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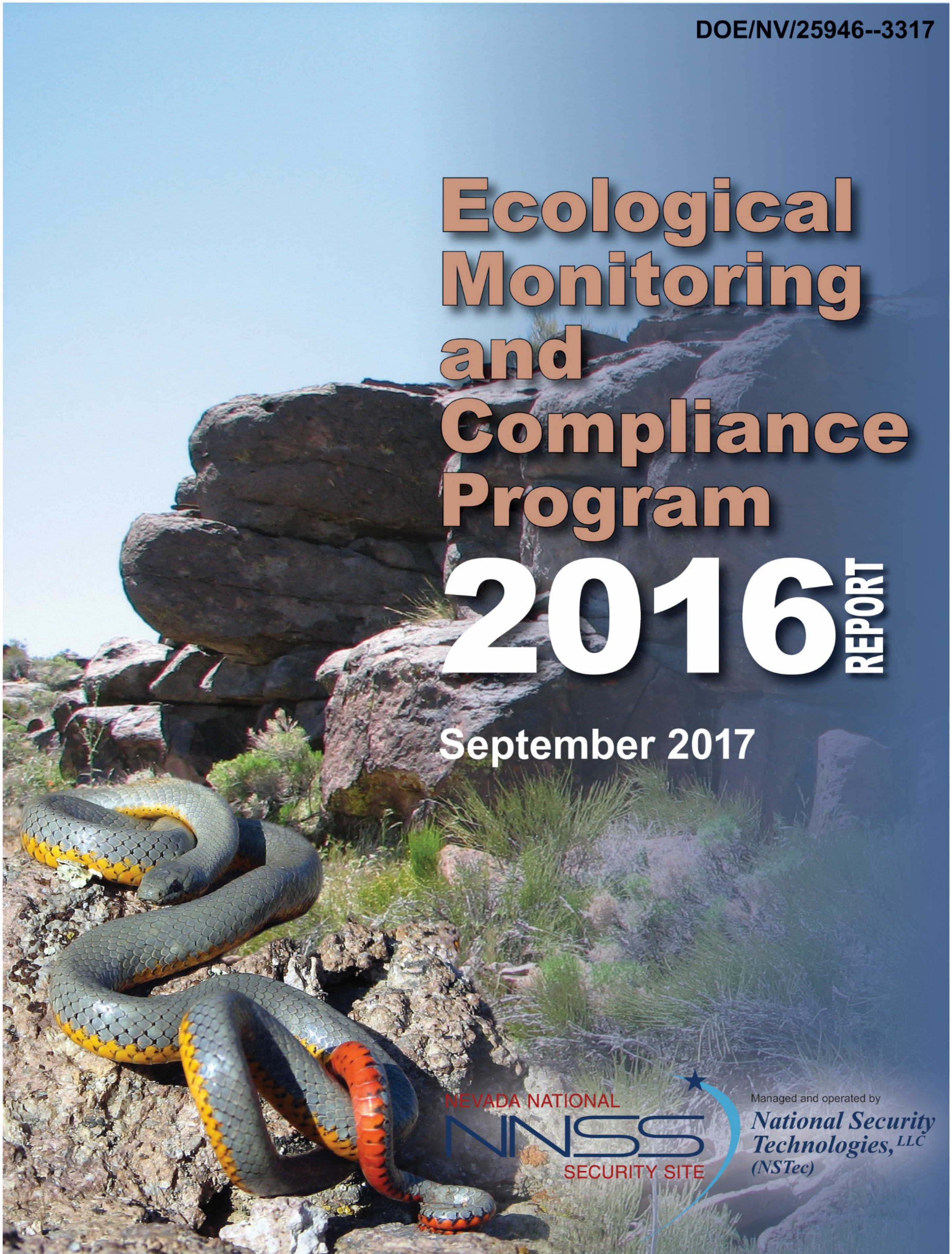
Ecological Monitoring and Compliance Program

2016 REPORT

September 2017



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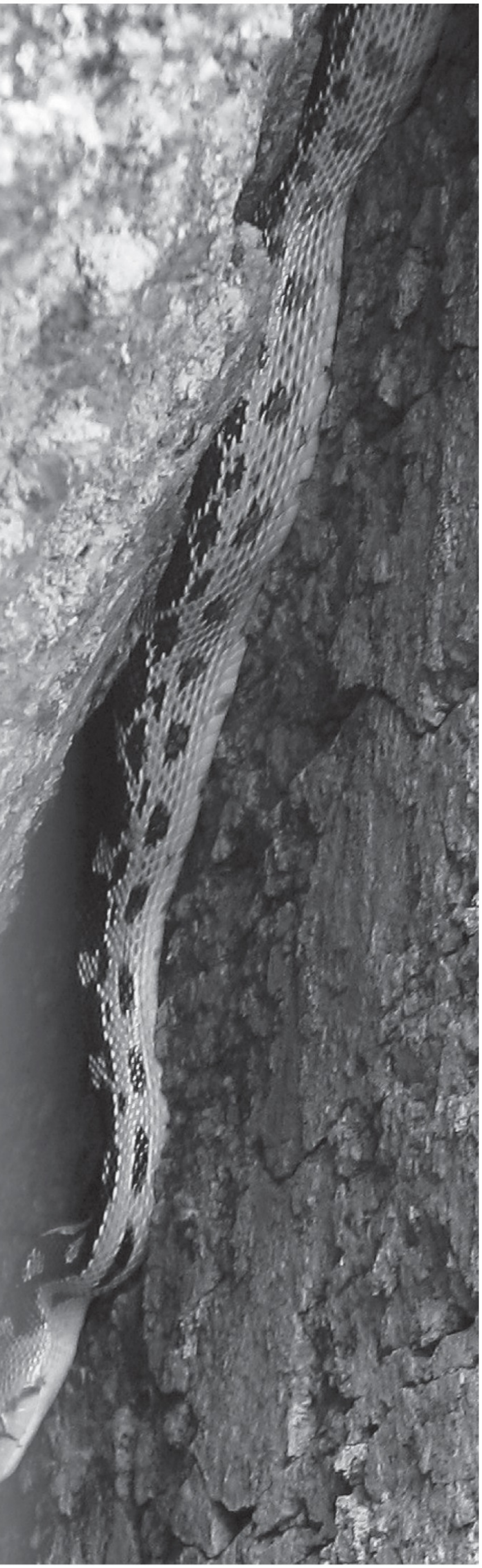
Derek B. Hall, W. Kent Ostler, and Jeanette A. Perry

September 2017



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EXECUTIVE SUMMARY

The Ecological Monitoring and Compliance Program (EMAC), funded through the U.S. Department of Energy, National Nuclear Security Administration Nevada Field Office (NNSA/NFO), monitors the ecosystem of the Nevada National Security Site (NNSS) and ensures compliance with laws and regulations pertaining to NNSS biota. This report summarizes the program's activities conducted by National Security Technologies, LLC (NSTec), during calendar year 2016. Program activities included (a) biological surveys at proposed activity sites, (b) desert tortoise compliance, (c) ecosystem monitoring, (d) sensitive plant species monitoring, (e) sensitive and protected/regulated animal monitoring, and (f) habitat restoration monitoring. During 2016, all applicable laws, regulations, and permit requirements were met, enabling EMAC to achieve its intended goals and objectives.

Sensitive and protected/regulated species of the NNSS include 42 plants, 1 mollusk, 2 reptiles, 237 birds, and 28 mammals. These species are protected, regulated, or considered sensitive according to state or federal regulations and natural resource agencies and organizations. The desert tortoise (*Gopherus agassizii*) and the western yellow-billed cuckoo (*Coccyzus americanus*) are the only species on the NNSS protected under the *Endangered Species Act*, both listed as threatened. However, only one record of the cuckoo has been documented on the NNSS, and there is no good habitat for this species on the NNSS. It is considered an extremely rare migrant. Biological surveys for the presence of sensitive and protected/regulated species and important biological resources on which they depend were conducted for 16 projects. A total of 156.96 hectares (ha) were surveyed for these projects. Sensitive and protected/regulated species and important biological resources found included 13 predator burrows, pronghorn antelope (*Antilocapra americana*), a desert cottontail rabbit (*Sylvilagus audubonii*), 5 red-tailed hawks (*Buteo jamaicensis*), a northern harrier (*Circus cyaneus*), several passerine species, Joshua trees (*Yucca brevifolia*), and 4 species of cacti. NSTec provided written summary reports to project managers of survey findings and mitigation recommendations, where applicable.

Eight of the 16 projects were within the range of the threatened desert tortoise, with two of these within the tortoise exclusion zone. Only one project disturbed pristine desert tortoise habitat (0.14 ha), and no tortoises were injured or killed by any project activities. One tortoise was accidentally killed by a vehicle. There were 36 sightings of desert tortoises on roads on the NNSS including one nearly two miles north of the northern boundary of their previously defined range. On 17 occasions, tortoises were moved off of the road and out of harm's way. Resident adult tortoises continued to be tracked to determine how much time they spent around roads or how many times they crossed roads. NSTec biologists continued to monitor 28 juvenile desert tortoises as part of a collaborative effort to study survival of translocated animals.

From 1978 until 2013, there has been an average of 11.2 wildland fires per year on the NNSS with an average of approximately 83.7 ha burned per fire. During 2016, two small fires (<0.4 ha) occurred on the NNSS in spite of a much higher than average fuel load. Rapid response by NNSS Fire and Rescue after fires were ignited was a key factor in minimizing wildland fire spread and severity.

Fourteen long-term vegetation-monitoring plots within the pinyon pine-big sagebrush (*Pinus monophylla-Artemisia tridentata*) vegetation type were sampled for plant cover, density, and species richness. These included two paired plots to compare burned versus unburned sites.

Wildlife use at 10 natural water sources, 1 well pond, 5 water troughs, and 3 radiologically contaminated sumps, was documented using motion-activated cameras. No field surveys for sensitive plants were conducted in 2016 on the NNSS. However, some new populations of sanicle biscuitroot (*Cymopterus ripleyi* var. *saniculoides*) and Clarke phacelia (*Phacelia filiae*) were found in the southern portion of Frenchman Flat while conducting other surveys.

Surveys of sensitive and protected/regulated animals during 2016 focused on birds, bats, feral horses (*Equus caballus*), mule deer (*Odocoileus hemionus*), desert bighorn sheep (*Ovis canadensis nelsoni*), and mountain lions (*Puma concolor*). Two golden eagles (*Aquila chrysaetos*) were observed during the winter raptor surveys. The red-tailed hawk (*Buteo jamaicensis*) was the most common species detected and raptor abundance and species richness was greater on the Yucca Flat route than on the Southern NNSS route.

Feral horse distribution was similar this year to last year with concentrated activity around Camp 17 Pond and Gold Meadows Spring especially during the hot, dry summer months. Mule deer abundance measured with standardized deer surveys increased this year but remains lower than the long-term average. Fifteen desert bighorn sheep were captured and thirteen of them were radiocollared for tracking purposes. Samples were taken to assess disease prevalence and relatedness to other southern Nevada populations.

A total of 70 mountain lion images (i.e., photographs or video clips) were taken during 218,849 camera hours at 9 of 28 sites sampled and another 10,840 images of at least 30 species other than mountain lions were documented. A minimum of five individual mountain lions (two radio-collared males [NNSS8 and NNSS9], one adult male, one adult female, and one subadult) were known to occur on the NNSS during 2016, compared to a minimum of three individuals in 2015 and four individuals in both 2014 and 2013. Two male mountain lions were captured in July and August and radio-collared for tracking purposes. Both lions were tracked through 2016. Results found five known kills for NNSS8 between August 10 and November 14, 2016. All kills were mule deer; three bucks, one doe, and one fawn. NNSS9 had 17 documented kills between August 3 and December 31, 2016 and one scavenged mule deer buck, which was a previous kill made by NNSS8. All 17 kills were mule deer; 11 bucks, 1 doe, and 5 fawns.

Additional information is presented about bird mortalities, *Migratory Bird Treaty Act* compliance, nuisance animals and their control, and increasing populations of feral burros (*Equus asinus*) and pronghorn antelope (*Antilocapra americana*).

Quantitative vegetation sampling was completed at four revegetated sites on the TTR; namely, CAU 400, Five Points Landfill; CAU 400, Bomblet Pit, CAU 404, Roller Coaster Lagoons and Trench, and CAU 407 Roller Coaster Radsafe Area. A visual assessment of the revegetated cover cap at CAU 110, U-3ax/bl was also conducted.

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ACRONYMS AND ABBREVIATIONS

α	statistical significance level
ARNO	*Artemisia nova* (black sagebrush) long-term monitoring plot
ARTR	*Artemisia tridentate* (big sagebrush) long-term monitoring plot
BECAMP	Basic Environmental Compliance and Monitoring Program
BYU	Brigham Young University
CAU	Corrective Action Unit
C	Celsius
cm	centimeter(s)
df	degrees of freedom
DOE	U.S. Department of Energy
DOE/NV	U.S. Department of Energy, Nevada Operations Office
EGIS	Ecological Geographic Information System
ELU	Ecological Landform Unit
EM	Environmental Monitor
EMAC	Ecological Monitoring and Compliance Program
FWS	U.S. Fish and Wildlife Service
g	gram(s)
GBS	Great Basin Skink
GIS	Geographic Information System
GPS	Global Positioning System
ha	hectare(s)
ICR	San Diego Zoo Institute for Conservation Research
kg	kilogram(s)
km	kilometer(s)
LANL	Los Alamos National Laboratory
m	meter(s)
m^2	square meter(s)
MBTA	Migratory Bird Treaty Act
MCL	midline carapace length
mm	millimeter(s)
mrem	millirem
n	Sample Size

NAC	Nevada Administrative Code
NAD	North American Datum
NDOW	Nevada Department of Wildlife
NNHP	Nevada Natural Heritage Program
NNPS	Nevada Native Plant Society
NNSA/NFO	U.S. Department of Energy, National Nuclear Security Administration Nevada Field Office
NNSS	Nevada National Security Site
NOAA	National Oceanic and Atmospheric Administration
NSTec	National Security Technologies, LLC
NTTR	Nevada Test and Training Range
p	probability
pCi/g	picocurie(s) per gram
pCi/L	picocuries per liter
PIMO-ARNO	*Pinus monophylla-Artemisia nova* (pinyon pine-black sagebrush) long-term monitoring plot
PIMO-ARTR	*Pinus monophylla-Artemisia tridentata* (pinyon pine-big sagebrush) long-term monitoring plot
r^2	regression coefficient
RWMC	Radioactive Waste Management Complex
sd	standard deviation
spp.	species
TCS	tortoise clearance survey
TTR	Tonopah Test Range
UGTA	Underground Test Area
USACE	U.S. Army Corps of Engineers
USGS	U.S. Geological Survey
UTM	Universal Transverse Mercator
VHF	very high frequency
WRTS	western red-tailed skink
χ^2	Chi-square statistic

1.0 INTRODUCTION

In accordance with U.S. Department of Energy (DOE) Order DOE O 231.1B, “Environment, Safety, and Health Reporting,” the Office of the Assistant Manager for Environmental Management of the U.S. Department of Energy, National Nuclear Security Administration Nevada Field Office (NNSA/NFO) requires ecological monitoring and biological compliance support for activities and programs conducted at the Nevada National Security Site (NNSS). National Security Technologies, LLC (NSTec), Ecological and Environmental Monitoring has implemented the Ecological Monitoring and Compliance Program (EMAC) to provide this support. EMAC is designed to ensure compliance with applicable laws and regulations, delineate and define NNSS ecosystems, and provide ecological information that can be used to predict and evaluate the potential impacts of proposed projects and programs on those ecosystems. During 2016, all applicable laws, regulations, and permit requirements were met, enabling EMAC to achieve its intended goals and objectives.

This report summarizes the EMAC activities conducted by NSTec during calendar year 2016. Monitoring tasks during 2016 included six program areas: (a) biological surveys, (b) desert tortoise compliance, (c) ecosystem monitoring, (d) sensitive plant monitoring, (e) sensitive and protected/regulated animal monitoring, and (f) habitat restoration monitoring. The following sections of this report describe work performed under these six areas.

2.0 BIOLOGICAL SURVEYS

Biological surveys are performed at project sites where land-disturbing activities are proposed. The goal is to minimize adverse effects of land disturbance on sensitive and protected/regulated plant and animal species (Table 2-1), their associated habitat, and other important biological resources. Sensitive species are defined as species that are at risk of extinction or serious decline or whose long-term viability has been identified as a concern. They include species on the Nevada Natural Heritage Program (NNHP) Animal and Plant At-Risk Tracking List (NNHP 2017) and bat species ranked as moderate or high in the Revised Nevada Bat Conservation Plan Bat Species Risk Assessment (Bradley et al. 2006). Protected/regulated species are those that are protected or regulated by federal or state law. Many species are both sensitive and protected/regulated (Table 2-1). Important biological resources include cover sites, nest or burrow sites, roost sites, or water sources important to sensitive species. Survey reports document species and resources found and provide mitigation recommendations.

2.1 SITES SURVEYED AND SENSITIVE AND PROTECTED/REGULATED SPECIES OBSERVED

During 2016, biological surveys for 16 projects were conducted on the NNSS (Figure 2-1 and Table 2-2). Scientists surveyed a total of 156.96 hectares (ha) for the projects (Table 2-2). The area surveyed included the project area and a buffer area typically extending 10 meters (m) beyond the project area. Eight projects were within the range of the threatened desert tortoise (*Gopherus agassizii*) (see Section 3.0), although two of these were in the tortoise exclusion zone (16-01 and 16-03). Sensitive and protected/regulated species and important biological resources found during the surveys included 13 predator burrows, pronghorn antelope (*Antilocapra americana*), a desert cottontail rabbit (*Sylvilagus audubonii*), 5 red-tailed hawks (*Buteo jamaicensis*), a northern harrier (*Circus cyaneus*), several passerine species, Joshua trees (*Yucca brevifolia*), and 4 species of cacti (Table 2-2). NSTec provided written summary reports to project managers of survey findings and mitigation recommendations, where applicable (Table 2-2).

2.2 POTENTIAL HABITAT DISTURBANCE

Surveys are conducted for all activities that would disturb habitat. These surveys are required whenever vegetation has re-colonized old disturbances and sensitive or protected/regulated species may occur in the area. For example, desert tortoises may move through revegetated earthen sumps and may be concealed under vegetation during activities where heavy equipment is used. Biological and tortoise clearance surveys are conducted to ensure that desert tortoises are not in harm's way. Burrowing owls frequently inhabit burrows, buried pipes with exposed openings and culverts at disturbed sites, so surveys are conducted to ensure that adults, eggs, and nestlings are not harmed.

Of the 16 projects surveyed, 7 were within sites previously disturbed (e.g., road shoulders, old building sites, utility corridors) (Table 2-2). Nine projects were located partially in previously disturbed areas. These projects could potentially disturb 21.02 ha of undisturbed land. During vegetation mapping of the NNSS (Ostler et al. 2000), Ecological Landform Units (ELUs) were evaluated for importance. Some ELUs were identified as *Pristine Habitat* (having few human-made disturbances), *Unique Habitat* (containing uncommon biological resources such as a natural wetland), *Sensitive Habitat* (containing vegetation associations that recover very slowly from direct disturbance or are susceptible to erosion), and *Diverse Habitat* (having high plant species diversity) (U.S. Department of Energy, Nevada Operations Office [DOE/NV] 1998). A single ELU could be classified as more than one type of these important habitats. Two projects occurred in areas designated as unique habitats (16-04 and 16-16 Figure 2-1,

Table 2-2), so the total area disturbed in hectares since 1999 comprises 9.46 (Pristine), 17.46 (Unique), 341.95 (Sensitive), and 87.05 (Diverse).

Table 2-1. List of sensitive and protected/regulated species known to occur on or adjacent to the NNSS.

Plant Species	Common Names	Status[a]
Moss Species		
Entosthodon planoconvexus	Planoconvex cordmoss	S, H
Flowering Plant Species		
Arctomecon merriamii	White bearpoppy	S, M
Astragalus beatleyae	Beatley's milkvetch	S, H
Astragalus funereus	Black woollypod	S, H
Astragalus oophorus var. *clokeyanus*	Clokey eggvetch	S, W
Camissonia megalantha	Cane Spring suncup	S, M
Cymopterus ripleyi var. *saniculoides*	Sanicle biscuitroot	S, M
Eriogonum concinnum	Darin buckwheat	S, M
Eriogonum heermannii var. *clokeyi*	Clokey buckwheat	S, W
Frasera pahutensis	Pahute green gentian	S, M
Galium hilendiae ssp. *kingstonense*	Kingston Mountains bedstraw	S, H
Hulsea vestita ssp. I*nyoensis*	Inyo hulsea	S, W
Ivesia arizonica var. *saxosa*	Rock purpusia	S, H
Penstemon fruticiformis ssp. *amargosae*	Death Valley beardtongue	S, H
Penstemon pahutensis	Pahute Mesa beardtongue	S, W
Phacelia beatleyae	Beatley scorpionflower	S, M
Phacelia filiae	Clarke phacelia	S, M
Phacelia mustelina	Weasel phacelia	S, Ma
Sclerocactus polyancistrus	Redspined fishhook cactus	S, CY, Ma
Agavaceae	Yucca (3 species), Agave (1 species)	CY
Cactaceae	Cacti (17 species)	CY
Juniperus osteosperma	Juniper	CY
Pinus monophylla	Pinyon	CY

Table 2-1. List of sensitive and protected/regulated species known to occur on or adjacent to the NNSS (continued).

Animal Species	Common Name	Status[a]
Mollusk Species		
Pyrgulopsis turbatrix	Southeast Nevada pyrg	S, A
Reptile Species		
Plestiodon gilberti rubricaudatus	Western red-tailed skink	S, IA
Gopherus agassizii	Desert tortoise	LT, S, NPT, A
Bird Species[b]		
Accipiter gentilis	Northern goshawk	S, NPS, A
Alectoris chukar	Chukar	G, IA
Aquila chrysaetos	Golden eagle	EA, NP, A
Buteo regalis	Ferruginous hawk	S, NP, A
Callipepla gambelii	Gambel's quail	G, IA
Coccyzus americanus	Western yellow-billed cuckoo	LT, S, NPS, IA
Corvus brachyrhynchos	American crow	G, IA
Falco peregrinus	Peregrine falcon	S, NPE, A
Haliaeetus leucocephalus	Bald eagle	EA, S, NPE, A
Ixobrychus exillis hesperis	Western least bittern	S, NP, IA
Lanius ludovicianus	Loggerhead shrike	NPS, A
Oreoscoptes montanus	Sage thrasher	NPS, IA
Phainopepla nitens	Phainopepla	S, NP, IA
Spizella breweri	Brewer's sparrow	NPS, IA
Toxostoma bendirei	Bendire's thrasher	S, NP, IA
Toxostoma lecontei	LeConte's thrasher	S, NP, IA
Mammal Species		
Antilocapra americana	Pronghorn antelope	G, A
Antrozous pallidus	Pallid bat	M, NP, A
Cervus elaphus	Rocky Mountain elk	G, IA
Corynorhinus townsendii	Townsend's big-eared bat	S, H, NPS, A
Equus asinus	Burro	H&B, A
Equus caballus	Horse	H&B, A
Euderma maculatum	Spotted bat	S, M, NPT, A

Table 2-1. List of sensitive and protected/regulated species known to occur on or adjacent to the NNSS (continued).

Animal Species	Common Name	Status[a]
Lasionycteris noctivagans	Silver-haired bat	M, A
Lasiurus blossevillii	Western red bat	S, H, NPS, A
Lasiurus cinereus	Hoary bat	M, A
Lynx rufus	Bobcat	F, IA
Microdipodops megacephalus	Dark kangaroo mouse	NP, A
Microdipodops pallidus	Pale kangaroo mouse	S, NP, A
Myotis californicus	California myotis	M, A
Myotis ciliolabrum	Small-footed myotis	M, A
Myotis evotis	Long-eared myotis	M, A
Myotis thysanodes	Fringed myotis	S, H, NP, A
Myotis yumanensis	Yuma myotis	M, A
Ovis canadensis nelsoni	Desert bighorn sheep	G, A
Odocoileus hemionus	Mule deer	G, A
Parastrellus hesperus	Canyon bat	M, A
Puma concolor	Mountain lion	G, A
Sorex tenellus	Inyo shrew	S, IA
Sylvilagus audubonii	Audubon's cottontail	G, IA
Sylvilagus nuttallii	Nuttall's cottontail	G, IA
Tadarida brasiliensis	Brazilian free-tailed bat	NP, A
Urocyon cinereoargenteus	Gray fox	F, IA
Vulpes macrotis	Kit fox	F, IA

[a] **Status Codes for Column 3**

Endangered Species Act, U.S. Fish and Wildlife Service

LT	Listed Threatened
C	Candidate for listing

U.S. Department of Interior

H&B	Protected under *Wild Free Roaming Horses and Burros Act*
EA	Protected under *Bald and Golden Eagle Act*

State of Nevada – Animals

S	Nevada Natural Heritage Program – Animal and Plant At-Risk Tracking List
NPE	Nevada Protected-Endangered, species protected under Nevada Administrative Code (NAC) 503

Table 2-1. List of sensitive and protected/regulated species known to occur on or adjacent to the NNSS (continued).

NPT	Nevada Protected-Threatened, species protected under NAC 503
NPS	Nevada Protected-Sensitive, species protected under NAC 503
NP	Nevada Protected, species protected under NAC 503
G	Regulated as game species under NAC 503
F	Regulated as fur bearer species under NAC 503
State of Nevada – Plants	
S	Nevada Natural Heritage Program (NNHP) – Animal and Plant At-Risk Tracking List
CY	Protected as a cactus, yucca, or Christmas tree from unauthorized collection on public lands
NNSS Sensitive Plant Ranking	
H	High
M	Moderate
W	Watch
Ma	Marginal
Long-term Animal Monitoring Status for the NNSS	
A	Active
IA	Inactive
The Revised Nevada Bat Conservation Plan – Bat Species Risk Assessment	
H	High
M	Moderate

[b] All bird species on the NNSS are protected by the *Migratory Bird Treaty Act* except for chukar, Gambel's quail, English house sparrow (*Passer domesticus*), Rock dove (*Columba livia*), Eurasian collared dove (*Streptopelia decaocto*) and European starling (*Sturnus vulgaris*).

Sources used: NNHP 2017, Nevada Native Plant Society (NNPS) 2017, NAC 2017, U.S. Fish and Wildlife Service (FWS) 2017, Bradley et al. 2006

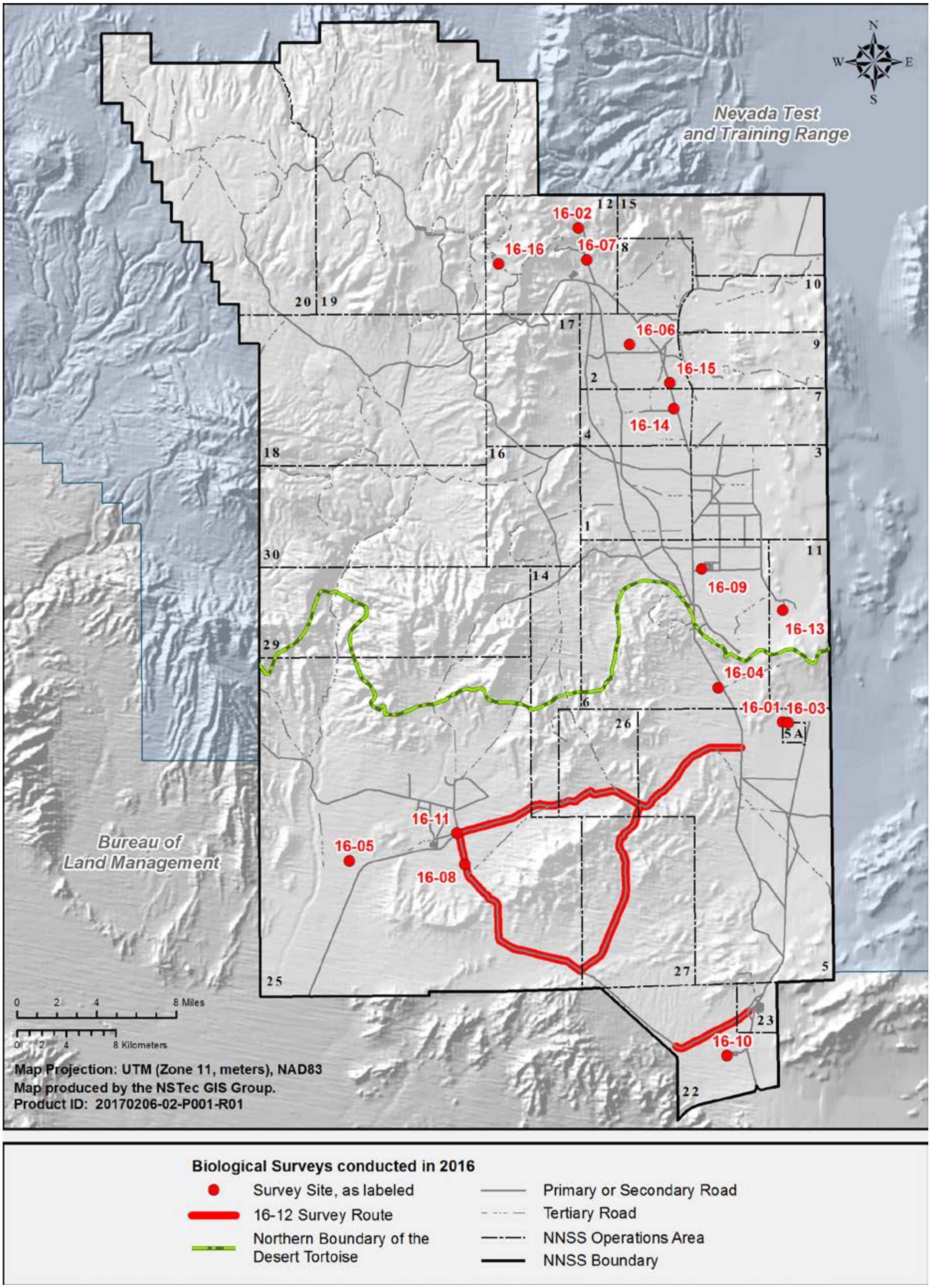

Figure 2-1. Biological surveys conducted on the NNSS during 2016.

Table 2-2. Summary of biological surveys conducted on the NNSS during 2016.

Project No.	Project	Important Species/Resources Found	Area Surveyed (ha)	Proposed Project Area in Undisturbed Habitat (ha)	Mitigation Recommendations
16-01	RWMC Expansion Area	2 predator burrows	0.93	0.46	Avoid burrows; Tortoise exclusion area
16-02	P Tunnel Modification	None	2.00	0	None
16-03	RWMC Pad	2 predator burrows	2.38	1.38	Avoid burrows; Tortoise exclusion area
16-04	RNCTEC New Pad	Joshua trees	0.33	0.14	TCS[a] required, EM[b] needed; avoid trees if possible
16-05	Area 25, Water Line Repair	Antelope buck, 1 predator burrow	0.04	0	TCS[a] required, EM[b] needed; avoid burrow
16-06	LLNL Field Experiment	2 predator burrows	24.97	1.77	Avoid burrows
16-07	Project 12-930	None	0.97	0	None
16-08	Area 25, Bury Phone Lines	None	0.07	0	TCS[a] required, EM[b] needed
16-09	Performance Optimized Data Center	None	7.14	0.23	None
16-10	Desert Rock Pole Replacement	Dead red-tailed hawk; Joshua tree, beavertail pricklypear, hedgehog cactus	0.30	0	TCS[a] required, EM[b] needed
16-11	Four Corners Water Line Repair	None	0.04	0	TCS[a] required, EM[b] needed
16-12	Road Edge Mowing	6 predator burrows	74.00	0	TCS[a] required, EM[b] needed; avoid burrows

Table 2-2. Summary of biological surveys conducted on the NNSS during 2016 (continued).

16-13	Neutron Source Pulsed Diagnostic	Desert cottontail, 4 red-tailed hawks, passerines, Joshua trees, Wiggins' cholla, cottontop cactus	29.7	15.0	Avoid Joshua trees and cacti if possible
16-14	DAG BEEF Trailer Park	Passerines	2.70	0.15	None
16-15	DAG Test Pad	Antelope tracks, northern harrier, passerines	10.9	2.88	None
16-16	DOE Point Intersection Expansion	None	0.49	0.01	None
		Total ha	**156.96**	**21.02**	

[a]TCS – Tortoise Clearance Survey; [b]EM – Environmental Monitor

3.0 DESERT TORTOISE COMPLIANCE

Desert tortoises occur within the southern one-third of the NNSS. This species is listed as threatened under the *Endangered Species Act*. In December 1995, NNSA/NFO completed consultation with the U.S. Fish and Wildlife Service (FWS) concerning the effects of NNSA/NFO activities, as described in the *Final Environmental Impact Statement for the Nevada Test Site and Off-Site Locations in the State of Nevada* (DOE/NV 1996), on the desert tortoise. NNSA/NFO received a final Biological Opinion (Opinion) from the FWS in August 1996 (FWS 1996). On July 2, 2008, NNSA/NFO provided the FWS with a Biological Assessment of anticipated activities on the NNSS for the next 10 years and entered into formal consultation with the FWS to obtain a new Opinion for the NNSS. NNSA/NFO received the final Opinion on February 12, 2009 (FWS 2009). This Opinion covers the anticipated activities at the NNSS until 2019.

The Desert Tortoise Compliance task of EMAC implements the terms and conditions of the 2009 Opinion, documents compliance actions taken by NNSA/NFO, and assists NNSA/NFO in FWS consultations. All terms and conditions listed in the Opinion were implemented by NSTec staff biologists in 2016, including (a) conducting 100% coverage tortoise clearance surveys (TCS) at project sites within 24 hours from the start of project construction, (b) ensuring that project managers have an environmental monitor (EM) on site during site clearing and heavy equipment operation, (c) developing effects analysis for proposed disturbances to append to the Opinion, and (d) preparing an annual compliance report for NNSA/NFO submittal to the FWS.

3.1 PROJECT SURVEYS AND COMPLIANCE DOCUMENTATION

During 2016, biologists conducted TCSs just prior to ground disturbing activities for six proposed projects within the range of the desert tortoise on the NNSS (Table 3-1, Figure 3-1). TCSs for two projects (16-01 and 16-03) were not done because they were located in the tortoise exclusion area (an area in Frenchman Flat with no tortoises and exempted from TCS requirements per the Opinion). All of the projects were in, or immediately adjacent to, roads, existing facilities, or other disturbances. No desert tortoises were observed in project areas.

Table 3-1. Summary of biological surveys conducted in desert tortoise habitat on the NNSS during 2016.

Project Number	Project	Compliance Activities 100% Coverage Clearance Survey	Tortoise Habitat Disturbed (Ha)
16-04	RNCTEC New Pad	Yes, post-activity survey completed	0.14
16-05	Area 25 Water Line Repair	Yes, post-activity survey completed	0
16-08	Area 25, Bury Phone Lines	Yes, post-activity survey completed	0
16-10	Desert Rock Pole Replacement	Yes, post-activity survey completed	0
16-11	Four Corners Water Line Repair	Yes, post-activity survey completed	0
16-12	Road Edge Mowing	Yes, post-activity survey completed	0
		TOTAL	0.14

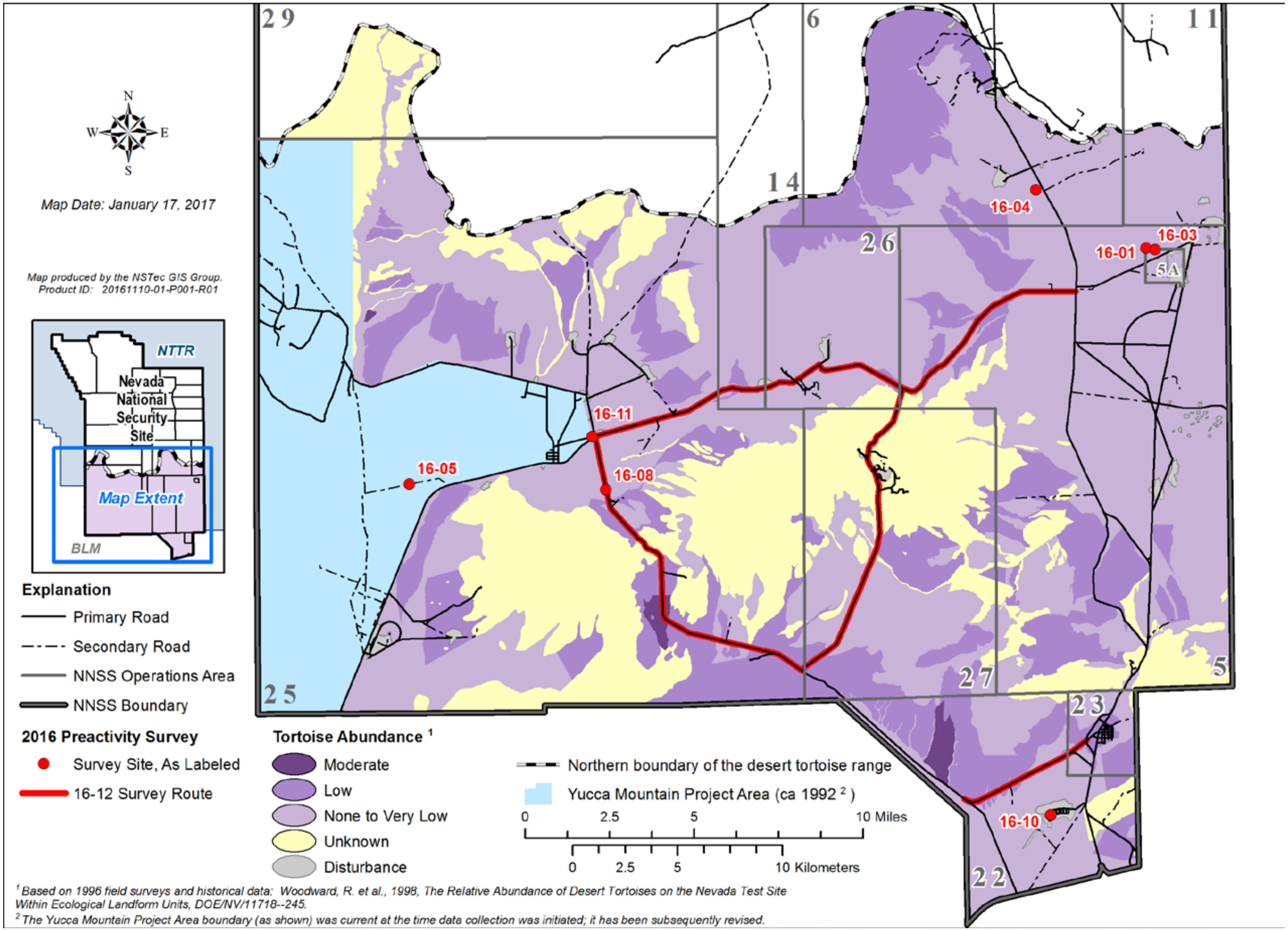

Figure 3-1. Biological surveys conducted in desert tortoise habitat on the NNSS during 2016.

One project (16-04) disturbed 0.14 ha of pristine desert tortoise habitat. Post-activity surveys to quantify the acreage of tortoise habitat actually disturbed were conducted for six projects during this reporting period (Table 3-1). All projects stayed within proposed project boundaries.

In January 2016, the annual report summarizing tortoise compliance activities conducted on the NNSS from January 1 through December 31, 2015, was submitted to the FWS. This report, required under the Opinion, contains (a) the location and size of land disturbances that occurred within the range of the desert tortoise during the reporting period; (b) the number of desert tortoises injured, killed, or removed from project sites; (c) a map showing the location of all tortoises sighted on or near roads on the NNSS; and (d) a summary of construction mitigation and monitoring efforts.

Compliance with the Opinion ensures the desert tortoise is protected on the NNSS and the cumulative impacts on this species are minimized (DOE/NV 1998). In the Opinion, the FWS determined the "incidental take" ("take" means to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect, or to attempt to engage in any such conduct, and "incidental take" is a take that results from activities that are otherwise lawful) of tortoises on the NNSS and the cumulative acreage of tortoise habitat disturbed on the NNSS are parameters that should be measured and monitored annually. During this calendar year, the threshold levels established by the FWS for these parameters were not exceeded (Table 3-2). No desert tortoises were injured or killed by project activities, however, one tortoise was accidentally killed by a vehicle on Mercury Highway just north of the intersection with US 95 (Figure 3-2). There were 36 sightings of desert tortoises on roads on the NNSS during 2016 (Figure 3-2) including one nearly two miles north of the northern boundary of their previously defined range. On 17 occasions, tortoises were moved off of the road and out of harm's way. The 17 tortoises that were moved from roads bring the total take for Roads in the "Other" category to 112 from 2009 to 2016. The cumulative take of tortoises killed or injured on NNSS roads is 10 from 2009 to 2016 (Table 3-2).

