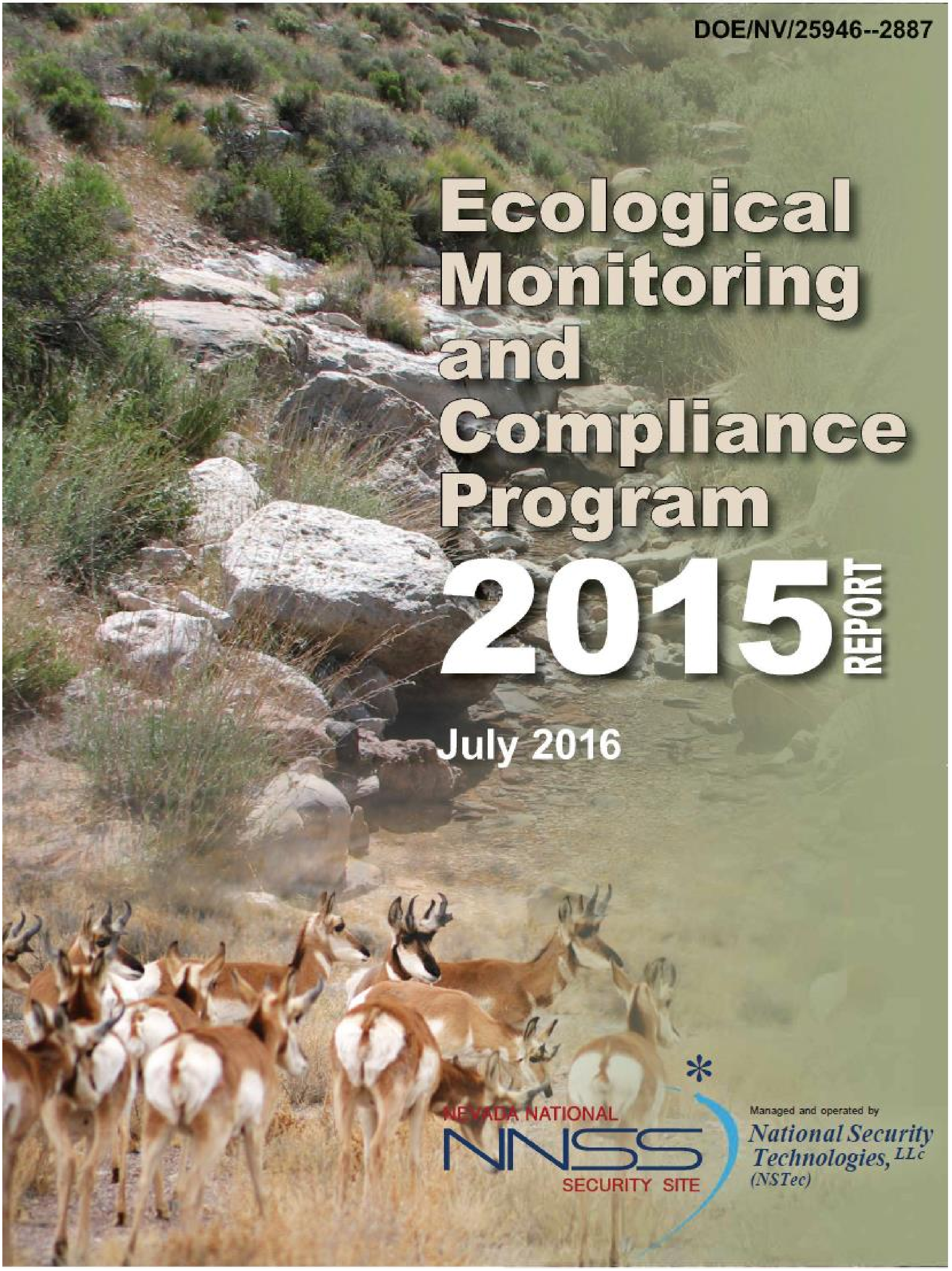


DOE/NV/25946--2887

Ecological Monitoring and Compliance Program

2015 REPORT

July 2016

NEVADA NATIONAL NNSS SECURITY SITE

Managed and operated by

National Security Technologies, LLC (NSTec)

Disclaimer

Document Availability

Available for sale to the public from:

U.S. Department of Commerce
National Technical Information Service
5301 Shawnee Road
Alexandria, Virginia 22312

Phone: **1-800-553-6847**
Fax: **(703) 605-6900**
E-mail: **orders@ntis.gov**
Online ordering: **http://www.ntis.gov/help/ordermethods.aspx**

Available electronically at **http://www.osti.gov/bridge** and at
http://www.nv.doe.gov/library/publications/emac.aspx

Available for a processing fee to the U.S. Department of Energy and its contractors, in paper, from:

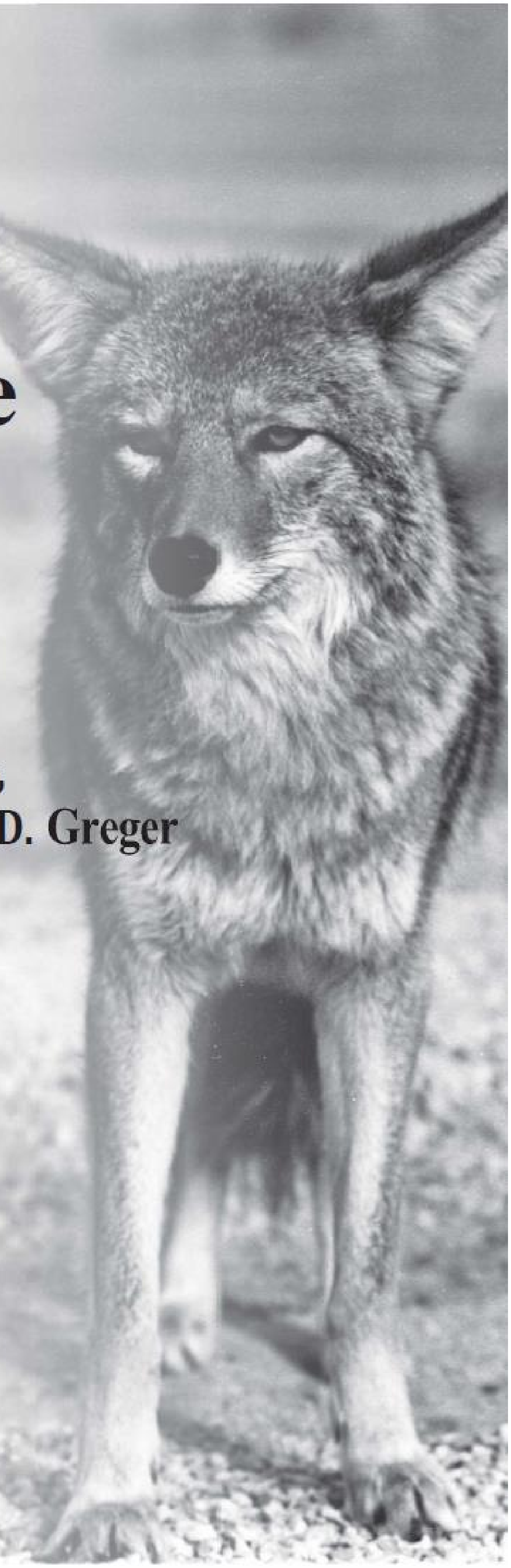
U.S. Department of Energy
Office of Scientific and Technical Information
P.O. Box 62
Oak Ridge, Tennessee 37831-0062

Phone: **(865) 576-8401**
Fax: **(865) 576-5728**
E-mail: **reports@adonis.osti.gov**

DOE/NV/25946--2887

Ecological Monitoring and Compliance Program

2015 REPORT



Derek B. Hall, W. Kent Ostler,
David C. Anderson, and Paul D. Greger

July 2016

Work performed under contract number:
DE-AC52-06NA25946

This report was prepared for:
U.S. Department of Energy
National Nuclear Security Administration
Nevada Field Office
Environmental Management Department
P.O. Box 98518
Las Vegas, Nevada 89193-8518

By:
National Security Technologies, LLC
Ecological and Environmental Monitoring
P.O. Box 98521
Las Vegas, Nevada 89193-8521

This Page Intentionally Left Blank

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 2015. 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 2015, 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, 236 birds, and 27 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 13 projects. A total of 261.35 hectares (ha) was surveyed for these projects. Sensitive and protected/regulated species and important biological resources found during these surveys included nine predator burrows, nine burrowing owl (*Athene cunicularia*) burrows, three active bird nests, ten inactive bird nests, several Joshua trees (*Yucca brevifolia*), and several species of cacti. NSTec provided written summary reports to project managers of survey findings and mitigation recommendations, where applicable.

Of the 13 projects on the NNSS, 5 occurred within the range of the threatened desert tortoise, and no desert tortoise habitat was disturbed. No desert tortoises were injured or killed by project activities. Two tortoises were accidentally killed by vehicles. On 17 occasions, tortoises were moved off the road and out of harm's way. Six tortoises were found and fitted with transmitters as part of an approved study to assess impacts of vehicles on tortoises on the NNSS. NSTec biologists continued to monitor 31 juvenile desert tortoises as part of a collaborative effort to study survival and temperament 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 about 83.7 ha burned per fire. There were four wildland fires documented on the NNSS during 2015, all less than 0.4 ha in size, and all were extinguished quickly by NNSS Fire and Rescue personnel. Results from the wildland fuel surveys showed a very low risk of wildland fire due to reduced fuel loads caused by limited natural precipitation. Ten long-term vegetation-monitoring plots within the pinyon pine-black sagebrush (*Pinus monophylla-Artemisia nova*) vegetation type were sampled for plant cover, density, and species richness. Raw cover and density data and species codes for these plots are included at the end of this report in three appendices.

The versatile fairy shrimp (*Branchinecta lindahli*) was documented for the first time on the NNSS this year. Limited reptile trapping and reptile roadkill surveys were conducted to better define species distribution on the NNSS. Forty-seven reptiles were trapped representing six lizard species. During the road kill surveys, a total of 38 snakes, representing 6 species, and 101 lizards, representing 6 species were detected. Ten new records of Great Basin skinks (*Plestiodon skiltonianus utahensis*) at five sites from 1975 were discovered and added to the reptile database. One new natural water source was found on the NNSS in the northwest corner of Area 20. Wildlife use at 10 natural water sources, 1 well pond, 5 water

troughs, and 6 radiologically contaminated sumps, was documented using motion-activated cameras. No field surveys were conducted this year for sensitive plants on the NNSS due to poor growing conditions.

Surveys of sensitive and protected/regulated animals during 2015 focused on western red-tailed skinks (*Plestiodon gilberti rubricaudatus*), birds, bats, feral horses (*Equus caballus*), mule deer (*Odocoileus hemionus*), desert bighorn sheep (*Ovis canadensis nelsoni*), and mountain lions (*Puma concolor*). 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 declined for the second year in a row. Six desert bighorn sheep were captured and five of them were radiocollared for tracking purposes. Samples were taken to assess disease prevalence, radiological burden, and relatedness to other southern Nevada populations.

A total of 110 mountain lion images (i.e., photographs or video clips) were taken during 231,989 camera hours at 14 of 33 sites sampled and another 10,138 images of at least 30 species other than mountain lions were taken as well. Efforts were made to capture a mountain lion but were unsuccessful. A minimum of three lions (adult male, adult female, subadult) were known to inhabit the NNSS during 2015. Additional information is presented about bird mortalities, *Migratory Bird Treaty Act* compliance, nuisance animals and their control on the NNSS, and increasing populations of feral burros and pronghorn antelope.

A summary of revegetation efforts at the 92-Acre Site at the Area 5 Radioactive Waste Management Complex is included in this report. Recommendations for future efforts to establish a permanent vegetative cover are discussed.

TABLE OF CONTENTS

Page

TABLE OF CONTENTS (continued)

Page

LIST OF FIGURES

LIST OF TABLES

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
MDC	minimum detectable concentration
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
PLS	Pure Live Seed
r^2	regression coefficient
RWMC	Radioactive Waste Management Complex
SAR	sodium absorption ratio
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 2015, 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 2015. Monitoring tasks during 2015 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 2016) 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 2015, biological surveys for 13 projects were conducted on the NNSS (Figure 2-1 and Table 2-2). Scientists surveyed a total of 261.35 hectares (ha) for the projects (Table 2-2). Five projects were within the range of the threatened desert tortoise (*Gopherus agassizii*) (see Section 3.0). Sensitive and protected/regulated species and important biological resources found included nine predator burrows, nine burrowing owl (*Athene cunicularia*) burrows, three active nests, ten inactive nests, Joshua trees (*Yucca brevifolia*), and several 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, including new projects, routine maintenance activities, or cleanup activities at old industrial or nuclear weapons testing sites. These surveys are required whenever vegetation has re-colonized old disturbances and sensitive or protected/regulated species are known to 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 surveys and tortoise clearance surveys are conducted to ensure that desert tortoises are not in harm's way. Burrowing owls frequently inhabit burrows and culverts at disturbed sites, so surveys are conducted to ensure that adults, eggs, and nestlings are not harmed.

Of the 13 projects surveyed, 9 were within sites previously disturbed (e.g., road shoulders, old building sites, industrial waste sites, or existing well pads) (Table 2-2). Four projects were located partially in areas that had been previously disturbed. These projects could potentially disturb 19.64 ha of land that were previously considered undisturbed. 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 four types of important habitats. Three projects occurred in areas designated as important habitats, so the total area disturbed in hectares since 1999 comprises 9.46 (Pristine), 17.31 (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
Agavaceae	Yucca (3 species), Agave (1 species)	CY
Cactaceae	Cacti (18 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
Pipistrellus hesperus	Western pipistrelle	M, A
Puma concolor	Mountain lion	G, A
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
NPT	Nevada Protected-Threatened, species protected under NAC 503

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

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, Rock dove, and European starling.

Sources used: NNHP 2016, Nevada Native Plant Society (NNPS) 2016, NAC 2016, U.S. Fish and Wildlife Service (FWS) 2016, Bradley et al. 2006

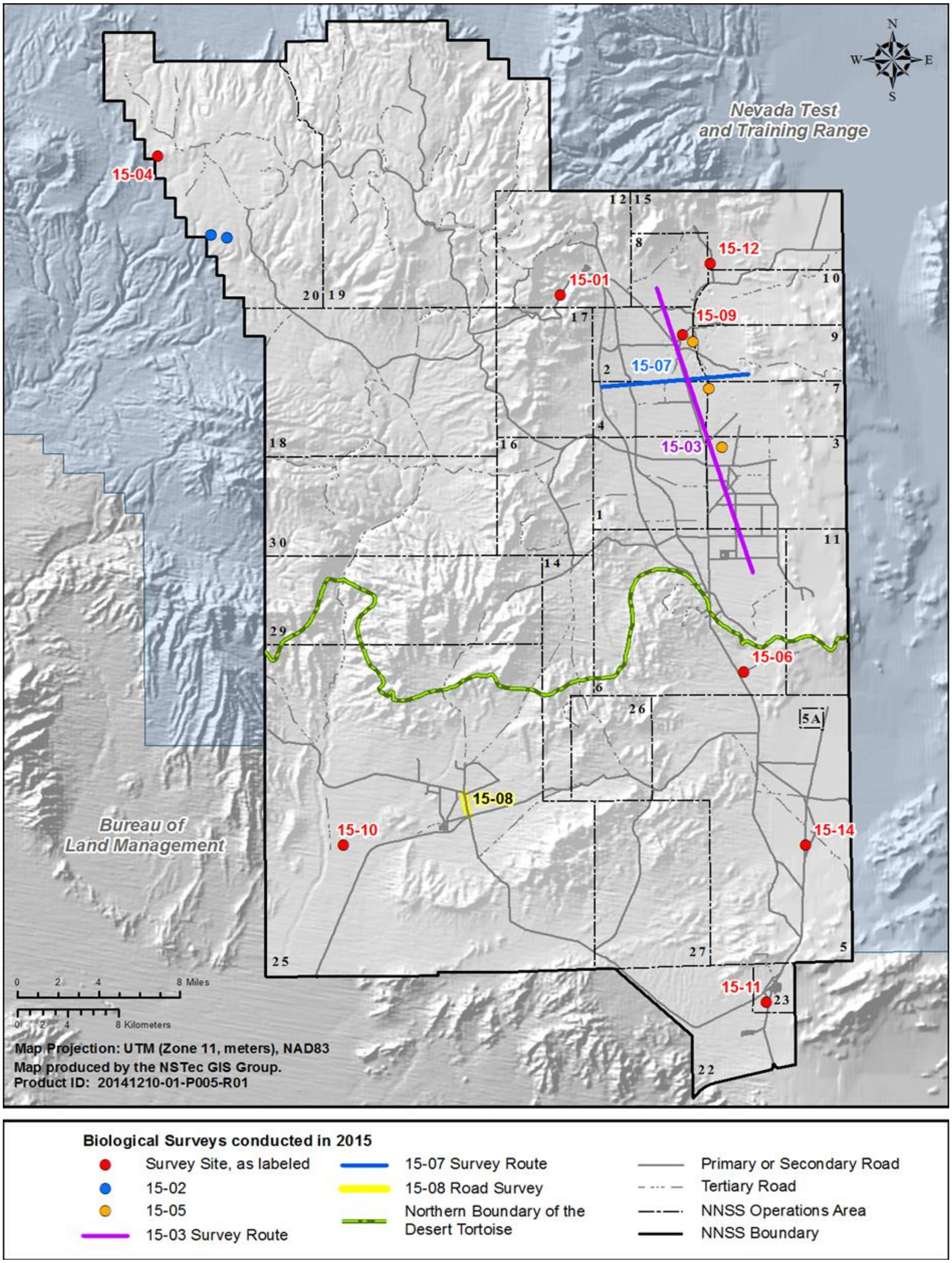


Figure 2-1. Biological surveys conducted on the NNSS during 2015

Table 2-2. Summary of biological surveys conducted on the NNSS during 2015

Project No.	Project	Important Species/Resources Found	Area Surveyed (ha)	Proposed Project Area in Undisturbed Habitat (ha)	Mitigation Recommendations
15-01	Area 12 Access Road	None	0.05	0.02	None
15-02	UGTA Well Access	None	0.05	0	None
15-03	Seismic Hammer	Pricklypear cacti, Joshua trees, cholla; 9 predator burrows, 6 burrowing owl burrows	150.3	0	Avoid cacti where possible; avoid burrows
15-04	UGTA ER-20-12	None	5.45	5.45	None
15-05	New Yucca Flat Wells	None	8.43	0.42	None
15-06	Tumbleweed Test Range	None	2.01	0	TCS required, EM needed
15-07	Thor II	3 active nests; 10 inactive nests; 3 potential burrowing owl burrows	68.74	13.75	Avoid nests/burrows
15-08	Area 25 Road Mowing	None	10.15	0	TCS required, EM needed
15-09	Removal of Surface Laid Cable	None	9.00	0	None
15-10	Area 25 Water Line Repair	None	0.16	0	TCS required, EM needed
15-11	Mercury Switch Station	None	0.25	0	TCS required, EM needed
15-12	Area 15 Trailer Park	None	1.10	0	None
15-14	Area 5 Borrow Pits	None	5.66	0	TCS required, EM needed
		Total ha	**261.35**	**19.64**	

EM – Environmental Monitor; TCS – Tortoise Clearance Survey

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 2015, including (a) conducting 100% coverage tortoise clearance surveys (TCS) at project sites within 1 day 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 2015, biologists conducted TCSs just prior to ground disturbing activities for five proposed projects within the range of the desert tortoise on the NNSS (Figure 3-1). All of the projects were in, or immediately adjacent to, roads, existing facilities, or other disturbances. No desert tortoises were observed in project areas.

No projects were initiated that disturbed previously undisturbed desert tortoise habitat. Post-activity surveys to quantify the acreage of tortoise habitat actually disturbed were conducted for three projects during this reporting period (Table 3-1). All projects stayed within proposed project boundaries. Post-activity surveys are generally not conducted if the projects are located within previously disturbed areas or if the environmental monitor documented that the project stayed within its proposed boundaries.

Table 3-1. Summary of biological surveys conducted in desert tortoise habitat on the NNSS during 2015

Project Number	Project	Compliance Activities 100% Coverage Clearance Survey	Tortoise Habitat Disturbed (Ha)
15-06	Tumbleweed Test Range	Yes, no post-activity survey	0
15-08	Area 25 Road Mowing	Yes, post-activity survey completed	0
15-10	Area 25 Water Line Repair	Yes, post-activity survey completed	0
15-11	Mercury Switch Station	Yes, post-activity survey completed	0
15-14	Area 5 Borrow Pits	Yes, project on-going	0
		TOTAL	0

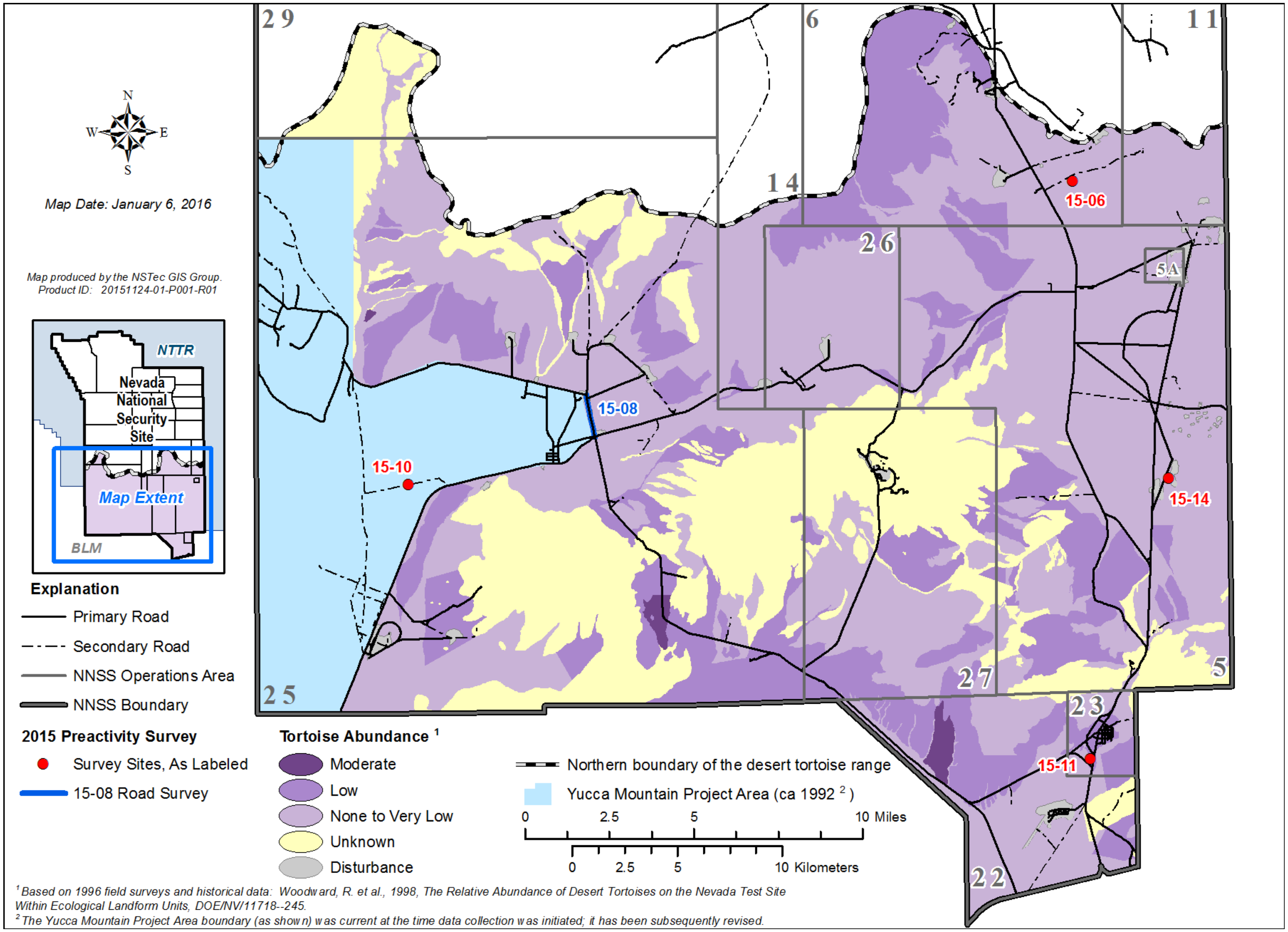


Figure 3-1. Biological surveys conducted in desert tortoise habitat on the NNSS during 2015

In January 2015, the annual report that summarized tortoise compliance activities conducted on the NNSS from January 1 through December 31, 2014, 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 that the desert tortoise is protected on the NNSS and that the cumulative impacts on this species are minimized (DOE/NV 1998). In the Opinion, the FWS determined that 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, two tortoises were accidentally killed by vehicles during 2015. On 17 occasions, tortoises were moved off the road and out of harm's way. These are included in tortoise observations in Figure 3-2. Four of the 17 tortoises found had transmitters attached as part of an approved study to assess impacts of vehicles on tortoises on the NNSS (see Section 3.3.1, "Desert Tortoise Road Study"). The 17 tortoises that were moved from roads and an additional 2 that received transmitters bring the total take for Roads in the "Other" category to 95 for 2009 to 2015 (Table 3-2). The cumulative take of tortoises killed or injured on NNSS roads is nine from 2009 to 2015 (Table 3-2).

Table 3-2. Cumulative incidental take (2009–2015) 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	13.15* (202)	0 (1)	0 (10)
Infrastructure Development	3.41 (40)	0 (1)	0 (10)
Roads	0 (0)	9 (15)	95 (125)
Totals	**18.83 (1,095)**	**9 (22)**	**95 (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.

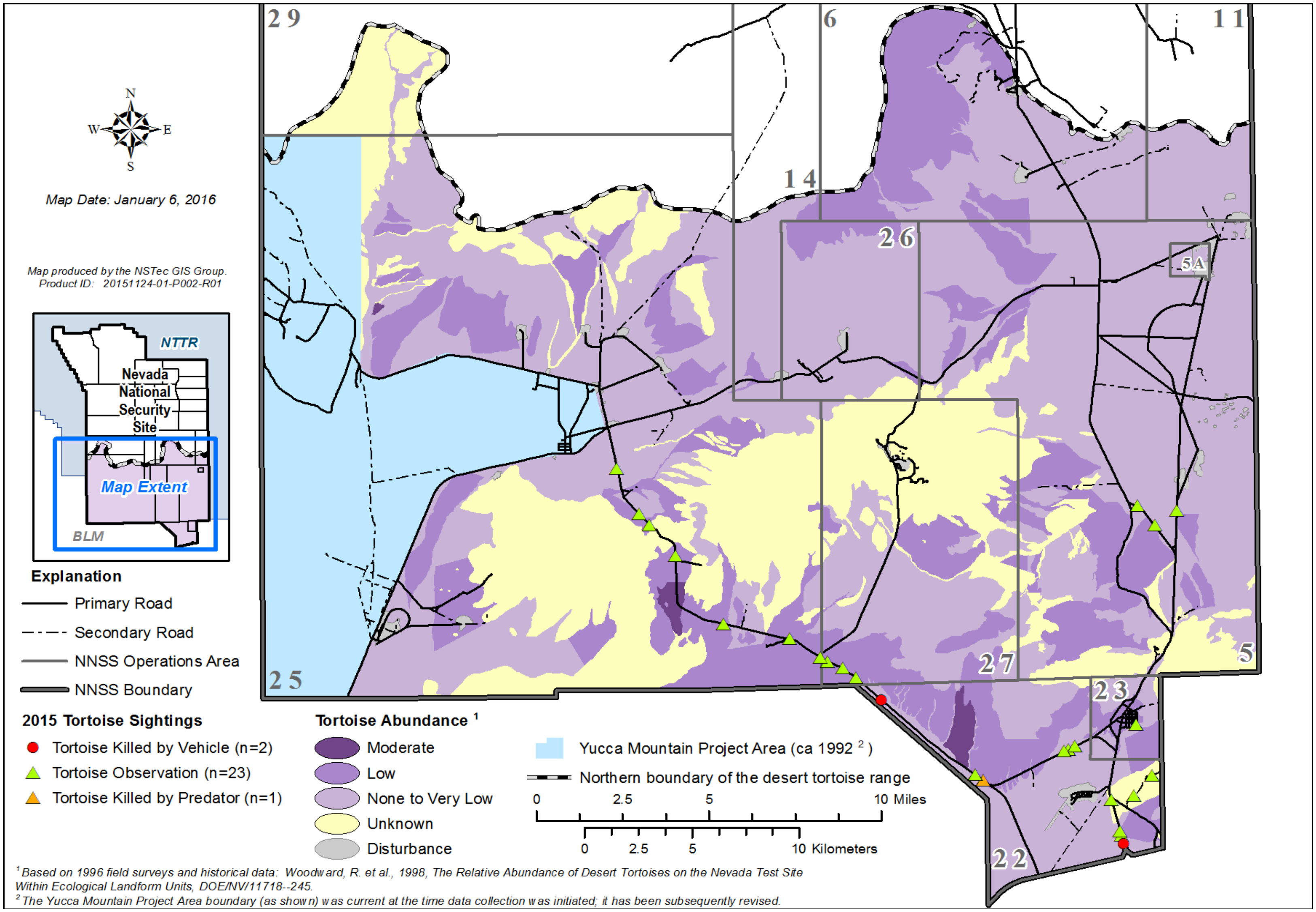


Figure 3-2. Location of tortoise roadside observations and mortalities during 2015

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. No projects disturbed tortoise habitat in 2015, so no mitigation was required.

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 desert tortoises (4 males and 7 females) were found (Figure 3-3) during the tortoise activity period and fitted with very high frequency (VHF) and Global Positioning System (GPS) transmitters. During 2013, an additional seven desert tortoises (five males and two females) were captured (Figure 3-3) and transmitters were attached to their shells. All 18 desert tortoises were monitored with VHF transmitters through 2013 except GOAG 13, which was found dead on June 26, 2013, 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 transmitters due to the limited number of transmitters available.

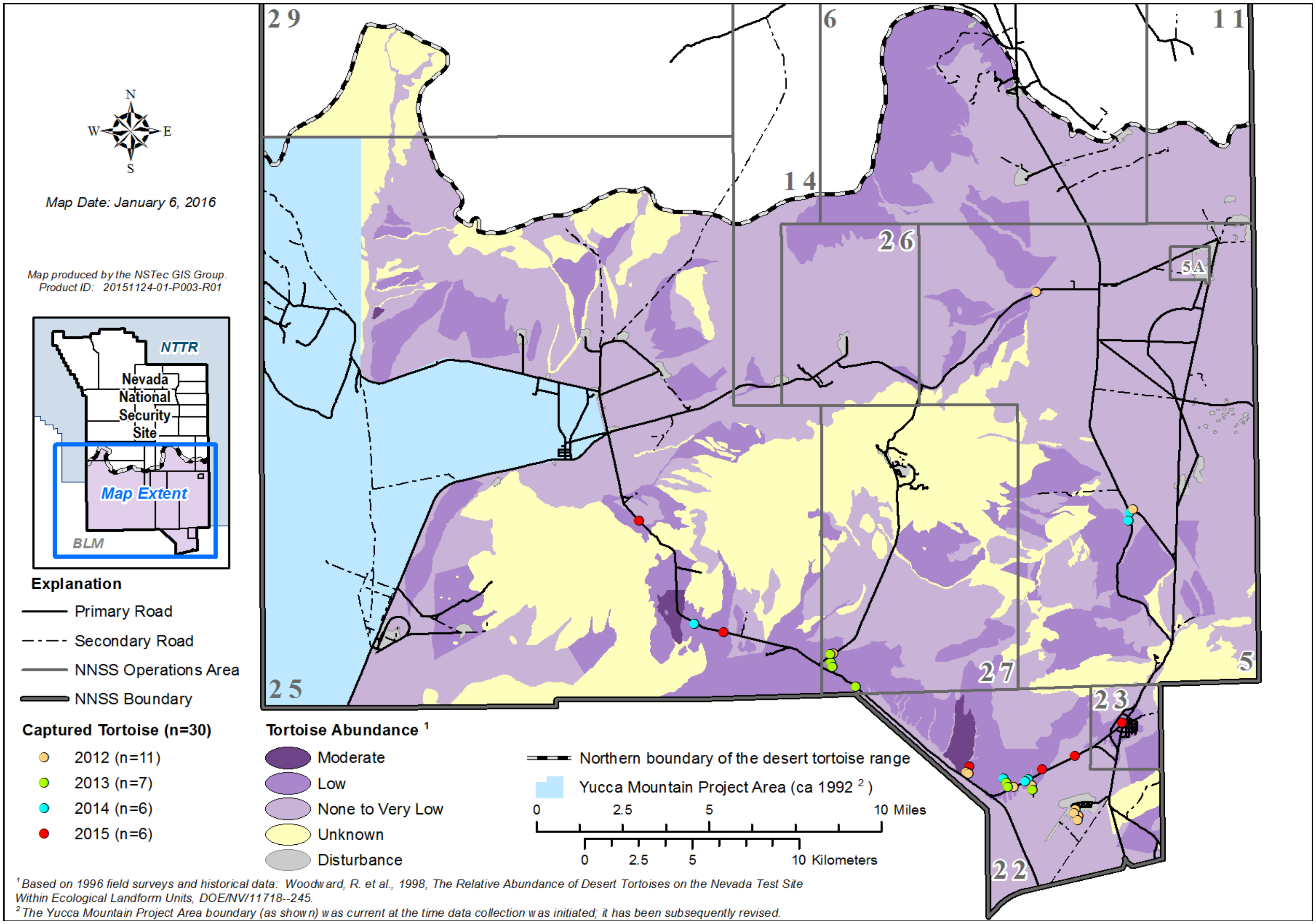


Figure 3-3. Tortoise capture locations 2012 (tan), 2013 (green), 2014 (blue), and 2015 (red) at the NNSS

During 2014, an additional six desert tortoises (four males, one female, and one unknown) were captured and radio-tagged (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 at a frequency of 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 and was unable to right itself.

Table 3-3 lists capture information for each of the 30 tortoises in the study. Health assessments were conducted in September 2014 by biologists from the San Diego Zoo's Institute for Conservation Research (ICR) for all tortoises that were accessible. All tortoises assessed were in good shape and had been able to survive the long drought period from winter to summer of 2014.

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

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)
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
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

Six desert tortoises (four males, two females) were captured and radio-tagged during 2015, making a total of 30 tortoises captured and marked for the road study (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 shape partially due to the summer thunderstorms and late season germination of annuals and re-growth of perennials and shrubs. Health assessment data will be reported when the project is completed.

A third tortoise in the study 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 radio-tagged tortoises were located by biologists at a frequency of once per week during the active season (March through October) and at least once per month during the inactive period (November through February). Tortoises were located a total of 826 times during 2015. That is an average of just over 29 locations for each tortoise monitored. 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 they finally settled into their winter burrows in mid to late November.

When a tortoise was found, biologists recorded information on where it was found (e.g., in a burrow, in the open, under vegetation). During 2015, tortoises were found a total of 535 times or 65% of the time in burrows (Figure 3-4). This is identical to what was found during a three-year study at Yucca Mountain (CRWMS 1997). This is despite the fact that we were often purposefully trying to sample when they would be most active aboveground so that GPS units could be changed. Data on the type of burrow was recorded for each location in addition to burrow width, height, length, aspect, and whether the burrow was hidden under vegetation. Burrow characteristics are very important for the survival of desert tortoises since they provide amelioration from temperature extremes, both in summer and winter (CRWMS 1997; Germano et al. 1994; Luckenbach 1982). The majority of the time tortoises were found in soil burrows (311 observations or 59%) (Figure 3-5). Caliche burrows were the second most common at 135 observations or 26% followed by rock burrows at 79 observations or 15% (Figure 3-5). While soil burrows are the most common type of burrow, they don't provide the best conditions for buffering winter and possibly summer temperatures. Caliche burrows were used for winter burrows (2014-15) much more than expected by chance (Figure 3-6). While caliche burrows represent only 26% of the total burrow observations, they represent 52% of the winter burrows for the 27 tortoises in this study.

The data also show that tortoises were found on roads on only six occasions (1%) (Figure 3-4). Four of six observations of tortoises on roads were for new unmarked tortoises that were added to this study. Desert tortoises were found in the open 132 times or 16.0% of the time and they were found under vegetation 151 times or 18% of the time (Figure 3-4). Desert tortoises use vegetation for cover so predators do not see them and for thermal cover during hot days. The species that was most often used by desert tortoises was creosote bush (*Larrea tridentata*) at 20% (Figure 3-7). Four species, creosote bush, water jacket (*Lycium andersonii*), blackbrush (*Coleogyne ramosissima*), and Nevada jointfir (*Ephedra nevadensis*), made up 63% of the observations in this category (Figure 3-7). Other species included Virgin River brittlebush (*Encelia virginensis*), burrobrush (*Hymenoclea salsola*), littleleaf ratany (*Krameria erecta*), shinyleaf sandpaper plant (*Petalonyx nitidus*), desert almond (*Prunus fasciculata*), and Mexican bladdersage (*Salazaria mexicana*).

The current Biological Opinion for this study allows only 30 individuals to be "taken," i.e. captured, handled, and monitored. The 2015 season was the last year for adding new individuals to the study because the limit of 30 was reached. The processing and analysis of data from the GPS receivers attached 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. In 2015, transmitters were removed from seven desert tortoises that had two or more years of movement data. When the data is fully processed and summarized, it will be provided to the FWS. In 2016, we will continue to monitor the 20 desert tortoises left in this study for movement patterns and activity near roads. Transmitters will be removed as we obtain sufficient data for each desert tortoise.

