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Ecological Monitoring and Compliance Program

2022 REPORT

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Ecological Monitoring and Compliance Program 2022 REPORT

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EXECUTIVE SUMMARY

The Ecological Monitoring and Compliance Program (EMAC), funded through the United States Department of Energy, National Nuclear Security Administration Nevada Field Office (NNSA/NFO), monitors the ecosystems 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 Mission Support and Test Services, LLC (MSTS), during calendar year 2022. Program activities included (a) biological surveys at proposed activity sites, (b) desert tortoise compliance, (c) ecosystem monitoring, (d) sensitive and protected/regulated plant monitoring, (e) sensitive and protected/regulated animal monitoring, and (f) habitat restoration implementation and monitoring. During 2022, all applicable laws, regulations, and permit requirements were met.

Sensitive and protected/regulated species of the NNSS include 43 plants, 1 mollusk, 2 reptiles, 240 birds, and 30 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*) is the only species on the NNSS protected under the Endangered Species Act and is listed as threatened. Biological surveys for the presence of sensitive and protected/regulated species and important biological resources on which they depend were conducted for 26 projects. A total of 266.82 hectares (ha) were surveyed for these projects. The surveyed area included the project area and a buffer area extending 10-20 meters beyond the project area. Some of the sensitive and protected/regulated species and important biological resources found during the surveys included western burrowing owl sites (*Athene cunicularia hypugaea*); two live tortoises; tortoise burrows; bat sign; active bird nests; desert cottontail (*Sylvilagus audubonii*); predator burrows (coyote [*Canis latrans*] and kit fox [*Vulpes macrotis*]); ungulate sign (pronghorn antelope [*Antilocapra americana*], feral burro [*Equus asinus*], and mule deer [*Odocoileus hemionus*]); yucca plants (Joshua tree [*Yucca brevifolia*] and Mojave yucca [*Yucca schidigera*]); singleleaf pinyon (*Pinus monophylla*); multiple cactus species; and one sensitive plant (Darin buckwheat [*Eriogonum concinnum*]). MSTS biologists communicated with ground crews and provided written summary reports to project managers of survey findings and mitigation recommendations when applicable.

Fifteen tortoise clearance surveys were conducted by MSTS biologists. One desert tortoise was observed hibernating in a project area and another tortoise was observed crossing a road during a project. No desert tortoises were reported injured or killed during projects. A total of 11.42 ha of tortoise habitat was disturbed. All projects that were monitored within tortoise habitat remained within the surveyed project area.

There were an unprecedented 115 reported desert tortoise roadside sightings. Of the 115 tortoises, 5 were roadkill (3 small and 2 large). Ninety-four tortoises were determined to be in harm's way and moved off the road in accordance with United States Fish and Wildlife Service-approved tortoise handling procedures. This number does not reflect unique tortoises, as many of the sightings were the same tortoise observed multiple times.

Juvenile tortoises continued to be monitored as part of a collaborative effort to study survival of translocated animals. After 124 months post-release, 10 of the 60 tortoises (16.7%) (4 female, 6 male) were known to be alive and 2 tortoises were missing, presumably due to transmitter failure.

From 1978 to 2022, an average of 10.1 wildland fires per year and about 119.5 ha per fire have burned on the NNSS. Many 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 [*Coleogyne ramosissima*] and pinyon pine/Utah juniper/sagebrush species [*Pinus monophylla/Juniperus osteosperma/Artemisia* spp.] plant communities). These vegetation 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).

Six wildland fires were documented on the NNSS in 2022. Four of these were human-caused or project related, one was caused by lightning, and one was started by an unknown cause. Each fire was <1.0 ha in size, and all fires combined burned <1.0 ha.

Wildlife use at 10 natural water sources (6 springs, 4 rock tanks) and 8 constructed water sources (1 well pond, 5 water troughs, and 2 radiologically contaminated sumps) was documented using motion-activated cameras.

There are currently 19 vascular plants and 1 non-vascular plant included in the NNSS sensitive plant monitoring program. A species evaluation continued for Lahontan beardtongue (*Penstemon palmeri* var. *macranthus*). Long-term monitoring continued for Black woollypod (*Astragalus funereus*), Clokey eggvetch (*Astragalus oophorus* var. *clokeyanus*), and Darin buckwheat (*Eriogonum concinnum*). Opportunistic encounters were documented for Pahute green gentian (*Frasera pahutensis*), Pahute Mesa Beardtongue (*Penstemon pahutensis*), and Sanicle biscuitroot (*Cymopterus ripleyi* var. *saniculoides*).

Surveys of sensitive and protected/regulated animals in 2022 focused on birds, bats, feral horses (*Equus caballus*), mule deer, pronghorn antelope, desert bighorn sheep (*Ovis canadensis nelsoni*), and mountain lions (*Puma concolor*). Additional information is presented about bird mortalities, Migratory Bird Treaty Act compliance, nuisance animals and their control, and increasing populations of feral burros.

A total of 39 dead birds were documented on the NNSS in 2022. Sixteen dead bird carcasses of varying stages of decay were found inside a fill pipe connected to a baker tank at Area 5 Radioactive Waste Management Complex (RWMC). Cause of death was entrapment. The pipe was modified so no more birds could be trapped. Additionally, all other baker tanks at Area 5 RWMC and elsewhere on the NNSS were checked to make sure the tanks were avian safe. An unknown passerine was rescued from a glue trap but later died of its injuries. Six bird carcasses were found inside the tower at Ice Cap event site in Yucca Flat. Five birds were electrocuted, and four birds were hit by vehicles. One red-tailed hawk (*Buteo jamaicensis*) chick died following a nest relocation. One mourning dove (*Zenaida macroura*) was found with a broken wing and had to be euthanized. It was collected and analyzed as part of our program to monitor potential radiation in wildlife. A total of 11 birds were found dead due to unknown causes and included the 6 dead birds found at the Ice Cap tower. No golden eagle (*Aquila chrysaetos*) deaths were recorded. Only 2 raptor species were detected during winter raptor surveys in 2022, with a total of 10 red-tailed hawk sightings on the southern NNSS route, 4 red-tailed hawk sightings on the Yucca Flat route, and 1 prairie falcon (*Falco mexicanus*) sighting on each of the routes. No golden eagle sightings were documented during any of the surveys which is uncharacteristic. Common ravens were more prevalent on the Yucca Flat route than on the southern route, and no loggerhead shrikes were observed on either route.

Feral horse distribution was similar this year to last year with concentrated activity around Camp 17 Pond and Gold Meadows Spring especially during the hot, dry summer months. A total of 26 deer were observed on both routes combined during fall surveys, which equates to an average of 4.3 deer per night. This is less than half the number of deer per night observed in 2021, when an average of 11.8 deer per night were recorded. This is the lowest number of deer per night ever recorded on the NNSS. Mountain lion predation and drought are likely candidates for the decrease during 2021 and 2022. Eight of 11 (73%) radio-collared mule deer that died during 2021 and 2022 were apparently killed by mountain lions and no fawns were observed on the deer surveys during 2021 and 2022.

Data collection for the mule deer and pronghorn antelope study concluded when the radio collars dropped off the animals on November 1 as programmed. At the beginning of 2022, 8 mule deer (7 does, 1 buck) and 8 pronghorn (5 does, 3 bucks) were alive. These animals were monitored until November 1.

Similar to 2020 and 2021, pronghorn spent a majority of time in Frenchman Flat and Yucca Flat with no large seasonal migrations although they remained close to water sources and shade during the hot, dry summer. Like previous years, mule deer made seasonal migrations, migrating primarily off the high elevation portions of Rainier and Pahute mesas to lower elevation areas in the CP Hills, Eleana Range, Pahute Mesa, Mine Mountain, and eastern slopes of Rainier Mesa. For the third year in a row, a doe (#705940) that wintered on the NNSS moved over 60 kilometers to the north through the Kawich Range to spend the summer in the Kawich Peak area which is open to hunting. Three pronghorn does and one buck were found dead in Yucca Flat during 2022. One doe had marks on the hindquarters that may have been from a predator attack. The other two does and buck died of unknown causes. One mule deer buck was killed by a mountain lion. Seven mule deer does, two pronghorn does, and two pronghorn bucks survived to the end of the study. Thus, overall survival of mule deer was 30% (7 of 23) (44% for does and 0% for bucks) and 22% for pronghorn (4 of 18) (17% for does, 33% for bucks). Detailed analyses to answer study objectives will be performed over the next two years and a summary report written.

Four marked desert bighorn sheep (3 ewes, 1 ram) and at least 12 unmarked sheep (6 ewes, 2 lambs, 4 rams) were documented with camera traps at water sources in the Shoshone Mountain, Yucca Mountain, Fortymile Canyon, and East Cat Canyon areas. In November, MSTS biologists collaborated with Nevada Department of Wildlife to capture several sheep on and around the NNSS (e.g., Bare Mountains, Nevada Test and Training Range, Specter Range) as part of a test and remove project to reduce the devastating impact of a disease that causes pneumonia in bighorn sheep. Three ewes were captured on or near the NNSS on November 11, 2022. Oral, nasal, and blood samples were taken for disease testing, radio collars were attached, and the animals were then released. None of the animals tested positive for the disease. Animals will be tracked, and locations documented over the next few years.

A total of 142 mountain lion images (i.e., photographs or video clips) were taken during 170,805 camera hours across all sites. This equates to about 0.8 mountain lion images per 1,000 camera hours. Mountain lions were detected at 11 of the 25 sites, including 9 water sources, 1 road, and 1 canyon. A minimum of three individual mountain lions (adult male, adult female, subadult) were known to occur on the NNSS in 2022. An additional 26,420 images of at least 81 species other than mountain lions were taken during 170,805 camera hours across all sites, which is about 155 images per 1,000 camera hours.

Habitat restoration activities in 2022 included: 1) visually assessing the vegetation at the U-3ax/bl closure cover (Corrective Action Unit [CAU] 110) (Area 3 Radioactive Waste Management Site) and the “92-Acre Site” (CAU 111) (Area 5 RWMC), 2) revegetating and monitoring seeding success at CAU 577 Cells 19/20, 3) assessing revegetation success at CAU 577 East and West Cover Caps (Area 5 RWMC), 4) transplanting creosote bush (*Larrea tridentata*) and white bursage (*Ambrosia dumosa*) and evaluating revegetation success on Cell 18 (Area 5 RWMC), and 4) monitoring results from a research study to evaluate the effectiveness of different herbicide and seeding treatments to control cheatgrass after the Cherrywood Fire.

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ACRONYMS AND ABBREVIATIONS

ac	acre(s)
APP	Avian Protection Plan
BCS	Body Condition Score
CAU	Corrective Action Unit
cm	centimeter(s)
DoD	Department of Defense
DOE	U.S. Department of Energy
DOE EM/NV	U.S. Department of Energy, Environmental Management Nevada Program
DOE/NV	U.S. Department of Energy, Nevada Operations Office
DTM	Desert Tortoise Monitor
EGIS	Ecological Geographic Information System
ELU	Ecological Landform Unit
EMAC	Ecological Monitoring and Compliance Program
ER	Environmental Restoration
ESA	Endangered Species Act
FWS	U.S. Fish and Wildlife Service
g	gram(s)
GOAG	desert tortoise
GPS	Global Positioning System(s)
ha	hectare(s)
ICR	San Diego Zoo Institute for Conservation Research
km	kilometer(s)
LANL	Los Alamos National Laboratory
m	meter(s)
m^2	square meter(s)
MBTA	Migratory Bird Treaty Act
MCL	midline carapace length
mm	millimeter(s)
MOU	Memorandum of Understanding
MSTS	Mission Support and Test Services, LLC
n	sample size
NABat	North American Bat Monitoring Program
NAC	Nevada Administrative Code

NAD	North American Datum
NDNH	Nevada Division of Natural Heritage
NDOW	Nevada Department of Wildlife
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
NTTR	Nevada Test and Training Range
oz	ounce(s)
pCi/L	picocuries per liter
PLS	pure live seed
PTT	platform transmitter terminal
R, R^2	correlation coefficient
RWMC	Radioactive Waste Management Complex
sd	standard deviation
spp.	species
ssp.	subspecies
TCS	tortoise clearance survey
UGTA	Underground Test Area
USDA	United States Department of Agriculture
USGS	United States Geological Survey
UTM	Universal Transverse Mercator
var.	variety

1.0 INTRODUCTION

In accordance with United States (U.S.) Department of Energy (DOE) Order DOE O 231.1B, "Environment, Safety, and Health Reporting," the Office of the Assistant Manager for Mission and Infrastructure of the DOE, 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). Mission Support and Test Services, LLC (MSTS) is the Management and Operations contractor for the NNSS. MSTS Ecological and Environmental Monitoring has implemented the Ecological Monitoring and Compliance Program (EMAC) to provide the aforementioned biological compliance support and ecological monitoring. 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 2022, all applicable laws and regulations were followed and the permit requirements were met.

This report summarizes the EMAC activities conducted by MSTS during calendar year 2022. Monitoring tasks during 2022 included six program areas: (a) biological surveys, (b) desert tortoise compliance, (c) ecosystem monitoring, (d) sensitive and protected/regulated plant monitoring, (e) sensitive and protected/regulated animal monitoring, and (f) habitat restoration implementation and monitoring. The following sections of this report describe work performed under these six program areas.

2.0 BIOLOGICAL SURVEYS

Projects or activities involving land-disturbing activities on the NNSS are reviewed by biologists to determine if 1) sensitive and protected/regulated species occur within the project area, 2) a biological survey is required to identify sensitive and protected/regulated species within the project area, and/or 3) develop mitigation measures to protect impacted species, if required. Projects submit a scope of work for review prior to start of work through several different company processes including, but not limited to, National Environmental Policy Act checklists, Real Estate Operations Permits (parcels of land with specified activities or facilities designated to remain with that parcel), and/or MSTS documents.

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 Division of Natural Heritage (NDNH) At-Risk Plant and Animal Tracking List (NDNH 2023). 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, track resources found, and provide mitigation recommendations.

2.1 Sites Surveyed and Sensitive and Protected/Regulated Species Observed

In 2022, biological surveys were conducted for 26 projects on the NNSS (Figure 2-1, Table 2-2). Several projects had multiple survey locations. Post-activity surveys were conducted for projects completed prior to 2022, as well as projects completed during 2022 (Figure 2-1, Table 2-2). MSTS biologists surveyed a total of 266.82 hectares (ha) for the projects (Table 2-2). The surveyed area included the project area and a buffer area extending 10-20 meters (m) beyond the project area. Total area surveyed was markedly higher than previous years, attributed to project 22-01, which focused on clearing overgrown vegetation along road shoulders to utilize existing roads as wildland fire breaks. Sensitive and protected/regulated plant and animal species and important biological resources found during the surveys included two live desert tortoises (*Gopherus agassizii*) (see Section 3.2.2, both tortoises avoided); western burrowing owl (*Athene cunicularia hypugaea*) sites; two active raven (*Corvus corax*) nests; several inactive bird nests; ungulate sign (pronghorn antelope [*Antilocapra americana*], feral burro [*Equus asinus*], and mule deer [*Odocoileus hemionus*]); one sensitive plant (Darin buckwheat [*Eriogonum concinnum*]); yucca plants (Joshua tree [*Yucca brevifolia*] and Mojave yucca [*Yucca schidigera*]); singleleaf pinyon (*Pinus monophylla*); and multiple cactus species (see Table 2-2 for resources listed by project). Scientists communicated with ground crews and provided written summary reports to project managers of survey findings and mitigation recommendations when applicable (Table 2-2).

