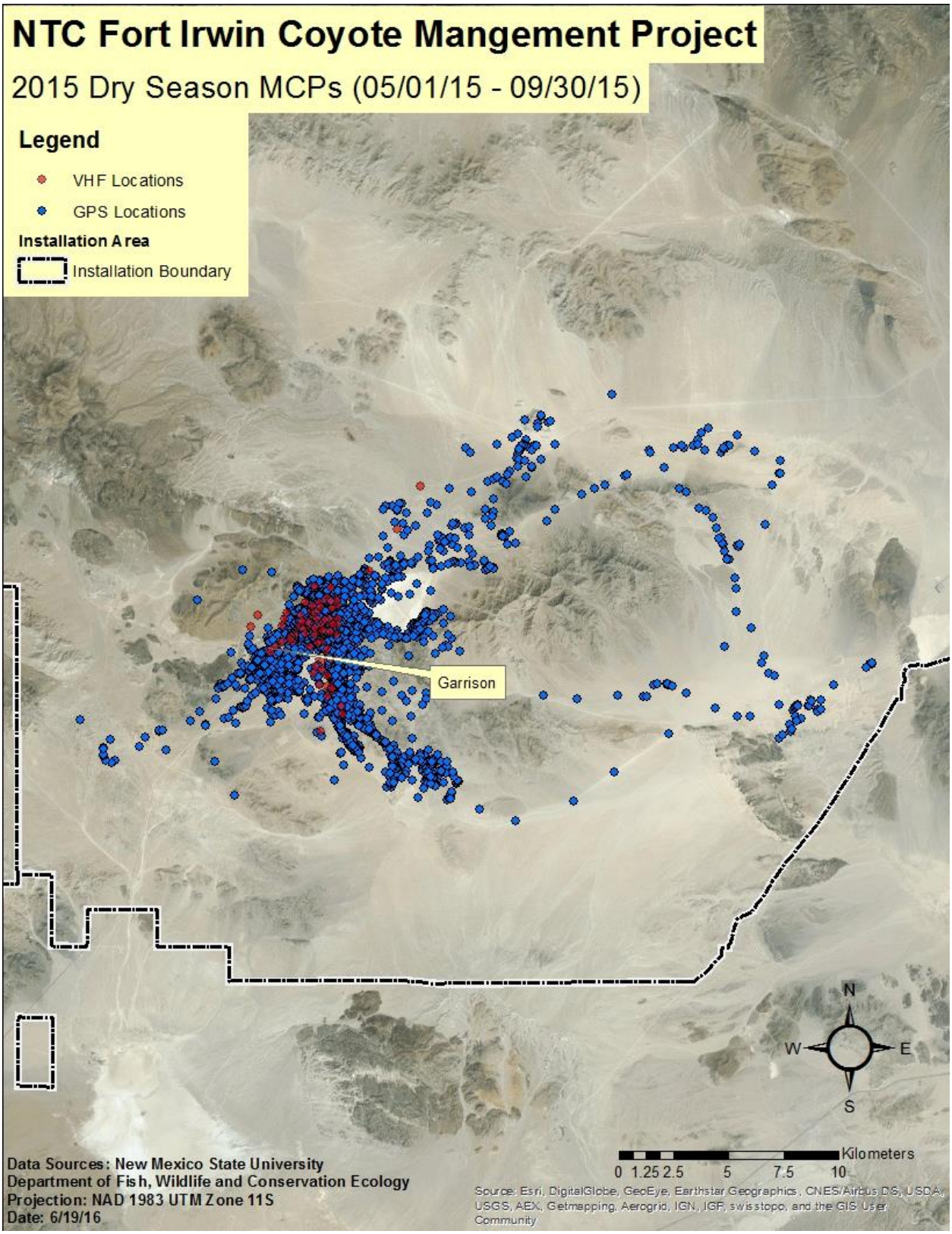


Figure 1. Installation view of the number of coyote locations obtained during the 2015 Dry Season (05/01/15 – 09/30/15) at the NTC Fort Irwin.

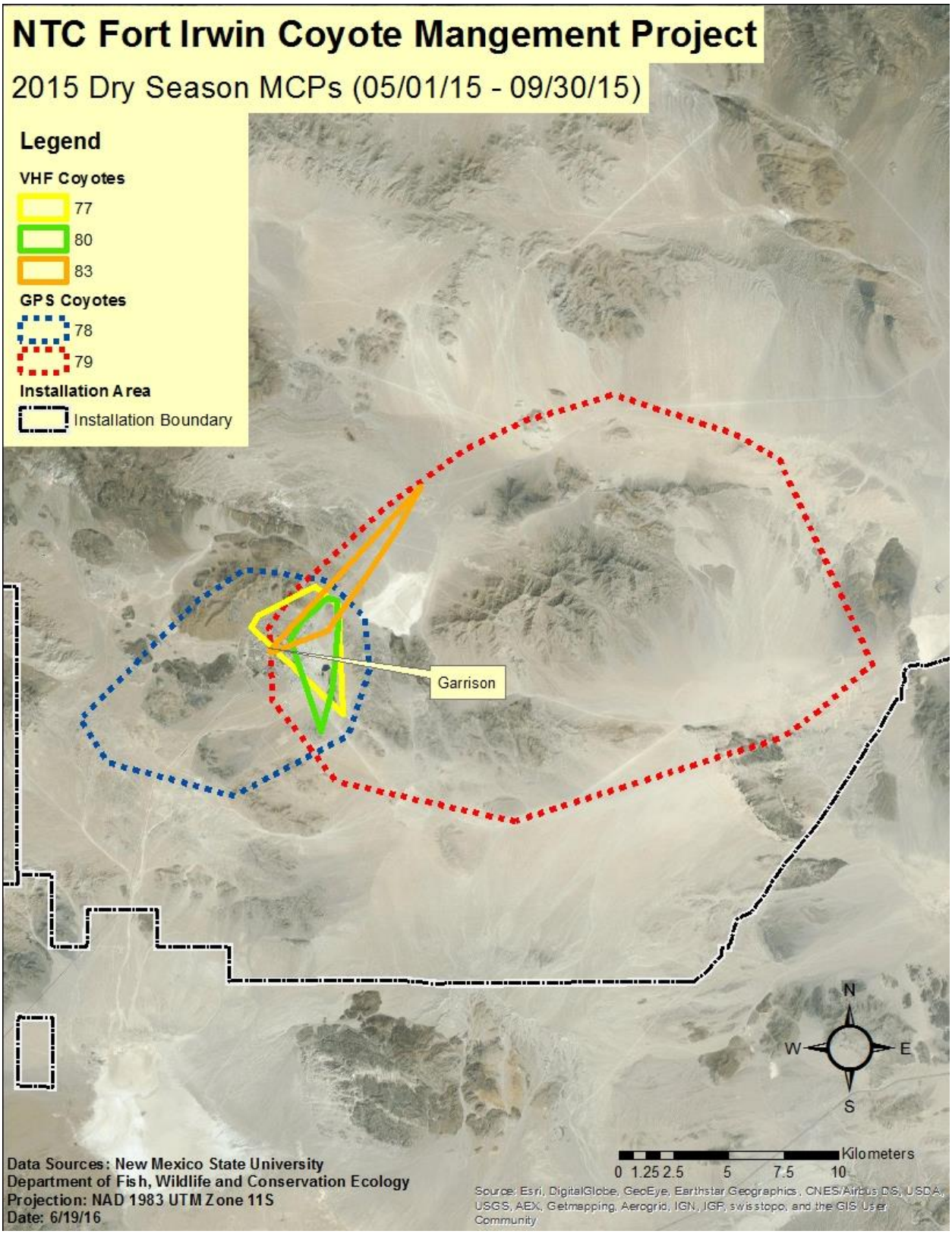


Figure 2. Installation view of estimates of the 100% MCPs for resident, urban coyotes for the 2015 Dry Season (05/01/15 – 09/30/15) at the NTC Fort Irwin.

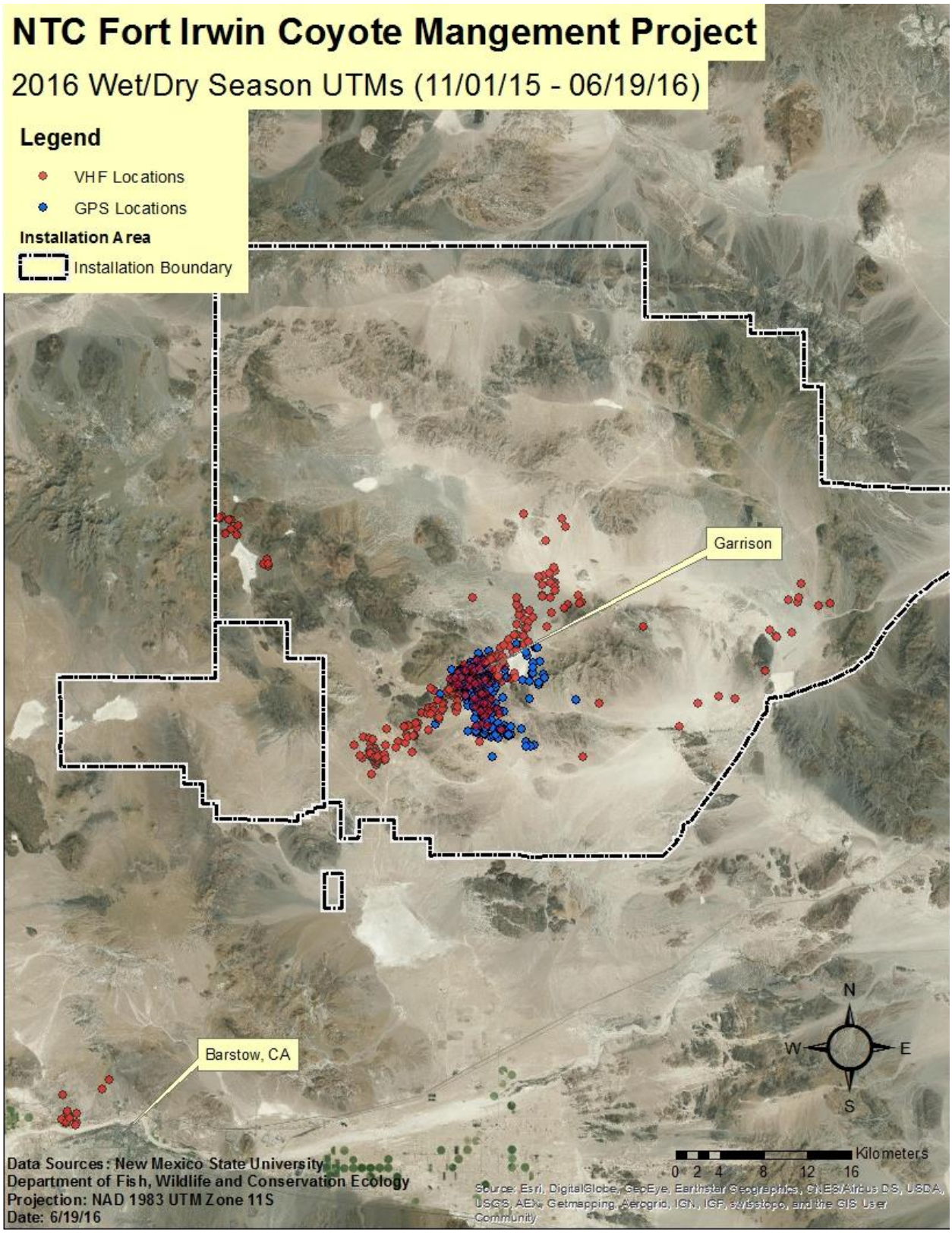


Figure 3. Installation view of the number of coyote locations obtained during the 2016 Wet/Dry Season (11/01/15 – 06/19/16) at the NTC Fort Irwin.