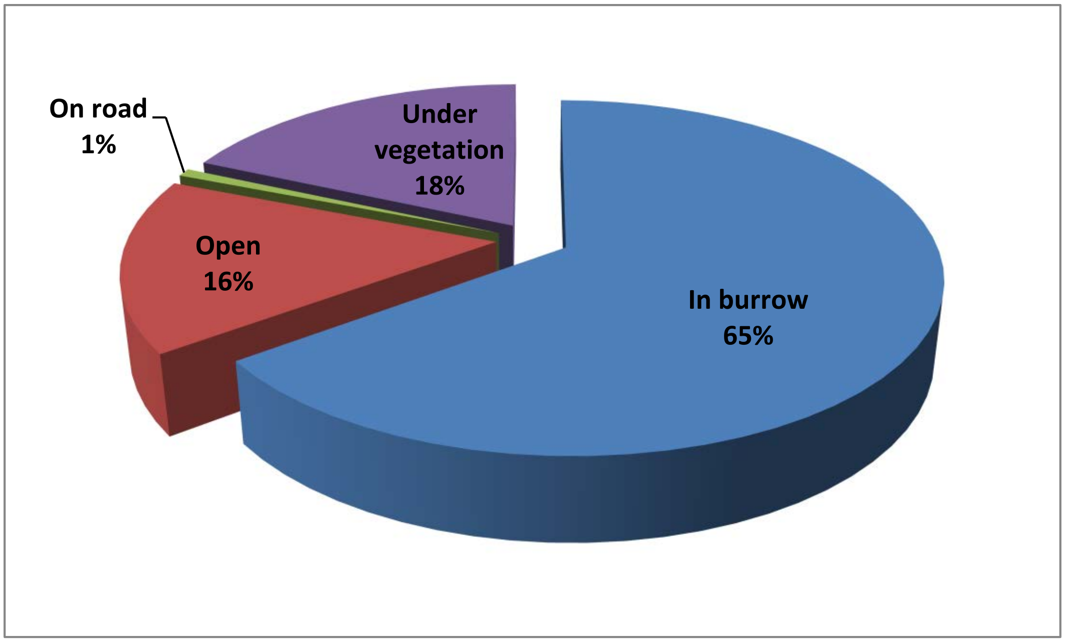


Figure 3-4. **Percentage of observations (n = 824; 2 were under rock) of adult tortoises by location during 2015**

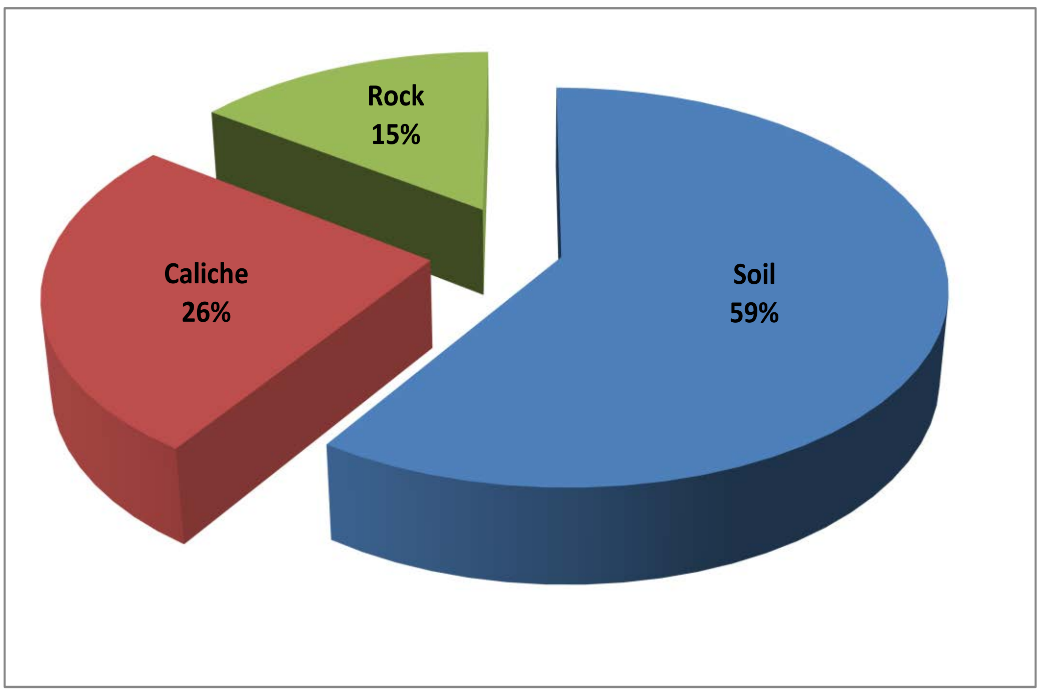


Figure 3-5. **Percentage of observations (n = 525) by burrow substrate used by adult tortoises during 2015**

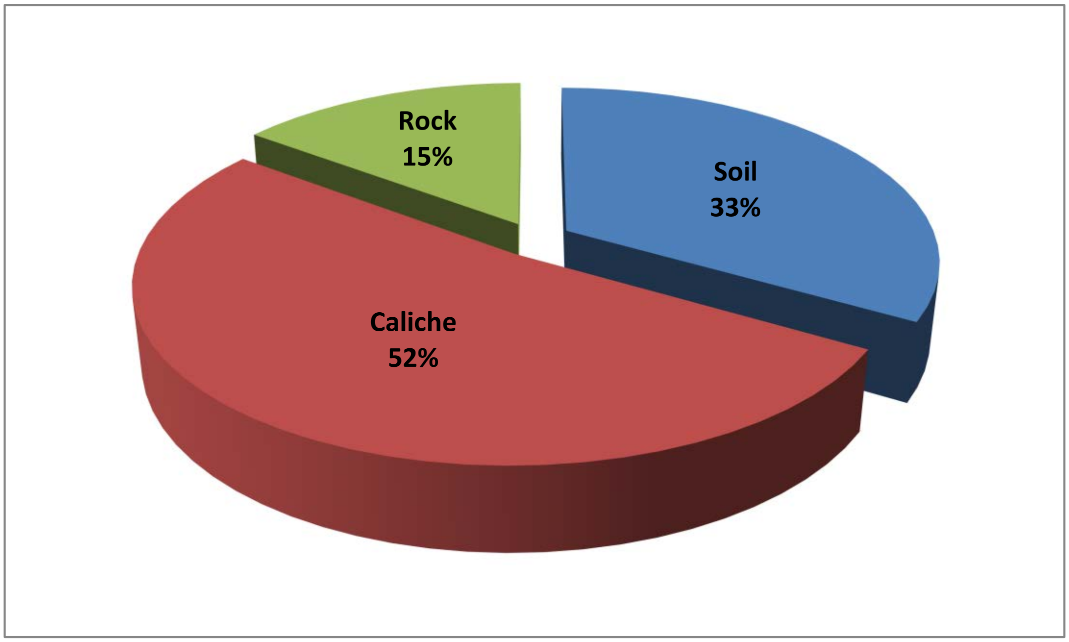


Figure 3-6. Percentage of winter burrows by burrow substrate used by 27 adult tortoises during winter 2014-15

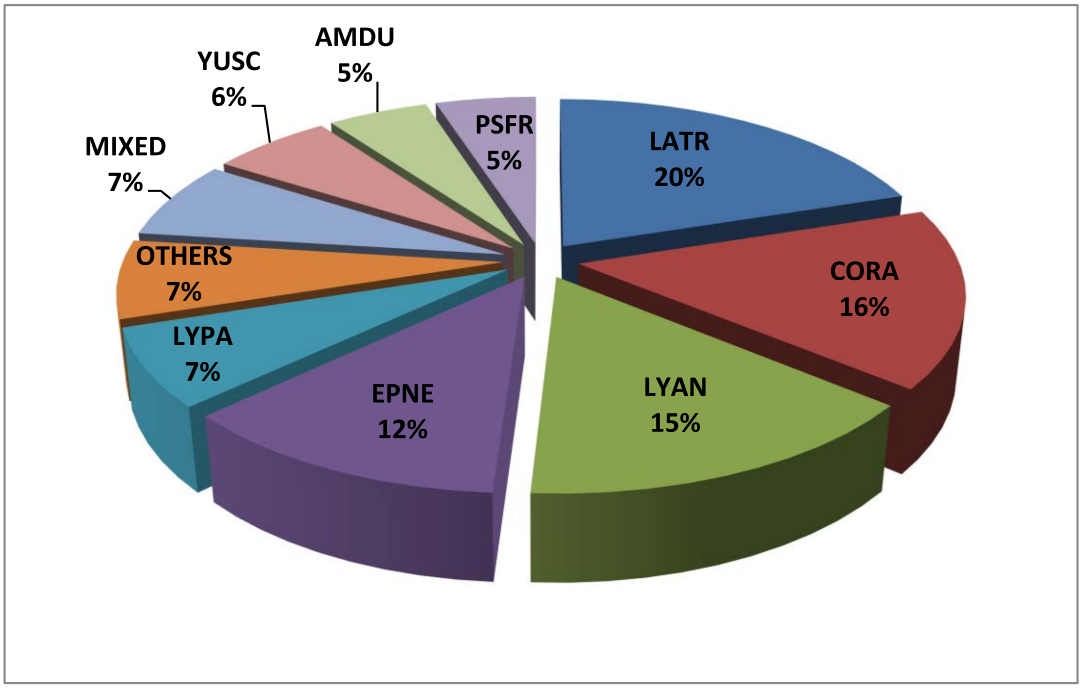


Figure 3-7. Percentage of observations by shrub species that provided cover for tortoises during 2015. CORA = Coleogyne ramosissima, EPNE = Ephedra nevadensis, LATR = Larrea tridentata, LYAN = Lycium andersonii, LYPA = Lycium pallidum, PSFR = Psorothamnus fremontii, YUSC = Yucca schidigera, AMDU = Ambrosia dumosa, Mixed = multiple shrub species clump, Others = six other species

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 had a VHF transmitter attached to its shell for tracking purposes (Figure 3-8). Regular monitoring was conducted during 2015—once in January, once in February, weekly March through October (except week of August 3), three times in November, and once in December. Tortoises were also monitored in mid-January 2016. Mid-January 2015 monitoring results showed that 31 of 60 (52%) tortoises were still alive. Mid-January 2016 monitoring results showed that 27 of 60 (45%) were known to be alive. Four tortoises, 3 females and 1 male, were found dead during 2015 (Table 3-4). One of the tortoises was chewed up, apparently having been scavenged or predated; two died of exposure; and one of unknown causes. The male had tested positive for *Mycoplasma testudineum* in 2013 and suspect in 2014, whereas the three females had tested negative for *M. agassizii* and *M. testudineum* in 2013 and 2014.

Figure 3-8. Juvenile tortoise (#4045) with a VHF transmitter attached

(Photo by D.B. Hall, April 15, 2015)

Table 3-4. Mortality, sex, distance in meters (m) between release site and winter burrows, total distance between monitored locations, and number of burrows used by 31 juvenile desert tortoises monitored during 2015

Tortoise Number	Sex	Distance (m) Release to Winter 2012-13	Distance (m) Winter 2012-13 to Winter 2013-14	Distance (m) Winter 2013-14 to Winter 2014-15	Distance (m) Winter 2014-15 to Winter 2015-16	Total Distance (m) between locations Winter 2015-16	Number of Burrows Used
4009	Female	32	2	0	0	87	2
4010	Female	533	703	59	111	2330	4
4014	Female	567	65	81	80	1260	7
4021	Female	9	23	44	Dead 6/16	NA	NA
4030	Female	68	45	102	0	1944	7
4044	Female	102	293	53	63	2082	8
4045	Female	158	75	0	89	1739	8
4046	Female	398	1	0	30	881	4
4049	Female	1136	89	0	73	1000	2
4052	Female	810	1022	201	Dead 4/8	NA	NA
4057	Female	2414	30	0	Dead 5/5	NA	NA
4004	Male	183	67	0	88	1376	10
4005	Male	156	49	60	0	2891	11
4007	Male	42	148	0	37	663	5
4011	Male	240	121	126	87	1778	7
4018	Male	124	76	38	0	514	4
4019	Male	215	22	71	91	2366	8
4024	Male	704	121	29	10	1881	8
4025	Male	1069	336	0	85	1509	6
4033	Male	89	3	57	58	1418	6
4034	Male	20	95	0	0	1863	7
4036	Male	19	612	0	108	1537	6
4037	Male	147	60	0	88	789	3
4038	Male	16	63	33	21	1584	8
4040	Male	62	505	79	55	1784	6
4041	Male	42	11	0	0	1318	5
4042	Male	43	70	1142	Dead 3/17	NA	NA
4048	Male	37	2	92	101	2369	6
4050	Male	60	92	186	131	941	7
4053	Male	332	4	0	0	595	2
4055	Male	6132	179	0	131	3182	5
	Average	**515**	**161**	**79**	**57**	**1544**	**6**

Of the 60 released, 30 were male, 29 were female, and the gender of 1 was unknown. Of the 27 still known to be alive in mid-January 2016, 19 were male and 8 were female. Thus, male survival is 63% and female survival is 28%, 40 months post-release. This indicates that in our translocated captive juveniles, female juvenile tortoises experienced higher mortality than males with the primary cause of mortality suspected to be canid predation. 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 be a factor in declining 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. The ratio of females to males for adults and particularly juveniles warrants further study in other wild tortoise populations.

Table 3-4 contains information about the 31 juvenile tortoises monitored during 2015. On average, the distance between the release location and first winter burrow (i.e., the burrow a juvenile was in during the first part of January) was 515 meters (m) (range 9–6,132 m; standard deviation [sd] 1,135 m). The average distance between the first winter burrow and the second winter burrow was substantially less at 161 m (range 1–1,022 m; sd 235 m). The average distance between the second winter burrow and the third winter burrow was 79 m (range 0–1,142 m; sd 201 m). For the 27 surviving tortoises, the average distance between the third winter burrow and the fourth winter burrow was 57 m (range 0-131 m; sd 44 m). Nearly 81% (22 of 27) of tortoises wintered in burrows within 100 m of their last year's winter burrow with 26% (7 of 27) 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 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 1,415 m, and for males 1,598 m. A two-tailed, t-test was used to determine if this difference was statistically significant at α (alpha level) = 0.05. It was not significant (p [probability] = 0.60). The average distance by monitoring period between locations for all 27 surviving tortoises was also calculated and is shown in Figure 3-9 along with precipitation (mm) by monitoring period. Peaks of movement occurred in May, mid-summer, and late fall. The latter peaks coincided with some significant rainfall events, and activity was extended into early November.

During 2015, burrows were marked with unique numbers and data taken including 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 (Table 3-4) to give some idea of how many burrows these juveniles were using. It is important to note that tortoise locations were only documented weekly, and therefore all burrows used may not have been documented. The number of unique burrows marked and measured during 2015 was 91. The average height of burrows was 8.9 mm (range 6-21 mm; sd 2.6 mm) and average width of burrows was 20.0 mm (range 7-68 mm; sd 7.0 mm). Average elevation of burrows was 1,084 m (range 1,067–1,194 m; sd 20.8 m). Burrow orientation showed significant differences, with southern exposures used more than expected by chance (χ^2 = 8.8; p=0.03; degrees of freedom [df] = 3).

Observations made from January 2015 to January 2016 on the 27 surviving juvenile tortoises totaled 1,089. Figure 3-10 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 3-11 depicts the percentage of observations tortoises were found under vegetation by species. Most noteworthy is the dominance of blackbrush with nearly 40% of observations of tortoises found under vegetation recorded under this particular species. The "Other" category included turpentinebroom (*Thamnosma montana*) (2.3%), Fremont's dalea (*Psorothamnus fremontii*) (1.4%), and white bursage (*Ambrosia dumosa*), spiny hopsage (*Grayia spinosa*), fourwing saltbush (*Atriplex canescens*), desert almond, desert prince's plume (*Stanleya pinnata*), littleleaf ratany, Mojave woodyaster (*Xylorhiza tortifolia*), and Mojave yucca (*Yucca schidigera*) at ≤1% each.

Tortoises used burrows on wash slopes more than expected by chance (χ^2 = 103; p < 0.001; df = 3) (Figure 3-12). Vegetation cover at burrows was found at 88% of the burrows, suggesting this is an important factor in burrow selection for these juveniles (Figure 3-13). Vegetation species did not seem to be a major factor with nine species represented. Mixed shrub clumps seemed to be the dominant cover. White bursage (4.4%), blackbrush (4.4%), spiny menodora (*Menodora spinescens*) (1.1%), desert almond (1.1%), and burrobrush (1.1%) made up the other category.

Gravel was the dominant substrate at juvenile tortoise burrows (Figure 3-14) with gravel/cobble and gravel/sandy 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. Combined categories such as gravel/sandy means that both were about equal in abundance.

On average, tortoises used six unique burrows (range 2–11; sd = 2) (Table 3-4) with no significant difference between females (5.3 burrows) and males (6.3 burrows) ($p = 0.28$). 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.

Evidence of foraging was documented on 24 individual tortoises 144 times during 1,089 observations (13%) of all 27 juveniles between January 2015 and January 2016. Foraging was detected between March 11 and October 26, 2015, with peaks in March and April (Figure 3-15). Annual plant production was below average during the spring but higher than the last two years, largely due to a precipitation event of over 27 mm of rain in early March. This may explain the peaks of foraging in March and April. A significant amount of rain was received in October (61 mm) which influenced activity and foraging well into October and early November (Figure 3-9, Figure 3-15). The species documented as most commonly eaten were desert globemallow (*Sphaeralcea ambigua*) (4.2%) and yellow cups (*Camissonia brevipes*) (2.1%). Other species eaten were red brome (*Bromus rubens*), bluedick (*Dichelostemma capitatum*), Gilia species, bristly fiddleneck (*Amsinckia tessellata*), devil's spineflower (*Chorizanthe rigida*), redstem stork's bill (*Erodium cicutarium*), cushion cryptantha (*Cryptantha circumscissa*), stonecrop phacelia (*Phacelia saxicola*), and desert princesplume. Most (86%) of the time, it was not possible to identify what the tortoises had eaten.

During August and September 2015, each tortoise was given a detailed health assessment, weighed and measured, and assigned a body condition score. Similar health assessments were performed during September 2013 and 2014 and before the tortoises were released in August and September 2012. This allows for comparison of growth rates, weight change, and overall health and body condition score over time.

Table 3-5 contains data (2012-2015) on mid-carapace length (MCL) (mm), weight without transmitters (g) and body condition score (scale 1-3 = under condition, 4-6 = good condition, 7-9 = over condition) for the 27 living juvenile tortoises. Two-tailed t-tests were used to test for significant differences at $\alpha = 0.05$. On average, females grew 0.4 mm and males 3.7 mm during 2015. This difference approached statistical significance ($p = 0.08$). On average, females lost 2 g and males gained 50 g during 2015 which also approached statistical significance ($p= 0.10$). These data suggest that males grew more and gained more weight during 2015. Whether this was biologically significant is yet to be determined. Body condition score was in the good range (4-6) during all years for all tortoises.

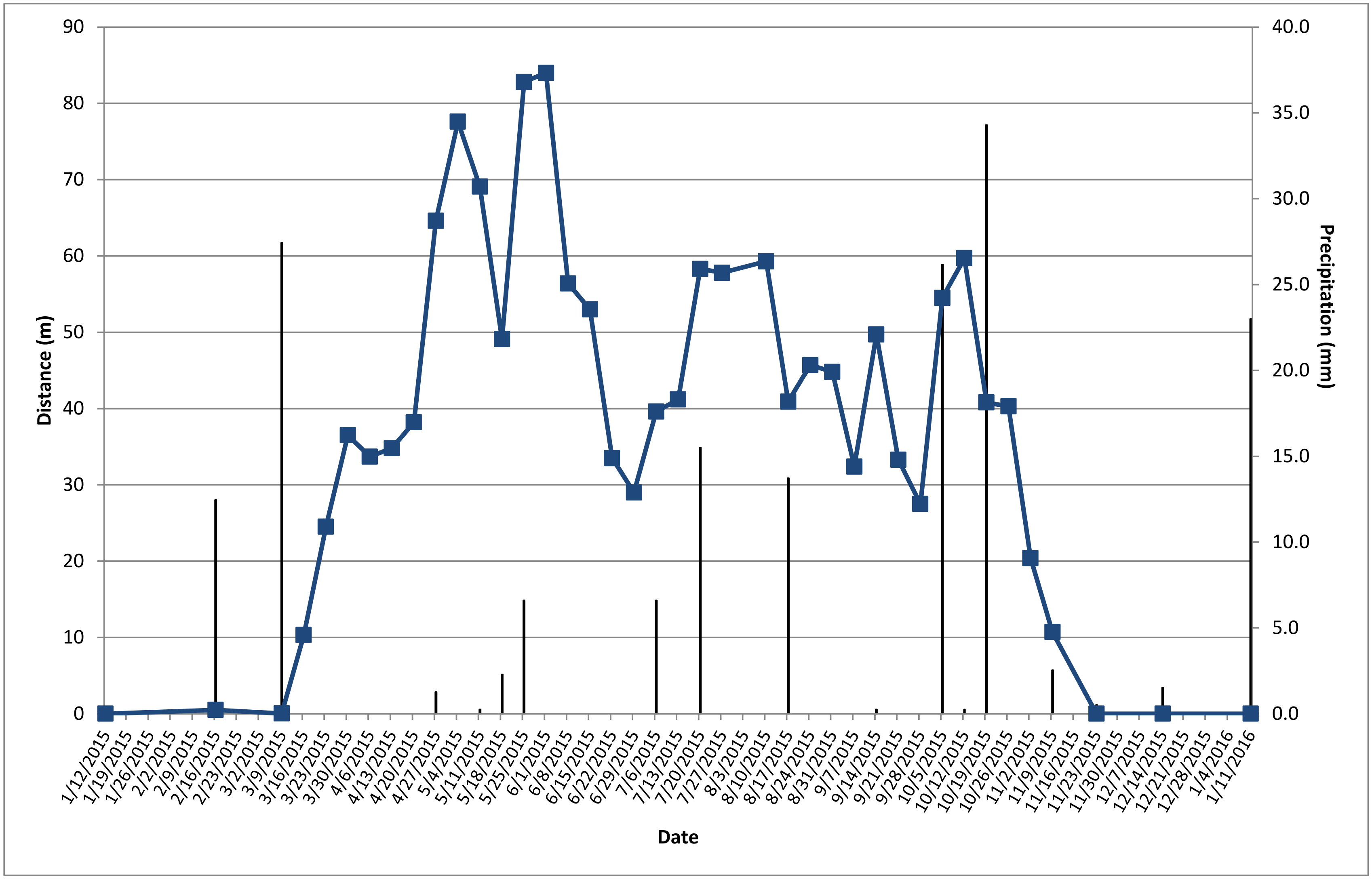


Figure 3-9. **Average distance (m) between locations for 27 surviving juvenile tortoises and precipitation (mm) received by monitoring period, January 2015–January 2016.**

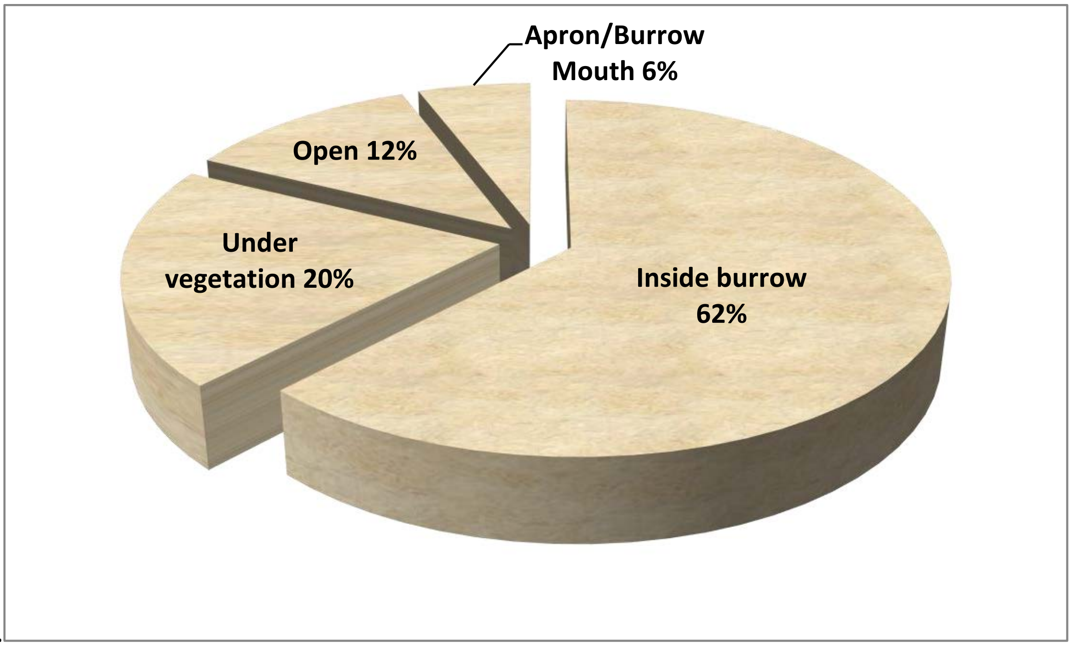


Figure 3-10. Percentage of observations (n = 1,089) of 27 juvenile tortoises by location, January 2015–January 2016

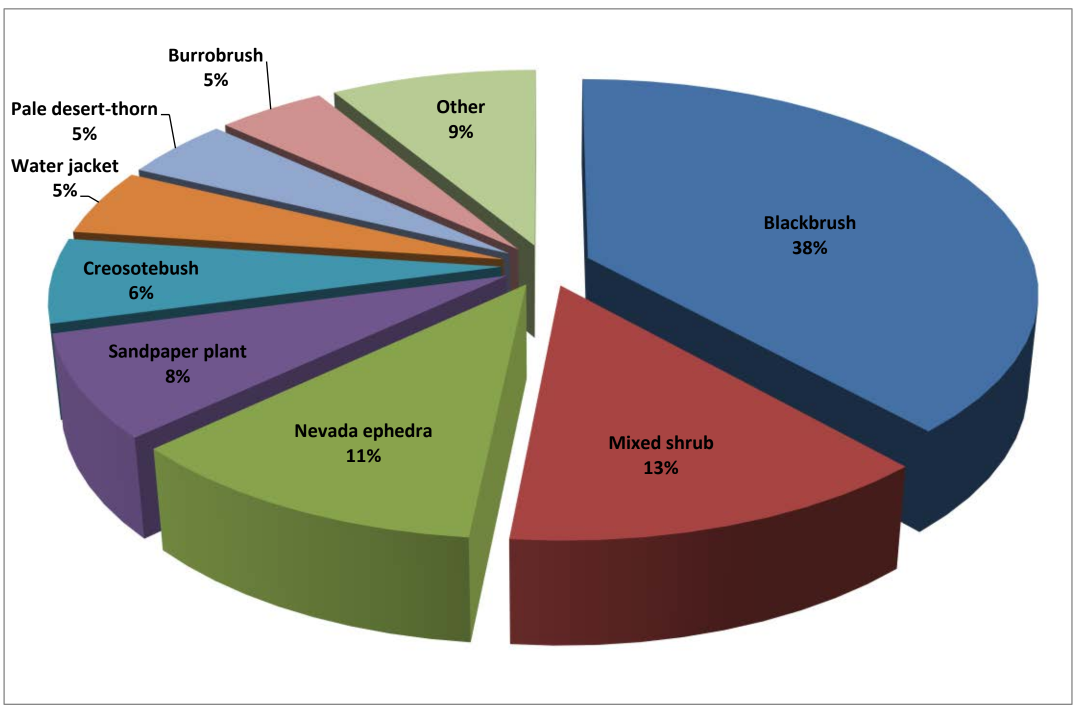


Figure 3-11. Percentage of observations (n = 219) of 27 juvenile tortoises found under vegetation by species, January 2015–January 2016

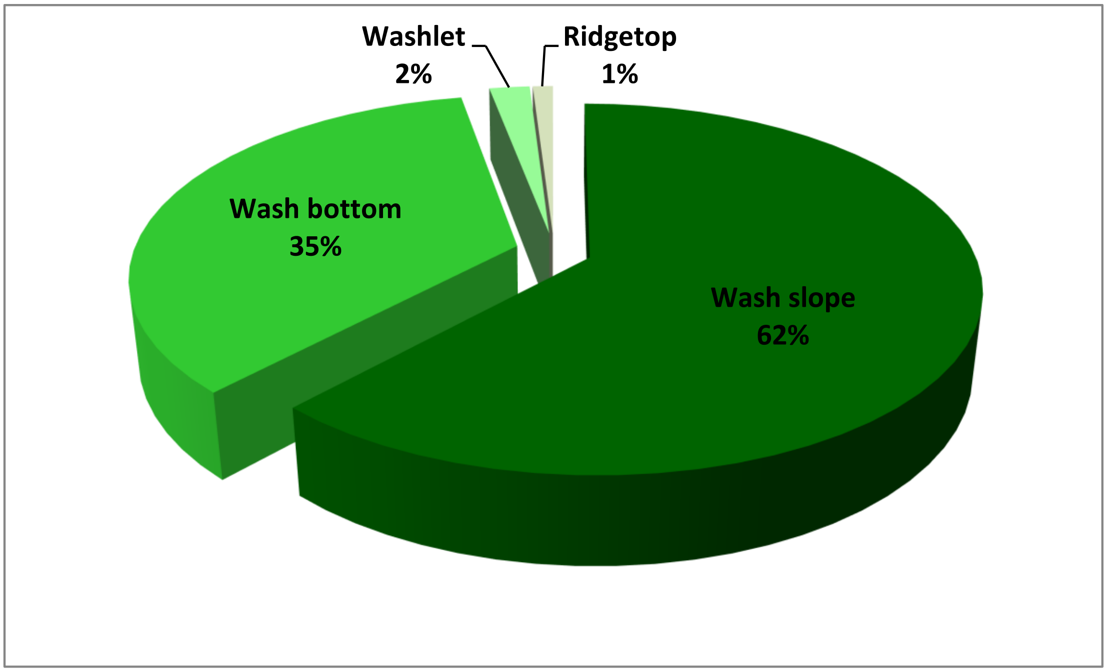


Figure 3-12. Percentage of juvenile tortoise burrows by topographic position, January 2015–January 2016 (n = 91)

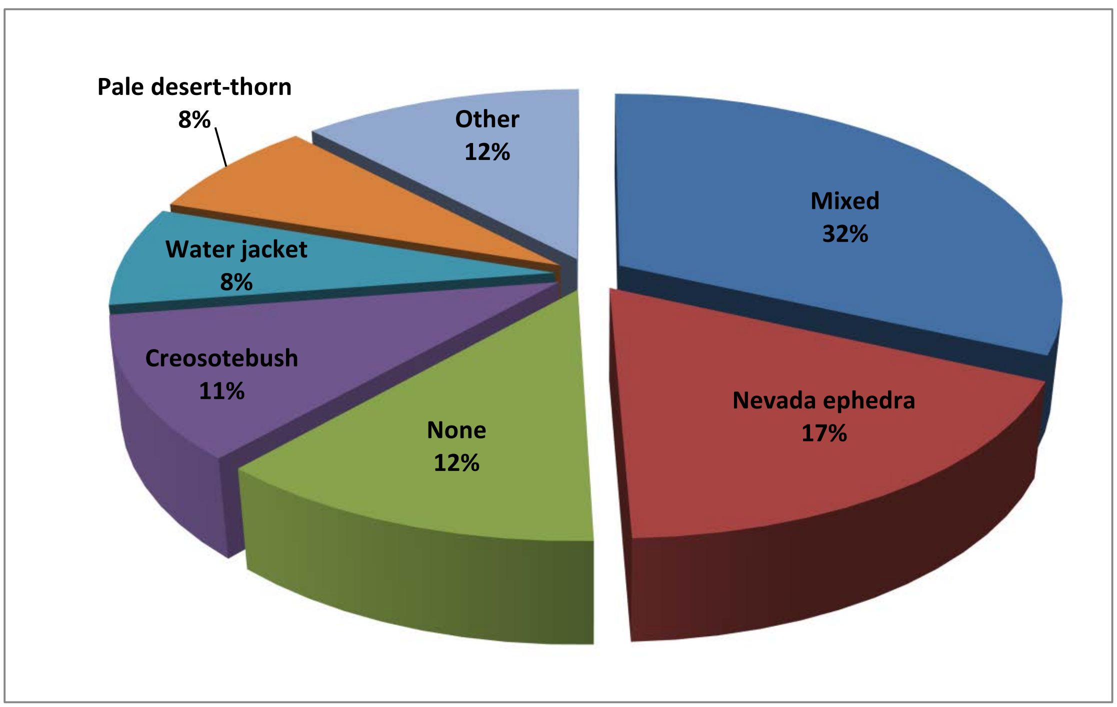


Figure 3-13. Percentage of juvenile tortoise burrows by vegetation cover at the burrow, January 2015–January 2016 (n = 91)

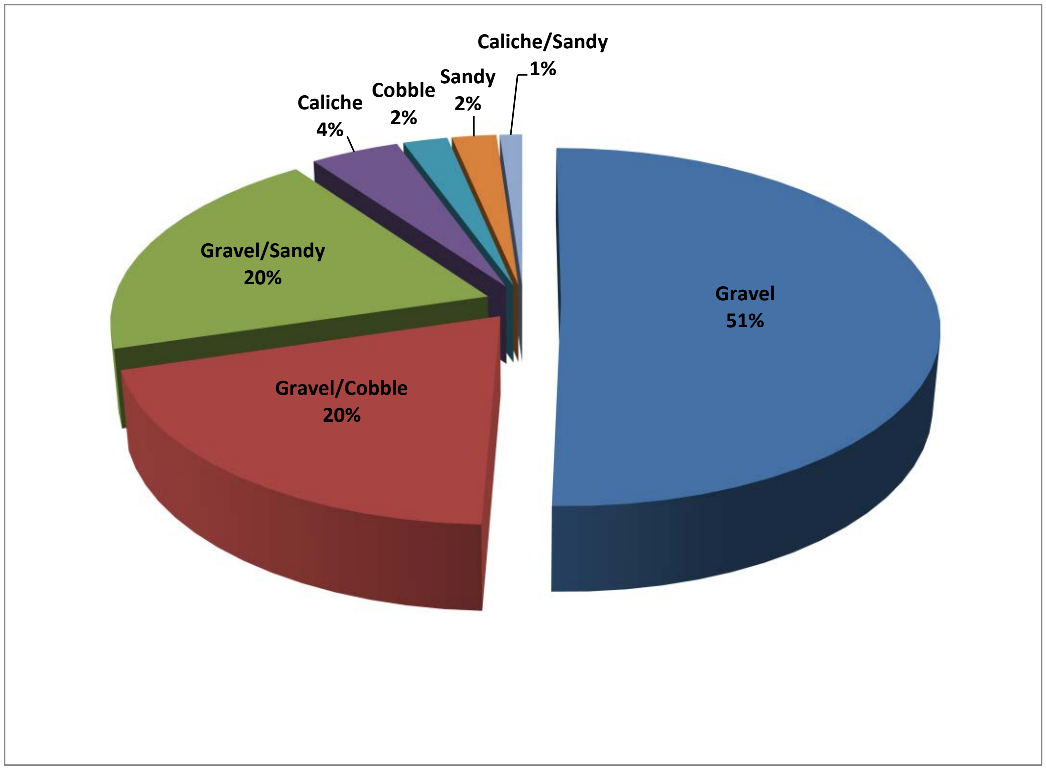


Figure 3-14. Percentage of juvenile tortoise burrows by substrate, January 2015–January 2016 (n = 91)

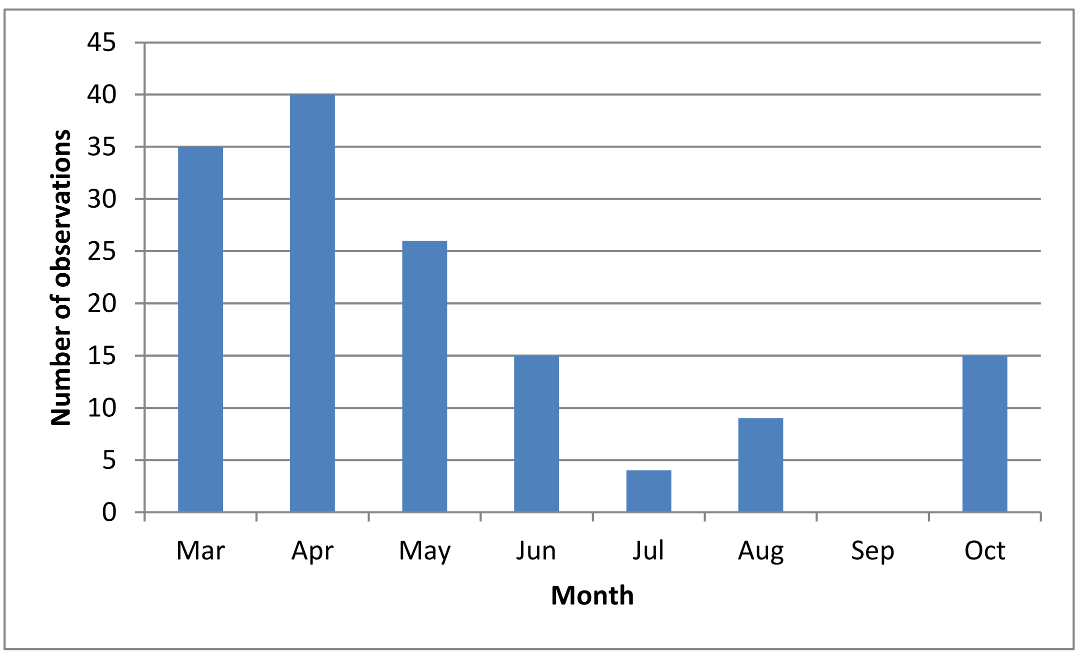


Figure 3-15. Number of times evidence of foraging was detected by month for 27 juvenile tortoises, January 2015–January 2016 (n = 144). (No evidence of foraging was detected in September, November, December, January, or February.)

Results from the health assessments performed during August 2015 showed that most tortoises were healthy and in good condition. A few exceptions were: 4014 showed clinical signs of the Upper Respiratory Tract Disease with a runny nose and eroded right naris; 4033 was lethargic and weak with skinny limbs and a big piece of scat stuck in its cloaca; 4009 had a lesion behind the right eye, which was protruding out and stuck open, possibly blind; 4045 had periocular swelling and mild discharge from the left eye; 4050 had localized inactive old trauma on the plastron near the head; and seven juveniles had sunken eyes.

The biggest factor for survival appears to be gender with higher survival of males than females. This has been observed by other researchers as well (Hall 2014). Size, weight, overall health, and presence of *Mycoplasma* species 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 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. The cause of the disparity between male and female mortality remains unknown. 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 olfaction as their dominant sense, it is possible that females are giving off scent that makes them easier to detect or perhaps something about 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 analyzed using a mass spectrometer in an attempt to detect any chemical differences between males and females and adults and juveniles that might cause increased canid predation.

A major precipitation event in mid-October resulted in overland water flow, and all primary washes in the study area flowed with several centimeters of water. No juvenile tortoises were killed but several burrows were destroyed. The increased precipitation, mild temperatures, and resultant plant green-up allowed tortoises to be active and forage longer into the season. All juveniles were at their winter 2015-2016 burrow by November 23. Only one (4%) was at its winter burrow by October 1 and 10 (37%) were at their winter burrow by October 23. In contrast, all juveniles were at their winter 2014-2015 burrow by November 18. Just over half of them were there by October 1 and all but three (90%) were at their 2014–2015 winter burrow by October 23. 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.

Table 3-5. Mid-carapace length (mm), weight (g) without transmitters, and body condition score for 27 juvenile tortoises, September 2012–August 2015 (* = estimated weight without transmitter)

Tortoise Number	Sex	Pre-release MCL (mm) (2012)	Year 1 MCL (mm) (Sep 2013)	Year 2 MCL (mm) (Sep 2014)	Year 3 MCL (mm) (Aug 2015)	Pre-release Weight (g) (2012)	Year 1 Weight (g) (Sep 2013)	Year 2 Weight (g) (Sep 2014)	Year 3 Weight (g) (Aug 2015)	Pre-release Body Condition (2012)	Year 1 Body Condition (Sep 2013)	Year 2 Body Condition (Sep 2014)	Year 3 Body Condition (Aug 2015)
4009	Female	138	138	138	135	472	444*	565	475*	4	5	5	5
4010	Female	Unknown	143	144	145	590	606*	662	675*	4	5	5	5
4014	Female	136	138	140	141	485	446*	521	552*	5	5	4	4
4030	Female	148	150	151	153	562	630	673	723*	4	5	5	4
4044	Female	146	145	146	143	484	555*	610	634*	4	5	5	5
4045	Female	129	129	132	134	400	437*	504	479*	4	5	4	4
4046	Female	126	130	137	138	476	465*	619	593*	4	4	4+	4
4049	Female	106	106	107	109	238	231*	272	281*	4	4	4	4
4004	Male	117	116	116	116	303	244*	288	325*	4	4	4+	4
4005	Male	140	140	140	141	564	534*	596	588*	5	5	5	5
4007	Male	121	120	121	120	363	338*	352	356*	5	4	4	4
4011	Male	144	150	157	163	634	579*	793	854*	4	5	5	5
4018	Male	105	105	105	105	213	183*	234	234*	4	4	4	4
4019	Male	150	150	158	160	654	636*	838	866*	4	4	4	4
4024	Male	146	148	154	167	565	645*	815	929*	5	5	5	5
4025	Male	127	128	128	129	357	325*	429	440*	5	5	4	5
4033	Male	126	130	129	127	430	418*	452	415*	4	4	4	4
4034	Male	128	130	134	138	407	401*	495	536*	4	4	4	4+
4036	Male	132	135	136	143	455	490*	521	633*	4	4	5	4+
4037	Male	105	106	108	110	223	224	251	266*	4	4	5	5
4038	Male	132	134	140	150	457	486	573	662*	4	4	5	4
4040	Male	140	140	142	143	493	489*	595	614*	4	4	4	4
4041	Male	119	118	120	122	322	300*	370	398*	4	4	5	4+
4048	Male	135	138	147	159	480	516	662	883*	5	4	5	5
4050	Male	138	139	142	142	502	502	573	516*	4	4	4+	4
4053	Male	150	151	153	153	681	670*	712	732*	4	5	4	4
4055	Male	151	155	162	175	602	690*	804	1052*	4	4	5	5

3.3.2 USGS Rock Valley Study

As part of continuing research pertaining to desert tortoises, the USGS in collaboration with the 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 2015 on this project.

3.3.3 Coordination with Other Biologists and Wildlife Agencies

During February 20–22, 2015, two NSTec biologists attended the Desert Tortoise Council's 40th annual meeting and symposium and co-authored a presentation given by ICR personnel. This meeting was held in Las Vegas, Nevada, and included numerous presentations on desert tortoise biology, ecology, and recovery efforts. On December 8, 2015, an NSTec biologist attended the meeting of the Management Oversight Group for the Northeastern Recovery Unit. Managers from multiple agencies attended and provided input for the Recovery Planning Team.

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 2015 focused on wildland fire fuels surveys, long-term vegetation monitoring plots, fairy shrimp identification, reptile trapping and roadkill sampling to fill in data gaps in reptile distributions, 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 2015

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 four wildland fires occurred on the NNSS during 2015, well below the average of 11 fires per year. All of these were less than 0.4 ha in size and were put out quickly by NNSS Fire and Rescue personnel. This is the third year in a row with below-normal fires in terms of both number and size. None of the fires had their perimeters mapped because they were so small.

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 2015 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 the 12 years of conducting fire fuel evaluations, the mean precipitation during these 5 months is correlated (r^2 [regression coefficient] = 0.770) with our estimations of the combined fuel loads. During 2015, the average precipitation from the remaining 14 rain gauge stations on the NNSS during December–April was 7.47 cm, or about 71.4% of the normal amount (i.e., the December-April average precipitation for the last 30 years—10.46 cm). This was the wettest year in the last four years. Temperatures were near normal during these months.