2.2 Potential Habitat Disturbance

Biological surveys are conducted for all activities that have the potential to disturb habitat. These surveys are required in undisturbed habitat, whenever vegetation has re-colonized old disturbances, and/or sensitive or protected/regulated species may occur in the area. For example, tortoises may move through project areas and may be concealed under vegetation during activities where heavy equipment is used. Western burrowing owls frequently inhabit burrows, buried pipes with exposed openings, and culverts at

Table 2-1. List of sensitive and protected/regulated species known to occur on 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
Chylismia megalantha	Cane Spring suncup	S, M
Cryptantha clokeyi	Clokey's cryptantha	S, E
Cymopterus ripleyi var. *saniculoides*	Sanicle biscuitroot	S, W
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. *inyoensis*	Inyo hulsea	S, W
Ivesia arizonica var. *saxosa*	Rock purpusia	S, H
Penstemon fruticiformis ssp. *amargosae*	Death Valley beardtongue	S, M
Penstemon pahutensis	Pahute Mesa beardtongue	S, W
Penstemon palmeri var. *macranthus*	Lahontan beardtongue	S, E
Phacelia beatleyae	Beatley scorpionflower	S, M
Phacelia filiae	Clarke phacelia	S, W
Phacelia mustelina	Weasel phacelia	S, W
Agavaceae	Yucca (3 species), Agave (1 species)	CY
Cactaceae	Cacti (17 species)	CY
Juniperus osteosperma	Utah juniper	CY
Pinus monophyla	Single-leaf pinyon	CY

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

Animal Species	Common Name	Status[a]
Mollusk Species		
Pyrgulopsis turbatrix	Southwest 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, NPS, A
Asio flammeus	Short-eared owl	S, NPS, A
Asio otus	Long-eared owl	S, NP, A
Callipepla gambelii	Gambel's quail	G, IA
Coccyzus americanus	Western yellow-billed cuckoo	LT, S, NPT, IA
Corvus brachyrhynchos	American crow	G, IA
Falco peregrinus	Peregrine falcon	S, NPS, A
Gymnorhinus cyanocephalus	Pinyon jay	S, NP, IA
Haliaeetus leucocephalus	Bald eagle	EA, S, NPS, A
Ixobrychus exillis	Least bittern	S, NP, IA
Lanius ludovicianus	Loggerhead shrike	NPS, A
Melanerpes lewis	Lewis's woodpecker	S, NP, IA
Oreoscoptes montanus	Sage thrasher	NPS, IA
Riparia riparia	Bank swallow	S, NP, IA
Spinus pinus	Pine siskin	S, NP, IA
Spizella breweri	Brewer's sparrow	NPS, IA
Toxostoma lecontei	LeConte's thrasher	S, NP, IA
Mammal Species		
Antilocapra americana	Pronghorn antelope	G, A
Antrozous pallidus	Pallid bat	NP, A
Cervus elaphus nelsoni	Rocky Mountain elk	G, IA
Corynorhinus townsendii	Townsend's big-eared bat	S, NPS, A

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

Animal Species	Common Name	Status[a]
Equus asinus	Burro	H&B, A
Eptesicus fuscus	Big brown bat	NP, A
Equus caballus	Horse	H&B, A
Euderma maculatum	Spotted bat	S, NPT, A
Lasionycteris noctivagans	Silver-haired bat	S, A
Lasiurus blossevillii	Western red bat	S, NPS, A
Lasiurus cinereus	Hoary bat	S, A
Lynx rufus	Bobcat	F, IA
Microdipodops megacephalus	Dark kangaroo mouse	NPS, IA
Microdipodops pallidus	Pale kangaroo mouse	S, NPS, IA
Myotis californicus	California myotis	NP, A
Myotis ciliolabrum	Western small-footed myotis	NP, A
Myotis evotis	Long-eared myotis	NP, A
Myotis thysanodes	Fringed myotis	S, NP, A
Myotis volans	Long-legged myotis	NP, A
Myotis yumanensis	Yuma myotis	NP, A
Ovis canadensis nelsoni	Desert bighorn sheep	G, A
Odocoileus hemionus	Mule deer	G, A
Parastrellus hesperus	Canyon bat	NP, A
Puma concolor	Mountain lion	G, A
Sorex tenellus	Inyo shrew	S, IA
Sylvilagus audubonii	Desert 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

U.S. Department of Interior

H&B Protected under *Wild Free Roaming Horses and Burros Act*

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

EA	Protected under *Bald and Golden Eagle Act*
State of Nevada – Animals	
S	Nevada Division of Natural Heritage (NDNH) – At-Risk Plant and Animal Tracking List
NPT	Nevada Protected-Threatened, species protected under Nevada Administrative Code (NAC) 503
NPS	Nevada Protected-Sensitive, species protected under NAC 503
NP	Nevada Protected, species protected under NAC 503
G	Regulated as game species under NAC 503
F	Regulated as fur bearer species under NAC 503
State of Nevada – Plants	
S	NDNH – At-Risk Plant and Animal Tracking List
CY	Protected as a cactus, yucca, or Christmas tree from unauthorized collection on public lands under NAC 527
NNSS Sensitive Plant Ranking	
H	High (high potential for NNSS populations to become at-risk in the future and/or is limited in range)
M	Moderate (moderate potential for NNSS populations to become at-risk in the future)
W	Watch (low potential for NNSS populations to become at-risk in the future)
E	Evaluate (status unknown)
Long-term Animal Monitoring Status for the NNSS	
A	Active
IA	Inactive

[b] All bird species on the NNSS are protected by the *Migratory Bird Treaty Act* except for chukar, Gambel's quail, English house sparrow (*Passer domesticus*), Rock dove (*Columba livia*), Eurasian collared dove (*Streptopelia decaocto*), and European starling (*Sturnus vulgaris*). Most bird species are also protected under NAC 503.

Sources used: NDNH 2023, NAC 2023, FWS 2023

disturbed sites. Biological surveys are completed to ensure sensitive or protected/regulated animal and plant species are not in harm's way.

Depending on the potential for sensitive and protected/regulated species to be within a project area, biologists conduct appropriate surveys for each land-disturbing activity prior to project start. A tortoise clearance survey is required within 24 hours before the start of a project when there is a possibility that a tortoise may be in the project area, adjacent land, or wander into the project area during construction activities. A pre-activity survey is completed by walking meandering transects or the entire area and is required when there is no possibility of a tortoise being encountered during the project's activities, but other sensitive and protected/regulated species may be encountered. A pre-activity survey for buildings is required prior to demolition of buildings, reactivation of decommissioned buildings, or relocation of trailers. The pre-activity survey for buildings also includes a survey for the outside of the building and the entire construction area. A pre-activity exit survey for tunnels or structures that may be used by bats is required prior to reactivation of deactivated tunnels or structures. A post-activity survey is required for

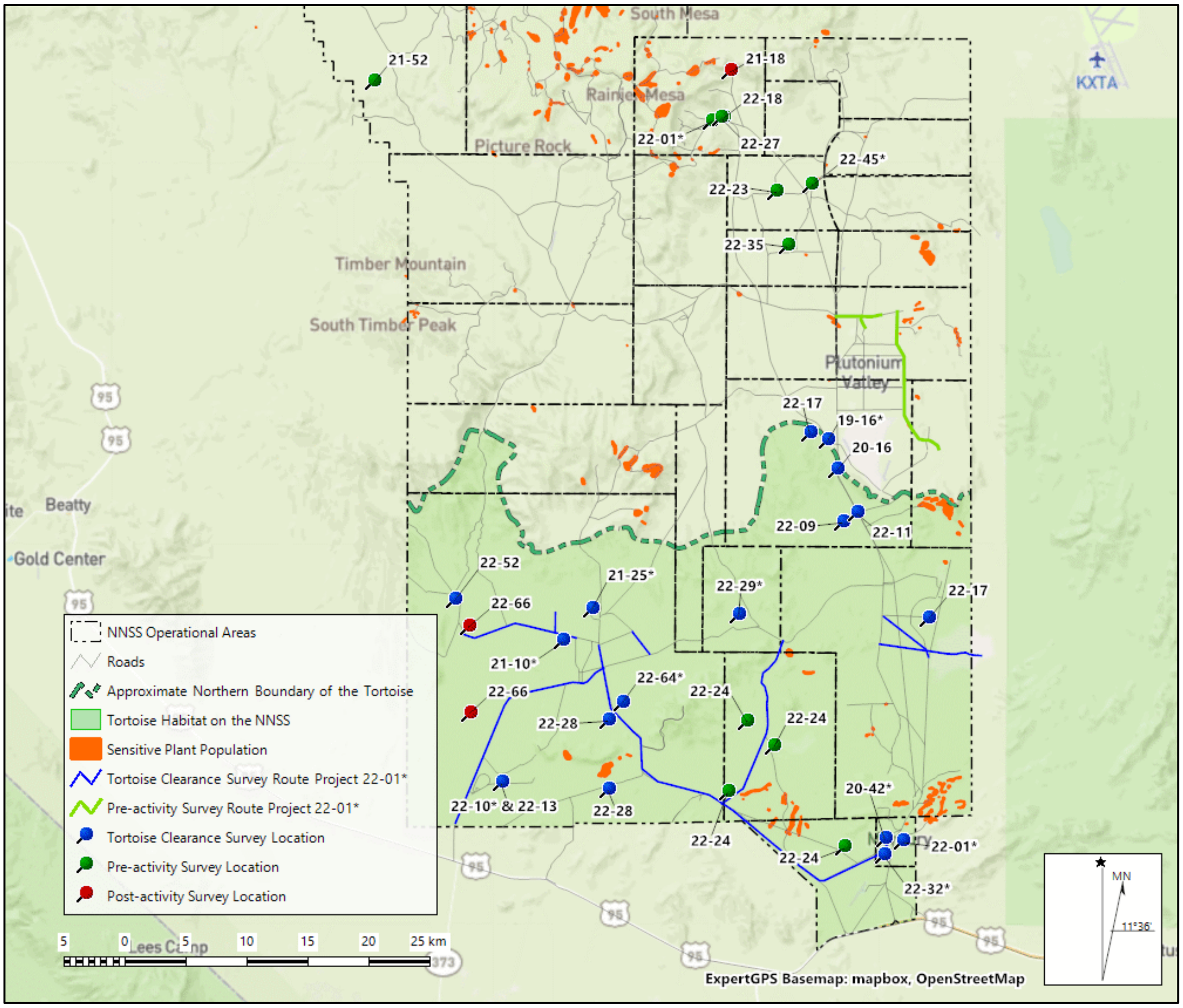

Figure 2-1. Biological surveys conducted in 2022. Projects with an asterisk (*) also had a post-activity survey completed in 2022.

certain projects to determine the total amount of habitat disturbed and ensure the project followed all applicable biological compliance. Table 2-2 lists the type of surveys required for each project.

During vegetation mapping surveys of the NNSS, delineated areas of homogeneous plant communities were identified and referred to as Ecological Landform Units (ELUs) (Ostler et al. 2000). These ELUs were evaluated for importance with the intent that comparable ELUs would respond similarly to land management practices. This concept was later applied to categorizing groupings of ELUs into important habitat types as follow: *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).

Project 18-09 disturbed 5.79 ha of *Sensitive Habitat*. The total area disturbed (ha) of important habitat types tracked since 1999 comprises 11.01 (*Pristine*), 22.32 (*Unique*), 403.59 (*Sensitive*), and 87.05 (*Diverse*). Projects in 2022 disturbed a total of 11.70 ha of undisturbed land (Table 2-2). Projects utilize previously disturbed areas as well as existing roads as much as possible to minimize the disturbance of habitat. Most notable is the amount of area surveyed compared to the actual disturbance (Table 2-2).

Table 2-2. Summary of biological surveys conducted on the NNSS during 2022.

Project No.	Project Name	Important Species/Resources Found	Area Surveyed (ha)	Project area in Undisturbed Habitat (ha)	Mitigation in 2022
19-16	Area 6 Tippipah Batch Plant	Yucca, cacti, juvenile tortoise burrow	6.60	5.79	TCS [a], Post-activity Survey
20-16	Area 6 Control Point Demolition	Yucca, cacti, active raven nest (avoided), dead bat, inactive bird nests, ungulate sign	0.91	0	TCS [a], Pre-activity Survey for Buildings
20-42	138 kilovolt Power Transmission System Replacement	Yucca, cacti	6.00	0	TCS [a], Post-activity Survey
21-10	Corrective Action Unit 114	Live tortoise (hibernating, penned, avoided), inactive bird nests, ungulate sign, cacti, coyote carcass, predator burrows	9.40	0.69	TCS [a], DTM [b], Post-activity Survey
21-18	Balloon System Launch Location	Pine trees, cacti, ungulate sign	NA	0	Post-activity Survey[c]
21-25	Corrective Action Unit 572	Yucca, cacti, old disarticulated adult tortoise carcass, inactive bird nest	6.90	0	TCS [a], Post-activity Survey
21-52	Well Site Clean-up Phase II	Sensitive plant (*Eriogonum concinnum*)	1.60	0	Pre-activity Survey
22-01	Roads and Grounds Activities	Live tortoise crossing a road, yucca, cacti, pine trees, predator burrows	157.32	0.13	TCS [a], DTM [b], Pre-activity Survey, Post-activity Survey
22-09	Geotech Soil Borings	Yucca, cacti, predator burrow	2.70	0	TCS [a]
22-10	Weed Clearing Building 25-202495	Ungulate sign	2.68	0	TCS [a], DTM [b], Post-activity Survey
22-11	7 Area Clean-up and Restore	Yucca, cacti	1.00	0	TCS [a]
22-13	Trailer Removal at Building 25-202495	None	NA	NA	Pre-activity Survey for Buildings
22-17	Wellhead Repairs	Ungulate sign, burrowing owl site	2.94	0	TCS [a]
22-18	Relocation Trailer 9136	None	NA	NA	Pre-activity Survey for Buildings
22-23	Area 2 Trailer Disposal	Bird sign	NA	NA	Pre-activity Survey for Buildings
22-24	Rock Valley Monitoring Stations	Cacti, active raven nest (avoided)	3.64	0	Pre-activity Survey
22-27	Area 12 Camp Structure Demo	Bat sign, desert cottontail	2.30	0	Pre-activity Survey
22-28	Rock Valley Seismic Station Reoccupation	Cacti, ungulate sign, predator burrows, tortoise burrows	2.30	0	TCS [a]
22-29	Bronze Ram	Predator burrows	6.40	3.56	TCS [a], DTM [b], Post-activity Survey
22-32	Mercury Switch Center Bypass	Yucca, cacti, tortoise burrow	5.67	0	TCS [a], DTM [b], Post-activity Survey

Table 2-2. Summary of biological surveys conducted on the NNSS during 2022 (continued).

Project No.	Project Name	Important Species/Resources Found	Area Surveyed (ha)	Project area in Undisturbed Habitat (ha)	Mitigation in 2022
22-35	Fire Break Expansion	Yucca, ungulate sign, predator burrow	14.70	In progress	Pre-activity Survey
22-44	Area 12 Demolition SS1 Structure	No survey completed – noncompliance	NA	NA	Pre-activity Survey for Buildings
22-45	Substation 2-1 Bypass	Bat site, burrowing owl site	6.86	0.15	Pre-activity Survey, Post-activity Survey
22-52	Yucca Mountain Borrow Pit	Ungulate sign, Sahara mustard (invasive plant)	14.4	0	TCS [a]
22-64	Jackass Flats Substation Expansion	Cacti, ungulate sign	1.90	1.38	TCS [a], DTM [b], Post-activity Survey
22-66	Emergency Off-road Driving	One collapsed burrow (vacant), cacti	10.60	0	Post-activity Survey [c]
		Total	**266.82**	**11.70**	

[a] Tortoise Clearance Survey
[b] Desert Tortoise Monitor
[c] Post activity survey completed in 2022. Area surveyed during TCSs or pre-activity surveys was reported in previous years' EMAC reports.