Table 3-2. Cumulative incidental take (2009–2016) and maximum allowed take for NNSA/NFO programs.

Program	**Number of Hectares Impacted** (maximum allowed)	**Number of Tortoises Anticipated to be Incidentally Taken (maximum allowed)**	
		Killed/Injured	**Other**
Defense	2.27 (202)	0 (1)	0 (10)
Waste Management	0 (40)	0 (1)	0 (2)
Environmental Restoration	0 (4)	0 (1)	0 (2)
Non-Defense R&D	0 (607)	0 (2)	0 (35)
Work for Others	13.29* (202)	0 (1)	0 (10)
Infrastructure Development	3.41 (40)	0 (1)	0 (10)
Roads	0 (0)	10 (15)	112 (125)
Totals	**18.97 (1,095)**	**10 (22)**	**112 (194)**

*Project is not yet completed but is anticipated to disturb 42.2 hectares over the life of the project. The actual amount disturbed will be reported in each annual report.

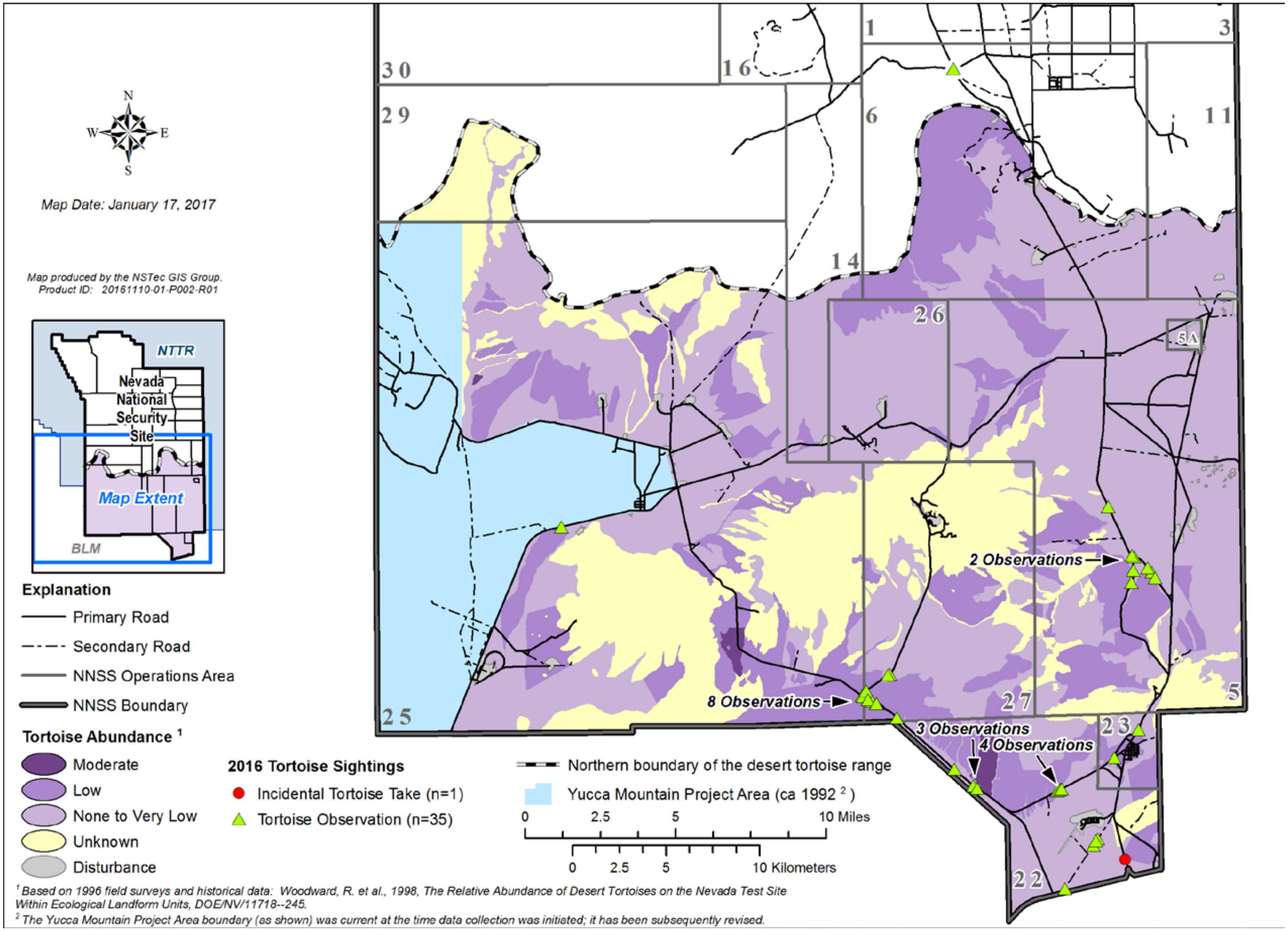

Figure 3-2. Location of tortoise roadside observations and mortalities during 2016.

3.1.1 Mitigation for Loss of Tortoise Habitat

Mitigation for the loss of tortoise habitat is required under Term and Condition 3c of the Opinion. This term and condition as amended in November 2013, requires NNSA/NFO to perform one of three mitigation options: (a) prepay funds into the Desert Tortoise Mitigation Fund for projects under the Work-for-Others Program, (b) apply the accrued costs to implement FWS-approved conservation studies on the NNSS as earned mitigation for the future loss of tortoise habitat by non-Work-for-Others projects, or c) prepay mitigation funds into the Desert Tortoise Mitigation Fund, then revegetate disturbed habitat following specified criteria; once the revegetation is successful, the money paid for mitigation will be refunded. The project (16-04) that disturbed 0.14 ha was part of the Radiological/Nuclear Countermeasures Test and Evaluation Complex (RNCTEC) expansion for which mitigation fees were prepaid in 2011 under "Work for Others" (Table 3-2).

3.2 CONSERVATION RECOMMENDATION STUDIES

Two desert tortoise projects have been approved by the FWS and are being implemented by NSTec biologists. The following is a synopsis of activities conducted for each of these projects since 2012. One of the conservation recommendations of the Opinion (FWS 2009) states that NNSA/NFO:

> ***should develop a strategy to minimize road mortalities on the NNSS by focusing efforts on roads that have a history of mortality or that traverse higher density desert tortoise areas*** *(page 29 of the Opinion)****.***

In order to address this conservation recommendation, results from prior desert tortoise surveys and historical roadside observation/mortality data were analyzed using a Geographic Information System (GIS) to identify areas with higher densities of desert tortoises and areas that may be at higher risk for tortoise mortalities caused by vehicles along NNSS roads. This analysis suggested the need for a better understanding of desert tortoise activity near roads with high desert tortoise use and the effects of the zone of depression (up to 0.4 kilometers [km] from road edges) on tortoise abundance (Boarman and Sazaki 2006) in order to better develop the strategy to minimize road mortalities.

Desert tortoises may be drawn to roads to forage and drink, especially after summer rains when water collects in depressions on or along roads, thus creating a short-term source of drinking water that may be critical to their survival. Further, roadside vegetation is typically more succulent than non-roadside vegetation due to a water-harvesting effect and stimulated plant growth from roadside maintenance activities such as mowing or blading. In addition, while some efforts to model desert tortoise habitat in the Mojave Desert have been made (Weinstein 1989, Andersen et al. 2000, Nussear et al. 2009), knowledge about fine-scale patterns of habitat use is still lacking.

3.3 DESERT TORTOISE ROAD STUDY

A desert tortoise road study was initiated in May 2012. The main objectives of this study are to (a) assess the risk of desert tortoise road mortality on the NNSS and (b) determine fine-scale patterns of habitat use of desert tortoises found near roads on the NNSS. An ancillary objective is to assess the health and condition of desert tortoises on the northern periphery of their range.

In 2012, 11 resident adult desert tortoises (4 males and 7 females) were found (Table 3-3, Figure 3-3) during the tortoise activity period (March through October) and fitted with very high frequency (VHF) transmitters and Global Positioning System (GPS) data loggers (Advanced Telemetry Systems, Model G30L) (Figure 3-4). During 2013, an additional seven desert tortoises (five males and two females) were captured (Table 3-3, Figure 3-3) and affixed with transmitters and data loggers. All 18 desert tortoises were monitored via radio telemetry through 2013 except GOAG 13, which was found dead on June 26, 2013,

Table 3-3. Desert tortoise capture information for the NNSS road mitigation project (MCL = midline carapace length in millimeters [mm]; g = grams).

Tortoise ID	Capture Date	Capture Time	Body Condition Score	Bladder Voided	VHF Transmitter Frequency	Sex	Weight (g)	Size MCL (mm)
GOAG 1	5/10/2012	1110	4	No	162.215	F	4270	285
GOAG 2	5/15/2012	0900	6	No	162.187	F	2570	233
GOAG 3	5/17/2012	0945	5	Yes	162.511	M	4500	288
GOAG 4	5/24/2012	1100	4	No	162.472	F	2870	257
GOAG 5	5/29/2012	1100	4	No	162.692	F	2312	243
GOAG 6	6/01/2012	0645	5	No	162.231	M	2140	227
GOAG 7	6/11/2012	1055	5	No	162.805	F	2450	238
GOAG 8	6/13/2012	1000	4	No	162.551	F	3050	258
GOAG 9	6/26/2012	0825	4	No	162.787	F	2520	251
GOAG10	7/12/2012	0922	5	No	162.431	M	2300	230
GOAG11	9/27/2012	1220	5	No	162.131	M	3350	257
GOAG12	4/30/2013	0900	4	No	162.263	F	3940	277
GOAG13	5/14/2013	0815	3.5	Yes	162.071	M	1800	206
GOAG14	6/12/2013	0905	4	No	162.001	F	1762	214
GOAG15	8/14/2013	1000	4.5	No	162.861	M	4000	280
GOAG16	9/04/2013	1000	4	No	162.971	M	5520	307
GOAG17	9/05/2013	0740	4	No	162.071	M	4180	282
GOAG18	9/11/2013	1256	4	No	162.497	M	3982	277
GOAG19	5/14/2014	1245	4	No	161.612	F	2400	253
GOAG20	6/11/2014	0720	3.5	No	161.668	U	950	180
GOAG21	7/01/2014	0818	5	No	162.620	M	4112	306
GOAG22	8/27/2014	0950	5	No	162.347	M	1605	215
GOAG23	9/08/2014	1500	4.5	No	161.552	M	3720	258
GOAG24	10/09/2014	1400	5	No	161.669	M	4100	268
GOAG25	3/24/2015	1540	5	Yes	161.717	M	2480	241
GOAG26	5/04/2015	0950	4	No	162.431	F	1562	212
GOAG27	5/26/2015	1045	5	No	162.724	M	2762	250

Table 3-3. Desert tortoise capture information for the NNSS road mitigation project (MCL = midline carapace length in millimeters [mm]; g = grams) (continued).

Tortoise ID	Capture Date	Capture Time	Body Condition Score	Bladder Voided	VHF Transmitter Frequency	Sex	Weight (g)	Size MCL (mm)
GOAG28	7/21/2015	0900	4.5	No	162.591	M	1462	215
GOAG29	7/21/2015	1415	5	Yes	162.992	F	2700	255
GOAG30	10/07/2015	1545	4	No	162.187	M	4150	279

after being captured on May 14, 2013. It had been either killed or scavenged by a coyote or bobcat. Only 15 of the remaining 17 tortoises were monitored with the GPS data loggers due to the limited number of data loggers available.

During 2014, an additional six tortoises (four males, one female, and one unknown sex) were captured and affixed with transmitters and data loggers (Table 3-3, Figure 3-3). Four of these were captured opportunistically as a result of reports of desert tortoises spotted along roads by workers. One of the males (GOAG 24) was radio-tagged when it was found interacting with a tagged female tortoise. Two of the tortoises were considerably smaller than the other tortoises in the study, and they received a smaller/lighter GPS transmitter (I-gotU), which scientists from the United States Geological Survey (USGS) had recommended. During 2014, 23 radio-tagged tortoises were located by biologists approximately once per week during the active period (March through October) and once per month during the inactive period (November through February). One tortoise (GOAG 8) died in 2014. It was found flipped over on a hillslope and assumed unable to right itself. Health assessments were conducted in September 2014 by biologists from the San Diego Zoo's Institute for Conservation Research (ICR) and NSTec for all tortoises that were accessible. All tortoises assessed were in good condition despite the long drought period from winter to summer in 2014.

Six desert tortoises (four males, two females) were captured and affixed with VHF transmitters and GPS data loggers during 2015, making a total of 30 tortoises captured and marked for the road study (Table 3-3, Figure 3-3). Health assessments on all living tortoises (n=27) were conducted during fall 2015 by NSTec and ICR biologists. All tortoises assessed were in good condition most likely due to the summer thunderstorms and late season germination of annuals and re-growth of perennials and shrubs. Detailed health assessment data will be reported when the project is completed. Oral, cloacal, and chin/forelimb swabs were taken for chemical analyses to investigate potential chemical signatures between females and males. A third tortoise in the study (GOAG29) was killed in 2015 most likely by a coyote since tracks and scat were observed at the kill location. This tortoise was missing the head and a couple of arms but the shell was generally intact. This tortoise had only been tracked for less than two months.

In 2015, a total of 28 tortoises were tracked via radio telemetry by biologists once per week during the active season and at least once per month during the inactive period. Because of the late summer rainfall, the germination of annuals and regrowth of many perennials and shrubs, and the warmer than usual temperatures during October and November, several of the tortoises remained active in November. These tortoises were monitored weekly or every other week until settling into their winter burrows in mid to late November. Transmitters were removed from seven tortoises in the fall because sufficient data had been collected for these individuals. A paper identification tag with the tortoise number was glued to the shell of each tortoise in the event it is encountered in the future.

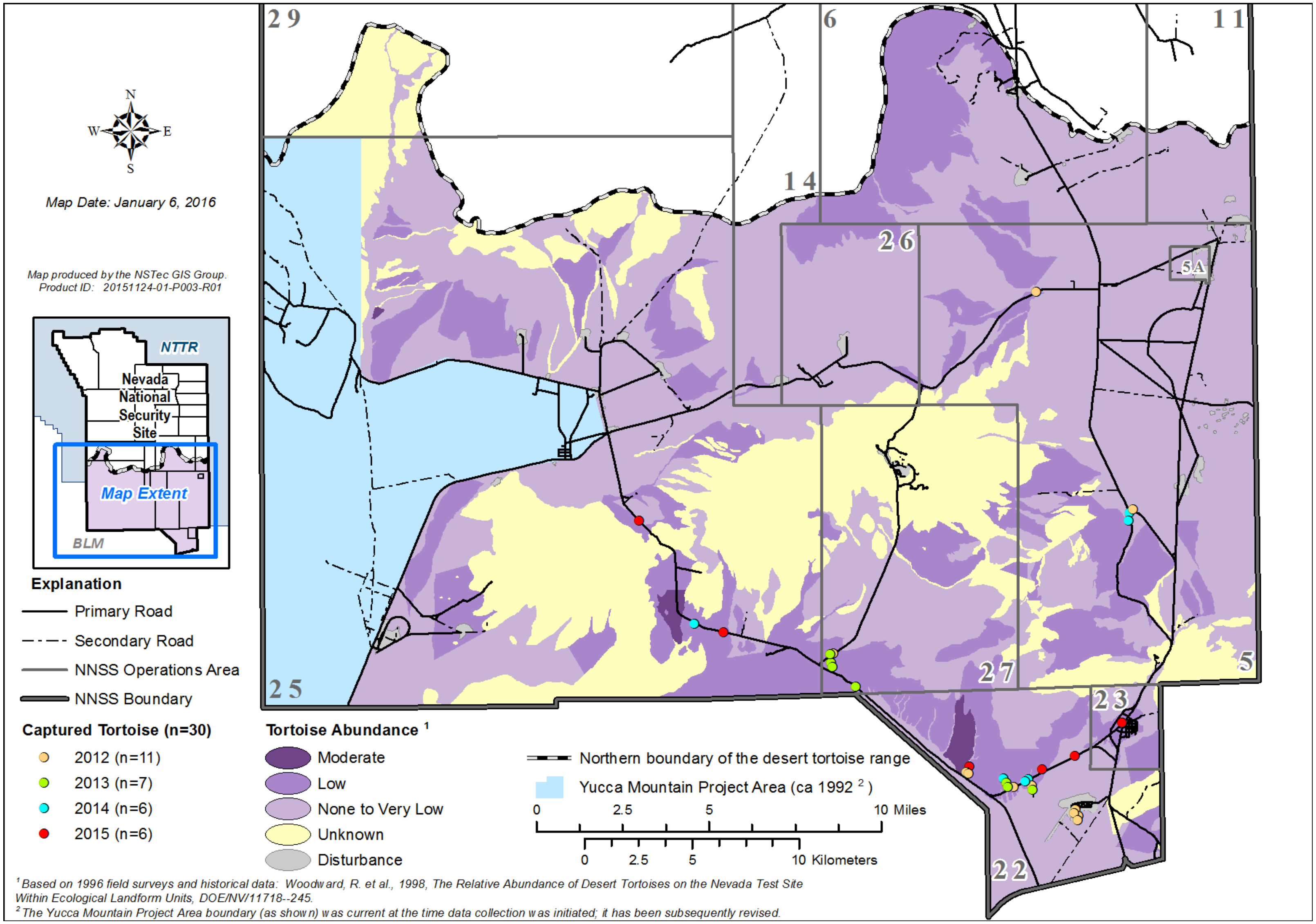

Figure 3-3. **Tortoise capture locations 2012 (tan), 2013 (green), 2014 (blue), and 2015 (red) at the NNSS.**

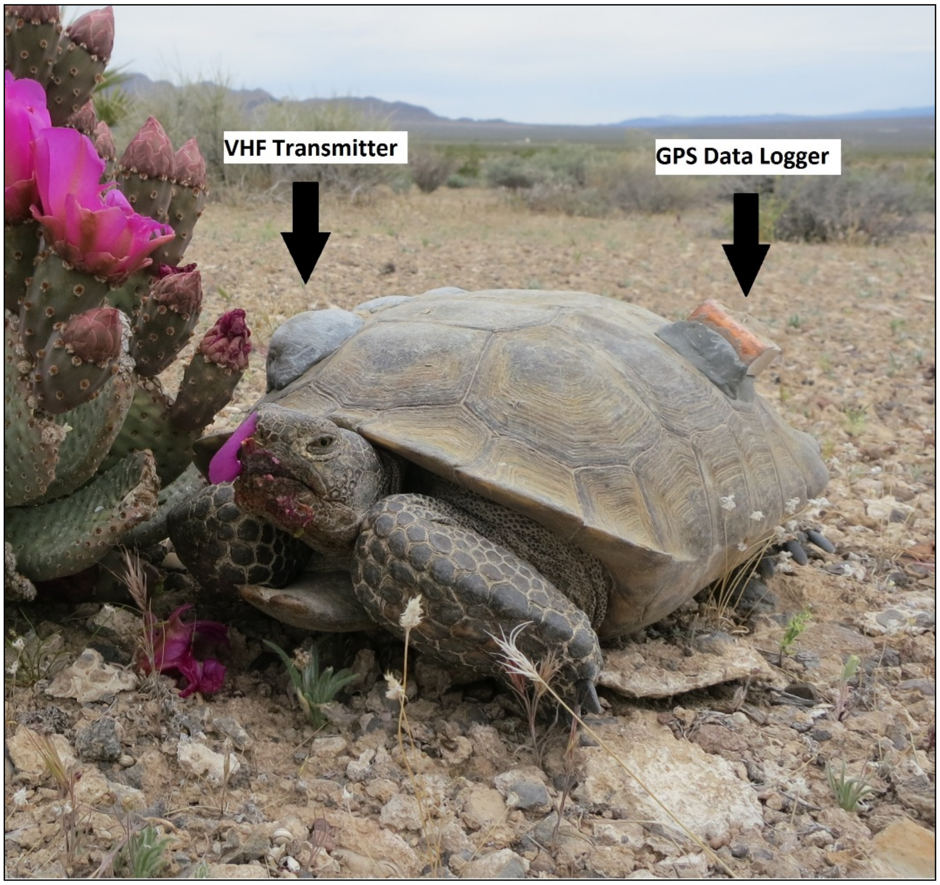

Figure 3-4. Adult tortoise (GOAG15) with a VHF transmitter (left) and GPS data logger (right) affixed to its shell.

(Photo by J. Perry, April 17, 2017)

During 2016, 20 adult tortoises were tracked via radio telemetry once per week March through October and at least once per month during November through February. When a tortoise was found, biologists recorded where it was found (e.g., in a burrow, in the open, under vegetation). During 2016, tortoises were found a total of 441 times or 59.3% of the time in burrows. This is a little less than what was found during a three-year study at Yucca Mountain that found tortoises in burrows 65% of the time (CRWMS 1997). Adult tortoises were found 174 times or 23.4% of the time in the open and 129 times or 17.3% of the time under vegetation. A total of 15 different plant species were used as cover by tortoises and 8 observations were under mixed shrub species clumps. Creosotebush (*Larrea tridentata*) and blackbrush (*Coleogyne ramosissima*) were the two plant species most commonly used as cover by tortoises. Marked tortoises were found on paved roads twice.

During the fall of 2016, transmitters were removed from seven tortoises. A paper identification tag with the tortoise number was glued to the shell of each tortoise in the event it is encountered in the future. In 2017, monitoring will continue on the 13 tortoises remaining in the study.

The current Biological Opinion for this study allows only 30 individuals to be “taken,” i.e. captured, handled, and monitored. The processing and analysis of data from the GPS data loggers affixed to the tortoises is ongoing. The goal is to have a minimum of two years of data for each tortoise for the analysis. Additional data will be collected if the tortoises are crossing roads routinely. When the data is fully processed and summarized, it will be provided to the FWS.

3.3.1 Juvenile Translocation Study

In September 2012, 60 captive juvenile tortoises were translocated from the Desert Tortoise Conservation Center in Las Vegas to the southern edge of the NNSS in Area 22 to evaluate the survival of juvenile tortoises released in the wild. The NNSS provides one of the largest protected habitat areas in southern Nevada. The project is part of a long-term collaborative effort involving the FWS, NSTec, and ICR. Few studies have investigated translocated, juvenile tortoise survival, so data obtained from this study will be valuable to assess translocation as a possible means of recovery of the tortoise.

Each tortoise was affixed with a VHF transmitter prior to release for post-release monitoring purposes. Regular monitoring of the animals occurred post-release from 2012 through 2016. During 2016, the monitoring schedule was as follows: once in January, twice in February, weekly March through October (except week of August 15), twice in November, and once in December. Tortoises were also monitored in mid-January 2017. In early 2016, the survival rate of the translocated juvenile tortoises was at 45% with 27 out of 60 tortoises observed alive. Although this survival rate continued through early 2017, there was one death in 2016 which was offset by a missing tortoise being located and re-added to the study. A tortoise (4039) that went missing in April 2013 was found in June 2016 with a failed VHF transmitter affixed to its shell. The transmitter was updated and the animal was added back into the study. Female tortoise 4009 was presumed dead in 2016 due to predation when its transmitter was found in September showing evidence of bite marks. No evidence of the remains of the animal were found. Thus, 28 individual tortoises were monitored during 2016 (Table 3-4). Figure 3-5 shows the release locations for all 60 translocated juveniles, the winter burrows for the surviving 27 tortoises, and the location of the transmitter found without a carcass of 4009. All transmitters were changed out in the fall and health assessments were completed on all 27 tortoises.

After 52 months post-release, 27 of the 60 juveniles are still alive (45% survival). This is slightly lower but similar to an estimated 50% survival (30 of 60 tortoises alive) based on an annual survival rate of 0.85 that Turner et al. (1987) calculated in a natural population (Roy Averill-Murray, FWS, personal communication, February 7, 2017). There is a much higher survival rate for males (63% [19 of 30]) compared to females (28% [8 of 29]) with most of the mortalities suspected as coyote and kit fox predations. Given the importance of females surviving to adulthood to reproduce, this may be a critical life stage for females, and if female juveniles are not making it to sexual maturity, this could lead to a decline in tortoise populations. The ratio of female to male adults captured in the wild for the road study is 12 females (40%) and 17 males (57%) with 1 of unknown gender (3%). Whether this is a result of differential mortality between sexes or an artifact of our opportunistic capture methodology is unknown. In contrast, a study by Turner et al. (1984) in Ivanpah Valley, CA showed a sex ratio of nearly 1:1. The ratio of females to males for adults and particularly juveniles as well as differential mortality between the sexes warrants further study in wild tortoise populations.

Table 3-4 contains information about the 28 juvenile tortoises monitored during 2016. On average, the distance between the release location and winter 2016-2017 burrow (i.e., the burrow a juvenile was in during the first part of January 2017) was 682 m (range 67–6,318 m; standard deviation [sd] 1,235 m). Nearly 75% (19 of 26) of tortoises wintered in burrows within 100 m of their last year's winter burrow with 15% (4 of 26) using the same winter burrow as the prior year.

The distance (m) between monitoring checks was calculated and is summarized in Table 3-4. This is not the total distance a tortoise moved during the year, but the summed distance between locations recorded during regular monitoring. Tortoises obviously moved on days between monitoring checks, which was not measured. For females the average distance was 1,992 m, and for males 1,701 m. A two-tailed, t-test

Table 3-4. Mortality, sex, distance in meters (m) between release site and January 2017 burrow, distance between January 2016 burrow and January 2017 burrow, total distance between monitored locations (January 2016 to January 2017), and number of used burrows and new burrows occupied by 28 juvenile desert tortoises monitored during 2016 (*=Found June 16, 2016, NA=Not Applicable).

Tortoise Number	Sex	Distance (m) Release to Jan. 2017 Burrow	Distance (m) Jan. 2016 Burrow to Jan. 2017 Burrow	Total Distance (m) between locations (Jan. 2016-Jan. 2017)	Number of Burrows Used (New Burrows)
4009	Female	Dead 9/21	NA	NA	NA
4010	Female	1168	46	1618	3 (0)
4014	Female	562	46	471	6 (4)
4030	Female	2328	2262	4227	8 (5)
4039*	Female	98	NA	NA	NA
4044	Female	316	127	1474	10 (6)
4045	Female	188	30	2110	7 (5)
4046	Female	402	54	2542	7 (5)
4049	Female	1248	31	1500	9 (8)
4004	Male	243	133	1847	6 (3)
4005	Male	337	219	2085	11 (8)
4007	Male	117	0	848	6 (2)
4011	Male	336	54	3916	8 (6)
4018	Male	282	108	814	5 (3)
4019	Male	187	118	4568	7 (5)
4024	Male	811	87	1707	4 (3)
4025	Male	1101	67	1622	10 (6)
4033	Male	124	95	802	6 (3)
4034	Male	67	27	1866	7 (4)
4036	Male	575	0	1656	6 (3)
4037	Male	149	20	777	3 (1)
4038	Male	115	72	1190	9 (7)
4040	Male	738	228	2016	10 (8)
4041	Male	118	95	1334	8 (3)
4048	Male	93	62	1603	7 (4)
4050	Male	105	0	1067	3 (2)
4053	Male	297	34	1642	3 (2)
4055	Male	6318	1	954	6 (5)
	Average	682	155	1779	7 (4)

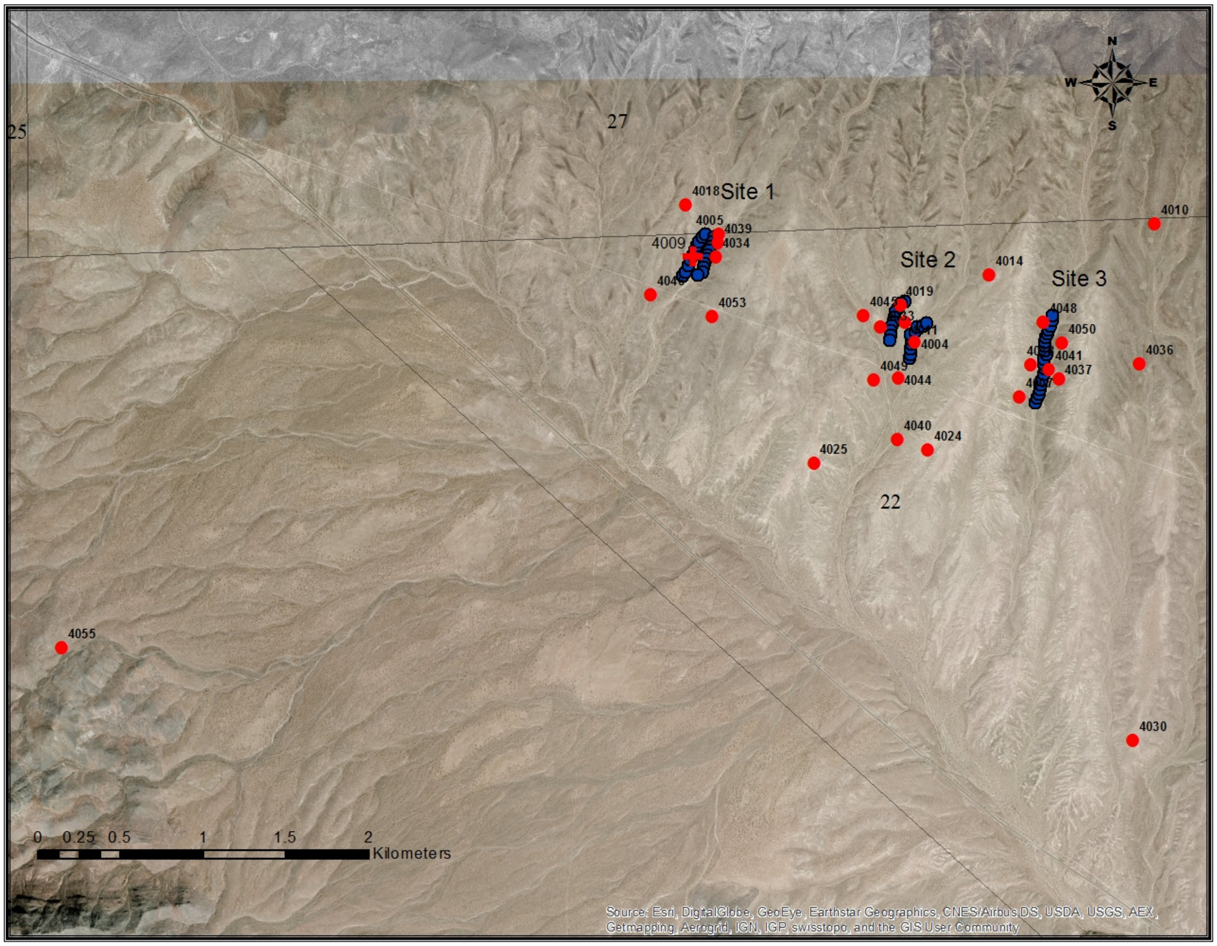

Figure 3-5. Release locations (blue dots) for all 60 translocated juvenile tortoise, mid-January 2017 locations (red dots) for surviving 27 tortoises, and location of presumed dead tortoise #4009 (red cross).

was used to determine if this difference was statistically significant at α (alpha level) = 0.05. It was not significant (p [probability] = 0.54). The average distance by monitoring period between locations for all 27 surviving tortoises was also calculated and is shown in Figure 3-6 along with precipitation by monitoring period. The largest peak in movement occurred in May but was influenced greatly by one individual (4030) that moved about two km to the south. Much smaller peaks of movement occurred in mid-April, mid-summer, and early fall.

During 2016, burrows were marked with unique numbers and data collected included Universal Transverse Mercator (UTM) coordinates (North American Datum [NAD] 83), burrow height, burrow width, burrow orientation, elevation, location, topographic position, vegetation cover and substrate. The number of unique burrows an individual used was calculated and is shown in Table 3-4. It is important to note that tortoise burrows were only documented during tracking checks, and therefore all burrows used may not have been documented. The number of unique burrows marked and measured during 2016 was 118. The average height of burrows was 9.7 mm (range 5-25 mm; sd 3.1 mm) and average width of burrows was 20.4 mm (range 12-47 mm; sd 4.4 mm). Average elevation for burrow locations was 1,085 m (range 1,021–1,194 m; sd 24.8 m). It appears that tortoises do not have a preference for burrow orientation (Chi-square [χ^2]= 6.1; p=0.1; degrees of freedom [df] = 3).

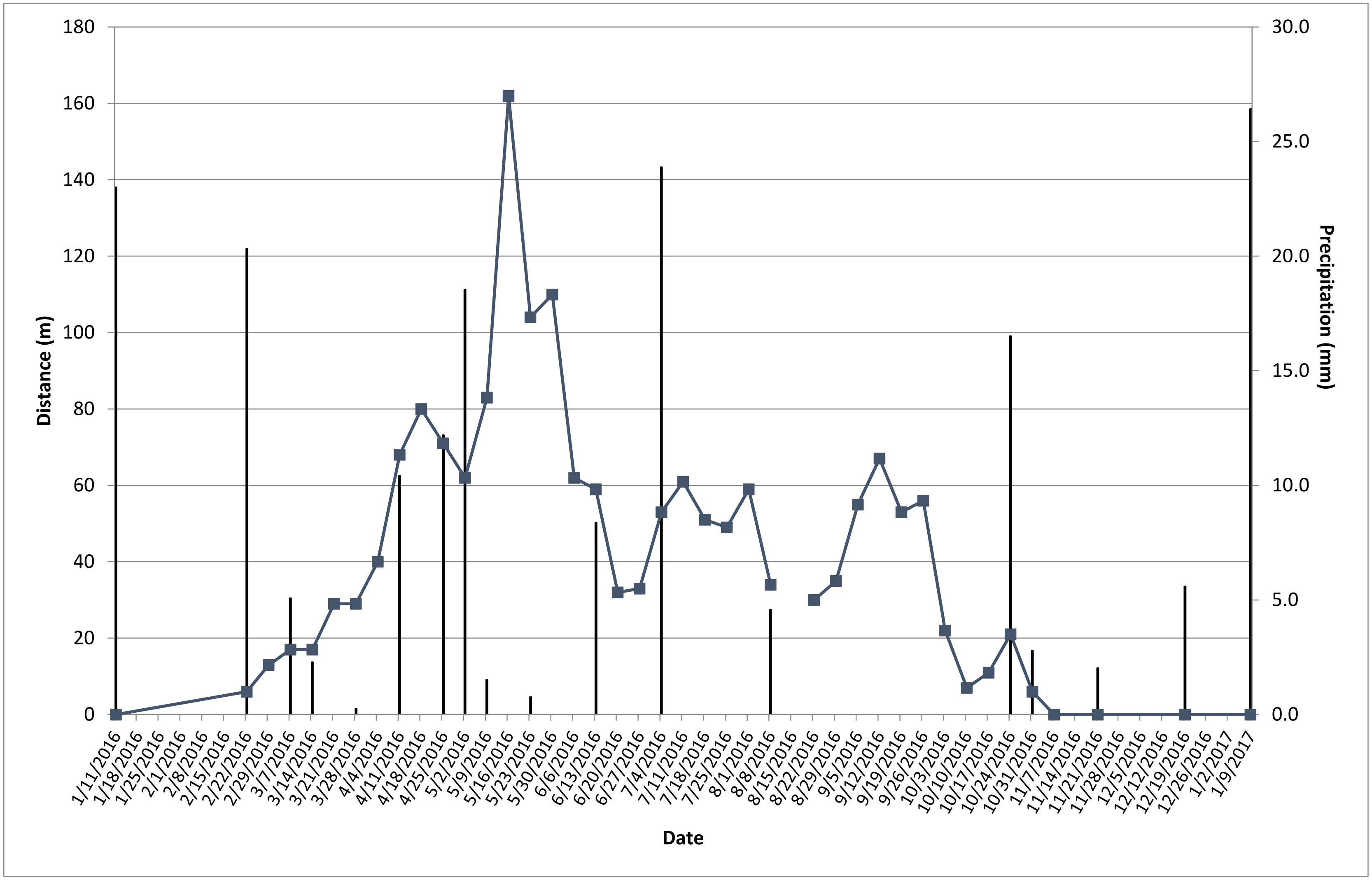

Figure 3-6. Average distance (m) between locations (horizontal line) for 28 surviving juvenile tortoises and precipitation (mm) (vertical bars) received by monitoring period, January 2016–January 2017.

On average, tortoises used seven unique burrows (range 3–11; sd = 2) (Table 3-4) with no significant difference between females (7.1 burrows) and males (6.5 burrows) ($p = 0.56$). Three burrows were used by multiple tortoises but only one of these was occupied by two tortoises at the same time, which was the 2015-16 hibernacula for 4033 and 4045.

All juveniles were at their winter 2016-2017 burrow by November 7, 2016 which is a bit earlier than last year when they were all at their winter burrow by November 23, 2015. All tortoises were at their 2014-2015 winter burrow by November 18, 2014. Four (15%) were at their winter burrow by October 1, 2016 and seven (26%) were at their winter burrow by October 23, 2016. Only one (4%) was at its winter 2015-2016 burrow by October 1, 2015 and 10 (37%) were at their winter 2015-2016 burrow by October 23, 2015. Just over half of them were there by October 1, 2014 and all but three (90%) were at their 2014–2015 winter burrow by October 23, 14.

Observations made during tracking from January 2016 to January 2017 on the 28 surviving juvenile tortoises totaled 1,106. Figure 3-7 illustrates the percentage of time tortoises were found in various locations. Two-thirds of the observations were of tortoises either inside their burrows, in the burrow entrance, or on the burrow apron. The remaining one-third of the observations found tortoises in the open or under vegetation. Tortoises were found under 17 different vegetation species and under mixed shrub clumps. Figure 3-8 depicts the percentage of observations tortoises were found under vegetation by species. Most noteworthy is the dominance of blackbrush and Nevada jointfir with nearly one-half of observations of tortoises found under these two species. The “Other” category included water jacket (*Lycium andersonii*) (2.9%), fourwing saltbush (*Atriplex canescens*) (2.2%), burrobrush (*Hymenoclea salsola*) (1.8%), Fremont’s dalea (*Psorothamnus fremontii*) (1.8%), turpentinebroom (*Thamnosma montana*) (1.1%), white bursage (*Ambrosia dumosa*) (1.1%), and spiny hopsage (*Grayia spinosa*), desert prince’s plume (*Stanleya pinnata*), littleleaf ratany (*Krameria erecta*), desert globemallow (*Sphaeralcea ambigua*), Mexican bladdersage (*Salazaria mexicana*), and Shockley’s goldenhead (*Acamptopappus shockleyi*) at ≤1% each.

Tortoises used burrows on wash slopes more than expected by chance ($\chi^2 = 96$; $p < 0.001$; df = 3) (Figure 3-9). Vegetation cover at burrows was found at 89% of the burrows, suggesting this is an important factor in burrow selection for these juveniles (Figure 3-10). It did not appear that tortoises preferred any particular plant species under which to dig a burrow. Mixed shrub clumps seemed to be the dominant cover. Blackbrush (3%), burrobrush (3%), spiny hopsage (2%), white bursage (2%), threadleaf snakeweed (*Gutierrezia microcephala*) (1%), shinyleaf sandpaper plant (1%), Mojave yucca (*Yucca schidigera*) (1%), and fourwing saltbush (1%) made up the other category (Figure 3-10).

Gravel was the dominant substrate at juvenile tortoise burrows (Figure 3-11) with gravel/sandy and gravel/cobble also important. Gravel is defined as rocks <2.5 centimeters (cm) in size, cobble as rocks between 2.5 and 12.7 cm, and rock as >12.7 cm. The other category is made up of gravel/caliche (4%), cobble (3%), cobble/sandy/gravel (3%), sandy (3%), caliche (2%), caliche/sandy (1%), cobble/rock (1%), and cobble/sandy (1%). Combined categories such as gravel/sandy means that both were equal in abundance.