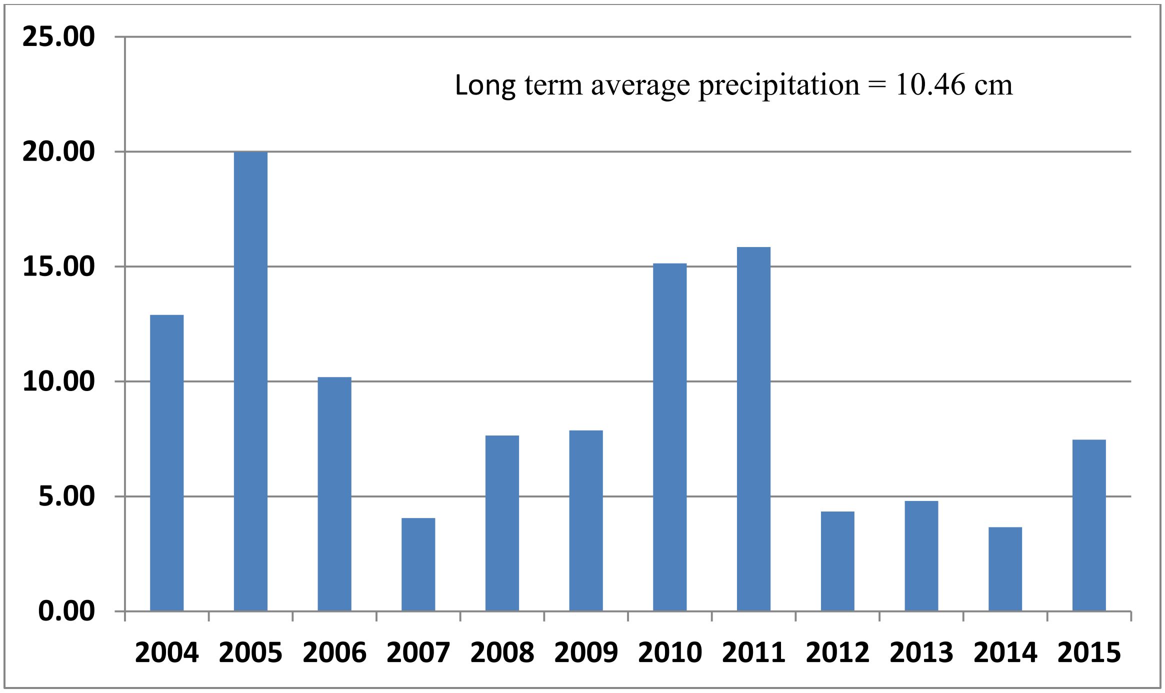


Figure 4-1. Average precipitation (cm) from December (previous year) through April for the years 2004 through 2015

4.1.3.2 Fuels

Because of the very spotty but generally below-normal precipitation that occurred during the spring of 2015, few annual or perennial plant seeds germinated. Perennial herbaceous grasses and forbs had little, if any, production during the spring of 2015 except in a few locations. While 2015 had more moisture during these winter/spring months than the last three years, both fine fuels and woody fuels were low (Table 4-1). The fine fuels index increased in 2015 (1.44) compared to 2014 (1.39), but was the second lowest recorded (Table 4-1). The woody fuels index value was slightly lower in 2015 (2.42) compared to 2014 (2.44), as foliar canopy cover decreased slightly (Table 4-1). This was the lowest ranking since 2004 when index values were initiated.

The combined index value (fine fuels plus woody fuels) for 2015 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 2015 was 3.87 (Table 4-1, Figure 4-2) the second lowest since 2004 and just slightly above 2014, suggesting below normal fuels for the NNSS.

The locations and results of the fine fuels, woody fuels, and combined fuels surveys at 104 stations on the NNSS inspected during 2015 are shown in Figures 4-3, 4-4, and 4-5, respectively. High combined index values occurred in Fortymile Canyon. Photographs were taken from permanent locations for all 104 sites during the past 10 years. Figure 4-6 shows photographs of Site 99 in Yucca Flat for the last 5 years (2013 was omitted since it showed an intermediate response). 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. The amount of fine fuels is slightly greater in 2015 compared with 2014 but much less than in 2011 or 2012. The woody fuels increased slightly in 2015 as shown by several green shrubs in the 2015 photo.

Table 4-1. Woody fuels, fine fuels, and combined fuels index values for 2004–2015

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

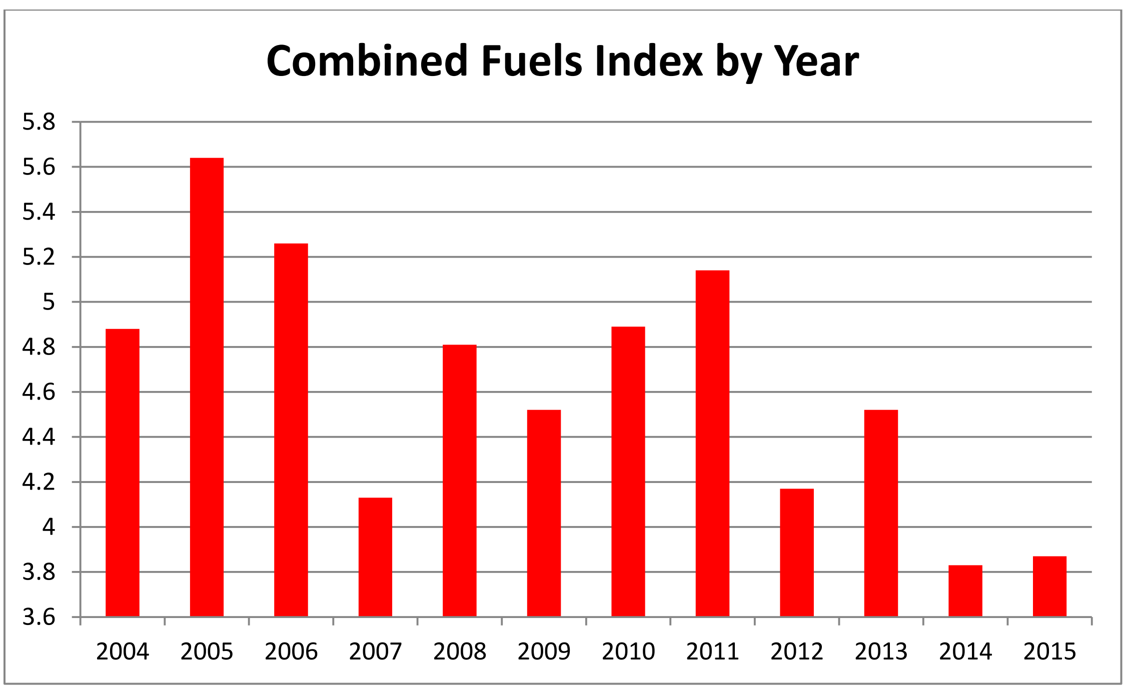


Figure 4-2. Mean combined fuels index for the years 2004 to 2015

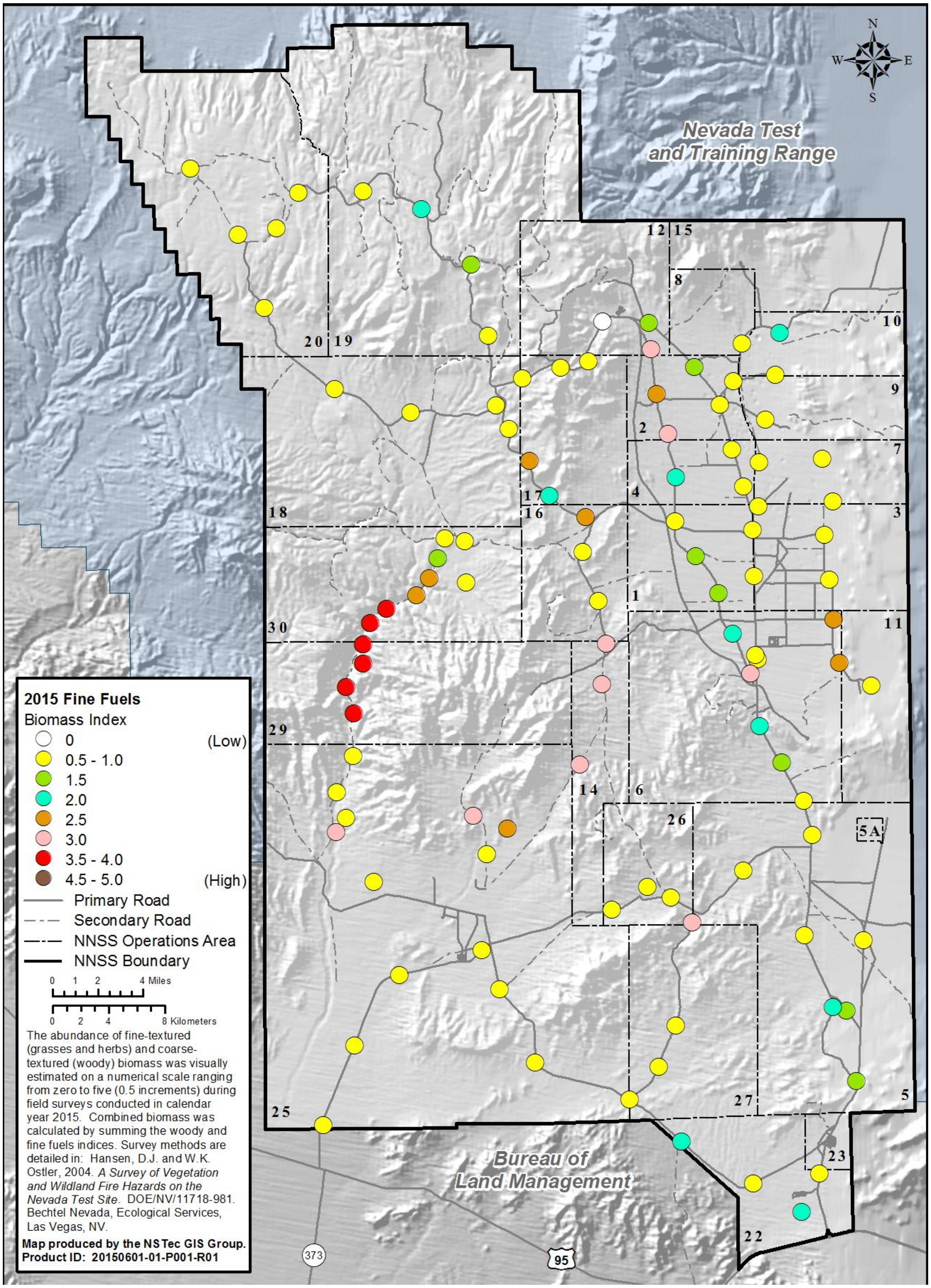


Figure 4-3. Index of fine fuels for 104 survey stations on the NNSS during 2015

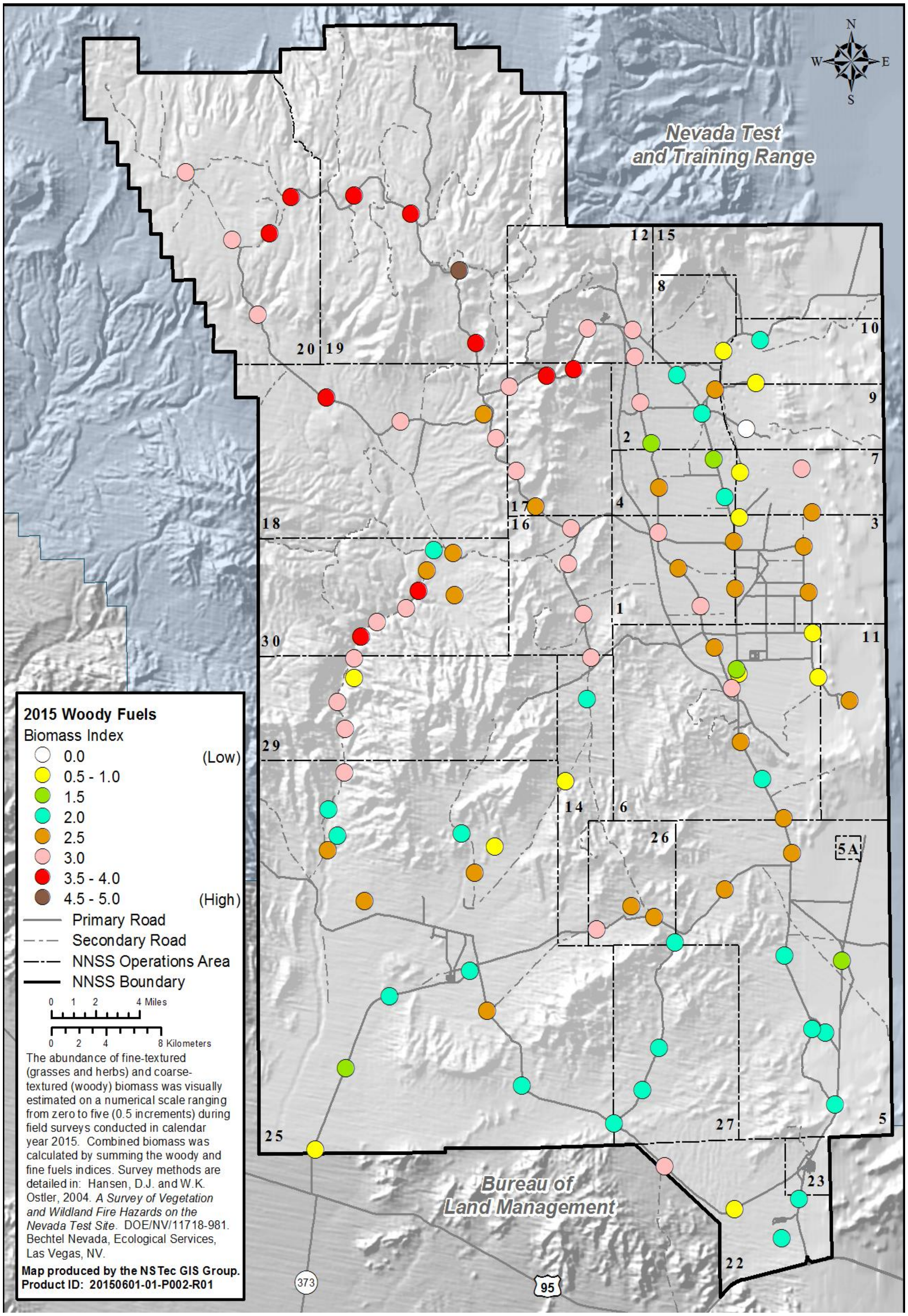


Figure 4-4. Index of woody fuels for 104 survey stations on the NNSS during 2015

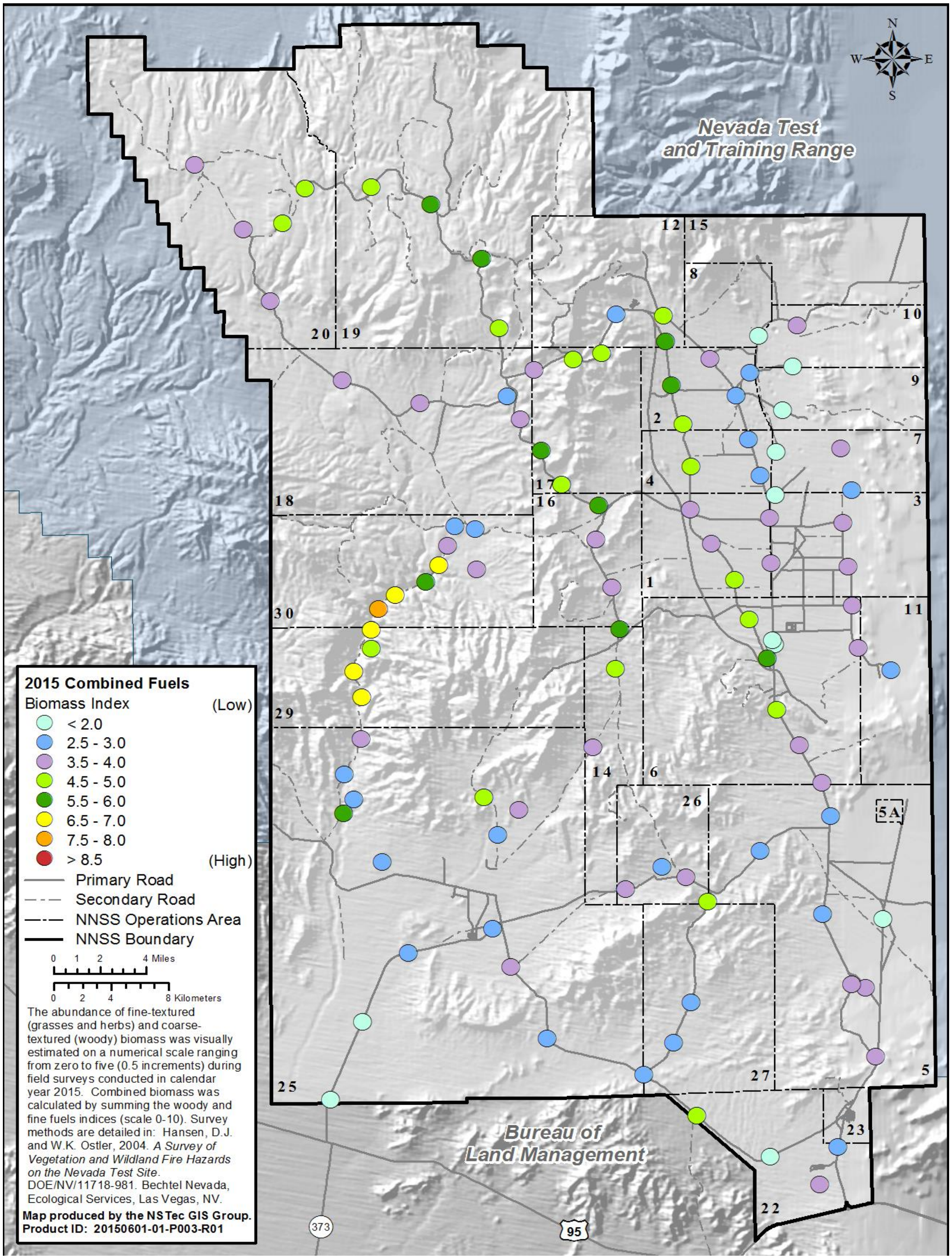


Figure 4-5. Index of combined fine fuels and woody fuels for 104 survey stations on the NNSS during 2015

Figure 4-6. Site 99 on the west side of Yucca Flat in 2011, 2012, 2014, and 2015

(Photos by W. K. Ostler, April 26, 2011 [top left]; April 10, 2012 [top right]; April 12, 2014 [bottom left]; and April 21, 2015 [bottom right])

As in past years, sites dominated by blackbrush and annual grasses appeared to respond to precipitation with greater variation in the amount of fine fuels and woody fuels than other vegetation community types (e.g., creosote bush or *Pinus monophylla*/*Juniperus osteosperma* [singleleaf pinyon/Utah juniper] communities). This results in increases in fine fuels at these sites compared with sites in the Mojave Desert (southern one-third of the NNSS) or the Great Basin Desert (northern one-third of the NNSS).

Fine fuels produced in 2015 were very spotty and generally lacking in most areas of the NNSS due to below normal precipitation. One primary exception was in northern Fortymile Canyon, which is normally high and remained high due to a wildland fire that burned through that area in 2011. Overall, the hazards of residual fuels contributing to wildland fires were lower than average, but the dry condition of both fine and woody fuels made them more susceptible to ignition by lightning or other sources. Once ignited, high ambient temperatures and high winds contribute to the spread of fire in areas where the abundance of fuels is sufficient to carry the flames of the fire. Rapid response by NNSS Fire and Rescue after fires are ignited is a key factor in minimizing wildland fire spread and severity.

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, 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 spring of 2015 and growth was marginal. Cheatgrass was the most common invasive plant occurring on 52.9% of the study sites although most plants were stunted due to lack of adequate rainfall. Both red brome (36.5%) and Arabian schismus (10.6%) had moderate 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 more likely to occur when regional storms provide precipitation to a greater number of areas across the NNSS. However, the responses of some species, both invasive and native, suggest that other variables, such as the timing of precipitation or temperatures required for germination, may also be contributing to plant response.

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 (*P. monophylla*/*J. 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, 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 2015 was the second lowest since 2004. Germination and growth of fine fuels during 2015 was very spotty and generally greatest at the middle elevations in Fortymile Canyon and Yucca Flat.

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
Mean Precipitation (cm) (December–April)	12.90	19.99	10.19	4.06	7.65	7.87	15.14	15.85	4.34	4.80	3.66	7.47
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	36.5
Bromus tectorum (cheatgrass)	40.3	54.0	60.7	0	59.2	66.0	67.0	79.2	17.0	70.2	61.5	52.9
Erodium cicutarium (filaree or 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
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
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
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
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

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. 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, eleven plots in big sagebrush, ten plots in pinyon/black sagebrush, and 12 plots in pinyon/big sagebrush. 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).

4.2.1 Plot Establishment

Locations of the 8 black sagebrush sites (ARNO), 11 big sagebrush sites (ARTR), 10 singleleaf pinyon/black sagebrush sites (PIMO-ARNO), and 12 singleleaf pinyon/big sagebrush sites (PIMO-ARTR) on the NNSS are shown in Figure 4-7. Examples of the four types of plots are shown in Figures 4-8 to 4-11. ARNO, ARTR, PIMO-ARNO, and PIMO-ARTR refer to the four-letter species codes for the dominant plant species found in these vegetation alliances (see Acronyms and Abbreviations List).

Randomly selected ELUs were visited in November and December 2007, and a suitable plot within each ELU was marked with a center lath. GPS coordinates and initial photographs of the plots were taken. The corners of each plot were marked with metal fence posts in the spring of 2008. UTM coordinates (NAD83) were recorded at each plot to document the location of corners. Accuracy of the coordinates was estimated to be ± 4.5 m. Plot size was approximately 50 m x 50 m and was established by GPS measurements due to the tall, woody vegetation that obscured line-of-sight and precluded use of a tape measure. Corner coordinates of the southeastern corner of each plot and plot locations and descriptions are included in Table 4-3. Rebar stakes were installed at the start and end of each transect on the plots. Parallel transects were set up at 10 m intervals starting 5 m west of the southeast corner post and continuing along the southern edge of each plot (Figure 4-12) and also along the northern edge of the plots at the same intervals. Fifty-meter tapes were stretched between the two rebar stakes at each interval and cover and density data were collected along the tape. All plots were sampled from south to north.

Plots were visited during the months of June, July, and August of 2008 as time became available from other field activities. Because vegetation was beginning to dry out and was not considered at its peak, only qualitative data were taken for cover, abundance, and phenology. Many of the annuals were in a late stage of phenological development. Qualitative data was taken for cover, abundance, and phenology. A species list for each plot was also recorded and reported in the 2008 EMAC report (Hansen et al. 2009). Within each plot, vegetation was sampled by two botanists traversing back and forth. New species were added to the list of plants as they were detected, and their percent cover and abundance was also recorded by seven classes (Table 4-4) and adjusted up or down as the plot was traversed to reflect their estimated values across the entire plot; phenology of the vegetation was recorded using four classes (Table 4-4). After traversing the entire plot, phenology values were discussed for each species based on observations, and mutual agreement as to the assigned value was made.

4.2.2 Field Sampling of ARNO, ARTR, and PIMO-ARNO Plots

In 2009, the ARNO and ARTR plots were sampled to determine cover and density. ARNO plots were sampled between May 20 and July 14, 2009, and ARTR plots were sampled between May 26 and August 24, 2009. Precipitation was very low in 2009 so values were expected to be lower than during a year of normal precipitation. The PIMO-ARNO and PIMO-ARTR sites were not sampled in 2009, due to other monitoring priorities. PIMO-ARNO plots were sampled between May 20 and August 6, 2015. Precipitation in 2015 was also below normal so many forb and grass species were difficult to detect and get accurate values for cover and density. In an effort to sample at the peak of vegetation cover and density, sampling of lower elevation sites generally occurred earlier than higher elevation sites.

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 (Figure 4-13). The first point was taken with the arm of the optical devise 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 (Figure 4-12). Cover was recorded as vegetation, bare ground, litter, gravel, cobble, or rock. When vegetation was encountered, it was identified and recorded by species. Five transects were sampled at 10-m intervals at every plot (Figure 4-12) 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 (Figure 4-12). Density within each plot was obtained by averaging data from the three transects. Species richness (total number of species) of a plot was measured by two biologists traversing back and forth across the plot. All species encountered including annuals were added to the list of species for each plot.

4.2.2.1 Results of Cover Measurements

Cover data by plot is reported in Table 4-5. Cover data for each transect and every species encountered is found in Appendix A. ARTR plots had average cover values higher than the ARNO plots (27.4% versus 21.8%, respectively). Gravel was the highest cover category for both vegetation types averaging 40.2% for ARNO plots and 29.6% for ARTR plots. Gravel was followed by vegetation cover and then litter (Table 4-5). In arid and semi-arid environments where vegetation may not fully protect the ground from erosion, gravel and litter can function to minimize soil erosion. Only about 10% of the ground is left exposed on these plots with the ARTR plots (13.9%) having more bare ground than the ARNO plots (9.3%). PIMO-ARNO plots had higher total vegetation cover than either of the sagebrush plots. On these plots the optical device was also pointed upward to get an estimate of overstory cover (Table 4-5). These overstory values represent a separate measure of cover above 1.5 m. They are not additive with understory to get total cover. On the PIMO-ARNO plots litter is equal to total vegetation cover at 29.5% cover. Similar to the sagebrush plots, gravel makes up a significant portion of protection for the soil.

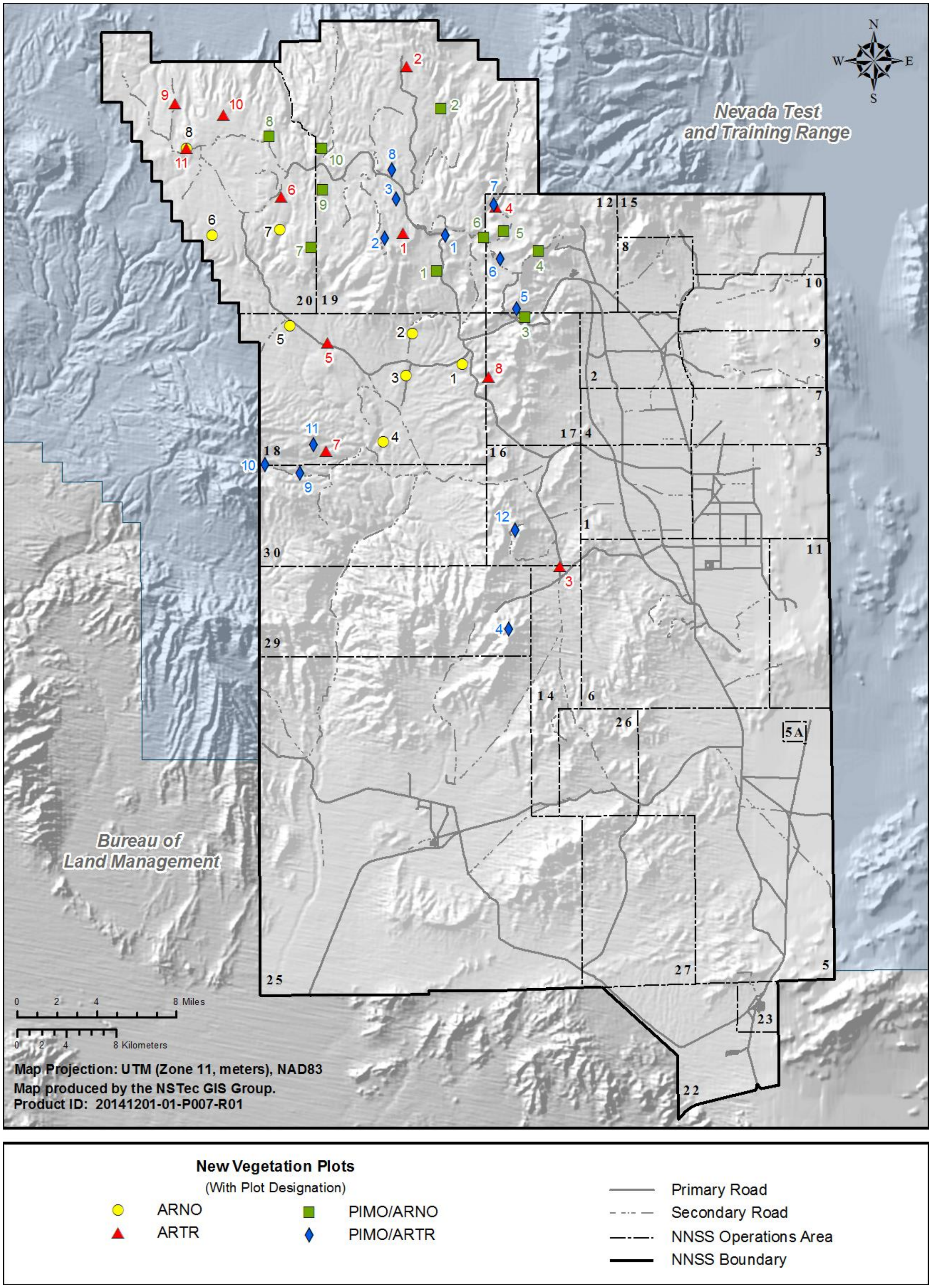


Figure 4-7. Location of new long-term monitoring plots established on the NNSS in 2008

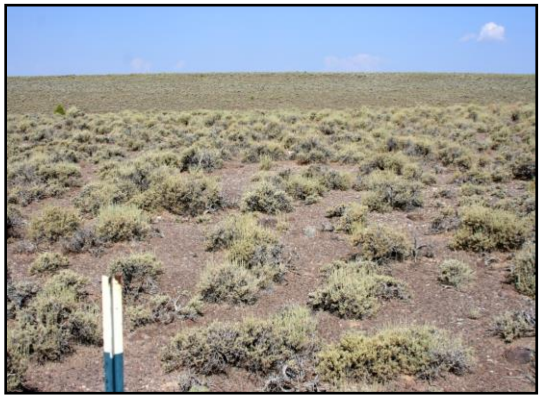


Figure 4-8. Example of black sagebrush vegetation association (Site: ARNO-06)

(Photo by W.K. Ostler in Area 20, July 15, 2008)

Figure 4-9. Example of big sagebrush vegetation association (Site: ARTR-01)

(Photo by W.K. Ostler in Area 19, July 15, 2008)

Figure 4-10. Example of pinyon/black sagebrush vegetation association (Site: PIMO-ARNO-05)

(Photo by W.K. Ostler in Area 12, July 29, 2008)

Figure 4-11. Example of pinyon/big sagebrush vegetation association (Site: PIMO-ARTR-03)

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

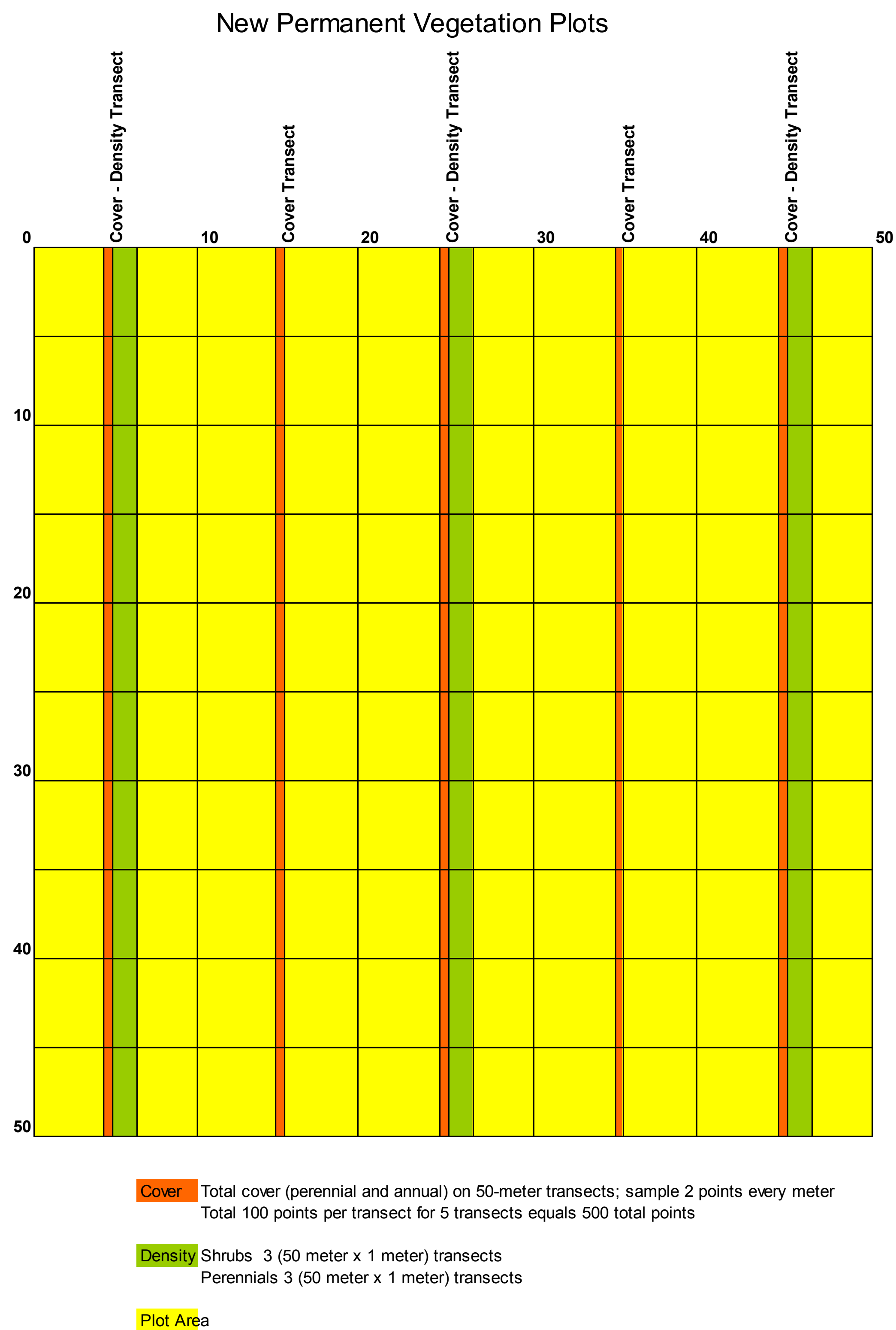


Figure 4-12. Sampling design of long-term vegetation monitoring plots

Table 4-4. Data sheet for recording species richness data by cover class, abundance, and phenology

Long-Term Vegetation Monitoring Plot Data Sheet

Site No.: **Date:** **Scientists:**
Slope: **Aspect:** **Elevation:**

	Species	Alphacode	% Cover	Abundance	Phenology
1					
2					
3					
4					
5					
6					
7					
8					
9					
10					
11					
12					
13					
14					
15					
16					
17					
18					
19					
20					
21					
22					

% Cover		Abundance		Phenology	
1	0-1	***0***	Inferred present from dead parts, but rare	***V***	Vegetative
2	>1-2	***1***	Rare with evidence of living presence	***FL***	Flowering
3	>2-5	***2***	Uncommon, widely scattered	***FR***	Fruiting
4	>5-10	***3***	Common, or scattered clusters	***PFR***	Past Fruiting
5	>10-25	***4***	Abundant or ubiquitous in plot		
6	>25-60	***5***	Very abundant, but not dominant		
7	>60	***6***	Very abundant and subdominant or dominant		

Notes:

Figure 4-13. Estimating cover with an optical scope

(Photo by W.K. Ostler, Jan. 1990)

4.2.2.2 Results of Density Measurements

Summarized density data is reported in Table 4-6. The raw data for density by species are presented in Appendix B. While there is tremendous variability within vegetation types, the ARTR plots had the highest average density (190.5) followed by the PIMO-ARNO plots (167.9) and ARNO plots (149.2). The ARNO plot densities were dominated by shrubs, which accounted for over 61% of all perennials (Table 4-6). This is obvious when observing these plots (see Figure 4-8) and seeing the dominance of black sagebrush on these plots. Only a few trees occur on the ARNO and ARTR plots so most of the plants in the trees and shrubs category are actually shrubs (Appendix B). Perennial forbs were nearly absent from the ARNO plots but this may be due in large part to the lack of precipitation prior to when the plots were sampled.

Because big sagebrush, singleleaf pinyon and Utah juniper are larger than black sagebrush, shrub densities in the ARTR and PIMO-ARNO plots are lower than in the ARNO plots (see Figures 4-9 and 4-10). ARTR and PIMO-ARNO plots generally receive more precipitation so the densities of grasses and forbs are higher in these plots than in the drier ARNO plots (Table 4-6).

Table 4-5. 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

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 4-5. 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 (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 4-6. 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. 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 4-6. 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. 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**

4.2.2.1 Results of Species Richness Measurements

Species richness (i.e., total number of species) was measured between 2008 and 2013. All plots were not sampled every year except in 2008 (Table 4-7). In 2009, only the ARNO and ARTR plots were sampled and in 2010 and 2013 only the PIMO-ARNO and PIMO-ARTR plots were sampled. Precipitation from December through April has been shown to be correlated to fine fuel levels (see section 4.1.3.1 Climate).

Precipitation for this time period was slightly below average in 2008 and 2009. It was much higher in 2010 and very low in 2013 (Figure 4-1). In 2008, when all sites were sampled, the PIMO-ARNO sites had the highest species richness averaging 25.0 species per plot, the ARNO plots had the second highest values at 23.4. The ARTR and PIMO-ARTR plots had lower species richness at 19.3 and 22.2, respectively. Species richness dropped in 2009 for the ARNO and ARTR plots (20.7 and 16.8, respectively). Species richness increased for the PIMO-ARNO and PIMO-ARTR plots in 2010 when precipitation was above average (29.7 and 27.5, respectively). Both plots increased nearly five species per plot with the increase in precipitation. In 2013, species richness dropped for PIMO-ARNO and PIMO-ARTR plots averaging 23.5 and 20.1, respectively, and were below the 2008 values. The increase in species richness in wet years is due to the increase in annual species with more precipitation.

Table 4-7. Species richness measured on all long-term monitoring plots from 2008-2013

SITE	2008	2009	2010	2013
ARNO-01	19	18		
ARNO-02	32	22		
ARNO-03	31	30		
ARNO-04	22	27		
ARNO-05	20	16		
ARNO-06	19	18		
ARNO-07	21	14		
ARNO-08		14		
MEAN	**23.4**	**20.7**		
ARTR-01	24	25		
ARTR-02	18	16		
ARTR-03	29	22		
ARTR-04	17	13		
ARTR-05	21	19		
ARTR-06	21	22		
ARTR-07	18	25		
ARTR-08	18	11		
ARTR-09	17	10		
ARTR-10	9	7		
ARTR-11	20	15		
MEAN	**19.3**	**16.8**		
PIMO-ARNO-01	22		29	16
PIMO-ARNO-02	27		35	24
PIMO-ARNO-03	29		35	26
PIMO-ARNO-04	20		27	29
PIMO-ARNO-05	27		29	26
PIMO-ARNO-06	24		28	27
PIMO-ARNO-07	30		29	22
PIMO-ARNO-08	22		26	16
PIMO-ARNO-09	29		34	33
PIMO-ARNO-10	20		25	16
MEAN	**25.0**		**29.7**	**23.5**
PIMO-ARTR-01	23		29	23
PIMO-ARTR-02	29		32	30
PIMO-ARTR-03	30		38	28
PIMO-ARTR-04	24		28	14
PIMO-ARTR-05	20		22	18
PIMO-ARTR-06	13		22	10
PIMO-ARTR-07	15		21	
PIMO-ARTR-08	21		26	17
PIMO-ARTR-09	25		32	
PIMO-ARTR-10	23		27	
PIMO-ARTR-11	22		26	
PIMO-ARTR-12	21		27	21
MEAN	**22.2**		**27.5**	**20.1**

4.3 FAIRY SHRIMP IDENTIFICATION

Fairy shrimp are small crustaceans that live in ephemeral water pools. They are found around the NNSS but are most abundant on Yucca Playa and Frenchman Playa. Three species are known from the NNSS: giant fairy shrimp (*Branchinecta gigas*), alkali fairy shrimp (*Branchinecta mackini*), and paddletail shrimp (*Thamnocephalus platyurus*).

A new species record for the NNSS was identified in 2015 by Dr. Christopher Rogers (University of Kansas) from a sample taken from Pahute Mesa Pond by Paul Greger (retired NNSS biologist). A collection made back in 2009 from this same pond was thought to be a new species of *Branchinecta* but was identified this year by Dr. Rogers as the versatile fairy shrimp (*Branchinecta lindahli*). This species is common throughout western North America but this is the first time it has been described from the NNSS. No fairy shrimp found on the NNSS are considered sensitive or protected/regulated. They may be an important food resource for migrating shorebirds.

4.4 REPTILE STUDIES

Field mapping of reptile distributions continued in 2015 by live-trapping at new and historical sites and conducting road surveys looking for road kills. Opportunistic reptile observations were also documented. 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, tissue samples from some specimens were collected and given to the Nevada Department of Wildlife (NDOW) for future genetic analysis. Work continued on a draft topical report about reptile distribution on the NNSS.

4.4.1 Reptile Trapping

Trapping involved setting un-baited funnel traps at multiple locations in Areas 4, 5, 22, and 27 from April 14-30. Total captures were limited to 47 individual reptiles including 15 western whiptails (*Cnemidophorus tigris*), 13 side-blotched lizards (*Uta stansburiana*), 9 desert spiny lizards (*Sceloporus magister*), 6 desert banded geckos (*Coleonyx variegatus*), 3 desert horned lizards (*Phrynosoma platyrhinos*), and 1 zebra-tailed lizard (*Callisaurus draconoides*). Reptiles were released at their capture location.

4.4.2 Roadkill Surveys

Reptile road kills were documented at various locations around the NNSS. However, semi-standardized surveys were limited to paved roads in the southern third of the NNSS and were conducted by driving slowly along a 67 km route at least weekly during April and May. Road kills were located, identified, weighed, and measured. Tissue samples (usually a 2-5 mm portion of tail) were collected for genetic analysis from selected specimens. A total of 38 snakes, representing 6 species, and 101 lizards representing 6 species were detected (Table 4-8). Similar to findings last year (Hall et al., 2015), the most common snake found was the red racer (*Masticophis flagellum*) with nearly half of all road kill snakes being red racers. Equal numbers of sidewinders (*Crotalus cerastes*), speckled rattlesnakes (*Crotalus mitchellii*), and gopher snakes (*Pituophis catenifer*) were observed (Table 4-1). The zebra-tailed and long-nosed leopard lizard were the most impacted lizards (Table 4-8). Three additional road kill gopher snakes were found on March 23 (Mercury Highway, Area 5), June 9 (Pahute Mesa Road, Area 17), and October 22 (Buckboard Mesa Road, Area 18).