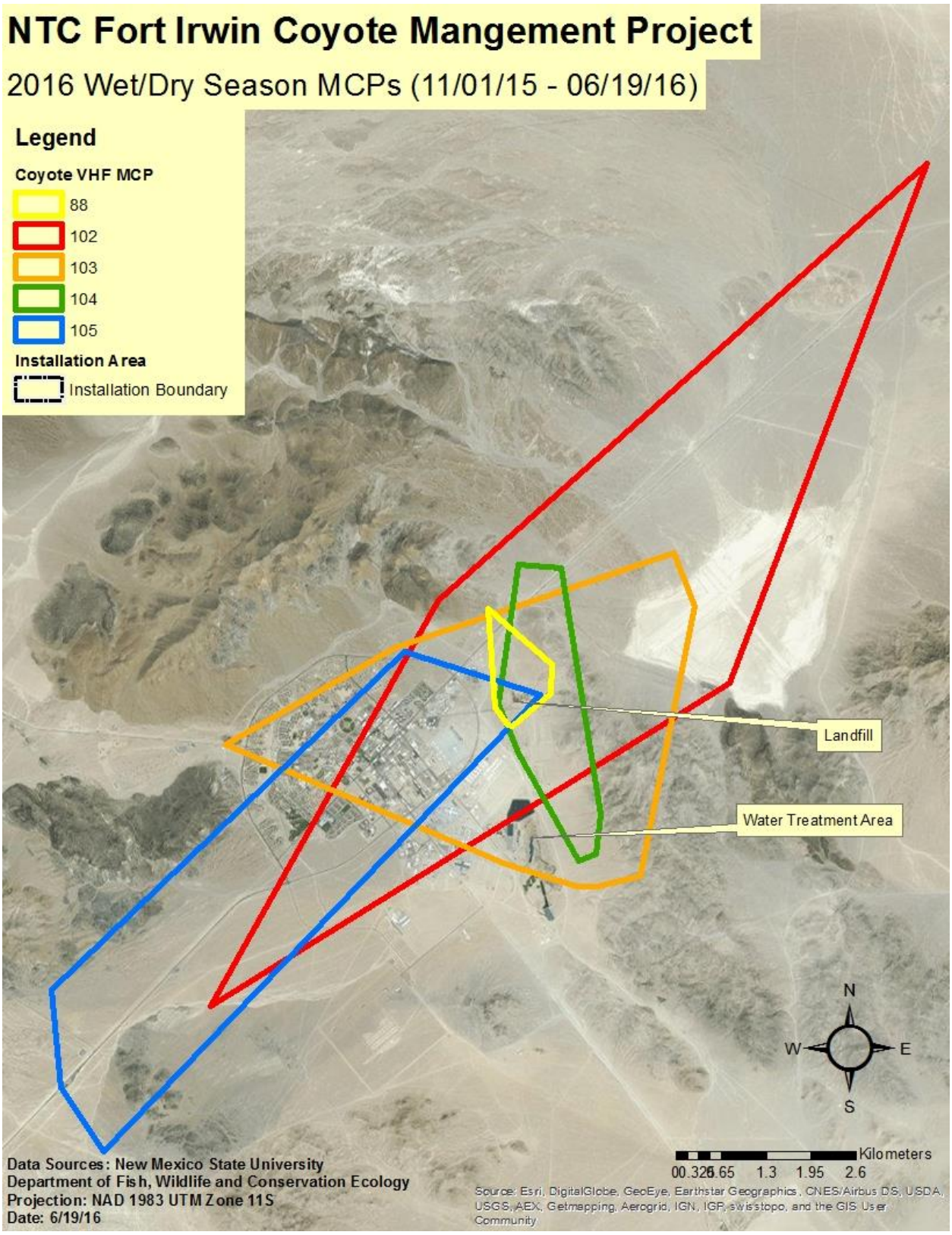


Figure 4. Garrison view of estimates of the 100% MCPs for resident, urban coyotes for the 2016 Wet/Dry Season (11/01/15 – 06/19/16) at the NTC Fort Irwin.

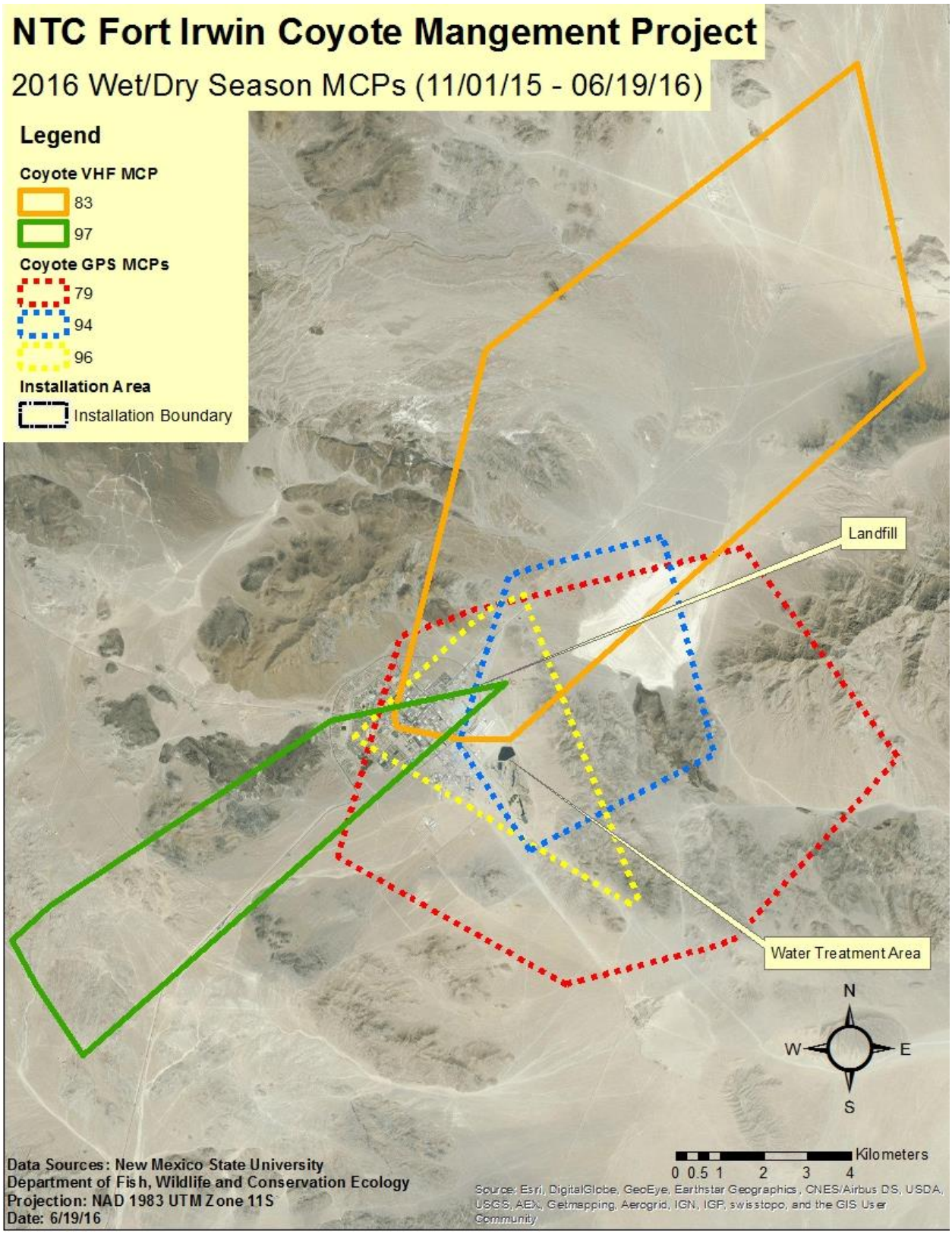


Figure 5. Garrison view of estimates of the 100% MCPs for resident, urban coyotes for the 2016 Wet/Dry Season (11/01/15 – 06/19/16) at the NTC Fort Irwin.