Evidence of foraging was documented on all 28 tortoises, 127 times during 1,106 observations (11%) between January 2016 and January 2017. Foraging was detected between February 22 and October 31, 2016, with peaks in March and April (Figure 3-12). Annual plant production and diversity was high during the spring, due to abundant precipitation received during the previous fall and winter. This likely explains the peaks of foraging in March and April. The species documented as most commonly eaten were bluedick (*Dichelostemma capitatum*) (3.9%) and desert globemallow (*Sphaeralcea ambigua*) (3.1%). Other species eaten were brightwhite (*Prenanthella exigua*), yellow cups (*Camissonia brevipes*), yelloweyes (*Lupinus flavoculatus*), Gilia species, and redstem stork’s bill (*Erodium cicutarium*). Most (88%) of the time, it was not possible to identify what the tortoises had eaten. On one occasion, a tortoise

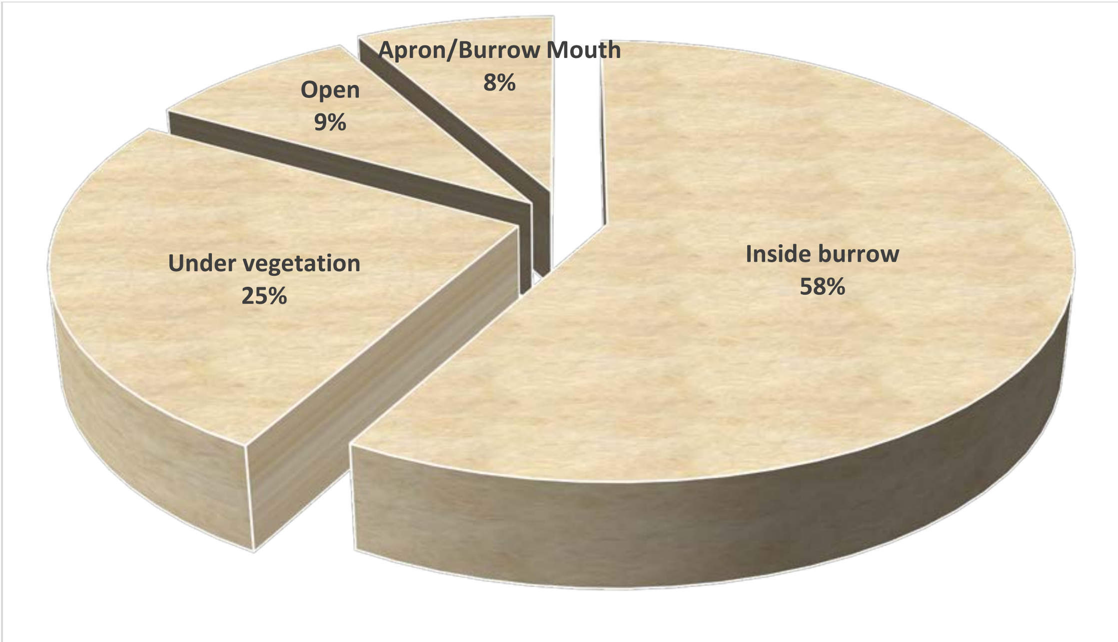

Figure 3-7. **Percentage of observations (n=1,106) of 28 juvenile tortoises by location, January 2016–January 2017.**

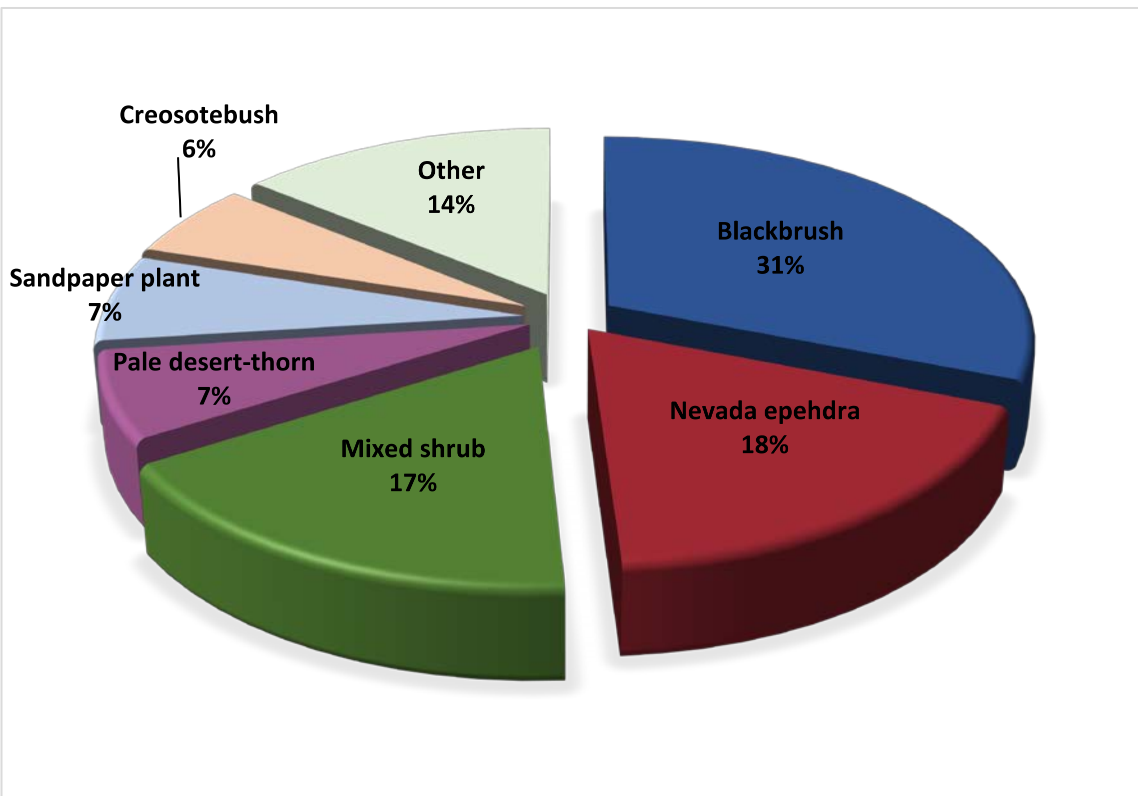

Figure 3-8. **Percentage of observations (n=276) of 28 juvenile tortoises found under vegetation by species, January 2016–January 2017.**

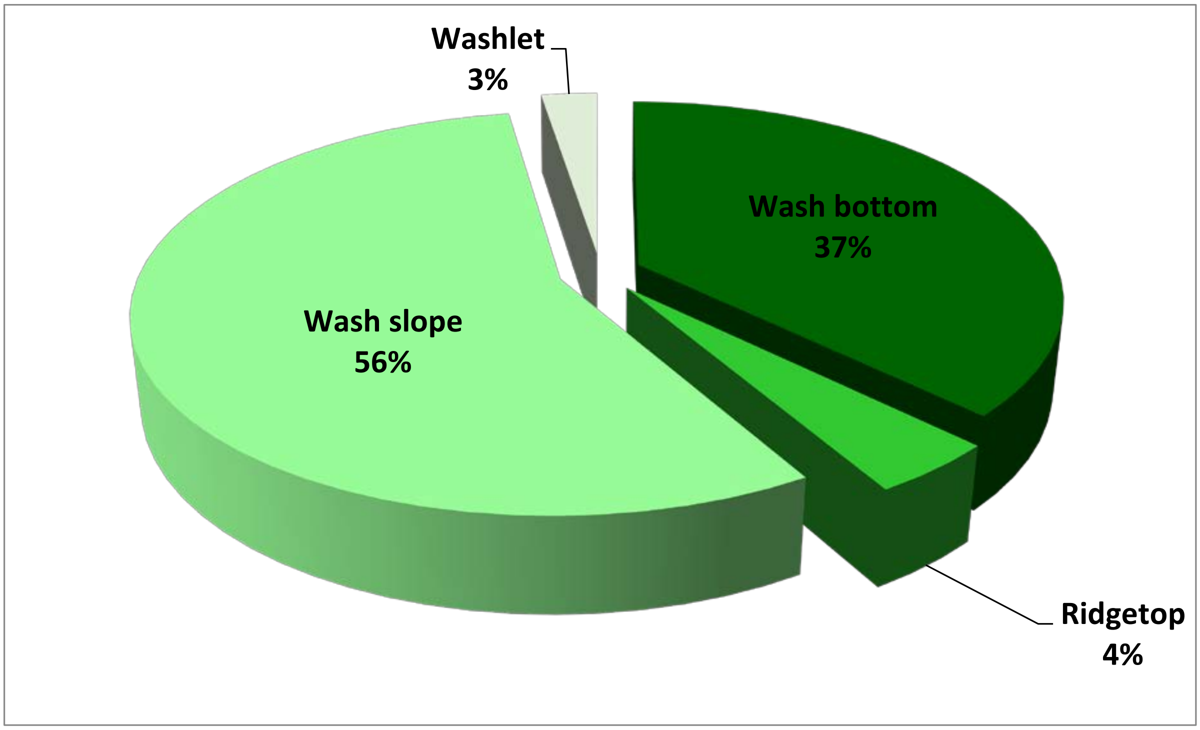

Figure 3-9. Percentage of juvenile tortoise burrows by topographic position, January 2016–January 2017 (n=118).

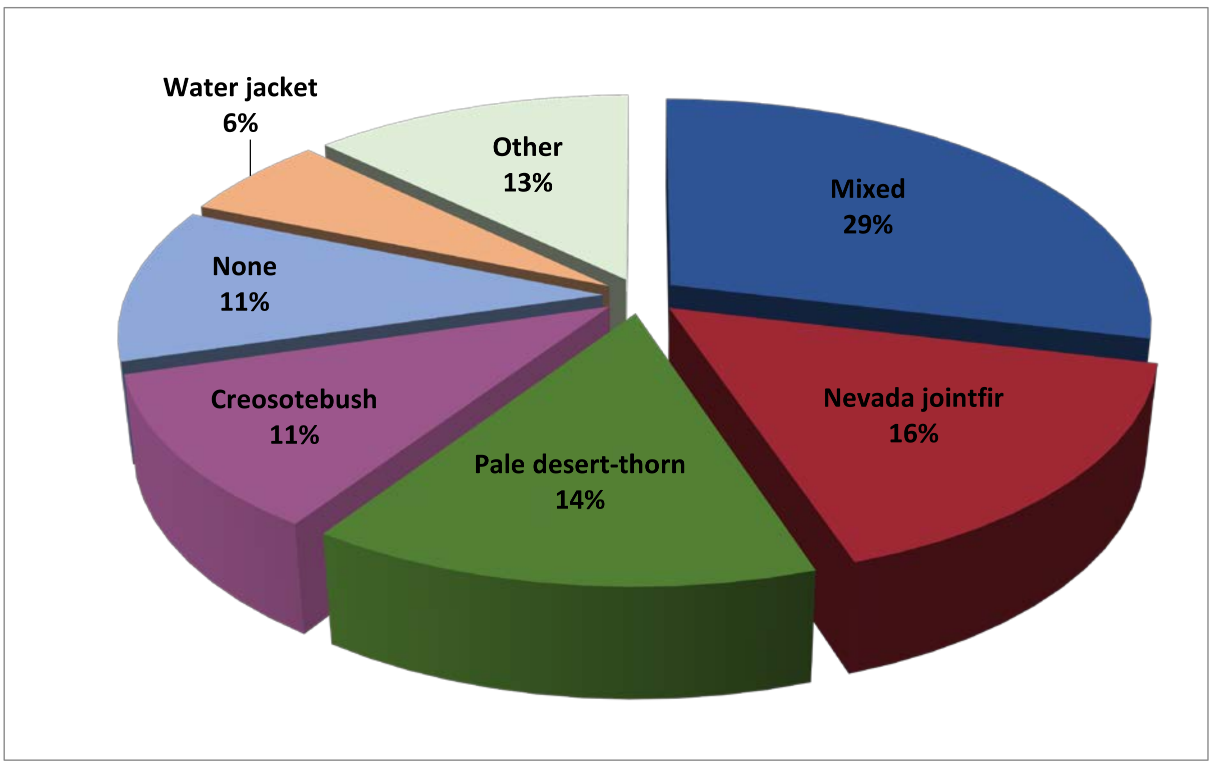

Figure 3-10. Percentage of juvenile tortoise burrows by vegetation cover at the burrow, January 2016–January 2017 (n=118).

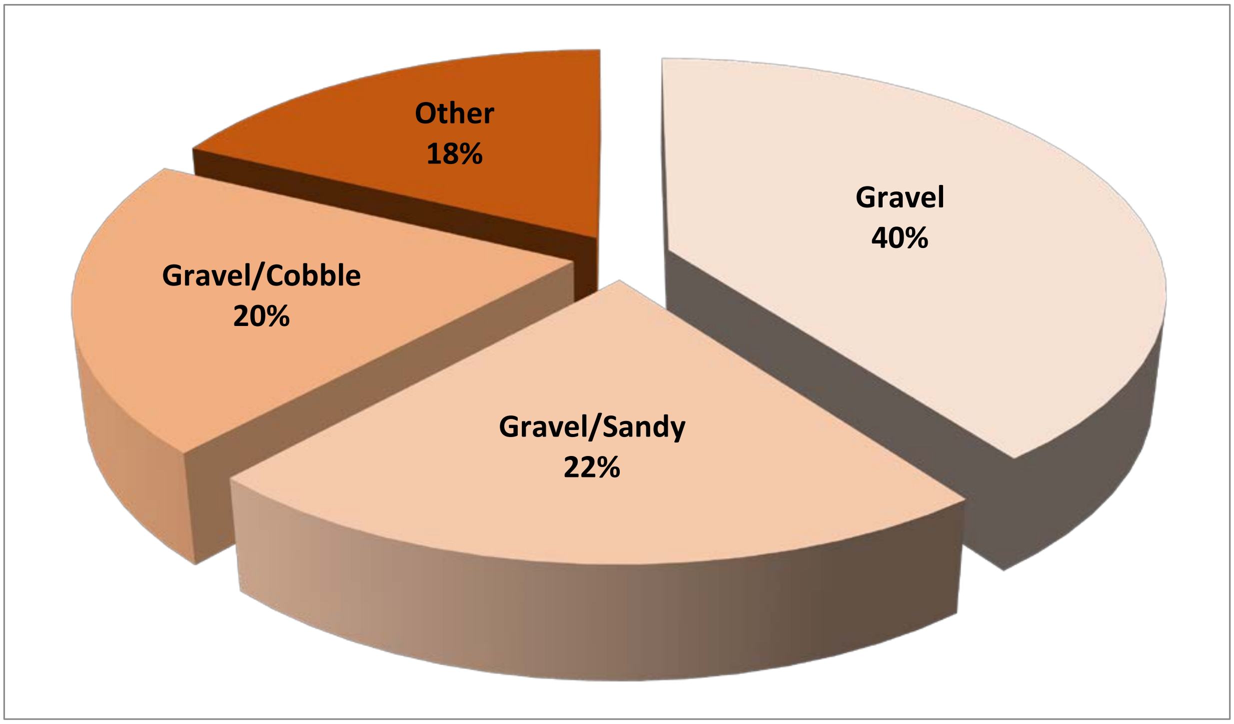

Figure 3-11. Percentage of juvenile tortoise burrows by substrate, January 2016–January 2017 (n=118).

was observed holding a desert globemallow plant down with its forelimb to reach the top part of the plant (Figure 3-13).

During September 2016, each tortoise was given a detailed health assessment. They were weighed, measured, and assigned a body condition score (1-3 = under condition, 4-6 = good condition, 7-9 = over condition) (Table 3-5). Tortoises were also assessed during March and April, 2016 (Table 3-5). Similar health assessments were performed pre-release in August and September 2012 (Table 3-5). This allows for comparison of growth rates, weight change and overall health and body condition score over time.

On average, the surviving 27 translocated juvenile desert tortoises increased 21 mm in MCL and 192 g in weight (without transmitters) from fall 2012 to fall 2016. Results from a two-tailed t-test showed there was no significant differences ($\alpha = 0.05$) in MCL growth between females (18 mm) and males (22 mm) ($p=0.45$) or in weight gain between females (147 g) and males (211 g) ($p=0.41$). Body condition scores indicated all tortoises were in good condition during 2016.

The main factor for survival appears to be gender with higher survival of males than females. This has been observed by other researchers as well (Melia Nafus, ICR, personal communication, December 4, 2014). Size, weight, overall health, and presence of *Mycoplasma* species (bacteria that causes upper respiratory disease in tortoises) do not seem to have any significant impact on survival. While it is impossible to determine if a tortoise was scavenged or preyed upon, a majority of dead tortoises have shown signs of being chewed on by mammalian predators. Given the presumed healthy status and low disease prevalence in the juveniles, it seems unlikely that they are dying and then being scavenged. This suggests that most of the mortality is due to predation. Coyote (*Canis latrans*) and kit fox (*Vulpes macrotis*) tracks have been observed on multiple occasions while conducting tortoise monitoring, and these canids appear to be the main predators killing juvenile tortoises. Why predators seek out female tortoises more than males is a question yet to be answered. Given the fact that coyotes and kit foxes use

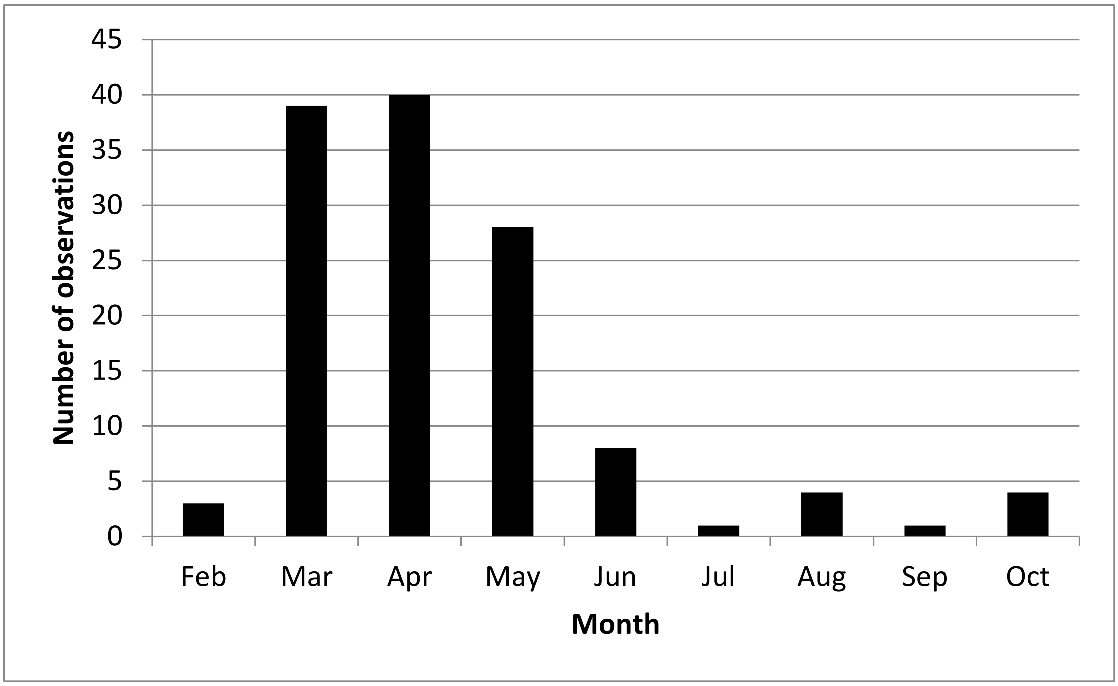

Figure 3-12. Number of times evidence of foraging was detected by month for 28 juvenile tortoises, January 2016–January 2017 (n = 127) (No evidence of foraging was detected in November, December, or January).

Figure 3-13. Juvenile tortoise holding down desert globemallow plant with forelimb to feed on the top part of the plant.

(Photo by D.B. Hall July 11, 2016).

Table 3-5. Midline carapace length (MCL) (mm), weight without transmitters (g), and body condition score during Fall 2012, Spring 2016, and Fall 2016 including MCL growth and weight gain from 2012 to 2016 (* = estimated weight).

Tortoise Number	Sex	Pre-release MCL (mm) (2012)	MCL (mm) (Spring 2016)	MCL (mm) (Fall 2016)	Change in MCL (mm) (2012-2016)	Pre-release Weight (g) (2012)	Weight (g) (Spring 2016)	Weight (g) (Fall 2016)	Change in Weight (g) (2012-2016)	Pre-release Body Condition (2012)	Body Condition (Spring 2016)	Body Condition (Fall 2016)
4009	Female	138	140	Dead	Dead	472	555*	Dead	Dead	4	4	Dead
4010	Female	Unknown	148	155	Unknown	590	710*	698	108	4	4.5	4.5
4014	Female	136	144	147	11	485	594*	504	19	5	4	4
4030	Female	148	157	164	16	562	754*	770	208	4	4.5	4.5
4039	Female	117	136	141	24	315	538	540	225	5	4.5	4.5
4044	Female	146	151	161	15	484	688*	702	218	4	4.5	4
4045	Female	129	138	145	16	400	540*	507	107	4	4.5	4
4046	Female	126	141	151	25	476	685	659	183	4	4.5	4.5
4049	Female	106	118	124	18	238	315	347	109	4	4.5	4
4004	Male	117	118	130	13	303	333	358	55	4	4	4
4005	Male	140	146	156	16	564	644*	723	159	5	4.5	4.5
4007	Male	121	122	125	4	363	357	350	-13	5	4	4
4011	Male	144	167	179	35	634	970*	953	319	4	4.5	4.5
4018	Male	105	107	112	7	213	237	242	29	4	4	4.5
4019	Male	150	166	181	31	654	1021*	1000	346	4	4.5	4.5
4024	Male	146	170	186	40	565	1074*	1150	585	5	4.5	4.5
4025	Male	127	135	147	20	357	506*	538	181	5	4.5	4.5
4033	Male	126	131	132	6	430	460*	380	-50	4	4	4
4034	Male	128	140	149	21	407	568	582	175	4	4	4.5
4036	Male	132	147	160	28	455	636*	705	250	4	4.5	4.5
4037	Male	105	113	115	10	223	287	243	20	4	4.5	4.5
4038	Male	132	154	173	41	457	764*	906	449	4	4.5	4.5
4040	Male	140	145	154	14	493	624*	626	133	4	4.5	4
4041	Male	119	125	134	15	322	400	418	96	4	4.5	4.5
4048	Male	135	164	184	49	480	934*	1150	670	5	5	5
4050	Male	138	145	155	17	502	595*	600	98	4	4.5	4.5
4053	Male	150	157	159	9	681	792*	726	45	4	4.5	4.5
4055	Male	151	182	192	41	602	1124*	1058	456	4	5	4

olfaction as one of their dominant senses, it is possible that females are giving off scent that makes them easier to detect or their behavior makes them more susceptible to predation. More research is needed to help understand the interaction between tortoises and their predators. Oral, cloacal, and chin/forelimb swabs were collected from all 27 juvenile tortoises and 27 adult tortoises from the road study (10 females, 16 males, 1 unknown) during fall 2015. These samples will be sent to the Monell Chemical Senses Center in early 2017 to be analyzed using a mass spectrometer in an attempt to detect any chemical differences between males and females as well as between adults and juveniles that might cause increased canid predation. NSTec will continue monitoring the remaining juveniles for an additional 1–5 years. Data analysis and publications will be a joint effort between NNSA/NFO and ICR.

3.3.2 USGS Rock Valley Study

As part of continuing research pertaining to desert tortoises, USGS in collaboration with FWS, ICR, and Penn State University is using three fenced 9 ha enclosures in Rock Valley for a portion of a desert tortoise epidemiology study. The three Rock Valley enclosures are located along the southern boundary of the NNSS in Area 25. In the spring of 2013, 15 tortoises were placed in each plot to reside in the plots for a year. Each tortoise was fitted with a proximity sensor, which is activated when two tortoises come within a specified distance of each other. This allows scientists to document tortoise interactions and social structure. In the spring of 2014, the second phase was initiated, when up to five additional tortoises were placed in the enclosures, for a total of 20 per enclosure. This will serve as a model for how translocated tortoises may interact with residents. Additional manipulations may be necessary and are planned in the succeeding years (2015–2018). NNSS staff biologists did not assist with any activities during 2016 on this project.

3.3.3 Coordination with Other Biologists and Wildlife Agencies

In February 2016, two NSTec biologists attended the Desert Tortoise Council's 41st annual meeting and symposium. One of the biologists gave a presentation entitled "Factors Influencing Survival of Translocated Juvenile Desert Tortoises." This meeting was held in Las Vegas, Nevada, and included numerous presentations on desert tortoise biology, ecology, and recovery efforts as well as a special session on desert bighorn sheep (*Ovis canadensis nelsoni*). The same presentation was given at the Nevada Chapter of The Wildlife Society annual symposium in Reno, Nevada in March.

4.0 ECOSYSTEM MONITORING

Biologists began comprehensive mapping of plant communities and wildlife habitat on the NNSS in 1996. Data were collected, describing selected biotic and abiotic habitat features within field mapping units called ecological landform units (ELUs). ELUs are landforms (Peterson 1981) with similar vegetation, soil, slope, and hydrology. Boundaries of the ELUs were defined using aerial photographs, satellite imagery, and field confirmation. ELUs are considered by site biologists to be the most feasible mapping unit by which sensitive plant and animal habitats can be described. In 2000 and 2001, topical reports describing the classification of vegetation types on the NNSS were published (Ostler et al. 2000, Wills and Ostler 2001). Ten vegetation alliances and 20 associations were reported to occur on the NNSS.

In addition to ELU mapping, ecosystem monitoring also entails monitoring a wide variety of terrestrial and aquatic habitats and non-sensitive and protected/regulated species. Efforts during 2016 focused on wildland fire fuels surveys, long-term vegetation monitoring plots, natural water source monitoring, and constructed water source monitoring, including contaminated sumps.

4.1 VEGETATION SURVEY FOR WILDLAND FIRE HAZARD ASSESSMENT

Wildland fires on the NNSS require considerable financial resources for fire suppression and mitigation. For example, costs for fire suppression on or near the NNSS can cost as much as $198 per ha (Hansen and Ostler 2004). Costs incurred from the Egg Point Fire in August 2002 (121 ha) were well over $1 million to replace 1 mile of burned power poles, and more than $200,000 for soil stabilization and revegetation of the burned area.

4.1.1 Wildland Fires in 2016

From 1978 to 2013, there has been an average of 11.2 wildland fires per year on the NNSS with an average of about 83.7 ha burned per fire. Historically, most wildland fires are caused by lightning and do not occur randomly across the NNSS, but occur more often in particular vegetation types (e.g., blackbrush plant communities). These types have sufficient woody and fine-textured fuels that are conducive to ignition and spread of wildland fires. Once a site burns, it is much more likely to burn again because of the invasive annual plants that quickly colonize these areas (Brooks and Lusk 2008).

Only two wildland fires occurred on the NNSS during 2016 (one in Area 20 and one in Area 5), well below the average of 11 fires per year. Both of these were less than 0.4 ha in size and were extinguished by rain or by NNSS Fire and Rescue personnel.

4.1.2 Fuel Survey Methods

Beginning in 2004, and in response to a request from NNSS Fire and Rescue Department, surveys were initiated on the NNSS to identify wildland fire hazards. Vegetation surveys were conducted in April and May 2016 at sites located along and adjacent to major NNSS corridors to estimate the abundance of fuels produced by native and invasive plants. Climate and wildland fire-related information reported by other government agencies was also identified and summarized as part of the wildland fire hazards assessment. Survey findings and fuels assessment maps were compiled and reported to NNSS Fire and Rescue Department.

The abundance of fine-textured (grasses and herbs) and coarse-textured (woody) fuels were visually estimated on numerical scales using an 11-point potential scale: 0 to 5 (in 0.5 increments, where 0.0 is barren and 5.0 is near maximum biomass encountered on the NNSS). Details of the methodology used to conduct the spring survey for assessing wildland fire hazards on the NNSS are described in a report by Hansen and Ostler (2004).

Photographs of sites typifying these different scale values are found in Appendix A of the *Ecological Monitoring and Compliance Program Calendar Year 2005 Report* (Bechtel Nevada 2006). Additionally, the numerical abundance rating for fine fuels at a site was added to the numerical abundance rating of woody fuels to derive a combined fuels rating for each site that ranged from 0 to 10 in one-half integer increments. The index ratings for fuels at these survey sites were then plotted on a GIS map and color-coded for abundance to indicate the wildland fire fuel hazards at various locations across the NNSS.

4.1.3 Fuel Survey Results

4.1.3.1 Climate

There were 17 rain gauges on the NNSS (Hansen and Ostler 2004) that have been used historically to measure precipitation. Data from these weather station gauges extend back more than 30 years (National Oceanic and Atmospheric Administration [NOAA] 2013). In the fall of 2011, most of the rain gauges on the NNSS were upgraded from weighing gauges to tipping-bucket style gauges with data transmitted directly to NOAA via telecommunications, rather than having to manually retrieve and process the data (Hansen 2012). In most cases, the new gauges were relocated near the previous locations. The changes were made to reduce costs, improve data reliability, and improve access time to the data after precipitation events. Because of these modifications, only 14 rain gauges remain from the original gauge stations. The Cane Spring, Tippipah Spring, and Rock Valley gauge stations were decommissioned. The Jackass Flats gauge was moved to Port Gaston in Area 26. The Little Feller 2 gauge was moved from the eastern part of Area 18 to the northwestern corner of Area 18. Precipitation data collected in 2015 reflect the changes and attempt to match, as closely as possible, data collected historically. Mean values were recalculated to account for periods when gauges were not functional.

In order to assess potential fuels, particularly fine fuels, a simple measure was needed. Precipitation during the months of December, January, February, March, and April was selected because of its simplicity and ease of calculation (Figure 4-1). While it is recognized that precipitation from other months is also important, as is the influence of temperature, winds, and relative humidity, precipitation during these months represent the period that most influences plant growth on the NNSS as observed along the survey route. This period occurs before the beginning of the fire season in June so it allows one to make a prediction of the fuels that may be present. During 2016, the average precipitation from the remaining 14 rain gauge stations on the NNSS during December–April was 108.7mm, or just above the normal amount received on the NNSS (i.e., the average precipitation for the last 30 years—104.6 mm).

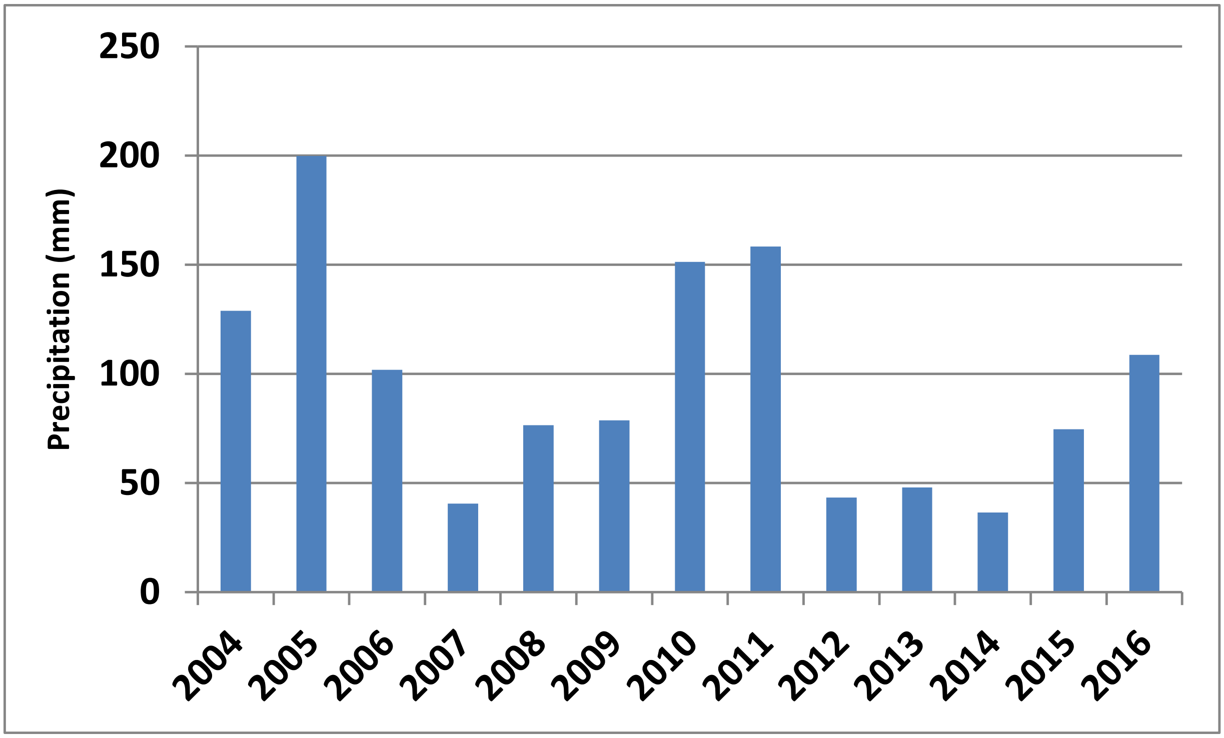

Figure 4-1. Average precipitation (mm) from December (previous year) through April for the years 2004 through 2016 (long-term average precipitation = 104.6 mm).

4.1.3.2 Fuels

Because of the precipitation, albeit average, received during the spring of 2016, a lot of annual or perennial plant seeds germinated. Perennial herbaceous grasses and forbs had good production during the spring of 2016 except in a few locations.

The fine fuels index increased in 2016 (2.67) compared to 2015 (1.44), and was the second highest recorded (Table 4-1). The woody fuels index value was slightly higher in 2016 (2.43) compared to 2015 (2.42), as foliar canopy cover increased slightly (Table 4-1). This was still a relatively low ranking in comparison to the other index values since 2004.

The combined index values (fine fuels plus woody fuels) for 2016 corresponds to the potential for fuels on the NNSS to support wildland fires once fuels are ignited. The higher the index, the greater the potential for wildland fires to spread. The NNSS average combined index value for fine fuels and woody fuels for 2016 was 5.10, the fourth highest since 2004 and just slightly below the 2005 maximum (Table 4-1), suggesting above normal fuels for the NNSS which posed an increased potential for wildland fires.

The locations and results of the fine fuels, woody fuels and combined fuels surveys at 104 stations on the NNSS inspected during 2016 are shown in Figures 4-2, 4-3, and 4-4, respectively. High combined index values occurred in Fortymile Canyon, Yucca Flat, and eastern Pahute Mesa.

Table 4-1. Woody fuels, fine fuels and combined fuels index values for 2004–2016

Year	Average Woody Fuels Index	Average Fine Fuels Index	Average Combined Fuels Index
2004	2.75	2.13	4.88
2005	2.80	2.83	5.64
2006	2.80	2.46	5.26
2007	2.62	1.52	4.13
2008	2.59	2.23	4.81
2009	2.63	1.95	4.52
2010	2.61	2.27	4.89
2011	2.58	2.56	5.14
2012	2.43	1.75	4.17
2013	2.49	2.03	4.52
2014	2.44	1.39	3.83
2015	2.42	1.44	3.87
2016	2.43	2.67	5.10

Photographs were taken from permanent locations for all 104 sites during the past 10 years. Figure 4-5 shows photographs of Site 99 in Yucca Flat for 2011, 2014, 2015, and 2016. These photographs are valuable for many reasons, including providing a permanent record of previous site conditions, comparing site conditions among sites and years, and evaluating current year production with residual fuels from previous years. There are significantly more fine fuels in 2016 compared with 2015. The woody fuels were similar to 2015.

Fine fuels produced in 2016 reflected the precipitation that occurred from a large storm that caused major flooding in October of 2015. That storm moved across the NNSS from the southwestern corner in Jackass Flats and across Mid Valley and northeast across Yucca Flat. This storm caused many species to germinate and consistent winter rains from El Nino caused the large increase in fine fuels biomass along that corridor. Overall, the hazards of residual fuels contributing to wildland fires were much higher than average. In spite of this increased fuel load only two small fires occurred on the NNSS during 2016. Rapid response by NNSS Fire and Rescue after fires were ignited was a key factor in minimizing wildland fire spread and severity.

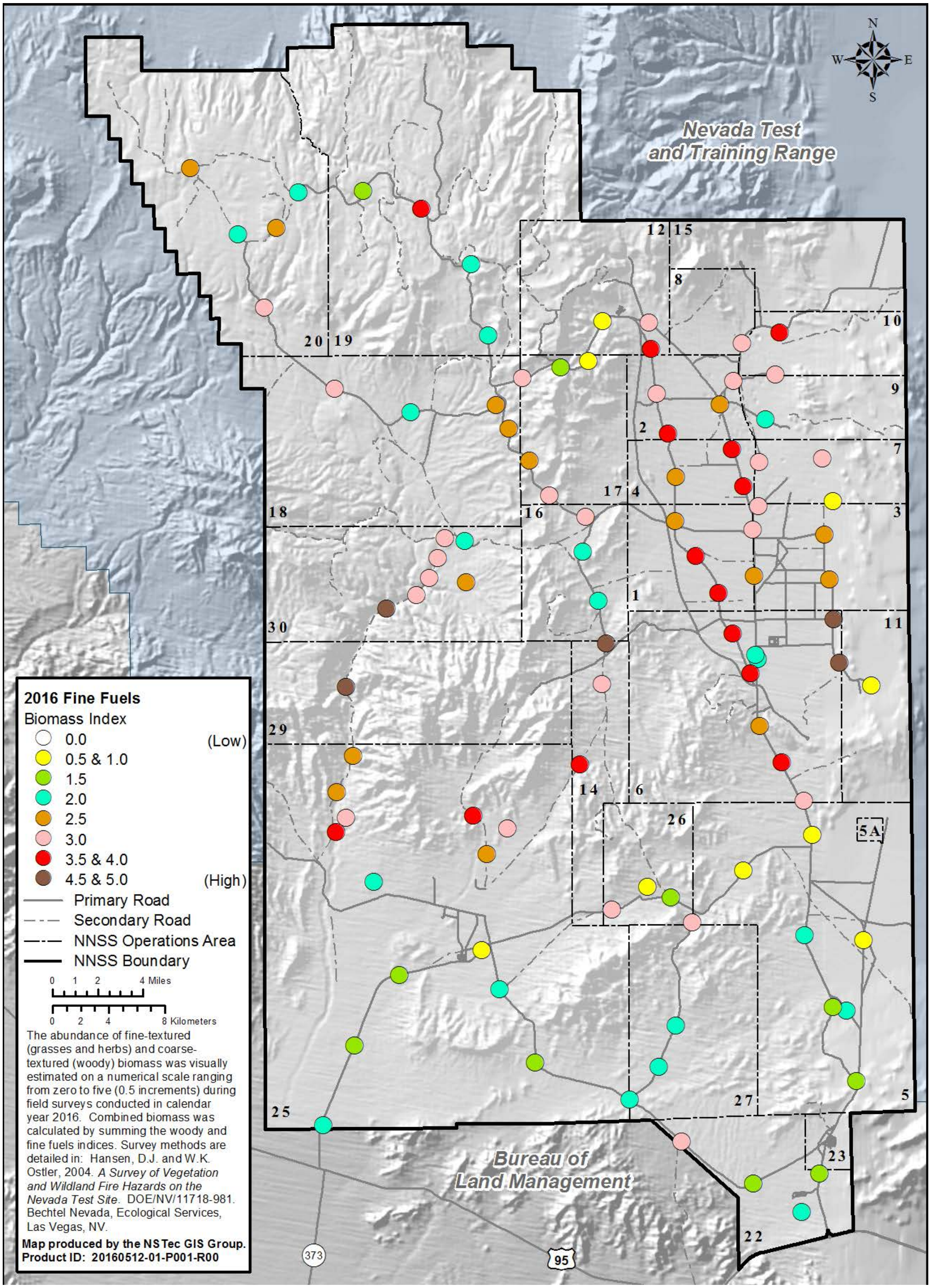

Figure 4-2. Index of fine fuels for 104 survey stations on the NNSS during 2016.

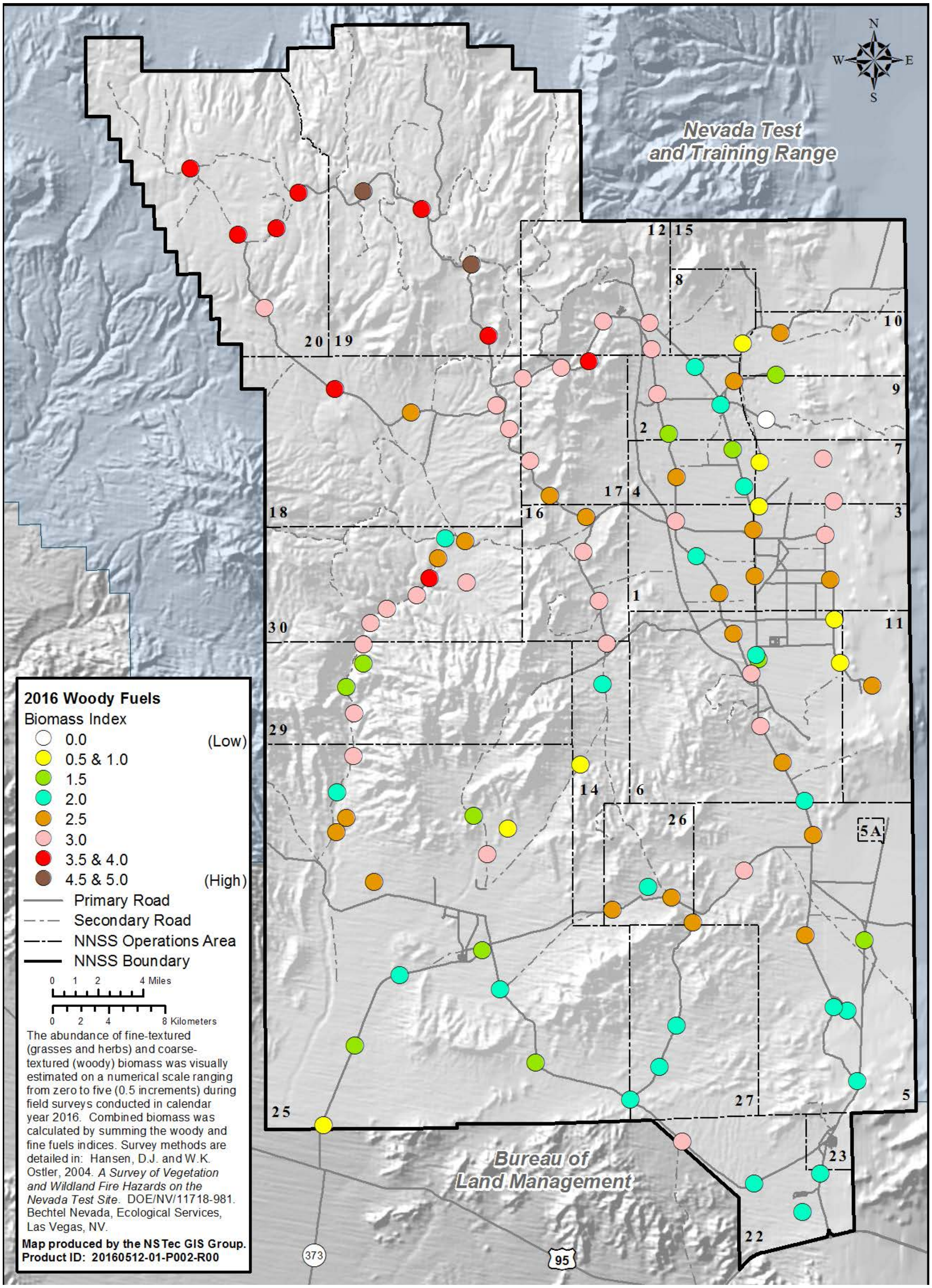

Figure 4-3. Index of woody fuels for 104 survey stations on the NNSS during 2016.