Table 4-8. Roadkilled reptiles collected April and May 2015 on the NNSS

	April	May	Totals	% of Taxa by Species
Snakes				
Red racer (*Masticophis flagellum*)	11	7	18	47.4
Sidewinder (*Crotalus cerastes*)	4	2	6	15.8
Speckled rattlesnake (*Crotalus mitchellii*)	4	2	6	15.8
Gopher snake (*Pituophis catenifer*)	3	3	6	15.8
Western patch-nosed snake (*Salvadora hexalepis*)	0	1	1	2.6
Western ground snake (*Sonora semiannulata*)	0	1	1	2.6
Total	**22**	**16**	**38**	**100**
Lizards				
Zebra-tailed lizard (*Callisaurus draconoides*)	16	15	31	30.7
Long-nosed leopard lizard (*Gambelia wislizenii*)	16	14	30	29.7
Desert horned lizard (*Phrynosoma platyrhinos*)	13	6	19	18.8
Desert spiny lizard (*Sceloporus magister*)	7	6	13	12.9
Western whiptail lizard (*Cnemidophorus tigris*)	1	6	7	6.9
Great Basin Collared lizard (*Crotaphytus bicinctores*)	0	1	1	1.0
Total	**53**	**48**	**101**	**100**
Grand Total	**75**	**64**	**139**	

4.4.3 Opportunistic Observations

Two sidewinders were found around buildings in Mercury and relocated a safe distance away from people. Four ground snakes (*Sonora semiannulata*) were found in and around buildings in Mercury, three of which were stuck on glue traps. All four were released back into the desert. A long-nosed snake (*Rhinocheilus lecontei*) was found on a glue trap in Mercury, removed from the glue trap and released. A red racer was observed near a building in Mercury. Two desert banded geckos were found in buildings in Mercury and were released back into the desert.

4.4.4 Great Basin Skink Distribution

Great Basin skinks (*Plestiodon skiltonianus utahensis*) (GBS) occur in the highest elevation habitats on the NNSS, usually above 2000 m. Although not considered an "at-risk" or sensitive species by the NNHP, they are a potential indicator species of the health and status of the high elevation habitats that would likely be the most impacted due to climate change in a predicted hotter, drier climate. For this reason, it is important to understand the current distribution of this species.

Researchers from Brigham Young University (BYU) conducted the initial wildlife studies on the NNSS, primarily in the 1960s. They documented 57 GBS at two sites, both on Rainier Mesa between 1961 and 1971 (Figure 4-14). An additional 10 GBS were documented at five sites in 1975 by Alexander Johnson (Figure 4-14). These records were found this year in the online database, VertNet (http://www.vertnet.org), based on information given to NNSS biologists by Phil Medica (retired USGS biologist). The specimens are curated at the Museum of Vertebrate Zoology at Berkeley. These specimens were examined (special thanks to Curator Carol Spencer) by an NSTec biologist and determined to all be GBS. In 1993, five GBS were captured at the northernmost historic BYU plot on Rainier Mesa (Figure 4-14) by BECAMP (Basic Environmental and Compliance Monitoring Program) biologists. An additional 20 GBS were documented at 14 new sites and one GBS at the historic BYU plot during reptile trapping efforts and mountain lion (*Puma concolor*) monitoring by NNSS biologists (2007-2013) (Figure 4-14). These new sites expand the known distribution of GBS to the west and north on the NNSS. The average elevation of these sites is 2,141 m (range 1,963-2,299; sd 99). The continued presence of GBS at the historic BYU plot for more than 50 years is noteworthy.

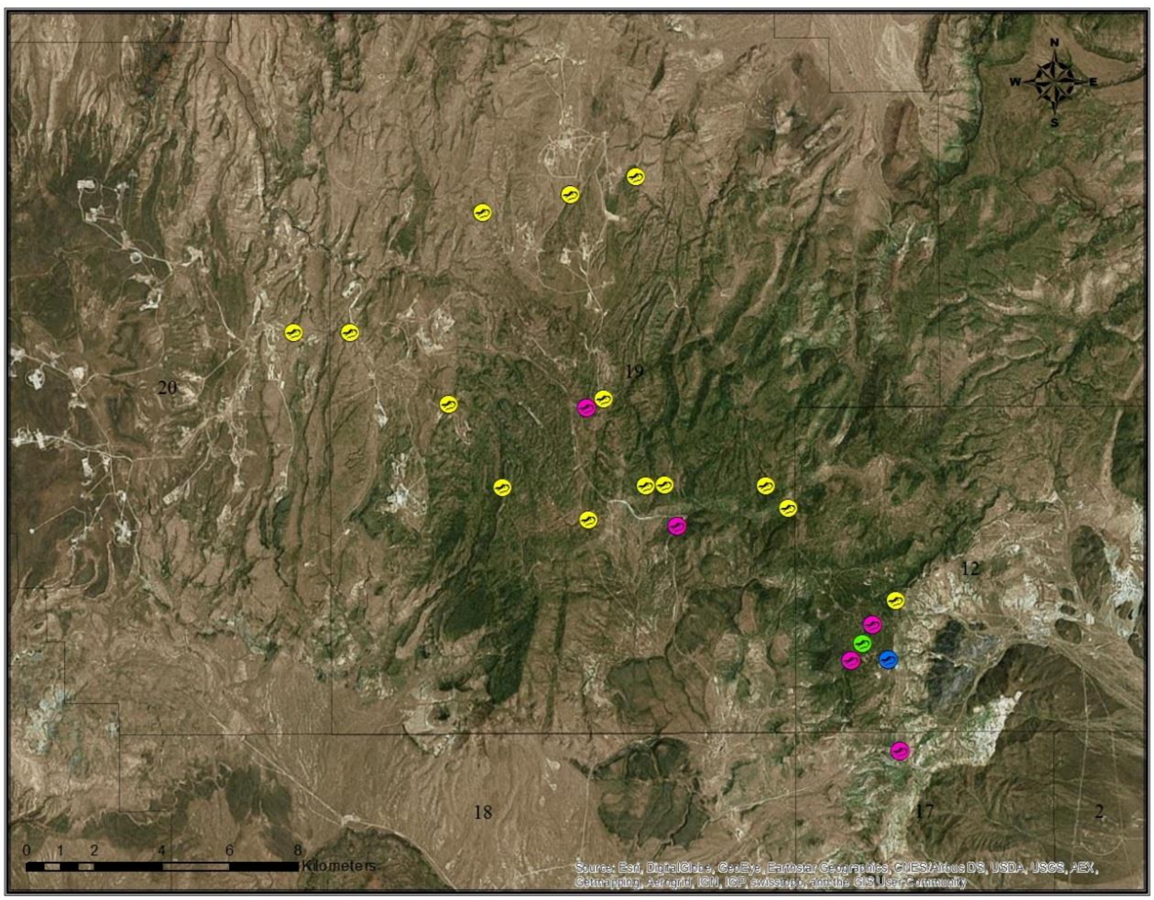


Figure 4-14. Great Basin Skink distribution on the NNSS (Yellow=recent observations/captures, 2007-2013; Pink=Alexander Johnson's collection records, 1975; Blue=Brigham Young University [BYU] records, 1961-1971; Green=records from BYU, 1993, and 2008)

4.5 NATURAL WATER SOURCE MONITORING

4.5.1 Existing Water Sources Monitored

Ten natural water sources (six springs, four rock tanks) were monitored with motion-activated cameras in 2015, primarily to document the presence of mountain lions and other wildlife (Figure 4-15). Results are found in Table 6-4 (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 (n=2,514) of any camera site with most of the images being of mule deer (*Odocoileus hemionus*) (n=843), horses (*Equus caballus*) (n=701), and pronghorn antelope (*Antilocapra americana*) (n=530). Over 100 images each of coyotes (*Canis latrans*), turkey vultures (*Cathartes aura*), and common ravens (*Corvus corax*) were also taken. Other species detected included mountain lion, bobcat (*Lynx rufus*), elk (*Cervus elaphus*), black-tailed jackrabbit (*Lepus californicus*), golden eagle (*Aquila chrysaetos*) and brown-headed cowbird (*Molothrus ater*).

Images at Captain Jack Spring were dominated by mule deer (1,440 of 1,556 images). Other species included mountain lion, bobcat, gray fox (*Urocyon cinereoargenteus*), coyote, desert cottontail (*Sylvilagus audubonii*), chukar (*Alectoris chukar*), mourning dove (*Zenaida macroura*), northern flicker (*Colaptes auratus*), pinyon jay (*Gymnorhinus cyanocephalus*), and common raven.

A total of 538 images were taken at Topopah Spring with most of these of chukar (279 images) and coyotes (178 images). Other species included mountain lion, bobcat, gray fox, desert bighorn sheep (*Ovis canadensis nelsoni*), mule deer, desert cottontail, black-tailed jackrabbit, rock squirrel (*Spermophilus variegatus*), mourning dove, and common raven.

Mule deer was the most common species photographed at Twin Spring (62 of 89 images). Other species included bobcat, coyote, desert bighorn sheep, chukar, greater roadrunner (*Geococcyx californianus*), and common raven. Bobcat was the most common species photographed at Cottonwood Spring (48 of 64 images). Other species included gray fox, coyote, mule deer, chukar, and an unidentified species of hummingbird. Only four species were photographed at Cane Spring and included bobcat (18 images), coyote (4 images), mule deer (24 images), and black-tailed jackrabbit (2 images).

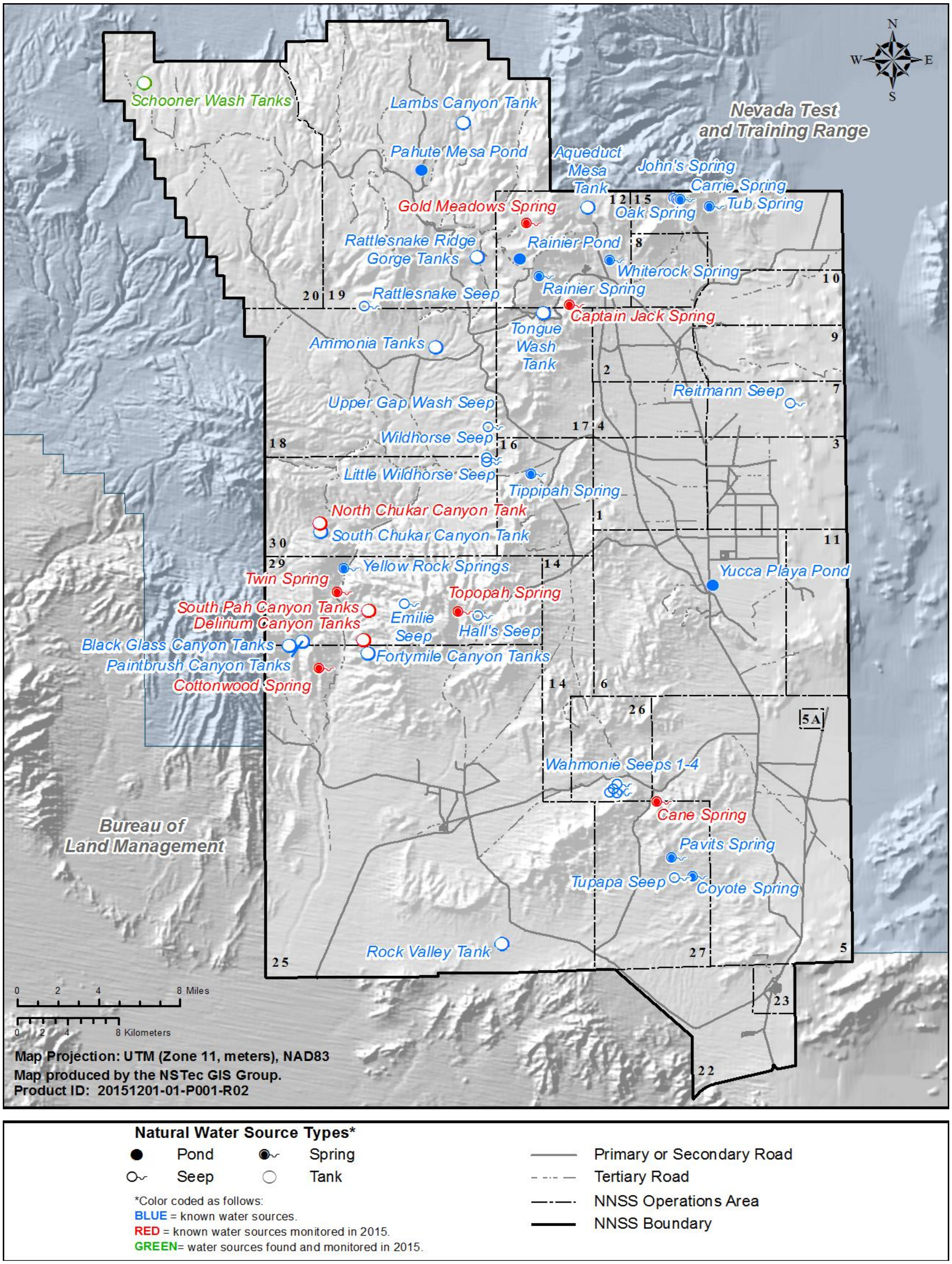


Figure 4-15. Natural water sources on the NNSS including those monitored and found in 2015

4.5.2 New Water Source

One new water source was documented on October 22, 2015, on the NNSS, Schooner Wash Tanks (Figure 4-16). It is located in the wash just east of Schooner Crater in Area 20 and straddles the boundary of the Radioactive Material Area (Figure 4-16). It consists of a series of rock catchments in exposed volcanic tuff at an elevation of 1,652 m. Dominant vegetation in the area is big sagebrush, rubber rabbitbrush (*Ericameria nauseosa*), and desert bitterbrush (*Purshia glandulosa*).

Figure 4-16. Schooner Wash Tanks, east of Schooner Crater, Area 20

(Photo by D.B. Hall, October 22, 2015)

4.6 CONSTRUCTED WATER SOURCE MONITORING

One new plastic-lined sump was constructed in 2015, ER 20-12. It is one of the largest sumps on the NNSS with a capacity of about 3.8 million gallons. Earthen escape ramps were built in the southeast and northeast corners. This site will be monitored for wildlife use with a motion-activated camera. Twelve additional constructed water sources were monitored with motion-activated cameras to document the presence of mountain lions and other wildlife. These include five water troughs installed to mitigate the loss of well ponds, one well pond (Camp 17 Pond), and six radiologically-contaminated sumps (Figure 4-17).

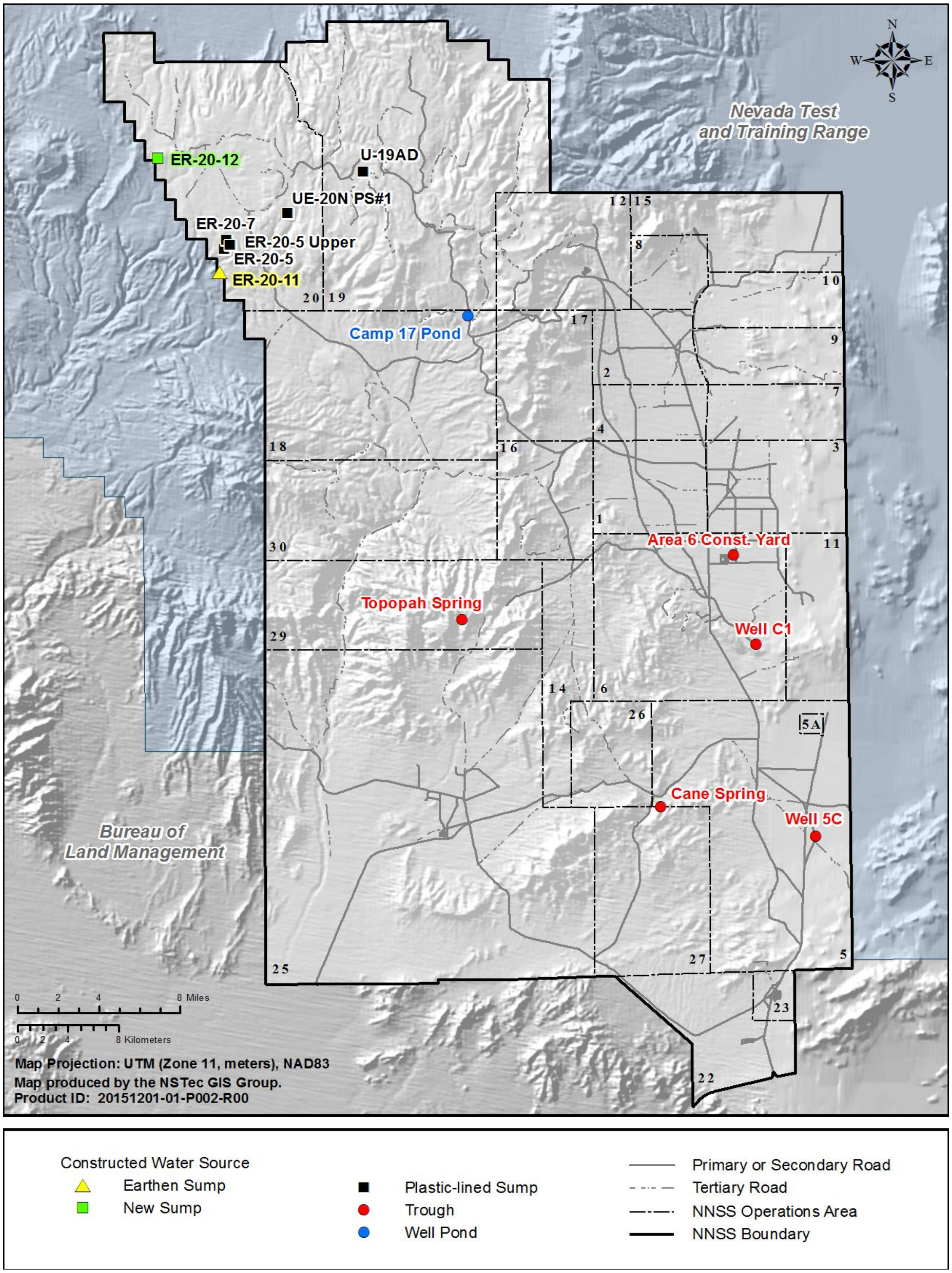


Figure 4-17. Constructed water sources built or monitored with motion-activated cameras for wildlife use during 2015

4.6.1 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 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 4-17). 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 2015 are included in Table 6-4 (see Section 6.7.1, Motion-Activated Cameras).

At the Area 6 LANL Pond, wildlife use of the trough was moderate (482 images) and peaked during the dry, summer months (Table 6-4). Similar to 2014, use was dominated by turkey vultures (166 images) and pronghorn antelope (134 images). At least 8 species (4 mammals and 4 birds) were documented through the year. Common ravens and coyotes were regular visitors with as many as three individual coyotes seen in some images (Figure 4-18). Additionally, two golden eagles were photographed multiple times.

Wildlife use at Well C1 trough was moderate (414 images) with at least 14 species (7 mammals and 7 birds) documented at the trough (Table 6-4). Use peaked during the dry, summer months. Use was dominated by common ravens (161 images). Noteworthy species documented included a badger (Taxidea taxus) and Cooper's hawk (Accipiter cooperii).

Wildlife use at Well 5C trough was moderate (681 images) with at least 10 species (5 mammals and 5 birds) photographed (Table 6-4). Mourning doves (247 images), burros (128 images), and antelope (118 images) were the most commonly photographed species. Noteworthy species documented were the golden eagle (Figure 4-19) and greater roadrunner.

Wildlife use at the trough at Cane Spring was moderate (496 images) with 11 species detected (5 mammals and 6 birds) (Table 6-4). Mourning doves (246 images), turkey vultures (107 images), and mule deer (95 images) were the most common users. A golden eagle was also photographed at the trough on June 25. The number of animal photographs taken at the trough (496 images) were more than 10 times greater than at the spring (48 images). More bobcat photos were taken at the spring than the trough (18 versus 1), whereas more mule deer photos were taken at the trough than the spring (95 versus 24). No birds were photographed at the spring whereas six bird species (387 images) were photographed at the trough.

Figure 4-18. Three coyotes at the Area 6 LANL Pond trough

(Photo by motion-activated camera, July 30, 2015)

Figure 4-19. Two immature golden eagles at the Well 5C trough

(Photo by motion-activated camera, September 18, 2015)

Wildlife use at the Topopah Spring trough was light (68 images) with 8 species (6 mammals and 2 birds) documented (Table 6-4). Most of the activity was from chukar (25 images). One image of a mountain lion was taken near the trough (Figure 4-20). In contrast to Cane Spring, the number of animal photographs taken at the Topopah Spring trough (68 images) was substantially less than at the spring (536 images). Such noteworthy differences include the following: 5 images of desert bighorn sheep were taken at the spring while none were taken at the trough; 178 images of coyotes were taken at the spring, and 8 were taken at the trough; 279 images of chukar were taken at the spring, and 25 were taken at the trough. 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. The data also imply that some species such as bighorn sheep and bobcats may prefer natural springs over the troughs. Waterfowl and shorebirds do not appear to be using the troughs very much 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.

Figure 4-20. Mountain lion by trough near Topopah Spring

(Photo by motion-activated camera, September 14, 2015)

4.6.2 Monitoring Wildlife Use at Potentially Contaminated Water Sources

During 2015, motion-activated cameras were set up at six 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, ER 20-5 Upper, ER 20-11, ER 20-7, U19ad, and Ue20n#1 (Figure 4-17). The cameras were also added to the network of cameras used for mountain lion monitoring (see Section 6.7.1, Motion-Activated Cameras). 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.

There are seven, plastic-lined sumps at ER 20-5. A camera was set up at the sump in the northwest corner. Results showed only minimal use with one photo of a bobcat and one photo of a common raven at the site (Table 6-4). ER 20-5 Upper is located about 200 m upslope from ER 20-5. Water was pumped into the northern plastic-lined sump in the spring and was dry by mid-summer. The camera worked for about a month and detected coyotes (3 images), common ravens (2 images), and an unknown passerine (three images).

The two sumps at ER 20-11 are earthen, unlined sumps so the water does not remain in it for very long due to infiltration and evaporation. A camera was set up at ER 20-11 from December 10, 2014, to June 10, 2015. No water was pumped into the sump during this time frame and the sump was dry when it was checked on April 8 and June 10. No images of wildlife had been taken (Table 6-4). The reason for monitoring this sump was to determine if water from precipitation remained in the sump long enough for wildlife to find and use this water source.

Wildlife use at the U19ad plastic-lined sump was minimal with only nine images of mule deer and one image of an unknown bird taken during 2015 (Table 6-4). Wildlife use at Ue20n#1 plastic-lined sump was light, with 19 images of coyotes, 2 images of mule deer, 18 images of common ravens, and 21 images of unknown birds taken (Table 6-4). No water was pumped into these sumps during 2015.

Water was pumped into the ER 20-7 plastic-lined sump during fall of 2014, and a camera was set up to document wildlife use on December 10, 2014. Wildlife use was light but some important species were detected including mule deer (6 images), ducks (2 images), and a red-tailed hawk (*Buteo jamaicensis*) (1 image). Twenty images of common ravens and three images of unknown birds were also documented.

Overall, wildlife use at the contaminated sumps is minimal. However, important species are using them and are potentially uptaking radiological contaminants. Huntable species such as mule deer and waterfowl are a potential pathway of exposure to the general public. Protected birds such as hawks and ravens 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, 2015) available at http://www.nv.energy.gov/library/publications/aser.aspx.

4.7 COORDINATION WITH SCIENTISTS AND ECOSYSTEM MANAGEMENT AGENCIES

Site biologists interfaced with other scientists and ecosystem management agencies in 2015 for the following activities:

- Responded to a request from Ernest Moniz, Secretary of Energy, to provide a contact person for 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. Three plots were identified on the NNSS for sampling.
- Assisted Dr. David Charlet (College of Southern Nevada) with collecting voucher specimens of singleleaf pinyon, Utah juniper, and Gambel oak (*Quercus gambelii*) from Yucca Mountain., Timber Mountain., Pahute Mesa, Eleana Range, and Shoshone Mountain.
- Assisted Dr. Krissa Skogen (Chicago Botanical Gardens) with field sampling of three species of *Oenothera*.
- Participated in a meeting of the Mojave Desert Initiative designed to address research needs in the areas of wildfires and reclamation of Mojave Desert lands.
- Reviewed a manuscript for the journal *Western North American Naturalist*.
- Provided information via interview with a freelance journalist, Justin Nobel, who is writing a full-length article about the effects of drought in Nevada.

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. 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.

No field surveys were conducted in 2015 on the NNSS. Growing conditions continued to be suboptimal, and plants of key species were not observed. Monitoring was scheduled for Cane Springs sunray (*Camissonia megalantha*) and Darin buckwheat (*Eriogonum concinnum*), as it has been for the last several years, but was not completed due to poor growing conditions. Monitoring will be conducted when growing conditions are favorable.

6.0 SENSITIVE AND PROTECTED/REGULATED ANIMAL MONITORING

The NNHP Animal and Plant At-Risk Tracking List (NNHP 2016); NAC 503, "Hunting, Fishing and Trapping; Miscellaneous Protective Measures" (NAC 2016); the FWS Endangered Species home page (FWS 2016); 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. 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 2015 focused on (a) western red-tailed skinks (*Plestiodon gilberti rubricaudatus*), (b) birds, (c) bats, (d) wild horses, (e) mule deer, (f) desert bighorn sheep, and (g) 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 WESTERN RED-TAILED SKINKS

No new records of western red-tailed skinks (WRTS) were made on the NNSS this year. However, one of the objectives of WRTS monitoring on the NNSS is to document all known WRTS records in Nevada because they are known from so few locations, and to learn how WRTS distribution on the NNSS fits into the WRTS distribution in southern Nevada. VertNet, a new online database containing records from multiple museums, was searched for WRTS records from Nevada. Five records, including two from Scofield Canyon (Grant Range), two from Charleston Peak (Spring Mountains), and one from Reese River Valley, were anomalous and would have extended the range of WRTS 167-250 km to the north and to over 3,350 m in elevation and greatly expanded the potential habitat for this species in Nevada.

The two specimens from the Grant Range were obtained from the University of California, Berkeley, Museum of Vertebrate Zoology (special thanks to curator Carol Spencer) and these specimens were identified by NNSS biologists (Derek Hall and Paul Greger) and Phil Medica as GBS based on the dorsolateral stripe extending well onto the tail and presence of 7 supralabials. WRTS generally have 8 supralabials and the stripe stops shortly behind the vent and does not extend much onto the tail (Figure 6-1). Photos of the two specimens from Charleston Peak were obtained from the San Diego Natural History Museum (special thanks to Bradford Hollingsworth and Laura Kabes) and identified as GBS by Derek Hall based on: 1) the dorsolateral stripe that extended well onto the tail, 2) the original collector noted the location as Charlestown Park which is in Kyle Canyon (not on Charleston Peak) and GBS are known from the Charlestown Park area, and 3) the lack of annotations available as to who identified the specimens and why.

The specimen from Reese River was collected by Charles Hubbs in 1938 and he simply identified it as the genus *Eumeces*, without any species designation. The location where it was trapped was determined from Hubbs' detailed field notes. Greg Schneider, curator for University of Michigan Museum, took photos and measurements of Hubbs' specimen. It had 8 supralabials but the stripe extended well onto the tail, so it was suspected to be a GBS. It had been called both GBS and WRTS. During July 2015, funnel traps were set in the area where Hubbs collected his specimen. A GBS was captured the first day (Figure 6-2) which suggests the species Hubbs caught was a GBS rather than a WRTS. Traps were also set at five other sites from Indian Valley to Austin Summit for a total of 180 trap days with no additional GBS or WRTS captures. It is noteworthy to document GBS is still present 77 years later at the same site Hubbs made his collection.

Figure 6-1. Hatchling western red-tailed skink (WRTS) (upper left), adult WRTS (lower left) and adult Great Basin skink (GBS) (right).

(Photos by D.B. Hall taken on the NNSS at various dates)

Figure 6-2. Adult Great Basin skink captured at the Hubbs site in Reese River Valley

(Photo by D.B. Hall, July 8, 2015)

To date, 98 records of WRTS have been documented in Nevada. Of those records, 54 have been documented from the NNSS and the remaining 44 from various mountain ranges in southern Nevada including 34 from the Spring Mountains, 2 from the Newberry Mountains, 2 from the McCullough Range, 2 from the Sheep Range, 2 from the Grapevine Mountains, and 2 from the Montezuma Range. This information was shared with NDOW and NNHP and included in the Nevada Chapter of The Wildlife Society Fall Newsletter.

6.2 BIRDS

6.2.1 Migratory Bird Treaty Act Compliance

The Migratory Bird Treaty Act (MBTA) is a federal law designed to protect most bird species. All but five birds known to occur on the NNSS are protected under the MBTA. Exceptions include the European starling (*Sturnus vulgaris*), English house sparrow (*Passer domesticus*), and rock dove or pigeon (*Columba livia*). 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 2015 included the following: 1) conducted preactivity surveys for proposed projects before surface-disturbing work to avoid harming birds or their nests, 2) removed an active red-tailed hawk nest from a drill rig with approval of FWS, 3) took distressed or injured birds (one American kestrel [*Falco sparverius*], one immature red-tailed hawk) to Wild Wing (FWS-approved bird rehabilitator) for treatment, and 4) released a trapped barn owl (*Tyto alba*) from an underground facility.

The active red-tailed hawk nest was on a drill rig and contained two non-viable eggs and a young chick. The drill rig was at a critical water well that supplies water to the NNSS and needed to go operational to repair the inoperable well. A Special Purpose-Relocate Permit (MB74902A-0) was obtained from FWS to allow the removal of the chick and the nest. The chick and nest were moved on April 28 to a nearby Joshua tree in hopes that the adults would find it, but they did not. The chick was then taken to Wild Wing Project in Las Vegas, Nevada, where it was kept and cared for until it was ready to fledge. The plan was to release it back on the NNSS but it self-released before that was possible.

During the process of receiving the Special Purpose-Relocate Permit, FWS suggested that NNSA/NFO apply for a Migratory Bird Special Purpose Utility Permit that would facilitate removal of active nests in the future and allow for the legal collection, transport, and temporary possession of dead migratory birds. Although not required to obtain this utility permit, FWS encourages companies to have an avian protection plan. NSTec biologists are currently assisting in the writing of a draft avian protection plan, anticipated to be finalized in 2016 or early 2017. The application for the Special Purpose-Utility Permit is anticipated to be submitted to the FWS in 2016 as well.

6.2.2 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 episodes of predation and disease outbreaks involving large numbers of dead birds, particularly during wet years (Figure 6-3).

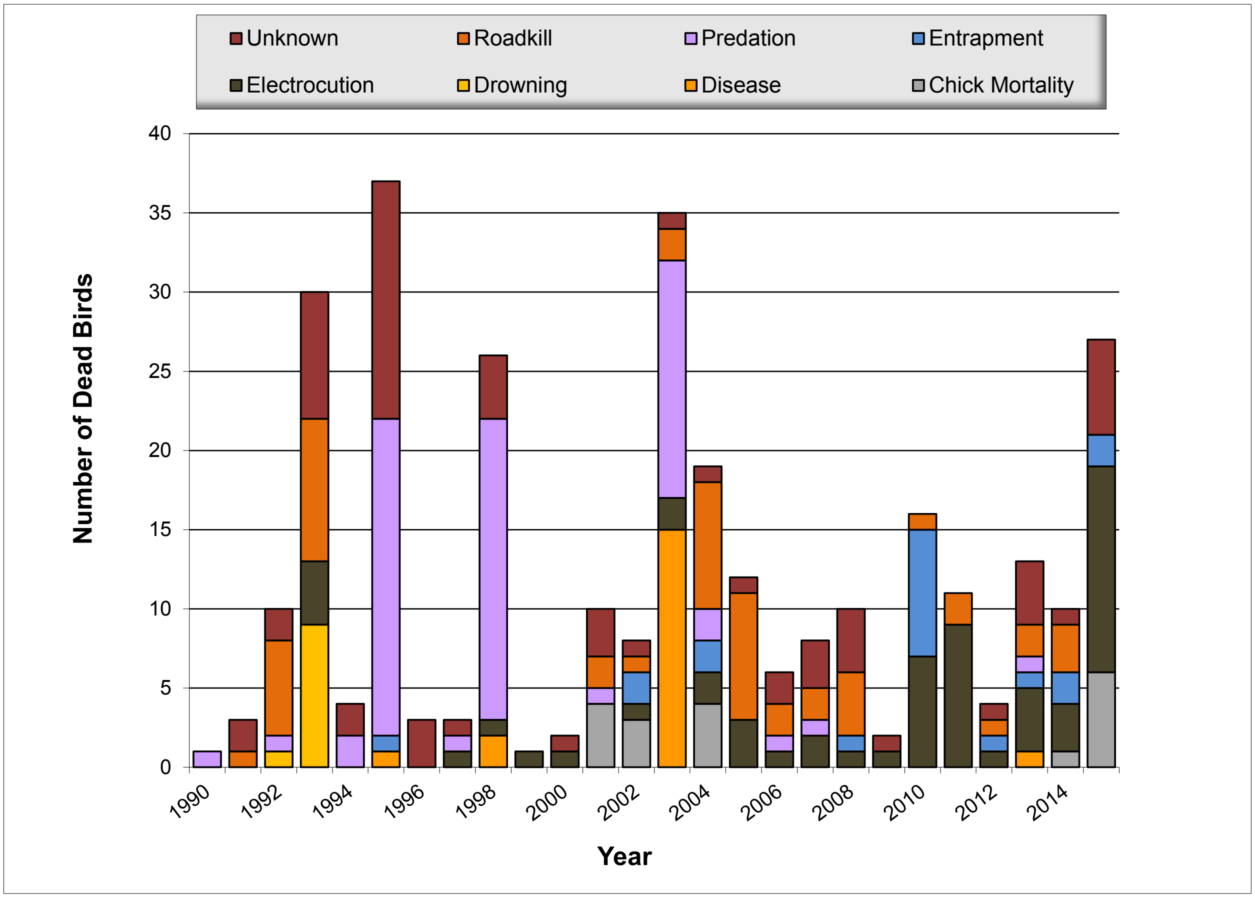


Figure 6-3. Records of reported bird deaths on the NNSS, 1990–2015

A total of 27 birds were found dead on the NNSS during 2015 (Figure 6-3). Thirteen of these were electrocuted, including six ravens, four red-tailed hawks, two golden eagles, and one great-horned owl (*Bubo virginianus*). Two birds were killed due to entrapment (Wilson's warbler [*Cardellina pusilla*] on glue trap, great-horned howl stuck in gate). Six Say's phoebe (*Sayornis saya*) chicks were found dead in multiple nests potentially killed from heat exposure because the nests were nearly touching the metal roof. Six birds (one great-horned owl, one Say's phoebe, one ruby-crowned kinglet [*Regulus calendula*] and three unknown passerines) were found dead from unknown causes. The number of dead birds was substantially higher than during the last several years, and the number of electrocutions was the highest ever recorded. This may be due to heightened awareness and increased reporting of dead birds. Additionally, breeding activity was greater this year than during the previous two years due to more rainfall.

The golden eagle deaths were reported to FWS and the carcasses given to FWS law enforcement. Potential mitigation of the poles and lines where the eagles were killed was discussed by FWS, an NSTec biologist, and the NSTec power group. Retrofits for several other poles and lines were suggested where other electrocutions occurred. Two retrofit projects were completed during 2015 at Power Substations 12-1 and 12-2 where bird guard was added to cover bare conductors and caps were placed on top of the bushings. Additionally, bird guard and caps were used to cover several wires and insulators and spikes were installed on metal cross arms on multiple poles and transformers at the Area 5 Radioactive Waste Management Complex (RWMC) (Figure 6-4). The bird mortality database maintained by NSTec biologists was updated in 2015 to include new information found for 2004, 2006, 2007, 2010, 2011, and 2013 (Figure 6-3).

Figure 6-4. Retrofit pole with bird guard, insulator caps and metal spikes on crossarms at the Area 5 RWMC

(Photo by D.B. Hall, December 15, 2015)

6.2.3 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 2015. 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 6-5). Data including common name, UTM coordinates (NAD 83), time, activity, age, 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 14 (Southern NNSS) and January 15 (Yucca Flat) to coincide with the national bald and golden eagle survey and on February 9 (Southern NNSS) and February 10 (Yucca Flat).

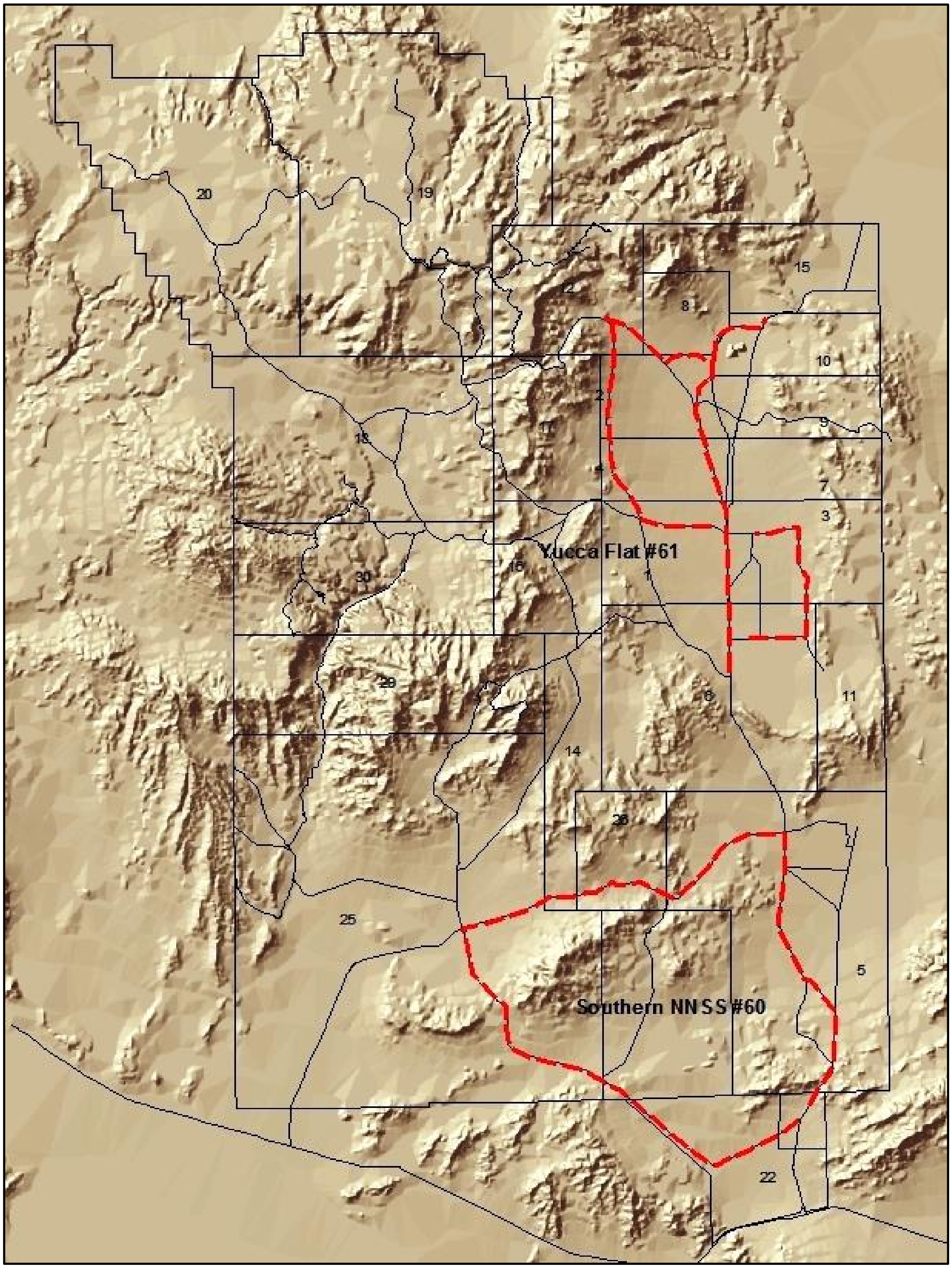


Figure 6-5. Winter raptor survey routes (red lines) on the NNSS

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. No bald eagles (*Haliaeetus leucocephalus*) or golden eagles were observed. Few raptors were observed on the southern route during both surveys. The red-tailed hawk was the most common species detected in Yucca Flat primarily during the January survey (Table 6-1). Abundance and species richness was greater on the Yucca Flat route than on the Southern NNSS route. On the southern route, overall raptor abundance was higher in 2014 than in 2015 (12 versus 3, respectively), but similar between years on the Yucca Flat route (16 versus 17, 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 2015 raptor surveys on the NNSS

Species	Southern NNSS (1/14/15)	Southern NNSS (2/9/15)	Yucca Flat (1/15/15)	Yucca Flat (2/10/15)
Red-tailed Hawk (*Buteo jamaicensis*)	1	0	10	1
Prairie Falcon (*Falco* mexicanus)	1	1	1	1
American Kestrel (*Falco sparverius*)	0	0	3	1
Total Raptors	**2**	**1**	**14**	**3**
Common Raven (*Corvus corax*)	1	1	5	5
Loggerhead Shrike (*Lanius ludovicianus*)	2	0	0	0

6.3 BAT SURVEYS

In 2015, bat monitoring focused on passive acoustic monitoring of bat activity at Camp 17 Pond and removing bats from buildings and documenting the building bat roosts.

6.3.1 Passive Acoustic Monitoring System at Camp 17 Pond

To learn more about long-term bat activity through different seasons and years, a passive acoustic monitoring system (Anabat II) was installed at Camp 17 Pond on September 22, 2003. Millions of electronic files containing bat calls have been recorded and are being analyzed by O'Farrell Biological Consulting as funding becomes available. Bat vocalizations and climatic data (e.g., temperature, humidity, wind, barometric pressure) were recorded again in 2015, but no analysis was performed due to a limited budget.