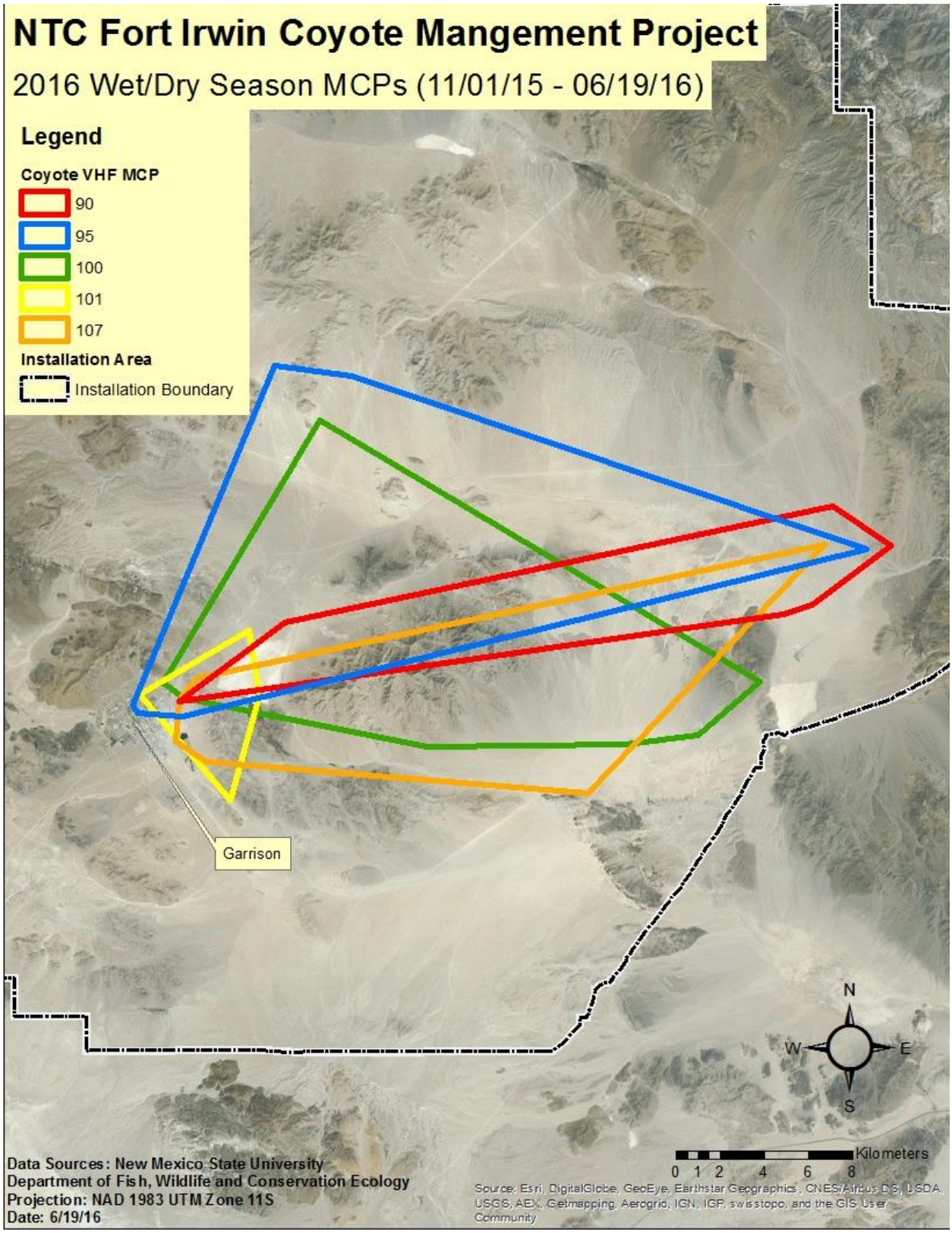


Figure 6. Installation view of estimates of the 100% MCPs for transient coyotes during the 2016 Wet/Dry Season (11/01/15 – 06/19/16) along the eastern portion of the NTC Fort Irwin.

Figure 7. Installation view of estimates of the 100% MCPs for transient coyotes during the 2016 Wet/Dry Season (11/01/15 – 06/19/16) along the western portion of the NTC Fort Irwin.

Coyote Camera Surveys

Occupancy modeling will be used to estimate the probabilities of detection and occupancy of coyotes within land cover types (see Table 6) surrounding the garrison (MacKenzie et al. 2006, Robinson et al. 2014). Cameras were randomly allocated among the exurban and wildland-interface regions proportional to the size of each region and to the land cover types within each region (Table 6). We could not place cameras northeast of the garrison as this is an active bombing range. Each camera was separated by at least 1.45 km or 33% of the mean home-range radius of an exurban coyote (Grinder and Krausman 2001). The sampling session consisted of six 5-day survey periods over 30 days with each survey considered closed to changes in occupancy. Each site featured a single Reconyx PC800 Hyperfire Camera (n = 60; Holmen, Wisconsin, USA) mounted on a 1 m stake with a can of cat food staked 5 m in front of the camera. To increase detection rates, cameras were set to capture 5 photographs per trigger with no delay.

The first sampling session was conducted between 12/13/15 to 01/11/16 for a total of 1800 camera days. Four mesocarnivore species were detected on multiple occasions, including: coyote, kit fox, gray fox (*Urocyon cinereoargenteus*), and bobcat (*Lynx rufus*) (Table 7). In addition, we had a single detection each of a western spotted skunk (*Spilogale gracilis*) and an American badger (*Taxidea taxus*). Sarcoptic mange was also detected on coyotes, although only when the infection was at least Class II or greater. Non-carnivore detections included feral burros (*Equus asinus*), ravens (*Corvus corax*), black-tailed jackrabbits, desert kangaroo rats (*Dipodomys deserti*), white-tailed antelope squirrels (*Ammospermophilus leucurus*), and greater roadrunners (*Geococcyx californianus*).

Coyotes and kit foxes were detected more often than other carnivores with coyotes detected in both the exurban (n = 57) and wildland-interface (n = 51) regions. Kit foxes were more often detected in the wildland-interface region (n = 86) than in the exurban region (n = 26). Gray foxes were only detected in the wildland-interface region (n = 6) and only at sites where either coyote or kit fox went undetected. Bobcats also exhibited higher detections in the wildland-interface region (n = 4) compared to the exurban region (n = 1). Finally, mange detections on coyotes were higher in the exurban region (n = 23) than in the wildland-interface region (n = 5).

Table 6. The area covered by the seven land-cover types at the NTC Fort Irwin.

Land-cover	Land-cover Type	Definition	Area (km2)	Coverage
Flatland	Non-Urban	Flat (<8° slope), limestone soil dominated by creosote and white bursage.	215	48.7%
Slope	Non-Urban	Hills with slopes >8°, limestone and granite, dominated by creosote.	196	44.5%
Wash	Non-Urban	Dry waterways; often travel corridors for coyotes (Grinder and Krausman 2001b).	14	3.2%
Residential	Urban	Section of garrison comprised of homes, schools, and parks.	5	1.1%
Commercial	Urban	Primary area where businesses and offices located; most consistently active portion of the garrison.	3	0.7%
Logistics	Urban	Staging area and offices for downrange activities; large tracts of open or semi-developed space; severely reduced activity during rotations.	5	1.1%
Waste Treatment	Urban	Sanitation facility, large compost piles, retention ponds for recycled water; golf course; large salt cedar (*Tamarix aphylla*) hedgerow.	3	0.7%

Table 7. The number of mesocarnivores detected from 12/13/15 to 01/11/16 during the camera survey conducted at the NTC Fort Irwin.

Land-cover	Coyote Detections	Kit Fox Detections	Gray Fox Detections	Bobcat Detections	Mange Detections
Exurban (*n* = 22)					
Flatland (9)	27	13	0	1	10
Slope (9)	13	8	0	0	5
Wash (4)	17	5	0	0	8
Wildland-Interface (*n* = 38)					
Flatland (15)	29	41	0	0	0
Slope (15)	22	27	6	3	3
Wash (8)	20	18	0	1	2
Total	128	112	6	5	28

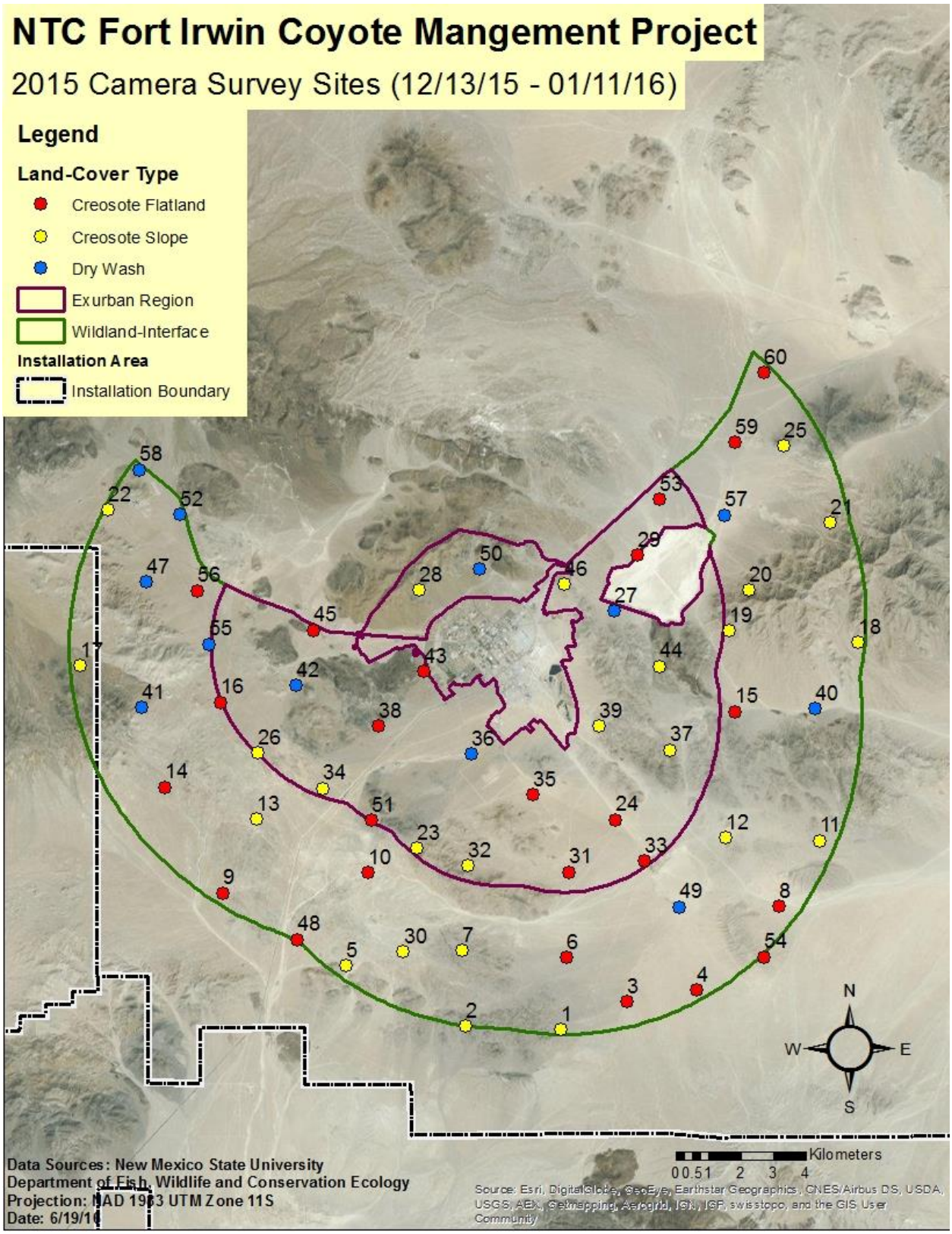


Figure 8. The distribution of camera sites, regions, and land-cover types for the occupancy modeling survey conducted at the NTC Fort Irwin during the winter of 2015-2016.