3.0 DESERT TORTOISE COMPLIANCE

Tortoises occur within the southern one-third of the NNSS. This species is listed as threatened under the Endangered Species Act (ESA). 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 tortoise. NNSA/NFO received a Biological Opinion from FWS in August 1996 (FWS 1996). On July 2, 2008, NNSA/NFO provided FWS with a Biological Assessment of anticipated activities on the NNSS from 2009 through 2019. NNSA/NFO received the Programmatic Biological Opinion on February 12, 2009 (FWS 2009). On February 27, 2019, NNSA/NFO provided FWS with a Biological Assessment of anticipated activities on the NNSS from 2019 through 2029 and entered into formal consultation with FWS to obtain a new Biological Opinion. NNSA/NFO received the Programmatic Biological Opinion (herein referred to as Opinion) on August 27, 2019 (FWS 2019).

The Desert Tortoise Compliance task of EMAC implements the protective measures of the Opinion, documents compliance actions taken by NNSA/NFO, and assists NNSA/NFO in FWS consultations. All protective measures listed in the Opinion were implemented by MSTS biologists in 2022, including (a) conducting one-hundred percent coverage tortoise clearance surveys (TCS) at project sites within 24 hours from the start of project construction, (b) ensuring projects have a desert tortoise monitor (DTM) 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 FWS.

3.1 Project Surveys and Compliance Documentation

Forty-eight projects occurring within the range of the tortoise were reviewed by biologists in 2022 and six projects in progress were carried over from previous years (Table 3-1). Projects are placed in one of three categories based on biological review: framework programmatic action (requires surveys and formal consultation with FWS), program-level action (requires surveys but no consultation with FWS), or no effects to the tortoise (surveys may still be required based on other important species in the project area). Once placed in one of the categories, required compliance activities are determined and completed (Table 3-1).

Fifteen TCSs were completed by biologists in 2022 (Figure 2-1, Table 2-2, Table 3-1). One tortoise was observed crossing a paved road during project 22-01 during removal of road shoulder vegetation along Jackass Flats Road. The tortoise was moved off the road and project activities were halted for the remainder of the week due to increased tortoise activity from rainstorms. Another tortoise was found hibernating in the buffer zone of project 21-10. The tortoise’s burrow was penned during the winter months in accordance with the Opinion’s terms and conditions to prevent the tortoise from being injured by project activities (Figure 3-1). No tortoises were reported injured or killed during projects. A total of 11.42 ha of tortoise habitat was disturbed during 2022.

In January 2023, the annual report summarizing tortoise compliance activities conducted on the NNSS from January 1 through December 31, 2022, was submitted to FWS. This report, required under the Opinion, contains (a) the location and size of land disturbances that occurred within the range of the tortoise; (b) the number of tortoises injured, killed, or relocated off project sites; (c) a map showing the location of all tortoises sighted or relocated from on or near roads as well as vehicular mortalities; and (d) a summary of construction mitigation and monitoring efforts.

Table 3-1. Summary of projects within the range of the tortoise that were reviewed, compliance activities required, surveys completed, and amount of tortoise habitat disturbed in 2022 (TCS = Tortoise clearance survey, DTM = Desert tortoise monitor).

Project No.	Project Name	Description of Compliance Activity Required	TCS Completed During 2022	Tortoise Habitat Disturbed During 2022 (ha)
17-12 (18-43) [a]	Power Pole Weed Abatement	Formal Consultation, TCS, DTM		0
18-05 [a]	RWMC Expansion	Formal Consultation, TCS, DTM		0
18-09 [a]	Test Bed South	Formal Consultation, TCS, DTM		0
19-16 [a]	Area 6 Tippipah Batch Plant	Formal Consultation, TCS, DTM	✓	5.79
20-01 [a]	RWMC Westward Expansion	Formal Consultation, TCS, DTM		0
20-16	Area 6 Control Point Demolition	TCS	✓	0
20-42 [a]	138 kilovolt Power Transmission System Replacement	Formal Consultation, TCS, DTM	✓	0
21-10	Corrective Action Unit 114	TCS, DTM	✓	0.69
21-25	Correction Action Unit 572	TCS, DTM	✓	0
21-44	Rock Valley Direct Comparison	Formal Consultation, TCS, DTM		0
21-46	Device Assembly Facility Surface Modernization	Formal Consultation, TCS, DTM		0
21-57	Antenna Assembly	None		0
22-01	Blading Maintenance Roads and Grounds 2022 Activities	TCS, DTM	✓	0
22-02	Lower Phoenix 26-2205	None		0
22-03	Project E2 Event 3	None		0
22-09	Geotech Soil Borings	TCS	✓	0
22-10	Weed Clearing 25-202495	TCS	✓	0
22-11	Device Assembly Facility 7 Area Clean-up and Restore	TCS	✓	0
22-13	Trailer Removal 25-202495	None		0
22-17	Wellhead Repairs	TCS	✓	0
22-18	Install Signs at Cattle Guard	None		0
22-20	Trench 23-630	None		0
22-24	Rock Valley Monitoring Stations	None		0
22-25	Replace Culvert 23-700	None		0
22-26	Fire Hydrant Repairs	None		0

Table 3-1. Summary of projects within the range of the tortoise that were reviewed, compliance activities required, surveys completed, and amount of tortoise habitat disturbed in 2022 (continued).

Project No.	Project Name	Description of Compliance Activity Required	Survey Completed During 2022	Tortoise Habitat Disturbed During 2022 (ha)
22-28	Rock Valley Seismic Station Reoccupation	TCS	✓	0
22-29	Bronze Ram	TCS, DTM	✓	3.56
22-30	Device Assembly Facility Power Stations	None		0
22-31	Mercury Sidewalks	None		0
22-32	Mercury Switch Center Bypass	TCS, DTM	✓	0
22-33	Indoor Firing Range	None		0
22-37	Replace Concrete Pad 23-128	None		0
22-38	Underground Conduit 05-20	None		0
22-39	Device Assembly Sensory Maintenance	None		0
22-40	Area 27 Tank Refurbishment	None		0
22-41	Surface Sampling	None		0
22-42	Electrical Hook Ups	None		0
22-47	23-117 Pothole	None		0
22-50	Port Gaston Power Upgrades	None		0
22-51	Mercury Block 1 Utilities	None		0
22-52	Yucca Mountain Borrow Pit Reactivation	TCS	✓	0
22-56	Demonstration Rocket for Agile Cislunar Operations	None		0
22-57	Area 25 Exercise	None		0
22-58	Set Geophones	None		0
22-60	Range Upgrade Utility Poles	None		0
22-61	Baseline Building Measurements	None		0
22-64	Antelope Ridge Jackass Flats Substation Expansion	TCS, DTM	✓	1.38
22-66	Emergency Off-road Driving	Post-activity Survey		0
22-68	Sidewalk Improvements Area 5	None		0

Table 3-1. Summary of projects within the range of the tortoise that were reviewed, compliance activities required, surveys completed, and amount of tortoise habitat disturbed in 2022 (continued).

Project No.	Project Name	Description of Compliance Activity Required	TCS Completed During 2022	Tortoise Habitat Disturbed During 2022 (ha)
22-70	Global Security Operations West Facility Area	None		0
22-71	Global Security Operations West New Trailer	None		0
22-73	Global Security Operations West H-Pad Trailers	None		0
22-74	Mini Tower Lower X Tunnel Pad	None		0
22-76	Rock Valley Control Points	None		0
			Total	**11.42**

[a] Project carried over from previous year.

Figure 3-1. Constructed pen kept in-place during winter months for project 21-10 to protect a hibernating tortoise.

(Photo by J.A. Perry, December 14, 2022).

Compliance with the Opinion ensures the tortoise is protected on the NNSS and the cumulative impacts on this species are minimized. In the Opinion, FWS determined the "incidental take" ("take" means to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect, or to attempt to engage in any such conduct, and "incidental take" is a take that results from activities that are otherwise lawful) of tortoises on the NNSS and the cumulative acreage of tortoise habitat disturbed on the NNSS are parameters that should be measured and monitored annually. Although all detected incidental take events are reported under the Opinion, new parameters set by FWS in 2019 require only large tortoises (>180 millimeters [mm] midline carapace length ([MCL]) be reported under the Opinion's incidental take limits. This is due to the low detection rate of small tortoises. Cumulative totals under the current Opinion reported in the FWS annual report are presented in Table 3-2. Cumulative totals tracked since 1992 are represented in Table 3-3.

There were an unprecedented 115 reported tortoise roadside observations on the NNSS during 2022 (Figure 3-2). The NNSS, being impacted by two years of below-average precipitation, had little to no annual forb germination in the spring. Tortoise habitat on the NNSS received desperately needed monsoon rain in August and September (average of 0.75 inches). The combination of forage availability being restricted to road edges and the rainfall in August and September drew tortoises to the roads at an uncommon rate this year (Figure 3-2). It was difficult to track incidental take because majority of sightings were the same tortoises observed several times by different employees, sometimes on the same day.

Of the 115 roadside sightings, 5 were roadkill (3 small and 2 large), 3 were observations of small tortoises that were not handled, 12 were observations of large tortoises that were not handled, 23 were of small tortoises that were moved off roads, 71 were of large tortoises that were moved off roads, and 1 was documented under project 22-01.

The 71 large tortoises moved off roads were determined to be incidental take. This number does not reflect unique tortoises, as it is apparent from Figure 3-2 that many of the sightings were the same tortoise observed multiple times.

Some of the tortoises that were observed and/or moved off roads were previously paper-tagged with unique numbers and identified multiple times: NNSS20 five times, NNSS21 fifteen times, NNSS26 two times, NNSS64 was observed twice then was hit and killed by a vehicle, NNSS65 three times, NNSS66 three times, NNSS67 one time, and NNSS68 five times.

Three of the roadkill tortoises were small; therefore, were not included as incidental take, but were detected and reported to FWS. All three were found dead upon arrival; two on a paved road (Jackass Flats Road) and one on a dirt road (Power Line Road). Two large tortoises were hit by vehicles on Jackass Flats Road and were included as incidental take. One was found dead upon arrival (NNSS64) and the other found injured. The injured tortoise was taken to a veterinarian in Las Vegas, Nevada and euthanized due to its injuries.

3.1.1 Mitigation for Loss of Tortoise Habitat

Prior to land-disturbing activities associated with any projects of the Work-for-Others (now the Strategic Partnership Projects) program, the proponent shall pay remuneration fees to minimize effects from disturbance of tortoise habitat on the NNSS in accordance with FWS-approved instructions (FWS 2019). For land-disturbing activities that occur under all other programs (i.e., Defense, Waste Management, Environmental Restoration, Nondefense Research and Development, and Infrastructure), NNSA/NFO will minimize effects from disturbance of tortoise habitat by funding and implementing FWS-approved conservation actions on the NNSS (FWS 2019). Remuneration fees are currently paid into the Mojave

Table 3-2. Summary of tortoise habitat disturbance, tortoise habitat disturbance limits, incidental take of large tortoises (>180 mm MCL), and anticipated number of incidental take of large tortoises under the current Opinion August 27, 2019 – December 31, 2022.

Program	Actual No. of Hectares Impacted (Limit Allowed)	No. of Tortoises Incidentally Taken (Maximum Allowed)	
		Non-injury or Non-mortality [a]	Detected Injury or Mortality
1) Continued Use of Existing Roads	NA	126 (350) [b]	2 (15) [c]
2) Defense	0.3 (202)	0 (10)	0 (2)
3) Waste Management	21.3 (101)	0 (10)	0 (2)
4) Environmental Restoration	0 (101)	0 (10)	0 (2)
5) Nondefense R&D [e]	6.1 (405)	0 (20)	0 (4)
6) Work-for-Others	0 (202)	0 (20)	0 (2)
7) Infrastructure	15.7 (202)	1 (20)	0 (4) [d]
Totals	**43.4 (1,213)**	**127 (440)**	**2 (31)**

[a] All tortoises observed in harm's way may be moved to a safe location
[b] No more than 35 non-injury or non-mortality tortoises in a given year and no more than 350 during the term of the Opinion.
[c] No more than 4 tortoises killed in a given year and no more than 15 killed during the term of the Opinion.
[d] No more than 2 tortoises killed in a given year and no more than 4 killed during the term of the Opinion.
[e] Research and Development

Desert Tortoise Sub-Account through the National Fish and Wildlife Foundation Chief Financial Officer for all Work-for-Others projects at the rate of $1,002 per acre of disturbance. All other projects can utilize the NNSS's accrued funds from implementation of FWS-approved conservation studies. Deductions from the accrued funds are applied at a level equal to the rate of $1,002 per acre of disturbance.

Four projects disturbed habitat in 2022. One was a framework programmatic action, 19-16, which disturbed 14.3 acres (ac) and prepaid remuneration fees under previous Opinion File No. 84320-2008-F-0416. The remaining three projects were programmatic actions: 21-10, 22-29, and 22-64. In addition, two projects, 21-44 and 21-46, were appended to the Opinion this year, and, although did not start work, a deduction of $25,050 (25 ac x $1,002) and $45,090 (45 ac x $1,002), respectively, were applied.

The following programmatic actions had remuneration fees deducted from accrued funds:

- 21-10 disturbed 1.7 ac; therefore, fees cost $1,703 (1.7 ac x $1,002)
- 22-29 disturbed 8.8 ac; therefore, fees cost $8,818 (8.8 ac x $1,002)
- 22-64 disturbed 3.4 ac; therefore, fees cost $3,407 (3.4 ac x $1,002)

3.2 Conservation Recommendations

Biologists continue to increase tortoise awareness by updating and increasing tortoise warning signs throughout the NNSS. Biologists continued placing temporary warning signs on either side of the road at recent tortoise roadkill locations. Signs are left out for two weeks following a tortoise mortality to increase driver's awareness. All nets radio announcements are also made when weather conditions are anticipated to increase tortoise activity.

Table 3-3. Summary of disturbance of tortoise habitat, tortoise roadside observations (live tortoises), number of tortoises moved safely off the road during roadside observations (Non-injury or Non-mortality Roadside Observations), and detected road mortalities (Detected Injury or Mortality) for all size classes 1992 – 2022.

Calendar Year	Hectares Disturbed	Total Roadside Observations	Non-injury or Non-mortality Roadside Observations [a]	Detected Injury or Mortality on Roads
1992-1996	57.4	Not documented	Not documented	2
1997	0.0	12	0	0
1998	0.0	3	3	1
1999	11.6	7	4	0
2000	2.5	7	7	0
2001	8.9	11	11	1
2002	6.3	3	3	0
2003	1.5	12	12	0
2004	9.1	17	17	3
2005	16.2	14	14	1
2006	5.5	35	14	1
2007	5.5	34	17	1
2008	2.6	19	19	0
2009	3.3	31	5	1
2010	1.8	22	13	2
2011	1.9	13	9	1
2012	6.2	19	18	1
2013	4.8	12	14	2
2014	2.2	16	17	0
2015	0.0	26	17	2
2016	0.1	36	19	1
2017	0.5	45	41	2
2018	6.0	34	31	0
2019	0.0	66	56	2
2020	9.9	41	32	2
2021	22.1	39	30	2
2022	11.4	115	71	2
Total	**197.2**	**997**	**848**	**30**

[a] All tortoises observed in harm's way may be moved to a safe location. If the tortoise is not in harm's way, it is allowed to move itself off the road, not counting towards incidental take.