6.3.2 Bats at Buildings

During 2015, NSTec biologists responded to five nuisance bat calls. All five were at buildings in Mercury. A very young pup was found in Building 751 on June 16, and was placed near the suspected nursery site in hopes the mother would find it. It was found dead the next day. An adult male California myotis (*Myotis californicus*) with a broken wing was found on September 22 on a flammables cabinet outside Building 652 and was euthanized. An unknown species was found on a glue trap in Building 726 on September 28 but managed to escape before a biologist could respond. An adult male California myotis was removed from Building 751 and released west of Mercury on September 21. An adult female and male California myotis were removed from Building 1010 near Gate 100 and released south of Mercury on October 12. Roost site locations at these buildings were entered in the EGIS faunal database.

6.4 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 2015, 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 photograph horses (see Section 6.7.1, Motion-Activated Cameras).

Based on opportunistic sightings and camera results, horses seem to be using the same areas as in previous years. Three to four horses were seen near Echo Peak (Area 19) on two occasions during deer surveys in September and eighteen photos of 1-5 horses were recorded on Pahute Mesa Road at the summit between July 11 and September 28 traveling both directions, onto Pahute Mesa and exiting Pahute Mesa. Pahute Mesa Road through the narrow pass at the summit appears to be a travel corridor for horses and potentially other wildlife to come from the main summer water source at Camp 17 Pond on to Pahute Mesa and also to exit the mesa. As in 2014, no horses were documented using Captain Jack Spring in 2015. Several foals were observed and photographed at various locations. Hundreds of horse photos were taken at Camp 17 Pond and Gold Meadows Spring (Table 6-4). These water sources are the core areas used by horses, especially during the hot, dry summer months.

6.5 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 2006-2015. In past years, the monitoring effort has emphasized estimating relative abundance and density but 2015 efforts focused solely on relative abundance.

6.5.1 Trends in Mule Deer Abundance

Mule deer abundance on the NNSS was measured by driving two standardized (59 km total length) road courses (Figure 6-6) to count and identify mule deer. One route (29 km) was centered around Rainier Mesa, and the second (30 km) was centered around 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 14-16 and 28-30, 2015, a total of 135 deer were observed, which equates to an average of 23 deer per night. On average this is 5 deer per night lower than in 2014 and 9 deer per night lower than the long-term average since 1989. There has been a decreasing trend ($y = -2.983x + 51.305$, $r^2 = 0.47$) the last 10 years (Figure 6-7), which may be due to the drought conditions experienced the last few years. Specific causes for the fluctuation in deer numbers is unknown and requires further investigation. A mountain lion was observed near E Tunnel Pond during one of the surveys, which may have lowered the number of deer present along this segment for at least a couple of nights.

The number of deer per km was nearly equal for both routes in 2015 (Figure 6-8). Rainier Mesa generally had higher counts per km from 2006-2013. In 2014, they were close as well. This is due largely to restructuring the deer route on the western region of Pahute Mesa. Fifteen km of route were removed from sampling due to the closure of Pahute Mesa Road west of the Dead Horse Flats intersection (Figure 6-6). In 2015, a total of 60 deer groups were detected. Group size varied from one to eight animals. Overall, Pahute Mesa and Rainier Mesa had nearly equal average group sizes of 2.3 and 2.2 deer, respectively.

6.5.2 Sex and Fawn/Doe Ratios

The deer sex ratio (number of bucks per 100 does) in 2015 was the lowest ratio ever measured on site (57 bucks/100 does) (Table 6-2). These sex ratios have varied greatly on the NNSS across years, but the last two 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 2013 (Table 6-2) was the highest ever measured on the NNSS. It was the second highest in 2015, and suggests that on average nearly half of the does had a fawn.

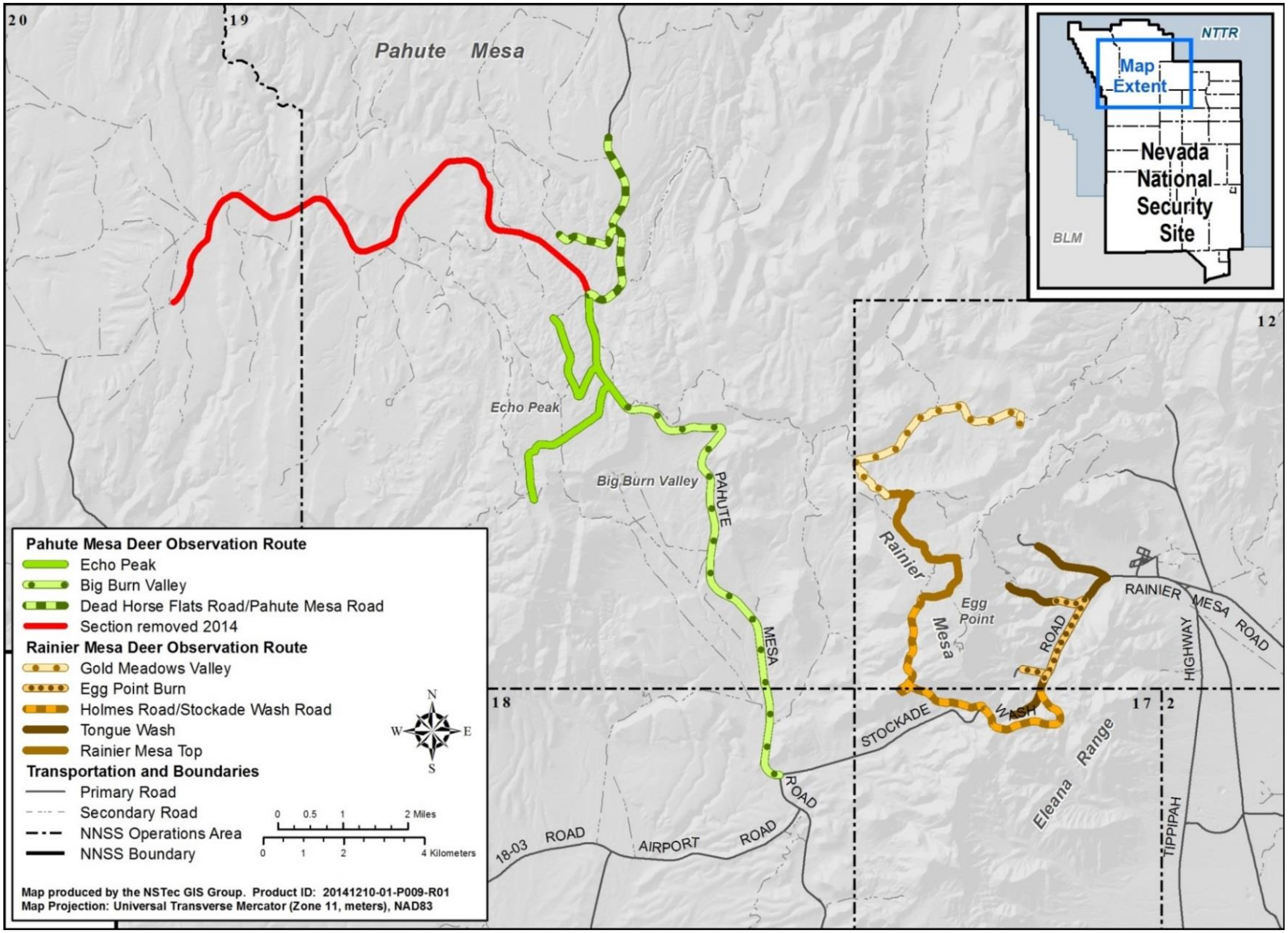


Figure 6-6. Road routes and sub-routes of two NNSS regions driven in 2015 to count deer and section removed due to road closure

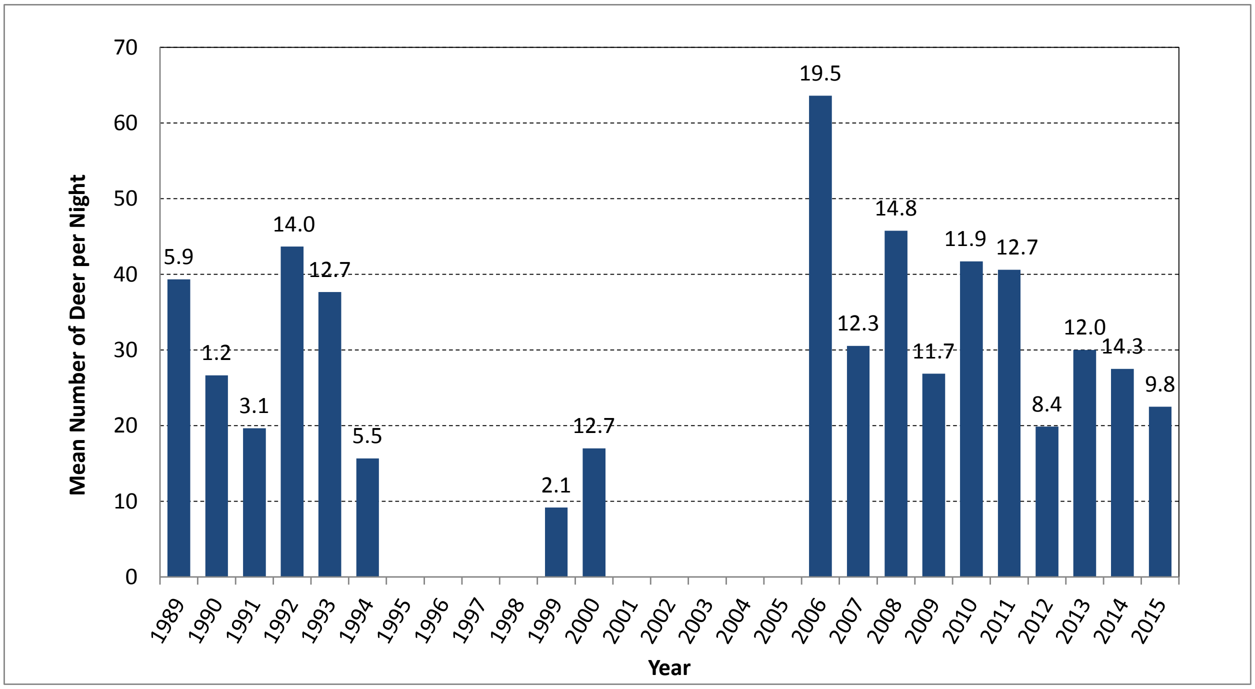


Figure 6-7. Trends in total deer count per night from 1989 to 2015 on the NNSS (surveys were not conducted during 1995–1998 or 2001–2005). Standard deviation values above bars.

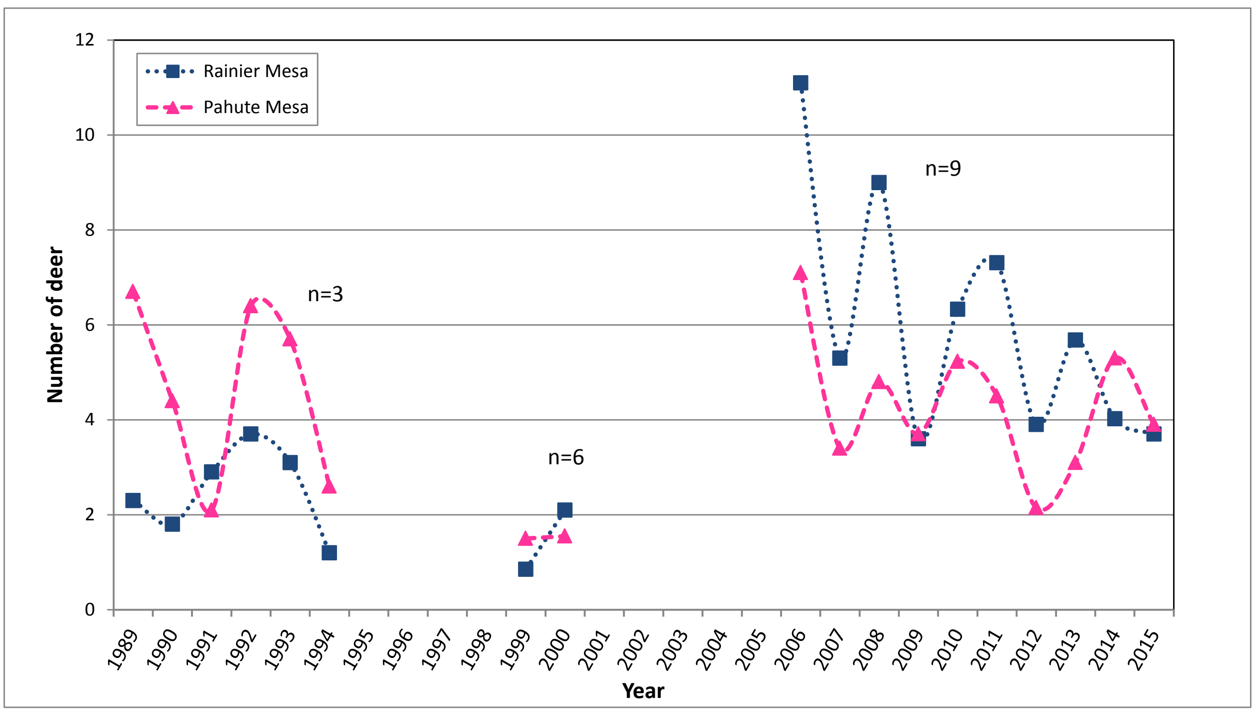


Figure 6-8. Mean number of mule deer per 10 km per night, counted on two routes (n = number of survey nights; exceptions n = 12 for 2012, n = 8 for 2013, n = 6 for 2015)

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

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

6.6 DESERT BIGHORN SHEEP

6.6.1 Captures and Monitoring

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. Since 2009, numerous observations of sheep and sheep sign (i.e., scat, beds, 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. It is currently thought that sheep have recolonized the NNSS from other sheep populations surrounding the NNSS (e.g., Stonewall Mountain, Thirsty Canyon, Specter Range, Spotted Range).

In an effort to better understand sheep movements, sheep radionuclide burdens, the potential dose to humans via hunting, the prevalence of pneumonia-causing bacteria in sheep, and the source of the sheep population on the NNSS, a major collaborative effort involving USGS, NSTec, and NDOW was made on November 17-18, 2015, to capture, radio-collar, and sample as many sheep as possible. A helicopter was used to locate sheep and maneuver them into a safe area. 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 6-9). 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 to determine radionuclide burden and for disease and genetic testing. Animals were then released.

Five sheep (2 ewes [Figure 6-10], 3 rams) were captured and radio-collared on the NNSS (Figure 6-11) on November 17. A sixth sheep was captured and marked with ear tags on November 18 but was not radio-collared because it was a young ram that was still growing and it was determined that a radio-collar would be too restrictive around the neck as the ram grew into adulthood. All but one ram have remained relatively close to their capture locations around Yucca Mountain, Fortymile Canyon, and the western portion of Shoshone Mountain. One ram took off soon after capture and has been in Thirsty Canyon and around Quartz Mountain on the Nevada Test and Training Range (NTTR) since then. Sheep movements will continue to be monitored over the next 3-5 years. Information about home range and habitat use will be obtained from the location data.

NNSS sheep captures were part of a larger collaborative effort among NDOW, USGS, NTTR, 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) radionuclide burdens of sheep on and off the NNSS and the potential dose to the public who hunt and eat sheep, 3) metapopulation structure (how different herds are related) of sheep populations in southern Nevada, and 4) movements and habitat use of sheep in areas never studied before. An NSTec biologist was involved in these captures. Twenty-seven sheep were captured on November 14-15 from the NTTR (Cactus Range, Stonewall Range, Mt. Helen, Obsidian Butte, Pahute Mesa [off NNSS], and Thirsty Canyon). Samples were collected for disease, radiological, and genetic testing. Sheep were also captured and radio-collared from the Bare Mountains (near Beatty) and the Specter Range in late October and tested for disease. Early results show movements of sheep on and off the NNSS. A ram captured on the NNSS moved to the Quartz Mountain area on NTTR. A ram captured on Bare Mountain moved to the Shoshone Mountain/Fortymile Canyon area on the NNSS and two rams captured on the Specter Range moved to Skull Mountain on the NNSS during mid-November. Timing of these movements coincided with the beginning of the bighorn sheep hunt, which ran from November 20-December 20 on the Specter Range (Hunting Unit 254) and the Bare Mountains (Hunting Unit 253).

During 2015, motion-activated cameras detected sheep at Topopah Spring (5 images), Delirium Canyon Tanks (138 images), South Pah Canyon Tanks (39 images), and Twin Spring (1 image). Images will be analyzed during 2016 to see how many unmarked animals are documented. If enough unmarked animals are present, additional captures will be considered for fall of 2016.

Figure 6-9. Desert bighorn sheep captures on the NNSS

(Photo taken November 17, 2015)

Figure 6-10. Ewe with radiocollar getting ready to be released

(Photo taken November 17, 2015)

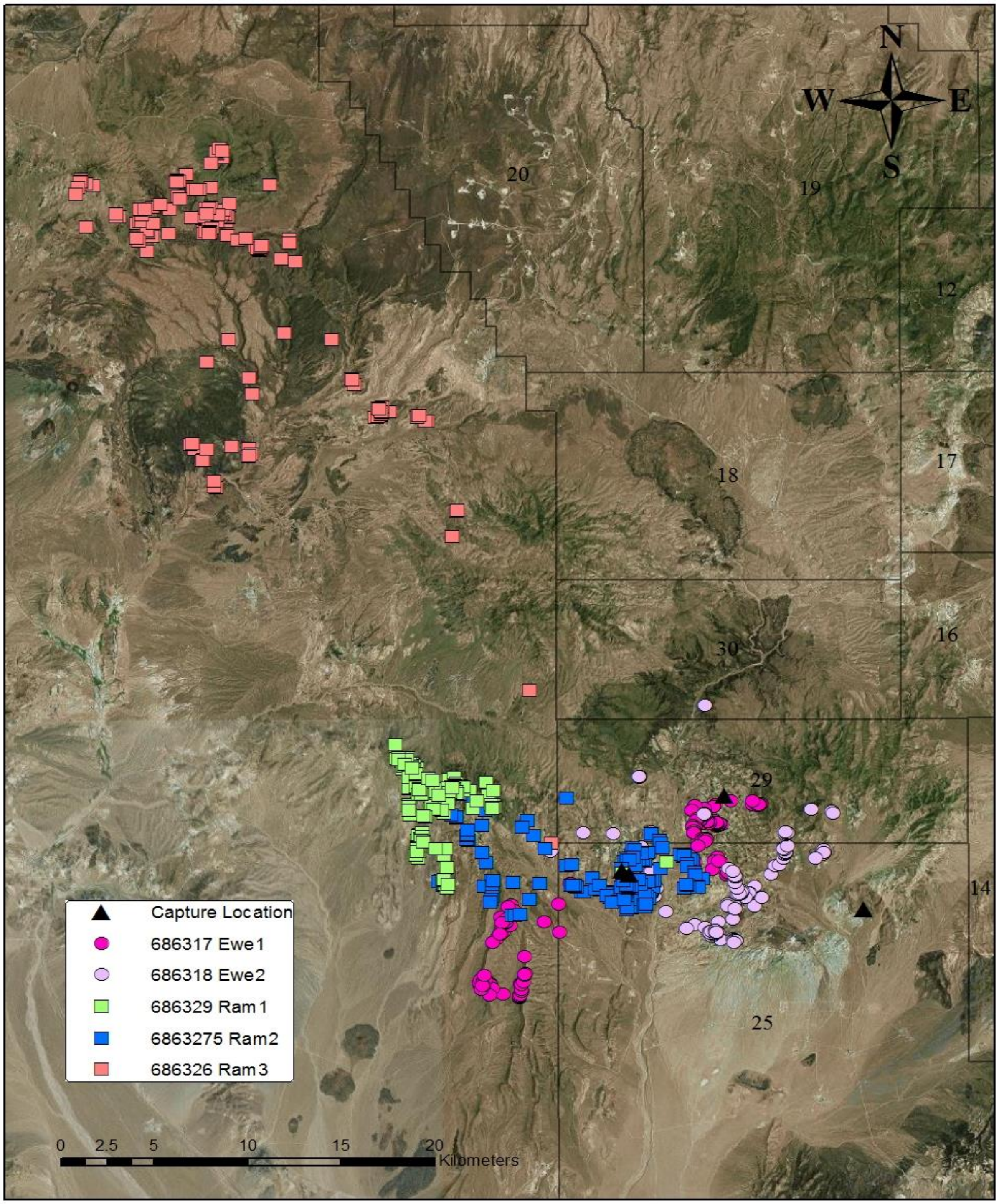


Figure 6-11. Capture locations and distribution of five radio-collared desert bighorn sheep (November 17 – December 31, 2015)

6.6.2 Radiological Analysis

Radiologically-contaminated areas occur on the NNSS and NTTR from previous nuclear testing activities. Because bighorn sheep distribution overlaps some of these areas, there is the potential for sheep to be exposed to contamination. However, a majority of the contaminated sites are located in areas that are not good sheep habitat so sheep do not spend any significant amount of time in these areas. Exceptions to this are the Buggy site in Area 30; E Tunnel Pond in Area 12; and ER 20-5, ER 20-7 and ER 20-12 in Area 20. Sheep hunting occurs along the NNSS and NTTR boundaries and on some portions of the NTTR, which introduces the potential risk of a radiologically-contaminated sheep being consumed by members of the public.

At the request of NTTR personnel, blood samples were taken from eight sheep, five from the Cactus Range, and three from Stonewall Mountain, for radiological analysis to determine the radionuclide burden of the animal and the potential dose a human would get by eating the sheep. These samples were in addition to the samples from six sheep captured on the NNSS. Additionally, blood samples from six California bighorn sheep (*Ovis canadensis californiana*) from northern Nevada (one from the Santa Rosa Range, one from the Snowstorm Mountains, one from the Trout Creek Mountains, and three from the Montana Mountains) were taken by NDOW to use as control samples for the NNSS and NTTR samples. Samples were shipped to ALS Fort Collins for radiological analysis in late December 2015. Analyses were performed on the 20 samples (Figure 6-12) to determine the presence/absence and quantities of gamma-emitting radionuclides, tritium, Americium-241, Strontium-90, Plutonium (Pu)-238, and Pu-239+240.

Only two man-made radionuclides were detected in the samples: Pu-238 and Pu-239+240 (Table 6-3). Shaded cells indicate those samples with detectable levels of plutonium above the minimum detectable concentration (MDC). This is the concentration at which a sample can be quantitatively distinguished from a blank sample and includes uncertainties from background radiation, sample size, counting time, and chemical recovery. Plutonium is a component of global fallout from atmospheric nuclear weapons tests conducted by both the United States and other countries (Former Soviet Union, United Kingdom, France, and China) (UNSCEAR 2008). Furthermore, in 1964, the SNAP-9A navigational satellite accident increased the global fallout of Pu-238 by about three-fold (Hardy et al. 1972). Thus, it is not surprising to find these low concentrations of plutonium in samples from all areas including the northern Nevada control samples.

All of these values are extremely low. There was no significant difference among concentrations in sheep from northern Nevada, the NTTR, or the NNSS (one-way analysis-of-variance, Pu-238 $p=0.09$, Pu-239+240 $p = 0.32$). Assuming that each bighorn sheep yields 35.4 kilograms (kg) of boneless meat and one person ate the entire amount with the maximum observed concentration, the dose received would be inconsequential at over 580 times lower than the limit set to protect human health and over 1000 times lower than the average person in the United States receives from inhaling natural radon. If one person ate all 20 of these bighorn sheep, they would receive a committed dose of about 1.1 millirem (mrem). This is about equal to what you get from one coast-to-coast airline flight from natural cosmic radiation or about 0.3% of the annual dose from all natural background radiation an average person receives in a year. There is no indication that bighorn sheep from the NNSS or NTTR have radionuclide concentrations that could pose a hazard to anyone eating them. The current guidance level for release of game animals from DOE facilities is 25 mrem. In other words, animals that could result in a dose of 25 mrem to someone consuming them should not be released from a DOE facility. The cumulative dose from sampled bighorn sheep is 4% of this release limit so there is no reason that the release of bighorn sheep for human consumption should be restricted, nor are these levels harmful to the sheep.

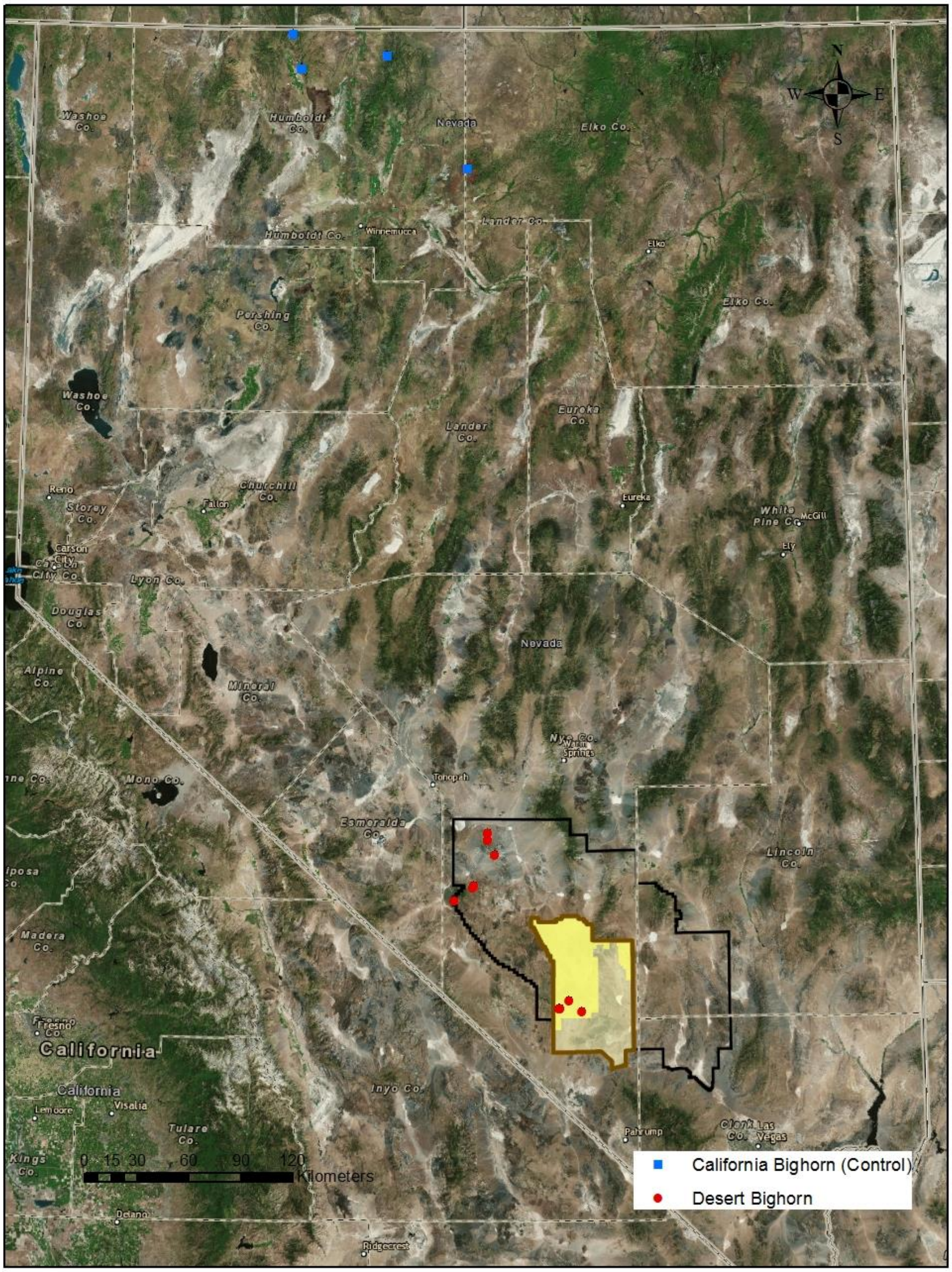


Figure 6-12. Capture locations of 20 bighorn sheep sampled for radionuclides from NNSS and NTTR (red dots) and northern Nevada (blue dots)

Table 6-3. Results of radiological analyses on 20 bighorn sheep (shaded cells indicate detectable levels; pCi/g = picocuries/gram)

AREA	Capture Date	SAMPLE ID	NDOW Tag Number	^{238}Pu (pCi/g)[a] Result	^{238}Pu Uncertainty[b]	^{238}Pu MDC[c]	$^{239+240}$Pu (pCi/g)[a] Result	$^{239+240}$Pu Uncertainty[b]	$^{239+240}$Pu MDC[c]
Northern Nevada (Snowstorm Mts.)	12/1/2015	EM25569	3734	0.00051	0.00054	0.00073	0.00039	0.00049	0.00073
Northern Nevada (Trout Creek Mts.)	12/1/2015	EM25570	10191	0.00042	0.00046	0.00068	0.00061	0.00047	0.00024
Northern Nevada (Montana Mts.)	12/1/2015	EM25571	10192	0.00055	0.00045	0.00025	0.00049	0.00047	0.00057
Northern Nevada (Montana Mts.)	12/1/2015	EM25572	10193	0.00050	0.00045	0.00027	0.00018	0.00040	0.00078
Northern Nevada (Montana Mts.)	12/1/2015	EM25573	10194	0.00015	0.00035	0.00067	0.00034	0.00035	0.00023
Northern Nevada (Santa Rosa Range)	12/1/2015	EM25568	10196	0.00000	0.00054	0.00133	0.00042	0.00052	0.00078
NNSS (Area 25)	11/17/2015	EM25448	NNSS10171	0.00052	0.00050	0.00070	0.00011	0.00036	0.00080
NNSS (Area 25)	11/17/2015	EM25449	NNSS10172	0.00011	0.00225	0.00498	0.00445	0.00322	0.00151
NNSS (Area 29)	11/18/2015	EM25450	NNSS10174	0.00027	0.00042	0.00076	0.00063	0.00050	0.00054
NNSS (Area 25)	11/17/2015	EM25451	NNSS10175	0.00108	0.00088	0.00108	0.00047	0.00058	0.00087
NNSS (Area 25)	11/17/2015	EM25452	NNSS10177	0.00000	0.00039	0.00026	0.00039	0.00039	0.00026
NNSS (Area 25)	11/17/2015	EM25453	NNSS10179	0.00023	0.00035	0.00063	0.00032	0.00033	0.00022
NTTR (Cactus Range)	11/14/2015	EM25440	NTTR10071	0.00049	0.00062	0.00103	0.00316	0.00132	0.00073
NTTR (Cactus Range)	11/14/2015	EM25441	NTTR10072	0.00064	0.00125	0.00244	0.00123	0.00112	0.00067
NTTR (Cactus Range)	11/14/2015	EM25442	NTTR10073	0.00107	0.00180	0.00281	0.00240	0.00227	0.00280
NTTR (Cactus Range)	11/14/2015	EM25443	NTTR10074	0.00157	0.00142	0.00085	0.00244	0.00199	0.00244
NTTR (Cactus Range)	11/14/2015	EM25444	NTTR10076	0.00073	0.00058	0.00062	0.00002	0.00040	0.00088
NTTR (Stonewall Mt.)	11/14/2015	EM25445	NTTR10079	0.00035	0.00177	0.00341	0.00079	0.00177	0.00341
NTTR (Stonewall Mt.)	11/14/2015	EM25446	NTTR10080	0.00045	0.00048	0.00064	0.00039	0.00049	0.00079
NTTR (Stonewall Mt.)	11/14/2015	EM25447	NTTR10086	0.00066	0.00058	0.00076	0.00068	0.00052	0.00026

[a] picocuries per gram wet-weight of blood

[b] Uncertainty = two standard deviations of analytical uncertainty

[c] minimum detectable concentration. This is the concentration at which a sample can be quantitatively distinguished from a blank sample (includes uncertainties from background radiation, sample size, counting time, and chemical recovery).

6.7 MOUNTAIN LION MONITORING

6.7.1 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 2015 at 33 sites, including three new sites (Figure 6-13 and Table 6-4). 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 2014 and early 2016 due to the accessibility and scheduling of camera trap visits.

A total of 116 mountain lion images (i.e., photographs or video clips) were taken during 234,847 camera hours across all sites (Figure 6-13 and Table 6-4). This equates to about 0.5 mountain lion images per 1,000 camera hours. Mountain lions were detected at 14 of the 33 sites, including 7 water sources, 3 dirt roads, 3 canyons and 1 mountain pass (Figure 6-13). Table 6-5 contains the camera trap results by month and location. A malfunctioning camera at Gold Meadows Spring made it impossible to determine the date and time of one of the mountain lion images taken in April or May, so it was not included in Table 6-5. A female and subadult cub were recorded at Camp 17 Pond (camera location #6) on June 26, July 1, and July 2 (Figure 6-14). It is difficult to tell individual mountain lions apart in the images and therefore determine the exact number of mountain lions on the NNSS. A minimum of three individuals (1 adult male, 1 adult female, and 1 subadult) were known to occur on the NNSS during 2015, compared to a minimum of four individuals on the NNSS during 2014 and 2013.

In order to investigate temporal activity of mountain lions, camera detection data from all 10 years (2006–2015) were combined. Mountain lions were detected every month with peak occurrences during June (n = 99), August (n = 82) and November (n = 93) (Figure 6-15). The number of images taken during summer and fall (June–November) (n = 415) accounted for nearly two-thirds of all images compared with the number of images taken during winter and spring (December–May) (n = 198) (Figure 6-15). Nearly 80% of mountain lion images were taken between 1700 to 0500 hours (Figure 6-16). From 2011 to 2015, twice as many images were taken when it was dark (n = 287) compared with when it was light (n = 136).

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 10,142 images of at least 30 species other than mountain lions were taken during 234,847 camera hours across all sites (Table 6-4). This is about 43 images per 1,000 camera hours. The most prevalent species photographed (35% of all images) was mule deer (3,524 images at 23 of 33 sites). Captain Jack Spring (1,440 images), Camp 17 Pond (852 images), and Gold Meadows Spring (843 images) are very important water sources for mule deer. These numbers are down from the previous year, however, which may coincide with fewer deer found on the spotlight surveys. Some of the rarer, more elusive species documented during camera surveys were desert bighorn sheep (see Section 6.5), Rocky Mountain elk (see Section 6.9), bobcat (found at 24 of 33 sites throughout the NNSS), gray fox (Figure 6-17), badger (*Taxidea taxus*), golden eagle, great-horned owl, greater roadrunner, and great blue heron (*Ardea herodias*). Greatest use and highest species richness was documented at water sources especially during the summer and fall, which emphasizes the importance of these water sources for several wildlife species, especially during the drier months.

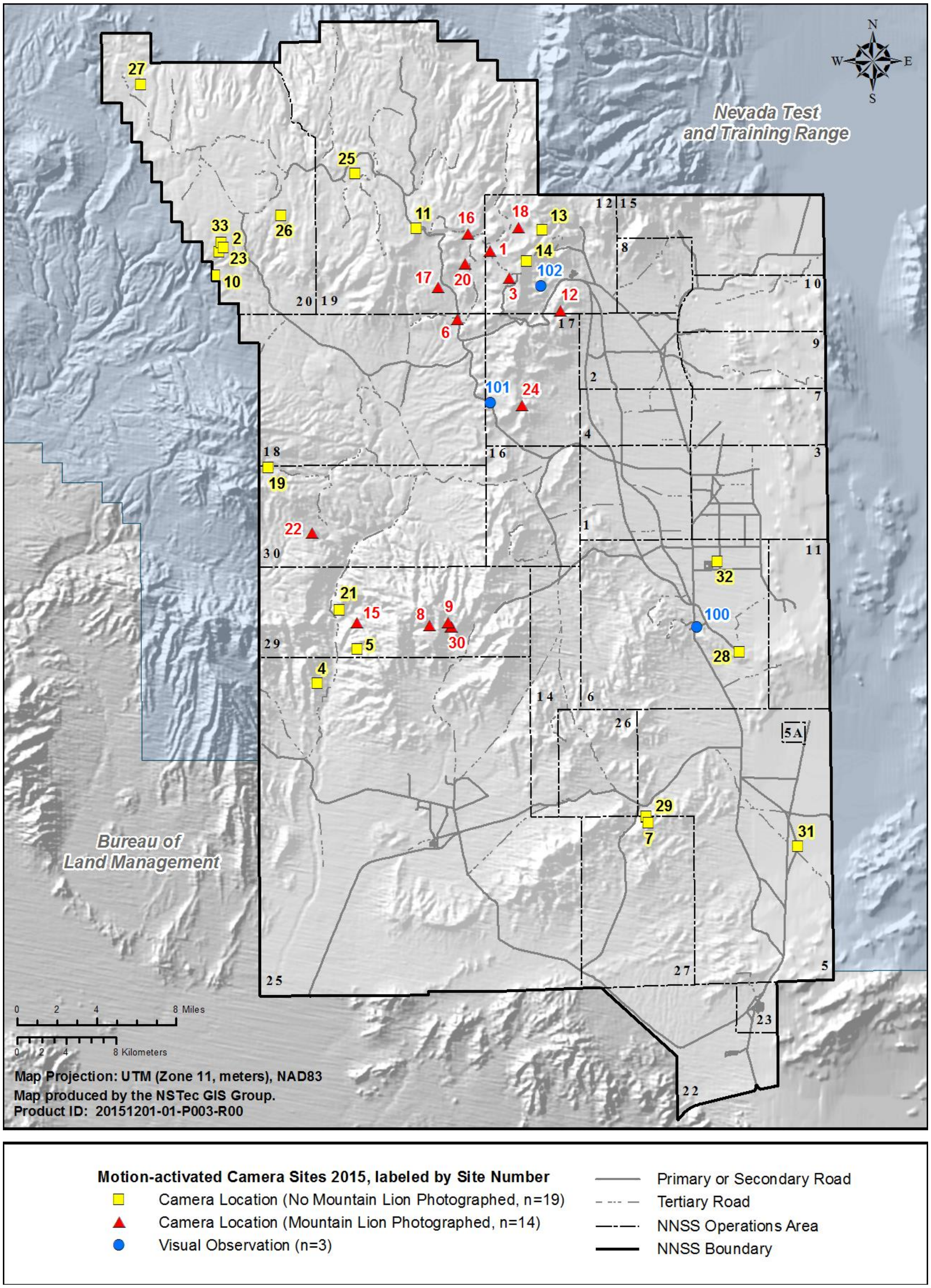


Figure 6-13. Locations of mountain lion photographic detections and camera traps on the NNSS during 2015

Table 6-4. Results of mountain lion camera surveys during 2015

Location (Site Number)	Dates Sampled	Camera Hours	Mountain Lion Images (Number of Images per 1,000 Camera Hours)	Other Observations (Number of Images)
Camp 17 Pond[a] (#6)	12/11/14-12/9/15[b]	4,969	34 (6.8)	Bobcat (3), coyote (117), mule deer (852), horse (422), black-tailed jackrabbit (342), desert cottontail (14), great blue heron (7), golden eagle (2), great-horned owl (5), red-tailed hawk (108), turkey vulture (160), pinyon jay (33), mourning dove (7), chukar (26), common raven (100), brown-headed cowbird (7)
Rattlesnake Ridge Gorge (#20)	12/11/14-12/9/15	8,713	32 (3.7)	Bobcat (2), gray fox (2), coyote (4), mule deer (1), rock squirrel (3), cliff chipmunk (1)
Redrock Valley Pass (#24)	12/10/14-4/8/15	2,856	6 (2.1)	Bobcat (2)
West Topopah Spring (#8)	12/16/14-12/22/15	8,909	13 (1.5)	Bobcat (10), coyote (1), desert cottontail (1), rock squirrel (1), chukar (1)
Captain Jack Spring (#12)	12/11/14-12/21/15	9,000	8 (0.9)	Bobcat (12), gray fox (1), coyote (6), mule deer (1,440), desert cottontail (8), chukar (45), mourning dove (30), northern flicker (1), pinyon jay (4), common raven (1)
12T-26, Rainier Mesa (#1)	12/11/14-12/9/15	8,709	6 (0.7)	Bobcat (2), coyote (5), badger (1), mule deer (2)
East 19-01 Road (#16)	12/11/14-12/9/15[b]	6,763	5 (0.7)	Bobcat (9), coyote (14), mule deer (12), cottontail rabbit (9), black-tailed jackrabbit (13), rock squirrel (1)
Gold Meadows Spring (#18)	12/11/14-12/9/15[b]	8,430	3 (0.4)	Bobcat (1), coyote (110), elk (4), pronghorn antelope (530), mule deer (843), horse (701) black-tailed jackrabbit (52), golden eagle (1), turkey vulture (106), common raven (161), brown-headed cowbird (2)

Table 6-4. Results of mountain lion camera surveys during 2015 (continued)