Spotlight Surveys

Nighttime spotlight surveys were conducted to measure seasonal lagomorph activity and estimate density for use in future resource and occupancy modeling analyses. Lagomorph densities will be estimated using distance sampling methods (Buckland et al. 2001, Robinson et al. 2014). Transects followed established roads throughout the urban, exurban, and wildland-interface regions. We attempted to survey every 4 weeks for a 3-day survey session. Surveys occurred during non-rotational periods (i.e., periods when there was no active training by military personnel) and began a half-hour after sunset.

Over the 2016 Wet/Dry Season, we conducted 3 urban and 6 non-urban spotlight surveys. The additional non-urban surveys were conducted at the same time as the camera surveys so these data could specifically be used in the occupancy modeling analysis. During the winter 2015/2016 survey (12/18/15 to 01/10/16), we detected 50 lagomorphs and 5 coyotes over 458 km of non-urban roads. During the spring 2016 survey (03/21/16 to 05/26/16), we detected 48 lagomorphs and 13 coyotes over 191 km of urban roads, and 111 lagomorphs and 4 coyotes over 569 km of non-urban roads. We did not attempt to estimate density at this time but we will once all data have been collected.

INVESTIGATIONS INTO CONTROL OF FERAL BURRO POPULATIONS

C. Description of Project

The feral burro population present on the National Training Center (NTC) Fort Irwin, California, is causing human-wildlife conflicts. The burro population has interrupted training exercises, caused vehicle accidents, and damaged urban landscapes (L. Aker, *pers. comm*). Burro use of the garrison typically increases during the dry season, as burros search for resources including water and greener forage, which may lead to a greater risk of collision with vehicles. The feral burro population may also negatively impact native vegetation through trampling and overgrazing. To aid in the development of mitigation strategies that will reduce human-burro conflicts on base, we have initiated a project to estimate the size of the burro population, examine their patterns of space use, and have employed non-lethal methods of immunocontraception and sterilization to reduce recruitment in an attempt to reduce population size and mitigate current levels of human-wildlife conflict.

D. Summary of Data Collected

Estimates of Burro Population Size

In collaboration with Dr. Paul Griffin (Research Coordinator, BLM Wild Horse and Burro Program), we conducted aerial surveys and utilized two different approaches to estimate the number of burros within select areas surveyed on the NTC. Surveys were conducted between 3/4/2016 and 3/6/2016. A total of 337 burros were observed within the area surveyed (Lubow 2016). Using the number of radio-collared burros present, it was possible to use the Chapman's modification of the Lincoln-Peterson estimator to estimate the size of the burro population within the surveyed area and within the entire base. These estimates yielded 412 burros (90% CI = 331-512) and 975 burros (90% CI = 649-1,467), respectively. A double-observer model, which estimates the probability of detection and thereby accounts for the fact that all burros cannot be observed, yielded a population estimate of 460 burros (90% CI = 383-622) for the area surveyed. For a complete account of the methods used to estimate population size from the data collected during the aerial surveys see Lubow (2016).

Burro Captures

Burros were trapped with corral traps from 08/05/15 until 10/05/15. Corral traps were baited with alfalfa hay, carrots, apples, and water. We captured 47 burros at 11 different trap sets over a total of 203 trap nights (Table 8). Burros were transported to the Bureau of Land Management's (BLM) Ridgecrest Regional Wild Horse and Burro Corrals and held until processed. Fourteen females and 31 males were captured in the corral traps (Tables 9 and 10). Twelve females were injected with an initial and follow up dose of Porcine Zona Pellucida (PZP), an immunocontraceptive, while held in the corrals; 2 females were too young to administer the immunocontraceptive. Twenty-four adult males were surgically vasectomized by a licensed veterinarian at the facility. However, 2 yearlings were not vasectomized because they were not sexually mature. Every burro was freeze branded with a unique number.

Due to the small sample size of females captured in the corral traps, we attempted to capture more females by darting. Darting involved the use of a dart gun (Dan-Inject or Pneu-dart) and a dart projectile containing a mixture of etorphine hydrochloride (3 mg) and xylazine (200 mg) injected intramuscularly. After processing, an antagonist, naltrexone (25 mg/mg etorphine, i.e. 25 mg of naltrexone are injected for every mg of etorphine hydrochloride injected) + tolazoline (2 mg/mg xylazine) was administered to initiate recovery. Darting began on 10/01/15 and lasted until 10/3/15. A total of 7 adult females were captured and all were given the initial dose of PZP (Table 9). Four females were darted with the second

dose of PZP, but the remaining 3 females moved to the Leech Lake Impact Area after release where they could not be darted to administer the second dose because the area is inaccessible due to unexploded ordinance. These latter females are being monitored closely and we will attempt to administer the second dose of PZP if the opportunity arises.

Table 8. Burro corral traps deployed from 08/05/15 to 10/05/15 at NTC Fort Irwin and associated capture statistics.

Trap Name	Date Set	First Capture	Trap Days	Capture Events	Total Captures	Trap Success*
Garlic	08/05/15	08/06/15	29	5	14	17.2%
Goldstone	08/06/15	08/07/15	35	3	11	8.6%
Outerloop	08/06/15	08/14/15	17	1	1	5.9%
Crackerjack	08/05/15	08/30/15	21	1	1	4.8%
Holding	08/09/15	-	3	0	0	0%
Apollo	08/24/15	08/31/15	33	6	12	18.1%
Echo	08/24/15	08/24/15	33	2	4	6.1%
Gold Gate	09/20/15	-	7	0	0	0%
Panther	09/27/15	-	8	0	0	0%
Drinkwater	09/27/15	10/03/15	9	1	2	11.1%
Leach Lake	09/28/15	10/03/15	8	1	2	12.5%
Total			203	20	47	9.9%

* Trap success was calculated as the number of capture events divided by the number of trap days times 100.

Table 9. The number of female burros captured from 08/06/15 to 10/05/15 at NTC Fort Irwin.

ID	Sex	Age (Years)	Capture Method	Capture Date	Collar	2nd PZP Injection	Status
GPS Collars (*n* = 10)							
04	F	3	Corral	08/07/15	GPS	Yes	Alive
05	F	5	Corral	08/11/15	GPS	Yes	Alive
06	F	5	Corral	08/07/15	GPS	Yes	Alive
28	F	7	Corral	08/27/15	GPS	Yes	Alive
31	F	5	Corral	09/05/15	GPS	Yes	Alive
26	F	4	Corral	08/26/15	GPS	Yes	Alive
59	F	*Adult	Darting	10/01/15	GPS	No	Alive; In Leach Lake Area
40	F	*Adult	Darting	10/01/15	GPS	No	Alive; In Leach Lake Area
41	F	*Adult	Darting	10/02/15	GPS	Yes	Alive
42	F	*Adult	Darting	10/03/15	GPS	No	Alive; In Leach Lake Area
VHF Collars (*n* = 7)							
01	F	3	Corral	08/08/15	VHF	Yes	Dead 11/27/15
03	F	9	Corral	08/07/15	VHF	Yes	Alive
30	F	5	Corral	08/24/15	VHF	Yes	Alive
62	F	2.5	Corral	10/03/15	VHF	Yes	Alive; In Leach Lake Area
45	F	*Adult	Darting	10/03/15	VHF	Yes	Alive
47	F	*Adult	Darting	10/03/15	VHF	Yes	Alive
43	F	*Adult	Darting	10/03/13	VHF	Yes	Dropped collar
Freeze Branded (*n* = 4)							
33	F	2	Corral	08/31/15	-	Yes	Alive; last observed 06/16/16
63	F	2	Corral	10/03/15	-	Yes	Not seen since release
32	F	0.9	Corral	09/05/15	-	-	Still with mother
27	F	0.6	Corral	08/26/15	-	-	Still with mother

*Burros captured by darting were not aged

Table 10. The number of male burros captured from 08/06/15 to 10/05/15 at NTC Fort Irwin.

ID	Sex	Age	Capture Method	Capture Date	Vasectomized	Status
VHF Collars (*n* = 13)						
08	M	4	Corral	08/06/15	Yes	Dead
09	M	2	Corral	08/08/15	Yes	Failed collar; status unknown
10	M	3	Corral	08/14/15	Yes	Alive
11	M	3	Corral	08/07/15	Yes	Alive
14	M	8	Corral	08/06/15	Yes	Alive
15	M	2	Corral	08/07/15	Yes	Dropped collar 1/27/16; status unknown
17	M	5	Corral	08/11/15	Yes	Alive
36	M	4	Corral	09/07/15	Yes	Alive
35	M	8	Corral	08/31/15	Yes	Alive
21	M	3	Corral	08/19/15	Yes	Dead
39	M	5	Corral	09/10/15	Yes	Alive
56	M	7	Corral	08/07/15	Yes	Dropped collar 3/2/16; status unknown
60	M	6	Corral	10/03/15	Yes	Alive
Freeze Branded (n= 18)						
02	M	-	Corral	08/08/15	No	Dead
07	M	-	Corral	08/07/15	No	Dead
12	M	4	Corral	08/07/15	Yes	Last seen alive on 11/15
13	M	1	Corral	08/07/15	No	Not seen since release
16	M	5	Corral	08/07/15	Yes	Not seen since release
18	M	7	Corral	08/07/15	Yes	Not seen since release
19	M	2	Corral	09/12/15	No	Not seen since release
20	M	5	Corral	09/12/15	Yes	Last seen alive on 6/16
22	M	3	Corral	08/19/15	Yes	Last seen alive on 11/15
23	M	7	Corral	08/21/15	Yes	Not seen since release
24	M	4	Corral	08/19/15	Yes	Last seen alive on 6/16
25	M	3	Corral	08/19/15	Yes	Last seen alive on 6/16
29	M	0.2	Corral	08/24/14	No	Still with mother
34	M	2	Corral	09/10/15	Yes	Not seen since release
37	M	4	Corral	09/7/15	Yes	Last seen alive on 11/9
38	M	3	Corral	09/10/15	Yes	Not seen since release
54	M	3	Corral	08/19/15	Yes	Last seen alive on 6/16
61	M	2.5	Corral	10/03/15	Yes	Last seen alive on 6/16

Monitoring of Radio Collared Burros

Burros collared with traditional VHF telemetry transmitters were tracked a minimum of 2 times a week during daylight hours using triangulation and homing techniques. When possible, an observation of the collared animal was made and its location estimated using a compass to determine azimuth and a range finder to determine distance from a known location that was determined with a GPS. Care was taken not to interrupt the animals' foraging behavior or movements. Triangulated locations were obtained by using ≥ 3 intersecting bearings between 20° and 160° collected in < 15 minutes to compensate for animal movement (White and Garrott 1990). Locations were calculated using Locate III (Truro Computing, Nova Scotia, Canada) and only locations with error ellipses < 0.25 ha and an azimuth standard deviation < 5° were recorded (White and Garrott 1990). Ten burros, all females, were collared with GPS collars programmed to collect a location every hour. These burros are also monitored for mortality and a location was recorded at least once a week using the method described above.