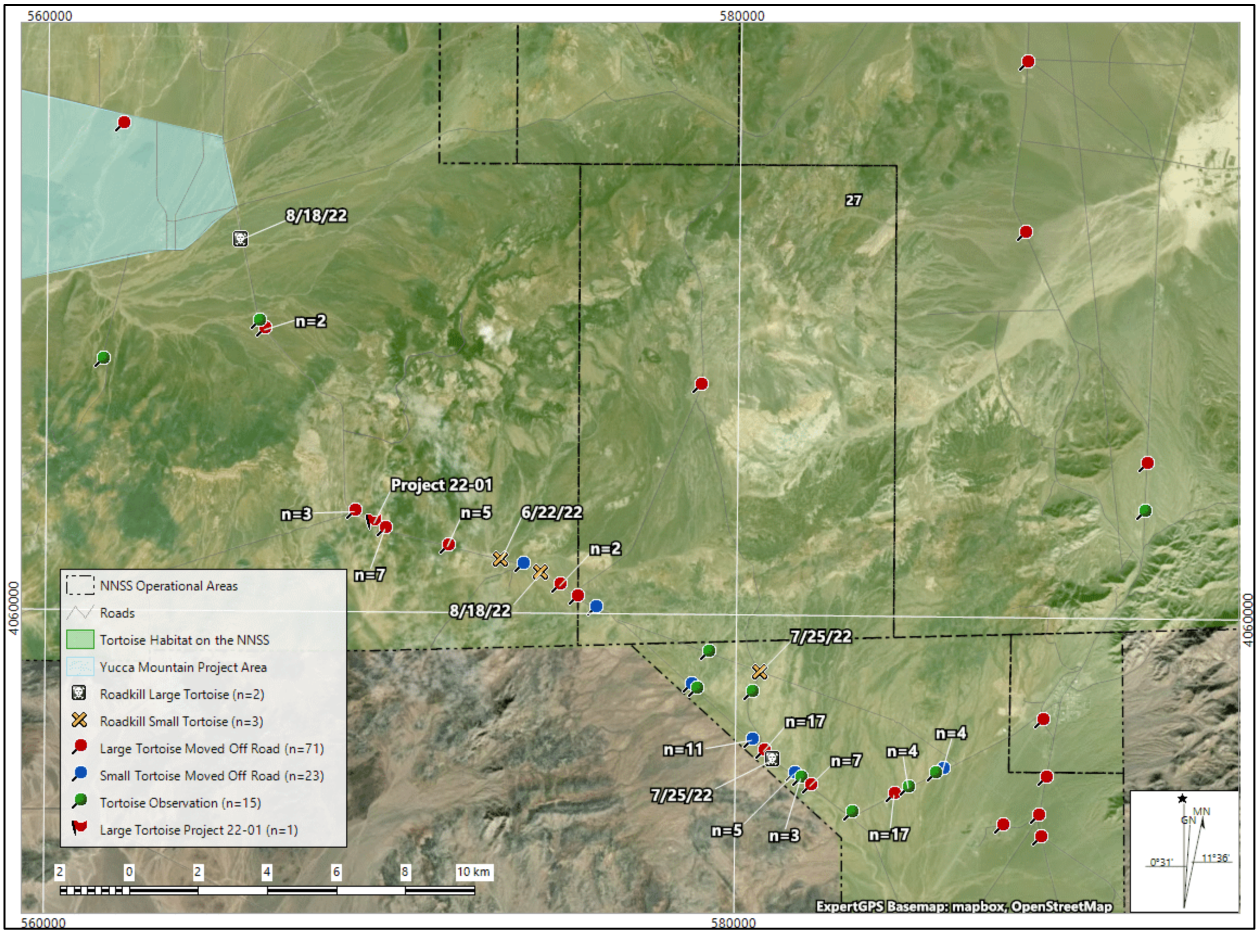

Figure 3-2. Locations of tortoise roadside observations on the NNSS (n=115) with associated size classes (large tortoises are >180 mm MCL and small are ≤180 mm MCL) from January 1, 2022 through December 31, 2022. Coordinates in UTM NAD83 (Zone 11, meters)

As a recommendation from FWS, MSTS biologists implemented a study in 2019 of tortoise exposure to radiological sources or fallout from nuclear testing by opportunistically testing tortoise carcasses found on the NNSS for radionuclides. Carcasses utilized for the study are selected from recent roadkills or found during the juvenile translocation study. No tortoise carcasses were tested in 2022. There are currently 16 tortoise carcasses approved by FWS to be processed and tested. They will be tested after Los Alamos National Laboratory (LANL) obtains scute samples for their study to determine radiation impacts through scute sampling, which is a collaborative study with MSTS biologists.

Two tortoise conservation research studies have been approved by FWS and are being implemented by MSTS biologists: the road study and juvenile translocation study. The following is a synopsis of activities conducted for each of these projects.

3.2.1 Road Study

With the expansion of infrastructure, namely roads, throughout the Mojave Desert, researchers are compelled to document short- and long-term impacts to habitat and wildlife to assist with developing conservation management strategies. The effects that linear habitat disturbances have on the tortoise extend beyond the footprint of the degraded habitat. This study, approved by FWS and conducted from

2012-2018, focused on increasing knowledge of tortoise activity near unfenced, moderately trafficked roads (<25 to >600 vehicles/day) within the northern range of the tortoise. Thirty tortoises were captured on or near paved roads and monitored for three active seasons using Global Position System (GPS) loggers and radio telemetry. The study examined habitat use, home range, speed, activity, road-crossings, and movement behavior. MSTS biologists collaborated with the Smithsonian Conservation Biology Institute for the study analysis. The resulting report will be published in 2023.

Biologists are currently implementing an opportunistic mark-recapture study to continue tracking road-crossing events. The study was approved by FWS and allows permitted biologists to attach identification numbers to tortoises when they are found and moved safely off NNSS roads. The objectives of the study are to (1) determine if tortoises moved safely off roads are repeat offenders, (2) identify trends in repeat offenders crossing roads, and (3) assist with collection of tortoise density data. Marking tortoises found on roads for future identification will provide information on population size and trends over time, which will assist in future conservation and management efforts (Pike et al. 2005). Five tortoises were paper-tagged this year: NNSS64–NNSS68. Tortoise NNSS64 was hit and killed by a vehicle two months after being tagged with a unique number.

3.2.2 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 FWS, MSTS, and the San Diego Zoo Institute for Conservation Research (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 tortoise recovery.

Each tortoise was affixed with a very high frequency transmitter prior to release for post-release monitoring purposes. Regular monitoring of the animals occurred post-release from 2012 through 2022. Regular monitoring was conducted during 2022—once in January and December; weekly in March, April, May, September, and October; and twice in February, June, July, August, and November. Additional monitoring was conducted in early January 2023 to determine each tortoise's winter burrow. Once a tortoise was located, information such as date and time, elevation, Universal Transverse Mercator (UTM) coordinates, position (i.e., in burrow and burrow number, under vegetation, in the open), habitat, substrate, activity, foraging evidence and species, temperature, cloud cover, and wind were recorded.

At the beginning of 2022, 12 tortoises were known to be alive (Table 3-4; Figure 3-3). By the end of 2022, 10 of the 60 tortoises (16.7%) (4 female, 6 male) were known to be alive and 2 tortoises were missing (1 female [4046], 1 male [4048]). These went missing in July and September, respectively, due to suspected transmitter failure. Several searches were made to detect a signal or find the missing tortoises. Searches will continue to be made for these missing tortoises during spring 2023. They are assumed to be alive.

Our survival rate of 20.0% (12 of 60 alive) after 10 years is a little lower but comparable to an estimated 21.7% (13 of 60 alive) survival based on an annual survival rate of 0.857 calculated for a natural population (Turner et al. 1987). Excluding the three males that went missing during the study (4003, 4040, 4041) there is a higher survival rate, albeit not as high as previous years, for males (25.9% [7 of 27]) compared to females (17.2% [5 of 29]) with most of the mortalities (34 of 45; 76%) caused by suspected coyote and kit fox (*Vulpes macrotis*) predation. Given the importance of females surviving to adulthood to reproduce, this may be a critical life stage for females. If female juveniles are not surviving to sexual maturity, this could contribute to a decline in tortoise populations. Mulder et al. (2017) found

Table 3-4. Mortality, sex, distance in meters (m) between release site and January 2023 burrow, distance between January 2022 burrow and January 2023 burrow, total distance between monitored locations (January 2022 to January 2023), and total number of burrows and new burrows occupied by 12 juvenile desert tortoises monitored during 2022.

Tortoise Number	Sex	Distance (m) Release to January 2023 Burrow	Distance (m) between January 2022 and January 2023 Burrows	Total Distance (m) between locations January 2022-2023	Number of Burrows Used (New Burrows)
4030	Female	2443	88	1202	5 (3)
4039	Female	275	141	729	4 (2)
4044	Female	227	0	567	4 (3)
4045	Female	196	32	1278	6 (3)
4046	Female	1085[a]	712[a]	Unknown	6 (2)[a]
4004	Male	261	42	1547	5 (2)
4007	Male	27	0	1478	4 (0)
4011	Male	637	0	3224	4 (1)
4025	Male	1048	52	1799	12 (4)
4034	Male	645	764	2413	7 (5)
4036	Male	636	118	1471	6 (4)
4048	Male	240[b]	0[b]	Unknown	1 (0)[b]
	Average	643	162	1571	

[a] As of 9/12/2022
[b] As of 7/11/2022

that adult female fitness and integration following translocation was high which suggests that survival, integration, and acceptance of translocated female tortoises into a natural population may be key to a successful translocation. The more females, resident or translocated, that survive, the greater the fecundity which should result in population increases. Understanding differential mortality in both resident and translocated juvenile tortoises of both sexes warrants further study.

Table 3-4 contains information about the 12 juvenile tortoises monitored during 2022. On average, the distance between the release location and winter 2022-2023 burrow (i.e., the burrow a juvenile was in during the first part of January 2023) was 643 m (range = 27 – 2,443 m, standard deviation [sd] = 660). On average, tortoises used winter burrows in 2023, 162 m away from their 2022 winter burrows. Two-thirds (8 of 12) of the tortoises wintered in burrows within 100 m of their last year's winter burrow, and one-third (4 of 12) used the same winter burrow as the previous year.

The average distance moved between monitoring checks was 1,571 m (range = 567 – 3,224 m; sd = 738 m). This is not the total distance a tortoise moved during the year, but the summed straight-line distance between locations recorded during regular monitoring. Movements tortoises made between monitoring checks were not recorded or measured.

During 2022, burrows were marked with unique numbers and data collected included UTM coordinates (North American Datum [NAD] 83), burrow height, burrow width, burrow orientation, elevation, location, topographic position, vegetation cover, and substrate. The number of unique burrows an individual used was calculated and is shown in Table 3-4. Tortoise burrows were only documented during tracking events, so it is likely that not all burrows used were documented. A total of 62 unique burrows were used during 2022, including 29 new burrows that were marked and measured. One burrow was used

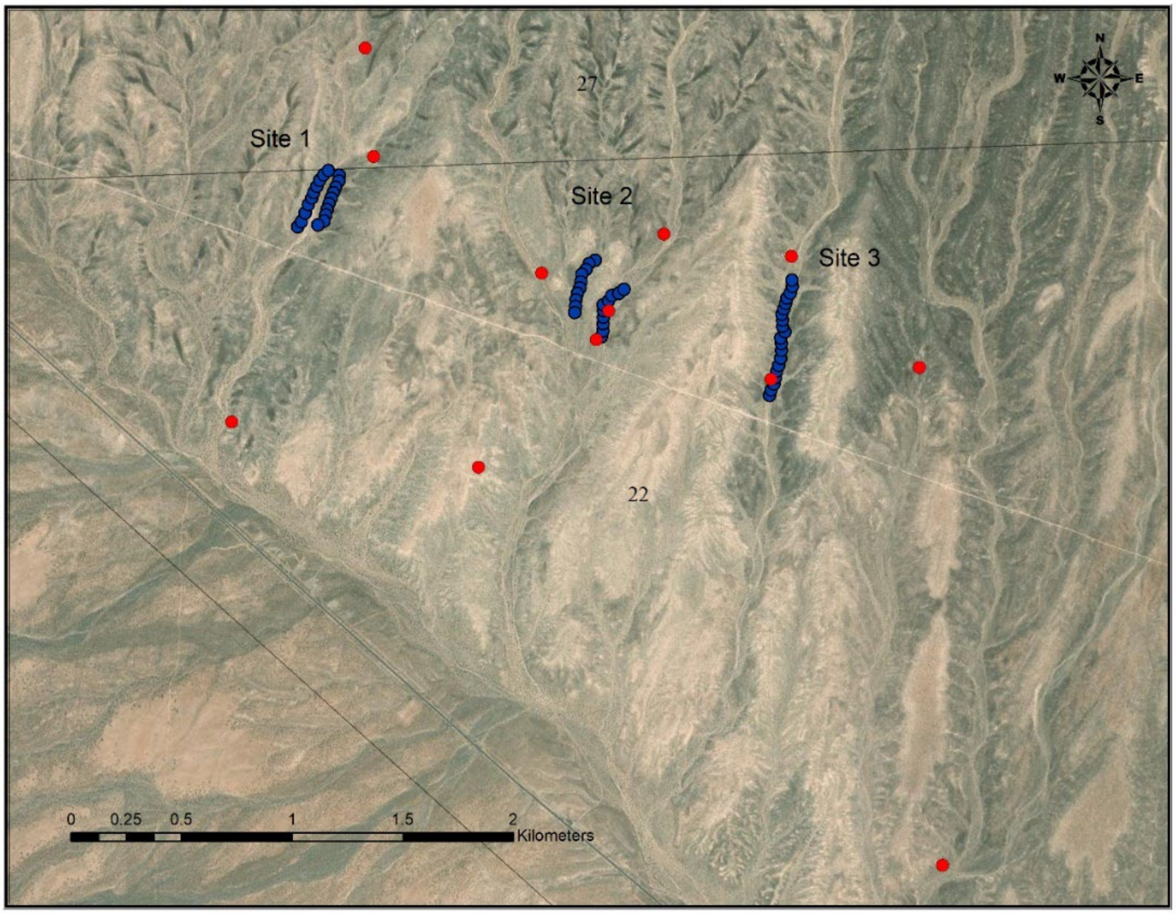

Figure 3-3. Release locations for 60 tortoises, September 2012 (blue dots, 20 at each site) and last known locations for 12 tortoises monitored during 2022 (red dots).

by two different tortoises on different dates. The average height of new burrows was 11.5 mm (range = 8 – 20 mm; sd = 3.0 mm) and average width of burrows was 23.0 mm (range = 15 – 32 mm; sd = 3.7 mm). On average, tortoises used 5.2 unique burrows (range = 1 – 12; sd = 2.6) (Table 3-4). Timing of arrival at winter burrows differs between years (Table 3-5) and appears to be influenced by temperature and moisture. If enough moisture is received in the fall to cause plant germination and regrowth and temperatures are mild, tortoises continue to move around and forage into November (Hall et al. 2016). Some precipitation was received in August and September resulting in patchy plant production but not enough to influence tortoise foraging much.