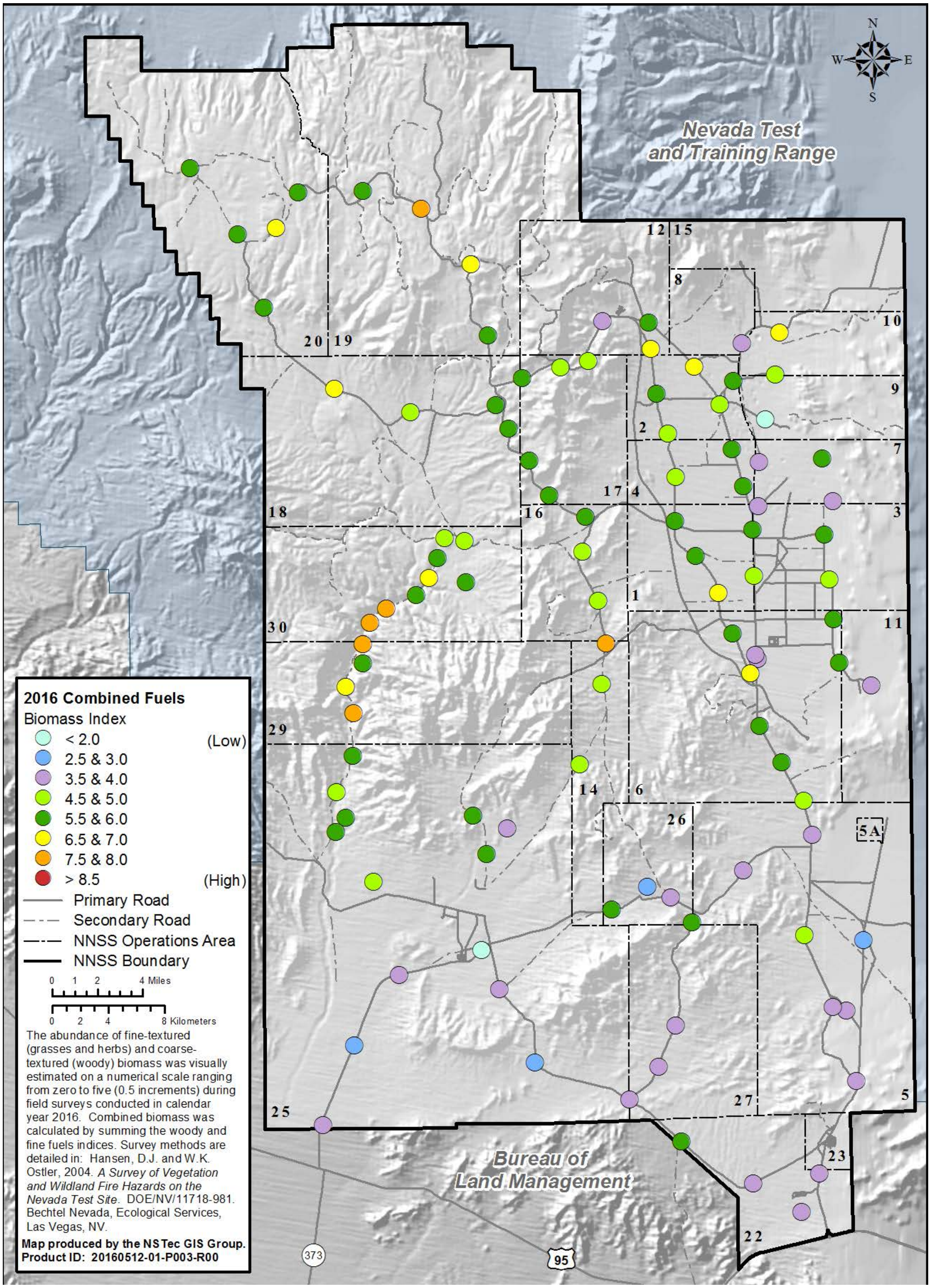

Figure 4-4. Index of combined fine fuels and woody fuels for 104 survey stations on the NNSS during 2016.

Figure 4-5. Site 99 on the west side of Yucca Flat in 2011, 2014, 2015 and 2016.

(Photos by W. K. Ostler, April 26, 2011 [top left]; April 12, 2014 [top right]; April 21, 2015 [bottom left]; and April 20, 2016 [bottom right])

4.1.3.3 Invasive Plants

The three most commonly observed invasive annual plants to colonize burned areas on the NNSS are Arabian schismus (*Schismus arabicus*), found at low elevations; red brome (*Bromus rubens*), found at low to moderate elevations; and cheatgrass (*Bromus tectorum*), found at middle to high elevations (Table 4-2). Most of the invasive annual plants germinated during the fall 2015 and continued growing through the spring of 2016. Cheatgrass was the most common invasive plant occurring at over 69% of the study sites. Plants were normal size or large in some areas such as Fortymile Canyon. Both red brome (54.8% of the study sites) and redstem stork's bill (*Erodium cicutarium*) (43.3% of the study sites) had good germination over the NNSS. Precipitation history (Figure 4-1) is also important in determining the percent presence of species across the NNSS. During periods of low precipitation, most annual species have low percent presence (i.e., the number of sites in which the plant was observed to be present and growing). Percent presence is generally greatest during periods of high precipitation, and appears to be a good indication of germination. Higher percent presence is also expected to occur when regional storms provide precipitation to a greater number of operational areas across the NNSS. However, the responses of some species, both invasive and native species, suggest that other variables, such as the timing of precipitation or temperatures required for germination, may also be contributing to plant response.

Table 4-2. Precipitation history and percent presence of key plant species contributing to fine fuels at surveyed sites.

Precipitation History	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Mean Precipitation (mm) (December–April)	129.0	199.9	101.9	40.6	76.5	78.7	151.4	158.5	43.4	48.0	36.6	74.7	108.7
Invasive Introduced Species													
Bromus rubens (red brome)	51.7	64.4	67.8	0	63.0	63.2	58.5	62.3	0	19.2	28.8	52.9	54.8
Bromus tectorum (cheatgrass)	40.3	54.0	60.7	0	59.2	66.0	67.0	79.2	17.0	70.2	61.5	36.5	69.2
Erodium cicutarium (redstem stork's bill)	5.2	6.2	24.6	0	21.3	27.4	33.0	42.4	0.9	37.5	33.7	25.0	43.3
Schismus arabicus (Arabian schismus)	4.7	2.8	5.2	0	11.4	9.4	3.8	11.3	0	9.6	6.7	10.6	15.4
Native Species													
Amsinckia tessellata (bristly fiddleneck)	34.0	62.0	16.1	0	63.0	48.1	67.9	63.2	1.8	41.3	26.0	47.1	66.4
Mentzelia albicaulis (whitestem blazingstar)	49.8	8.1	0	0	2.4	18.9	51.9	16.0	3.7	6.7	20.2	43.3	41.4
Chaenactis fremontii (pincushion flower)	27.0	8.0	0	0	1.4	11.3	13.2	0.5	0	6.7	2.9	7.7	32.7

Colonization by invasive species increases the likelihood of future wildland fires because they provide abundant fine fuels that are more closely spaced than native vegetation. Blackbrush vegetation types appear to be the most vulnerable plant communities to fire, followed by pinyon pine/Utah juniper/sagebrush (*Pinus monophylla/Juniperus osteosperma/Artemisia* species [spp.]) vegetation types. Wildland fires are costly to control and to mitigate once they occur. Revegetation of severely burned areas can be very slow without reseeding or transplanting with native species and other rehabilitation efforts. Blackbrush, sagebrush, Utah juniper and pinyon pine do not resprout following fires. Untreated areas become much more vulnerable to future fires once invasive species, rather than native species, colonize a burned area.

Growth of fine fuels produced by invasive, introduced annual species (especially cheatgrass) and other native annual species during 2016 was the second highest recorded since 2004. Germination and growth of fine fuels during 2016 was greatest at the middle elevations and on previously burned sites.

4.2 LONG-TERM VEGETATION MONITORING PLOTS

In 1963, Janice Beatley established 68 long-term ecological monitoring plots on the NNSS. These plots are located throughout much of the southern and eastern portions of the NNSS and represent the vegetation alliances in those areas. Beatley originally classified the northwestern portions of the NNSS as mountains in her vegetation map of the NNSS (Beatley 1976). The major vegetation associations in this area include black sagebrush (*Artemisia nova*), big sagebrush (*Artemisia tridentata*), singleleaf pinyon/black sagebrush, and singleleaf pinyon/big sagebrush (Ostler et al. 2000). In addition, Utah juniper usually occurs with singleleaf pinyon. These vegetation associations collectively make up 31.4% of the total area of the NNSS although they are nearly excluded in sites selected by Beatley for long-term monitoring. Beatley had only one plot in each of these four vegetation associations. In 2000-2002, these plots were resampled by USGS scientists. Data and comparisons with earlier sampling by Beatley are presented in a paper by Webb et al. (2003).

In 2007-2008, NSTec biologists established supplemental plots in the four vegetation associations listed above to better characterize the vegetation that occurs in the higher elevation portions of the NNSS and to document baseline conditions that can be compared with future vegetation communities that may be impacted by climate change. These plots were selected randomly from ELUs that were located in major geographic areas of the NNSS that make up these four vegetation associations (Ostler et al. 2000). Eight plots were selected in black sagebrush (ARNO), eleven plots in big sagebrush (ARTR), ten plots in pinyon/black sagebrush (PIMO/ARNO), and twelve plots in pinyon/big sagebrush (PIMO/ARTR) (Figure 4-6). Two paired plots were added during 2016 to compare burned versus unburned areas. The PIMO/ARTR4 plot was not burned. However, a nearby area had burned several years ago, so a plot was established in this burned area. The original PIMOARTR11 plot burned in a wildfire during 2011, so a new plot was established this year in an adjacent unburned area. Table 4-3 contains descriptive information about all 43 plots. The number of plots per vegetation association varied to reflect the total acreage of these associations on the NNSS. Results of the initial surveys are described in Hansen et al. (2009) and a summary of how plots were established, data collection methods, and results from 2008 to 2015 are found in Hall et al. (2016).

4.2.1 Field Sampling of PIMO-ARTR Plots

In 2016, the PIMO-ARTR plots were sampled to determine cover and density. Plots were sampled between July 14 and November 10. Sampling at some plots occurred later in the season than desired due to wildfire restrictions, so some plant species were not detected or easily identified, especially the perennial grasses and forbs and annuals. Precipitation in 2016 was slightly above normal, so many forb and grass species germinated and grew but went undetected due to the late sampling time period.

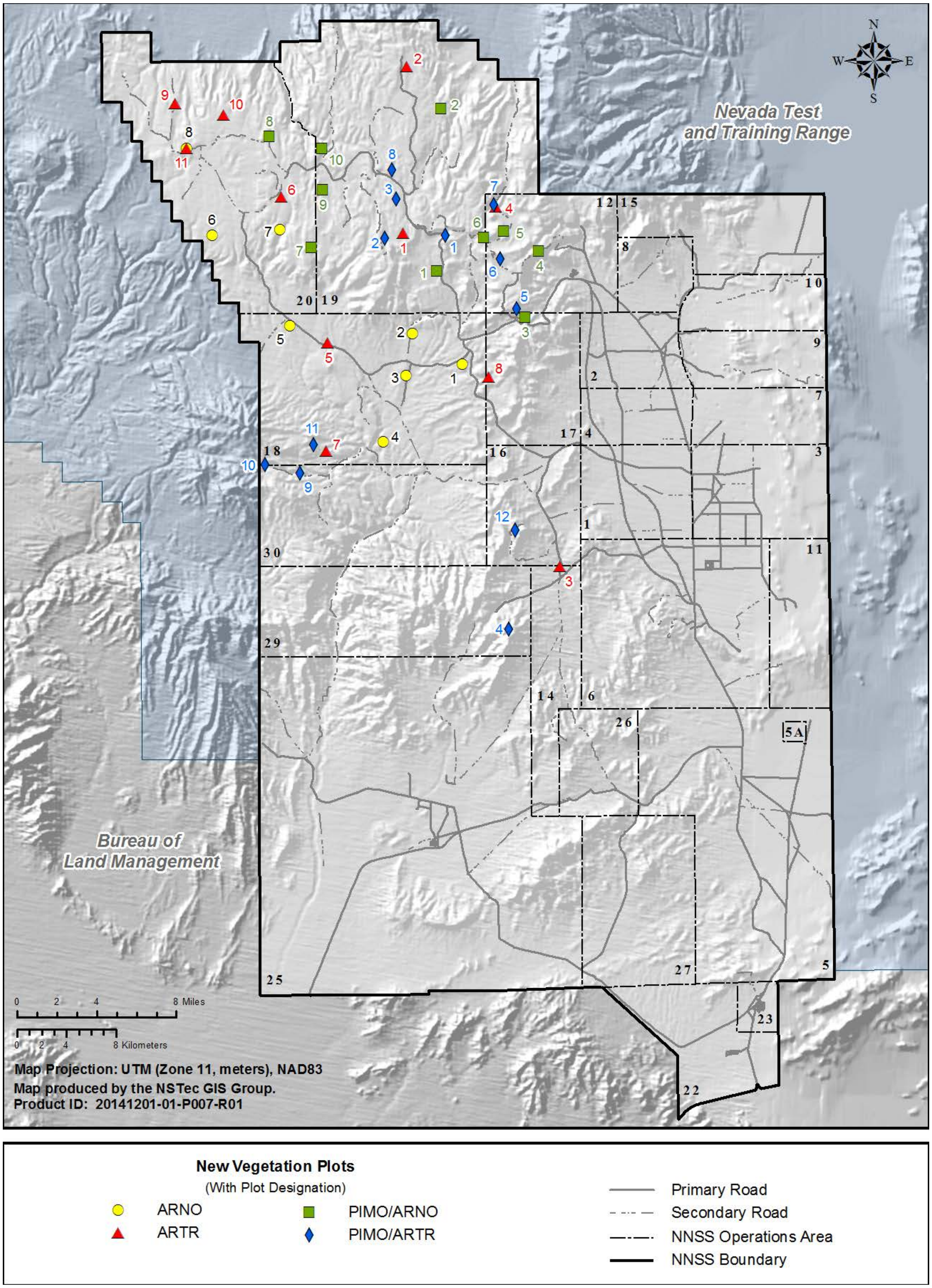

Figure 4-6. Location of new long-term monitoring plots established on the NNSS in 2008.

Table 4-3. Locations and descriptions of long-term monitoring plots.

Plot number	ELU#	Easting	Northing	Vegetation Association	Nevada Quadrangle	Area
ARNO-1	949	565730	4109500	ARNO	Ammonia Tanks	18
ARNO-2	1092	561650	4111980	ARNO	Ammonia Tanks	18
ARNO-3	1104	561170	4108560	ARNO	Buckboard Mesa	18
ARNO-4	1112	559380	4103250	ARNO	Buckboard Mesa	18
ARNO-5	1172	551770	4112560	ARNO	Scrugham Peak	18
ARNO-6	1239	545470	4119950	ARNO	Scrugham Peak	20
ARNO-7	1299a	551010	4120380	ARNO	Scrugham Peak	20
ARNO-8	1344	544000	4126800	ARNO	Trail Ridge	20
ARTR-1	1531	560950	4120070	ARTR	Ammonia Tanks	18
ARTR-2	1418	561270	4133610	ARTR	Dead Horse Flats	19
ARTR-3	827	573610	4093120	ARTR	Mine Mountain	14
ARTR-4	904	568420	4122220	ARTR	Rainier Mesa	12
ARTR-5	619	554850	4111190	ARTR	Scrugham Peak	18
ARTR-6	1299	551100	4123030	ARTR	Scrugham Peak	18
ARTR-7	1194	554750	4102490	ARTR	Timber Mountain	18
ARTR-8	948	567900	4108490	ARTR	Tipipah Spring	17
ARTR-9	1276	542460	4130600	ARTR	Trail Ridge	20
ARTR-10	1385	546420	4129640	ARTR	Silent Butte	20
ARTR-11	1344	543450	4126990	ARTR	Trail Ridge	20
PIMO-ARNO-1	1508	563610	4117080	PIMO-ARNO	Ammonia Tanks	19
PIMO-ARNO-2	1554	563990	4130190	PIMO-ARNO	Dead Horse Flats	19
PIMO-ARNO-3	859	570770	4113310	PIMO-ARNO	Rainier Mesa	12
PIMO-ARNO-4	863	571950	4118680	PIMO-ARNO	Rainier Mesa	12
PIMO-ARNO-5	894	569050	4120260	PIMO-ARNO	Rainier Mesa	12
PIMO-ARNO-6	896	567480	4119740	PIMO-ARNO	Rainier Mesa	12
PIMO-ARNO-7	1441	553400	4118980	PIMO-ARNO	Scrugham Peak	19
PIMO-ARNO-8	1389	550100	4127950	PIMO-ARNO	Silent Butte	20
PIMO-ARNO-9	1403	554420	4123600	PIMO-ARNO	Silent Butte	19
PIMO-ARNO-10	1399	554340	4126910	PIMO-ARNO	Silent Butte	19
PIMO-ARTR-1	683	564370	4119910	PIMO-ARTR	Ammonia Tanks	19
PIMO-ARTR-2	1532	559370	4119720	PIMO-ARTR	Ammonia Tanks	19
PIMO-ARTR-3	1464	560410	4122840	PIMO-ARTR	Dead Horse Flats	19
PIMO-ARTR-4	872	569470	4088080	PIMO-ARTR	Mine Mountain	29
PIMO-ARTR-5	860	570070	4114010	PIMO-ARTR	Rainier Mesa	12
PIMO-ARTR-6	862	568830	4118000	PIMO-ARTR	Rainier Mesa	12
PIMO-ARTR-7	903	568270	4122440	PIMO-ARTR	Rainier Mesa	12
PIMO-ARTR-8	1425	560050	4125220	PIMO-ARTR	Dead Horse Flats	19
PIMO-ARTR-9	1193	552570	4100630	PIMO-ARTR	Timber Mountain	30
PIMO-ARTR-10	1500	549730	4101340	PIMO-ARTR	Timber Mountain	30
PIMO-ARTR-11	1195	553680	4102900	PIMO-ARTR	Timber Mountain	18
PIMO-ARTR-12	1541	570000	4096080	PIMO-ARTR	Tipipah Spring	16
PIMO-ARTR-4 Burned	872	569039	4087972	PIMO-ARTR	Mine Mountain	29
PIMO-ARTR-11 Unburned	1195	553630	4102900	PIMO-ARTR	Timber Mountain	18

Plant cover was estimated using an optical point projection device (Buckner 1985). The optical device was placed at 1-meter intervals and 2 points were taken at each interval. The first point was taken with the arm of the optical device at a 45-degree angle to the transect. The arm was then positioned at a 135-degree angle and a second sample was recorded. This process was repeated every meter along the 50-m long permanent transect yielding 100 points for each transect. Cover was recorded as vegetation (by species), bare ground, litter, gravel (<2.5 cm), cobble (2.5-12.7 cm), or rock (>12.7 cm). Five transects were sampled at 10-m intervals at every plot yielding 500 total cover points per plot. These points were then averaged to obtain a mean cover for each plot.

Density was estimated using a 1-m wide linear transect with one edge being the transect used for estimating cover. The total number of individual perennial plants by species within each 5-m segment of the transect was recorded. Annuals were not included in this sampling since they vary tremendously among years. The data were averaged over all the segments along each 50-m long transect. Three density transects were sampled in each plot. Density within each plot was obtained by averaging data from the three transects.

4.2.1.1 Results of Cover Measurements

Cover data for all four plot types is reported in Table 4-4. Perennial plant cover was lower and gravel cover higher in ARNO plots than the other three types. Bare ground averaged between 3.0% and 13.9% which is a good indicator that the soil in these areas is somewhat erosion-resistant. On PIMO-ARNO and PIMO-ARTR plots the optical device was also pointed upward to get an estimate of overstory cover. These overstory values represent a separate measure of cover above 1.5 m. They are not additive with understory to get total cover. Overstory values were similar in the two plot types.

Comparisons between the PIMO-ARTR burned and unburned plots (Table 4-4) reveal a pattern of increased total vegetation cover in burned versus unburned plots. This difference is particularly pronounced at PIMO-ARTR-11 which is caused by an abundance of cheatgrass (79.6% cover) that invaded the site soon after the wildfire in 2011. Perennial plant cover is also substantially lower on the burned sites compared to the unburned sites.

4.2.1.2 Results of Density Measurements

Summarized density data (number of plants per 50 square meters) is reported in Table 4-5. While there is tremendous variability within vegetation types, the ARTR plots had the highest average density (190.5) followed by the PIMO-ARNO and PIMO-ARTR plots (167.9 and 165.0, respectively) and lastly ARNO plots (149.6). Singleleaf pinyon was the dominant tree with an average of about 5.6 plants per 50 square meters while Utah juniper averaged 0.9 plants per 50 square meters in the PIMO-ARTR plots. Big sagebrush dominated the shrub category with an average of 24.5 plants per 50 square meters. Sandberg bluegrass (*Poa secunda*) dominated the grasses with 52.4 plants per 50 square meters, and ballhead sandwort (*Arenaria congesta)* and matted buckwheat (*Eriogonum caespitosum*) dominated the forbs with 10.7 and 9.6 plants per 50 square meters, respectively.

Total perennial species densities were higher in unburned plots than burned plots. This difference was especially pronounced for all plant growth forms at PIMO-ARTR-11 (Table 4-5) which burned in 2011.

Table 4-4. Percent cover data for long-term vegetation monitoring plots. Black sagebrush plots (ARNO) and big sagebrush plots (ARTR) were sampled in 2009. Singleleaf pinyon-black sagebrush plots (PIMO-ARNO) were sampled in 2015. Singleleaf pinyon-big sagebrush plots (PIMO-ARTR) were sampled in 2016.

Plots	Total Vegetation	Understory (Perennial)	Overstory	Litter	Bare ground	Gravel	Cobble	Rock
ARNO-01	21.6	14.0	0.0	31.4	9.4	32.6	3.6	1.4
ARNO-02	26.6	26.0	0.0	20.6	9.8	25.4	6.8	10.8
ARNO-03	22.8	19.8	0.0	18.4	10.0	41.0	4.6	3.2
ARNO-04	16.4	12.4	0.0	21.8	12.4	39.8	5.4	4.2
ARNO-05	23.4	21.8	0.0	19.2	8.4	46.2	2.2	0.6
ARNO-06	24.8	24.8	0.0	10.4	8.6	48.8	2.6	4.8
ARNO-07	27.4	27.4	0.0	17.6	9.8	35.6	4.8	4.8
ARNO-08	28.2	28.2	0.0	12.0	6.0	51.8	0.8	1.2
Mean	**23.9**	**21.8**	**0.0**	**18.9**	**9.3**	**40.2**	**3.9**	**3.9**
ARTR-01	40.8	37.2	0.0	33.2	21.2	4.8	0.0	0.0
ARTR-02	29.4	29.4	0.0	24.4	29.0	16.4	0.4	0.4
ARTR-03	34.0	19.2	0.0	32.0	4.8	29.0	0.2	0.0
ARTR-04	43.4	43.4	0.0	28.8	14.2	13.4	0.2	0.0
ARTR-05	22.6	21.2	0.0	25.2	16.2	35.2	0.8	0.0
ARTR-06	28.8	28.6	0.0	13.8	24.4	25.8	3.8	3.4
ARTR-07	28.0	20.6	0.0	19.4	9.6	41.6	0.6	0.8
ARTR-08	26.4	21.4	0.0	25.8	6.8	41.0	0.0	0.0
ARTR-09	24.8	24.2	0.0	27.0	8.2	39.8	0.0	0.2

Table 4-4. Percent cover data for long term vegetation monitoring plots. Black sagebrush plots (ARNO) and big sagebrush plots (ARTR) were sampled in 2009. Singleleaf pinyon-black sagebrush plots (PIMO-ARNO) were sampled in 2015. Singleleaf pinyon-big sage sagebrush plots (PIMO-ARTR) were sampled in 2016 (continued).

Plots	Total Vegetation	Understory (Perennial)	Overstory	Litter	Bare ground	Gravel	Cobble	Rock
ARTR-10	25.0	25.0	0.0	24.6	10.6	37.2	2.2	0.4
ARTR-11	29.2	29.2	0.0	18.0	8.4	41.6	0.4	2.4
Mean	**30.2**	**27.2**	**0.0**	**24.7**	**13.9**	**29.6**	**0.8**	**0.7**
PIMO-ARNO-01	31.0	24.4	9.8	36.8	9.6	24.2	1.4	3.6
PIMO-ARNO-02	31.4	23.4	17.0	27.8	4.2	14.8	2.2	27.6
PIMO-ARNO-03	34.0	23.2	19.4	33.0	8.8	23.4	2.0	9.6
PIMO-ARNO-04	34.0	23.0	20.0	25.3	2.7	30.7	6.0	12.3
PIMO-ARNO-05	46.2	32.0	30.2	36.0	4.4	10.6	3.6	13.2
PIMO-ARNO-06	42.2	28.4	22.8	37.0	4.0	21.4	1.2	7.8
PIMO-ARNO-07	45.0	41.0	10.6	23.8	8.6	14.4	1.6	10.6
PIMO-ARNO-08	32.4	22.6	15.0	26.2	3.0	29.2	4.4	14.6
PIMO-ARNO-09	34.6	25.2	18.8	25.0	2.6	23.0	2.8	21.4
PIMO-ARNO-10	35.0	29.2	13.8	24.2	12.6	15.8	4.4	13.8
Mean	**36.6**	**27.3**	**17.7**	**29.5**	**6.1**	**20.8**	**3.0**	**13.5**

Table 4-4. Percent cover data for long-term vegetation monitoring plots. Black sagebrush plots (ARNO) and big sagebrush plots (ARTR) were sampled in 2009. Singleleaf pinyon-black sagebrush plots (PIMO-ARNO) were sampled in 2015. Singleleaf pinyon-big sagebrush plots (PIMO-ARTR) were sampled in 2016 (continued).

Plots	Total Vegetation	Understory (Perennial)	Overstory	Litter	Bare ground	Gravel	Cobble	Rock
PIMO-ARTR-01	34.8	33.0	24.6	38.4	4.2	11.4	4.8	6.8
PIMO-ARTR-02	41.8	41.8	21.2	37.4	6.2	9.0	0.6	4.0
PIMO-ARTR-03	23.4	23.0	34.2	43.4	1.4	12.4	6.2	12.8
PIMO-ARTR-04 Burned	39.2	12.2	0	9.0	1.6	46.4	1.4	2.2
PIMO-ARTR-04 Unburned	29.7	29.1	26.0	39.6	4.0	23.0	2.0	2.4
PIMO-ARTR-05	24.4	24.4	30.2	42.6	3.8	21.2	2.2	5.2
PIMO-ARTR-06	36.2	35.8	25.6	45.8	1.4	16.2	0.0	0.0
PIMO-ARTR-07	24.8	23.0	47.6	45.6	0.2	26.2	1.0	1.2
PIMO-ARTR-08	28.8	28.8	26.0	32.0	7.8	23.2	1.0	6.6
PIMO-ARTR-09	34.4	25.8	7.6	13.8	1.2	47.0	1.2	0.4
PIMO-ARTR-10	36.0	34.6	23.0	27.2	1.4	19.6	6.4	3.4
PIMO-ARTR-11 Burned	82.2	2.4	0	3.2	3.4	4.8	1.4	4.2
PIMO-ARTR-11 Unburned	31.8	27.4	8.0	17.4	4.0	31.2	2.8	7.4

Table 4-4. Percent cover data for long-term vegetation monitoring plots. Black sagebrush plots (ARNO) and big sagebrush plots (ARTR) were sampled in 2009. Singleleaf pinyon-black sagebrush plots (PIMO-ARNO) were sampled in 2015. Singleleaf pinyon-big sagebrush plots (PIMO-ARTR) were sampled in 2016 (continued).

Plots	Total Vegetation	Understory (Perennial)	Overstory	Litter	Bare ground	Gravel	Cobble	Rock
PIMO-ARTR-12	26.2	25.0	10.6	19.6	1.4	21.0	27.2	3.8
Mean	**35.3**	**26.2**	**20.3**	**29.6**	**3.0**	**22.3**	**4.2**	**4.3**

4.3 REPTILE STUDIES

No formal trapping or roadkill studies took place during 2016. However, some opportunistic reptile observations were documented and tissue samples from two specimens (one red racer [*Masticophis flagellum*], one king snake [*Lampropeltis getula*]) were collected and given to the Nevada Department of Wildlife (NDOW) for future genetic analysis. The purpose of ongoing reptile sampling is to fill in data gaps for species that have not been documented recently or are rare on the NNSS. Additionally, an NSTec biologist helped NDOW collect and prepare genetic samples from dozens of snake and lizard specimens from Nevada to be stored for future analysis.

4.3.1 Opportunistic Observations

A total of five snakes including one juvenile night snake (*Hypsiglena torquata*), one juvenile red racer, and three western ground snakes (*Sonora semiannulata*) were found in buildings around Mercury and released back into the desert. One of the ground snakes and the red racer were found alive on glue traps, extricated, and then released. One dead juvenile king snake was found on a glue trap in a building in Mercury.

4.4 NATURAL WATER SOURCE MONITORING

4.4.1 Existing Water Sources Monitored

Ten natural water sources (six springs, four rock tanks) were monitored with motion-activated cameras in 2016, primarily to document the presence of mountain lions and other wildlife (Figure 4-7). Results are found in Table 6-3 (see Section 6.7.1, Motion-Activated Cameras). General assessments were also made of each spring and surrounding area to document major disturbances or changes to these important water sources. Topopah Spring was nearly dry with just a small wet spot in the cave pool. Vegetation was heavily trampled by mule deer at Twin Spring and there was only a small pool of standing water.

Gold Meadows Spring had the greatest number of images (1,173 images) of any natural water source monitored with most of the images being pronghorn antelope (586 images), mule deer (*Odocoileus hemionus*) (334 images), and horses (*Equus caballus*) (165 images). Other species detected were golden eagle (*Aquila chrysaetos*) (48 images), elk (*Cervus elaphus*) (24 images), coyote (*Canis latrans*) (5 images), and common raven (*Corvus corax*) (11 images). The number of images taken in 2016 was nearly half of the number of images taken in 2015 for unexplained reasons.

Table 4-5. Density data for long-term vegetation monitoring plots. Black sagebrush plots (ARNO) and big sagebrush plots (ARTR) were sampled in 2009. Singleleaf pinyon-black sagebrush plots (PIMO-ARNO) plots were sampled in 2015. Singleleaf pinyon-big sagebrush plots (PIMO-ARTR) were sampled in 2016. Data represent number of individual plants per 50 square meters.

Plots	All Perennials	Trees & Shrubs	Perennial grasses	Perennial forbs
ARNO-01	65.0	54.7	9.0	1.3
ARNO-02	233.3	96.3	114.7	22.3
ARNO-03	75.6	72.0	2.0	1.6
ARNO-04	52.0	42.0	9.7	0.3
ARNO-05	80.3	75.7	4.0	0.7
ARNO-06	206.7	139.7	64.0	3.0
ARNO-07	144.0	126.0	14.7	3.3
ARNO-08	340.0	129.3	195.3	15.3
MEAN	**149.6**	**92.0**	**51.7**	**6.0**
ARTR-01	488.3	109.3	112.7	266.3
ARTR-02	316.0	119.0	193.0	4.0
ARTR-03	166.7	28.3	43.0	95.3
ARTR-04	211.0	100.3	69.7	41.0
ARTR-05	116.7	59.3	43.0	14.3
ARTR-06	220.7	111.3	67.3	42.0
ARTR-07	69.7	38.3	22.7	8.7
ARTR-08	74.7	45.0	29.7	0.0
ARTR-09	76.0	51.7	24.3	0.0
ARTR-10	98.3	81.0	17.3	0.0
ARTR-11	257.3	73.3	176.0	8.0
MEAN	**190.5**	**74.2**	**72.6**	**43.6**

Table 4-5. Density data for long-term vegetation monitoring plots. Black sagebrush plots (ARNO) and big sagebrush plots (ARTR) were sampled in 2009. Singleleaf pinyon-black sagebrush plots (PIMO-ARNO) plots were sampled in 2015. Singleleaf pinyon-big sagebrush plots (PIMO-ARTR) were sampled in 2016. Data represent number of individual plants per 50 square meters (continued).

Plots	All Perennials	Trees & Shrubs	Perennial grasses	Perennial forbs
PIMO-ARNO-01	137.7	78.0	12.3	47.3
PIMO-ARNO-02	154.0	73.7	45.7	34.7
PIMO-ARNO-03	156.7	51.7	67.0	38.0
PIMO-ARNO-04	469.5	121.0	126.5	222.0
PIMO-ARNO-05	192.7	51.3	86.3	55.0
PIMO-ARNO-06	244.3	52.7	113.3	78.3
PIMO-ARNO-07	116.7	72.7	34.7	9.3
PIMO-ARNO-08	42.7	36.0	2.0	4.7
PIMO-ARNO-09	75.3	50.0	11.3	14.0
PIMO-ARNO-10	89.3	63.3	12.3	13.7
MEAN	**167.9**	**65.0**	**51.1**	**51.7**
PIMO-ARTR-01	261.0	74.7	109.0	77.3
PIMO-ARTR-02	264.0	76.7	135.7	51.7
PIMO-ARTR-03	180.0	42.7	91.0	46.3
PIMO-ARTR-04 Burned	43.0	5.0	12.0	26.0
PIMO-ARTR-04 Unburned	59.3	34.0	13.7	11.7
PIMO-ARTR-05	138.0	30.7	51.0	56.3
PIMO-ARTR-06	77.7	48.7	26.7	2.3
PIMO-ARTR-07	32.7	8.3	18.3	6.0
PIMO-ARTR-08	64.7	35.7	7.3	21.7
PIMO-ARTR-09	175.3	81.3	73.7	20.3
PIMO-ARTR-10	274.0	68.3	172.3	33.3

Table 4-5. Density data for long-term vegetation monitoring plots. Black sagebrush plots (ARNO) and big sagebrush plots (ARTR) were sampled in 2009. Singleleaf pinyon-black sagebrush plots (PIMO-ARNO) plots were sampled in 2015. Singleleaf pinyon-big sagebrush plots (PIMO-ARTR) were sampled in 2016. Data represent number of individual plants per 50 square meters (continued).

Plots	All Perennials	Trees & Shrubs	Perennial grasses	Perennial forbs
PIMO-ARTR-11 Burned	71.0	4.3	61.3	5.3
PIMO-ARTR-11 Unburned	475.7	73.7	281.7	120.3
PIMO-ARTR-12	194.3	98.0	68.3	28.0
Mean	**165.0**	**48.7**	**80.1**	**36.2**

More than 1,000 images were taken at Cottonwood Spring including mourning dove (*Zenaida macroura*) (925 images), chukar (*Alectoris chukar*) (138 images), bobcat (*Lynx rufus*) (29 images), mule deer (3 images) and greater roadrunner (*Geococcyx californianus*) (1 image). Images at Captain Jack Spring were dominated by mule deer (822 of 1,009 images) with 13 other species detected. Of particular note was the photo of a northern saw-whet owl (*Aegolius acadicus*) only the second one ever detected on the NNSS (see Section 6.1.2 for details about the first one). A total of 264 images were taken at Topopah Spring with most of these of coyotes (194 images). Mule deer was the most common species photographed at Twin Spring (59 of 85 images). Only four species were photographed at Cane Spring and included coyote (18 images), mule deer (74 images), mourning dove (7 images), and common raven (12 images).

4.5 CONSTRUCTED WATER SOURCE MONITORING

Nine constructed water sources were monitored with motion-activated cameras to document the presence of mountain lions and other wildlife during 2016. These included one well pond (Camp 17 Pond), five water troughs installed to mitigate the loss of well ponds, and three radiologically-contaminated sumps (Figure 4-8).

Camp 17 Pond had the greatest number of images documented (3,278 images) during 2016 of any of the cameras in operation with 16 species (8 mammal, 8 bird) being photographed (Table 6-3). Red-tailed hawk (*Buteo jamaicensis*) (1,295 images) and mule deer (1,003) accounted for most of the activity. This is the highest number of red-tailed hawk images ever documented in a single year at any site monitored with motion-activated cameras on the NNSS. In many images there are 10-15 hawks within the field of view (Figure 4-9). This is very atypical to have such a high concentration of hawks. Most of the activity occurred between late July and mid-October. Other noteworthy observations include one pronghorn antelope and 36 images of golden eagles. Raptor activity at this site was unusually high this year.

4.5.1 Mitigating Water Loss for Wildlife

Water conservation measures were implemented on the NNSS during 2012 at four sites: Area 6 Construction Yard (Area 6 Los Alamos National Laboratory [LANL] Pond), Well C1 Pond, Well 5B Pond, and J11 Pond. In order to conserve millions of gallons of water being lost to drainage and

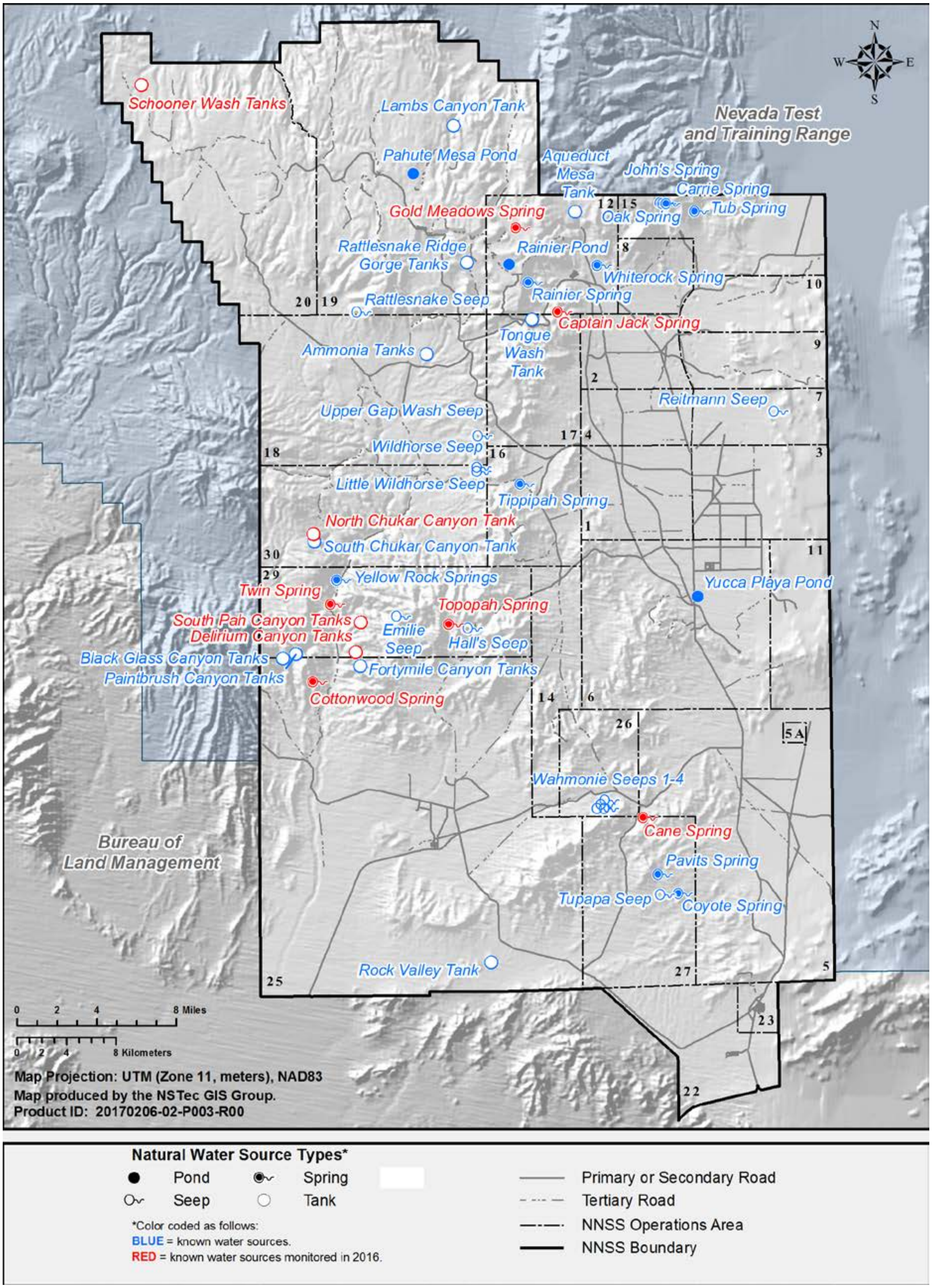

Figure 4-7. Natural water sources on the NNSS including those monitored in 2016.