Three burros dropped their collars during the reporting period, possibly caused by fraying of the belting. The 3 burros with dropped collars can still be identified by their freeze brands and are regularly observed. Another collar has failed, but the burro has been seen still wearing the collar.

Table 11. Feral burro locations and seasonal minimum convex polygon home range sizes from 10/01/15 to 06/19/16.

ID	Collar	No of Locations	Locality	Status	Wet Season 100% MCP (km^2)	Dry Season 100% MCP (km^2)
Currently Tracking (*n* = 23)						
03	VHF	58	Garlic	Tracking	157.1	52.7
10	VHF	37	Goldstone	Tracking	76.1	49.9
11	VHF	28	Goldstone	Tracking	78.4	17.8
14	VHF	59	Garlic	Tracking	107.7	29.3
17	VHF	53	Garlic	Tracking	68.3	50.3
30	VHF	42	Goldstone	Tracking	67.3	11.5
35	VHF	51	Goldstone	Tracking	55.1	5.2
36	VHF	22	Goldstone	Tracking	66.6	4.2
39	VHF	33	Goldstone	Tracking	49.7	12.6
45	VHF	71	Downrange	Tracking	16.3	62.7
47	VHF	65	Downrange	Tracking	21.8	44.5
60	VHF	53	Downrange	Tracking	17.6	22.0
62	VHF	1	Leech Lake	Tracking	-	-
04	GPS	57	Garlic	Tracking	139.1	54.5
05	GPS	61	Garlic	Tracking	129.5	52.3
06	GPS	64	Garlic	Tracking	81.2	65.9
26	GPS	52	Goldstone	Tracking	63.5	12.6
28	GPS	56	Garlic	Tracking	38.3	29.3
31	GPS	28	Goldstone	Tracking	38.5	30.6
40	GPS	4	Leech Lake	Tracking	-	-
41	GPS	14	Goldstone	Tracking	-	-
42	GPS	3	Leech Lake	Tracking	-	-

59	GPS	2	Leech Lake	Tracking	-	-
No Longer Tracking (*n* = 7)						
01	VHF	7	Garlic	Dead	-	-
08	VHF	8	Garlic	Dead	-	-
09	VHF	27	Goldstone	Failed collar	128.3	23.6
15	VHF	12	Goldstone	Dropped collar	-	-
21	VHF	13	Goldstone	Dead	-	89.0
43	VHF	45	Downrange	Dropped collar	13.5	-
56	VHF	21	Goldstone	Dropped collar	-	-

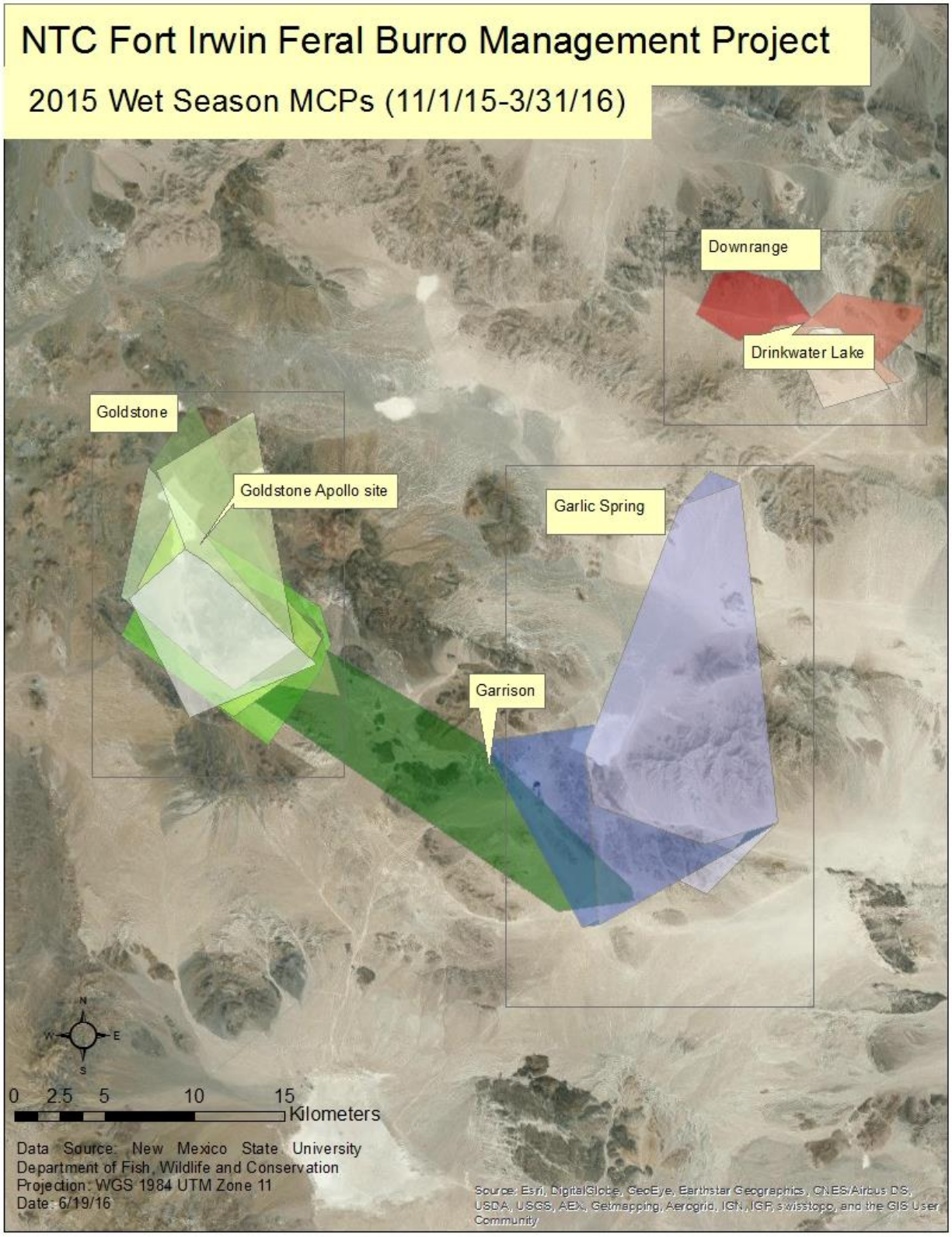


Figure 9. Installation view of 100% MCP home ranges of burros during the 2015 wet season.