Between early January 2022 and early January 2023, 394 observations were recorded. Tortoises were at burrows 82% of the time and aboveground 18% of the time including under vegetation (12%), in the open (6%), inside the burrow (79%), in the burrow mouth (2%), or on the burrow apron (1%) (Figure 3-4). Of the 47 observations under vegetation, 32% were under blackbrush (*Coleogyne ramosissima*), 24% were under Nevada jointfir (*Ephedra nevadensis*), 11% were under pale desert-thorn (*Lycium pallidum*), 6% were under cheesebush (*Hymenoclea salsola*), 4% were under creosote bush (*Larrea tridentata*), 4% were under white bursage (*Ambrosia dumosa*), 13% were under mixed shrub species clumps, and the remaining 6% under three other shrub species (2% Fremont's dalea [*Psorothamnus fremontii*], 2% Mojave yucca [*Yucca schidigera*], and 2% range ratany [*Krameria erecta*]) (Figure 3-5).

Table 3-5. Percentage of tortoises at their winter burrow by October 1 and October 23 and the date by which all tortoises were at their winter burrows for the years 2014–2022.

Year	By October 1	By October 23	Date All Tortoises at Winter Burrow
2014	53	90	November 18
2015	4	37	November 23
2016	15	26	November 7
2017	41	89	November 6
2018	38	96	October 29
2019	13	78	December 12
2020	38	88	November 23
2021	25	83	October 28
2022	30	90	November 7

For the 29 new burrows, tortoises used burrows on wash slopes 55% of the time followed by burrows in wash bottoms (35%), active washes (7%), and washlets (3%) (Figure 3-6). Vegetation cover at burrows was found at 93% of the burrows, suggesting this may be an important factor in burrow use for these juveniles. Creosote bush was the dominant species (17%) followed by mixed shrub clumps (14%), Nevada jointfir (14%), water jacket (14%), and pale desert thorn (10%). White bursage, blackbrush, and spiny hopsage (*Grayia spinosa*) all had 7%. Range ratany was at 3% (Figure 3-7).

Gravel was the dominant substrate at 52% of all new juvenile tortoise burrows followed by cobble (21%), sandy/gravel (20%), and gravel/cobble (7%) (Figure 3-8). Gravel is defined as rocks <2.5 centimeters (cm) in size, cobble as rocks between 2.5 and 12.7 cm, rock as >12.7 cm, and solid rock is bedrock. Combined categories such as gravel/cobble means that both were equal in abundance.

Evidence of foraging was documented on six tortoises, 15 times between February 28 and September 12, 2022, with a foraging peak in April (7 times) (Figure 3-9). This was similar to last year and a substantial decrease from prior years. The one documented species eaten was red brome (*Bromus rubens*) (6.7%). Most (93.3%) of the time, it was not possible to identify what the tortoises had eaten. Winter and spring precipitation was about half of normal and production of annual forbs and grasses, even *Bromus* species, was virtually non-existent. Some precipitation was received in August and September resulting in some patchy plant production but not enough to influence tortoise foraging. Like 2021, there were reduced foraging opportunities for tortoises during 2022.

Transmitters were changed out in the fall and health assessments were completed for seven tortoises. Biologists were unable to find three of the tortoises (Male 4025, Female 4039, and Female 4044) aboveground in the fall and two tortoises (Female 4046 and Male 4048) were missing due to transmitter failure. Their transmitters were not changed out and health assessments were not performed on these five individuals. Three transmitters were changed out in the spring (Male 4025, Female 4039, and Female 4044) because these tortoises were not found outside their burrows during fall 2021.

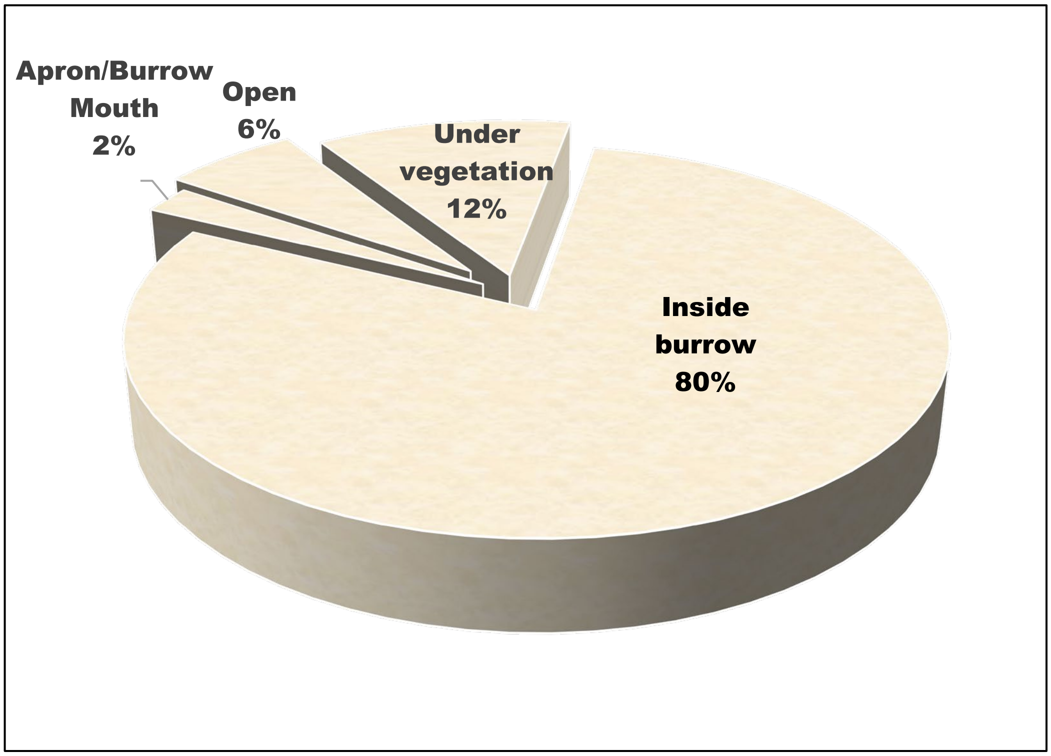

Figure 3-4. Percentage of observations (n = 394) of 12 juvenile tortoises by location, January 2022–January 2023.

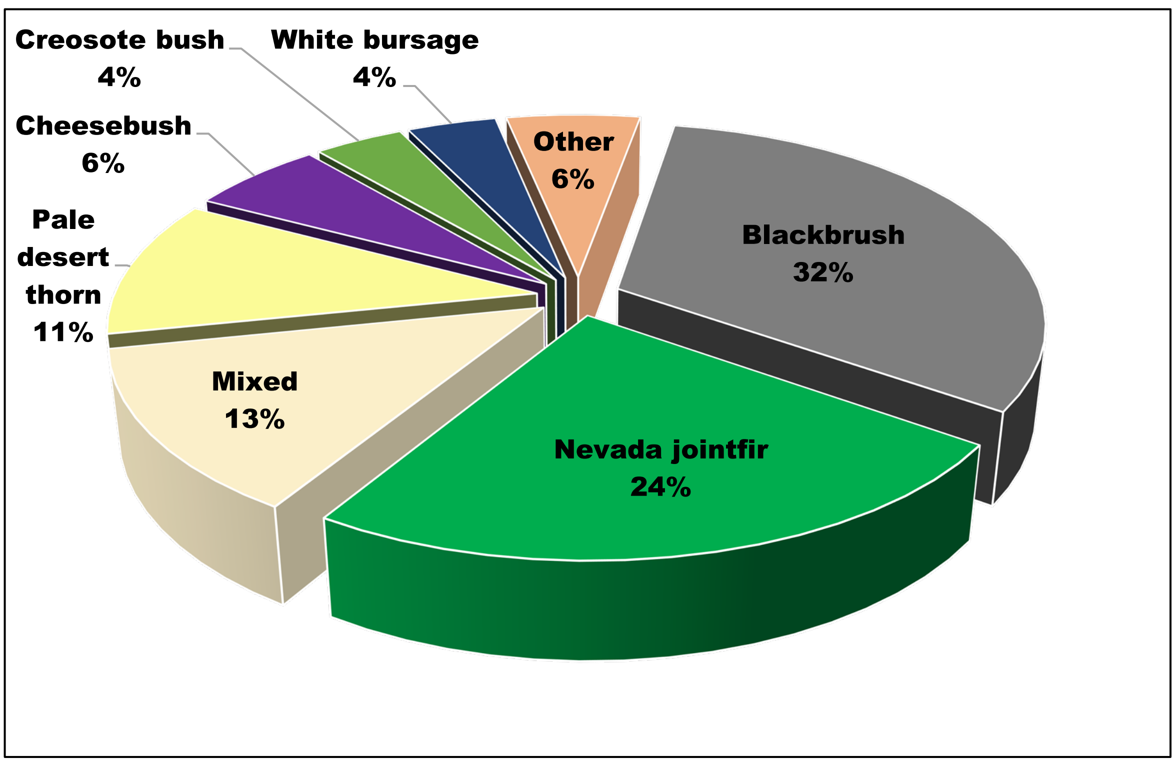

Figure 3-5. Percentage of observations (n = 47) of 12 juvenile tortoises found under vegetation by species, January 2022–January 2023.

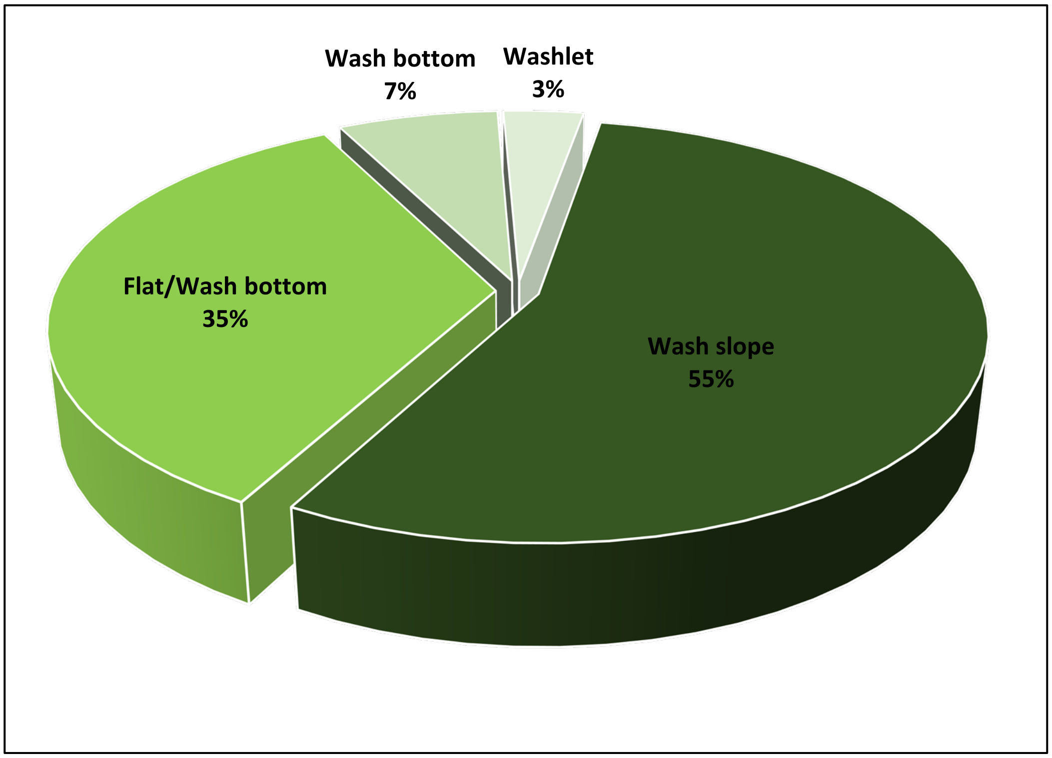

Figure 3-6. Percentage of new juvenile tortoise burrows by topographic position, January 2022–January 2023 (n = 29).

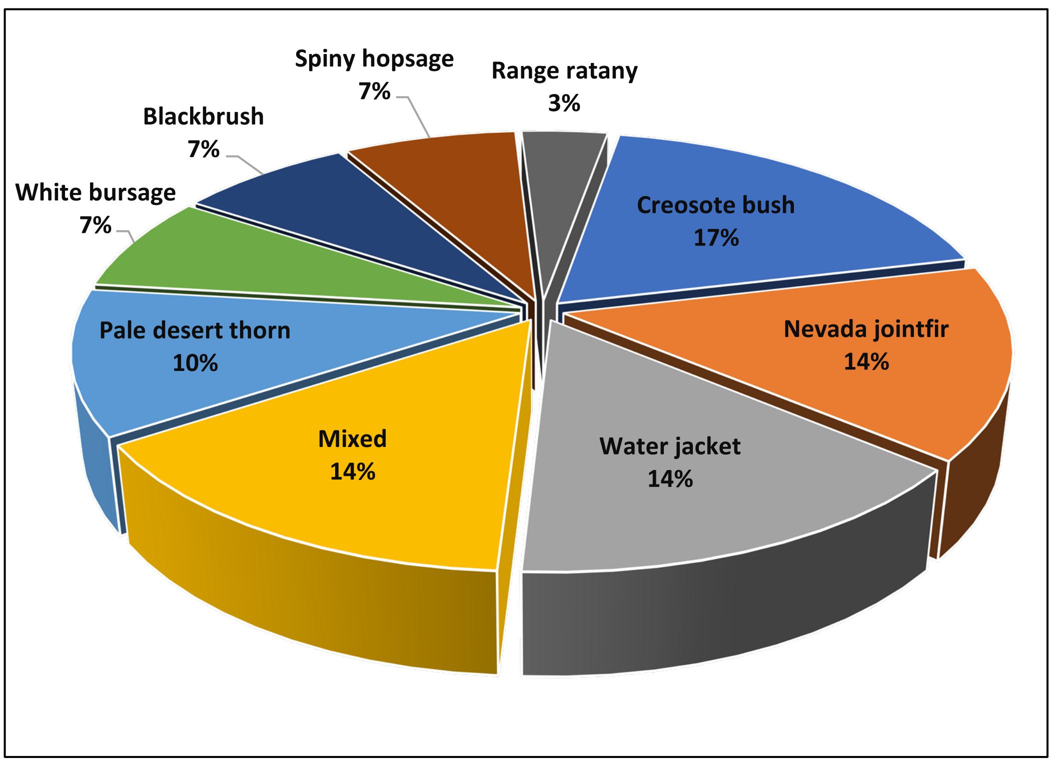

Figure 3-7. Percentage of new juvenile tortoise burrows by vegetation cover at the burrow, January 2022–January 2023 (n = 29).