Location (Site Number)	Dates Sampled	Camera Hours	Mountain Lion Images (Number of Images per 1,000 Camera Hours)	Other Observations (Number of Images)
Water Bottle Canyon (#17)	12/10/14-12/9/15	8,733	3 (0.3)	Bobcat (1), coyote (1), mule deer (3)
Topopah Spring (#9)	12/16/14-12/22/15	8,908	2 (0.2)	Bobcat (10), gray fox (2), coyote (178), desert bighorn sheep (5), mule deer (17), desert cottontail (14), black-tailed jackrabbit (8), rock squirrel (1), chukar (279), mourning dove (21), common raven (1)
North Chukar Canyon Tank (#22)	12/15/14-12/9/15[b]	6,264	1 (0.2)	Bobcat (2), badger (3), coyote (16), chukar (16), mourning dove (6), greater roadrunner (1), common raven (1)
Topopah Spring Trough (#30)	12/16/14-12/22/15	8,908	1 (0.1)	Bobcat (3), coyote (8), mule deer (6), desert cottontail (7), black-tailed jackrabbit (14), chukar (25), mourning dove (4)
Dick Adams Cutoff Road, Rainier Mesa (#3)	12/11/14-12/9/15	9,399	1 (0.1)	Mule deer (85)
South Pah Canyon (#15)	12/17/14-1/11/16[b]	6,679	1 (0.1)	Bobcat (2), gray fox (1), desert bighorn sheep (39), rock squirrel (1), red-tailed hawk (2), great-horned owl (5), pinyon jay (111), chukar (38), mourning dove (129), lizard (1)
East Cat Canyon (#19)	12/15/14-12/9/15[b]	7,834	0 (0.0)	Bobcat (3), coyote (4), mule deer (12), black-tailed jackrabbit (6)
Pahute Mesa Summit, Road (#11)	12/10/14-12/9/15	8,734	0 (0.0)	Gray fox (1), coyote (1), mule deer (24), horse (18)
East Gold Meadows Pass (#13)	12/11/14-12/9/15	8,711	0 (0.0)	Bobcat (3), coyote (5), mule deer (70), black-tailed jackrabbit (3)
Cottonwood Spring (#4)	12/17/14-1/11/16[b]	5,165	0 (0.0)	Bobcat (48), gray fox (1), coyote (3), mule deer (2), chukar (9), hummingbird (1)
Rainier Mesa Top, Above B Tunnel (#14)	12/11/14-12/9/15	8,708	0 (0.0)	Gray fox (1), elk (1), mule deer (32)

Table 6-4. Results of mountain lion camera surveys during 2015 (continued)

Location (Site Number)	Dates Sampled	Camera Hours	Mountain Lion Images (Number of Images per 1,000 Camera Hours)	Other Observations (Number of Images)
Schooner Wash Tanks (#27)	10/22-12/22/15	1,463	0 (0.0)	Bobcat (1), rabbit (1)
Twin Spring (#21)	12/17/14-1/11/16[b]	9,220	0 (0.0)	Bobcat (2), coyote (11), desert bighorn sheep (1), mule deer (62), chukar (11), greater roadrunner (1), common raven (1)
Delirium Canyon (#5)	12/17/14-1/11/16[b]	6,190	0 (0.0)	Bobcat (1), gray fox (2), coyote (9), desert bighorn sheep (138), mourning dove (20)
Cane Spring (#7)	12/16/14-12/21/15[b]	8,665	0 (0.0)	Bobcat (18), coyote (4), mule deer (24), black-tailed jackrabbit (2)
Cane Spring Trough (#29)	12/16/14-12/21/15[b]	8,539	0 (0.0)	Bobcat (1), coyote (6), mule deer (95), desert cottontail rabbit (1), black-tailed jackrabbit (6), golden eagle (1), red-tailed hawk (4), turkey vulture (107), mourning dove (246), common raven (28), unknown accipiter (1)
Well 5C Trough (#31)	12/16/14-12-21/15	8,882	0 (0.0)	Bobcat (2), coyote (57), pronghorn antelope (118), burro (128), black-tailed jackrabbit (76), golden eagle (10) turkey vulture (8), greater roadrunner (2), mourning dove (247), common raven (33)
Area 6 LANL Pond Trough (#32)	12/15/14-12/21/15	8,903	0 (0.0)	Coyote (53), pronghorn antelope (134), mule deer (2), black-tailed jackrabbit (14), golden eagle (22), red-tailed hawk (11), turkey vulture (166), common raven (80)
Well C1 Pond Trough (#28)	12/15/14-12/21/15[b]	5,956	0 (0.0)	Bobcat (16), badger (1), coyote (56), pronghorn antelope (19), mule deer (13), burro (37), black-tailed jackrabbit (4), red-tailed hawk (59), Cooper's hawk (4), great-horned owl (12), turkey vulture (26), mourning dove (4), brown-headed cowbird (2), common raven (161)
ER 20-5 Upper (#33)	4/8-8/18/15[b]	765	0 (0.0)	Coyote (3), common raven (2), passerine (3)

Table 6-4. Results of mountain lion camera surveys during 2015 (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 20-5 Plastic-lined Sump (#2)	12/10/14-12/22/15b	8,065	0 (0.0)	Bobcat (1), common raven (1)
ER 20-11 (#10)	12/10/14-6/10/15	4,375	0 (0.0)	None
U19ad Plastic-lined Sump (#25)	12/10/14-12/22/15	9,044	0 (0.0)	Mule deer (9), unknown bird (1)
Ue20n#1 Plastic-lined Sump (#26)	12/10/14-10/22/15[b]	5,974	0 (0.0)	Coyote (19), mule deer (2), common raven (18), unknown birds (21)
ER 20-7 (#23)	12/10/14-10/22/15	7,579	0 (0.0)	Mule deer (6), red-tailed hawk (1), duck (2), common raven (20)

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

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

Table 6-5. 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-14	Jan-15	Feb-15	Mar-15	Apr-15	May-15	Jun-15	Jul-15	Aug-15	Sep-15	Oct-15	Nov-15	Dec-15
Gold Meadows Spring (#18)										2			
12T-26, Rainier Mesa (#1)				1		1	3	1					
Dick Adams Cutoff Road (#3)									1				
East 19-01 Road (#16)				2		1	1	1					
Rattlesnake Ridge Gorge (#20)	1	1	4	17	2				2	3		2	
Water Bottle Canyon (#17)			1							2			
Camp 17 Pond (#6)							12	8	12	1		1	
Captain Jack Spring (#12)		2											6
North Chukar Canyon Tank (#22)						1							
South Pah Canyon (#15)					1								
Canyon West of Topopah Spring (#8)	1			1	1	2		2		2	1	1	2
Topopah Spring (#9)						1				1			
Topopah Spring Trough (#30)										1			
Redrock Valley Pass (#24)	2	2		2									

Number of mountain lion images

Camera operational, no mountain lions detected

Camera not operational

Figure 6-14. Female and subadult mountain lions at Camp 17 Pond

(Photo #907 taken June 26, 2015, by motion-activated camera)

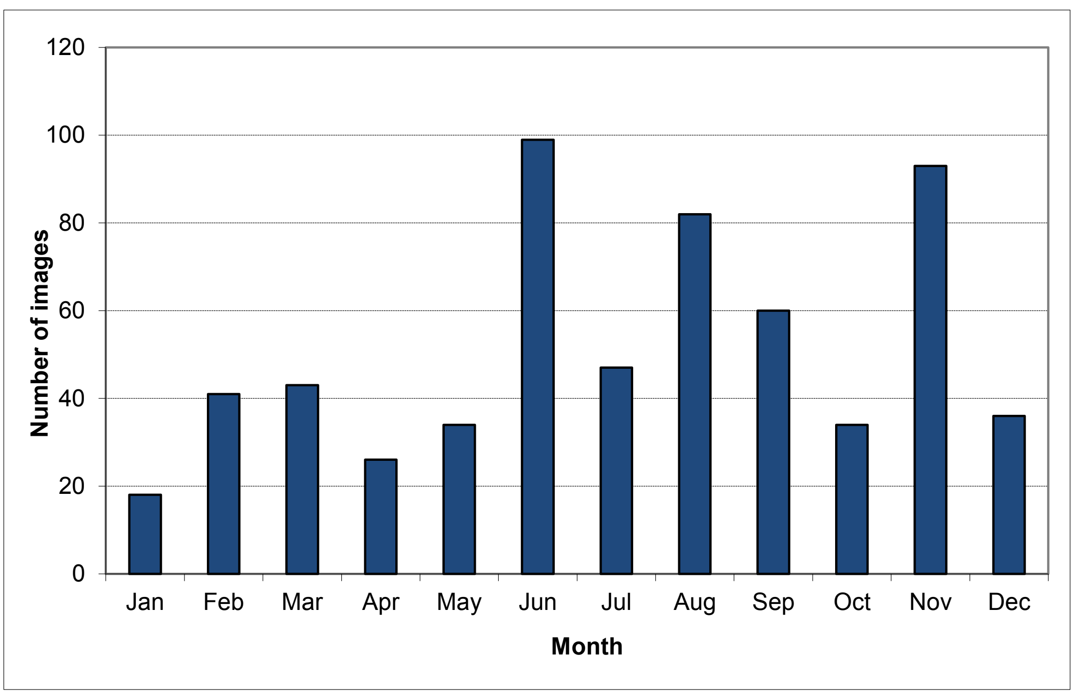


Figure 6-15. Number of mountain lion images by month for camera sites where mountain lions were detected from 2006 through 2015 (n = 613)

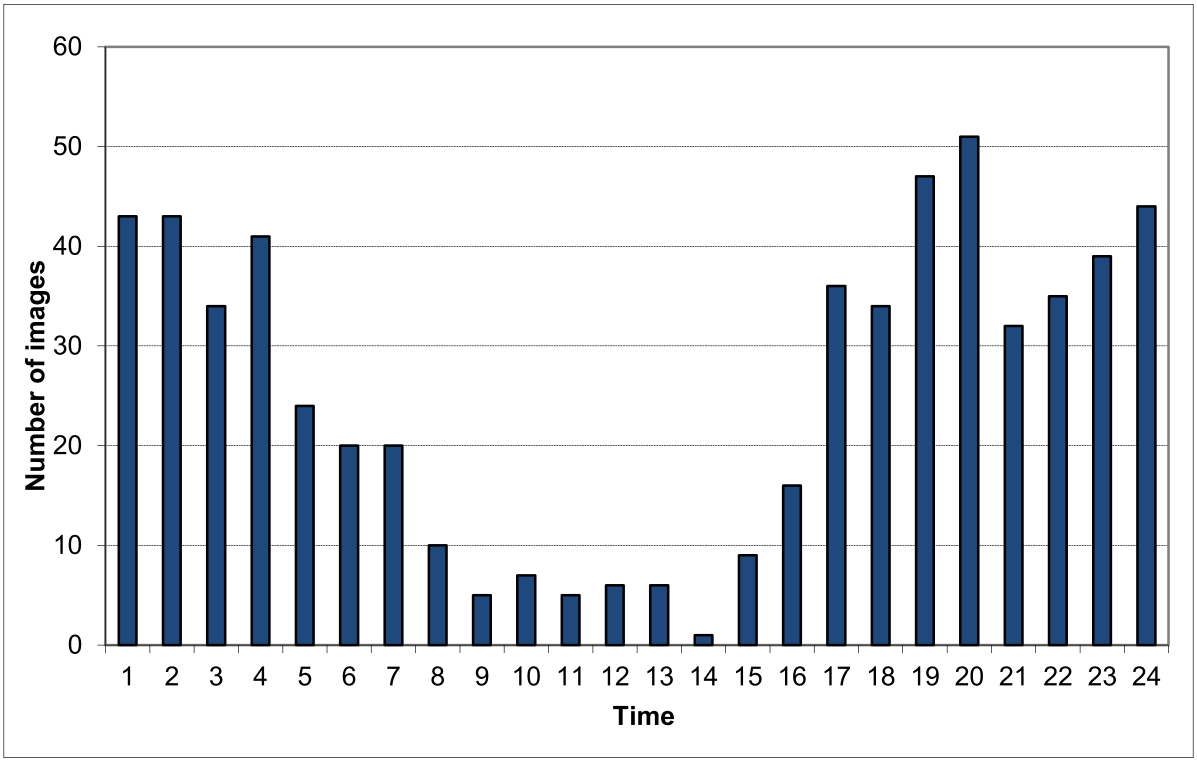


Figure 6-16. Number of mountain lion images by time of day (Pacific Standard Time) for camera sites where mountain lions were detected from 2006 through 2015 (n = 608)

Figure 6-17. Two gray foxes on Pahute Mesa Road, Area 19

(Photos by motion-activated camera, July 26, 2015)

6.7.2 Mountain Lion Telemetry Study

A collaborative effort between Kathy Longshore and David Choate (USGS) and site biologists continued during 2015 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 2015 was to capture and radio-collar four mountain lions and track them for 1–1.5 years.

David Choate and McLain Mecham (trapper) led the trapping effort that occurred from May 17 to June 14, 2015. During this period, efforts to track and capture mountain lions involved setting and monitoring snares over 27 days and hunting with the use of hounds. Trapping efforts were focused on Rainier Mesa, eastern Pahute Mesa/Big Burn Valley, and Timber Mountain. Trailing with hounds occurred during a 10-day period (May 22-31) that overlapped with the operation of traps. This effort involved searching roads daily for mountain lion sign, and using mules to search and pursue any lion trails found in more remote areas.

Frequent heavy rain and thunderstorms hindered tracking efforts for the first 10 days, with intermittent showers thereafter. Mountain lions were trailed using hounds on five separate occasions without any captures, including formerly collared NNSS7, and 1 additional male and 1 undetermined individual (young transient male or adult female). During pursuits, individual lions circumvented trap sites while traveling considerable distances. For example, on May 28, a male lion appeared on a camera trap at the North Chukar Canyon Tank (Site#22). Tracks were encountered from this individual crossing over from Timber Mountain. On May 30, it was trailed from Shoshone Mountain along a ridge north as far as the crossing point to Red Rock Valley. The following day, its trail was picked up crossing Stockade Wash Road at the pass, and the individual was pursued up and across Rainier Mesa then down into Aqueduct Canyon. The male did not appear to stop or linger at any location, and covered great distances while walking, making it difficult to catch up to the individual for capture. Further, an adult male (likely NNSS7) walked past active snares without triggering them on two occasions. The wariness with regards to snares and hounds suggests several of the individual mountain lions encountered during this trapping period have had previous experience with the same equipment used during trapping efforts earlier in the study. No captures were made in 2015.

6.7.3 Risk to Humans

Two mountain lion observations were reported to NNSS biologists by NNSS workers during 2015. One was in Area 6 on the 6-01 road on January 7. The worker reported it as a young mountain lion. A search was made for tracks to verify the identification but none were found. It is possible it was a bobcat because multiple sightings of bobcats were reported in this area later in the spring and summer. The other observation was made on December 5 on Pahute Mesa Road in Area 17 near the Sugar Loaves. It was headed northeast toward the Eleana Range. An additional observation was made by biologists during deer surveys at E Tunnel Pond on September 28.

The sighting in Area 6 is rare and not in typical habitat for mountain lions. A few records from Frenchman Playa, Control Point Hills, and Yucca Flat have been recorded but are extremely isolated and rare. Based on historic records and data obtained from seven radiocollared 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 quite 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.

6.8 NUISANCE AND POTENTIALLY DANGEROUS WILDLIFE

During 2015, NNSS biologists responded to 55 calls regarding nuisance, injured, or potentially dangerous wildlife in or around buildings, power lines, and work areas on the NNSS, one at the North Las Vegas Complex (released tree lizard from B3 Building), and one at the Remote Sensing Laboratory (injured American kestrel taken to Wild Wing Project for rehabilitation and later released). Problem or injured animals at the NNSS included birds (25 calls), bats (5 calls), coyotes (3 calls), other mammals (4 calls including removing a spotted skunk (*Spilogale putorius*) from a building in Area 6), and reptiles (18 calls, including 4 rattlesnakes). Mitigation measures taken usually involved moving the animal away from people 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) (Figure 6-18). 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 the source population for the young bull is to the north, possibly in the Groom or Kawich Range.

Figure 6-18. Young bull elk at Gold Meadows Spring

(Photo by motion-activated camera, June 28, 2015)

Pronghorn antelope appear to be increasing in number and expanding their range on the NNSS. During 2015, a herd of 43 was seen during the mule deer survey in Gold Meadows on September 14. This is the largest number of antelope ever documented on the NNSS. A total of 530 antelope photos were recorded at Gold Meadows Spring during 2015 with 436 of those taken between mid-August and early December. Antelope were also photographed at the Well 5C water trough (118 images), the Area 6 LANL Pond water trough (134 images), and the Well C1 water trough (19 images). Antelope are regularly seen 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 2015, burros and their sign (e.g., scat, tracks) were documented as far north as Twin Spring (Area 29) in Fortymile Canyon with an abundance of tracks and scat along the road from Yucca Mountain to Twin Spring. In fact, four individuals (two females, two young) were seen near Twin Spring on November 4, 2015, and nine were seen in January 2016 including three young. A group of three have been routinely photographed at the water troughs at Well 5C and Well C1 the last couple of years and occasionally at the Area 6 LANL Pond trough.

6.10 COORDINATION WITH BIOLOGISTS AND WILDLIFE AGENCIES

Site biologists interfaced with other biologists and wildlife agencies in 2015 for the following activities:

- Gave 9 reptile genetic samples and 13 voucher specimens (1 red racer, 3 Great Basin skinks, 5 western red-tailed skinks, 3 shrews, and 1 chipmunk) to NDOW and the Monte L. Bean Museum at BYU.
- Gave a presentation about wildlife monitoring on the NNSS at the Nevada Chapter of The Wildlife Society Annual Meeting in Reno, Nevada, in February 2015.
- Wrote an article about western red-tailed skinks and Great Basin skinks for the fall newsletter of the Nevada Chapter of The Wildlife Society.
- Contributed to a film documentary that USGS is producing about desert bighorn sheep and mountain lions on the NNSS.
- Attended Nevada Bat Working Group Meeting in Las Vegas, Nevada, in December 2015.

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 2015 included visually assessing the vegetation at the U-3ax/bl closure cover and quantitative and qualitative assessments of vegetation at the North-North Closure Cover, "92-Acre Site." A description of previous revegetation efforts at the 92-Acre Site is also presented.

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

No quantitative sampling occurred on this site in 2015. 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 111, NORTH-NORTH CLOSURE COVER, "92-ACRE SITE"

Corrective Action Unit (CAU) 111 encompasses the southern portion of the Area 5 RWMC and was recently designated for final closure operations. CAU 111 is referred to as the "92-Acre Site" and comprises four roughly rectangular areas separated by drainage channels and access roads. The four areas are designated as the North-North Cover, the South-North Cover, the South Cover and the West Cover. The total area of the four covers is approximately 18 ha.

7.2.1 2011 and 2013 Revegetation Efforts and Monitoring Results

The original attempt in 2011 to establish a native perennial plant community on the closure covers incorporated reclamation techniques successfully employed at other sites on the NNSS and the TTR and included soil ripping, seeding with native species, straw mulching and supplemental irrigation as described in Ostler et al. (2002). Vegetation monitoring in the spring of 2013 revealed that seed germination and plant establishment were below expectations (Hall et al. 2014) and remedial revegetation would be required to establish a viable plant community, an integral component of the evapo-transpirative closure cover designed for CAU 111.

The approach taken was to first evaluate different remedial revegetation scenarios on one of the covers. Once a successful revegetation methodology was identified, then the remaining CAU 111 covers would be revegetated using that methodology. The North-North Cover was selected in 2013 for the first series of research trials, which included the evaluation of hydroseeding/broadcast seeding, and mulching rates.

The North-North Cover was divided into four sections (Figure 7-1). The two eastern-most sections were selected to be broadcast seeded using a modified Tye Rangeland drill seeder to broadcast seeds. The two western-most sections were selected to be hydroseeded. Various mulch rates were also applied in the different treatments (Figure 7-1).

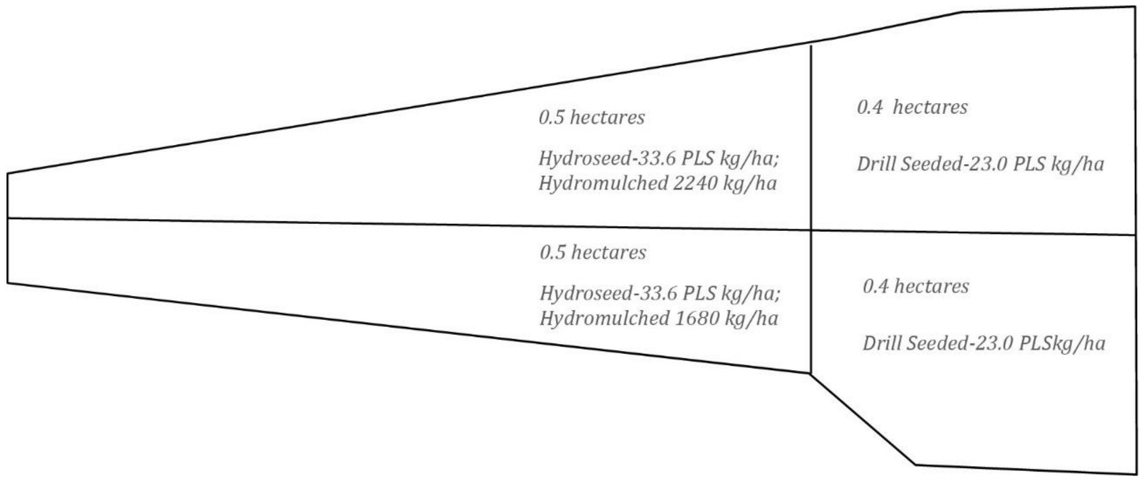


Figure 7-1. Design to test different revegetation methods on the North-North cover, Fall 2013; drill seeded plots used a drill seeder to broadcast the seed

Monitoring conducted during 2014 found that seeded species were more common on areas that were broadcast seeded than on the hydroseeded treatments. Invasive species were present within every quadrat sampled. The most commonly occurring species on both treatments were Nevada jointfir, Indian ricegrass (*Achnatherum hymenoides*), squirreltail (*Elymus elymoides*), desert marigold (*Baileya multiradiata*), and fourwing saltbush. The density of Indian ricegrass and Nevada jointfir was the same, although Indian ricegrass was found within more quadrats than was Nevada jointfir. Seedlings of nine of the eleven species that were included in the seed mix were found on the broadcast area, but only five were encountered on the hydroseeded area. The density of Russian thistle (*Salsola tragus*) and halogeton (*Halogeton glomeratus*) was lower on the hydroseeded treatment whereas Arabian schismus was ten times higher on the hydroseeded treatment than on the broadcast seeded treatment.

On the broadcast seeded area there was a slight mulch effect. The density of seeded species on the standard mulch plot (1,680 kg/ha) was 15% higher than on the heavier mulched plot. On the hydroseeded area, the mulch rate appears to have an opposite effect than was observed on the broadcast seeded area. Plant density for seeded species was 30% higher on the heavier mulched area than where the standard mulch rate was used.

Signs of herbivory were evident at many locations. Stems of halogeton had been cut and left without being eaten, but signs of herbivory was most notable on Nevada jointfir and Indian ricegrass (Figure 7-2). Many young seedlings had been grazed to ground level and others showed signs of moderate to heavy grazing. The abundance of rabbits was documented by recording the presence of rabbit scat (pellets) within sample quadrats. Based on observations, it is evident that small mammals, especially rabbits, were detrimental to seedling success. The heavily grazed plants were difficult to see and many may have died, which suggests that the magnitude of this issue may be underestimated and future reseeding efforts should definitely address protection from grazing animals, mainly rabbits.

There was not a preferred methodology for successfully revegetating the 92-Acre Site that could be recommended with confidence, but from the 2013 research trials on the North-North cover, it appeared that broadcast seeding with a drill seeder is the preferred method of seeding. Higher mulching rates showed no beneficial effects on seedling establishment and, in fact, it is questionable whether mulch is even necessary. Supplemental irrigation continued to favor invasive species over seeded species. An observation made on the 2013 research trials was the impact of small grazing animals, specifically rabbits, which may be a key factor in establishing a viable plant community on the 92-Acre Site.

Figure 7-2. Indian ricegrass that has been eaten by rabbits

(Photo by D.C. Anderson, March 11, 2015)

7.2.2 2014 Revegetation Trial on South-North Cover

The following 2014 remedial revegetation plan addressed the concerns discussed above. As with the previous remedial revegetation efforts, it was recommended that future efforts first be conducted on one of the four covers within the 92-Acre Site. The South-North cover was selected for the next phase of remedial revegetation.

The 2014 plan for remedial revegetation evaluated the effect of mulch, supplemental irrigation, and any interaction between mulch and supplemental irrigation on seed germination and plant establishment. The design is shown in Figure 7-3, as well as the location of a rabbit-proof fence installed to eliminate herbivory on young seedlings.

7.2.2.1 Methods

Soil Testing – Four soil samples were taken from the South-North site and sent to a lab to analyze for suitability for plant growth. Results showed high values for salinity and sodium absorption ratio (SAR) which are not conducive to good plant growth. Further, the individual elements of sodium and calcium were high compared to the native soil samples taken near the RWMC. Sodium levels of the native soils averaged 0.02% while the samples from the South-North site averaged 0.13%. Calcium was also higher in the South-North, site averaging 2.49%, while the native soils averaged 0.78%. These high levels of salts in the soil are marginal for growing plants.

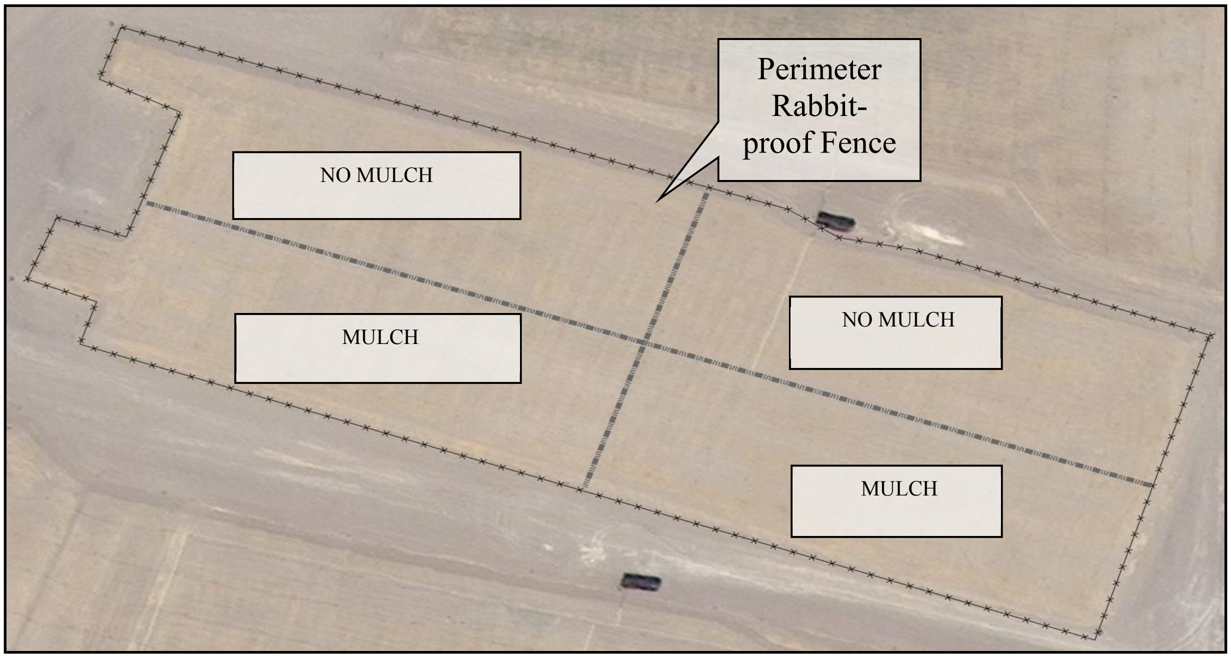


Figure 7-3. Diagram of remedial revegetation design for the South-North cover, Fall 2014

Site Preparation – On October 21, 2014, the soil surface on the South-North cover was harrowed to break up soil compaction and prepare the soil for seeding. The site was not disked.

Seed – The viability of the seed was certified and reported by the vendor (Table 7-1) based on seed testing that occurred within six months of purchase. To verify the current viability of the seeds, samples of seven of the nine species included in the seed mix were sent to the Montana State Seed Testing Laboratory to be tested for seed viability. Results indicated that seed viability was acceptable for six of the species (Table 7-1). The viability of white bursage seeds was significantly lower than was reported by the vendor. Seeds for this species were further evaluated by another seed laboratory. Overall, the seed mix was considered to have an acceptable level of seed viability.

Seeding – On October 29, 2014, the South-North cover was seeded with a mix of five shrub species, two grasses and two perennial forbs (Table 7-2). All species used in the seed mix are native to the area and show a tolerance to saline soils. To maximize the potential germination of creosote bush and white bursage seed, seeds of both species were pre-treated prior to seeding. Seeds were soaked and rinsed for approximately 30 hours, dried, and then mixed with the other species and seeded at a rate of 30.0 kg of pure live seed per ha (PLS kg/ha)

Site Protection – One of the main recommendations from the 2013 trials was the need to protect any new seeding efforts from grazing/browsing animals. A rabbit-proof fence was installed around the South-North site (Figure 7-4). It was placed at the base of the cover with the bottom 15 cm of fence buried. Unfortunately, the fence was not completed until late spring after germination had already occurred.

Table 7-1. Seeded species with results of viability tests from vendor (Granite Seed) and an independent testing site (Montana State Seed Lab) for the 2014 South-North cover revegetation trial (TZ=tetrazolium test)

Species	Variety	Granite Seed (Vendor)			Montana State Seed Lab	
		Germination	Viability (TZ)	Lab	Germination	Viability (TZ)
White bursage	None	-	95	Dept. of Ag, NM	8	20
Fourwing saltbush	None	-	52	Dept. of Ag, NM	27	71
Shadscale saltbush	None	-	60	Dept. of Ag, NM	27	73
Nevada jointfir	None	-	67	Idaho State, ID	92	82
Creosote bush	None	-	58	Dept. of Ag, NM	11	77
Indian ricegrass	RIMROCK	-	92	Dept. of Ag, WA	79	94
Squirreltail	PUEBLO	-	93	Native Seed Labs, SD	91	92

Table 7-2. Seed mix and seeding rates for the 2014 South-North cover revegetation trial

Lifeform		Common Name (Scientific Name)	Broadcast Seeding Rate PLS kg/ha
SHRUBS		White bursage (*Ambrosia dumosa*)	5.0
		Fourwing saltbush (*Atriplex canescens*)	2.2
		Shadscale saltbush (*Atriplex confertifolia*)	4.5
		Nevada jointfir (*Ephedra nevadensis*)	5.6
		Creosote bush (*Larrea tridentata*)	8.4
GRASSES		Indian ricegrass (*Achnatheum hymenoides*)	2.2
		Squirreltail (*Elymus elymoides*)	1.4
FORBS		Desert marigold (*Baileya multiradiata*)	0.3
		Desert globemallow (*Sphaeralcea ambigua*)	0.3
		Totals	**30.0**

Figure 7-4. Fence installed around South-North cover to protect new seedlings from rabbits

(Photo by D.C. Anderson, May 2015)

Mulch – To conserve soil moisture and protect seeds a mulch (HydroStraw), composed of renewable natural fibers (straw), tackifier, and other vendor-proprietary additives, was applied to approximately half of the South-North cover. The mulch was applied at a rate of 2,128 kg/ha at a ratio of 340 kg of mulch/3,785 liters of water on November 25 and 26, 2014. Half of the seeded area was hydro-mulched using the standard rate and the remaining half was not mulched. This was done to evaluate the effect of mulching on seed germination and plant establishment (Figure 7-3).

Irrigation - Supplemental irrigation was applied (Figure 7-5) from December 2014 to February 2015, and then again in late spring (May) to facilitate the germination of creosote bush seed. Irrigation amounts provided a supplement to the natural rainfall so soil moisture was sufficient for seed germination and plant establishment. A total of 107 mm of supplemental irrigation was applied to the site. Combined with the 38 mm of natural precipitation, the 145 mm was just less than the 174 mm typically received during a good growing season (Table 7-3). Average precipitation for the site is approximately 115 mm.

Table 7-3. Amount of natural precipitation and supplemental irrigation applied to the South-North cover from December 2014 to May 2015

Month	Goal	Natural Precipitation (mm)	Supplemental Irrigation (mm)	Total
Dec. 2014	38.1	11.7	13.2	24.9
Jan. 2015	38.1	5.1	23.1	28.2
Feb. 2015	57.2	8.9	44.5	53.4
Mar. 2015	25.4	11.7	13.2	24.9
May 2015	15.2	0.3	13.0	13.3
Total	**174.0**	**37.7**	**107.0**	**144.7**

Figure 7-5. The supplemental irrigation system in operation on the North-North cover which was moved and used for the South-North cover

(Photo by D.C. Anderson, unknown date)

Vegetation Monitoring - The objective of vegetation monitoring the first year after revegetation was to determine if seeds had germinated and if seedlings were establishing on the site. For CAU 111 there were added objectives: vegetation monitoring was also designed to evaluate the effect of the two seeding techniques and the two mulching rates on seed germination and plant establishment. The sampling design for the South-North cover included the placement of one, 100-meter transect within each of the four treatments.

7.2.2.2 2015 Vegetation Monitoring Results

March Visual Assessment – On March 11, 2015, an NSTec biologist visited the site to assess if germination had occurred. Germination had occurred on both the mulched and non-mulched treatments that were irrigated (Figures 7-6, 7-7, and 7-8) but not on the non-irrigated plots. Density of seeded species was not taken at that time. It was noted that the rabbit-proof fence was not completed and that rabbit pellets were common on the seeded areas (Figure 7-9).

August Quantitative Sampling - Vegetation monitoring on a quantitative basis was performed on August 5, 2015. It was noted that those seeded species that were present in the spring were absent by the summer sampling. Total seeded plant density on both the irrigated and non-irrigated areas was 0.0 plants/square meter (m^2). There were no seeded species encountered along the sample transects. The only species encountered were Russian thistle and halogeton. The cover of these two weedy species totaled 34% on the irrigated sites and 2% on the non-irrigated areas (Table 7-4).

Figure 7-6. Germination of Indian ricegrass on the South-North cover non-mulched/irrigated plot

(Photo by D.C. Anderson, March 11, 2015)

Figure 7-7. Germination of Nevada jointfir on the South-North cover non-mulched/irrigated plot

(Photo by D.C. Anderson, March 11, 2015)

Figure 7-8. Germination of Nevada jointfir on the mulched/irrigated plot

(Photo by D.C. Anderson, March 11, 2015)

Figure 7-9. Young seedlings of Indian ricegrass on the South-North cover in the spring of 2015 Note the number of rabbit pellets (brown) in the foreground.

(Photo by D.C. Anderson, March 11, 2015)

At the August sampling there were only a few individuals of fourwing saltbush left on the South-North cover. These were on the irrigated plots but were so few that they did not show up in the sampling. Although no transects were sampled in spring, germination of several species was documented in photographs of the site. These young seedlings appear to have been eaten by the rabbits that were inside the fence.

Irrigation – Spring observations generally showed that irrigation was necessary to produce seed germination. Natural precipitation of 38 mm that occurred during the December to March period was not adequate to induce germination. The irrigation treatment added 107 mm bringing the total water for germination to 145 mm, which was enough for several species to germinate. It was not possible to determine a treatment effect during the August sampling because so few seeded species seedlings were left most likely due to herbivory by rabbits. Irrigation substantially increased percent cover of Russian thistle and halogeton.

Mulch Rate – It was not possible to determine if mulch had an effect since no seedlings remained on the plots. Invasive annuals had the same cover values in the mulched and un-mulched plots. Russian thistle benefited from the mulch treatment while halogeton was more common on the un-mulched plots.

Wildlife Observations-Small mammal burrows were observed on the site but none encountered within the quadrats during vegetation sampling. A few burrows were observed on the cover, but were widely scattered. Signs of herbivory were evident at many locations on the cover.

Table 7-4. Seeded species density (plants/m2) and percent cover of non-seeded annual forbs on the South-North cover, August 2015

			Irrigated		Non-irrigated	
	Irrigated	Non-irrigated	Standard Mulch	No Mulch	Standard Mulch	No Mulch
SHRUBS						
White bursage	0.0	0.0	0.0	0.0	0.0	0.0
Fourwing saltbush	0.0	0.0	0.0	0.0	0.0	0.0
Shadscale saltbush	0.0	0.0	0.0	0.0	0.0	0.0
Nevada jointfir	0.0	0.0	0.0	0.0	0.0	0.0
Creosote bush	0.0	0.0	0.0	0.0	0.0	0.0
			Irrigated		**Non-irrigated**	
	Irrigated	**Non-irrigated**	**Standard Mulch**	**No Mulch**	**Standard Mulch**	**No Mulch**
GRASSES						
Indian ricegrass	0.0	0.0	0.0	0.0	0.0	0.0
Squirreltail	0.0	0.0	0.0	0.0	0.0	0.0
FORBS						
Desert marigold	0.0	0.0	0.0	0.0	0.0	0.0
Desert globemallow	0.0	0.0	0.0	0.0	0.0	0.0
ANNUAL FORBS (% cover)						
Russian thistle	11.0	0.0	18.0	4.0	0.0	0.0
Halogeton	23.0	2.0	16.0	30.0	2.0	2.0

7.2.2.3 Discussion

The initial plan for remedial revegetation of the 92-Acre Site considered several different scenarios. One was to allow the site to naturally revegetate, which was not selected because research has shown that natural plant establishment can take several decades (Angerer et al. 1995). Another scenario was to re-seed the four closure covers with no additional mulching or supplemental irrigation. Not knowing whether this approach would be successful and would still involve a substantial investment of labor and materials, it was concluded that a more cost effective approach would be to first test several revegetation scenarios on the North-North cover. Once a successful methodology was identified, then it would be applied to the rest of the 92-Acre Site. It was understood that if a successful methodology was not identified, other approaches would be identified and evaluated (Hall et al. 2014).

The following sections summarize the findings from research trials conducted this past year. Based on these findings and general observations, some recommendations are proposed that address key factors for the successful establishment of a native plant community on the 92-Acre Site.

Seeding - The original seeding method was broadcast seeding using a modified drill seeder, which is a method that has been successfully used on the NNSS at several revegetation sites (Anderson and Ostler 2002). This technique was validated during the 2013 trials on the North-North cover and should be the recommended technique when seeding.

The seed mix used to revegetate the 92-Acre Site in the fall of 2011 included ten species of native shrubs, three grasses and three forbs (Hall et al. 2013). There were several species in the mix that were marginally adapted to the 92-Acre Site, but it was unknown whether they would establish on the site. Vegetation monitoring in 2013 revealed that four shrub species, one grass, and one forb did not germinate; therefore, they were not included in the seed mix that was used to reseed the North-North cover during 2013 trials. Brittlebush (*Encelia virginensis*) was not encountered during vegetation monitoring in 2013, but it was considered to be a species that could still potentially establish on the 92-Acre Site. However, no seedlings of brittlebush were found on the North-North trials so this species will not be used in future seed mixes for revegetation efforts at the 92-Acre Site. It is recommended that the seeding rate used for future revegetation efforts at the 92-Acre Site be increased by 20-30% to compensate for the reduction in seed viability and germination experienced during the last two years.

Mulching - Mulching in 2011 included the spreading of native straw using a straw blower and then securing the straw using a crimper. Crimping is inherently not 100% effective and a substantial amount of the straw blew off the covers and into areas where it posed a hazard and had to be removed. Hydro-mulching is an alternative to blowing and crimping. It was demonstrated in 2013 that a heavier mulch rate did not result in higher plant densities. The 2014 trial on the South-North cover was intended to see if mulching was necessary. Due to the complete loss of seedlings to herbivory, this question was not answered. The litter and residual mulch that is accumulating on the covers may be as effective in promoting seed germination and plant establishment as would be achieved with the application of more mulch.

Wildlife Control - It was originally assumed that the lack of vegetation within the RWMC and the heavy vehicle traffic would deter the presence of grazing and browsing animals such as rabbits, small mammals, antelope, and burros. It was known that the perimeter fences were not constructed to prohibit rabbit or small mammal movement onto the site nor would they keep antelope and burros out.

Based on observations this year, it is evident that small mammals, especially rabbits, were present on the site. Many young seedlings of Indian ricegrass and Nevada jointfir had been grazed to ground level or showed signs of moderate grazing (Figure 7-2). The heavily grazed plants were difficult to see and many heavily grazed plants died, which suggests that the magnitude of this issue may be underestimated at this site. This was the second year that rabbits have had a major negative impact on the success of reseeding efforts. It is apparent that a rabbit-proof fence around the perimeter of the cover that is monitored regularly and maintained is needed for seedling establishment and also for protection of transplants. It may also be necessary to live-trap rabbits if they are seen within the fenced areas and remove them.

Invasive Weed Control - In 2012, **t**he first year after the original seeding, which included supplemental irrigation, halogeton and Russian thistle were abundant and covered the majority of all four covers within the 92-Acre Site. In 2013, the second year, with no supplemental irrigation and during another year of below normal rainfall, halogeton and Russian thistle were essentially absent (Hall et al. 2014). In 2013, both species were present on the other three covers within the 92-Acre Site, but at a fraction of the density and cover experienced on the irrigated North-North cover. There was abundant cover of these species on the irrigated plots in 2015, averaging 34% cover, but relatively little on the non-irrigated plots, which averaged 2% cover. In the future, it may be necessary to apply herbicides on the invasive weeds prior to seed set to deter the production of more seeds. Care must be taken to choose the right herbicide and apply it at the right time so future seedings of native perennials won't be impacted.

Irrigation - Rainfall the last several years has been below normal. A couple of rainstorms in October and December 2014 were encouraging, but in January and February 2015, when rainfall is critical for good seed germination, only 14 mm were received, compared to approximately 95 mm that are typically received during a good growing season. Successful revegetation was achieved at the U-3ax/bl site with 109 mm of natural precipitation and 125 mm of supplemental irrigation. About 107 mm of supplemental irrigation was applied between December 2014 and May 2015 to the South-North cover, augmenting the meager 38 mm of natural rainfall. The supplemental irrigation was enough to germinate some of the seeded species. No germination of seeded species occurred on the non-irrigated plot, which received only the 38 mm of natural precipitation.