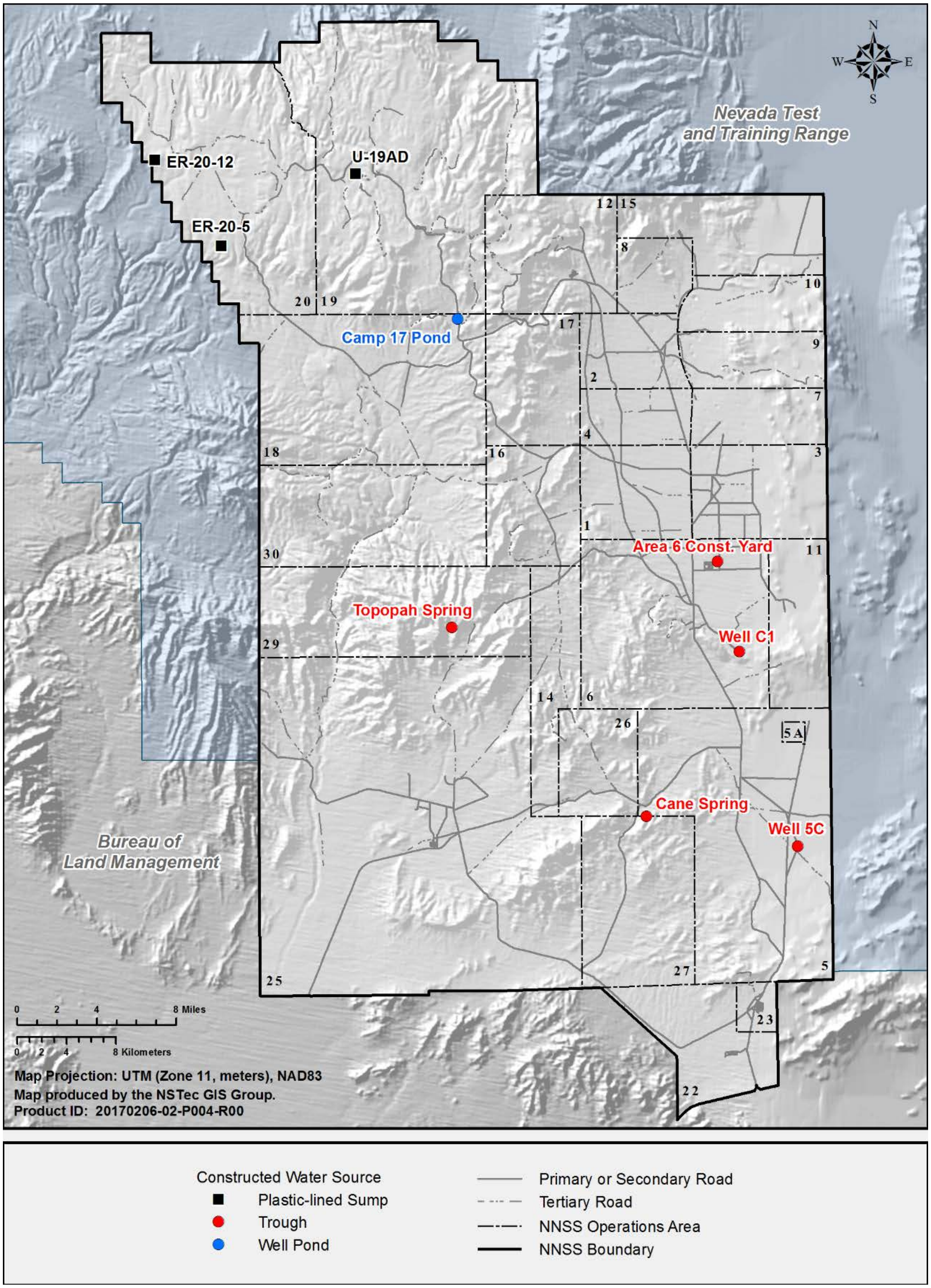

Figure 4-8. Constructed water sources monitored with motion-activated cameras for wildlife use during 2016.

Figure 4-9. Numerous red-tailed hawks at Camp 17 Pond.

(Photo by motion-activated camera, July 27, 2016)

evaporation, pumping water to fill these ponds was stopped. Wildlife observation data gathered over several decades documented more than 100 species of wildlife using these artificial water sources. These included carnivores, ungulates, rabbits, bats, and dozens of species of waterfowl, passerines, and other birds.

Drying these ponds up resulted in the loss of valuable wildlife habitat, so water troughs were installed to help mitigate the loss of the well ponds. The water troughs were not meant to replace the well ponds as wildlife habitat, but were meant to provide at a minimum some supplemental water in areas with very limited perennial water sources and at sites where animals had become accustomed to finding water.

Water troughs were installed adjacent to the Area 6 LANL Pond and Well C1 Pond to mitigate the loss of these ponds, at Well 5A (Well 5C) to mitigate the loss of the Well 5B Pond, and at Cane Spring and Topopah Spring to mitigate the loss of the J11 Pond (Figure 4-8). Motion-activated cameras were set up at each trough during the fall of 2012 and have been monitored since then to document wildlife use. These cameras were also added to the network of cameras used for monitoring mountain lions and results for 2016 are included in Table 6-3 (see Section 6.7.1, Motion-Activated Cameras).

Wildlife use at Well C1 trough was heavy (2,367 images) with at least 15 species (6 mammals and 9 birds) documented at the trough (Table 6-3). Use peaked during the dry, summer months. Use was dominated by common ravens (1,501 images) and mourning doves (623 images). Noteworthy species documented included golden eagle, Cooper's hawk (*Accipiter cooperii*), and greater roadrunner.

At the Area 6 LANL Pond, wildlife use of the trough was moderate (579 images) and peaked during the dry, summer months (Table 6-3). Use was dominated by turkey vultures (*Cathartes aura*) (226 images), pronghorn antelope (134 images), and common ravens (130 images). At least 11 species (4 mammals and 7 birds) were documented through the year including golden eagles (19 images).

Wildlife use at Well 5C trough was light (70 images) with at least 9 species (6 mammals and 3 birds) photographed (Table 6-3). Black-tailed jackrabbits (23 images) and burros (*Equus asinus*) (21 images) were the most commonly photographed species. Four photos of golden eagles and a domestic dog with a radio collar were also documented.

Wildlife use at the trough at Cane Spring was light (24 images) with six species detected (3 mammals and 3 birds) (Table 6-3). These included bobcat (1 image), coyote (5 images), mule deer (7 images), turkey vulture (1 image), mourning dove (9 images), and common raven (1 image). Wildlife use was greatly reduced during 2016 compared to 2015. Unlike 2015, the number of animal photographs taken at the trough (24 images) were five times less than those taken at the spring (111 images) with mule deer being the most different (74 versus 7). Bobcat (1 image) and turkey vulture (11 images) were detected at the trough but not at the spring.

Wildlife use at the Topopah Spring trough was light (63 images) with 4 species (3 mammals and 1 bird) documented (Table 6-3). Most of the activity was from mule deer (58 images). One image of a desert bighorn sheep was taken near the trough (Figure 4-10). In contrast to Cane Spring, the number of animal photographs taken at the Topopah Spring trough (63 images) was substantially less than at the spring (264 images) with six mammal species and two bird species detected at the spring. Differences in use may be a preference for the natural setting at the spring versus using the artificial trough or water availability or a combination of both.

In summary, several wildlife species are using the water troughs, indicating that the troughs are benefiting many wildlife species on the NNSS, especially certain bird species, ungulates, and coyotes. Waterfowl and shorebirds do not appear to be using the troughs and undoubtedly have been negatively impacted by the removal of the well ponds. Although the water troughs did not replace the well ponds as a wildlife resource, they still attract and benefit a multitude of wildlife species.

4.5.2 Monitoring Wildlife Use at Potentially Contaminated Water Sources

During 2016, motion-activated cameras were set up at three potentially contaminated water sources which are sumps constructed to retain groundwater and drilling fluids from Underground Test Area (UGTA) wells during drilling, well development, and groundwater testing. The sumps included those located at UGTA wells ER 20-5, U19ad, and ER20-12 that was constructed during 2015 (Figure 4-3). The cameras were also added to the network of cameras used for mountain lion monitoring (see Section 6.7.1, Motion-Activated Cameras). Typically, discharge water and drilling fluids having ≥400,000 picocuries/liter (pCi/L) of tritium are diverted to plastic-lined sumps to evaporate; otherwise, they are diverted to unlined sumps. Inactive well sumps can also retain precipitation, which can become contaminated from sediments accumulated in the sumps. The cameras were set up to document which wildlife species were using the sumps and their frequency of use to assess the potential transport of radionuclides off-site by wildlife as well as the potential impact to the wildlife themselves.

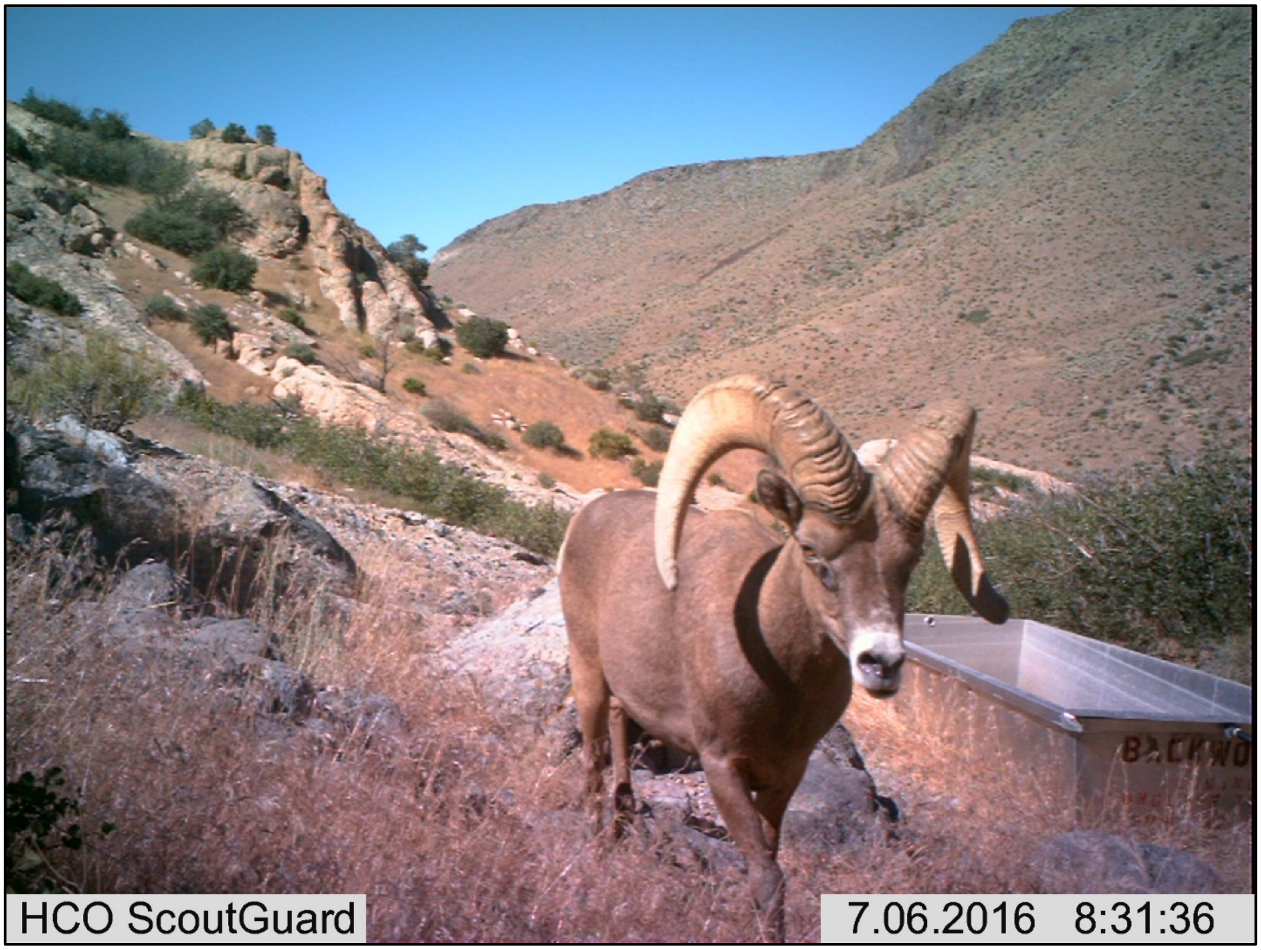

Figure 4-10. Desert bighorn sheep ram by trough near Topopah Spring.

(Photo by motion-activated camera, July 6, 2016)

There are five, plastic-lined sumps at ER 20-5. A camera was set up at the sump in the northwest corner. Results showed some use with 9 images of coyotes, 2 images of mule deer, 9 images of mourning doves and 11 images of common ravens at the site (Table 6-3). Wildlife use at the U19ad plastic-lined sump was minimal with only 14 images of mule deer and 1 image of a common raven documented during 2016 (Table 6-3).

ER 20-12 was constructed during 2015 and because of its large size, two cameras (one in the northeast corner, one in the southeast corner by the sediment ramps) were installed in January 2016 to monitor wildlife use. More wildlife images were taken at the southeast corner (Figure 4-11) than the northeast corner (45 versus 28). Data from both cameras combined showed at least seven species (1 mammal, 6 birds) using the site (Table 6-3). Common raven (48 images) was the most commonly photographed species. Mule deer (2 images), mourning dove (3 images), great-horned owl (*Bubo virginianus*) (3 images), shorebirds (8 images), unknown hawk (1 image), and a passerine (1 image) were also detected (Table 6-3).

Overall, wildlife use at the contaminated sumps was minimal. However, important species are using them and are potentially uptaking radiological contaminants. Huntable species such as mule deer and mourning doves are a potential pathway of exposure to the general public. Protected birds such as hawks and ravens

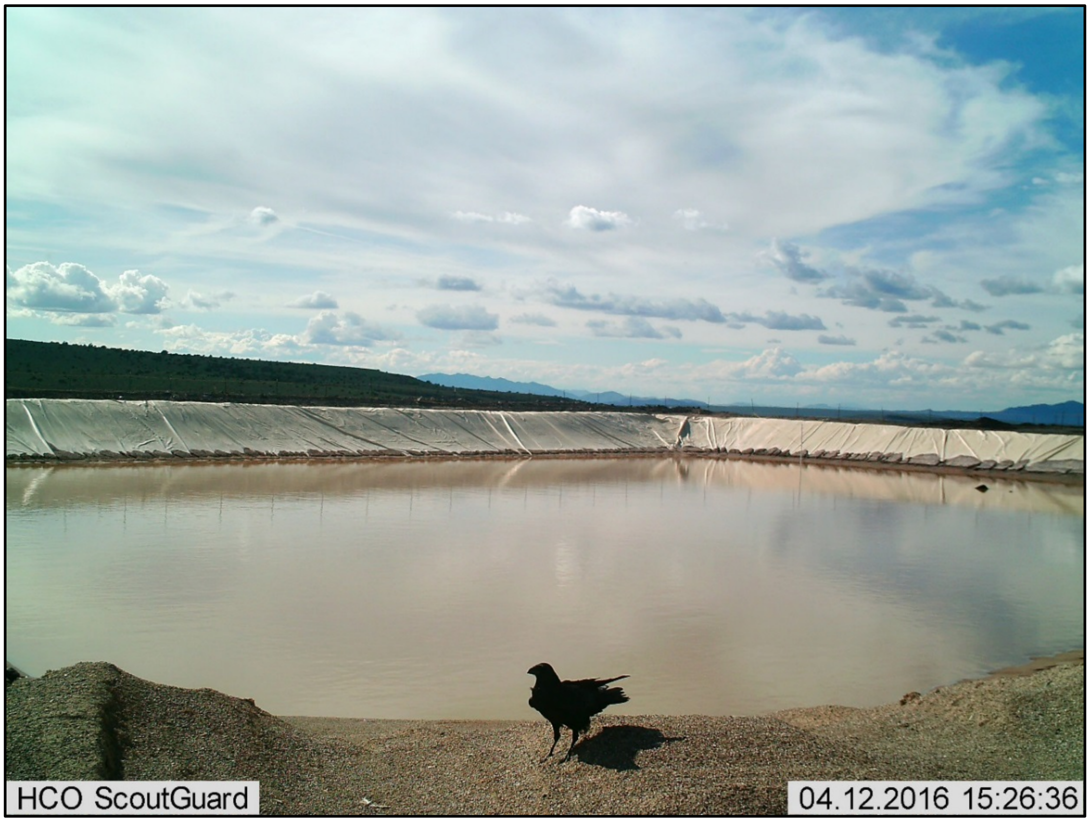

Figure 4-11. ER20-12 sump as seen from southeast corner with common raven in foreground.

(Photo by motion-activated camera, April 12, 2016)

may also be impacted. UGTA sumps will continue to be monitored to determine their level of use by various wildlife species and to calculate the potential dose someone eating contaminated wildlife may receive and if the dose is harmful to the animal. More detailed information about potential dose to humans and wildlife can be found in the annual Nevada National Security Site Environmental Reports (e.g., NSTec, 2016) available at http://www.nnss.gov/pages/resources/library/NNSSER.html.

4.6 COORDINATION WITH SCIENTISTS AND ECOSYSTEM MANAGEMENT AGENCIES

Site biologists interfaced with other scientists and ecosystem management agencies in 2016 for the following activities:

- Prepared an assessment of pollinator habitat and best management practices used on the NNSS in response to the presidential initiative on pollinator health.
- Coordinated with U.S. Forest Service to provide them access for field sampling of pinyon-juniper sites for the Interior West Forest Inventory and Analysis Program.
- A site biologist received his recertification as a Certified Wildlife Biologist from The Wildlife Society.
- Participated in a two-day training course on assessing impacts of climate change to site resources.
- Prepared an informational poster for the 65th Anniversary of the NNSS entitled “Ten Reasons why the Nevada National Security Site is a National Ecological Treasure.”

5.0 SENSITIVE PLANT MONITORING

The list of sensitive plants on the NNSS (see Table 2-1) is reviewed annually to ensure that the appropriate species are included in the NNSS Sensitive Plant Monitoring Program. The review takes into consideration information gathered on sensitive plants during the current year by NSTec botanists as well as input from regional botanists with expertise or knowledge with particular species. The redspined fishhook cactus was added back onto the NNSS sensitive plant list this year because it is on the NNHP "At-risk species list." This species is relatively common on the NNSS, so it was given a marginal status (Table 2-1). As part of the Adaptive Management Plan for Sensitive Plant Species (Bechtel Nevada 2001), the status of each plant is monitored periodically to ensure NNSS activities are not impacting the species. Field surveys are also conducted to verify previously reported locations, to better define population boundaries, and to identify potential habitat for sensitive plant species known to occur on or adjacent to the NNSS. Information gathered each year on sensitive plants is disseminated to state and federal agencies and other interested entities.

Sensitive plant monitoring surveys were not conducted in 2016 on the NNSS. However, some new populations of sanicle biscuitroot (*Cymopterus ripleyi* var. *saniculoides*) and Clarke phacelia (*Phacelia filiae*) were found in the southern portion of Frenchman Flat while conducting other surveys.

6.0 SENSITIVE AND PROTECTED/REGULATED ANIMAL MONITORING

The NNHP Animal and Plant At-Risk Tracking List (NNHP 2017); NAC 503, "Hunting, Fishing and Trapping; Miscellaneous Protective Measures" (NAC 2017); the FWS Endangered Species home page (FWS 2017); and other sources were reviewed to determine if any changes had been made to the status of animal species known to occur on the NNSS. One species, the Inyo shrew (*Sorex tenellus*), was added to the NNSS list during 2016. In addition, two new bird species were added to the NNSS bird species list. These include the northern saw-whet owl and the Eurasian collared dove (*Streptopelia decaocto*) (observed in Area 5, March 15, 2016). The complete list with current designations is found in the Sensitive and Protected/Regulated Animal Species List (Table 2-1).

Surveys of sensitive and protected/regulated animals during 2016 focused on (a) birds, (b) bats (c) wild horses, (d) mule deer, (e) desert bighorn sheep, and (f) mountain lions. Information about other noteworthy wildlife observations, bird mortalities, and a summary of nuisance animals and their control on the NNSS is also presented.

6.1 BIRDS

Bird monitoring on the NNSS during 2016 focused on Migratory Bird Treaty Act Compliance, documenting bird mortalities, and conducting winter raptor surveys. Also noteworthy is the recording of several greater roadrunner observations across the NNSS in Areas 23, 5, 16, 30, and 12. Roadrunners were also documented on motion-activated cameras in Areas 29 (West Topopah Spring), 19 (Water Bottle Canyon), and 6 (Well C1 Pond Trough) (Table 6-3). Nearly as many roadrunner observations were documented this year than in the past 20 years combined.

6.1.1 Migratory Bird Treaty Act Compliance

The Migratory Bird Treaty Act (MBTA) is a federal law designed to protect most bird species. All but six birds known to occur on the NNSS are protected under the MBTA. Exceptions include the European starling (*Sturnus vulgaris*), English house sparrow (*Passer domesticus*), rock dove or pigeon (*Columba livia*), and the Eurasian collared dove (Federal Register, Volume 70, Number 49, March 15, 2005). The chukar and Gambel's quail (*Callipepla gambelii*) are also not protected under the MBTA but are regulated by Nevada state law as gamebirds.

Actions taken to comply with the MBTA during 2016 included the following: 1) conducted preactivity surveys for proposed projects before surface-disturbing work to avoid harming birds or their nests, 2) rescued and released three grounded birds including a common loon (*Gavia immer*), juvenile barn owl (*Tyto alba*), and juvenile poorwill (*Phalaenoptilus nuttallii*), 3) installed bird guard, protective covers and other retrofits on powerlines to reduce avian mortality, and 4) submitted draft Avian Protection Plan to FWS for comments.

6.1.2 Bird Mortalities

Bird mortality is a measure of impacts that NNSA/NFO activities may have on protected bird species. NNSA/NFO activities that have affected birds typically have been of three types: collisions with buildings, electrocution from power lines, and vehicle mortalities. Workers and biologists work together to observe and report mortalities. Historically, reported deaths of birds are sometimes numerous, with

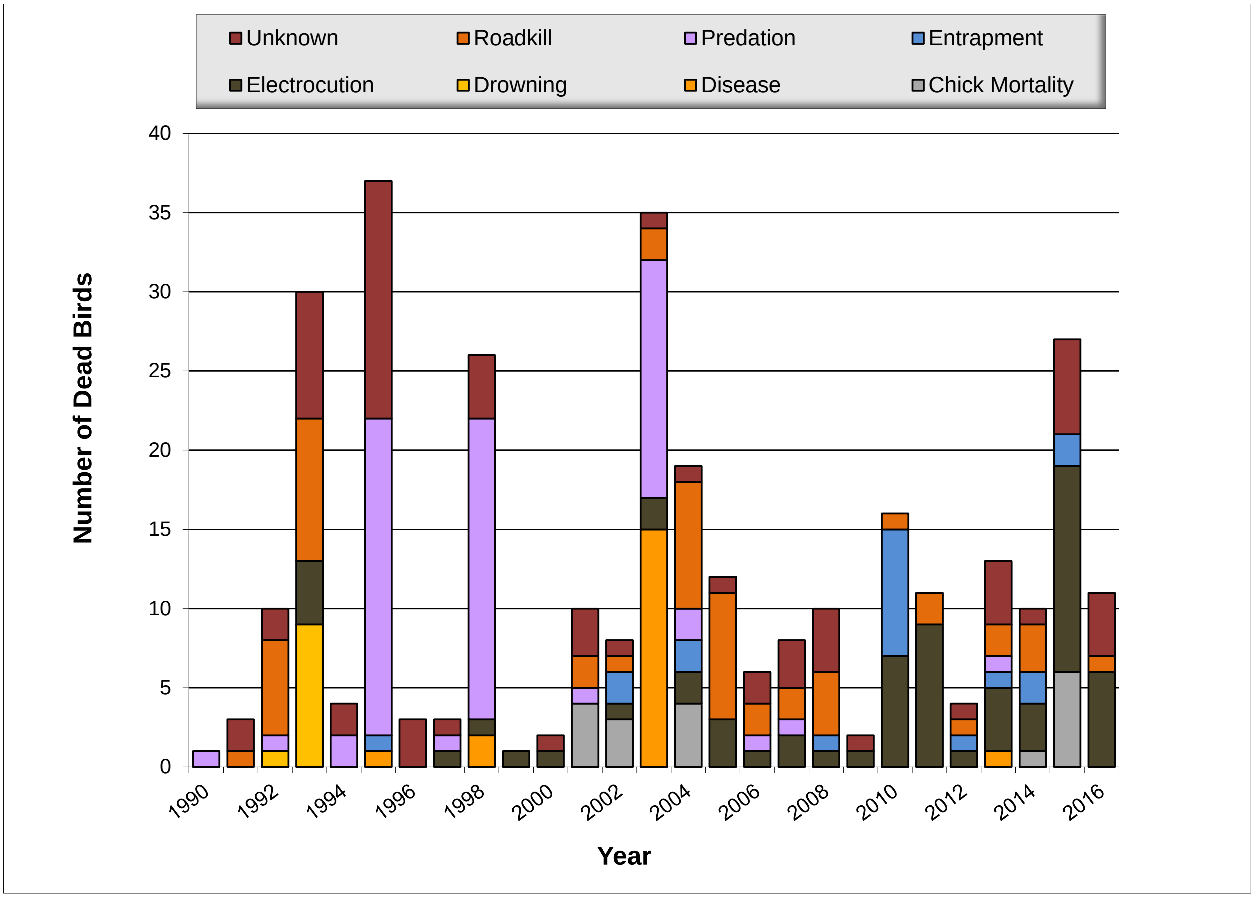

Figure 6-1. Records of reported bird deaths on the NNSS, 1990–2016.

episodes of predation and disease outbreaks involving large numbers of dead birds, particularly during wet years (Figure 6-1).

A total of 11 birds were found dead on the NNSS during 2016 (Figure 6-1). Six of these were electrocuted, including one golden eagle, three great-horned owls, and two red-tailed hawks. A turkey vulture was killed when it collided with a vehicle. Four birds were found dead of unknown causes including two red-tailed hawks, one northern saw-whet owl, and one horned lark (*Eremophila alpestris*). The northern saw-whet owl was found dead in Frenchman Flat near the Area 5 Radioactive Waste Management Complex (RWMC) on January 12, 2016. This was the first time this species had been documented on the NNSS.

The number of dead birds observed in 2016 was substantially lower than last year, and the number of electrocutions was nearly half what it was in 2015. There was an increase in bird activity due to the increased, albeit normal precipitation received during 2016, yet the number of electrocutions was substantially lower. The decrease in electrocutions could be due in part to NFO's dedication in retrofitting poles to make them avian friendly over the past few years.

The golden eagle death was reported to FWS and the carcass given to FWS law enforcement. Potential mitigation of the poles and lines where the eagle was killed was discussed by FWS, an NSTec biologist, and the NSTec power group, and are planned for completion during 2017. Two retrofit projects were completed during 2016 at sites where golden eagles had been electrocuted previously. One was in Area 1 on poles DAE 20-25 and the other was in Area 3 at poles CX 35-41 (Figure 6-2). Retrofitting included

Figure 6-2. Retrofit pole with insulator caps and a red-tailed hawk perched on top of the pole.
(Photo by D.B. Hall, February 8, 2017)

placing non-conducting covers over energized insulators and wires to prevent birds from being electrocuted.

6.1.3 Winter Raptor Surveys

Winter raptor surveys were initiated during 2014, in an effort to better understand wintering raptors on the NNSS and as a collaborative effort to provide data to the U.S. Army Corps of Engineers (USACE) for their nationwide mid-winter bald eagle survey and to NDOW for their statewide monitoring effort. These surveys continued during 2016. Surveys were conducted by driving a standard route and identifying all raptors observed (i.e., eagles, hawks, owls, and vultures). Two official routes were established on the NNSS: Southern NNSS, Route #60, and Yucca Flat, Route #61 (Figure 6-3). Data including common name, UTM coordinates (NAD 83), time, activity, age class, and perpendicular distance from the road were recorded, and climatic data (i.e., temperature, wind speed, and cloud cover) were taken at the beginning and end of each survey. Surveys were conducted January 12 (Southern NNSS) and January 13 (Yucca Flat) to coincide with the national bald and golden eagle survey and on February 8 (Southern NNSS) and February 9 (Yucca Flat).

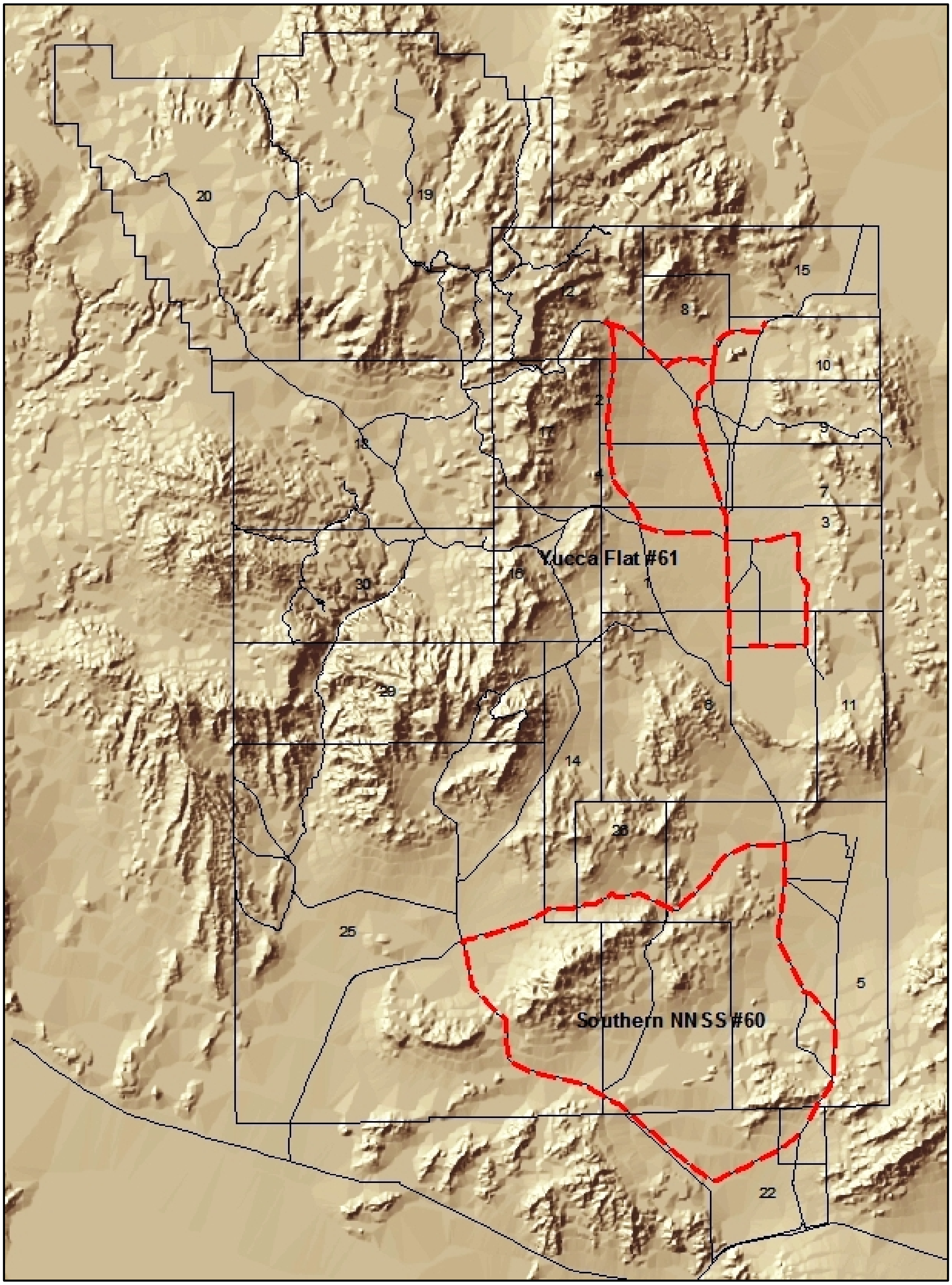

Figure 6-3. Winter raptor survey routes (red lines) on the NNSS.

The intent is for these surveys to be conducted each year for numerous years to look at long-term trends in winter raptor occurrence on the NNSS. Much is known about raptors on the NNSS in the summer, but winter data are lacking. Winter data may be important to detect changes in species composition related to climate change. Data on common ravens and loggerhead shrikes (*Lanius ludovicianus*) were also recorded because ravens are known desert tortoise predators, and the loggerhead shrike is a sensitive species. The southern route is located primarily in the Mojave Desert portion of the NNSS while the Yucca Flat route is located in the transition zone between the Mojave Desert and Great Basin Desert. Detailed driving directions for each route are given below:

- Southern NNSS—Begin route at the junction of Mercury Bypass and Jackass Flats Road (588818mE, 4057221mN). Drive west and north along Jackass Flats Road all the way to the intersection with Cane Spring Road. Turn right and drive east on Cane Spring Road all the way to Mercury Highway. Turn right and drive south on Mercury Highway all the way to the north end of the Mercury Bypass/Mercury Highway junction, which is where the route ends (590060mE, 4058668mN). Total length is 82.6 km.

- Yucca Flat—Begin route on Tweezer Road (585801mE, 4092926mN). Drive east to junction with Orange Blossom Road. Turn left and drive north along Orange Blossom Road to the intersection with 3-03 Road. Turn left and drive west along 3-03 Road to 586224mE, 4100626mN. This ends this section. Drive to the start of the next section on Pahute Mesa Road, west of Mercury Highway at the A4 RadSafe sign (583156mE, 4101146mN). Resume looking for raptors and proceed west on Pahute Mesa Road to the junction of Tippipah Highway. Turn right on Tippipah Highway and drive north to the intersection of Rainier Mesa Road. Turn right and drive southeast on Rainier Mesa Road to the intersection with 2-07 Road. Turn left on 2-07 Road and drive east to the junction of Circle Road. Turn left on Circle Road and drive past Sedan Crater, past the junction with Mercury Highway all the way to 586977mE, 4116348mN. This ends this section. Turn around and drive back to the Circle Road/2-07 Road intersection where you start the final section of the route (583225mE, 4113195mN). Drive south and follow the paved road. Curve right at the 10C landfill road intersection and proceed south along Mercury Highway all the way to the junction with Tippipah Highway. The route ends at 584446mE, 4090143mN. Total length is 75.0 km.

Results are found in Table 6-1. Two golden eagles were observed during the surveys; one in Yucca Flat during the January survey and one on the southern NNSS route during the February survey. The red-tailed hawk was the most common species detected on both routes. Abundance and species richness was greater on the Yucca Flat route than on the Southern NNSS route. Common ravens and loggerhead shrikes were more prevalent on the Yucca Flat route than the southern NNSS route. On the southern route, overall raptor abundance was higher in 2014 than in 2015 and 2016 (12 versus 3 versus 9, respectively), but similar among years on the Yucca Flat route (16 versus 17 versus 16, respectively). Data were entered into the Ecological Geographic Information System (EGIS) faunal database, and given to NDOW for inclusion in their analysis and to the USACE.

Table 6-1. Results of Winter 2016 raptor surveys on the NNSS.

Species	Southern NNSS (1/12/16)	Southern NNSS (2/8/16)	Yucca Flat (1/13/16)	Yucca Flat (2/9/16)
Golden Eagle (*Aquila chrysaetos*)	0	1	1	0
Northern Harrier (*Circus cyaneus*)	0	0	1	1
Red-tailed Hawk (*Buteo jamaicensis*)	4	2	5	3
Praire Falcon (*Falco mexicanus*)	1	0	1	1
American Kestrel (*Falco sparverius*)	0	0	1	2
Unknown Accipiter	1	0	0	0
Total Raptors	**6**	**3**	**9**	**7**
Common Raven (*Corvus corax*)	2	1	6	5
Loggerhead Shrike (*Lanius ludovicianus*)	1	0	3	2

6.2 BAT SURVEYS

Bat monitoring in 2016, consisted of removing bats from buildings and documenting the roost site. Passive acoustic monitoring of bat activity at Camp 17 Pond was discontinued indefinitely.

Four bats were found roosting in buildings and were removed and released away from populated areas. These included one adult male California myotis (*Myotis californicus*) (Mercury), two adult female California myotis (Mercury), and a juvenile male California myotis (Area 6). A dead juvenile male canyon bat (*Parastrellus hesperus*) was found in a building in Mercury and disposed of. A pallid bat (*Antrozous pallidus*) was observed roosting outside a building entrance and was left in place. It left after a few days. Another bat, a myotis species, was found in a building near the Area 5 RWMC and left in place. It eventually left as well. Roost site locations at these buildings were entered in the EGIS faunal database.

6.3 WILD HORSE SURVEYS

Annual horse monitoring has been conducted to determine the abundance, recruitment (i.e., survival of horses to reproductive age), and distribution of the horse population on the NNSS from 1989-2014. During 2016, no formal horse surveys were conducted due to limited resources. However, opportunistic sightings were noted and motion-activated cameras at water sources known to be heavily used by horses in the past (Camp 17 Pond, Gold Meadows Spring, and Captain Jack Spring) were used to document the presence or absence of horses (see Section 6.7.1, Motion-Activated Cameras).

Based on opportunistic sightings and camera results, horses were observed using the same areas as in previous years. One possible exception was the potential sighting of scat and horses in Area 20, near Schooner Crater. It is uncertain if these were horses or burros but it is feasible that horses from the Nevada Test and Training Range (NTTR) could have moved south into this area. Further monitoring will be done to verify the presence of horses in this area.

As in 2014 and 2015, no horses were documented using Captain Jack Spring in 2016. Several foals were observed and photographed at various locations. Numerous horse photos were taken at Camp 17 Pond (275 images) and Gold Meadows Spring (165) (Table 6-3). These water sources are the core areas used by horses, especially during the hot, dry summer months. The horse population on the NNSS is not known but at least 33 horses were observed in one day during September. These included three bands of 9, 7, and 6 horses, respectively observed around Camp 17 Pond and one band of 11 horses seen in Gold Meadows.

6.4 MULE DEER

Initial studies of mule deer at the NNSS were conducted by Giles and Cooper (1985) from 1977 to 1982 when they performed mark and recapture studies on about 100 marked deer. They estimated the population to be about 1,500–2,000 deer. Spotlighting surveys for deer on the NNSS were conducted during 1989–1994, 1999–2000, and 2006-2016. In past years, the monitoring effort has emphasized estimating relative abundance and density but 2016 efforts focused solely on relative abundance.

6.4.1 Trends in Mule Deer Abundance

Mule deer abundance on the NNSS was measured by driving two standardized (59 km total length) road courses (Figure 6-4) to count and identify mule deer. One route (29 km) was centered around Rainier Mesa, and the second (30 km) was centered around the eastern portion of Pahute Mesa. Selection of the two routes was based on information from Giles and Cooper (1985) who determined there are two main deer herd components in these regions on the NNSS. Locations of mule deer were recorded with a GPS unit from the road centerline. Perpendicular distance from the road to each deer group was measured with a laser range finder.