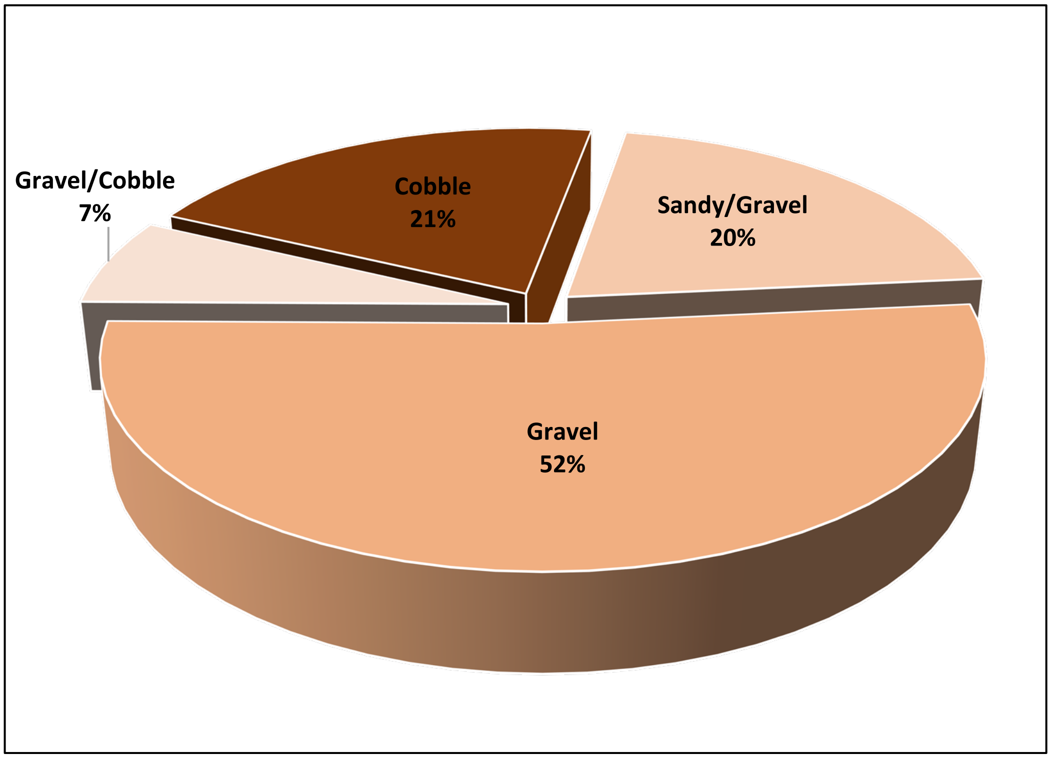

Figure 3-8. Percentage of juvenile tortoise burrows by substrate, January 2022–January 2023 (n = 29).

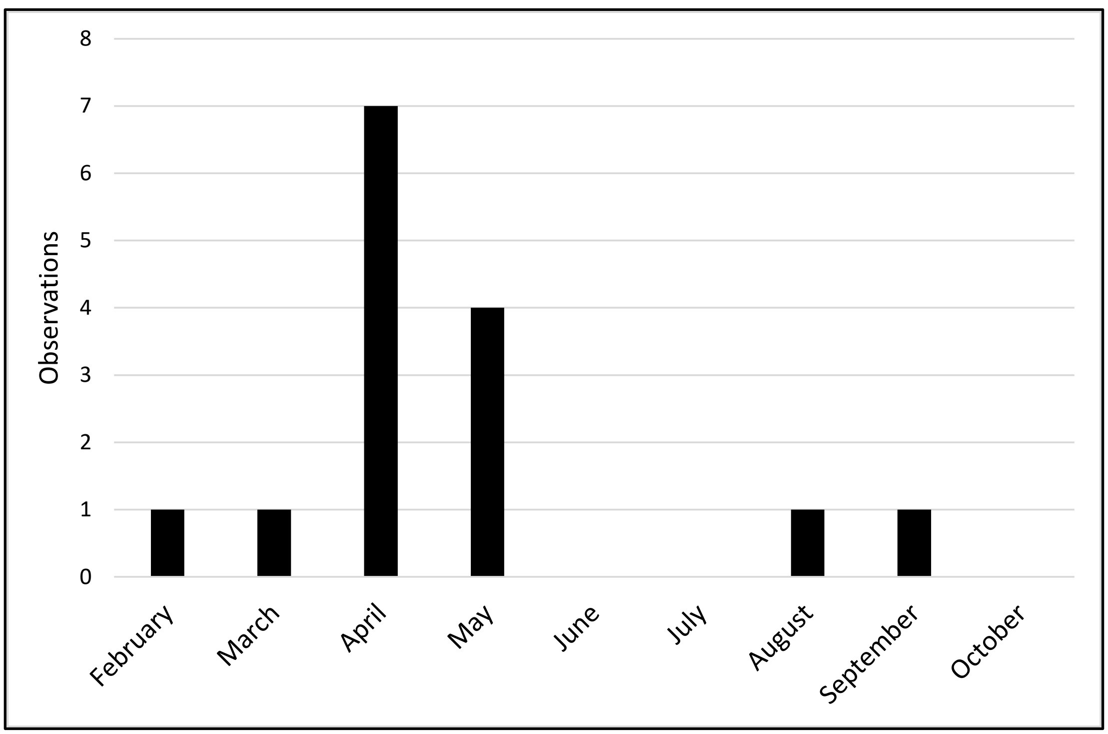

Figure 3-9. Number of times evidence of foraging was detected by month for 12 juvenile tortoises, January 2022–January 2023 (n = 15) (no evidence of foraging was detected in January, June, July, October, November, or December).

Most of the tortoises were also measured, weighed, and given a Body Condition Score (BCS) in both spring and fall. Table 3-6 contains information on MCL (mm) and BCS for fall 2012 (pre-release), spring 2022 and fall 2022, and weight without transmitter in grams (g) for fall 2012 (pre-release) and fall 2022. Also included is information on growth (mm) from fall 2012 to fall 2022, spring 2022 to fall 2022, and weight gain (g) from fall 2012 to fall 2022. Surviving juvenile tortoises have grown an average of 49 mm MCL (range = 22 – 73 mm; sd = 16.0 mm) and gained an average of 751 g (range = 254 – 1,366 g; sd = 335 g) between time of release in fall 2012 and fall 2022. In addition, average growth between spring and fall 2022 was minimal at 1.0 mm. This is most likely due to the drought conditions during 2022 and lack of forage.

Results from health assessments showed that all tortoises were in good condition (BCS = 4). Some observations from the health assessments included: one tortoise (Male 4036) had an occluded left naris; one tortoise (Male 4034) had localized inactive trauma on the carapace and plastron from a suspected predation attempt; and one tortoise (Female 4045) had localized active trauma on the carapace on left costal scutes 2 and 3, possibly due to transmitter attachment/removal. No tortoises voided during handling. Female 4044 was found in April with some minor injuries associated with an apparent kit fox predation attempt. It was provided a water bath for nearly an hour to allow it to rehydrate. It continued to move around within its home range the rest of the year.

The main factor for survival appears to be sex with higher survival of males than females. This has been observed by other researchers as well (Esque et al. 2010; Melia Nafus, ICR, personal communication, December 4, 2014). Size, weight, overall health, and presence of *Mycoplasma* species (bacteria that causes upper respiratory disease in tortoises) do not seem to have any significant impact on survival. While it is impossible to determine if a tortoise was scavenged or preyed upon, a majority of dead tortoises have shown signs of being chewed on by mammalian predators. Given the presumed healthy status and low disease prevalence in the juveniles, it seems unlikely that they are dying and then being scavenged. This suggests that most of the mortality is due to predation. Coyote and kit fox tracks have been observed on multiple occasions while conducting tortoise monitoring and at several of the mortality sites which suggests these canids are the main predators of our study animals. To better understand the predator community and visitation frequency, a camera trap was set up at Site 2 for 140 days from March to August, 2017; 318 days between January and December, 2018; 239 days between May and December, 2019; 315 days between January and December, 2020; 358 days between January and December 2021; and 249 days between January and September 2022 for a total of 1,619 days. Results showed 12 coyote images which is about one every 135 days, 13 kit fox images which is about one every 125 days, 12 badger (*Taxidea taxus*) images which is about one every 135 days, and 4 bobcat (*Lynx rufus*) images which is about one every 405 days.

Why canid predation is higher on females than males is a question yet to be answered. It does not appear to be due to females being aboveground more than males or moving farther (Hall and Perry 2020). Coyotes and kit foxes use olfaction as one of their dominant senses, therefore it is possible that differences in chemical signatures between females and males either attract or repel canid predators. Differences between juvenile female and male chemical signatures have been identified but results from field trials did not find a difference in predator response, either positive or negative, to the synthesized female and male tortoise scent (Hall and Perry 2020). Further research is needed to determine if differential canid predation between females and males is occurring in natural or other translocated populations and to investigate the predation ecology of canids on tortoises and possible deterrents.

A habitat selection study was initiated during 2022 to be able to determine if the translocated juvenile tortoises are selecting for specific habitat features such as position (e.g., under vegetation, in the open), plant species composition, landform (e.g., wash bottom, wash slope, ridge), and substrate (e.g., sand,

Table 3-6. Midline carapace length (MCL) (mm) and body condition score in fall 2012, spring 2022, and fall 2022; weight without transmitters (gram [g]) in fall 2012 and fall 2022; MCL growth and weight gain from fall 2012 to fall 2022; and MCL growth spring 2022 to fall 2022 for 12 tortoises monitored in 2022.

Tortoise Number	Sex	Pre-release MCL (mm) 2012	MCL (mm) (Spring 2022)	MCL (mm) (Fall 2022)	MCL Growth (mm) 2012-2022	MCL Growth (mm) Spring 2022 to Fall 2022	Pre-release Weight (g) (2012)	Weight (g) (Fall 2022)	Weight gain (g) 2012-2022	Pre-release Body Condition (2012)	Body Condition (Spring 2022)	Body Condition (Fall 2022)
4030	Female	148	190	192	44	2	562	1350	788	4	4.5	4
4039	Female	117	162	*	*	*	315	*	*	5	4	*
4044	Female	146	202	*	*	*	484	*	*	4	4	*
4045	Female	129	168	168	39	0	400	947	547	4	4	4
4046	Female	126	193	*	*	*	476	*	*	4	4	*
4004	Male	117	173	172	55	-1	303	1020	717	4	4	4
4007	Male	121	140	143	22	3	363	617	254	5	4	4
4011	Male	144	217	217	73	0	634	2000	1366	4	4.5	4
4025	Male	127	194	*	*	*	357	*	*	5	4	*
4034	Male	128	182	186	58	4	407	1200	793	4	4	4
4036	Male	132	188	187	55	-1	455	1250	795	4	4	4
4048	Male	135	*	*	*	*	480	*	*	5	*	*
	Average	131	183	181	49	1	436	1198	751	4	4	4

* = data not taken due to mortality or unable to get tortoise out of its burrow

gravel, cobble). Random locations will be sampled for these features and compared to similar data already collected from known tortoise locations to test for habitat preferences. Data collection began in the fall and should be completed by summer 2023.

Overall, the remaining 12 translocated tortoises seem to be doing well. A pattern of reduced activity was evident during 2022, likely due to the drought conditions that prevailed through most of the year. Hopefully, additional moisture will fall in 2023 to provide tortoises more foraging opportunities that will allow them to replenish their energy reserves. MSTS will continue monitoring the remaining juvenile study animals well into adulthood with adjustments to the monitoring schedule based on the animals' movement activities.

3.2.3 Coordination with Other Biologists and Wildlife Agencies

- MSTS biologists are working on two separate manuscripts for publication about the juvenile translocation study. The first manuscript titled, "Differential Canid Predation of Translocated Juvenile Desert Tortoises (*Gopherus agassizii*) and Chemical Signature Differences Between Female and Male Adult and Juvenile Desert Tortoises" was submitted to Herpetological Conservation and Biology for publication consideration in December. The second manuscript is titled, "Factors Influencing Survival of Translocated Juvenile Desert Tortoises of Known Sex in Southern Nevada" and contains results from the first 10 years of the study. It is anticipated that this will be submitted for publication during 2024.
- MSTS biologists are collaborating with LANL on a study to determine radiation impacts on tortoises through scute sampling.
- An MSTS biologist presented on the protection and monitoring of the desert tortoise on the NNSS at the DOE/NNSA Nevada Field Office Annual Tribal Update Meeting in Las Vegas, Nevada on April 12, 2022.
- An MSTS biologist attended the Mojave Tortoise Habitat Restoration Workshop January 24-25, 2022, hosted by the Clark County Desert Tortoise Conservation Program. The workshop brought together 79 partners from across the Mojave representing federal, state and local agencies, universities, and organizations. Partners met virtually to discuss and evaluate the current state of knowledge regarding desert tortoise habitat restoration; share current management actions and discuss successful methods; and identify critical management, monitoring and research needs.

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 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 MSTS 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 2022 focused on wildland fire fuels surveys, natural water source monitoring, and constructed water source monitoring, including contaminated sumps.

4.1 Wildland Fire Fuel Surveys and Recovery Plans

Wildland fires on the NNSS can cause significant ecological damage and require considerable financial resources for fire suppression and mitigation. Estimated costs for fire suppression efforts for the 2021 Cherrywood Wildland Fire were $457 per ha. Costs incurred from the Egg Point Fire in August 2002 (121 ha) were well over $1 million to replace one mile of burned power poles, and more than $200,000 for soil stabilization and revegetation of the burned area. The loss of wildlife habitat and ecosystem function is also a big problem, especially in mid-elevation areas where conversion to invasive annual grasslands destroys habitat and greatly increases the frequency of wildland fires in those areas. There is a need to minimize the number and extent of wildland fires and assess the annual wildland fire risk on the NNSS. This section contains information about wildland fires that occurred on the NNSS during 2022 and methods and results of fuel surveys designed to assess annual wildland fire risk on the NNSS.

4.1.1 Wildland Fires in 2022

From 1978 to 2022, an average of 10.1 wildland fires per year and about 119.5 ha per fire have burned on the NNSS. Many 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 and pinyon pine/Utah juniper/sagebrush species [*Pinus monophylla/Juniperus osteosperma/Artemisia* spp.] plant communities). These vegetation 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).

Six wildland fires were documented on the NNSS in 2022. Four of these were human-caused or project related, one was caused by lightning, and one was started by an unknown cause. Each fire was <1.0 ha in size, and all fires combined burned <1.0 ha.

4.1.2 Wildland Fire Recovery Plans

A relatively new requirement identified in the Consolidated Emergency Management Plan (NFO-EOC-PLN-101) necessitates the development of recovery plans for specified fires based on their impact and magnitude of acreage burnt. Due to the low impact and small size of fires, no wildland fire recovery plans were required to be written during 2022.

4.1.3 Fuel Survey Methods

Beginning in 2004, and in response to DOE Order 231.1B Environment, Safety and Health Reporting (DOE O 231.1B), surveys were initiated on the NNSS to identify wildland fire hazards. Vegetation surveys were conducted between April 13 and June 1, 2022, at sites located along and adjacent to major NNSS corridors to estimate the abundance of fuels produced by native and invasive plants. Information about climate was also identified and summarized as part of the wildland fire hazards assessment.

The abundance of fine-textured (grasses and herbs) and coarse-textured (woody shrubs and trees) 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 Geographic Information System map and color-coded for abundance to indicate the wildland fire fuel hazards at various locations across the NNSS.