Irrigation has been used at sites where the immediate establishment of a vegetative cover is a high priority. The Double Tracks site on the NTTR and the U-3ax/bl site on the NNSS are two examples. At other sites, such as the Central Nevada Test Area, five CAUs on the TTR, and the Control Point Water line, no supplemental irrigation was used, yet due to favorable natural rainfall events, a viable native plant community has established at all of those sites (Hall et al. 2013, NSTec 2007, Anderson and Ostler 2002). There are other factors associated with rainfall events that enhance seed germination and plant establishment, such as soil and air temperature. Future revegetation procedures may consider evaluating not using supplemental irrigation if there is a high probability of more favorable environmental conditions that would, in turn, promote better seed germination and plant establishment. This might be in years when the probability of an "El Niño" weather pattern is high. Experience on the NNSS and the TTR has shown that successful revegetation can be achieved without supplemental irrigation.

If supplemental irrigation is used in the future, the timing and amounts should be evaluated to ensure the greatest benefit for seeded plant species while minimizing the benefit to invasive plant species. One such scenario would be to provide supplemental irrigation only in the late winter/early spring months of February and March. Observations at the NNSS suggest that rainfall during these months seems to favor native plant growth, whereas late spring precipitation seems to favor growth of annuals, including invasive annual species such as halogeton and Russian thistle. Supplemental irrigation in late spring may be required for the successful germination of creosote bush seed, which requires soil temperatures between 15˚ Celsius (C) and 37˚ C along with sufficient soil moisture (Ostler et al. 2002). Creosote bush is an important component of the native plant community and efforts should be made to meet seed germination requirements of this species.

8.0 REFERENCES

Andersen, M. C., J. M. Watts, J. E. Freilich, S. R. Yool, G. I. Wakefield, J. F. McCauley, and P. B. Fahnestock. 2000. "Regression-Tree Modeling of Desert Tortoise Habitat in the Central Mojave Desert." *Ecological Applications*. 10:890–900.

Anderson, D. C., and W. K. Ostler. 2002. "Revegetation of Degraded Lands at U.S. Department of Energy and U.S. Department of Defense Installations: Strategies and Successes." *J. Arid Land Research and Management.* 16(3):197–212.

Angerer, J. P, W. K. Ostler, W. D. Gabbert, and B. W. Schultz. 1995. *Secondary Plant Succession on Disturbed Sites at Yucca Mountain, Nevada.* EG&G/EM 11265-1118 UC-702. 72 p.

Beatley, J. C. 1976. *Vascular Plants of the Nevada Test Site and Central-southern Nevada: Ecologic and Geographic Distribution.* U.S. Energy Research and Development Administration. TID-26881, 308 p.

Bechtel Nevada. 2001. *Adaptive Management Plan for Sensitive Plant Species on the Nevada Test Site.* Environmental Monitoring, Ecological Services, Las Vegas, NV. March 2001.

Bechtel Nevada. 2006. *Ecological Monitoring and Compliance Program Calendar Year 2005 Report.* Environmental Monitoring, Ecological Services, March 2006. Las Vegas, NV.

Boarman, W. I., and M. Sazaki. 2006. "A Highway's Road-Effect Zone for Desert Tortoises (*Gopherus agassizii*)." *Journal of Arid Environments.* 65:94–101.

Bradley, P. V., M. J. O'Farrell, J. A. Williams, and J. E. Newmark. 2006. *The Revised Nevada Bat Conservation Plan*. Nevada Bat Working Group. Reno, NV. 216 p.

Brooks, M. and M. Lusk. 2008. *Fire Management and Invasive Plants: A Handbook*. U.S. Fish and Wildlife Service, Arlington, VA. 27 p.

Buckner, D.L. 1985. "Point-intercept Sampling in Revegetation Studies: Maximizing Objectivity and Repeatability." *Proc. American Society for Surface Mining and Reclamation 1985 Meetings*. Denver, CO.

Civilian Radioactive Waste Management System, Management and Operating Contractor.1997. Rautenstrauch, K.R., D.L. Rakestraw, G.A. Brown, J.L. Boone, A.L. Hughes. *Patterns of Burrow Use by Desert Tortoises at Yucca Mountain, Nevada*. B00000000-017-5705-00041REV 00. Las Vegas, NV.

Collins, E., T. P. O'Farrell, and W. A. Rhoads. 1982. Biologic Overview for the Nevada Nuclear Waste Storage Investigations, Nevada Test Site, Nye County, Nevada. EGG 1183-2460, EG&G Energy Measurements, January 1982. Santa Barbara, CA.

CRWMS, see Civilian Radioactive Waste Management System, Management and Operating Contractor

DOE, see U.S. Department of Energy.

DOE/NV, see U.S. Department of Energy, Nevada Operations Office.

E.O., see U.S. Executive Order.

FWS, see U.S. Fish and Wildlife Service.

Germano, D.J., R. B. Bury, T.C. Esque, T.H. Fritts, and P.A. Medica. 1994. "Range and Habitats of the Desert Tortoise." In R.B. Bury and D.J. Germano (Eds*.), Biology of North American Tortoises* (pp 73-84). National Biological Survey, Fish and Wildlife Research 13. Fish and Wildlife Service. Washington, D.C.

Giles, K., and J. Cooper. 1985. *Characteristics and Migration Patterns of Mule Deer on the Nevada Test Site*. EPA 600/4-85-030.

Hall, D. B. 2014. Personal communication with Melia Nafus, San Diego Zoo Institute for Conservation Research. December 4, 2014. Las Vegas, NV.

Hall, D. B., D. C. Anderson, P. D. Greger, W. K. Ostler, and D. J. Hansen. 2013. *Ecological Monitoring and Compliance Program 2012 Report.* DOE/NV/25946--1776. National Security Technologies, LLC, Ecological Services, July 2013. Las Vegas, NV.

Hall, D. B., D. C. Anderson, P. D. Greger, and W. K. Ostler. 2014. *Ecological Monitoring and Compliance Program 2013 Report.* DOE/NV/25946--2045, National Security Technologies, LLC, Ecological Services, July 2014. Las Vegas, NV.

Hall, D. B., D. C. Anderson, P. D. Greger, and W. K. Ostler. 2015. *Ecological Monitoring and Compliance Program 2014 Report.* DOE/NV/25946--2431. National Security Technologies, LLC, Ecological Services, July 2015.Las Vegas, NV.

Hansen, D. J., 2012. Personal communication with Rick Lantrip, Air Resources Laboratory, Special Operations Division. May 4, 2012. Mercury, NV.

Hansen, D. J., and W. K. Ostler. 2004. *A Survey of Vegetation and Wildland Fire Hazards on the Nevada Test Site*. DOE/NV/11718--981. Bechtel Nevada, Ecological Services, Las Vegas, NV.

Hansen, D. J., D. C. Anderson, D. B. Hall, P. D. Greger, and W. K. Ostler. 2009. *Ecological Monitoring and Compliance Program 2008 Report*. DOE/NV/25946--704, National Security Technologies, LLC, Ecological Services, July 2009. Las Vegas, NV.

Hardy, E. P., P.W. Krey, and H. L. Volchok. 1972. *Global Inventory and Distribution of Pu-238 from SNAP-9A.* Report, HASL-250. United States Atomic Energy Commission, New York, NY.

Jorgensen, C. D. and C. L. Hayward. 1965. "Mammals of the Nevada Test Site." *Brigham Young University Science Bulletin*. 6(3):1-81.

Luckenbach, R.A. 1982. "Ecology and Management of the Desert Tortoise (*Gopherus agassizii*) in California." In R.B. Bury (Ed.), *North American Tortoises: Conservation and Ecology* (pp 1-37). Fish and Wildlife Service, Wildlife Research Report 12. Washington, D.C. U.S. Fish and Wildlife Service.

NAC, see Nevada Administrative Code.

National Oceanic and Atmospheric Administration, Air Resources Laboratory/Special Operations and Research Division, 2013. Nevada Test Site (NTS) Climatological Rain Gauge Network. Available at: http://www.sord.nv.doe.gov/home_climate_rain.htm. North Las Vegas, NV. [Accessed May 15, 2013]

National Security Technologies, LLC. 2015. *Nevada Test Site Environmental Report 2014*. DOE/NV/25946--2566, prepared for U.S. Department of Energy, National Nuclear Security Administration Nevada Field Office, September 2015. Las Vegas, NV.

National Security Technologies, LLC. 2007. *Ecological Monitoring and Compliance Program 2006 Report*. DOE/NV/25946--174. March 2007. Las Vegas, NV.

Nevada Administrative Code. 2016. Chapter 503 - Hunting, Fishing and Trapping; Miscellaneous Protective Measures. Available at: http://www.leg.state.nv.us/NAC/NAC-503.html Carson City, NV. [Accessed January 11, 2016]

Nevada Native Plant Society. 2016. Status Lists. Maintained at Nevada Natural Heritage Program. Available at: http://heritage.nv.gov/lists/nnnpstat. Carson City, NV. [Accessed January 11, 2016].

Nevada Natural Heritage Program. 2016. Animal and Plant At-Risk Tracking List, November 2010. Maintained by the Nevada Natural Heritage Program. Available at: http://heritage.nv.gov/sites/default/files/library/track.pdf Carson City, NV. [Accessed on January 11, 2016]

NNHP, see Nevada Natural Heritage Program.

NNPS, see Nevada Native Plant Society.

NOAA, see National Oceanic and Atmospheric Administration.

NSTec, see National Security Technologies, LLC.

Nussear, K. E., T. C. Esque, R. D. Inman, L. Gass, K. A. Thomas, C. S. A. Wallace, J. B. Blainey, D. M. Miller, and R. H. Webb. 2009. *Modeling Habitat of the Desert Tortoise (Gopherus Agassizii) in the Mojave and Parts of the Sonoran Deserts of California, Nevada, Utah, and Arizona.* U.S. Geological Survey Open File Report 2009-1102, 18 p.

Ostler, W. K., D. J. Hansen, D. C. Anderson, and D. B. Hall. 2000. *Classification of Vegetation on the Nevada Test Site.* DOE/NV/11718--477, Bechtel Nevada, Ecological Services, December 6, 2000. Las Vegas, NV.

Ostler, W. K., D. C. Anderson, D. B. Hall, and D. J. Hansen. 2002. *New Technologies to Reclaim Arid Lands User's Manual.* DOE/NV/11718--731. Bechtel Nevada Ecological Services, Las Vegas, NV.

Peterson, F. F. 1981. "Landforms of the Basin & Range Province Defined for Soil Survey." Technical Bulletin 28, Nevada Agricultural Experiment Station, January 1981. University of Nevada, Reno.

Saethre, M. B. 1994. "Trends in Small Mammal Populations on the Nevada Test Site, 1992." DOE/NV/11432-58. In: *Status of the Flora and Fauna on the Nevada Test Site, 1992*. Hunter, R. B. compiler, pp. 84-143.

UNSCEAR. 2008. Sources and Effects of Ionizing Radiation. UNSCEAR 2008 Report Volume I, Annex B. United Nations Scientific Committee on the Effects of Atomic Radiation, United Nations, New York, NY.

U.S. Department of Energy (DOE) Order DOE O 231.1B, "Environment, Safety, and Health Reporting."

U.S. Department of Energy, Nevada Operations Office. 1996. *Final Environmental Impact Statement for the Nevada Test Site and Off-Site Locations in the State of Nevada*. Volume 1, Chapters 1–9, DOE/EIS--0243, August 1996. Las Vegas, NV.

U.S. Department of Energy, Nevada Operations Office. 1998. *Nevada Test Site Resource Management Plan.* DOE/NV--518, December 1998. Las Vegas, NV.

U.S. Executive Order EO 13112, "Invasive Species." February 3, 1999.

U.S. Fish and Wildlife Service. 1996. *Final Programmatic Biological Opinion for Nevada Test Site Activities.* File No. 1-5-96-F-33, August 22, 1996. Reno, NV.,

U.S. Fish and Wildlife Service. 2009. Final Programmatic Biological Opinion for Implementation of Actions on the Nevada Test Site, Nye County Nevada. File No. 84320-2008-F-0416 and 84320-2008-B-0015. February 12, 2009. Las Vegas, NV.

U.S. Fish and Wildlife Service. 2016. Endangered Species Program Home Page. Maintained at: http://www.fws.gov/endangered. [Accessed January 11, 2016]

Webb, R.H., M.B. Murov, T.C. Esque, D.E. Boyer, L.A. DeFalco, D.F. Haines, D. Oldershaw, S.J. Scoles, K.A. Thomas, J.B. Blainey and P.A. Medica. 2003. *Perennial Vegetation Data from Permanent Plots on the Nevada Test Site, Nye County, Nevada.* U.S. Geological Survey, Open-File Report 03-336. Tucson, Arizona.

Weinstein, M. N. 1989. "Modeling Desert Tortoise Habitat: Can a Useful Management Tool Be Developed from Existing Transect Data?" Los Angeles, University of California, unpublished Ph.D. dissertation.

Wills, C. A., and W. K. Ostler. 2001. *Ecology of the Nevada Test Site: An Annotated Bibliography, with Narrative Summary, Keyword Index, and Species Lists.* DOE/NV/11718--594, Bechtel Nevada, Ecological Services, September 2001. Las Vegas, NV.

9.0 APPENDICES

Appendix A: Percent Cover Data by Plant Species and Inorganic Material for Select Long-Term Monitoring Plots

Appendix B: Plant Density Data for Select Long-Term Monitoring Plots

Appendix C: Species Alphacodes with Corresponding Scientific and Common Names

This Page Intentionally Left Blank

APPENDIX A

Percent Cover Data by Plant Species and Inorganic Material for Select Long-Term Monitoring Plots

Percent cover data by species from ARNO (2009), ARTR (2009), and PIMO-ARNO (2015) long-term vegetation monitoring plots. P = Perennial, A = Annual. Species codes are identified in Appendix C.

	ARNO1	ARNO2	ARNO3	ARNO4	ARNO5	ARNO6	ARNO7	ARNO8
SHRUBS								
ARNO								
1	12	20	16	7	11	7	21	26
2	12	21	11	12	14	25	23	27
3	10	16	11	8	26	21	37	18
4	12	22	13	10	8	24	22	21
5	13	9	18	10	16	25	22	22
Mean	11.8	17.6	13.8	9.4	15.0	20.4	25.0	22.8
ARTR								
1	2							
2								

	ARNO1	ARNO2	ARNO3	ARNO4	ARNO5	ARNO6	ARNO7	ARNO8
3								
4								
5								
Mean	0.4							

ATCA

1					1			
2	1							
3						2		
4								
5								
Mean	0.2				0.2	0.4		

CHVIV

Total			3		14		5	
Mean			0.6		2.8		1.0	

	ARNO1	ARNO2	ARNO3	ARNO4	ARNO5	ARNO6	ARNO7	ARNO8
EPNE								
1		4	3		2		1	
2		2	4	2	1	3	1	
3	6	3	9			1		
4		3	3	3	2		1	
5		1	4	6	5		2	1
Mean	1.2	2.6	4.6	2.2	2.0	0.8	1.0	0.2
ERCO23								
Total		4						
Mean		0.8						
ERNAL								
Total		3		2				
Mean		0.6		0.4				

		ARNO1	ARNO2	ARNO3	ARNO4	ARNO5	ARNO6	ARNO7	ARNO8
GRSP									
	Total			1	1	3	1		
	Mean			0.2	0.2	0.6	0.2		
KRLA									
	Total			1		1			
	Mean			0.2		0.2			
LYAN									
	Total	1	3	2		3	2		
	Mean	0.2	0.6	0.4		0.6	0.4		
PIDE									
	Total		2						
	Mean		0.4						
	Total Shrub Cover	**13.8**	**22.6**	**19.8**	**12.2**	**21.4**	**22.2**	**27.0**	**23.0**

P. GRASSES

ELEL

	ARNO1	ARNO2	ARNO3	ARNO4	ARNO5	ARNO6	ARNO7	ARNO8
1				1				2
2						1		1
3		1				2		
4	1	1				1		
5		1				3		4
Mean	0.2	0.6		0.2		1.4		1.4

ACHY

	ARNO1	ARNO2	ARNO3	ARNO4	ARNO5	ARNO6	ARNO7	ARNO8
Total						2	1	1
Mean						0.4	0.2	0.2

ACSP

	ARNO1	ARNO2	ARNO3	ARNO4	ARNO5	ARNO6	ARNO7	ARNO8
Total		1			1			
Mean		0.2			0.2			

	ARNO1	ARNO2	ARNO3	ARNO4	ARNO5	ARNO6	ARNO7	ARNO8
PLJA								
Total		13				3		1
Mean		2.6				0.6		0.2
POSE								
Total						1		16
Mean						0.2		3.2
Total P. Grass	**0.2**	**3.4**	**0.0**	**0.2**	**0.2**	**2.6**	**0.2**	**5.0**

P. FORBS

	ARNO1	ARNO2	ARNO3	ARNO4	ARNO5	ARNO6	ARNO7	ARNO8
PHST								
Total							1	1
Mean							0.2	0.2

	ARNO1	ARNO2	ARNO3	ARNO4	ARNO5	ARNO6	ARNO7	ARNO8
SPAM								
Total					1			
Mean					0.2			
Total P. Forbs	**0.0**	**0.0**	**0.0**	**0.0**	**0.2**	**0.0**	**0.2**	**0.2**
TOTAL PERENNIALS	**14.0**	**26.0**	**19.8**	**12.4**	**21.8**	**24.8**	**27.4**	**28.2**

A. GRASSES

BRRU

1	4		1	3				
2	6		1	3				
3	9	1	6	5	1			
4	5	2	2	3	2			
5	7		2	5	1			
Mean	6.2	0.6	2.4	3.8	0.8			

	ARNO1	ARNO2	ARNO3	ARNO4	ARNO5	ARNO6	ARNO7	ARNO8
BRTE								
Total	3		1					
Mean	0.6		0.2					
Total A. Grasses	**6.8**	**0.6**	**2.6**	**3.8**	**0.8**	**0.0**	**0.0**	**0.0**
A. FORBS								
AMTE								
Total	1		1					
Mean	0.2		0.2					
CHFR								
Total					4			
Mean					0.8			
CHST								
Total			1					
Mean			0.2					

	ARNO1	ARNO2	ARNO3	ARNO4	ARNO5	ARNO6	ARNO7	ARNO8
CRCI								
Total	1							
Mean	0.2							
ERNI								
Total				1				
Mean				0.2				
SYFR								
Total	2							
Mean	0.4							
Total A. Forbs	**0.8**	**0.0**	**0.4**	**0.2**	**0.8**	**0.0**	**0.0**	**0.0**
Total Vegetative Cover	**21.6**	**26.6**	**22.8**	**16.4**	**23.4**	**24.8**	**27.4**	**28.2**
Litter								
1	28	19	17	22	22	8	23	15
2	36	20	16	20	12	11	12	13

	ARNO1	ARNO2	ARNO3	ARNO4	ARNO5	ARNO6	ARNO7	ARNO8
3	33	26	16	29	17	15	10	11
4	26	21	24	15	25	7	19	13
5	34	17	19	23	20	11	24	8
Mean	31.4	20.6	18.4	21.8	19.2	10.4	17.6	12.0
Bare ground								
1	10	12	14	8	8	10	8	7
2	12	11	14	12	9	13	10	2
3	12	13	5	14	10	7	10	2
4	10	5	8	12	12	8	16	12
5	3	8	9	16	3	5	5	7
Mean	9.4	9.8	10.0	12.4	8.4	8.6	9.8	6.0
Gravel								
1	39	33	43	45	46	65	35	47
2	25	16	43	40	51	38	40	52

	ARNO1	ARNO2	ARNO3	ARNO4	ARNO5	ARNO6	ARNO7	ARNO8
3	24	28	43	36	41	46	40	58
4	39	25	39	46	45	48	29	50
5	36	25	37	32	48	47	34	52
Mean	32.6	25.4	41.0	39.8	46.2	48.8	35.6	51.8
Cobble								
1	1	2	1	10	1	3	3	1
2	6	8	3	7	5	3	5	
3	3	7	8	3	1	3	3	1
4	3	7	3	1	2	1	6	
5	5	10	8	6	2	3	7	2
Mean	3.6	6.8	4.6	5.4	2.2	2.6	4.8	0.8
Rock								
1	1	9	3	4	1	7	8	1
2	2	15	4	1	1	3	4	1
3	1	4	2	5		2		3

	ARNO1	ARNO2	ARNO3	ARNO4	ARNO5	ARNO6	ARNO7	ARNO8
4	2	9	5	9		7	6	
5	1	17	2	2	1	5	6	1
Mean	1.4	10.8	3.2	4.2	0.6	4.8	4.8	1.2

	ARTR1	ARTR2	ARTR3	ARTR4	ARTR5	ARTR6	ARTR7	ARTR8	ARTR9	ARTR10	ARTR11
Shrubs											
ARNO											
1		5									
2		3									
3											
4											
5											
Mean		1.6									
ARTR											
1	33	26	9	23	17	18	13	18	15	16	24
2	17	13	7	22	16	20	18	15	21	34	17
3	18	26	6	26	13	21	12	18	14	28	16
4	22	20	1	31	9	22	12	14	13	20	17
5	22	19	11	29	15	21	12	11	20	22	14
Mean	22.4	20.8	6.8	26.2	14.0	20.4	13.4	15.2	16.6	24.0	17.6

	ARTR1	ARTR2	ARTR3	ARTR4	ARTR5	ARTR6	ARTR7	ARTR8	ARTR9	ARTR10	ARTR11
ATCA											
1											
2											
3					2			4			
4											
5											
Mean					0.4			0.8			
EPNE											
1			10		4		1		3	1	
2			6		1		11		1	1	1
3			5						8		3
4			6		1		3		9		1
5			1		9		1		5		2
Mean			5.6		3.0		3.2		5.2	0.4	1.4
CHVIV											
Total	13	4		25	2	20	5	13			
Mean	2.6	0.8		5.0	0.4	4.0	1.0	2.6			

	ARTR1	ARTR2	ARTR3	ARTR4	ARTR5	ARTR6	ARTR7	ARTR8	ARTR9	ARTR10	ARTR11
ERLI											
Total							1				
Mean							0.2				
ERNAL											
Total				1							
Mean				0.2							
GRSP											
Total					2		2		8		5
Mean					0.4		0.4		1.6		1.0
JUOS											
Total							3				1
Mean							0.6				0.2
LEPU											
Total	9			17		1					
Mean	1.8			3.4		0.2					

	ARTR1	ARTR2	ARTR3	ARTR4	ARTR5	ARTR6	ARTR7	ARTR8	ARTR9	ARTR10	ARTR11
PUTR											
Total	1										
Mean	0.2										
TECA											
Total				14							
Mean				2.8							
TEGL											
Total					1						
Mean					0.2						
Total Shrub Cover	**27.0**	**23.2**	**12.4**	**37.6**	**18.4**	**24.6**	**18.8**	**18.6**	**23.4**	**24.4**	**20.2**

P. GRASSES

ELEL

	ARTR1	ARTR2	ARTR3	ARTR4	ARTR5	ARTR6	ARTR7	ARTR8	ARTR9	ARTR10	ARTR11
1	3	1	1		4			1	1	1	5
2	2	3	1		5	1	3	5	2		7
3	4	1			2		1	1	1		6
4	3	1			1		1	2		1	3

	ARTR1	ARTR2	ARTR3	ARTR4	ARTR5	ARTR6	ARTR7	ARTR8	ARTR9	ARTR10	ARTR11
5	1	1				1		5			8
Mean	2.6	1.4	0.4		2.4	0.4	1.0	2.8	0.8	0.4	5.8
ACHY											
Total		3		4							4
Mean		0.6		0.8							0.8
ACPA											
Total	1										
Mean	0.2										
ACSP											
Total			27				3				
Mean			5.4				0.6				
HECO											
Total	18	14		7		16					
Mean	3.6	2.8		1.4		3.2					
PLJA											
Total		6			1						4
Mean		1.2			0.2						0.8

	ARTR1	ARTR2	ARTR3	ARTR4	ARTR5	ARTR6	ARTR7	ARTR8	ARTR9	ARTR10	ARTR11
POSE											
Total	1						1				7
Mean	0.2						0.2				1.4
Total P. Grass	**6.6**	**6.0**	**5.8**	**2.2**	**2.6**	**3.6**	**1.8**	**2.8**	**0.8**	**0.4**	**8.8**
P. FORBS											
ASSPP											
Total			1								
Mean			0.2								
CALI											
Total				3							
Mean				0.6							
ERNU											
Total				6							
Mean				1.2							

	ARTR1	ARTR2	ARTR3	ARTR4	ARTR5	ARTR6	ARTR7	ARTR8	ARTR9	ARTR10	ARTR11
EROV											
Total	1					1					
Mean	0.2					0.2					
ERRA											
Total	1										
Mean	0.2										
LUAR											
Total				5							
Mean				1							
LUCA											
Total	4			4							
Mean	0.8			0.8							
MOSS											
Total		1			1					1	
Mean		0.2			0.2					0.2	

	ARTR1	ARTR2	ARTR3	ARTR4	ARTR5	ARTR6	ARTR7	ARTR8	ARTR9	ARTR10	ARTR11
PHST											
Total	10		3			1					1
Mean	2		0.6			0.2					0.2
POSU											
Total	1										
Mean	0.2										
SEMU											
Total	1										
Mean	0.2										
SPAM											
Total			1								
Mean			0.2								
Total P. Forbs	**3.6**	**0.2**	**1.0**	**3.6**	**0.2**	**0.4**	**0.0**	**0.0**	**0.0**	**0.2**	**0.2**
TOTAL PERENNI-ALS	**37.2**	**29.4**	**19.2**	**43.4**	**21.2**	**28.6**	**20.6**	**21.4**	**24.2**	**25.0**	**29.2**

A. GRASSES

BRRU

	ARTR1	ARTR2	ARTR3	ARTR4	ARTR5	ARTR6	ARTR7	ARTR8	ARTR9	ARTR10	ARTR11
1			7				6				
2			12								
3			13								
4			9				10				
5			13								
Mean			10.8				3.2				

BRTE

	ARTR1	ARTR2	ARTR3	ARTR4	ARTR5	ARTR6	ARTR7	ARTR8	ARTR9	ARTR10	ARTR11
Total			20		2		20				
Mean			4.0		0.4		4.0				

	ARTR1	ARTR2	ARTR3	ARTR4	ARTR5	ARTR6	ARTR7	ARTR8	ARTR9	ARTR10	ARTR11
Total A. Grasses	**0.0**	**0.0**	**14.8**	**0.0**	**0.4**	**0.0**	**7.2**	**0.0**	**0.0**	**0.0**	**0.0**

	ARTR1	ARTR2	ARTR3	ARTR4	ARTR5	ARTR6	ARTR7	ARTR8	ARTR9	ARTR10	ARTR11

A.FORBS

AMTE

Total							1				
Mean							0.2				

CETH

Total					1			1			
Mean					0.2			0.2			

CHAL

Total					1						
Mean					0.2						

CHFR

Total								6	3		
Mean								1.2	0.6		

CHMA

Total					1						
Mean					0.2						

	ARTR1	ARTR2	ARTR3	ARTR4	ARTR5	ARTR6	ARTR7	ARTR8	ARTR9	ARTR10	ARTR11
ERER											
Total	15				1	1		9			
Mean	3.0				0.2	0.2		1.8			
ERNI											
Total								4			
Mean								0.8			
GARA											
Total	1										
Mean	0.2										
GISPP											
Total	2										
Mean	0.4										
MACA											
Total					1						
Mean					0.2						

	ARTR1	ARTR2	ARTR3	ARTR4	ARTR5	ARTR6	ARTR7	ARTR8	ARTR9	ARTR10	ARTR11
STEX											
Total								5			
Mean								1.0			
Total A. Forbs	**3.6**	**0.0**	**0.0**	**0.0**	**1.0**	**0.2**	**0.2**	**5.0**	**0.6**	**0.0**	**0.0**
Total Cover	**40.8**	**29.4**	**34.0**	**43.4**	**22.6**	**28.8**	**28.0**	**26.4**	**24.8**	**25.0**	**29.2**
Litter											
1	31	24	31	36	23	21	17	30	30	27	22
2	38	29	37	25	14	14	16	21	19	20	16
3	24	18	36	27	28	7	18	27	25	19	13
4	34	25	34	29	34	13	26	25	34	33	18
5	39	26	22	27	27	14	20	26	27	24	21
Mean	33.2	24.4	32.0	28.8	25.2	13.8	19.4	25.8	27.0	24.6	18.0
Bare ground											
1	15	19	3	4	16	30	11	5	9	12	13
2	20	28	3	27	22	19	9	6	8	17	7
3	30	28	10	24	19	26	14	6	10	9	6

	ARTR1	ARTR2	ARTR3	ARTR4	ARTR5	ARTR6	ARTR7	ARTR8	ARTR9	ARTR10	ARTR11
4	21	36	5	5	14	31	5	8	8	6	9
5	20	34	3	11	10	16	9	9	6	9	7
Mean	21.2	29.0	4.8	14.2	16.2	24.4	9.6	6.8	8.2	10.6	8.4
Gravel											
1	4	19	28	20	35	22	48	42	39	40	29
2	4	20	21	4	40	24	35	42	44	27	47
3	4	16	23	8	30	31	39	31	42	41	51
4	7	12	35	19	36	23	42	48	33	34	44
5	5	15	38	16	35	29	44	42	41	44	37
Mean	4.8	16.4	29.0	13.4	35.2	25.8	41.6	41.0	39.8	37.2	41.6
Cobble											
1		1				1				2	
2					1	8	1			1	1
3					1	5				3	1
4				1	1	2	1			4	
5		1	1		1	3	1			1	
Mean		0.4	0.2	0.2	0.8	3.8	0.6			2.2	0.4

Rock

	ARTR1	ARTR2	ARTR3	ARTR4	ARTR5	ARTR6	ARTR7	ARTR8	ARTR9	ARTR10	ARTR11
1		1				3				1	1
2						3	1		1		2
3		1				1	1				1
4						4				1	4
5						6	2				4
Mean		0.4				3.4	0.8		0.2	0.4	2.4

		PIMO-ARNO1	PIMO-ARNO2	PIMO-ARNO3	PIMO-ARNO4	PIMO-ARNO5	PIMO-ARNO6	PIMO-ARNO7	PIMO-ARNO8	PIMO-ARNO09	PIMO-ARNO10
ARNO											
	1	6	7	3	5	3	5	3	2	8	5
	2	3	6	4	5	3	3	6	4	2	1
	3	7	3	2	3		1	8	2	4	5
	4	8	2	1		2	9	9	2	3	6
	5	3	6	2		1	4	2		9	5
	Mean	5.4	4.8	2.4	4.3	1.8	4.4	5.6	2.0	5.2	4.4
ARTR											
				1							
				0.2							
CHVIS											
	1		1								
	2	1		1							
	3		1	1		1		1			
	4										

		PIMO-ARNO1	PIMO-ARNO2	PIMO-ARNO3	PIMO-ARNO4	PIMO-ARNO5	PIMO-ARNO6	PIMO-ARNO7	PIMO-ARNO8	PIMO-ARNO09	PIMO-ARNO10
	5		2								
	Mean	0.2	0.8	0.4		0.2		0.2			
EPVI											
	Total		4						4		2
	Mean		0.8						0.8		0.4
ERCA											
	1				1	1					
	2	1				1					
	3	1						1			
	4	2		1							
	5										
	Mean	0.8		0.2	0.3	0.4		0.2			
ERMIL											
					1						
					0.3						

	PIMO-ARNO1	PIMO-ARNO2	PIMO-ARNO3	PIMO-ARNO4	PIMO-ARNO5	PIMO-ARNO6	PIMO-ARNO7	PIMO-ARNO8	PIMO-ARNO09	PIMO-ARNO10
ERNAL										
Total		4						10	1	
Mean		0.8						2	0.2	
JUOS										
1	9	1	7		12	7	2		3	4
2	11	3	4	1	7		8	7	14	3
3	9	5	7		14	7	6	5	8	1
4	6	8	5		6		3	4	3	
5	10	6			5	1	11		7	
Mean	9.0	4.6	4.6	0.3	8.8	3.0	6.0	3.2	7.0	1.6
LEPU										
Total		4								
Mean		0.8								
OPPO										
Total		3		1	5		1			1
Mean		0.6		0.3	1		0.2			0.2

	PIMO-ARNO1	PIMO-ARNO2	PIMO-ARNO3	PIMO-ARNO4	PIMO-ARNO5	PIMO-ARNO6	PIMO-ARNO7	PIMO-ARNO8	PIMO-ARNO09	PIMO-ARNO10
PIMO										
1	7	1	21	22	8	6	27	1	12	19
2	12	8	11	8	10	9	35	4	8	23
3	6	18	4	9	15	22	18	8	8	25
4	1	9	8		24	9	19	10	15	25
5	3	1	8		18	1	28	16	4	20
Mean	5.8	7.4	10.4	13.0	15.0	9.4	25.4	7.8	9.4	22.4
PUST										
1			2				8	5	2	
2		3	2				1	2	6	
3	2	4	3					6	4	
4	2		7		4		6	9		
5		3					1	10		
Mean	0.8	2.0	2.8		0.8		3.2	6.4	2.4	

		PIMO-ARNO1	PIMO-ARNO2	PIMO-ARNO3	PIMO-ARNO4	PIMO-ARNO5	PIMO-ARNO6	PIMO-ARNO7	PIMO-ARNO8	PIMO-ARNO09	PIMO-ARNO10
PUTR											
	1	1			1	3	6				
	2	3			2	1	1				
	3						2				
	4	4					5				
	5	2					13				
	Mean	2.0			1.0	0.8	5.4				
QUGA											
	Total				5		6				
	Mean				1.7		1.2				
RICE											
	Total					3					
	Mean					0.6					
SYLO											
	Total								2		
	Mean								0.4		

	PIMO-ARNO1	PIMO-ARNO2	PIMO-ARNO3	PIMO-ARNO4	PIMO-ARNO5	PIMO-ARNO6	PIMO-ARNO7	PIMO-ARNO8	PIMO-ARNO09	PIMO-ARNO10
YUBA										
Total			2							
Mean			0.4							
Total Woody	**24.0**	**22.6**	**21.4**	**21.3**	**29.4**	**23.4**	**40.8**	**22.6**	**24.2**	**29.0**
P. GRASSES										
ELEL										
1										
2			1			1				
3				1		1			1	
4			1						1	
5			2							
Mean			0.8	0.3		0.4			0.4	
ACHY										
Total		2								
Mean		0.4								

		PIMO-ARNO1	PIMO-ARNO2	PIMO-ARNO3	PIMO-ARNO4	PIMO-ARNO5	PIMO-ARNO6	PIMO-ARNO7	PIMO-ARNO8	PIMO-ARNO09	PIMO-ARNO10
ACPI											
	Total				2						
	Mean				0.7						
PLJA											
	Total										1
	Mean										0.2
HECO											
	Total			1							
	Mean			0.2							
POFE											
	Total			3	2						
	Mean			0.6	0.7						
POSE											
	Total	2	2	1		8	14	1			
	Mean	0.4	0.4	0.2		1.6	2.8	0.2			
Total P. Grass		**0.4**	**0.8**	**1.8**	**1.7**	**1.6**	**3.2**	**0.2**	**0.0**	**0.4**	**0.2**

	PIMO-ARNO1	PIMO-ARNO2	PIMO-ARNO3	PIMO-ARNO4	PIMO-ARNO5	PIMO-ARNO6	PIMO-ARNO7	PIMO-ARNO8	PIMO-ARNO09	PIMO-ARNO10
P. FORBS										
ARKI										
Total									1	
Mean									0.2	
CAAP										
Total					2					
Mean					0.4					
PEHU										
Total						1				
Mean						0.2				
PEPU										
Total						5			2	
Mean						1.0			0.4	

	PIMO-ARNO1	PIMO-ARNO2	PIMO-ARNO3	PIMO-ARNO4	PIMO-ARNO5	PIMO-ARNO6	PIMO-ARNO7	PIMO-ARNO8	PIMO-ARNO09	PIMO-ARNO10
STCO										
Total					1	1				
Mean					0.2	0.2				
STLE										
Total						2				
Mean						0.4				
Total P. Forbs					**0.6**	**1.8**			**0.6**	
Total Perennials	**24.4**	**23.4**	**23.2**	**23.0**	**31.6**	**28.4**	**41.0**	**22.6**	**25.2**	**29.2**

A. GRASSES

	PIMO-ARNO1	PIMO-ARNO2	PIMO-ARNO3	PIMO-ARNO4	PIMO-ARNO5	PIMO-ARNO6	PIMO-ARNO7	PIMO-ARNO8	PIMO-ARNO09	PIMO-ARNO10
BRTE										
1										
2					2					
3										
4										

	PIMO-ARNO1	PIMO-ARNO2	PIMO-ARNO3	PIMO-ARNO4	PIMO-ARNO5	PIMO-ARNO6	PIMO-ARNO7	PIMO-ARNO8	PIMO-ARNO09	PIMO-ARNO10
5										
Mean					0.4					
Total A. Grasses	**0.0**	**0.0**	**0.0**	**0.0**	**0.4**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**

A. FORBS

Total A. Forbs	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
Total Understory Cover	**24.4**	**23.4**	**23.2**	**23.0**	**32.0**	**28.4**	**41.0**	**22.6**	**25.2**	**29.2**
Total Overstory Cover	**9.8**	**17.0**	**19.4**	**20.0**	**30.2**	**22.8**	**10.6**	**15.0**	**18.8**	**13.8**
Total Vegetative Cover	**31.0**	**31.4**	**34.0**	**34.0**	**46.2**	**42.2**	**45.0**	**32.4**	**34.6**	**35.0**

	PIMO-ARNO1	PIMO-ARNO2	PIMO-ARNO3	PIMO-ARNO4	PIMO-ARNO5	PIMO-ARNO6	PIMO-ARNO7	PIMO-ARNO8	PIMO-ARNO09	PIMO-ARNO10
Litter										
1	49	28	29	18	37	36	22	30	33	18
2	33	30	26	28	42	33	27	34	30	25
3	47	17	33	30	43	51	18	9	22	29
4	22	41	26		29	30	27	38	21	25
5	33	23	51		29	35	25	20	19	24
Mean	36.8	27.8	33.0	25.3	36.0	37.0	23.8	26.2	25.0	24.2
Bare ground										
1	9	9	5	5	3	3	12	2	3	15
2	16	1	5	2	4	6	6	4	4	11
3	10	3	9	1	3	1	11	4	1	7
4	7	3	19		6	6	6	2	1	9
5	6	5	6		6	4	8	3	4	21
Mean	9.6	4.2	8.8	2.7	4.4	4.0	8.6	3.0	2.6	12.6
Gravel										
1	16	21	25	25	11	23	9	25	15	19

	PIMO-ARNO1	PIMO-ARNO2	PIMO-ARNO3	PIMO-ARNO4	PIMO-ARNO5	PIMO-ARNO6	PIMO-ARNO7	PIMO-ARNO8	PIMO-ARNO09	PIMO-ARNO10
2	14	8	34	34	8	19	11	26	25	17
3	16	18	28	33	6	4	20	39	26	11
4	38	13	19		12	31	17	27	21	19
5	37	14	11		16	30	15	29	28	13
Mean	24.2	14.8	23.4	30.7	10.6	21.4	14.4	29.2	23.0	15.8
Cobble										
1		2		4	2		3	5	2	7
2		2	1	9	5	2	1	4	3	2
3		2	1	5	4		2	6	1	4
4	3	1	3		3	2		3	4	3
5	4	4	5		4	2	2	4	4	6
Mean	1.4	2.2	2.0	6.0	3.6	1.2	1.6	4.4	2.8	4.4
Rock										
1	3	29	6	17	13	11	14	23	21	12
2	6	31	11	5	13	13	5	12	8	17
3	2	24	9	15	13	3	13	18	24	16

	PIMO-ARNO1	PIMO-ARNO2	PIMO-ARNO3	PIMO-ARNO4	PIMO-ARNO5	PIMO-ARNO6	PIMO-ARNO7	PIMO-ARNO8	PIMO-ARNO09	PIMO-ARNO10
4	5	20	10		13	5	13	3	29	13
5	2	34	12		14	7	8	17	25	11
Mean	3.6	27.6	9.6	12.3	13.2	7.8	10.6	14.6	21.4	13.8

This Page Intentionally Left Blank

APPENDIX B

Plant Density Data for Select Long-Term Monitoring Plots

Plant density (plants/50 m²) by perennial species from ARNO (2009), ARTR (2009), and PIMO-ARNO (2015) long-term vegetation monitoring plots. Species codes are identified in Appendix C.