During six surveys conducted September 12-14 and 26-28, 2016, a total of 151 deer were observed, which equates to an average of 25 deer per night. On average this is two deer per night higher than in 2015, and six deer per night lower than the long-term average since 1989. There has been a decreasing trend ($y = -2.6781x + 50.085$, $r^2 = 0.48$) the last 11 years with counts fluctuating widely (Figure 6-5). The standard deviation was the highest recorded since 2006, and deer counts ranged from 9 to 50 deer (Figure 6-5). Specific causes for the fluctuation in deer numbers is unknown and requires further investigation. Mountain lions were seen on three separate occasions during the surveys, which may have lowered the number of deer present along certain segments for at least a couple of nights.

The number of deer per km was higher on Pahute Mesa than Rainier Mesa this year (Figure 6-6) possibly suggesting deer are increasing in the Pahute Mesa area or perhaps deer from Rainier Mesa are moving onto Pahute Mesa. In 2016, a total of 87 deer groups were detected. Group size varied from one to six animals. Overall, Pahute Mesa and Rainier Mesa had nearly equal average group sizes of 1.7 and 1.9 deer, respectively.

6.4.2 Sex and Fawn/Doe Ratios

The deer sex ratio (number of bucks per 100 does) in 2016 was the second lowest ratio ever measured on site (74 bucks/100 does) (Table 6-2). These sex ratios have varied greatly on the NNSS across years, but the last three years they have been the lowest ever recorded. Our values overall show some similarity to historical sex ratios noted by Giles and Cooper (1985), who attributed the higher number of males to a lack of hunting on the NNSS. Generally, deer populations in hunted areas in the western U.S. have significantly fewer males compared to females in the population than measured on the NNSS. The fawn/doe ratio (number of fawns per 100 does) in 2016 (Table 6-2) was the third highest ever measured on the NNSS (Table 6-2) with 40 fawns per 100 does.

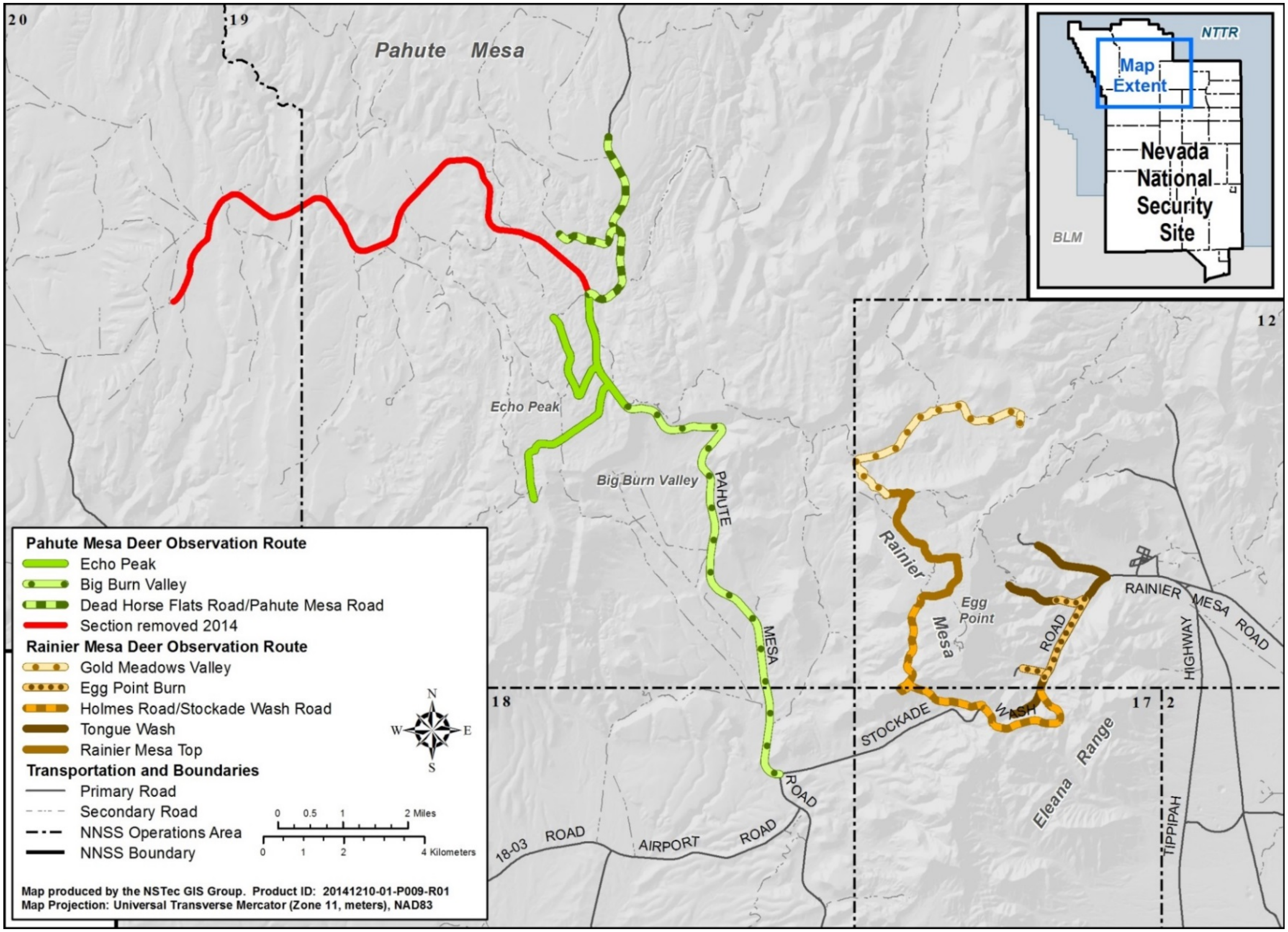

Figure 6-4. Road routes and sub-routes of two NNSS regions driven in 2016 to count deer and section removed due to road closure.

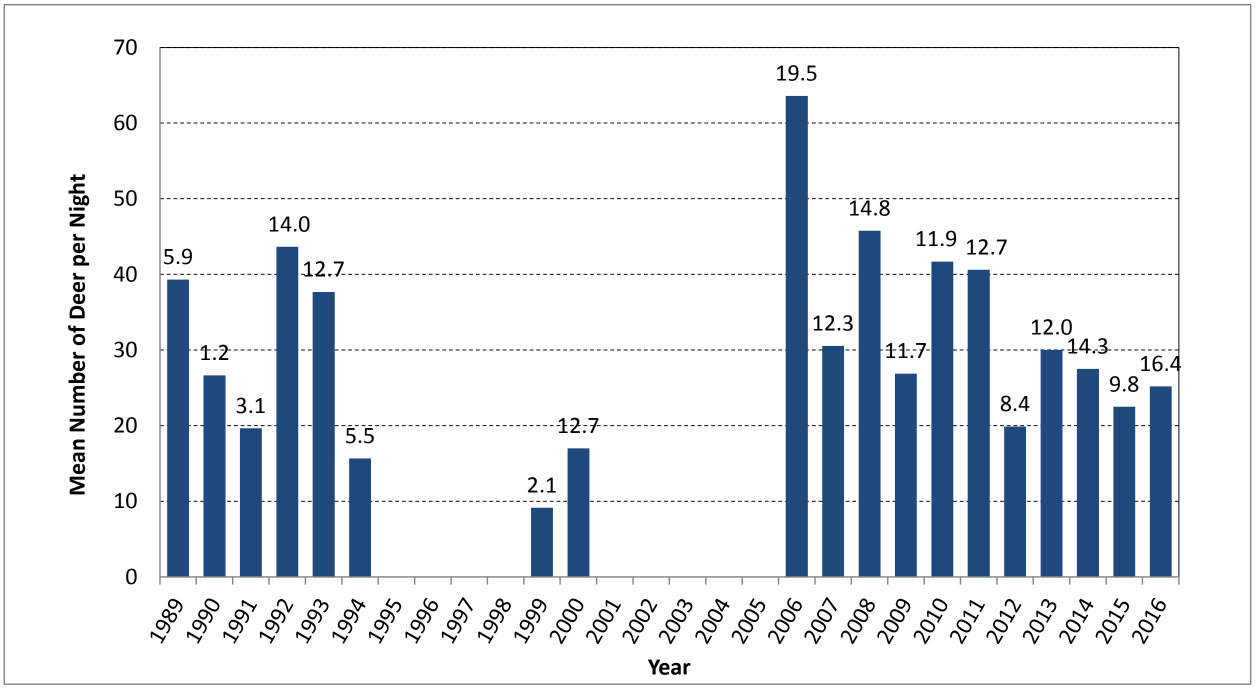

Figure 6-5. **Trends in total deer count per night from 1989 to 2016 on the NNSS (surveys were not conducted during 1995–1998 or 2001–2005). Standard deviation values above bars.**

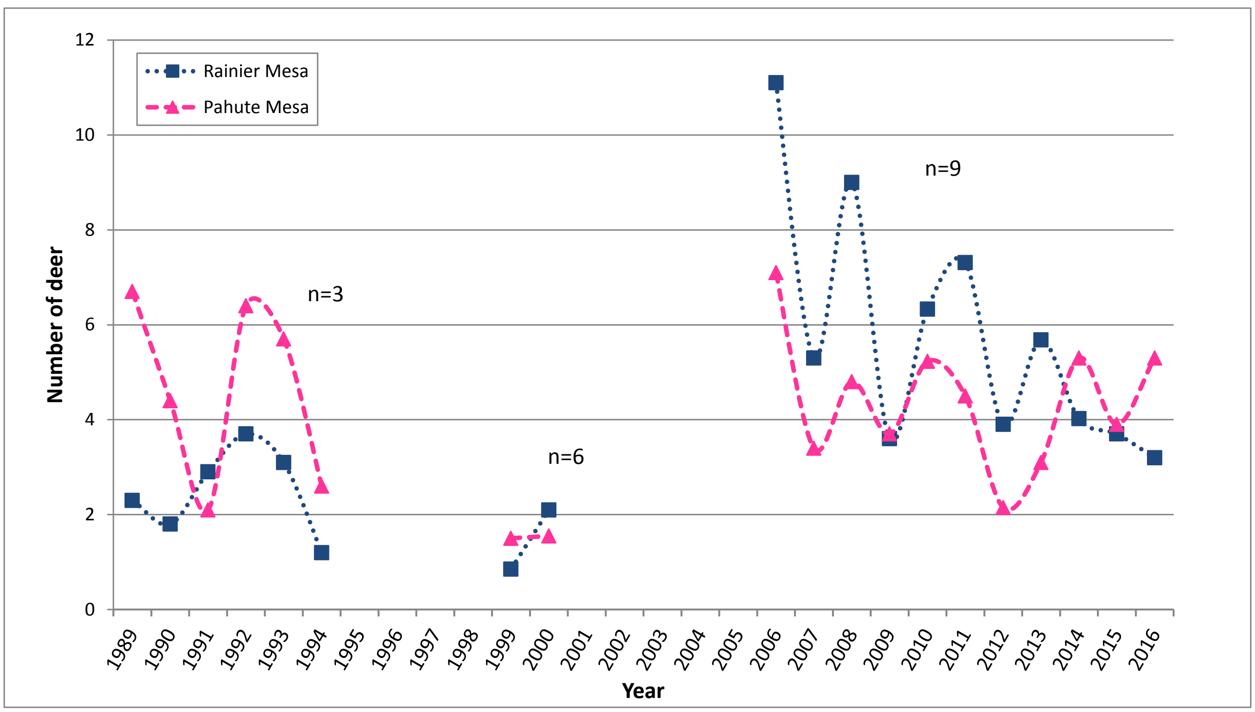

Figure 6-6. **Mean number of mule deer per 10 km per night, counted on two routes (n = number of survey nights; exceptions n = 12 for 2012, n = 8 for 2013, n = 6 for 2015 and 2016).**

Table 6-2. Mule deer classified by sex and age, with sex ratios, and fawn to doe ratios from 2006 to 2016 on the NNSS (12 survey nights for 2012, 8 for 2013, 6 for 2015 and 2016, 9 for all other years).

Year	Total Deer	Bucks	Does	Unclassified Sex	Bucks/100 does	Fawns	Fawns/100 does
2006	573	224	222	96	101	31	14
2007	275	148	68	59	218	0	0
2008	408	164	147	50	112	47	32
2009	242	98	102	35	96	7	7
2010	365	133	150	50	89	32	21
2011	477	189	184	67	103	37	19
2012	179	65	67	28	97	19	30
2013	243	106	68	38	156	31	45
2014	249	76	94	60	81	19	20
2015	135	33	58	19	57	25	43
2016	151	43	58	27	74	23	40

6.5 DESERT BIGHORN SHEEP

Up until a few years ago, desert bighorn sheep (sheep) appeared to be rare on the NNSS with only nine recorded observations of their presence on or near the NNSS between 1963 and 2009. These observations were recorded in the southern part of the NNSS (Areas 5, 23, and 25) and were most likely reintroduced sheep from the Spotted Range, east of Mercury, and the Specter Range, southwest of Mercury. There have also been unconfirmed anecdotal reports of a few sheep around Yucca Mountain in the 1990's. Since 2009, numerous observations of sheep and sheep sign (i.e., scat, beds, and remains) have been detected with motion-activated cameras and during the mountain lion study, including the discovery of ewes and lambs in the Yucca Mountain/Fortymile Canyon area and the southern flank of Pahute Mesa. These new data have expanded the known distribution of sheep on and near the NNSS and have prompted further study of these important animals including the capture, radio-collaring, and tracking of nearly 20 individuals over the last two years. This study is being led by Kathy Longshore (USGS) with NDOW and NSTec as collaborators. A helicopter was used to locate sheep and maneuver them into a safe area and then a net gun was fired from the helicopter that entangled the sheep. Net-gunning is the accepted method for capturing sheep and has the added benefit of not having to tranquilize the animals. The crew landed a safe distance away and processed the sheep (Figure 6-7). Processing entailed determining the sex and age of the animal, marking each individual with unique ear tags, securing a satellite radio-collar around the neck, performing a visual health assessment on the animal, and taking blood samples and swabs. Blood samples will be analyzed for disease and genetic testing. Animals were then released.

During 2016, motion-activated cameras detected sheep at Topopah Spring (2 images), Topopah Spring Trough (1 image), Delirium Canyon Tanks (36 images), and Twin Spring (14 images).

6.5.1 2015 NNSS Capture Results

Five sheep (two ewes and three rams) were captured, radio-collared, and marked with ear tags on the NNSS (Figure 6-8) on November 17, 2015. A sixth sheep was captured and marked with ear tags on

Figure 6-7. Kiwi Air capture crew with three bighorn sheep ready to be released.

(Photo by B. Malo, November 29, 2016)

November 18. This young ram was not radio-collared as it was still growing and it was determined that a radio-collar would be too restrictive around the neck as the ram grew into adulthood. The intent was to track the animals until May 2017 to determine home range and habitat use. Unfortunately, due to a programming error by the manufacturing company, the radio collars dropped off a full year prematurely in May 2016. Figure 6-8 shows all the locations for all five sheep for the six months the collars were operational. The two ewes (Figure 6-8, yellow and green dots) were found on Yucca Mountain, Shoshone Mountain and in Fortymile Canyon. Ram 1 (Figure 6-8, orange dots) was found on Yucca Mountain and in Fortymile Canyon, while Ram 2 (Figure 6-8, purple dots) was found from east Shoshone Mountain through Fortymile Canyon to the far west side of Yucca Mountain. Within a few days after being captured, Ram 3 (Figure 6-8, blue dots) moved over 20 miles to the north and spent approximately three months on Quartz Mountain, Black Mountain, and in Thirsty Canyon. He moved back to Yucca Mountain in late February and spent the first two weeks of March on Bare Mountain and then moved back north around Black Mountain.

On August 5, 2016, Ram 2 and the uncollared young ram were photographed with a motion-activated camera at Delirium Canyon Tanks and were identified by their unique ear tags. Ram 2 was legally harvested by a hunter during the fall of 2016 in the hills north of Bare Mountain off the NNSS. This validated the supposition that bighorn sheep found on the NNSS are capable of moving off the NNSS and hunted. Results from radiological analysis of this animal showed no detectable levels of radionuclides (Hall et al. 2016).

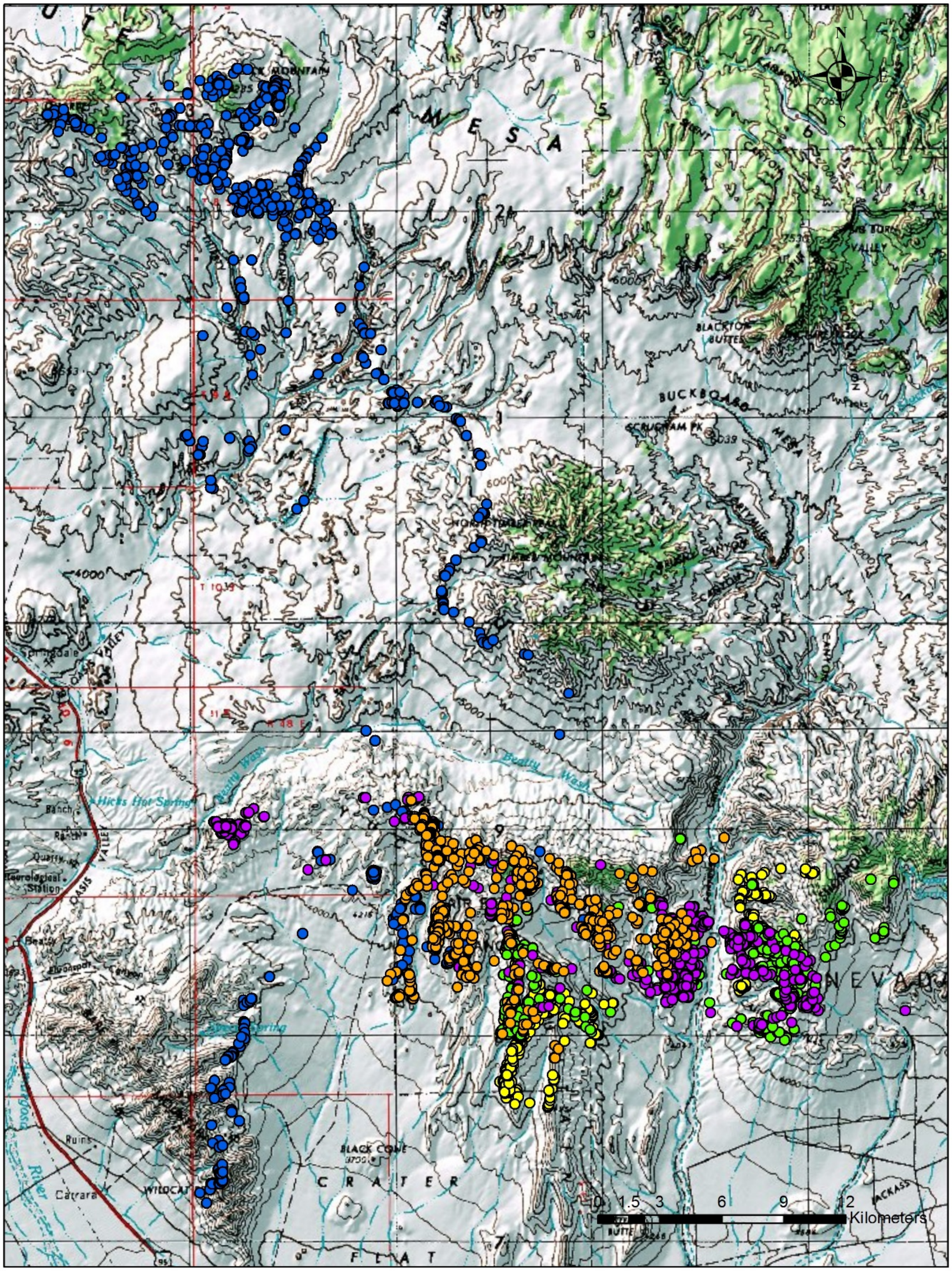

Figure 6-8. Locations of five bighorn sheep from November 18, 2015 until May 1, 2016 (Ewe 1 = yellow dots, Ewe 2 = green dots, Ram 1 = orange dots, Ram 2 = purple dots, Ram 3 = blue dots).

6.5.2 2016 NNSS Captures

On November 28-29, 2016, 15 desert bighorn sheep (7 ewes and 8 rams) were captured on or near the NNSS on Yucca Mountain, Shoshone Mountain and in Fortymile Canyon. Thirteen of these (6 ewes and 7 rams) were radio-collared with satellite transmitters to track their movements over the next one to two years. Figures 6-9 and 6-10 show the locations of the six ewes from capture through January 18, 2017. Figures 6-11 and 6-12 show the locations of the seven rams from capture through January 18, 2017. Most of the locations occurred on Yucca Mountain, Shoshone Mountain and in Fortymile Canyon with two rams in Thirsty Canyon and the Bare Mountains.

At the time of capture, blood samples were taken for genetic and disease testing and nasal swabs were taken for disease testing. A unique combination of ear tags were attached for identification purposes especially in images taken by camera traps set up in the Fortymile Canyon area. Preliminary disease analysis results indicate the presence of pneumonia-causing bacteria in the NNSS sheep population.

6.5.3 NTTR and Other Off-site Captures

NNSS sheep captures were part of a larger collaborative effort among NDOW, USGS, NTTR, FWS, and NNSA/NFO to get valuable data on 1) the prevalence of pneumonia responsible for killing large numbers of bighorn sheep in southern Nevada, 2) metapopulation structure (how different herds are related) of sheep populations in southern Nevada, and 3) movements and habitat use of sheep in areas never studied before. On November 11-13, 2016 an NSTec biologist assisted in the capture and processing of nearly 40 desert bighorn sheep on the NTTR. Twenty-six of these were captured on the Pintwater Range near Creech Air Force base on the southern NTTR ranges. Twenty-one of these were radio-collared and will be tracked over the next couple of years. At least 10 sheep were captured and 4 radio-collared on the northern NTTR ranges in Thirsty Canyon, Tolicha Peak, Stonewall Mountain and Cactus Range. Samples were collected for disease and genetic testing.

Movements of other sheep captured in the Specter Range and Bare Mountains in the fall of 2015 by NDOW continued to be monitored during 2016. One ram that spent most of its time in the Specter Range and Striped Hills area was found dead west of the small community of Amargosa Valley, south of US Highway 95 on October 30th. It appeared to be heading for the Funeral Mountains. Two other rams moved between the Specter Range and Skull Mountain and Little Skull Mountain on the NNSS multiple times during 2016. One ram captured in the Bare Mountains spent its time mostly on the NNSS on Shoshone Mountain and Yucca Mountain, and two rams from the Bare Mountains spent time on Bare Mountain and the western part of Yucca Mountain, mostly off the NNSS.

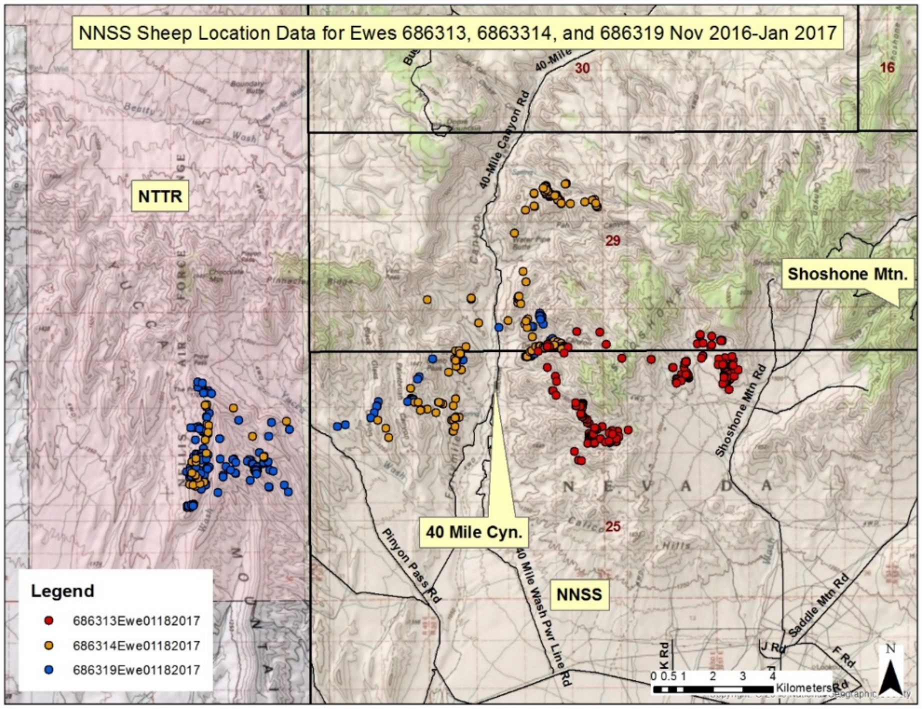

Figure 6-9. Locations of ewes 686313 (red dots), 686314 (yellow dots), and 686319 (blue dots) from capture through January 18, 2017.

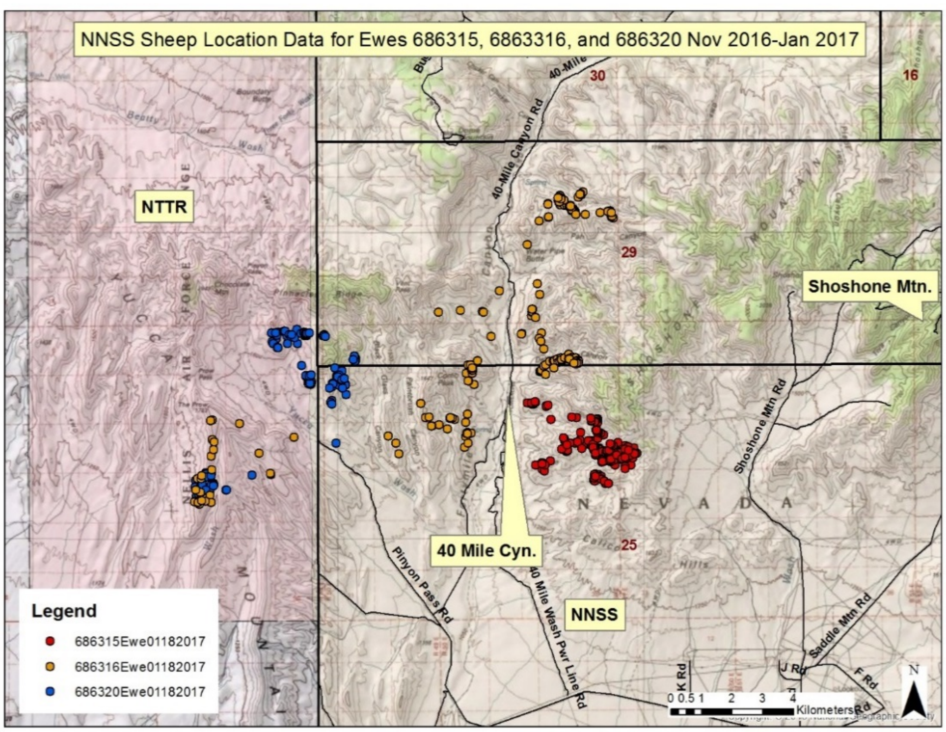

Figure 6-10. Locations of ewes 686315 (red dots), 686316 (yellow dots), and 686320 (blue dots) from capture through January 18, 2017.

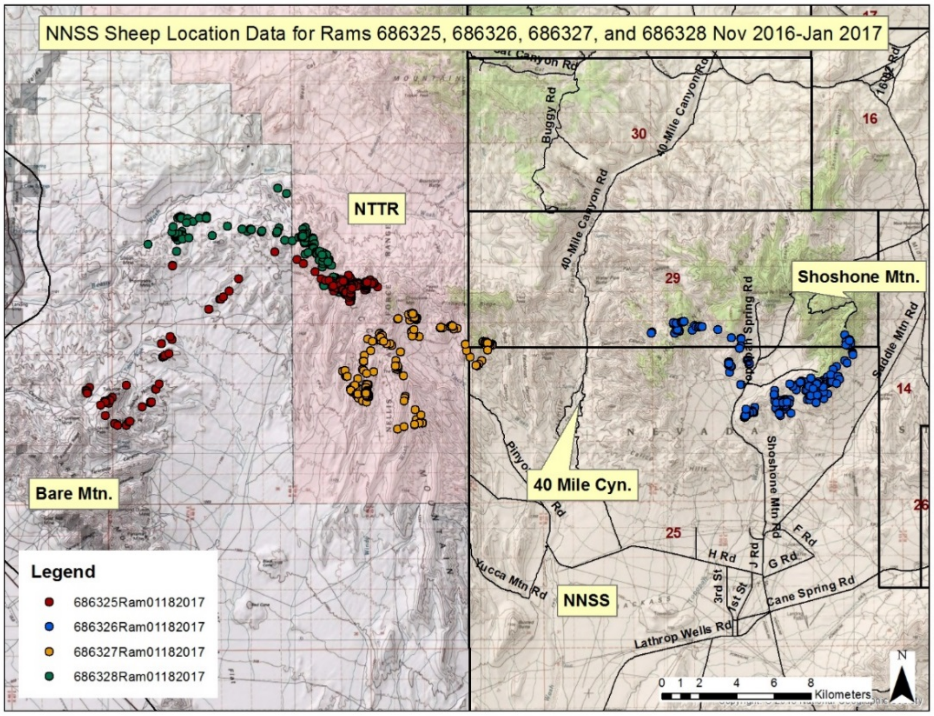

Figure 6-11. Locations of rams 686325 (red dots), 686326 (blue dots), 686327 (yellow dots), and 686328 (green dots) from capture through January 18, 2017.

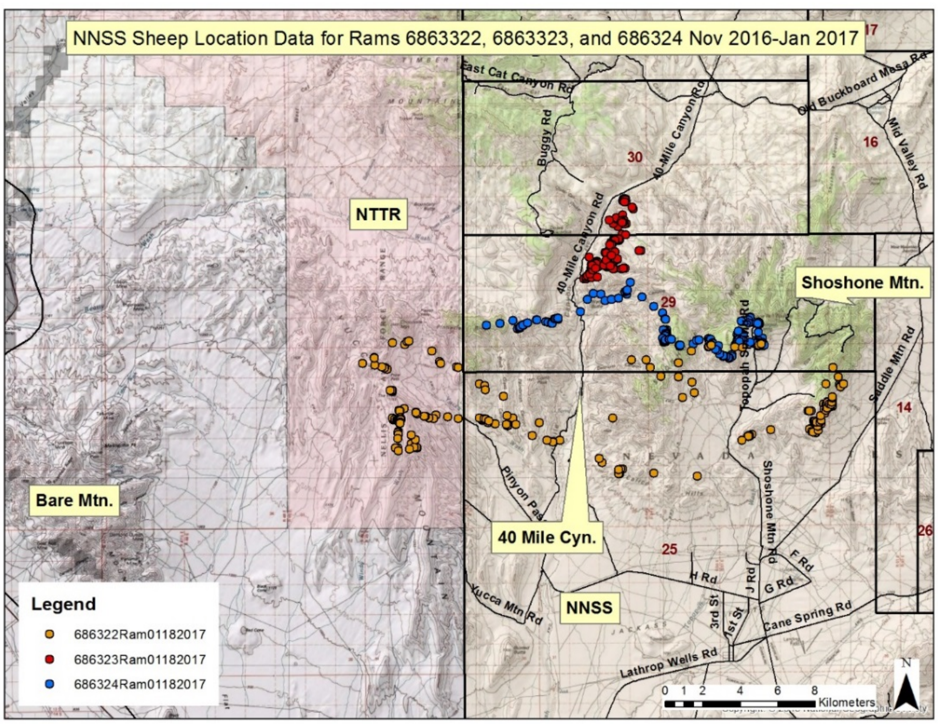

Figure 6-12. Locations of rams 686322 (yellow dots), 686323 (red dots), and 686324 (blue dots) from capture through January 18, 2017.

6.6 MOUNTAIN LION MONITORING

6.6.1 Motion-Activated Cameras

Few data exist for mountain lion numbers and their distribution in southern Nevada, including the NNSS. Since 2006, site biologists have collaborated with Dr. Erin Boydston and Dr. Kathy Longshore, USGS research scientists, to use remote, motion-activated cameras to determine the distribution and abundance of mountain lions on the NNSS. Cameras used this way are referred to as camera traps. Camera traps have also been used the last few years to assist with the capture effort for the telemetry study by identifying where mountain lions occur as well as the frequency of occurrence at those sites. Remote, motion-activated cameras were used in 2016 at 28 sites (Figure 6-13 and Table 6-3). Sites were selected at locations with previous or new mountain lion sightings or sign, on roads or landform features that are potential movement corridors from one area to another, and in areas of good mule deer habitat (mule deer are a primary prey species for mountain lions). The number of images reported is based on a 1-minute interval between images taken during a single episode. Some images reported herein were taken during late 2015 and early 2017 due to the accessibility and scheduling of camera trap visits.

A total of 70 mountain lion images (i.e., photographs or video clips) were taken during 218,849 camera hours across all sites (Figure 6-13 and Table 6-3). This equates to about 0.3 mountain lion images per 1,000 camera hours. Mountain lions were detected at 9 of the 28 sites, including 4 water sources, 3 canyons and 2 dirt roads (Figure 6-13). Table 6-4 contains the camera trap results by month and location. An additional mountain lion image not included in Table 6-3 or Table 6-4 was detected at a mule deer carcass near Gold Meadows Spring. The camera from the spring was moved to the kill site for two days to detect which animals visited the carcass. Other than the mountain lion, there were 53 images of turkey vultures at the carcass.

An uncollared female and collared male (NNSS9) were detected at Captain Jack Spring in early January, 2017 (Figure 6-14). It is possible that the female will give birth to cubs in early April that may be detected on cameras during 2017. It is difficult to tell individual mountain lions apart from camera trap images and determine the exact number of mountain lions on the NNSS. Having radio-collared individuals helps identify unique individuals. A minimum of five individuals (2 radio-collared males [NNSS8 and NNSS9], 1 adult male, 1 adult female, and 1 subadult) were known to occur on the NNSS during 2016, compared to a minimum of three individuals in 2015 and four individuals in both 2014 and 2013.

In order to investigate temporal activity of mountain lions, camera detection data from all 11 years (2006–2016) were combined. Mountain lions were detected every month with peak occurrences during June (n = 99), August (n = 95) and November (n = 97) (Figure 6-15). The number of images taken during summer and fall (June–November) (n = 457) accounted for nearly three-fourths of all images compared with the number of images taken during winter and spring (December–May) (n = 226) (Figure 6-15). Nearly 80% of mountain lion images were taken between 1700 to 0500 hours (Figure 6-16). From 2011 to 2016, nearly twice as many images were taken when it was dark (n = 318) compared with when it was light (n = 175).

A secondary objective of the camera surveys is to detect other species using these areas and thus to better define species distributions on the NNSS. A total of 10,840 images of at least 30 species other than mountain lions were taken during 218,849 camera hours across all sites (Table 6-3) which is about 50 images per 1,000 camera hours.

The most prevalent species photographed (24% of all images) was mule deer (2,605 images at 21 of 28 sites). Captain Jack Spring (822 images), Camp 17 Pond (1,003 images), and Gold Meadows Spring (334 images) are very important water sources for mule deer. Some of the rarer, more elusive species documented during camera surveys were desert bighorn sheep (see Section 6.5), Rocky Mountain elk (see

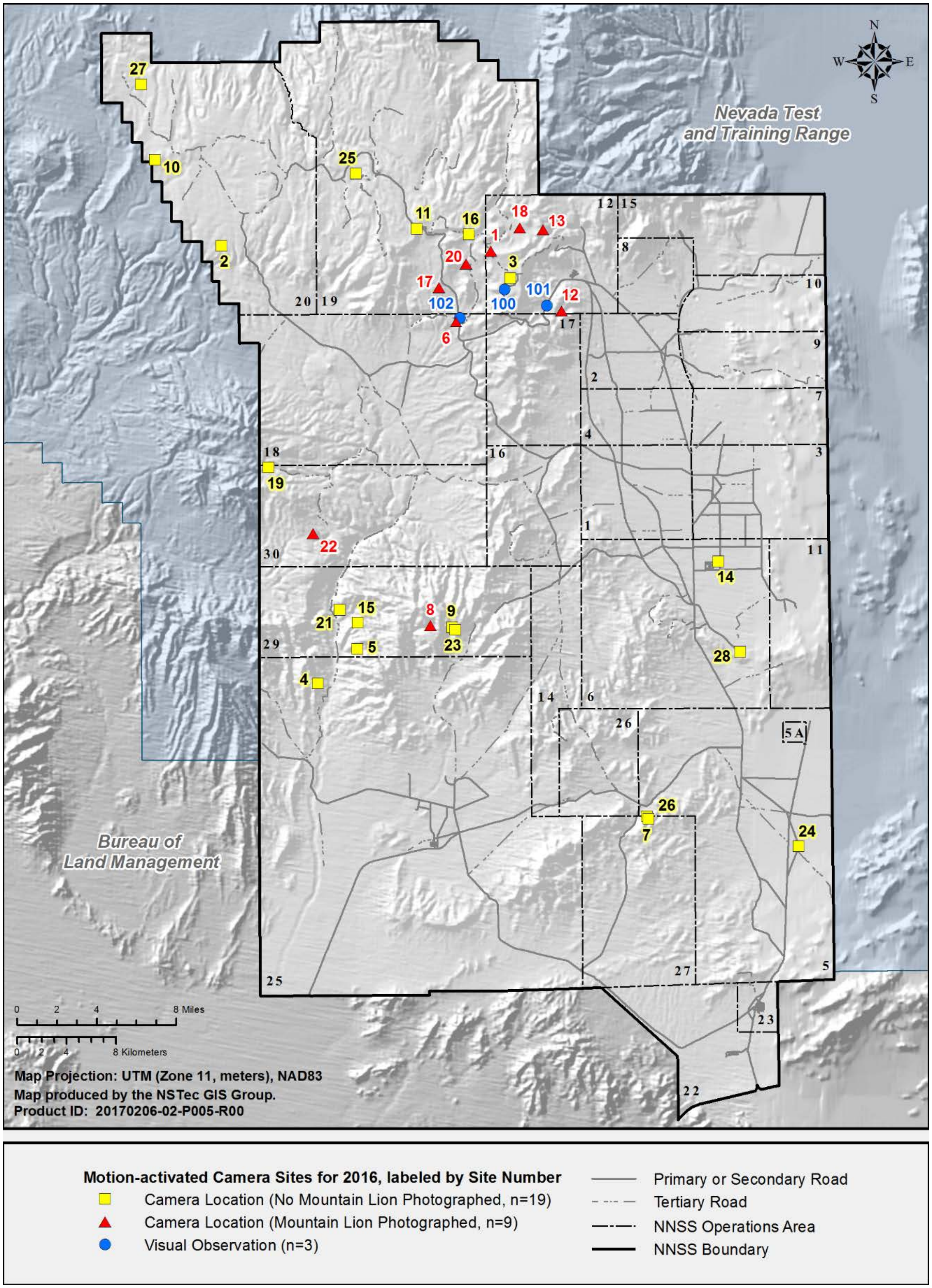

Figure 6-13. Locations of mountain lion photographic detections, camera traps, and visual observations on the NNSS during 2016.

Table 6-3. Results of mountain lion camera surveys during 2016.

Location (Site Number)	Dates Sampled	Camera Hours	Mountain Lion Images (Number of Images per 1,000 Camera Hours)	Other Observations (Number of Images)
Captain Jack Spring (#12)	12/21/15-1/5/17	9,143	26 (2.8)	Bobcat (38), gray fox (6), coyote (14), mule deer (822), desert cottontail (20), black-tailed jackrabbit (8), rock squirrel (3), Cooper's hawk (3), northern saw-whet owl (1), chukar (43), mourning dove (40), common raven (9), western fence lizard (2)
Camp 17 Pond[a] (#6)	12/9/15-12/15/16[b]	5,439	13 (2.4)	Bobcat (7), coyote (106), mule deer (1,003), horse (275), pronghorn antelope (1), black-tailed jackrabbit (184), desert cottontail (2), great blue heron (44), golden eagle (36), great-horned owl (2), red-tailed hawk (1,295), turkey vulture (164), mourning dove (68), chukar (22), common raven (69)
Rattlesnake Ridge Gorge (#20)	12/9/15-12/14/16	8,908	13 (1.5)	Bobcat (7), coyote (1), desert cottontail (2), rock squirrel (1), mourning dove (1)
West Topopah Spring (#8)	12/22/15-1/10/17	9.238	11 (1.2)	Bobcat (2), gray fox (2), black-tailed jackrabbit (2), rock squirrel (8), greater roadrunner (1), common raven (1)
12T-26, Rainier Mesa (#1)	12/9/15-12/14/16[b]	7,924	2 (0.3)	Mule deer (4), desert cottontail (1), black-tailed jackrabbit (5)
Water Bottle Canyon (#17)	12/9/15-12/15/16	8,928	2 (0.2)	Coyote (12), mule deer (11), desert cottontail (1), greater roadrunner (1)
East Gold Meadows Pass (#13)	12/9/15-5/4/16	3,531	1 (0.3)	Coyote (2), mule deer (4)
North Chukar Canyon Tank (#22)	12/9/15-1/4/17[b]	5,874	1 (0.2)	Bobcat (2), coyote (24), golden eagle (1), chukar (27), mourning dove (83)

Table 6-3. Results of mountain lion camera surveys during 2016 (continued).