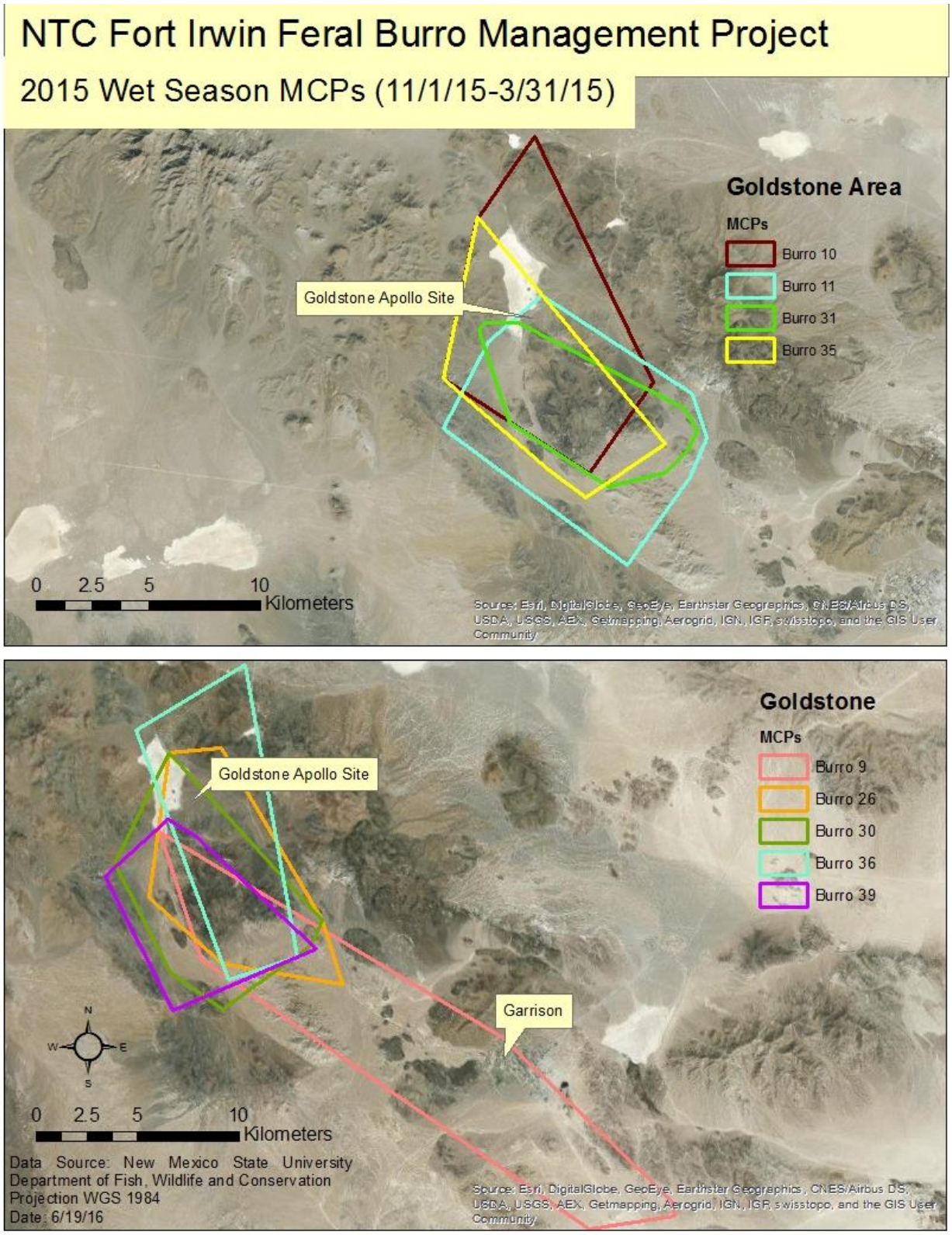
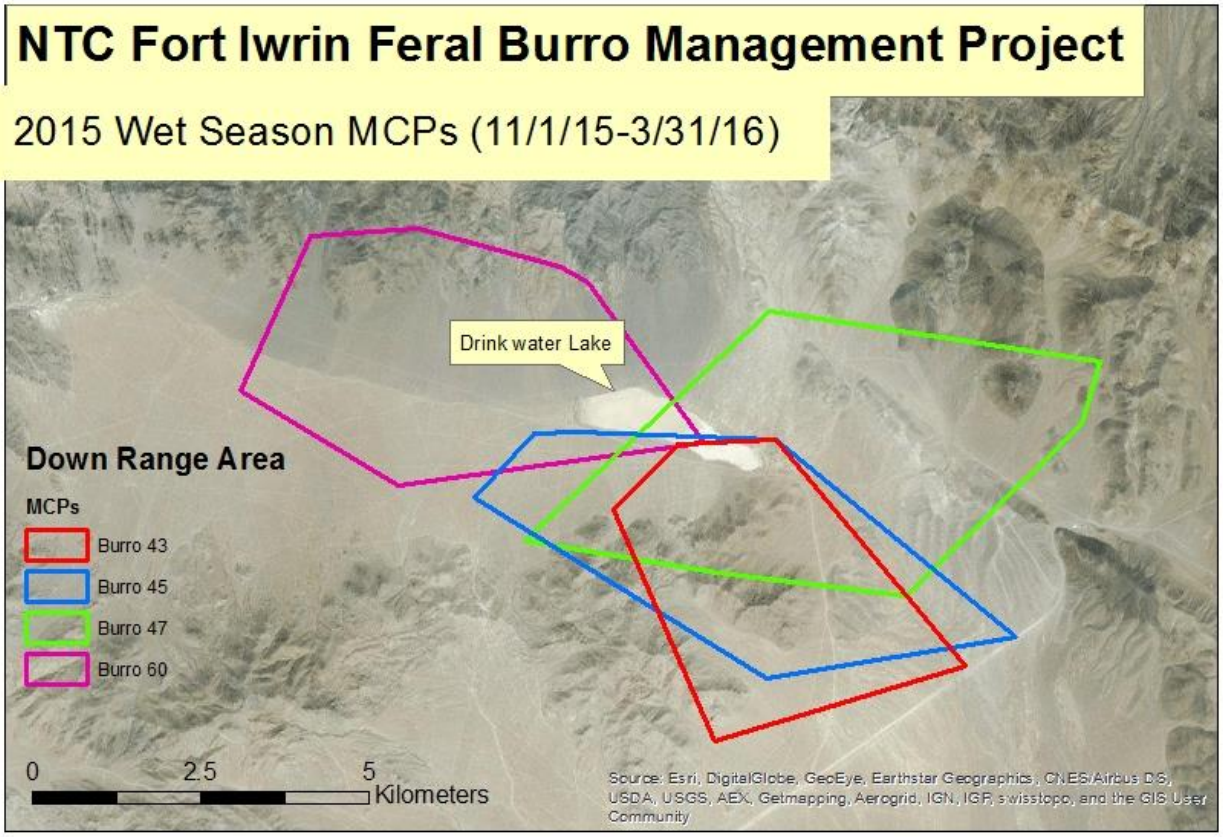


Figure 10. View of 100% MCP home ranges of burros on Goldstone during the 2015 wet season.



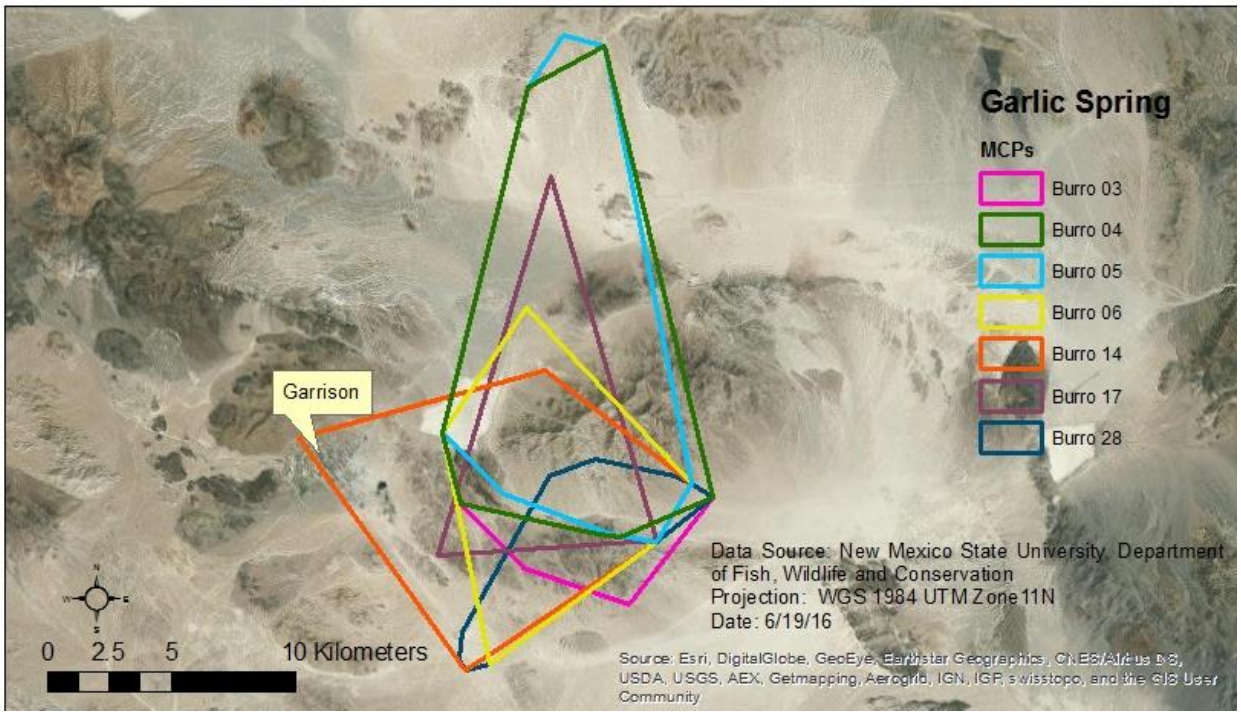


Figure 11. View of 100% MCP home ranges of burros down range and near Garlic Spring during the 2015 wet season.

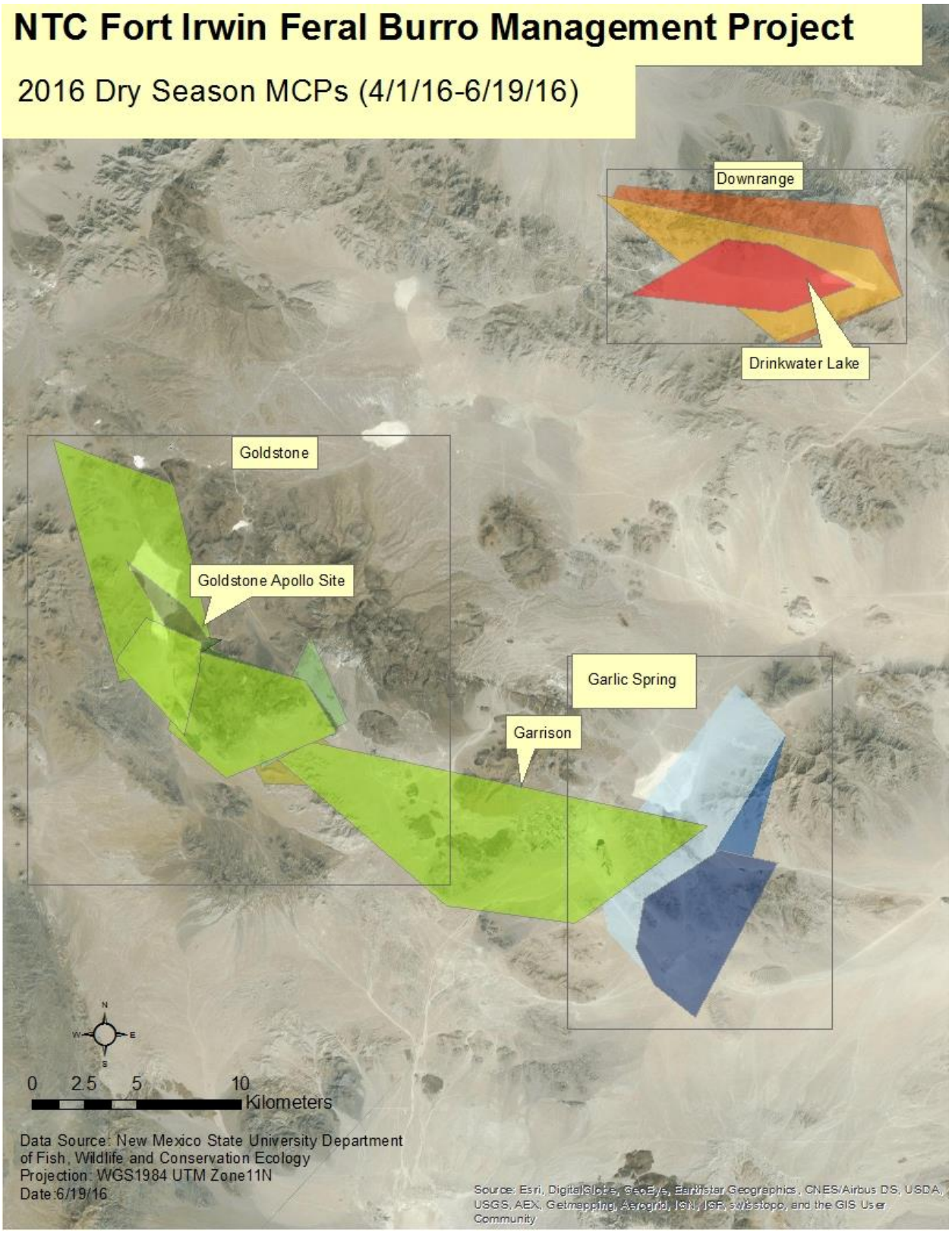


Figure 12. Installation view of 100% MCP home ranges of burros during the early 2016 wet season.