	ARNO1				ARNO2				ARNO3			
Species Code	Transect 1	Transect 3	Transect 5	**Mean**	Transect 1	Transect 3	Transect 5	**Mean**	Transect 1	Transect 3	Transect 5	**Mean**
Shrubs												
ARNO	61	46	51	52.7	69	78	56	67.7	27	40	62	43.0
ARTR				0.0				0.0				0.0
ATCA				0.0				0.0				0.0
ATCO				0.0				0.0				0.0
CHVIV				0.0				0.0	9	6	3	6.0
ECEN				0.0	1			0.3				0.0
EPNE		3		1.0	22	21	11	18.0	15	13	14	14.0
ERCO23				0.0		3	19	7.3				0.0
ERMIS				0.0				0.0	1			0.3
ERNAL				0.0		2	1	1.0				0.0

	ARNO1				ARNO2				ARNO3			
Species Code	Transect 1	Transect 3	Transect 5	**Mean**	Transect 1	Transect 3	Transect 5	**Mean**	Transect 1	Transect 3	Transect 5	**Mean**
GRSP		2		0.7	2	4		2.0	10	2	1	4.3
JUOS				0.0				0.0				0.0
KRLA				0.0				0.0	2	3	3	2.7
LEPU				0.0				0.0				0.0
LYAN	1			0.3				0.0	3	1	1	1.7
TEGL				0.0				0.0				0.0
Grasses												
ACHY		7	2	3.0				0.0	1	1		0.7
ACSP		2	3	1.7	10	5	2	5.7				0.0
ARPU9				0.0			2	0.7				0.0
BOGR				0.0				0.0				0.0
ELEL	7	3	2	4.0	16	28	4	16.0			4	1.3
HECO				0.0				0.0				0.0
PLJA				0.0	90	36	151	92.3				0.0
POSE			1	0.3				0.0				0.0

	ARNO1				ARNO2				ARNO3			
Species Code	Transect 1	Transect 3	Transect 5	**Mean**	Transect 1	Transect 3	Transect 5	**Mean**	Transect 1	Transect 3	Transect 5	**Mean**
Forbs												
ARPUG				0.0		1	1	0.7	1			0.3
ASLE				0.0				0.0				0.0
ASPUT				0.0				0.0				0.0
CAAP				0.0				0.0			1	0.3
CAFL	1		1	0.7				0.0				0.0
ERCOC				0.0			27	9.0				0.0
EROV				0.0				0.0				0.0
MACA				0.0				0.0				0.0
PHST				0.0	16	8	13	12.3				0.0
SPAM	1		1	0.7			1	0.3		1		0.3
TOTAL				**65.0**				**233.3**				**75.0**

	ARNO4				ARNO5				ARNO6			
Species Code	Transect 1	Transect 3	Transect 5	**Mean**	Transect 1	Transect 3	Transect 5	**Mean**	Transect 1	Transect 3	Transect 5	**Mean**
Shrubs												
ARNO	35	36	33	34.7	45	62.0	47.0	51.3	177	90.0	140.0	135.7
ARTR				0.0				0.0				0.0
ATCA				0.0	5	1		2.0		1		0.3
ATCO	1			0.3				0.0				0.0
CHVIV	2	1		1.0	27	11	1	13.0				0.0
ECEN				0.0				0.0				0.0
EPNE	2	2	9	4.3	7	1	8	5.3		3	7	3.3
ERCO23				0.0				0.0				0.0
ERMIS				0.0				0.0				0.0
ERNAL				0.0				0.0				0.0
GRSP	1	1	1	1.0	2	1	3	2.0		1		0.3
JUOS				0.0				0.0				0.0
KRLA				0.0			1	0.3				0.0
LEPU				0.0				0.0				0.0

	ARNO4				ARNO5				ARNO6			
Species Code	Transect 1	Transect 3	Transect 5	**Mean**	Transect 1	Transect 3	Transect 5	**Mean**	Transect 1	Transect 3	Transect 5	**Mean**
LYAN		1		0.3	1	1	3	1.7				0.0
TEGL		1		0.3				0.0				0.0
Grasses												
ACHY	1			0.3		2		0.7	4	6	19	9.7
ACSP				0.0		2		0.7				0.0
ARPU9				0.0				0.0				0.0
BOGR				0.0				0.0				0.0
ELEL	13	5	10	9.3	5	2	1	2.7	40	39	65	48.0
HECO				0.0				0.0				0.0
PLJA				0.0				0.0		17		5.7
POSE				0.0				0.0	2			0.7
Forbs												
ARPUG				0.0				0.0			1	0.3
ASLE				0.0				0.0				0.0
ASPU				0.0				0.0	2			0.7
CAAP				0.0				0.0			1	0.3

	ARNO4				ARNO5				ARNO6			
Species Code	Transect 1	Transect 3	Transect 5	**Mean**	Transect 1	Transect 3	Transect 5	**Mean**	Transect 1	Transect 3	Transect 5	**Mean**
CAFL	1			0.3				0.0	1		2	1.0
ERCOC				0.0				0.0			1	0.3
EROV				0.0				0.0			2	0.7
MACA				0.0				0.0				0.0
PHST				0.0				0.0			1	0.3
SPAM				0.0			2	0.7				0.0
TOTAL				**52.0**				**80.3**				**206.7**

	ARNO7				ARNO8			
Species Code	Transect 1	Transect 3	Transect 5	**Mean**	Transect 1	Transect 3	Transect 5	**Mean**
Shrubs								
ARNO	131	126	101	119.3	131	127	119	125.7
ARTR				0.0			1	0.3
ATCA				0.0				0.0
ATCO				0.0				0.0
CHVIP			2	0.7				0.0
CHVIV	9			3.0				0.0
ECEN				0.0				0.0
EPNE	3		6	3.0		4	4	2.7
ERCO23				0.0				0.0
ERMIS				0.0				0.0
ERNAL				0.0				0.0
GRSP				0.0	1			0.3
JUOS				0.0			1	0.3
KRLA				0.0				0.0
LEPU				0.0				0.0

	ARNO7				ARNO8			
Species Code	Transect 1	Transect 3	Transect 5	**Mean**	Transect 1	Transect 3	Transect 5	**Mean**
LYAN				0.0				0.0
TEGL				0.0				0.0
Grasses								
ACHY	2	4	2	2.7	6	2	7	5.0
ACSP				0.0				0.0
ARPU9				0.0				0.0
BOGR				0.0				0.0
ELEL	3	27	6	12.0	35	53	75	54.3
HECO				0.0				0.0
PLJA				0.0				0.0
POSE				0.0	215	117	76	136.0
Forbs								
ARPUG				0.0			2	0.7
ASLE				0.0		2		0.7
ASPU				0.0	2	1	2	1.7
CAAP	1		6	2.3		10		3.3

	ARNO7				**ARNO8**			
Species Code	Transect 1	Transect 3	Transect 5	**Mean**	Transect 1	Transect 3	Transect 5	**Mean**
CAFL	1			0.3				0.0
ERCOC				0.0				0.0
EROV				0.0				0.0
MACA				0.0		1		0.0
PHST	3			1.0	2	6	18	8.7
SPAM				0.0				0.0
TOTAL				**144.0**				**340.0**

	ARTR-01				ARTR-02				ARTR-03			
Species Code	Transect 1	Transect 3	Transect 5	**Mean**	Transect 1	Transect 3	Transect 5	**Mean**	Transect 1	Transect 3	Transect 5	**Mean**
Shrubs												
ARNO				0.0	35	9	3	15.7				0.0
ARTR	107	74	64	81.7	82	87	84	84.3	33	10	16	19.7
ATCA				0.0				0.0				0.0
ATCO				0.0				0.0				0.0
CHVIV	31	10	24	21.7	38	15	2	18.3				0.0
CHVIP				0.0				0.0				0.0
CORA				0.0				0.0	1			0.3
EPNE				0.0				0.0	19	5	1	8.3
EPVI				0.0				0.0				0.0
ERCO23				0.0				0.0				0.0
ERLI				0.0				0.0				0.0
ERMIS				0.0				0.0				0.0
ERNAL				0.0				0.0				0.0
GRSP				0.0				0.0				0.0
JUOS				0.0				0.0				0.0

	ARTR-01				ARTR-02				ARTR-03			
Species Code	Transect 1	Transect 3	Transect 5	**Mean**	Transect 1	Transect 3	Transect 5	**Mean**	Transect 1	Transect 3	Transect 5	**Mean**
KRLA				0.0	1			0.3				0.0
LEPU	7	5	5	5.7			1	0.3				0.0
LYAN				0.0				0.0				0.0
OPPO				0.0				0.0				0.0
PUTR			1	0.3				0.0				0.0
TEGL				0.0				0.0				0.0
Grasses												
ACHY	1	1		0.7	26	7	1	11.3			2	0.7
ACSP				0.0				0.0	34	36	24	31.3
ARPU9				0.0				0.0				0.0
BOGR	40			13.3				0.0				0.0
ELEL	35	34	26	31.7	64	33	60	52.3	16	10	7	11.0
HECO	67	60	73	66.7	45	53	61	53.0				0.0
PLJA				0.0		103	126	76.3				0.0
POSE		1		0.3				0.0				0.0

	ARTR-01				ARTR-02				ARTR-03			
Species Code	Transect 1	Transect 3	Transect 5	**Mean**	Transect 1	Transect 3	Transect 5	**Mean**	Transect 1	Transect 3	Transect 5	**Mean**
Forbs												
AGGL	48		116	54.7				0.0				0.0
ARPUG				0.0				0.0				0.0
ASCA	1			0.3				0.0		2		0.7
ASLE				0.0			1	0.3	4		6	3.3
ASPUT				0.0				0.0				0.0
CAAP				0.0				0.0				0.0
CAFL				0.0		2		0.7				0.0
CALI				0.0				0.0				0.0
CHAL				0.0				0.0				0.0
CRCO		4		1.3				0.0				0.0
CRFL				0.0	3			1.0				0.0
ERCA		4		1.3		1		0.3				0.0
ERCOC				0.0				0.0				0.0
ERCO18				0.0				0.0				0.0
ERNU				0.0				0.0				0.0

	ARTR-01				ARTR-02				ARTR-03			
Species Code	Transect 1	Transect 3	Transect 5	**Mean**	Transect 1	Transect 3	Transect 5	**Mean**	Transect 1	Transect 3	Transect 5	**Mean**
EROV	12			4.0				0.0				0.0
ERRA	18	6	3	9.0				0.0				0.0
ERUM		5	6	3.7				0.0				0.0
LUCA	12	2	8	7.3				0.0				0.0
MACA				0.0				0.0				0.0
PHST	187	213	138	179.3	4	1		1.7	114	119	4	79.0
POSU	1	5	3	3.0				0.0				0.0
SEMU	2	5		1.7				0.0				0.0
SPAM				0.0				0.0	8	15	14	12.3
TOTAL				**488.3**				**316.0**				**166.7**

	ARTR-04				ARTR-05				ARTR-06			
Species Code	Transect 1	Transect 3	Transect 5	**Mean**	Transect 1	Transect 3	Transect 5	**Mean**	Transect 1	Transect 3	Transect 5	**Mean**
Shrubs												
ARNO				0.0				0.0				0.0
ARTR	49	43	34	42.0	65	34	27	42.0	94	67	78	79.7
ATCA				0.0	1	1		0.7				0.0
ATCO				0.0				0.0				0.0
CHVIP				0.0				0.0	39	16	30	28.3
CHVIV	42	24	20	28.7			14	4.7				
CORA				0.0				0.0				0.0
EPNE				0.0	7	2	21	10.0				0.0
EPVI												
ERCO23				0.0				0.0				0.0
ERLI												
ERMIS				0.0				0.0				0.0
ERNAL	2			0.7				0.0				0.0
GRSP				0.0		2	4	2.0				0.0
JUOS				0.0				0.0				0.0

	ARTR-04				ARTR-05				ARTR-06			
Species Code	Transect 1	Transect 3	Transect 5	**Mean**	Transect 1	Transect 3	Transect 5	**Mean**	Transect 1	Transect 3	Transect 5	**Mean**
KRLA				0.0				0.0		1	3	1.3
LEPU	9	15	33	19.0				0.0	1			0.3
LYAN				0.0				0.0				0.0
OPPO									1			0.3
PIDE											4	1.3
TEGL	10	15	5	10.0				0.0				0.0
Grasses												
ACHY	15	41	41	32.3	1	1	2	1.3	4		2	2.0
ACSP				0.0				0.0				0.0
ARPU9				0.0				0.0				0.0
BOGR			69	23.0				0.0				0.0
ELEL				0.0	78	37	10	41.7	11	19	19	16.3
HECO	35	4	4	14.3				0.0	76	46	24	48.7
PLJA				0.0				0.0		1		0.3
POSE				0.0				0.0				0.0

	ARTR-04				ARTR-05				ARTR-06			
Species Code	Transect 1	Transect 3	Transect 5	**Mean**	Transect 1	Transect 3	Transect 5	**Mean**	Transect 1	Transect 3	Transect 5	**Mean**
Forbs												
AGGL				0.0				0.0			2	0.7
ARPUG				0.0				0.0				0.0
ASCA				0.0				0.0				0.0
ASLE				0.0				0.0	4	1		1.7
ASPUT				0.0				0.0				0.0
CAAP				0.0				0.0			1	0.3
CAFL				0.0				0.0				0.0
CALI	11	1	3	5.0				0.0				0.0
CHAL				0.0	42			14.0				0.0
CRCO				0.0				0.0				0.0
CRFL				0.0				0.0				0.0
ERCA				0.0				0.0				0.0
ERCOC				0.0				0.0	7	12	3	7.3
ERCO18				0.0				0.0				0.0
ERNU	2	8	7	5.7				0.0				0.0

	ARTR-04				ARTR-05				ARTR-06			
Species Code	Transect 1	Transect 3	Transect 5	**Mean**	Transect 1	Transect 3	Transect 5	**Mean**	Transect 1	Transect 3	Transect 5	**Mean**
EROV				0.0				0.0	3	3	1	2.3
ERRA				0.0				0.0				0.0
ERUM				0.0				0.0				0.0
LUCA	32	33	26	30.3				0.0				0.0
MACA				0.0				0.0	1			0.3
PHST				0.0				0.0	45	28	14	29.0
POSU				0.0				0.0				0.0
SEMU				0.0				0.0				0.0
SPAM				0.0			1	0.3			1	0.3
TOTAL				**211.0**				**116.7**				**220.7**

Species Code	ARTR-07 Transect 1	Transect 3	Transect 5	Mean	ARTR-08 Transect 1	Transect 3	Transect 5	Mean	ARTR-09 Transect 1	Transect 3	Transect 5	Mean
Shrubs												
ARNO				0.0				0.0				0.0
ARTR	22	24	34	26.7	43	25	32	33.3	55	42	31	42.7
ATCA				0.0		2	1	1.0		1		0.3
ATCO				0.0				0.0				0.0
CHVIP	4	9	5	6.0	3	12	17	10.7				0.0
CORA				0.0				0.0				0.0
EPNE	4		5	3.0				0.0	4	4	8	5.3
EPVI		2	1	1.0				0.0				0.0
ERCO23				0.0				0.0				0.0
ERLI		1		0.3				0.0				0.0
ERMIS				0.0				0.0				0.0
ERNAL				0.0				0.0				0.0
GRSP		1	2	1.0				0.0	5	3	2	3.3
JUOS			1	0.3				0.0				0.0
KRLA				0.0				0.0				0.0

	ARTR-07				ARTR-08				ARTR-09			
Species Code	Transect 1	Transect 3	Transect 5	**Mean**	Transect 1	Transect 3	Transect 5	**Mean**	Transect 1	Transect 3	Transect 5	**Mean**
LEPU				0.0				0.0				0.0
LYAN				0.0				0.0				0.0
OPPO				0.0				0.0				0.0
PIDE				0.0				0.0				0.0
TEGL				0.0				0.0				0.0
Grasses												
ACHY	1		2	1.0				0.0	1	1		0.7
ACSP		9	1	3.3				0.0				0.0
ARPU9				0.0				0.0				0.0
BOGR				0.0				0.0				0.0
ELEL	8	22	13	14.3	48	16	25	29.7	21	30	16	22.3
HECO				0.0				0.0				0.0
PLJA			4	1.3				0.0				0.0
POSE	3		5	2.7				0.0	4			1.3
Forbs												
AGGL				0.0				0.0				0.0

	ARTR-07				ARTR-08				ARTR-09			
Species Code	Transect 1	Transect 3	Transect 5	**Mean**	Transect 1	Transect 3	Transect 5	**Mean**	Transect 1	Transect 3	Transect 5	**Mean**
ARPUG				0.0				0.0				0.0
ASCA				0.0				0.0				0.0
ASLE				0.0				0.0				0.0
ASPUT				0.0				0.0				0.0
CAAP				0.0				0.0				0.0
CAFL				0.0				0.0				0.0
CALI				0.0				0.0				0.0
CHAL				0.0				0.0				0.0
CRCO				0.0				0.0				0.0
CRFL				0.0				0.0				0.0
ERCA				0.0				0.0				0.0
ERCOC				0.0				0.0				0.0
ERCO18				0.0				0.0				0.0
ERNU				0.0				0.0				0.0
EROV				0.0				0.0				0.0
ERRA				0.0				0.0				0.0

	ARTR-07				ARTR-08				ARTR-09			
Species Code	Transect 1	Transect 3	Transect 5	**Mean**	Transect 1	Transect 3	Transect 5	**Mean**	Transect 1	Transect 3	Transect 5	**Mean**
ERUM				0.0				0.0				0.0
LUCA				0.0				0.0				0.0
MACA				0.0				0.0				0.0
PHST	8	6	10	8.0				0.0				0.0
POSU				0.0				0.0				0.0
SEMU			1	0.3				0.0				0.0
SPAM	1			0.3				0.0				0.0
TOTAL				**69.7**				**74.7**				**76.0**

	ARTR-10				ARTR-11			
Species Code	Transect 1	Transect 3	Transect 5	**Mean**	Transect 1	Transect 3	Transect 5	**Mean**
Shrubs								
ARNO				0.0				0.0
ARTR	78	73	88	79.7	70	46	68	61.3
ATCA				0.0				0.0
ATCO				0.0				0.0
CHVIV	3			1.0			2	0.7
CHVIP				0.0			2	0.7
CORA				0.0				0.0
EPNE	1			0.3	2	14	11	9.0
EPVI				0.0				0.0
ERCO				0.0				0.0
ERLI				0.0				0.0
ERMIS				0.0				0.0
ERNAL				0.0				0.0
GRSP				0.0	3	1	1	1.7
JUOS				0.0		1	1	0.7

	ARTR-10				ARTR-11			
Species Code	Transect 1	Transect 3	Transect 5	**Mean**	Transect 1	Transect 3	Transect 5	**Mean**
KRLA				0.0				0.0
LEPU				0.0				0.0
LYAN				0.0				0.0
OPPO				0.0				0.0
PIDE				0.0				0.0
TEGL				0.0				0.0
Grasses								
ACHY				0.0	12	9	17	12.7
ACSP				0.0				0.0
ARPU9				0.0				0.0
BOGR				0.0				0.0
ELEL	13	21	18	17.3	47	60	27	44.7
HECO				0.0				0.0
PLJA				0.0	115		18	44.3
POSE				0.0	94	55	74	74.3

	ARTR-10				ARTR-11			
Species Code	Transect 1	Transect 3	Transect 5	**Mean**	Transect 1	Transect 3	Transect 5	**Mean**
Forbs								
AGGL				0.0				0.0
ARPUG				0.0				0.0
ASCA				0.0				0.0
ASLE				0.0			2	0.7
ASPUT				0.0				0.0
CAAP				0.0	1		1	0.7
CAFL				0.0				0.0
CALI				0.0				0.0
CHAL				0.0				0.0
CRCO				0.0				0.0
CRFL				0.0				0.0
ERCA				0.0				0.0
ERCOC				0.0				0.0
ERCO18				0.0				0.0
ERNU				0.0				0.0

	ARTR-10				ARTR-11			
Species Code	Transect 1	Transect 3	Transect 5	**Mean**	Transect 1	Transect 3	Transect 5	**Mean**
EROV				0.0			2	0.7
ERRA				0.0				0.0
ERUM				0.0				0.0
LUCA				0.0				0.0
MACA				0.0				0.0
PHST				0.0	8	5	5	6.0
POSU				0.0				0.0
SEMU				0.0				0.0
SPAM				0.0				0.0
TOTAL				**98.3**				**257.3**

Species Code	PIMO-ARNO 1 Transect 1	PIMO-ARNO 1 Transect 3	PIMO-ARNO 1 Transect 5	PIMO-ARNO 1 Mean	PIMO-ARNO 2 Transect 1	PIMO-ARNO 2 Transect 3	PIMO-ARNO 2 Transect 5	PIMO-ARNO 2 Mean	PIMO-ARNO 3 Transect 1	PIMO-ARNO 3 Transect 3	PIMO-ARNO 3 Transect 5	PIMO-ARNO 3 Mean
ARNO	56	66	44	55.3	55	20	40	38.3	23	22	30	25.0
ARTR				0.0				0.0	1	2		1.0
CHVIV	4	3	0	2.3	7	15	10	10.7	1	6	9	5.3
CHVIP				0.0	0	3	2	1.7			0	0.0
EPVI		1		0.3	0	1	0	0.3	4	5	3	4.0
ERMIS				0.0	4	1	1	2.0	1	3		1.3
ERMIL				0.0				0.0				0.0
ERNA7				0.0		2	2	1.3				0.0
JUOS	11	3	15	9.7	0	2	5	2.3	5	5	2	4.0
OPPO	1		0	0.3	9	7	13	9.7	2	1	1	1.3
PIMO	7	3	7	5.7	4	6	6	5.3	12	3	4	6.3
PUST		3	0	1.0	2	4		2.0	1	3	3	2.3
PUTR	2	5	3	3.3				0.0		1		0.3
QUGA				0.0				0.0				0.0
RIVE				0.0				0.0				0.0
SYLO				0.0				0.0				0.0

	PIMO-ARNO 1				**PIMO-ARNO 2**				**PIMO-ARNO 3**			
Species Code	Transect 1	Transect 3	Transect 5	**Mean**	Transect 1	Transect 3	Transect 5	**Mean**	Transect 1	Transect 3	Transect 5	**Mean**
YUBA				0.0				0.0		1	1	0.7
Total Woody				**78.0**				**73.7**				**51.7**
ACHY	4	1	0	1.7	7	12	37	18.7				0.0
ACPI				0.0	10			3.3				0.0
ACSP				0.0				0.0				0.0
ARPU9				0.0				0.0				0.0
BOGR				0.0				0.0				0.0
ELEL	1			0.3		1	9	3.3	19	14	14	15.7
HECO				0.0				0.0	4	41	1	15.3
PLJA				0.0				0.0			12	4.0
POFE				0.0				0.0	22	15	48	28.3
POSE	10	21		10.3	18	22	21	20.3	3	6	2	3.7
Total Grasses				**12.3**				**45.7**				**67.0**
ARCO	1		6	2.3				0.0				0.0
ARPUG				0.0		1		0.3	3			1.0

	PIMO-ARNO 1				PIMO-ARNO 2				PIMO-ARNO 3			
Species Code	Transect 1	Transect 3	Transect 5	**Mean**	Transect 1	Transect 3	Transect 5	**Mean**	Transect 1	Transect 3	Transect 5	**Mean**
ASBE				0.0				0.0				0.0
ASCA				0.0				0.0		1		0.3
ASLE				0.0				0.0				0.0
ASPUT				0.0				0.0	2			0.7
CAAP				0.0				0.0				0.0
CRFL				0.0				0.0	1	5		2.0
CRVI				0.0	17	3	1	7.0				0.0
IPCO				0.0	2	1		1.0				0.0
ERCA	23	30	46	33.0				0.0	12	9	10	10.3
ERCOC				0.0				0.0		3	4	2.3
EROV				0.0				0.0				0.0
ERUM				0.0	5		2	2.3				0.0
HYFI				0.0				0.0				0.0
LEKIK				0.0		1		0.3				0.0
LEPU				0.0	18	25	11	18.0		9	5	4.7
PEFL	1			0.3				0.0				0.0

	PIMO-ARNO 1				PIMO-ARNO 2				PIMO-ARNO 3			
Species Code	Transect 1	Transect 3	Transect 5	**Mean**	Transect 1	Transect 3	Transect 5	**Mean**	Transect 1	Transect 3	Transect 5	**Mean**
PEHU		1	9	3.3				0.0				0.0
PEPU				0.0				0.0				0.0
PHSA				0.0		6	6	4.0				0.0
PHST	8		11	6.3				0.0	21	15	14	16.7
SEMU				0.0		2	3	1.7				0.0
STCO		5	1	2.0				0.0				0.0
Total Forbs				**47.3**				**34.7**				**38.0**
TOTAL	**129**	**142**	**142**	**137.7**	**158**	**135**	**169**	**154.0**	**137**	**170**	**163**	**156.7**

	PIMO-ARNO 4				PIMO-ARNO 5				PIMO-ARNO 6			
Species Code	Transect 1	Transect 3	Transect 5	**Mean**	Transect 1	Transect 3	Transect 5	**Mean**	Transect 1	Transect 3	Transect 5	**Mean**
ARNO	74	105		89.5	23	20	12	18.3	43	14	21	26.0
ARTR				0.0				0.0				0.0
CHVIV				0.0		2		0.7				0.0
CHVIP				0.0				0.0				0.0
EPVI				0.0				0.0				0.0
ERMIS				0.0				0.0				0.0
ERMIL	15	1		8.0				0.0	8	1	2	3.7
ERNA7				0.0				0.0				0.0
JUOS				0.0	2	4	3	3.0		1	1	0.7
OPPO		4		2.0	12	24	15	17.0	12	4	1	5.7
PIMO	8	6		7.0	6	7	8	7.0	8	7	1	5.3
PUST				0.0				0.0				0.0
PUTR	16	1		8.5	7	2	3	4.0	5	2	17	8.0
QUGA	12			6.0				0.0		10		3.3
RIVE				0.0	1		3	1.3				0.0
SYLO				0.0				0.0				0.0

	PIMO-ARNO 4				PIMO-ARNO 5				PIMO-ARNO 6			
Species Code	Transect 1	Transect 3	Transect 5	**Mean**	Transect 1	Transect 3	Transect 5	**Mean**	Transect 1	Transect 3	Transect 5	**Mean**
YUBA				0.0				0.0				0.0
Total Woody				**121.0**				**51.3**				**52.7**
ACHY				0.0				0.0				0.0
ACPI		64		32.0	16			5.3	7	1	1	3.0
ACSP				0.0				0.0				0.0
ARPU9				0.0				0.0				0.0
BOGR				0.0				0.0				0.0
ELEL	15	33		24.0	22	2	5	9.7	48	2	18	22.7
HECO				0.0		1		0.3				0.0
PLJA				0.0				0.0				0.0
POFE	91	50		70.5	8			2.7			1	0.3
POSE				0.0	92	57	56	68.3	76	109	77	87.3
Total Grasses				**126.5**				**86.3**				**113.3**
ARCO	140	130		135.0	14	4	28	15.3	26	1	3	10.0
ARPUG	2			1.0				0.0				0.0

	PIMO-ARNO 4				PIMO-ARNO 5				PIMO-ARNO 6			
Species Code	Transect 1	Transect 3	Transect 5	**Mean**	Transect 1	Transect 3	Transect 5	**Mean**	Transect 1	Transect 3	Transect 5	**Mean**
ASBE				0.0				0.0				0.0
ASCA	24	12		18.0				0.0	1		6	2.3
ASLE				0.0				0.0				0.0
ASPUT				0.0				0.0				0.0
CAAP				0.0	3	2	7	4.0				0.0
CRFL				0.0		4		1.3				0.0
CRVI				0.0				0.0				0.0
IPCO				0.0				0.0				0.0
ERCA	47	56		51.5	9	1	22	10.7	16		56	24.0
ERCOC		12		6.0		5	3	2.7		3	9	4.0
EROV				0.0				0.0				0.0
ERUM				0.0			1	0.3		1		0.3
HYFI		4		2.0	3		1	1.3			37	12.3
LEKIK				0.0				0.0				0.0
LEPU				0.0	5	7	4	5.3	1			0.3
PEFL				0.0				0.0				0.0

	PIMO-ARNO 4				PIMO-ARNO 5				PIMO-ARNO 6			
Species Code	Transect 1	Transect 3	Transect 5	**Mean**	Transect 1	Transect 3	Transect 5	**Mean**	Transect 1	Transect 3	Transect 5	**Mean**
PEHU	4	10		7.0				0.0		1		0.3
PEPU				0.0				0.0	37	1	20	19.3
PHSA				0.0				0.0				0.0
PHST	2	1		1.5	8			2.7				0.0
SEMU				0.0		6	3	3.0		4	1	1.7
STCO				0.0	13	5	7	8.3	11			3.7
Total Forbs				**222.0**				**55.0**				**78.3**
TOTAL	**450**	**489**		**469.5**	**244**	**153**	**181**	**192.7**	**299**	**162**	**272**	**244.3**

	PIMO-ARNO 7				PIMO-ARNO 8				PIMO-ARNO 9			
Species Code	Transect 1	Transect 3	Transect 5	**Mean**	Transect 1	Transect 3	Transect 5	**Mean**	Transect 1	Transect 3	Transect 5	**Mean**
ARNO	43	54	25	40.7	8	12	6	8.7	33	15	32	26.7
ARTR				0.0				0.0				0.0
CHVIV		1		0.3	1	1	3	1.7	6	2	3	3.7
CHVIP	8	10		6.0				0.0				0.0
EPVI				0.0	2	2	1	1.7				0.0
ERMIS				0.0			2	0.7	2		1	1.0
ERMIL				0.0				0.0				0.0
ERNA7				0.0	13	5	20	12.7	6	2	5	4.3
JUOS	5		5	3.3		1	1	0.7	1	2	3	2.0
OPPO	4	2		2.0		1	1	0.7	3	3	2	2.7
PIMO	24	16	15	18.3		3	5	2.7	6	6	8	6.7
PUST	3	1	2	2.0	3	6	9	6.0	2	5	2	3.0
PUTR				0.0				0.0				0.0
QUGA				0.0				0.0				0.0
RIVE				0.0				0.0				0.0
SYLO				0.0	2			0.7				0.0

	PIMO-ARNO 7				PIMO-ARNO 8				PIMO-ARNO 9			
Species Code	Transect 1	Transect 3	Transect 5	**Mean**	Transect 1	Transect 3	Transect 5	**Mean**	Transect 1	Transect 3	Transect 5	**Mean**
YUBA				0.0				0.0				0.0
Total Woody				**72.7**				**36.0**				**50.0**
ACHY		1		0.3				0.0				0.0
ACPI				0.0				0.0	1		1	0.7
ACSP				0.0				0.0				0.0
ARPU9				0.0				0.0				0.0
BOGR				0.0				0.0				0.0
ELEL				0.0		1	1	0.7	8	8	3	6.3
HECO			41	13.7				0.0	1			0.3
PLJA				0.0				0.0				0.0
POFE				0.0				0.0				0.0
POSE	34	19	9	20.7			4	1.3	3	5	4	4.0
Total Grasses				**34.7**				**2.0**				**11.3**
ARCO	5	6		3.7				0.0	2	1	2	1.7
ARPUG				0.0				0.0				0.0

	PIMO-ARNO 7				PIMO-ARNO 8				PIMO-ARNO 9			
Species Code	Transect 1	Transect 3	Transect 5	**Mean**	Transect 1	Transect 3	Transect 5	**Mean**	Transect 1	Transect 3	Transect 5	**Mean**
ASBE				0.0	11	2		4.3				0.0
ASCA				0.0				0.0				0.0
ASLE				0.0				0.0				0.0
ASPU				0.0				0.0				0.0
CAAP				0.0				0.0				0.0
CRFL				0.0				0.0	5	1	3	3.0
CRVI				0.0				0.0				0.0
IPCO				0.0				0.0				0.0
ERCA	1	7	8	5.3				0.0				0.0
ERCO				0.0				0.0				0.0
EROV				0.0				0.0				0.0
ERUM				0.0			1	0.3				0.0
HYFI				0.0				0.0				0.0
LEKIK				0.0				0.0				0.0
LEPU				0.0				0.0	4			1.3
PEFL				0.0				0.0				0.0

	PIMO-ARNO 7				**PIMO-ARNO 8**				**PIMO-ARNO 9**			
Species Code	Transect 1	Transect 3	Transect 5	**Mean**	Transect 1	Transect 3	Transect 5	**Mean**	Transect 1	Transect 3	Transect 5	**Mean**
PEHU				0.0				0.0				0.0
PEPU				0.0				0.0		13	10	7.7
PHAC				0.0				0.0				0.0
PHST		1		0.3				0.0			1	0.3
SEMU				0.0				0.0				0.0
STCO				0.0				0.0				0.0
Total Forbs				**9.3**				**4.7**				**14.0**
TOTAL	**127**	**118**	**105**	**116.7**	**40**	**34**	**54**	**42.7**	**83**	**63**	**80**	**75.3**

PIMO-ARNO 10

Species Code	Transect 1	Transect 3	Transect 5	Mean
ARNO	46	51	52	49.7
ARTR				0.0
CHVIV				0.0
CHVIP				0.0
EPVI	2		1	1.0
ERMIS	1			0.3
ERMIL				0.0
ERNAL				0.0
JUOS	4		5	3.0
OPPO	1	3	3	2.3
PIMO	7	7	7	7.0
PUST				0.0
PUTR				0.0
QUGA				0.0
RIVE				0.0
SYLO				0.0

PIMO-ARNO 10

Species Code	Transect 1	Transect 3	Transect 5	**Mean**
YUBA				0.0
Total Woody				**63.3**
ACHY	2	2		1.3
ACPI		5	1	2.0
ACSP				0.0
ARPU9				0.0
BOGR				0.0
ELEL			1	0.3
HECOC				0.0
PLJA		26		8.7
POFE				0.0
POSE				0.0
Total Grasses				**12.3**
ARCO				0.0
ARPUG				0.0
ASBE				0.0

PIMO-ARNO 10

Species Code	Transect 1	Transect 3	Transect 5	**Mean**
ASCA				0.0
ASPU				0.0
CAAP				0.0
CRFL				0.0
CRVI				0.0
IPCO				0.0
ERCA		23	10	11.0
ERCOC				0.0
EROV				0.0
ERUM				0.0
HYFI	1			0.3
LEKIK				0.0
LEPU		1	3	1.3
PEFL				0.0
PEHU				0.0
PEPU				0.0

PIMO-ARNO 10

Species Code	Transect 1	Transect 3	Transect 5	**Mean**
PHAC				0.0
PHST			3	1.0
SEMU				0.0
STCO				0.0
Total Forbs				**13.7**
TOTAL	**64**	**118**	**86**	**89.3**

This Page Intentionally Left Blank

APPENDIX C

Species Alphacodes with Corresponding Scientific and Common Names

AlphaCode	*Genus*	*Species*	Common Name
ACHY	*Achnatherum*	*hymenoides*	Indian ricegrass
ACPA	*Achnatherum*	*parishii*	Parish's needlegrass
ACPI	*Achnatherum*	*pinetorum*	pinewoods needlegrass
ACSP	*Achnatherum*	*speciosum*	desert needlgrass
AMTE	*Amsinckia*	*tessellata*	bristly fiddleneck
AGGL	*Agoseris*	*glauca var. lanciniata*	False agoseris
ARCO	*Arenaria*	*congesta var. subcongesta*	subcongesta sandwort
ARNO	*Artemisia*	*nova*	black sagebrush
ARPU9	*Aristida*	*purpurea*	purple threeawn
ARPUG	*Arabis*	*pulchra var. gracilis*	desert rockcress
ARTR	*Artemisia*	*tridentata ssp. tridentata*	basin big sagebrush
ASBE	*Astragalus*	*beatleyae*	Beatley milkvetch
ASCA	*Astragalus*	*calycosus var. calycosus*	Torrey milkvetch
ASLE	*Astragalus*	*lentiginosus var. fremontii*	Fremont's milkvetch
ASPUT	*Astragalus*	*purshii var. tinctus*	woollypod milkvetch
ASSPP	*Ástragalus*	species	milkvetch species
ATCA	*Atriplex*	*canescens var. canescens*	fourwing saltbush
ATCO	*Atriplex*	*confertifolia*	shadscale saltbush
BOGR	*Bouteloua*	*gracilis*	blue grama
BRRU	*Bromus*	*rubens*	red brome

AlphaCode	*Genus*	*Species*	Common Name
BRTE	*Bromus*	*tectorum*	cheatgrass
CAAP	*Castilleja*	*applegatei*	wavyleaf Indian paintbrush
CAFL	*Calochortus*	*flexuosus*	winding mariposa lily
CALI	*Castilleja*	*linariifolia*	Wyoming Indian paintbrush
CETH	*Centrostegia*	*thurberi*	red triangles
CHAL	*Chenopodium*	*album*	pigweed, lambsquarters
CHFR	*Chaenactis*	*fremontii*	pincushion flower
CHMA	*Chaenactis*	*macrantha*	bighead dustymaiden
CHST	*Chaenactis*	*stevioides*	Steves duskymaiden
CHVIP	*Chrysothamnus*	*viscidiflorus ssp. puberulus*	green rabbitbrush
CHVIV	*Chrysothamnus*	*viscidiflorus ssp. viscidiflorus*	green rabbitbrush
CORA	*Coleogyne*	*ramosissima*	blackbrush
CRCI	*Cryptantha*	*circumscissa*	cushion catseye
CRCO	*Cryptantha*	*confertiflora*	basin yellow catseye
CRFL	*Cryptantha*	*flavoculata*	roughseed catseye
CRVI	*Cryptantha*	*virginensis*	Virgin River catseye
ECEN	*Echinocereus*	*engelmannii*	saints cactus
ELEL	*Elymus*	*elymoides ssp. elymoides*	Bottlebrush squirreltail
EPNE	*Ephedra*	*nevadensis*	Nevada jointfir
EPVI	*Ephedra*	*viridis*	Mormon tea
ERCA	*Eriogonum*	*caespitosum*	matted buckwheat
ERCO18	*Eriogonum*	*concinnum*	mourning buckwheat
ERCO23	*Ericameria*	*cooperi*	Cooper's heathgoldenrod
ERCOC	*Erigeron*	*concinnus var. concinnus*	Navajo fleabane

AlphaCode	*Genus*	*Species*	Common Name
ERER	*Eriastrum*	*eremicum*	desert woolstar
ERLI	*Ericameria*	*linearifolia*	narrowleaf goldenbush
ERMIL	*Eriogonum*	*microthecum var. lapidicola*	slender buckwheat
ERMIS	*Eriogonum*	*microthecum var. simpsonii*	Simpson's buckwheat
ERNA7	*Ericameria*	*nanus*	dwarf heathgoldenrod
ERNAL	*Ericameria*	*nauseosa ssp. consimilis var. leiosperma*	rubber rabbitbrush
ERNI	*Eriogonum*	*nidularium*	bird nest buckwheat
ERNU	*Eriogonum*	*nummulare*	money buckwheat
EROV	*Eriogonum*	*ovalifolium var. ovalifolium*	cushion buckwheat
ERRA	*Eriogonum*	*racemosum*	redroot buckwheat
ERUM	*Eriogonum*	*umbellatum*	sulphur wildbuckwheat
GARA	*Gayophytum*	*ramosissimum*	pinyon groundsmoke
GISPP	*Gilia*	species	Gilia species
GRSP	*Grayia*	*spinosa*	spiny hopsage
HECO	*Hesperostipa*	*comata ssp. comata*	needle-and-thread
HYFI	*Hymenopappus*	*filifolius var. megacephalus*	fineleaf hymenopappus
IPCO	*Ipomopsis*	*congesta*	ballhead gilia
JUOS	*Juniperus*	*osteosperma*	Utah juniper
KRLA	*Krascheninnikovia*	*lanata*	winterfat
LEKIK	*Lesquerella*	*kingii ssp. kingii*	Kings bladderpod
LEPU	*Leptodactylon*	*pungens*	granite pricklygilia
LUAR	*Lupinus*	*argenteus ssp. argenteus var. laxiflorus*	spur lupine
LUCA	*Lupinus*	*caudatus*	tailcup lupine

AlphaCode	*Genus*	*Species*	Common Name
LYAN	*Lycium*	*andersonii*	Anderson's wolfberry
MACA	*Machaeranthera*	*canescens ssp. canescens*	hoary aster
MOSS	*Moss*	species	Moss species
OPPO	*Opuntia*	*polyacantha var. rufispina*	hairspine pricklypear
PEFL	*Penstemon*	*floridus var. austinii*	Austin's beardtongue
PEHU	*Penstemon*	*humilis ssp. humilis*	low beardtongue
PEPU	*Petradoria*	*pumila*	grassy rockgoldenrod
PHSA	*Phacelia*	*saxicola*	stonecrop phacelia
PHST	*Phlox*	*stansburyi*	colddesert phlox
PIDE	*Picrothamnus*	*desertorum*	bud sagebrush
PIMO	*Pinus*	*monophylla*	singleleaf pinyon
PLJA	*Pleuraphis*	*jamesii*	galleta grass
POFE	*Poa*	*fendleriana*	muttongrass
POSE	*Poa*	*secunda*	Sandberg's bluegrass
POSU	*Polygala*	*subspinosa*	spiny polygala
PUST	*Purshia*	*stansburiana*	Stansbury cliffrose
PUTR	*Purshia*	*tridentata*	antelope bitterbrush
QUGA	*Quercus*	*gambelii*	Gambel oak
RIVE	*Ribes*	*velutinum var. velutinum*	desert gooseberry
SEMU	*Senecio*	*multilobatus*	lobeleaf groundsel
SPAM	*Sphaeralcea*	*ambigua ssp. ambigua*	apricot globemallow
STCO	*Streptanthus*	*cordatus var. cordatus*	heartleaf twistflower
STEX	*Stephanomeria*	*exigua ssp. exigua*	small wire-lettuce
SYFR	*Syntrichopappus*	*fremontii*	yellowray fremontsgold

AlphaCode	*Genus*	*Species*	Common Name
SYLO	*Symphoricarpos*	*longiflorus*	desert snowberry
TECA	*Tetradymia*	*canescens*	spineless horsebrush
TEGL	*Tetradymia*	*glabrata*	littleleaf horsebrush
YUBA	*Yucca*	*baccata*	Banana yucca

This Page Intentionally Left Blank

Distribution

10.0 DISTRIBUTION

U.S. Department of Energy — 2 CDs (uncontrolled)
National Nuclear Security Administration
Nevada Field Office
Public Reading Facility
c/o Nuclear Testing Archive
P.O. Box 98521, M/S 400
Las Vegas, NV 89193-8521

U.S. Department of Energy — 1 electronic copy (uncontrolled)
Office of Scientific and Technical Information
P.O. Box 62
Oak Ridge, TN 37831-0062

This Page Intentionally Left Blank