Location (Site Number)	Dates Sampled	Camera Hours	Mountain Lion Images (Number of Images per 1,000 Camera Hours)	Other Observations (Number of Images)
Gold Meadows Spring (#18)	12/9/15-12/14/16[b]	6,854	1 (0.1)	Coyote (5), elk (24), pronghorn antelope (586), mule deer (334), horse (165), golden eagle (48), common raven (11)
Topopah Spring[a] (#9)	12/22/15-1/10/17[b]	6,000	0 (0.0)	Bobcat (2), gray fox (2), coyote (194), desert bighorn sheep (2), mule deer (35), black-tailed jackrabbit (1), chukar (25), mourning dove (3)
Topopah Spring Trough (#23)	12/22/15-1/10/17	9,239	0 (0.0)	Coyote (2), desert bighorn sheep (1), mule deer (58), mourning dove (2)
Dick Adams Cutoff Road, Rainier Mesa (#3)	12/9/15-12/14/16	8,907	0 (0.0)	Mule deer (66), rock squirrel (1), cliff chipmunk (1)
South Pah Canyon (#15)	1/11/16-1/18/17[b]	5,421	0 (0.0)	Bobcat (2), gray fox (6), rock squirrel (1), mourning dove (90), hummingbird (8)
East Cat Canyon (#19)	12/9/15-1/4/17	9,405	0 (0.0)	Bobcat (1), mule deer (7), black-tailed jackrabbit (1)
East 19-01 Road (#16)	12/9/15-12/14/16[b]	7,679	0 (0.0)	Bobcat (12), gray fox (2), coyote (23), mule deer (34), desert cottontail (2), black-tailed jackrabbit (4), rock squirrel (2)
Pahute Mesa Summit, Road (#11)	12/9/15-4/14/16	3,048	0 (0.0)	None
Schooner Wash Tanks (#27)	12/22/15-12/15/16	8,619	0 (0.0)	Bobcat (3), coyote (6), turkey vulture (1)
Cottonwood Spring (#4)	1/11/16-1/18/17[b]	5,890	0 (0.0)	Bobcat (29), mule deer (3), chukar (138), greater roadrunner (1), mourning dove (925)
Twin Spring (#21)	1/11/16-1/18/17	8,951	0 (0.0)	Coyote (2), desert bighorn sheep (14), mule deer (59), common raven (10)
Delirium Canyon (#5)	1/11/16-1/18/17	8,951	0 (0.0)	Bobcat (38), gray fox (5), desert bighorn sheep (36), chukar (9), mourning dove (35)

Table 6-3. Results of mountain lion camera surveys during 2016 (continued).

Location (Site Number)	Dates Sampled	Camera Hours	Mountain Lion Images (Number of Images per 1,000 Camera Hours)	Other Observations (Number of Images)
Cane Spring (#7)	12/21/15-1/4/17[b]	8,809	0 (0.0)	Coyote (18), mule deer (74), mourning dove (7), common raven (12)
Cane Spring Trough (#26)	12/16/14-12/21/15[b]	8,949	0 (0.0)	Bobcat (1), coyote (5), mule deer (7), turkey vulture (1), mourning dove (9), common raven (1)
Well 5C Trough[a] (#24)	12/21/15-1/4/17[b]	4,641	0 (0.0)	Coyote (3), pronghorn antelope (5), mule deer (1), burro (21), dog (1), black-tailed jackrabbit (23), golden eagle (4), mourning dove (8), common raven (4),
Area 6 LANL Pond Trough (#14)	12/21/15-1/4/17	9,115	0 (0.0)	Coyote (23), pronghorn antelope (107), mule deer (24), black-tailed jackrabbit (23), golden eagle (19), red-tailed hawk (11), Swainson's hawk (3), great-horned owl (3), turkey vulture (226), mourning dove (10), common raven (130)
Well C1 Pond Trough (#28)	12/21/15-1/4/17[b]	6,356	0 (0.0)	Bobcat (12), coyote (19), pronghorn antelope (25), mule deer (41), burro (45), black-tailed jackrabbit (11), golden eagle (9), red-tailed hawk (62), Cooper's hawk (3), great-horned owl (5), turkey vulture (9), mourning dove (623), greater roadrunner (1), house finch (1), common raven (1, 501)
ER 20-5 Plastic-lined Sump (#2)	12/22/15-12/15/16	8,619	0 (0.0)	Coyote (9), mule deer (2), mourning dove (9), common raven (11)
U19ad Plastic-lined Sump (#25)	12/22/15-12/15/16	8,619	0 (0.0)	Mule deer (14), common raven (1)
ER 20-12 Plastic-lined Sump NE Corner (#10)	1/21/16-12/15/16	7,896	0 (0.0)	Mourning dove (1), common raven (17), shorebirds (8), owl (1), hawk (1)

Table 6-3. Results of mountain lion camera surveys during 2016 (continued).

Location (Site Number)	Dates Sampled	Camera Hours	Mountain Lion Images (Number of Images per 1,000 Camera Hours)	Other Observations (Number of Images)
ER 20-12 Plastic-lined Sump SE Corner (#10)	1/21/16-12/15/16	7,896	0 (0.0)	Mule deer (2), great-horned owl (3), mourning dove (2), common raven (31), shorebirds (6), passerine (1)

[a] Camera hours not known for some time periods.

[b] Non-continuous operation due to camera problems, dead batteries, full memory cards, etc.

Table 6-4. Number of mountain lion images taken with camera traps by month and location (orange=number of mountain lion images; yellow=camera operational, no mountain lion images, green=camera not operational).

Camera Location (Site number)	Dec-15	Jan-16	Feb-16	Mar-16	Apr-16	May-16	Jun-16	Jul-16	Aug-16	Sep-16	Oct-16	Nov-16	Dec-16	Jan-17
Gold Meadows Spring (#18)									1					
12T-26, Rainier Mesa (#1)								1	1					
East Gold Meadows Pass (#13)					1									
Rattlesnake Ridge Gorge (#20)			1		3			4	1	1		3		
Water Bottle Canyon (#17)					1			1						
Camp 17 Pond (#6)								2	4	6	1			
Captain Jack Spring (#12)			2						5	5			7	7
North Chukar Canyon Tank (#22)											1			
Canyon West of Topopah Spring (#8)			1	2	1	1			1		3	1	1	

Number of mountain lion images | Camera operational, no mountain lions detected | Camera not operational

Figure 6-14. Upper-uncollared female, lower-collared male (NNSS9) at Captain Jack Spring.

(Photos taken January 5, 2017, by motion-activated camera)

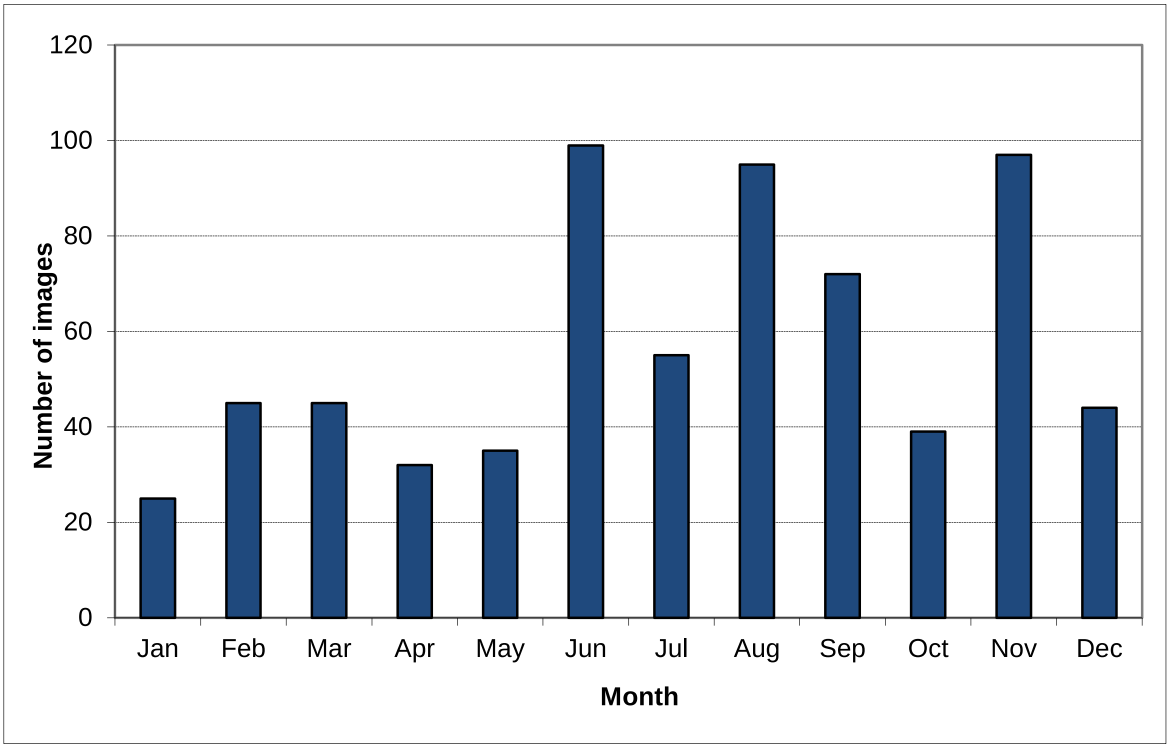

Figure 6-15. Number of mountain lion images by month for camera sites where mountain lions were detected from 2006 through 2016 (n = 683).

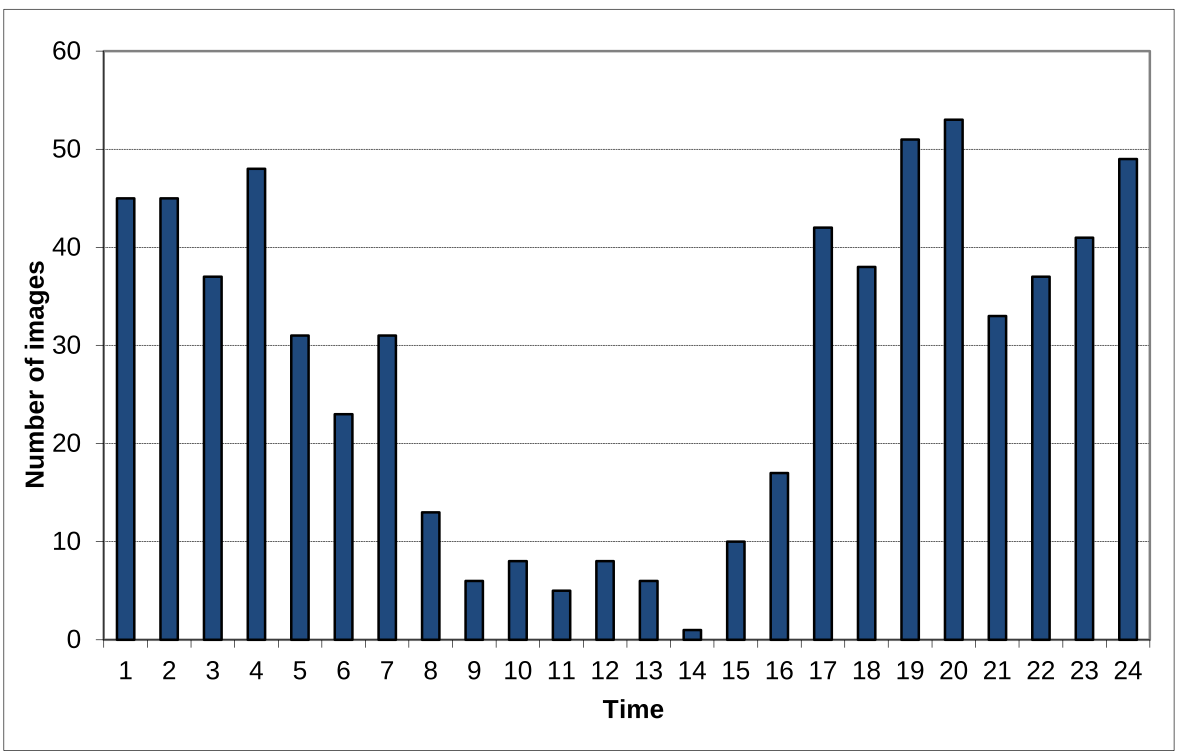

Figure 6-16. Number of mountain lion images by time of day (Pacific Standard Time) for camera sites where mountain lions were detected from 2006 through 2016 (n = 678).

Section 6.8), bobcat (found at 14 of 28 sites throughout the NNSS), gray fox (found at 6 of 28 sites), golden eagle, great-horned owl, greater roadrunner, northern saw-whet owl, and great blue heron (*Ardea herodias*). Noteworthy observations of some of the more common species include 468 images of coyotes at 18 of 28 sites, 1,916 images of mourning doves at 17 of 28 sites, and 1,808 images of common ravens at 14 of 28 sites. Greatest use and highest species richness was documented at water sources (both natural and constructed) especially during the summer and fall, which emphasizes the importance of these water sources for several wildlife species, especially during the drier months.

6.6.2 Mountain Lion Telemetry Study

A collaborative effort between Kathy Longshore (USGS) and site biologists continued during 2016 to provide information to assess the risk of human encounters with mountain lions on the NNSS and determine what mountain lions eat and where they make their kills. This effort provides information about their natural history and ecology as well. The NNSS and surrounding areas, encompassing the NTTR, Tonopah Test Range (TTR), and Desert National Wildlife Range, constitute one of the largest areas (over 15,540 square kilometers) in North America where human-caused mountain lion mortality is extremely low. The size of this area is large enough to allow population dynamics to emerge that likely typify an unexploited population of lions. This area is also located in some of the driest ecosystems in North America with relatively low prey densities. The goal for 2016 was to capture and radio-collar two mountain lions and track them for one year. Radio collars were programmed to record locations every hour for the first five days of each month and every six hours the remaining days of each month.

Brian Jansen led the trapping effort that occurred from mid-July to early August, 2016. During this period, efforts to track and capture mountain lions involved setting and monitoring snares and hunting with the use of hounds. The trapping effort consisted of a total of 179 trap nights and resulted in the capture of two individual male mountain lions, NNSS8 and NNSS9. Trapping efforts were focused around Rainier Mesa, eastern edge of Pahute Mesa, and the Big Burn Valley area.

6.6.2.1 NNSS8

NNSS8 was first captured in a snare trap on July 22, 2016 after 34 trap nights. It was estimated to be 5-6 years old and weigh 55.3 kilograms (kg). Due to radio-collar failure, NNSS8 was captured an additional two times in an attempt to get a functioning collar on the animal. The second capture occurred on July 28, 2016 in the northern part of Mouse Meadow, and was accomplished by “treeing” the mountain lion (Figure 6-17) using hounds. It was first cornered by the hounds on a rock cliff but it was not a safe place to tranquilize the animal so it was chased from the cliff, ran a short distance, and then climbed to the top of a pinyon pine tree. The animal was safely tranquilized, a different radio-collar was attached and the animal was released. This was the first time ever that a mountain lion had been “treed” using hounds on the NNSS. This collar also malfunctioned most likely due to corrosion around the GPS antenna after being stored for a few years. NNSS8 was captured a third time on July 30, 2016 using hounds to pursue it and corner it in a rock pile (Figure 6-18) on the eastern edge of Rainier Mesa. A third radio-collar that was brand new from Telonics was attached to the animal and the animal was safely released. This collar also malfunctioned and only recorded approximately 10-20% of the points through the satellite download.

Figure 6-19 shows the documented locations of NNSS8 from July 30 to January 1, 2017. It spent the first couple of weeks on the eastern portion of Pahute Mesa and then moved to the Belted Range north of the NNSS until early November when it moved to the Oak Spring Butte area and the Gold Meadows area (Area 12) for a couple of weeks. On November 23, 2016 it was back in the Belted Range near Indian Spring. The next known point is on January 1, 2017 which is located east of Wheelbarrow Peak in the low elevation foothills of the Belted Range. Five known kills were documented between August 10 and November 14, 2016. One around Echo Peak (August 10), two in the Belted Range (August 26 and

Figure 6-17. NNSS8 in pinyon pine tree after being "treed" by hounds.

(Photo taken by D.B. Hall, July 28, 2017)

Figure 6-18. NNSS8 in rock pile on eastern edge of Rainier Mesa after being cornered by hounds.

(Photo taken by D.B. Hall, July 30, 2017)

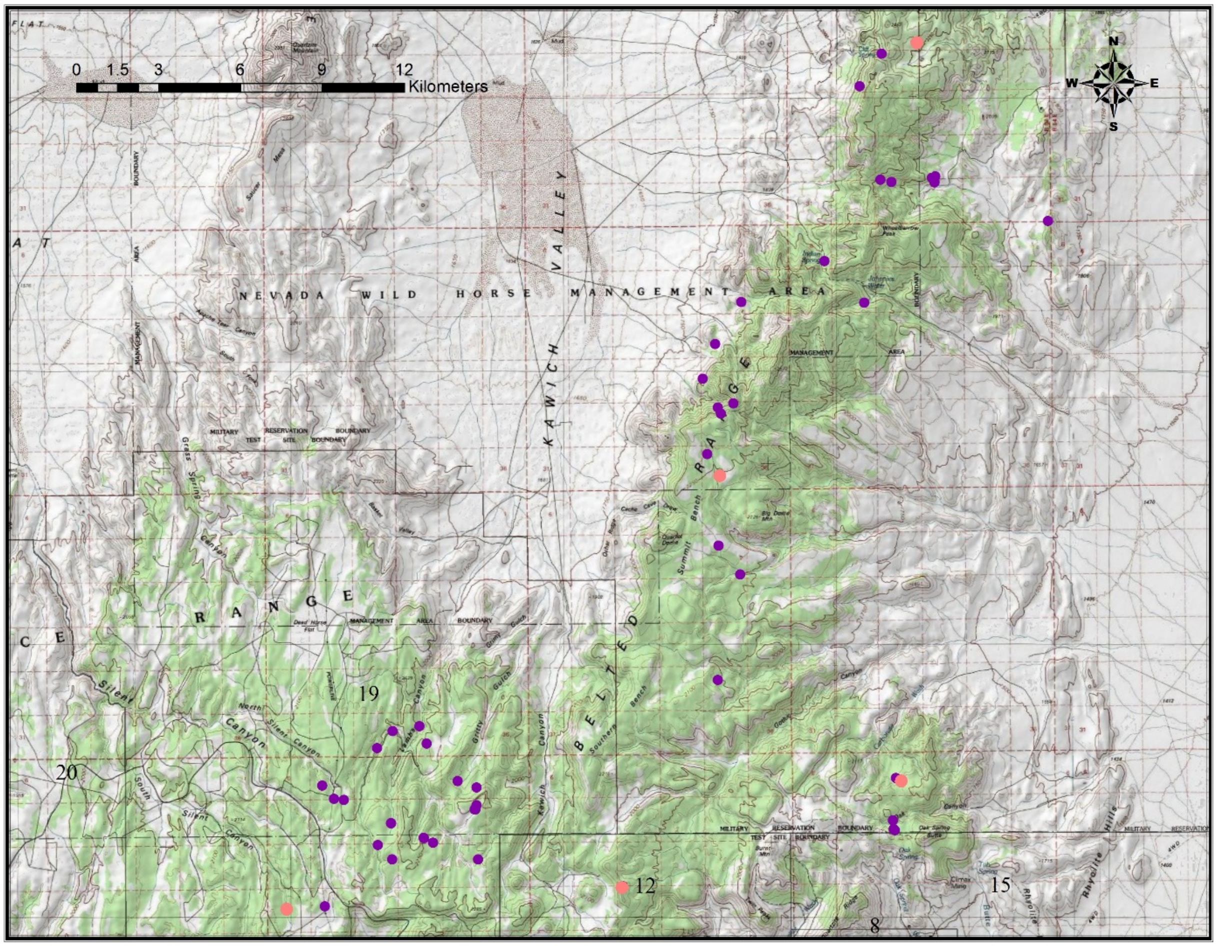

Figure 6-19. Locations of NNSS8 from July 30, 2016 to January 1, 2017 (purple dots). Recorded mule deer kill locations (pink dots).

September 30), one in east Gold Meadows (November 1), and one north of Oak Spring Butte (November 14) (Figure 6-19). All kills were mule deer; three bucks, one doe, and one fawn.

6.6.2.2 NNSS9

NNSS9 was captured in a snare trap on the 19-01 road on August 3, 2016 after 145 trap nights. It was estimated to be 3-4 years old and weigh 58.5 kg. Figure 6-20 shows the documented locations of NNSS9 from August 3, 2016 to January 1, 2017. It spent most of its time around Rainier Mesa and the eastern portion of Pahute Mesa with movements into the southern Belted Range, Oak Springe Butte area, and northern Eleana Range. A total of 38 clusters were checked between capture and January 1, 2017 with 17 documented kill sites and one scavenged site (mule deer) which also happened to be the first kill site of NNSS8 (Figure 6-20). All 17 kills were mule deer; 11 bucks, 1 doe, and 5 fawns.

6.6.3 Risk to Humans

The only recorded observations of mountain lions during 2016 other than from camera traps and trapping efforts were recorded by NNSS biologists during mule deer surveys in the fall. One was near Camp 17 Pond on September 13, one was off of Holmes Road near the Rainier Mesa summit on September 14, and one was off of Rainier Mesa Road near the G Tunnel Road intersection on September 27 (Figure 6-13). None of the observed mountain lions were radio-collared and it was not determined if it was the same animal or different animals.

A few records from Frenchman Playa, Control Point Hills, and Yucca Flat have been recorded in the past but these sightings are extremely isolated and rare. Based on historic records and data obtained from nine radio-collared mountain lions, it is evident that these animals prefer rugged, mountainous, typically forested habitat in the northern and western portions of the NNSS. Very few active projects occur in these areas, so the overall risk of human encounters with mountain lions on the NNSS appears to be low. Facilities in these areas include the Calico Hills firing range (Area 25), several tunnel complexes in Area 12 (e.g., G, U, V, and P Tunnels), and communication towers and power substations in Area 19 (Echo Peak and Pahute Mesa), Area 12 (DOE Point), and Area 29 (Shoshone Mountain). Personnel who work in these mountainous, remote areas (e.g., communication and power system maintenance workers, military personnel, etc.), especially at night, are most at risk and should be aware that mountain lions do occur around these facilities.

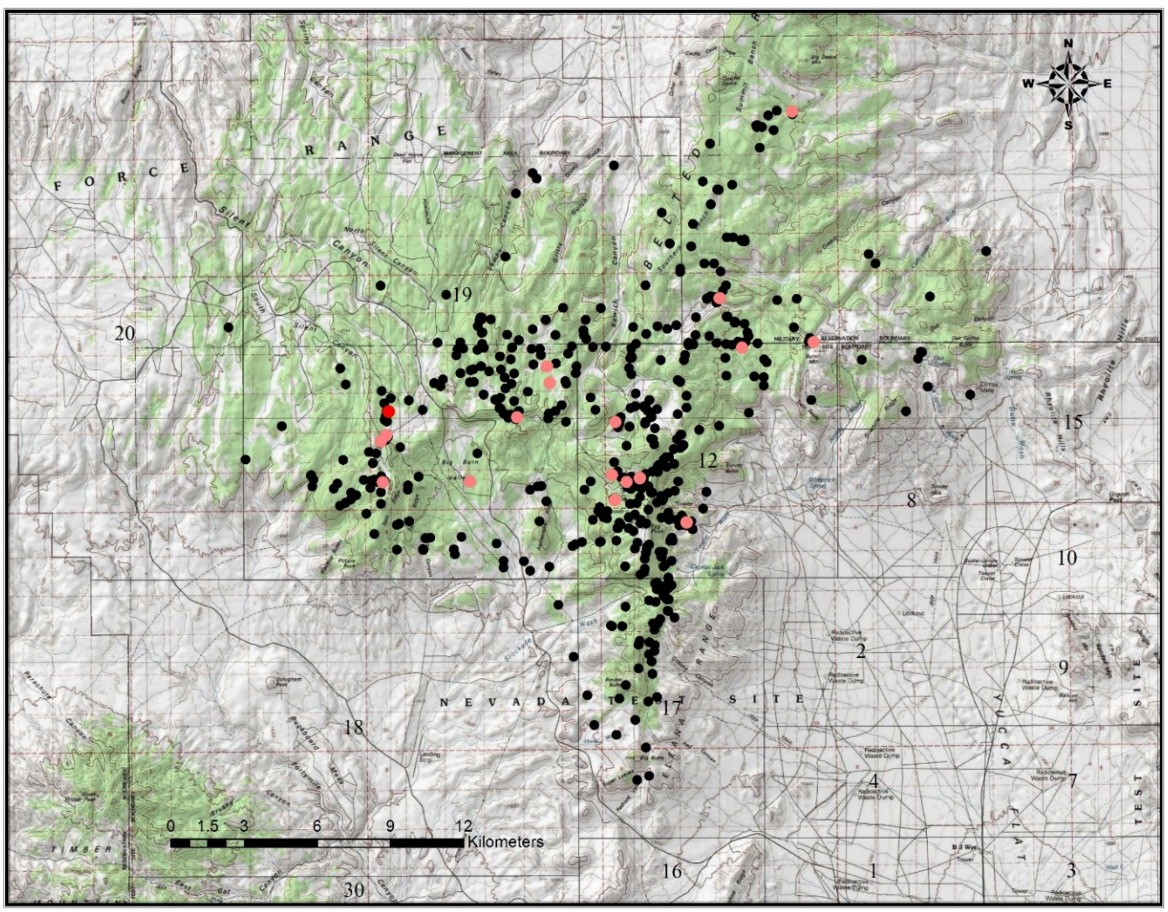

Figure 6-20. Locations of NNSS9 from August 3, 2016 to January 1, 2017 (black dots). Recorded mule deer kill locations (pink dots) and one scavenged site (red dot).

6.7 RADIOLOGICAL SAMPLING

Sampling for radionuclides in mountain lions and their prey was performed in order to 1) determine uptake of radionuclides left over from previous nuclear testing on the NNSS, 2) estimate the dose to a human potentially consuming a contaminated animal, and 3) estimate the dose to the animal and determine if the dose is harmful. Four opportunistic roadkill pronghorn antelope (one in Frenchman Flat and three in Yucca Flat) were also sampled for radionuclides. Mountain lions and their favored prey, mule deer and bighorn sheep, as well as pronghorn antelope are regulated as big game animals by NDOW and are hunted. These species are also known to have large home ranges and are likely to leave the NNSS and move into areas where hunting is allowed. This is therefore, a potential pathway for humans to receive a dose from radionuclides found on the NNSS and must be accounted for.

During 2016, 23 samples were collected and analyzed. These included 11 mule deer killed by mountain lions (muscle tissue and water), 4 roadkill antelope (muscle tissue and water), 6 mountain lion scat (water), and 2 mountain lion blood (water) samples. Water was distilled from the samples and submitted to a laboratory for tritium (^{3}H) analysis, and the remaining tissue samples were submitted for Strontium-90 (^{90}Sr), Plutonium-238 (^{238}Pu), Plutonium-239+240 ($^{239+240}Pu$), Americium-241 (^{241}Am), and gamma spectroscopy analysis.

Man-made radionuclides were detected in one antelope (Area 2), in 10 of the 11 mule deer, and in both mountain lions (Table 6-5). ^{90}Sr, ^{238}Pu, $^{239+240}Pu$, ^{3}H and ^{241}Am were detected in mule deer but only ^{3}H was detected in the antelope. Activity levels in mule deer and mountain lion samples were dominated by ^{3}H. Doses from these concentrations are overall very low and do not present a hazard to the animal or a person eating them (NSTec, 2017 in review).

6.8 NUISANCE AND POTENTIALLY DANGEROUS WILDLIFE

During 2016, NNSS biologists documented 51 calls regarding nuisance, injured, dead or potentially dangerous wildlife in or around buildings, power lines, and work areas on the NNSS. Problem, injured, or dead animals included birds (20 calls), bats (9 calls), other mammals (11 calls), reptiles (10 calls, including 3 rattlesnakes), and bees (1 call). Mitigation measures taken typically involved relocating the animals away from people, instructing workers to leave the animal in place, or disposing of dead animals.

6.9 ELK, PRONGHORN ANTELOPE, AND WILD BURROS

Historic studies on the NNSS do not mention the presence of either Rocky Mountain elk or pronghorn antelope (Jorgensen and Hayward 1965; Collins et al. 1982). Likewise, horses but not burros were mentioned by Jorgensen and Hayward (1965). Collins et al. (1982) conducted a biologic overview of the Yucca Mountain area and found that individual burros were occasionally observed near Cane and Topopah springs and documented numerous burro droppings in the central section of Yucca Mountain along the major ridges and in the eastern side canyons. They did not see any animals and concluded that burros used this area in winter and spring when ephemeral water and succulent plants were present. Site characterization studies at Yucca Mountain in the late 1980s and 1990s rarely if ever documented burros, and elk and antelope were not documented at all.

Saethre (1994) reported that Rocky Mountain elk are resident outside the NNSS and rarely observed on the NNSS but did not document any specific sightings. In 2009-2010, a young bull roamed around Rainier Mesa and eastern Pahute Mesa for about 1.5 years and then disappeared. In 2015, a young bull was photographed four times at Gold Meadows Spring (Area 12) on May 31, June 20, and June 28 (2 photos). An elk was also recorded on top of Rainier Mesa, above B Tunnel (Area 12) on April 18. The head is not visible in the video clip so it is difficult to tell if this is the same individual as the one at Gold Meadows Spring. Young bull elk are known to disperse from their natal range, and it is likely that the

Table 6-5. Concentrations of man-made radionuclides in animals sampled during the mountain lion study and from opportunistic roadkill in 2016.

	Radionuclide Concentrations ± Uncertainty[a]				
Sample	^{3}H (pCi/L)[b]	^{90}Sr (pCi/g)[c]	^{238}Pu (pCi/g)[c]	$^{239+240}$Pu (pCi/g)[c]	^{241}Am (pCi/g)[c]
Mule deer					
Area 12 / NNSS 9-2	23,400 ± 2,190	0.009 ± 0.009	0.0023 ± 0.0015	0.0042 ± 0.0020	0.0029 ± 0.0024
Area 19 / NNSS 9-3	1,630 ± 294	0.031 ± 0.014	0.0014 ± 0.0011	0.0060 ± 0.0025	0.0034 ± 0.0030
Area 19 / NNSS 9-11	566 ± 183	0.013 ± 0.008	0.0017 ± 0.0013	0.0086 ± 0.0030	0.0036 ± 0.0023
Area 19 / NNSS 9-12	33 ± 136	-0.016 ± 0.026	0.0021 ± 0.0029	0.0010 ± 0.0046	0.0012 ± 0.0024
Area 12 / NNSS 9-16	70,800 ± 6,350	-0.002 ± 0.026	0.0010 ± 0.0020	0.0049 ± 0.0044	0.0134 ± 0.0082
Area 12 / NNSS 9-22	904 ± 218	-0.001 ± 0.012	0.0014 ± 0.0011	0.0024 ± 0.0014	0.0014 ± 0.0016
Area 12 / NNSS 9-23	21,200 ± 2,000	0.031 ± 0.033	0.0024 ± 0.0028	0.0040 ± 0.0036	0.0048 ± 0.0068
Area 12 / NNSS 8-5	20,100 ± 1,890	0.021 ± 0.024	0.0012 ± 0.0075	0.0018 ± 0.0048	0.0004 ± 0.0023
Area 12 / NNSS 9-26	9,480 ± 969	-0.002 ± 0.016	0.0001 ± 0.0020	0.0009 ± 0.0014	0.0000 ± 0.0012
NTTR / NNSS 9-28	6,240 ± 736	0.024 ± 0.019	0.0043 ± 0.0024	0.0270 ± 0.0060	0.0066 ± 0.0042
NTTR / NNSS 8-6	405 ± 207	-0.006 ± 0.015	0.0004 ± 0.0015	0.0330 ± 0.0067	0.0033 ± 0.0029
Average Concentration	14,069	0.009	0.0017	0.0085	0.0037
Average MDC[d]	265	0.031	0.0032	0.0029	0.0037
Mountain lion (NNSS8)					
Area 12	839 ± 588	---	---	---	---
Area 12 / NNSS 8-5	9,890 ± 1,000	---	---	---	---
NTTR / NNSS 8-6	6,170 ± 729	---	---	---	---
Average Concentration	5,633	(Mountain lion samples were only analyzed for ^{3}H)			
Average MDC[d]	502				
Mountain lion (NNSS9)					
Area 19	2,500 ± 973	---	---	---	---
Area 12 / NNSS 9-2	2,510 ± 358	---	---	---	---
Area 12 / NNSS 9-22	48,900 ± 4,430	---	---	---	---
Area 12 / NNSS 9-23	27,500 ± 2,550	---	---	---	---
NTTR / NNSS 9-28	7,420 ± 852	---	---	---	---
Average Concentration	17,766				
Average MDC[d]	499				
Opportunistic Sampling					
Pronghorn (Area 2)	1,950 ± 298	-0.016 ± 0.023	0.0076 ± 0.0088	0.0017 ± 0.0048	-0.0032 ± 0.0056
Pronghorn (Area 5)	139 ± 212	0.012 ± 0.026	0.0003 ± 0.0014	0.0006 ± 0.0014	-0.0005 ± 0.0012
Pronghorn (Area 3)	-138 ± 177	-0.005 ± 0.016	0.0019 ± 0.0056	0.0035 ± 0.0068	0.0003 ± 0.0041
Pronghorn (Area 4)	373 ± 233	-0.055 ± 0.046	0.0087 ± 0.0103	0.0035 ± 0.0097	0.0000 ± 0.0077
Average Concentration	581	-0.016	0.0046	0.0023	-0.0008
Average MDC[d]	318	0.058	0.0099	0.0099	0.0100

(a) ± 2 standard deviations
(b) picocuries per liter water from sample
(c) Picocuries per gram wet weight of sample
(d) Average sample specific MDC

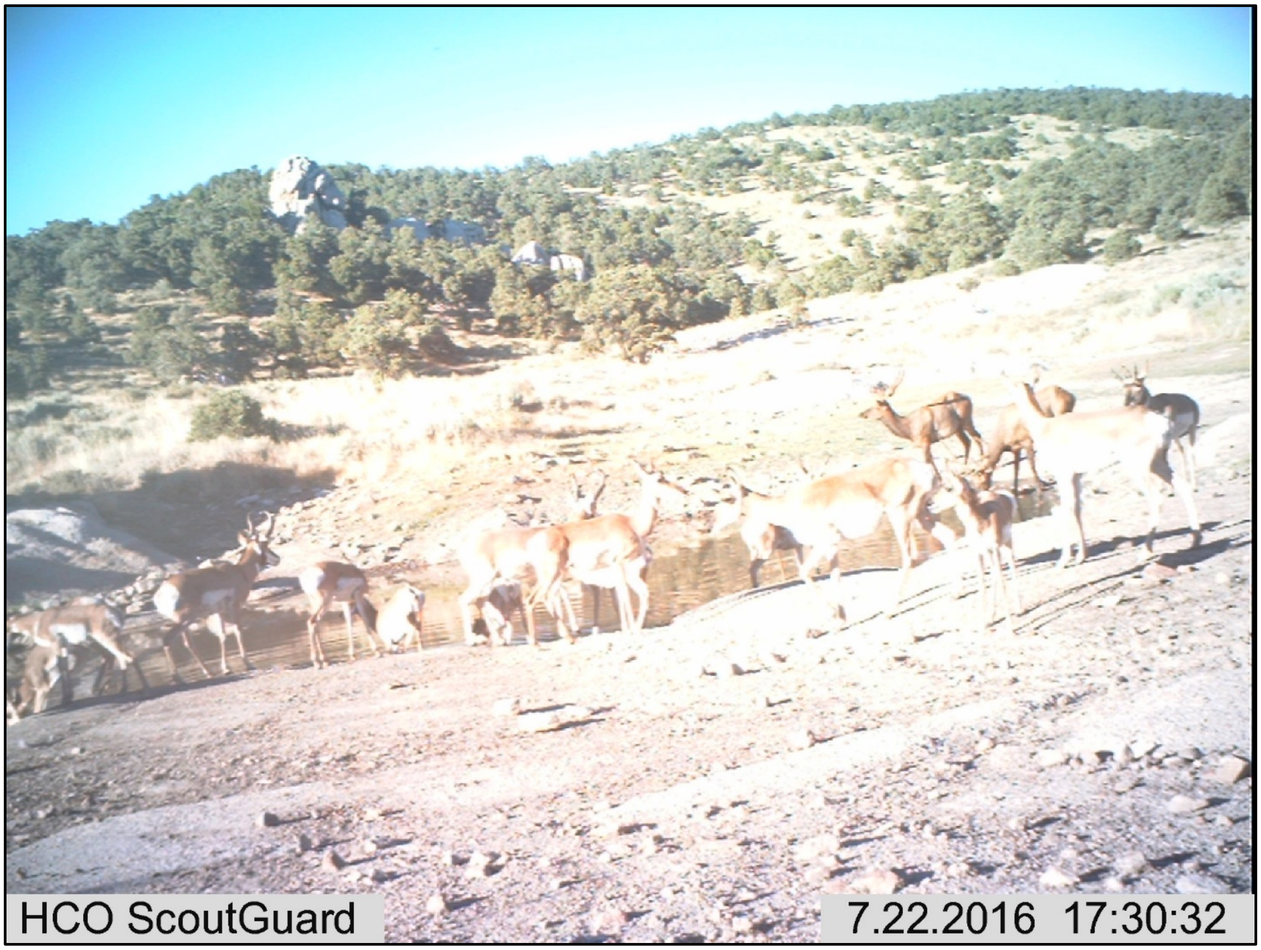

Figure 6-21. Two bull elk and several pronghorn antelope using Gold Meadows Spring.

(Photo by motion-activated camera, June 22, 2016)

source population for the young bulls is to the north, possibly in the Groom or Kawich Range. During 2016, two young bull elk were photographed at Gold Meadows Spring several times between June 12 and July 22. A single bull was photographed at the same site on May 22. Both elk and pronghorn antelope have been observed using this water source simultaneously (Figure 6-21).

Pronghorn antelope appear to be increasing in number and expanding their range on the NNSS. During 2016, a herd of 98 was seen in Gold Meadows on September 20 (Figure 6-22). This is the largest number of antelope ever documented on the NNSS. A total of 586 antelope photos were recorded via camera traps at Gold Meadows Spring during 2016 with the majority recorded between late June and mid-November. Antelope were also photographed at the Well 5C water trough (5 images), the Area 6 LANL Pond water trough (107 images), the Well C1 water trough (25 images), and Camp 17 Pond (1 image). Antelope are regularly observed around Mercury, in Frenchman Flat and in Yucca Flat.

Wild burros also appear to be increasing in number and expanding their range on the NNSS in recent years. A resident herd has been known to occupy Crater Flat, west of the NNSS for decades but sightings on the NNSS have been rare. During 2016, burros and their sign (e.g., scat, tracks) were documented as far north as Twin Spring (Area 29) in Fortymile Canyon with tracks and scat along the road from Yucca Mountain to Twin Spring. In fact, nine individuals were seen near Twin Spring on January 11, 2016, including three young. Forty-five and 21 images of two burros were taken at Well C1 trough and Well 5C

Figure 6-22. A herd of nearly 100 pronghorn antelope in Gold Meadows.

(Photo by M. Townsend, September 20, 2016)

trough, respectively during 2016. Six burros, including two young were observed in southern Mercury Valley crossing Mercury Highway on March 10 and burro scat was seen on Jackass Flats Road near the Mercury Sewage Lagoons.

6.10 COORDINATION WITH BIOLOGISTS AND WILDLIFE AGENCIES

Site biologists interfaced with other biologists and wildlife agencies in 2016 for the following activities:

- Assisted FWS biologists with the collection and genetic testing of southeast Nevada pyrgs (*Pyrgulopsis turbatrix*) from Cane Spring.
- Published paper entitled "Distribution and Habitat Partitioning of Two Skink Species on the Nevada National Security Site in South-central Nevada" in Herpetological Review.
- Reviewed western burrowing owl (*Athene cunicularia*) diet paper for the Journal of Raptor Research.
- Contributed to a film documentary that USGS is producing about desert bighorn sheep and mountain lions on the NNSS.
- Wrote species account for long-legged myotis (*Myotis volans*) and did threats assessment for Nevada bats for the Nevada Bat Conservation Plan.
- Attended Nevada Bat Working Group Meeting in Reno, Nevada, in December 2016.