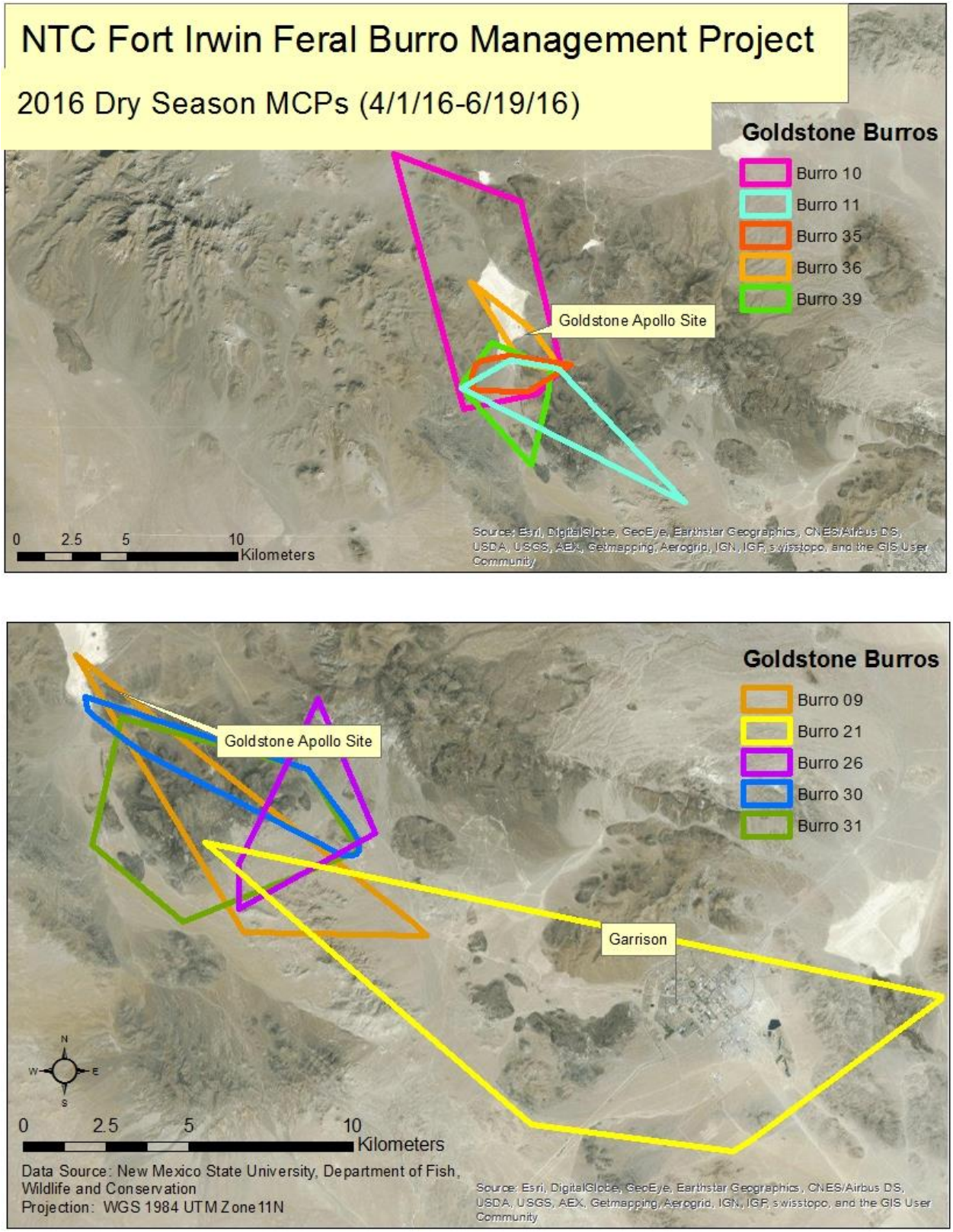
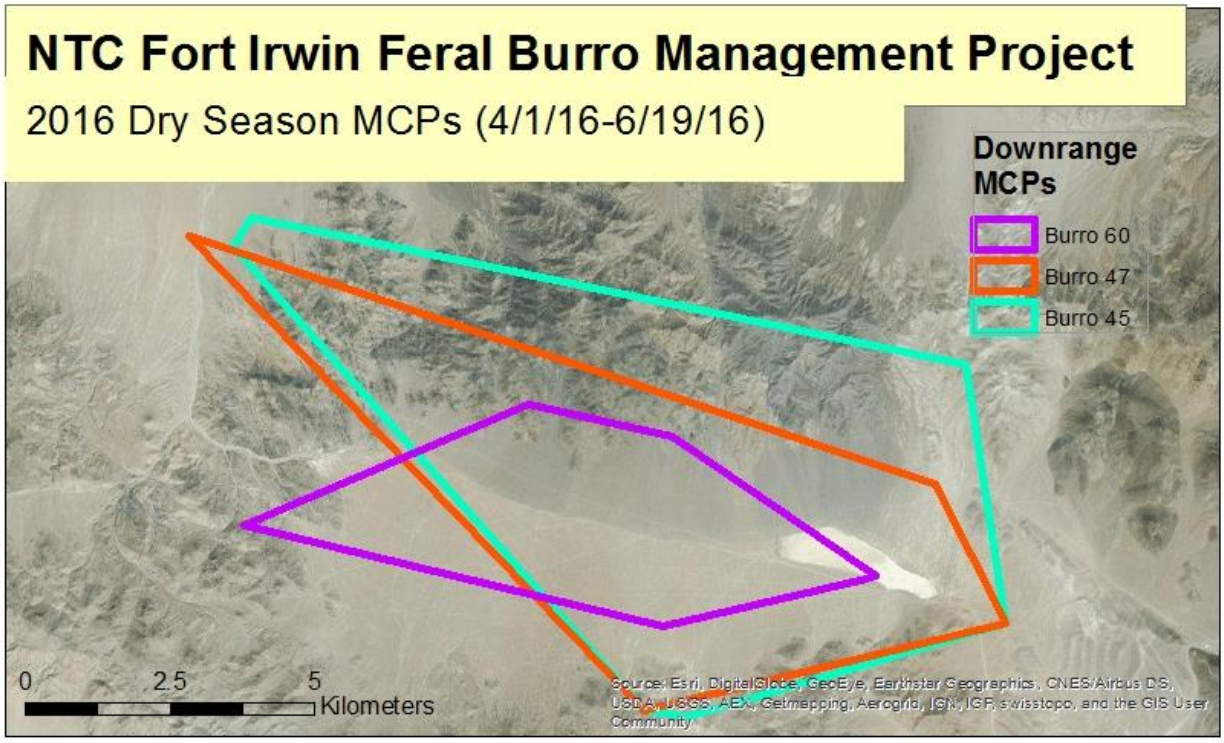


Figure 13. View of 100% MCP home ranges of burros on Goldstone site during the early 2016 wet season.



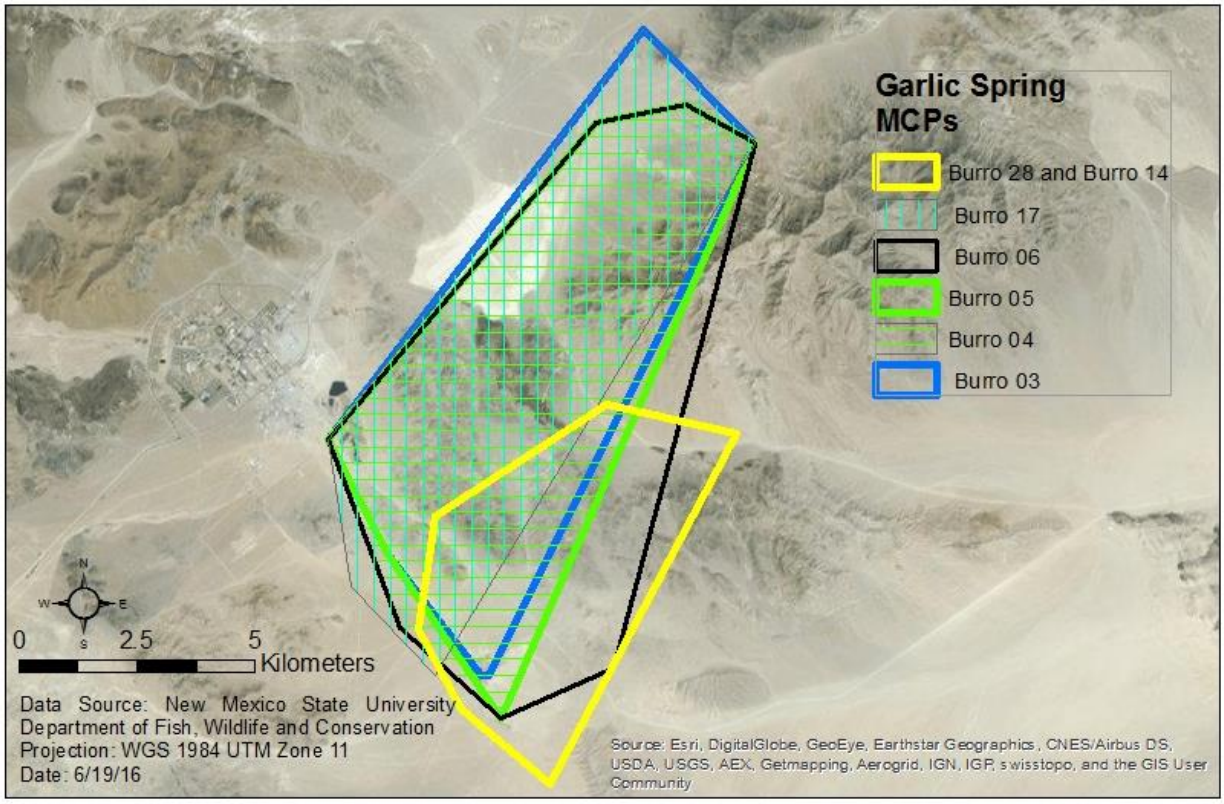


Figure 13. View of 100% MCP home ranges of burros down range and near Garlic Spring during the early 2016 wet season.