4.1.4 Fuel Survey Results

4.1.4.1 Climate

There are 17 rain gauges on the NNSS (Hansen and Ostler 2004) that have been used historically to measure precipitation. Data from these weather station gauges extends 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 manually retrieving and processing the data (Hansen 2012). In most cases, the new gauges were relocated nearby to facilitate data collection. The changes were made to reduce costs, improve data reliability, and improve access time to the data after precipitation events. As a result 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 2022 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 whether the spring of the year would be relatively wet, normal, or dry, a simple measure of precipitation 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 represents the period that most influences plant growth on the NNSS as observed along the

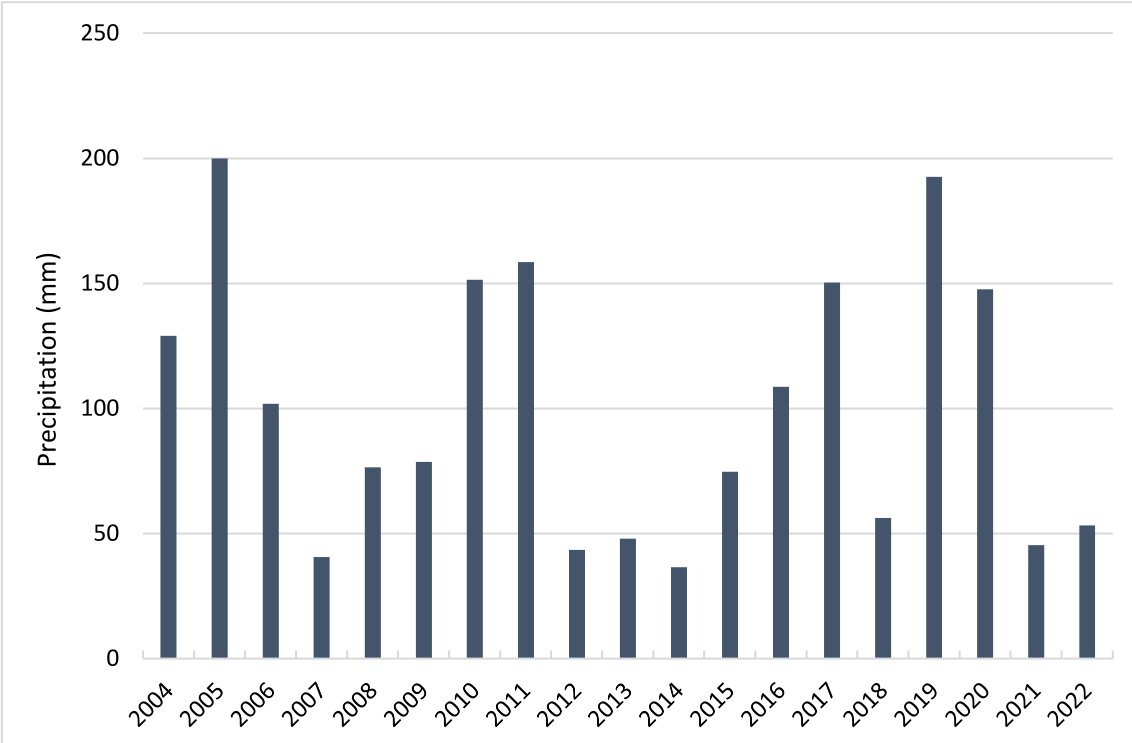

Figure 4-1. Average precipitation from December (previous year) through April for the years 2004 through 2022 (long-term average [2004-2022] 99.7 mm).

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 first 10 years of conducting fire fuel evaluations (2004-2013), the mean precipitation during these 5 months is correlated (R= 0.770) with our estimations of the combined fuel loads. During 2022, the average precipitation from the remaining 14 rain gauge stations on the NNSS during December–April was 53.3 mm, which is about half the average amount of the long-term average (2004-2022) of 99.7 mm received on the NNSS.

4.1.4.2 Fuels

Due to the well below-average precipitation received during winter/spring 2021-2022, production of annual forbs and grasses was virtually non-existent at the lower elevations, low at the middle elevations and moderate at the upper elevations. Production of perennial herbaceous grasses and forbs was near zero at the lower elevations and low to moderate at the middle and upper elevations. However, residual fine fuels, primarily *Bromus* species, from the past two years persisted in some areas.

The fine-textured fuels index decreased from 2.14 in 2021 to 1.79 in 2022. This was the fifth lowest value recorded since 2004, and slightly below the long-term average (2004-2022) of 2.12 (Table 4-1). Most of the fine fuels were from invasive annual grasses such as red brome and cheatgrass (*Bromus tectorum*) with most of the biomass persisting from the previous two years' growth rather than from current year's growth, except in previously burned areas at the middle and upper elevations which had moderate cheatgrass production this year. This highlights the wildland fire risk these invasives create not just in high production (wet) years but for multiple years after wet years even during drought conditions like the past two years.

Table 4-1. Woody fuels, fine fuels, and combined fuels index values for 2004–2022.

Year	Average Woody Fuels Index	Average Fine Fuels Index	Average Combined Fuels Index
2004	2.75	2.13	4.88
2005	2.80	2.83	5.64
2006	2.80	2.46	5.26
2007	2.62	1.52	4.13
2008	2.59	2.23	4.81
2009	2.63	1.95	4.52
2010	2.61	2.27	4.89
2011	2.58	2.56	5.14
2012	2.43	1.75	4.17
2013	2.49	2.03	4.52
2014	2.44	1.39	3.83
2015	2.42	1.44	3.87
2016	2.43	2.67	5.10
2017	2.49	2.38	4.87
2018	2.49	1.83	4.32
2019	2.59	2.41	5.00
2020	2.60	2.53	5.13
2021	2.56	2.14	4.70
2022	**2.56**	**1.79**	**4.35**
Average 2004-2022	**2.57**	**2.12**	**4.69**

The coarse-textured or woody fuels index value remained the same as 2021 at 2.56 (Table 4-1). This was an average value in comparison to the other index values since 2004. Woody values are not expected to change as much as fine fuel values due to the longer life span of shrub and tree species that comprise the woody fuels category.

The combined index value (fine fuels plus woody fuels) 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 decreased from 4.70 in 2021 to 4.35 in 2022 (Table 4-1). This is the sixth lowest value since 2004, and just slightly below the long-term average (2004-2022) value of 4.69, suggesting an average fuel load 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 2022 are shown in Figures 4-2, 4-3, and 4-4, respectively. The highest combined index values (Figure 4-4) and thus the highest potential for wildland fires occur in Fortymile Canyon (previously burned areas), Mid Valley (previously burned areas), Area 26 along Cane Springs Road (blackbrush), southern Yucca Flat (blackbrush), northwest Yucca Flat (blackbrush), and northeast Big Burn Valley (pinyon-juniper). High amounts of fine fuels were found in Fortymile Canyon, southern Yucca Flat, and Mid Valley (Figure 4-2). Abundant woody fuels were primarily found in the forested portions of Pahute Mesa, but also occurred along Stockade Wash Road, Cane Spring Road, and upper Fortymile Canyon (Figure 4-3).

Photographs were taken from permanent locations for all 104 sites during the past 15 years. For example, Figure 4-5 shows photographs of Site 99 in Yucca Flat for the years 2019, 2020, 2021, and 2022. 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.

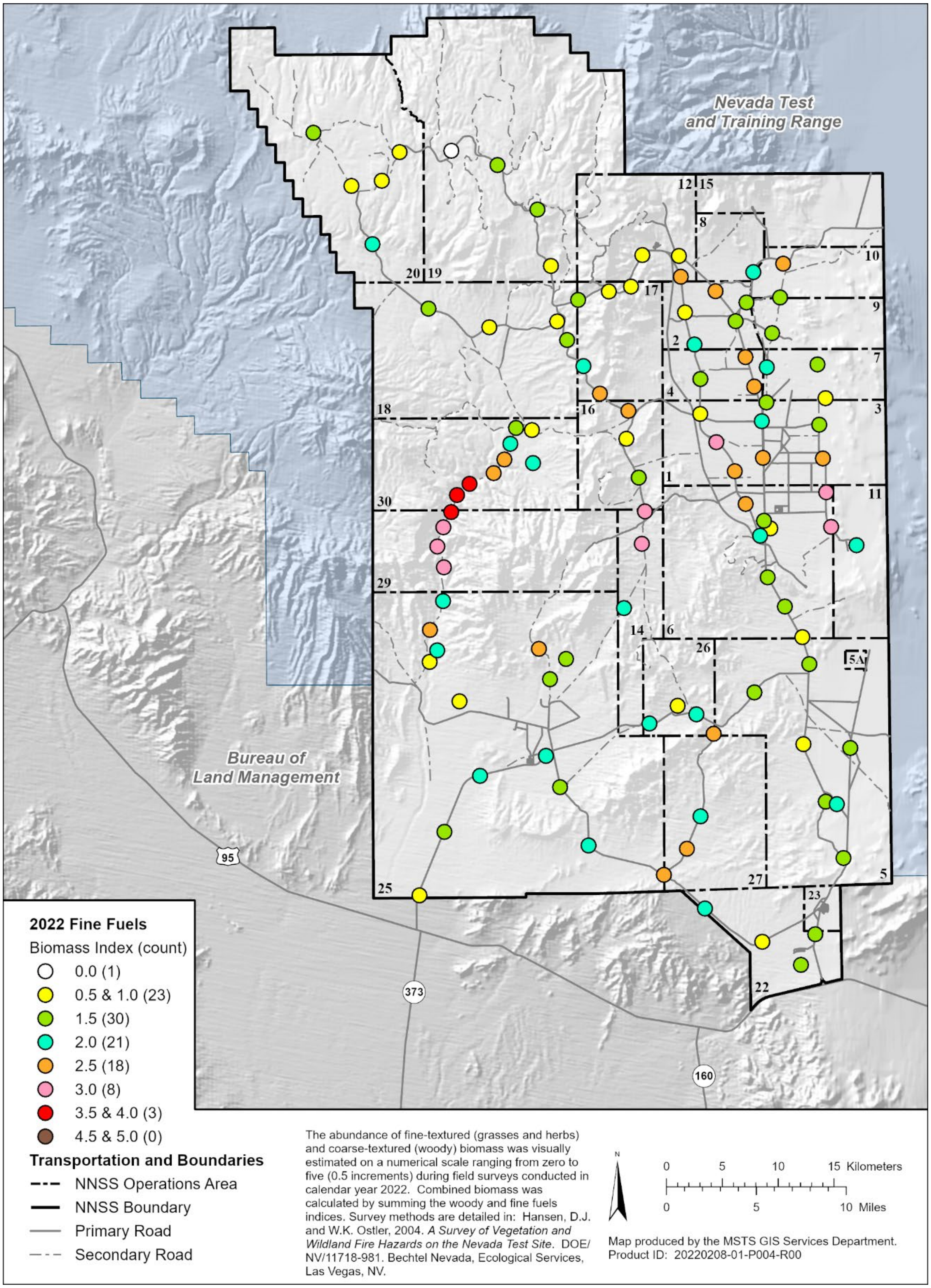

Figure 4-2. Index of fine fuels for 104 survey stations on the NNSS during 2022.

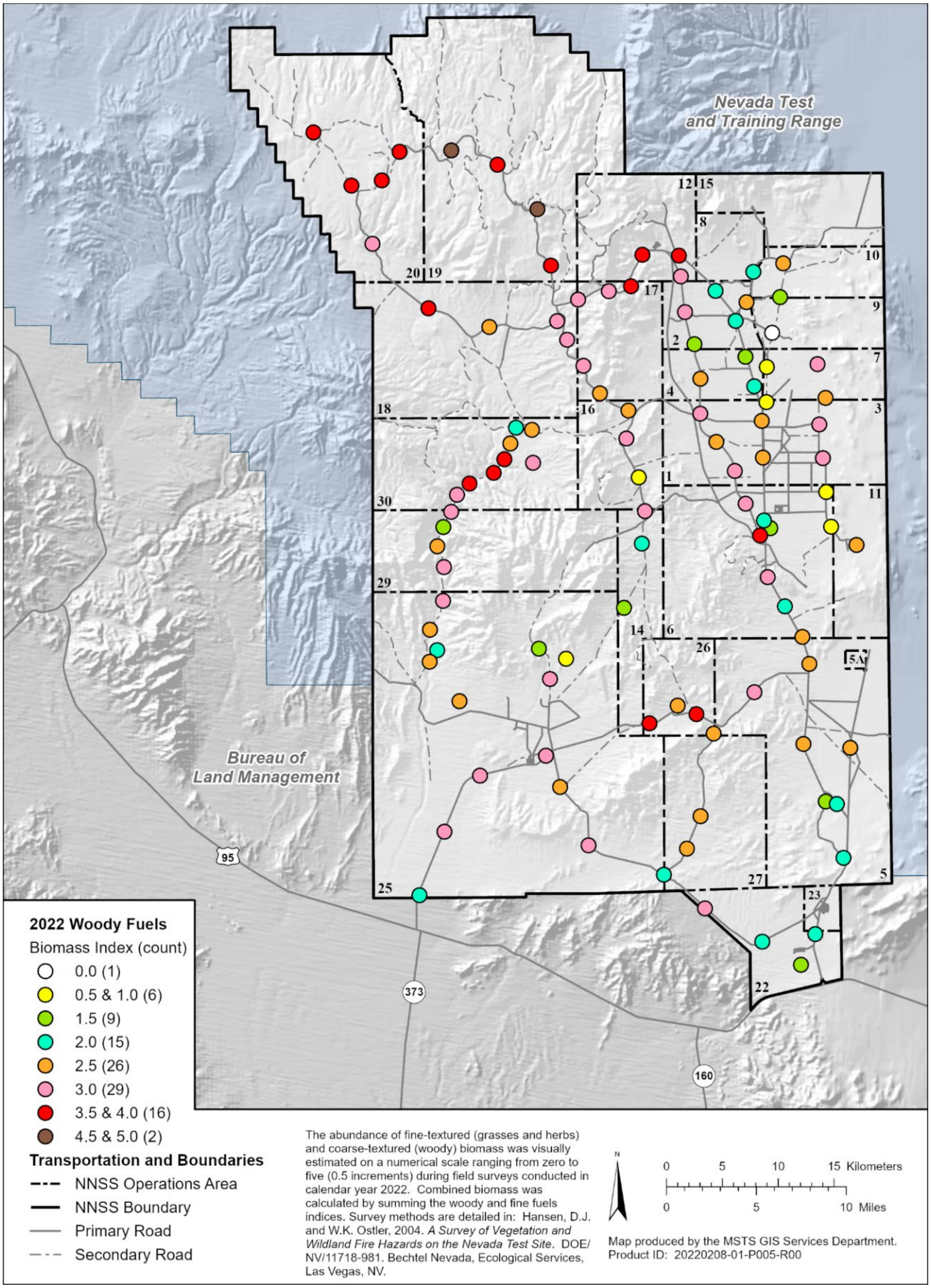

Figure 4-3. Index of woody fuels for 104 survey stations on the NNSS during 2022.