7.0 HABITAT RESTORATION MONITORING

NSTec biologists have conducted revegetation activities at disturbances on and off the NNSS in support of NNSA/NFO programs and continue to evaluate previous revegetation efforts. Revegetation supports the intent of Executive Order EO 13112, "Invasive Species," to prevent the introduction and spread of non-native species and restore native species to disturbed sites. Revegetation also may qualify as mitigation for the loss of desert tortoise habitat under the current Opinion. Activities conducted in 2016 included visually assessing the vegetation at the U-3ax/bl closure cover and quantitative assessments of vegetation at four sites on the TTR; Corrective Action Unit (CAU) 400 Five Points Landfill, CAU 400 Bomblet Pit, CAU 404 Roller Coaster Lagoons and Trench, and CAU 407 Roller Coaster Radsafe Area.

The four TTR sites were inspected on June 14-15, 2016. Plant cover and density estimates were made, wildlife usage was noted, and erosion conditions were evaluated. Plant cover was estimated using an optical point projection device. Sample points were taken at given intervals along a permanent linear transect. Cover was recorded by species. Plant density was estimated using 1-square meter (m^2) quadrats at given intervals along each transect. The total number of individual plants within each quadrat was recorded and the data were averaged over all quadrats.

Species richness was calculated from density data. The number of different plant species within each quadrat was averaged over all quadrats to determine the average number of different species present. This provides indication of the diversity or heterogeneity of the plant community.

Revegetation is considered successful when a pre-determined percentage of plant cover and density is achieved. These are typically a percentage of plant cover and density on an adjacent area that represents an undisturbed plant community. A typical percentage used to determine reclamation success is 70 percent. The time needed for reestablishment of a native plant community on a disturbed location depends on factors such as degree of disturbance, soil type, climate conditions, precipitation amounts and patterns, and temperature extremes. Revegetation success is achieved after several consecutive years of meeting, or exceeding, success criteria.

Wildlife usage was determined from the presence of animal burrows or scat, browsing by animals, and the observation of animals. Erosion was measured using the modified Bureau of Land Management erosion condition classification. Pedestalling of soils, movement of surface litter, and rilling or gullying on the surface provided an objective characterization of erosion.

7.1 CAU 110, U-3AX/BL, CLOSURE COVER

No quantitative sampling occurred on this site in 2016. A visual assessment indicated that the vegetative cover continues to show signs of a stable plant community capable of removing water from the soil profile through evapotranspiration.

7.2 CAU 400, FIVE POINTS LANDFILL

In 2016, four transects were sampled, two in the area that had not flooded (staging area) (Figures 7-1 and 7-2), one in the area that had flooded and was reseeded in 2004 (Figure 7-2), and one in the reference area (Figure 7-3).

Figure 7-1. Staging area at CAU 400, Five Points Landfill.

(Photo by D.B. Hall, June 15, 2016)

Figure 7-2. Staging area (lower right) and reseeded area (upper left) at CAU 400, Five Points Landfill.

(Photo by D.B. Hall, June 15, 2016)

Figure 7-3. Reference area at CAU 400, Five Points Landfill.

(Photo by D.B. Hall, June 15, 2016)

7.2.1 Percent Plant Cover

Total plant cover on the staging area was almost 25 percent (Table 7-1) which was five percent less than cover on the reference area. Fourwing saltbush (*Atriplex canescens*) contributed over 30 percent of the total cover. There were no grasses found on the staging area. The majority of the plant cover came from Esteve's pincushion (*Chaenactis stevioides*), an annual forb common to the native community. For the reference area, Greene's rabbitbrush (*Chrysothamnus greenei*) contributed most of the shrub cover in addition to fourwing saltbush. Indian ricegrass (*Achnatherum hymenoides*) made up all of the grass cover. Forb cover was about the same as on the staging area and made up more than 50% of the total cover. The two main forbs that contributed to cover on the reference area were Esteve's pincushion and whitestem blazingstar (*Mentzelia albicaulis*), both native annual species.

Shrub cover on the reseeded area (Figure 7-2) was much lower than the reference area. Again annual forbs made up the largest cover percentage. Three species of annuals were found on the reseeded area, western tansymustard (*Descurainia pinnata*), whitestem blazingstar and prickly Russian thistle (*Salsola iberica*), an invasive weed.

Table 7-1. Plant cover (%) on CAU 400, Five Points Landfill, June 2016.

	Staging	Reseeded	Reference	Standard
Shrubs				
Fourwing saltbush (*Atriplex canescens*)	8.33	2.00	2.50	
Greene's rabbitbrush (*Chrysothamnus greenei*)	0.00	0.00	5.00	
Total Shrubs	8.33	2.00	7.50	5.25
Grasses				
Indian ricegrass (*Achnatherum hymenoides*)	0.00	0.00	6.67	
James' galleta (*Pleuraphis jamesii*)	0.00	1.00	0.00	
Total Grasses	0.00	1.00	6.67	4.67
Forbs/Annuals				
Esteve's pincushion (*Chaenactis stevioides*)	15.83	0.00	4.17	
Western tansymustard (*Descurainia pinnata*)	0.83	12.00	0.00	
Great Basin woollystar (*Eriastrum sparsiflorum*)	0.00	0.00	0.83	
Nye Gilia (*Gilia nyensis*)	0.00	0.00	2.50	
Purple desert lupine (*Lupinus shockleyi*)	0.00	0.00	0.83	
Whitestem blazingstar (*Mentzelia albicaulis*)	0.00	2.00	5.00	
Tufted evening primrose (*Oenothera caespitosa*)	0.00	0.00	2.50	
Prickly Russian thistle (*Salsola iberica*)	0.00	3.00	0.83	
Total Forbs	16.66	17.00	16.66	11.66
Total Plant Cover	**24.99**	**20.00**	**30.83**	**21.58**
Bare Ground	65.00	35.00	60.84	
Litter	10.00	45.00	8.33	

7.2.2 Plant Density (Plants/m^2)

Total plant density on the staging area exceeded that on the reference area (Table 7-2). Shrub density was also higher on the staging area compared to the reference area. Only one shrub, fourwing saltbush, made up the shrub density on the staging area. Two species of grasses contributed to grass density, Indian ricegrass and James' galleta (*Pleuraphis jamesii*), but grass density on the staging area was less than half of the grass density on the reference area. Four grasses were found on the reference area. On the reseeded area, total density was only slightly less than the reference area.

There were a variety of forbs on all of the three sites this year due to fair precipitation. There was very little differences among the three sites for forb cover but the performance of species varied among sites. Esteve's pincushion and whitestem blazingstar were the most abundant forbs in the staging area. Prickly Russian thistle dominated the reseeded area and Nye gilia (*Gilia nyensis*) was the most abundant on the reference area.

7.2.3 Species Richness

There were about six different species found within each square meter area on the staging area (Table 7-3). This included shrubs, grasses, but mostly forbs/annuals. There was only one native shrub species encountered on the staging area, fourwing saltbush, along with two native grasses, Indian ricegrass and James' galleta. Two native shrubs, fourwing saltbush and Greene's rabbitbrush, occurred on the reference area. Four species of grasses occurred on the reference area, Indian ricegrass, James galleta, squirreltail (*Elymus elymoides*), and alkali sacaton (*Sporobolus airoides*). Two of these also occurred on the staging area. There were a total of 10 forb species found on the staging area, 7 species on the reseeded areas, and 16 species on the reference area.

Species richness on the reseeded area was low. On average, there was just over two species per m^2 on the reseeded area compared to nearly six on the staging area. The only shrub encountered was fourwing saltbush. Indian ricegrass was found on the site but was not as abundant as squirreltail, a grass that was very common in this area before it was flooded.

7.2.4 Revegetation Success

The staging area has successfully revegetated. Using 70 percent of plant cover, plant density, and species richness on the reference area as a standard for successful revegetation, plant cover, density and species richness all exceeded the standard. Overall plant cover was 24.99 percent, which was higher than the standard of 21.58 percent. When considering success by life form, shrubs and forbs exceeded the standard. Shrub cover and forb cover were about 50 percent higher than the standard. There was no grass cover on the staging area. Shrub cover maintained at a relatively high level over the past five years, but grass cover has declined to zero over the last several years. Growing conditions have not been optimal for the last several years, and grasses were most affected by the dry conditions. Forb growth corresponds to the timing and intensity of precipitation, and the fluctuations in forb cover over the last five years indicated such a response. The reseeded area met or exceeded the standard for density but did not meet the standard for cover or species richness. This area appeared to have flooded again this past year although not as much as in previous years.

Table 7-2. Plant density (plants/m^2) on CAU 400, Five Points Landfill, June 2016.

	Staging	Reseeded	Reference	Standard
Shrubs				
Fourwing saltbush (*Atriplex canescens*)	0.50	0.28	0.07	
Greene's rabbitbrush (*Chrysothamnus greenei*)	0.00	0.00	0.17	
Total Shrubs	**0.50**	**0.28**	**0.24**	**0.17**
Grasses				
Indian ricegrass (*Achnatherum hymenoides*)	0.37	0.08	1.03	
James' galleta (*Pleuraphis jamesii*)	0.10	0.00	0.03	
Squirreltail (*Elymus elymoides*)	0.00	0.12	0.07	
Alkali sacaton (*Sporobolus airoides*)	0.00	0.00	0.13	
Total Grasses	**0.47**	**0.20**	**1.23**	**0.86**
Forbs				
Lambsquarters (*Chenopodium album*)	0.00	0.04	0.00	
Desert Parsley(*Cymopterus* species)	0.00	0.00	0.03	
Cushion cryptantha (*Cryptantha circumscissa*)	0.07	0.00	0.33	
Great Basin woollystar (*Eriastrum sparsiflorum*)	1.40	0.04	2.17	
Woolly desert marigold (*Baileya pleniradiata*)	0.00	0.00	0.03	
Esteve's pincushion (*Chaenactis stevioides*)	14.80	0.92	2.47	
Flatcrown buckwheat (*Eriogonum deflexum*)	0.53	0.00	0.23	
Hoary tansyaster (*Machaeranthera canescens*)	0.33	0.00	0.50	
Saltlover (*Halogeton glomerata*)	0.00	0.04	0.00	
Purple desert lupine (*Lupinus shockleyi*)	0.00	0.00	1.73	
Nye gilia (*Gilia nyensis*)	3.37	0.00	12.17	
Prickly Russian thistle (*Salsola iberica*)	1.33	19.00	0.80	
Tufted evening primrose (*Oenothera caespitosa*)	0.00	0.00	0.87	

Table 7-2. Plant density (plants/m²) on CAU 400, Five Points Landfill, June 2016 (continued).

Fanleaf crinklemat (*Tiquilia plicata*)	0.80	0.00	1.60	
Small wirelettuce (*Stephanomeria exigua*)	0.00	0.00	0.07	
Sowthistle desertdandelion (*Malacothrix sonchoides*)	0.00	0.00	0.07	
Western tansymustard (*Descurainia pinnata*)	0.33	4.80	0.33	
Whitestem blazingstar (*Mentzelia albicaulis*)	12.60	3.00	6.30	
Total Forbs	**35.56**	**27.84**	**29.47**	**20.63**
Total Plant Density	**36.53**	**28.32**	**30.94**	**21.66**

Table 7-3. Species richness (species/m²) on CAU 400, Five Points Landfill, June 2016.

	Staging	Reseeded	Reference	Standard
Shrubs	0.37	0.16	0.17	0.12
Grasses	0.47	0.16	0.70	0.49
Forbs/Annuals	4.96	2.05	6.83	4.78
Total Species	**5.80**	**2.37**	**7.70**	**5.39**

7.2.5 Wildlife Use

Small mammal burrows were observed on the southeastern section of the site. Shrubs did not show signs of excessive browsing. There was no sign of large animals (horses and antelope).

7.2.6 Soil Erosion

There were some signs of heavy water movement through the channel that traverses the site. The lower areas had some addition of silts that had been washed in but nothing like previous erosion events. Soil outside the lower areas appears to be stable and shows no signs of erosion.

7.2.7 Summary/Recommendations

The plant community is viable and persistent. Total density exceeded the adjacent native community. Cover and species richness on the staging area exceeded success standards, indicating the plant community has established on the site and is diverse and viable.

A concern for the non-flooded areas is the composition of plant cover and density. Over the last few years, the amount of precipitation received throughout the region has been low. Grasses have suffered from the dry conditions and grass cover has gradually declined over the last few years.

Another concern is the establishment of a plant community where water accumulates from floods or moderate precipitation events. When water does not infiltrate quickly, plant roots may be submerged for extended periods of time, resulting in plant mortality. Correcting the drainage issue would be labor intensive and costly. It is recommended that the flood areas continue to be monitored to document changes in the plant community and to identify and document conditions that may prohibit plant establishment and growth.

7.3 CAU 400, BOMBLET PIT

Two transects were sampled, one in the revegetated area (Figure 7-4) and one in the reference area (Figure 7-5) directly east of the site.

7.3.1 Percent Plant Cover

Total percent plant cover on the revegetated area was higher than the reference area in 2016, and was made up almost entirely of forb/annual cover (Table 7-4). On the revegetated area, shadscale saltbush (*Atriplex confertifolia*) accounted for all of the shrub cover. On the reference area, there were two shrubs, shadscale saltbush and bud sagebrush (*Picrothamnus desertorum*), but like the staging area, the bulk of plant cover was contributed by forbs/annuals.

Figure 7-4. Revegetated area at CAU 400, Bomblet Pit.

(Photo by D.B. Hall, June 15, 2016)

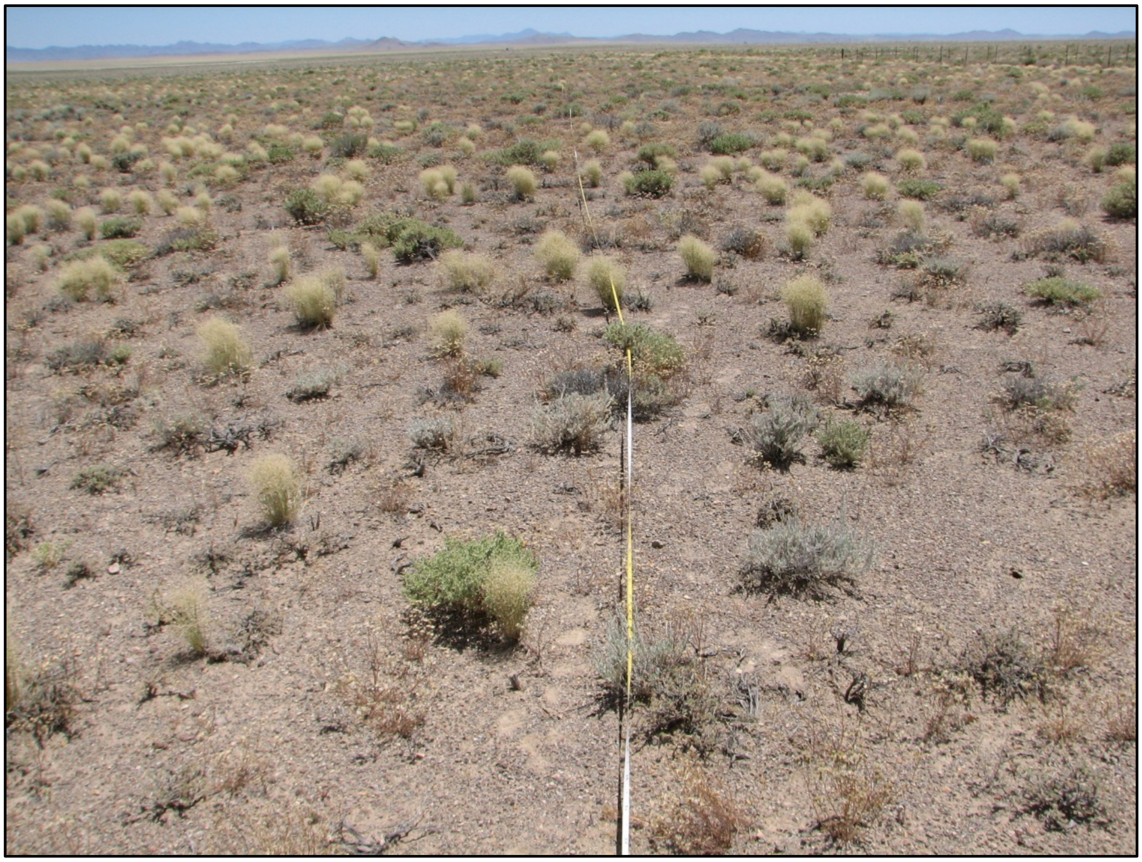

Figure 7-5. Reference area east of CAU 400, Bomblet Pit.

(Photo by D.B. Hall, June 15, 2016)

Table 7-4. Plant cover (%) on CAU 400, Bomblet Pit, June 2016.

	Staging	Reference	Standard
Shrubs			4.38
Shadscale saltbush (*Atriplex confertifolia*)	1.25	3.75	
Bud sagebrush (*Picrothamnus desertorum*)	0.00	2.50	
Grasses	0.00	1.25	0.88
Forbs/Annuals	23.75	10.00	7.00
Total Plant Cover	**25.00**	**17.50**	**12.25**
Bare Ground	57.50	71.25	
Litter	17.50	11.25	

7.3.2 Plant Density (Plants/m^2)

Shrub density on the revegetated area has declined particularly for bud sagebrush (Table 7-5). The two most common species on this area, bud sagebrush and shadscale saltbush, were also on the reference area. There were no grasses on the revegetated area, and only two species were found on the reference area. Forb density was very high on the revegetated area with saltlover (*Halogeton glomeratus*), a noxious invasive weed dominating. Esteve's pincushion was the dominant forb on the reference area. This species also occurred on the revegetated area but at lower densities.

Table 7-5. Plant density (plants/m^2) on CAU 400, Bomblet Pit, June 2016.

	Staging	Reference	Standard
<u>Shrubs</u>			
Bud sagebrush (*Picrothamnus desertorum*)	0.45	2.05	
Shadscale saltbush (*Atriplex confertifolia*)	0.45	0.45	
Winterfat (*Krascheninnikovia lanata*)	0.00	0.25	
Total Shrubs	**0.90**	**2.75**	**1.92**
<u>Grasses</u>			
Indian ricegrass (*Achnatherum hymenoides*)	0.00	0.25	
James' galleta (*Pleuraphis jamesii*)	0.00	0.05	
Total Grasses	**0.00**	**0.30**	**0.21**
<u>Forbs</u>			
Esteve's pincushion (*Chaenactis stevioides*)	3.80	10.25	
Cushion cryptantha (*Cryptantha circumscissa*)	0.05	0.10	
Western tansymustard (*Descurainia pinnata*)	0.00	0.05	
Gilia (*Gilia* spp.)	0.00	0.05	
Shaggyfruit pepperweed (*Lepidium lasiocarpum*)	1.05	0.50	
Saltlover (*Halogeton glomerata)*	38.90	1.05	
Hoary tansyaster (*Machaeranthera canescens*)	0.00	0.10	
Desert globemallow (*Sphaeralcea ambigua*)	0.05	0.00	
Total Forbs	**43.85**	**12.10**	**8.47**
Total Plant Density	**44.75**	**15.15**	**10.60**

7.3.3 Species Richness

Species richness was relatively low, including on the reference area (Table 7-6). On average there were just under three species encountered within a square meter on the revegetated area compared to over four species on the reference area. Shadscale saltbush and bud sagebrush were common to both the revegetated and reference areas and winterfat (*Krascheninnikovia lanata*) was only found on the reference area. Five species of forb were found on the revegetated area while seven species were found on the reference area.

Table 7-6. Species richness (species/m^2) on CAU 400, Bomblet Pit, June 2016.

	Staging	**Reference**	**Standard**
Shrubs	0.75	1.65	1.16
Grasses	0.00	0.20	0.14
Forbs/Annuals	2.20	2.30	1.61
Total Species	**2.95**	**4.15**	**2.91**

7.3.4 Revegetation Success

Plant cover, density, and species richness exceeded the standards due to the high densities of annual forbs, primarily saltlover, a noxious weed. Shrubs have persisted through less than optimal growing conditions the last few years but did not reach the success standard. The native plant community did not have a rich forb or grass component. The absence of grasses did not indicate failure of revegetation efforts; rather the abundance of shrubs suggest that a stable plant community similar to the adjacent undisturbed plant community has established at the site.

7.3.5 Wildlife Use

The site is relatively flat and few small mammal burrows were present. The majority of small mammal activity was along the fence where soil accumulated and provided a burrowing medium. There was no evidence of excessive browsing.

7.3.6 Soil Erosion

There was no evidence of erosion at this site.

7.3.7 Summary/Recommendations

The goals of revegetation have been accomplished. Native plant species were established and contributed to overall plant cover and density. Although plant cover, density and species richness exceeded success standards in 2016 most of this is attributed to the abundance of annual forbs on the site from adequate rainfall. Many seeded species have persisted the last few years during poor growing conditions, and when those conditions improve, species that have contributed to plant cover and density in the past may return.

7.4 CAU 404, ROLLER COASTER LAGOONS AND TRENCH

Three transects on the staging area (Figure 7-6), three on the cover cap (Figure 7-7), and three on the reference area (Figure 7-8) were sampled. The reference area is northwest of the site.

Figure 7-6. Staging area on CAU 404, Roller Coaster Lagoons and Trench.

(Photo by D.B. Hall, June 15, 2016)

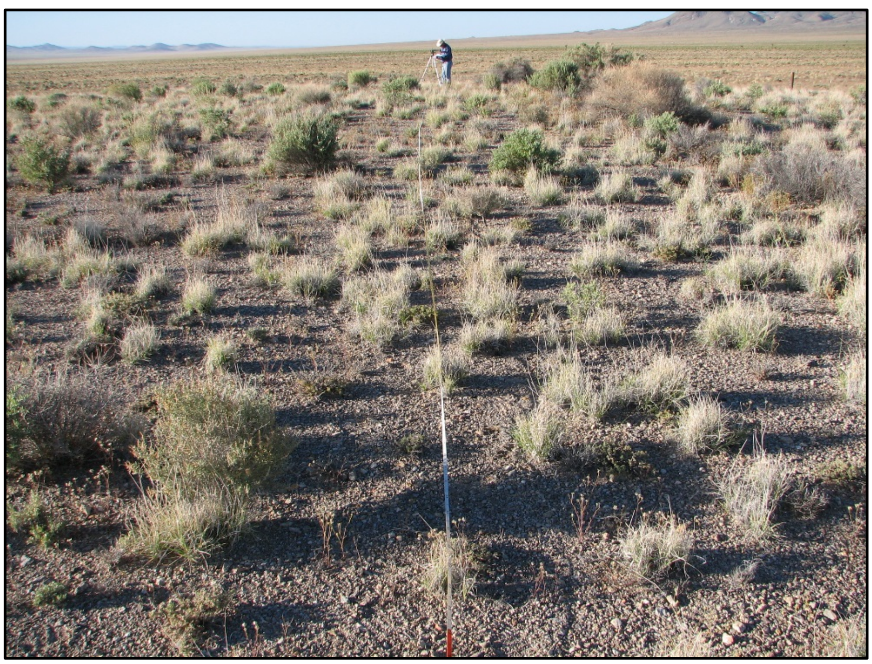

Figure 7-7. Cover cap at CAU 404, Roller Coaster Lagoons and Trench.

(Photo by D.B. Hall, June 16, 2016)

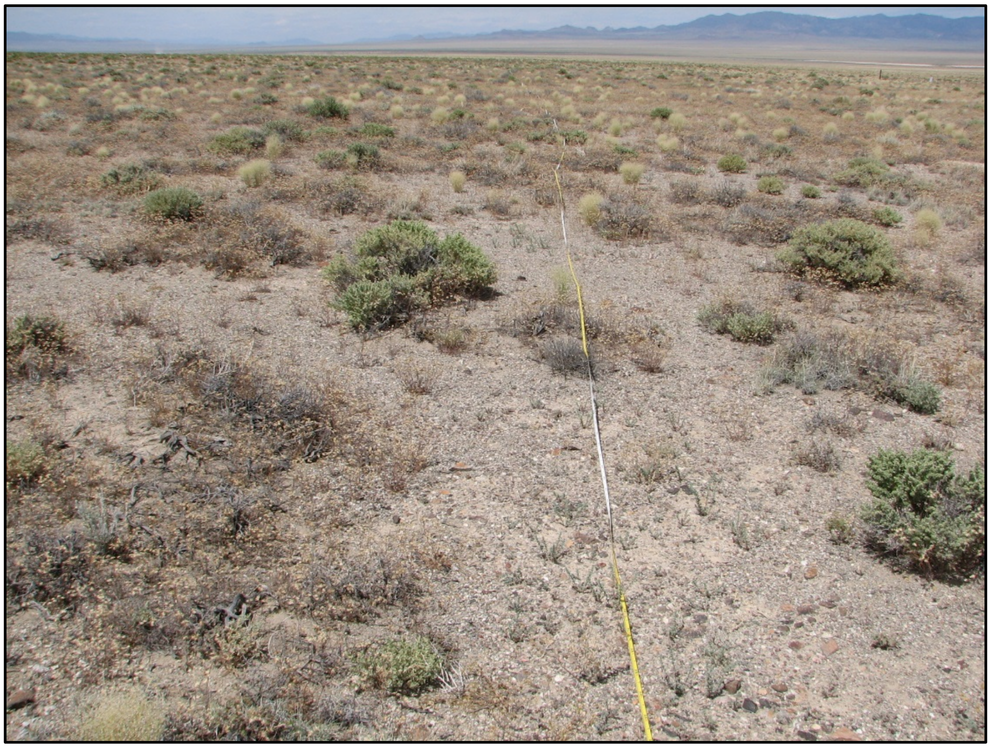

Figure 7-8. Reference area just west of gate to CAU 404, Roller Coaster Lagoons and Trench.

(Photo by D.B. Hall, June 15, 2016)

7.4.1 Percent Plant Cover

Total percent plant cover on the staging area was about half of what it was on the reference area and was dominated by Esteve's pincushion (Table 7-7). Shrub cover was comprised of shadscale saltbush and some bud sagebrush. Only one grass, James' galleta, contributed to plant cover on the staging area.

Total plant cover on the cover cap was higher than on the staging area but lower than on the reference area. Fourwing saltbush and bud sagebrush were the only shrubs on the cover. James' galleta was the only grass but made up 10% of the total cover. Shadscale saltbush had the highest cover of the shrubs and Indian ricegrass and James' galleta were the only two grasses found on the reference area, and Esteve's pincushion dominated the forb cover.

7.4.2 Plant Density (Plants/m^2)

Density on the staging area was about 50 plants/m^2 (Table 7-8). Annual forbs accounted for about 98 percent of total density with Esteve's pincushion being the most abundant species. Plant density on the cover cap was dominated by Esteve's pincushion and James' galleta.

Plant density on the reference area was 39.87 plants/m^2, which was less than density on the staging area but almost double the cover cap. Common shrubs on the reference area were bud sagebrush and shadscale. There were five grasses present and only four forbs encountered on the reference area. Esteve's pincushion was the most abundant plant on the reference area.

Table 7-7. Plant cover (%) on CAU 404, Roller Coaster Lagoons and Trench, June 2016.

	Staging	Cover	Reference	Standard
Shrubs				
Bud sagebrush (*Picrothamnus desertorum*)	0.56	0.83	1.67	
Fourwing saltbush (*Atriplex canescens*)	0.00	2.50	0.00	
Shadscale saltbush (*Atriplex confertifolia*)	2.78	0.00	5.00	
Winterfat (*Krascheninnikovia lanata*)	0.00	0.00	0.56	
Total Shrubs	**3.34**	**3.33**	**7.23**	**5.06**
Grasses				
Indian ricegrass (*Achnatherum hymenoides*)	0.00	0.00	2.22	
James' galleta (*Pleuraphis jamesii*)	0.56	10.00	1.67	
Total Grasses	**0.56**	**10.00**	**3.89**	**2.72**
Forbs/Annuals				
Esteve's pincushion (*Chaenactis stevioides*)	11.11	6.67	15.56	
Shaggyfruit pepperweed (*Lepidium lasiocarpum*)	0.00	0.00	0.56	
Total Forbs/Annuals	**11.11**	**6.67**	**16.12**	**11.29**
Total Plant Cover	**15.01**	**20.00**	**27.24**	**19.07**
Bare Ground	61.11	75.83	56.67	
Litter	23.88	4.17	16.11	

7.4.3 Species Richness

Species richness was highest on the cover cap and lowest on the staging area, although the difference was less than one plant per m^2 (Table 7-9). Fourteen species were documented on the staging area including four shrub species, three grass species and seven forb species. Thirteen species were documented on the cover cap including three shrubs, two grasses and eight forbs. Twelve species were documented on the reference area including three shrubs, five grasses, and four forbs.

Table 7-8. Plant density (plants/m^2) on CAU 404, Roller Coaster Lagoons and Trench, June 2016.

	Staging	Cover	Reference	Standard
Shrubs				
Bud sagebrush (*Picrothamnus desertorum*)	0.22	0.53	1.80	
Fourwing saltbush (*Atriplex canescens*)	0.04	0.40	0.00	
Shadscale saltbush (*Atriplex confertifolia*)	0.71	0.30	0.40	
Winterfat (*Krascheninnikovia lanata*)	0.02	0.00	0.10	
Total Shrubs	**0.99**	**1.23**	**2.30**	**1.61**
Grasses				
Indian ricegrass (*Achnatherum hymenoides*)	0.02	0.07	0.20	
James' Galleta (*Pleuraphis jamesii*)	0.09	4.67	1.20	
Low woollygrass (*Dasyochloa pulchella*)	0.00	0.00	0.33	
Squirreltail (*Elymus elymoides*)	0.02	0.00	0.02	
Alkali sacaton (*Sporobolus airoides*)	0.00	0.00	0.02	
Total Grasses	**0.13**	**4.74**	**1.77**	**1.24**
Forbs				
Freckled milkvetch (*Astragalus lentiginosus*) and Hoary tansyaster (*Machaeranthera canescens*)	0.00/0.00	0.10/0.10	0.00/0.00	
Desert globemallow (*Sphaeralcea ambigua*)	0.27	0.33	0.22	
Esteve's pincushion (*Chaenactis stevioides*)	37.89	15.33	35.00	
Gilia (*Gilia* spp.)	0.02	0.17	0.00	
Saltlover (*Halogeton glomeratus*)	11.62	0.30	0.40	
Manybranched ipomopsis (*Ipomopsis polycladon*)	0.24	0.03	0.00	
Shaggyfruit pepperweed (*Lepidium lasiocarpum*)	0.27	0.20	0.18	
Bashful Four o' clock (*Mirabilis pudica*)	0.02	0.00	0.00	
Total Forbs	**50.33**	**16.56**	**35.80**	**25.06**
Total Plant Density	**51.45**	**22.53**	**39.87**	**27.91**

Table 7-9. Species richness (species/m^2) on CAU 404, Roller Coaster Lagoons and Trench, June 2016.

	Staging	Cover	Reference	Standard
Shrubs	0.62	0.90	1.29	0.90
Grasses	0.13	1.00	0.47	0.33
Forbs/Annuals	2.07	1.73	1.48	1.04
Total Species	**2.82**	**3.63**	**3.24**	**2.27**

7.4.4 Revegetation Success

Total plant cover exceeded standards for only the cover cap. For the staging area, shrub cover and grass cover were below the standard and forb cover was about equal to the standard. For the cover cap, shrub cover and forb cover were below the standard but grass cover exceeded the standard.

The pattern was similar for density. Shrub and grass density on the staging area were below the standard and forb density was double the standard. Grass density on the cover cap was almost four times the standard while shrub and forb density were below the standard.

On both the staging area and cover cap, species richness exceeded the standard for total species. For the staging area, shrubs and grasses were below the standard, but forbs exceeded the standard. For the cover cap all categories equaled or exceeded the standard.

7.4.5 Wildlife Use

There were no signs of heavy use of plants by small mammals. The fence has protected the site from large grazing animals such as horses and antelope. The slopes of the cover cap are the most heavily used portion of the site, where small mammals have constructed numerous burrows.

7.4.6 Soil Erosion

There were no serious erosion issues at the site. During heavy precipitation, water moved down the site access road and onto the revegetated area, creating a few small erosion channels.

7.4.7 Summary/Recommendations

Overall plant cover on the staging area and cover cap showed mixed results. Density of perennial species (shrubs and grasses) also were mixed. Shrubs appeared to be declining on both sites. Species richness increased this year due to a large increase in forbs and annuals. Total species richness exceeded the standard for both the staging and cover areas. The invasion of weedy species is not a concern at this site. The native plant community has established on both the staging area and cover cap. Cover and density may improve over time, and the revegetated areas will more closely resemble adjacent areas.

7.5 CAU 407, ROLLER COASTER RADSAFE AREA

Three transects were sampled at this site in 2016 (Figure 7-9). The reference area for this site is the same reference area used for CAU 404, Roller Coaster Lagoons and Trench (Figure 7-8).

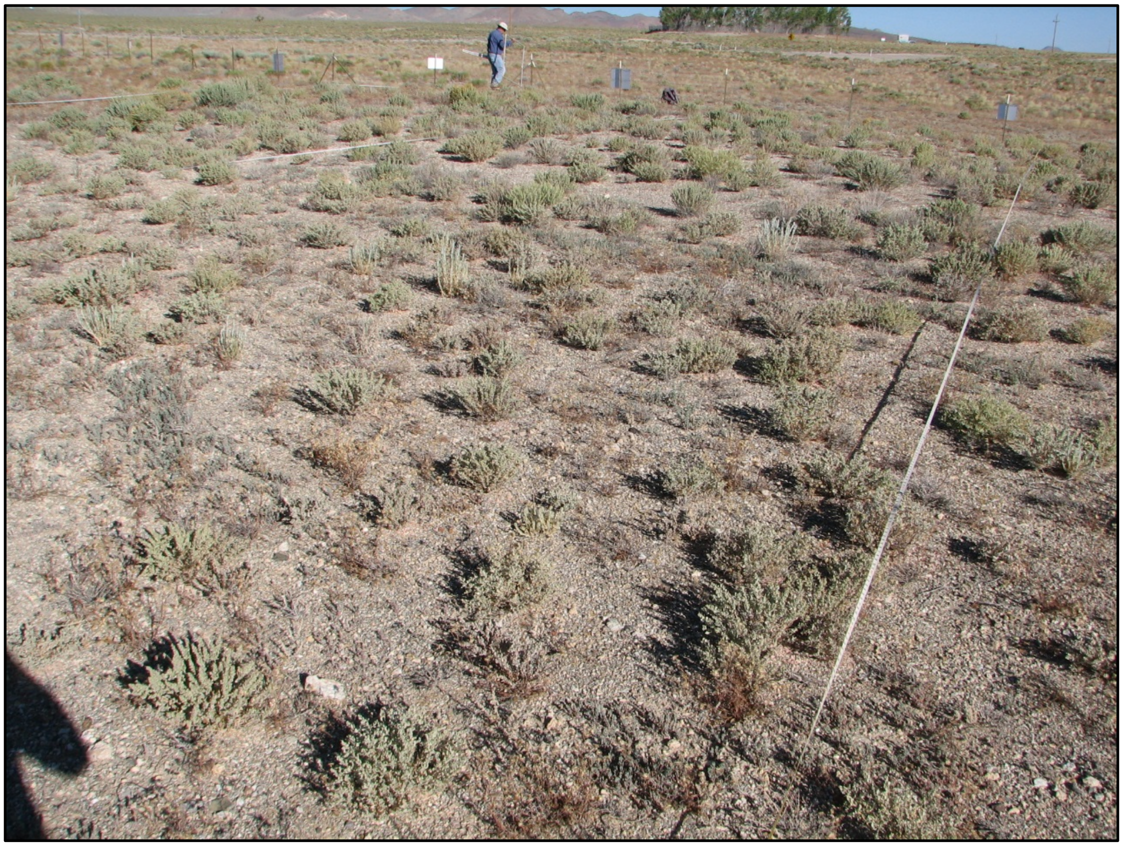

Figure 7-9. Cover cap on CAU407, Rollercoaster Radsafe Area.

(Photo by D.B. Hall, June 16, 2016)

7.5.1 Percent Plant Cover

Total percent plant cover on the cover cap was about five percent lower than percent plant cover on the reference area. Shrub cover dominated the total plant cover with shadscale saltbush being the dominant species followed by fourwing saltbush (Table 7-10). There was no grass cover on the cover cap. Esteve's pincushion, a native forb, and saltlover, an introduced noxious weed, were the two forb species found on the cover cap.

7.5.2 Plant Density (Plants/m^2)

Density has declined over the past 5 years but was up tremendously in 2016 to over 41 plants per m^2 (Table 7-11). The majority of these were annuals that responded well to good precipitation during 2016.

Table 7-10. Plant cover (%) on CAU 407, Roller Coaster Radsafe Area, June 2016.

	Cover	Reference	Standard
Shrubs			
Bud sagebrush (*Picrothamnus desertorum*)	0.00	1.67	
Fourwing saltbush (*Atriplex canescens*)	4.17	0.00	
Shadscale saltbush (*Atriplex confertifolia*)	11.67	5.00	
Winterfat (*Krascheninnikovia lanata*)	0.00	0.56	
Total Shrubs	15.84	7.23	5.06
Grasses			
Indian ricegrass (*Achnatherum hymenoides*)	0.00	2.22	
James' galleta (*Pleuraphis jamesii*)	0.00	1.67	
Total Grasses	0.00	3.89	2.72
Forbs/Annuals			
Esteve's pincushion (*Chaenactis stevioides*)	4.17	15.56	
Saltlover (*Halogeton glomerata*)	2.50	0.00	
Shaggyfruit pepperweed (*Lepidium lasiocarpum*)	0.00	0.56	
Total Forbs/Annuals	6.67	16.12	11.29
Total Plant Cover	**22.51**	**27.24**	**19.07**
Bare Ground	69.17	56.67	
Litter	8.33	16.11	

Table 7-11. Plant density (plants/m^2) on CAU 407, Roller Coaster Radsafe Area, June 2016.

	Cover	Reference	Standard
Shrubs			
Bud sagebrush (*Picrothamnus desertorum*)	0.00	1.80	
Fourwing saltbush (*Atriplex canescens*)	0.40	0.00	
Shadscale saltbush (*Atriplex confertifolia*)	4.00	0.40	
Winterfat (*Krascheninnikovia lanata*)	0.07	0.10	
Total Shrubs	**4.47**	**2.30**	**1.61**
Grasses			
Indian ricegrass (*Achnatherum hymenoides*)	0.00	0.20	
James' Galleta (*Pleuraphis jamesii*)	0.00	1.20	
Low woollygrass (*Dasyocholoa pulchella*)	0.00	0.33	
Squirreltail (*Elymus elymoides)*	0.00	0.02	
Alkali sacaton (*Sporobolus airoides*)	0.00	0.02	
Total Grasses	**0.00**	**1.77**	**1.24**
Forbs			
Redstem stork's bill (*Erodium cicutarium*)	0.07	0.00	
Desert globemallow (*Sphaeralcea ambigua*)	0.00	0.22	
Esteve's pincushion (*Chaenactis steviodes*)	9.40	35.00	
Shaggyfruit pepperweed (*Lepidium lasiocarpum*)	0.07	0.18	
Saltlover (*Halogeton glomeratus*)	27.50	0.40	
Total Forbs	**37.07**	**35.80**	**25.06**
Total Plant Density	**41.51**	**39.87**	**27.91**

Total plant density on the cover cap was slightly higher than on the reference area. The major portion of the density on the cover cap was contributed by saltlover. Shadscale saltbush was the most common shrub species, and no grasses were encountered during 2016. Four annual forbs were found; saltlover, an introduced noxious weed, and Esteve's pincushion, a native annual, were the most common.

7.5.3 Species Richness

Total species richness was just over four species/m^2 and exceeded the success standard (Table 7-12). Both shrubs and forbs on the cover cap exceeded the standard for species richness. Grasses on the cover cap did not meet the success standard for species richness.

Table 7-12. Species richness (species/m^2) on CAU 407, Roller Coaster Radsafe Area, June 2016.

	Staging	Reference	Standard
Shrubs	1.13	1.29	0.90
Grasses	0.00	0.47	0.33
Forbs/Annuals	2.93	1.48	1.04
Total Species	**4.06**	**3.24**	**2.27**

7.5.4 Revegetation Success

Plant cover, density, and species richness exceeded the standards for revegetation success. Shrub cover and shrub and forb density and species richness exceeded standards but forb cover and grass cover, density, and species richness did not. Three shrub and four forb species were detected, and no grasses were found.

7.5.5 Wildlife Use

Burrows were present on the side slopes of the cover cap. The burrows appeared to be shallow, and the soil moved to the surface appeared to be fill material used in the construction of the cover.

7.5.6 Soil Erosion

The soil on the cover cap and side slopes appeared stable and compacted.

7.5.7 Summary/Recommendations

Plant cover and density was higher than on the reference area even after declines in density over the last four years. There was no evidence that water is moving off the cover and creating erosion gullies on the side slopes. Some burrowing was evident along the edges of the cover; however, the volume and characteristics of excavated soil suggested the burrows were shallow. The site should continue to be monitored to document establishment of a viable plant community and identify remedial revegetation. The occurrence and abundance of saltlover should also be monitored and corrective actions taken if necessary to control this invasive weed.

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