Burro Mortalities

There were 6 study animals that died and one unmarked burro that died. A foal captured at the Garlic trap was reportedly attacked and killed by coyotes while at the Ridgecrest facility, and an adult male captured at the Apollo trap had colic and had to be euthanized by the veterinarian on base. Burro 08 was found on 11/24/15; the carcass was fresh and it was suspected he died during the night. There was pink foam coming out of his nose and the dirt was brushed aside as if he had had a seizure. There were no other indications of the cause of the mortality. Burro 01 was found dead within 50 meters of an unknown burro. Both burros were in the same stage of decomposition. Due to scavenging it was impossible to tell cause of mortality. Burro 21 and Burro 02 were hit by cars on Fort Irwin Road in the early morning on 05/13/16. These burros died from their injuries before the police arrived to euthanize them. The driver said there was a third burro that was also hit, but it survived with injuries.

Table 12. Recorded mortalities of study and non-study burros at NTC Fort Irwin from 02/22/15 to 06/19/16.

ID	Sex	Date	Cause	Comments
01	Female	11/27/15	Unknown	Found dead with unknown burro.
08	Male	11/27/15	Unknown	Found with foam coming out of his nose.
21	Male	05/13/16	Vehicle collision	
02	Male	05/13/16	Vehicle collision	
07	Male	09/25/15	Predation	Killed by coyote in holding pen.
NA	Male	09/25/15	Euthanized	It had colic and was euthanized by base vet.
NA	-	11/27/15	Unknown	Found dead with Burro 01.

Spring Cameras

Trail cameras were set at 6 active springs on base starting on 05/13/15. The cameras are checked monthly and photos are sorted into triggering events by burro group size. No Name Spring, Desert King Spring, and Cave Spring are closed off to burro access. Burros have dug out and diverted the flow at Panther Spring and can access water during the wet season. Bitter Spring is always open to burros and has had water the majority of the monitoring period. Bitter Spring also has multiple flows and burros can access water at different points near this spring. Garlic Spring is usually open to burro use but was closed off to burros during the time when we were trapping them; the camera used to monitor the spring had to be taken down for a planned burn in the late fall. Garlic Spring is now closed off to burro access due to an archeological find that could be a hazard to the burros. Marked burros were visiting Garlic Spring, No Name Spring, and Panther Spring (Table 13, Figures 14-16). Other burros can be individually identified by unique coloration and scaring at all of the spring cameras.

Table 13. Burro activity at Spring Camera Sites on Fort Irwin NTC.

				Triggering event by group size						
Spring	Session Start	Days Active	No. of Photos	1 burro	2 burros	3 burros	4 burros	> 4 burros	Largest group size	Comments
Garlic	05/13/15	26	5583	7	5	3	4	13	6	
Garlic	06/08/15	27	11835	15	12	4		29	7	
Garlic	07/21/15	5	2211	9	3	1		5	5	
Garlic	07/26/15	6	2052	12	2	1	1	1	8	
Garlic	08/01/15	26	3577	6	1	2			3	closed off
Garlic	08/27/15	26	4382						0	no burros
Garlic	09/22/15	39	9987	9	4	3	1	3	5	marked burros
Garlic	02/03/16	29	1261	3	2			2	5	marked burros
Garlic	03/03/16	63	13863	2	1	2		9	5	
Garlic	01/14/16	19	274	1				1	5	
Cave	05/26/15	19	886	0	0	0	0	0	0	no burros
Cave	06/14/15	21	575	0	0	0	0	0	0	no burros
Cave	07/21/15	13	571	0	0	0	0	0	0	no burros
Cave	08/03/15	24	417	0	0	0	0	0	0	no burros
Cave	08/27/15	11	136	1	0	0	0	0	1	
Cave	09/07/15	47	492	1					1	
Cave	10/24/15	36	569	15	1	2			3	
Cave	11/29/15	43	2529	19	3	2		3	5	
Cave	01/11/16	22	660	6	1	4			3	
No Name	05/23/15	25	510	3	1		1		4	
No Name	06/17/15	15	56	1					1	
No Name	07/06/15	28	138	3					1	
No Name	08/03/15	24	45		1				2	
No Name	08/27/15	94	1563	9	4	1		1	5	marked burros
No Name	11/29/15	43	2958	4	3		1		4	
No Name	02/03/16	30	377	2	1				2	
No Name	03/04/16	53	1011	15	7		4		4	
Bitter	05/22/15	17	2193	5	7	6	11	5	8	
Bitter	06/08/15	27	42	1		1		1	5	
Bitter	07/05/15	53	196	2	2	1			3	
Bitter	08/27/15	11	365						0	no burros
Bitter	09/07/15	28	4186	6	5	20			3	
Bitter	10/17/15	33	705	1		3		3	5	
Bitter	03/03/16	57	489						0	no burros

				Triggering event by group size						
Spring	Session Start	Days Active	No. of Photos	1 burro	2 burros	3 burros	4 burros	> 4 burros	Largest group size	Comments
Desert King	05/22/15	26	4005	22	6	2	2		4	
Desert King	06/17/15	16	690	7	2				2	
Desert King	07/03/15	36	165	3	1				2	
Desert King	08/08/15	19	440	8	3				2	
Desert King	08/27/15	11	616	7	3	1			3	
Desert King	09/07/15	29	668	9	9			1	6	
Desert King	10/06/15	27	1378	2	8	5		2	5	
Desert King	01/11/16	14	1959	10	3	1			3	
Desert King	02/03/16	85	16985	50	9	1		1	5	
Panther	05/22/15	23	30565	38	4	4		12	8	
Panther	07/03/15	12	48	7	3	1			4	
Panther	07/21/15	13	662	18	1	1			4	
Panther	08/03/15	9	76	4					2	
Panther	08/12/15	16	96	3	1				3	
Panther	08/28/15	9	86	6	1				3	
Panther	09/08/15	14	3040	13	6	5		5	6	
Panther	10/27/15	33	577	3	2			2	5	marked burros
Panther	02/02/16	31	90	5		1			4	

Figure 14. Burro 03 at No Name Spring.

Figure 15. An unmarked female and her foal at Garlic Spring.

Figure 16. A group of burros at Garlic Spring**.**

F. Mileage

Table 14. Mileage for all vehicles throughout the reporting period.

Reporting Period	2002 Ford F-150 (G51232)	2013 Chevrolet Silverado (I433768)	*Ford F-250 (used to transport trailer)	Budgeted Monthly Mileage
Apr 2015	0	799	1626	777
May 2015	1512	1216	0	1500
Jun 2015	990	681	0	1500
Jul 2015	443	880	0	1500
Aug 2015	1274	2960	0	1500
Sep 2015	989	2912	0	1500
Oct 2015	1088	2448	0	1500
Nov 2015	760	1743	0	1500
Dec 2015	811	1579	0	1500
Jan 2016	1167	1065	0	1500
Feb 2016	775	1968	0	1500
Mar 2016	827	1933	0	1500
Apr 2016	1352	1703	0	1500
May 2016	779	1532	0	1500
Jun 2016	443	2741	0	1500
Total	13,210	26,160	1,626	21,700

H. References

Gese, E. M., D. E. Andersen, and O. J. Rongstad. 1990. Size of resident coyotes from home-range locations. The Journal of Wildlife Management 54:501–506.

Gese, E. M., R. L. Ruff, and R. L. Crabtree. 1996. Social and nutritional factors influencing the dispersal of resident coyotes. Animal Behaviour 52:1025–1043.

Grinder, M. I., and P. R. Krausman. 2001. Home range, habitat use, and nocturnal activity of coyotes in an urban environment. Journal of Wildlife Management 65:887-898.

Housman, D. C. 2013. Fort Irwin 2013 Annual Climate Report. DPW Environmental Division, Fort Irwin, California.

Laundré, J. W., and B. L. Keller. 1984. Home-range size of coyotes: a critical review. The Journal of Wildlife Management 48:127-139.

Lubow, B. 2016. Memorandum: Statistical analysis for January 2016 burro survey of Fort Irwin National Training Center, CA. 10pp.

MacKenzie, D. I., J. D. Nichols, G. B. Lachman, S. Droege, J. A. Royle, and C. A. Langtimm. 2002. Estimating site occupancy rates when detection probabilities are less than one. Ecology 83:2248–2255.

MacKenzie D.I., J.D. Nichols, J. A. Royle, K.H. Pollock, L.L. Bailey, and J.E. Hines. 2006. Occupancy estimation and modeling: Inferring patterns and dynamics of species occurrence. New York, Academic Press, Elsevier Inc.

Pence, D. B., L. A. Windberg, and R. Sprowls. 1983. The epizootiology and pathology of sarcoptic mange in coyotes, *Canis latrans*, from south Texas. Journal of Parasitology 69:1110-1115.

Pollock, K. H., Winterstein, S. R., Bunck, C. M. and Curtis, P. D. 1989. Survival analysis in telemetry studies: the staggered entry design. The Journal of Wildlife Management 53:7–15.

Robinson, Q. H., D. Bustos, and G. W. Roemer. 2014. The application of occupancy modeling to evaluate intraguild predation in a model carnivore system. Ecology 95:3112-3123.

Rodgers, A.R., A.P. Carr, H.L. Beyer, L. Smith, and J.G. Kie. 2007. HRT: Home Range Tools for ArcGIS. TWS Conference.

Roemer, G. W., D. A. Smith, D. K. Garcelon, and R. K. Wayne. 2001. Behavioural ecology of the island fox. Journal of Zoology 255:1-14.

Sikes, R. S., and W. L. Gannon. 2011. Guidelines of the American Society of Mammalogists for the use of wild mammals in research. Journal of Mammalogy 92:235–253.

Timm, R. M., R. O. Baker, J. R. Bennett, and C. C. Coolahan. 2004. Coyote attacks: an increasing suburban problem. Transactions of the North American Wildlife and Natural Resources Conference 69:67-88.

Turner, F. B., P. A. Medica, and C. L. Lyons. 1984. Reproduction and survival of the desert tortoise (*Scaptochelys agassizii*) in Ivanpah Valley, California. Copeia 1984:811-820.

White, G. C., and R. A. Garrott. 1990. Analysis of wildlife radiotracking data. Academic Press, San Diego, California, USA.