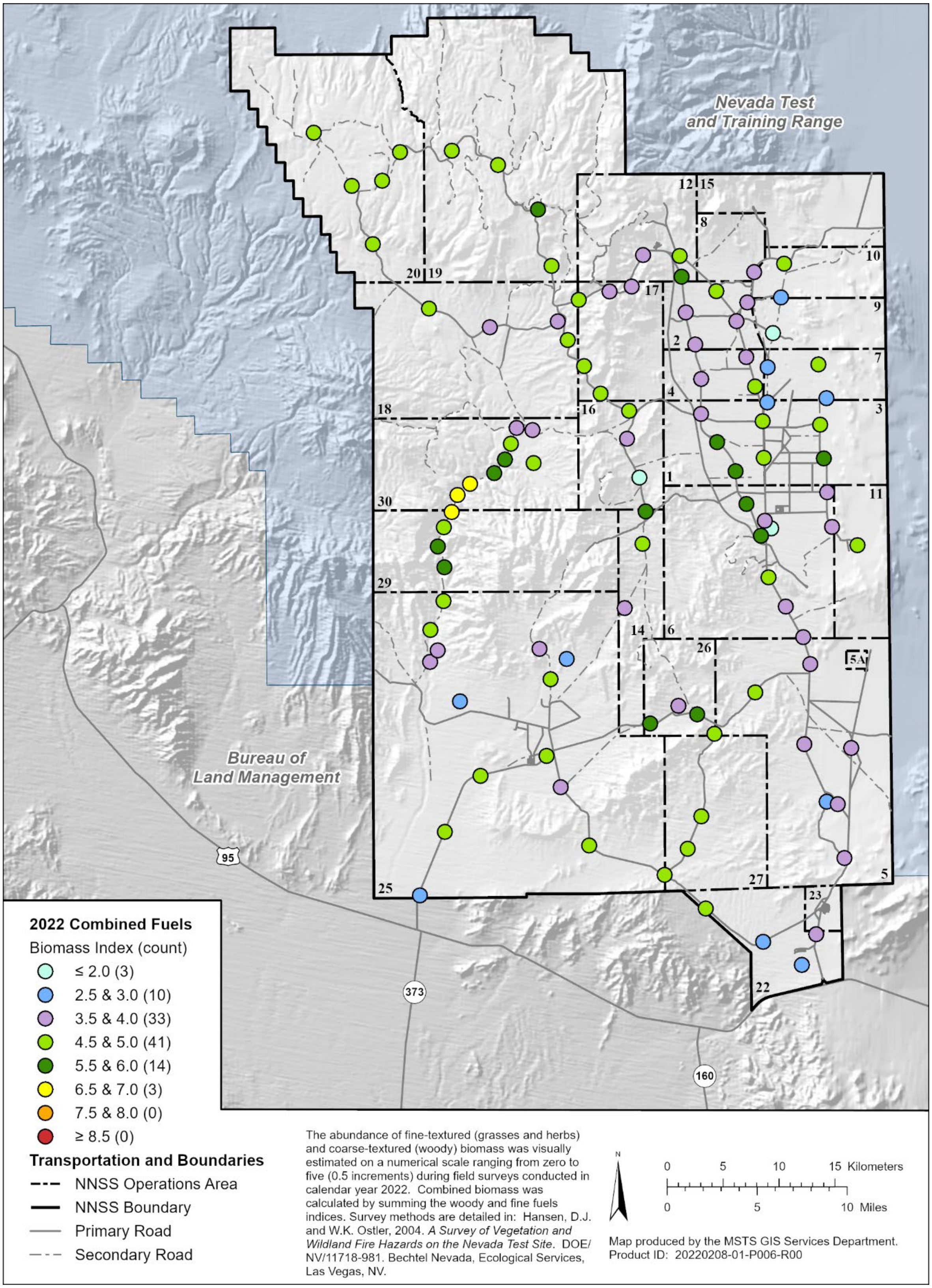

Figure 4-4. Index of combined fine fuels and woody fuels for 104 survey stations on the NNSS during 2022.

Figure 4-5. Site 99 on the west side of Yucca Flat in 2019, 2020, 2021, and 2022.

(Photos by J.A. Perry, May 14, 2019 [top left], May 6, 2020 [top right], May 20, 2021 [bottom left], and May 10, 2022 [bottom right])

4.1.4.3 Invasive Plants

The three most commonly observed invasive annual plants to colonize the NNSS are Arabian schismus (*Schismus arabicus*), found at low elevations; red brome, found at low to moderate elevations; and cheatgrass, found at all elevations (Table 4-2). Values in Table 4-2 only reflect plants germinated this year. Cheatgrass was the most common invasive plant found in 2022 occurring at over half of the sampling locations. While it was predominantly found at middle to higher elevations it was found at lower elevation sites as well. It was sparse at most locations but moderately dense in previously burned areas in Fortymile Canyon and Mid Valley creating the potential to carry wildfire in these areas. Red brome was found at almost one-third of the sites, mostly at moderate elevations in blackbrush habitat because it was too dry at the lower elevations. Likewise, Arabian schismus which is only found at lower elevations was only found at one percent of locations because it was too dry for it to germinate. In fact, there was very little to no germination or new growth of any species in the lower elevation creosote bush-white bursage (*Larrea tridentata-Ambrosia dumosa*) vegetation communities.

Native annual forbs were found in low densities this year but were more abundant than last year (Table 4-2). Precipitation history (Figure 4-1, Table 4-2) is important in determining the percent presence of species across the NNSS. During periods of low precipitation, most annual species have low percent presence (i.e., the number of sites in which the plant was observed to be present and growing). Percent presence is generally greatest during periods of high precipitation and appears to be a good indication of germination. Higher percent presence is also expected to occur when regional storms provide precipitation to a greater number of operational areas across the NNSS. However, the response of some species, both invasive and native species, suggest that other variables, such as the timing of precipitation or temperatures required for germination, may also be contributing to plant response both in terms of plant abundance and biomass produced.

Colonization by invasive species such as cheatgrass, red brome, and Arabian schismus increases the likelihood of future wildland fires because they provide abundant fine fuels that grow under shrubs as well as in the interspace between shrubs which allows fire to spread from one shrub to another, thus creating a near continuous fuel layer. Blackbrush vegetation types appear to be the most vulnerable plant communities to fire, followed by pinyon pine/Utah juniper/sagebrush species 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 that can be costly. Blackbrush, sagebrush, juniper, and pinyon pine do not resprout following fires. Untreated areas become much more vulnerable to future fires once invasive grass species, rather than native species, colonize a burned area.

Overall, the combined fuel load for 2022 is about average. However, given the drought conditions, the residual fine fuels combined with the dry perennials create a substantial wildland fire risk for this year. 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. This is particularly acute in areas such as Fortymile Canyon, Mid Valley, and the eastern slopes of Timber Mountain that have burned previously and now consist of almost pure stands of cheatgrass and/or red brome. Early detection and rapid fire suppression response by NNSS Fire and Rescue after fires are ignited is a key factor in minimizing wildland fire spread and severity.

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

Precipitation History	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**
Mean Precipitation (mm) (December–April)	129.0	199.9	101.9	40.6	76.5	78.7	151.4	158.5	43.4	48.0	36.6	74.7	108.7	150.4	56.3	192.6	147.7	45.3	53.3
Invasive Introduced Species																			
Bromus rubens (red brome)	51.7	64.4	67.8	0	63.0	63.2	58.5	62.3	0	19.2	28.8	52.9	54.8	68.3	43.3	67.3	68.3	**18.3**	**31.7**
Bromus tectorum (cheatgrass)	40.3	54.0	60.7	0	59.2	66.0	67.0	79.2	17.0	70.2	61.5	36.5	69.2	79.8	59.6	78.8	79.8	**24.0**	**51.0**
Erodium cicutarium (redstem stork's bill)	5.2	6.2	24.6	0	21.3	27.4	33.0	42.4	0.9	37.5	33.7	25.0	43.3	47.1	46.2	50	45.2	**2.9**	**11.5**
Schismus arabicus (Arabian schismus)	4.7	2.8	5.2	0	11.4	9.4	3.8	11.3	0	9.6	6.7	10.6	15.4	15.4	21.1	18.3	9.6	**1.0**	**1.0**
Native Species																			
Amsinckia tessellata (bristly fiddleneck)	34.0	62.0	16.1	0	63.0	48.1	67.9	63.2	1.8	41.3	26.0	47.1	66.4	54.8	50	65.4	59.6	**1.0**	**26.0**
Mentzelia albicaulis (whitestem blazingstar)	49.8	8.1	0	0	2.4	18.9	51.9	16.0	3.7	6.7	20.2	43.3	41.4	25.0	3.8	23.1	7.7	**3.8**	**17.3**
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	32.7	38.5	12.5	28.8	10.6	**0**	**8.7**

4.2 Reptile Studies

No formal trapping or roadkill studies took place in 2022. However, some opportunistic reptile observations were 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.

A record number of nine rattlesnakes were reported in project areas or around buildings and relocated away from people. This included seven sidewinder rattlesnakes (*Crotalus cerastes*) (three at Engine Maintenance and Disassembly facility in Area 25, two in Mercury, one at Area 5 Radioactive Waste Management Complex [RWMC], and one in Area 12), and two speckled rattlesnakes (*Crotalus mitchellii*) (one at Building 6-625 and one near Jackass Flats substation). An adult common kingsnake (*Lampropeltis getula*) was removed from a glue trap in Area 26 and released back into the desert. An adult red racer (*Masticophis flagellum*) and three western whiptail lizards (*Cnemidophorus tigris*) were extracted from glue traps found in Building 6-911 and released back into the desert.

4.3 Natural Water Source Monitoring

Ten natural water sources (six springs, four rock tanks) were monitored with motion-activated cameras in 2022 to document the presence of mountain lions (*Puma concolor*) and other wildlife (Figure 4-6). Results are found in Table 6-3 with site numbers referenced in Figure 6-17 (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. During 2022, Topopah Spring was nearly dry with just a small wet spot in the cave pool. Vegetation was heavily trampled primarily by feral burros *(Equus asinus*) at Twin Spring with numerous burro trails on the slope leading to the spring. There was also a small perennial pool of standing water. Vegetation at Captain Jack Spring was dense in the absence of feral horses using the perennial spring, and cattails (*Typha domingensis*) were very dense around Cane Spring. Feral burros continued to use Cottonwood Spring and the area around it was heavily trampled with little to no vegetation left. Gold Meadows Spring dried up in early April and filled back up in August after late summer rains.

Cottonwood Spring (#4) had the most images (8,601; 8 mammals, 4 birds) with a vast majority being feral burros (8,323 images). Twin Spring (#21) was a close second with 7,304 images (5 mammals, 6 birds, 3 reptiles) with 7,256 images of feral burros. Delirium Canyon Tanks (#5) had 1,858 images (7 mammals, 4 birds) with 1,720 desert bighorn sheep (*Ovis canadensis nelsoni*). Captain Jack Spring (#12) had 1,215 images of 5 mammals and 8 birds. Mule deer (*Odocoileus hemionus*) was the most commonly photographed animal (723 images) followed by mourning doves (*Zenaida macroura*) (314 images) and pinyon jays (*Gymnorhinus cyanocephalus*) (82 images). Gold Meadows Spring (#18) had 280 images of 10 mammals and 7 birds.

Rock Valley Tank (#2) was monitored for the first time this year, starting in May. Sixty images of six mammal species were recorded including bobcats, kit foxes, a coyote, a badger (Figure 4-7), and desert bighorn sheep. Fifteen images of 3 mammals and 3 birds including a golden eagle (*Aquila chrysaetos*) were taken at Fortymile Canyon Tanks (#11). Only 6 images of a bobcat and mule deer were detected at Cane Spring (#7), and 8 images of a mountain lion (*Puma concolor*), coyote and chukar (*Alectori*s *chukar*) were recorded at Topopah Spring (#9).

The highest species richness at any natural water source was documented at South Pah Canyon Tanks (#15) and included 9 mammal species, 17 bird species, and 1 reptile species in 320 images including 89 with bats. Two photographs of a bat were taken around mid-day on March 30, which is very uncharacteristic of the typically nocturnal bat (Figure 4-8). It appears to be either a pallid bat

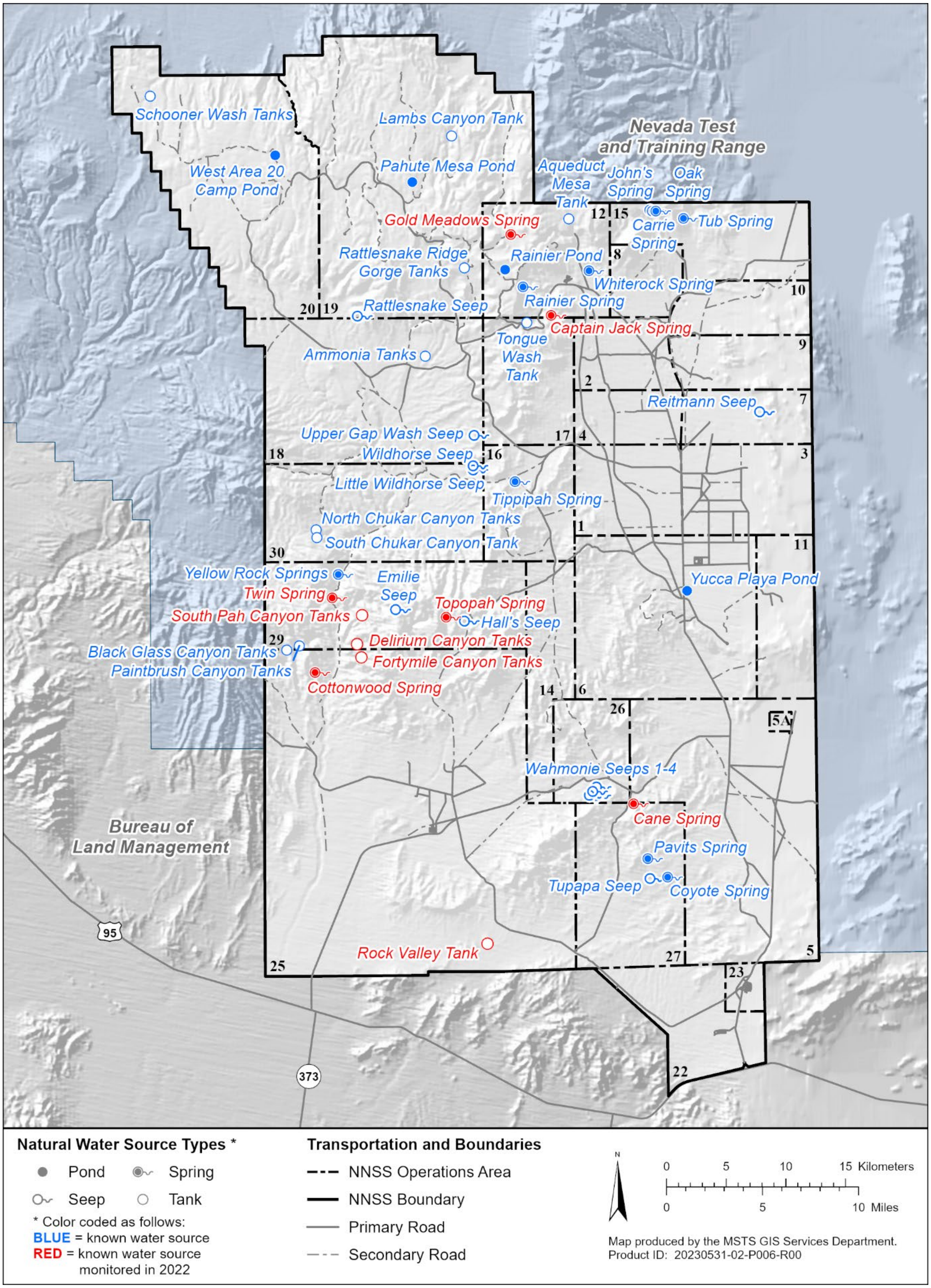

Figure 4-6. Natural water sources on the NNSS, including those monitored in 2022.

Figure 4-7. Badger at the Rock Valley Tank (#2).

(Photo by motion-activated camera, December 4, 2022)

Figure 4-8. Bat flying over water during mid-day at South Pah Canyon Tanks (#15).

(Photo by motion-activated camera, March 20, 2022, 12:26 pm)

(*Antrozous pallidus*), or Townsend's big-eared bat (*Corynorhinus townsendii*) based on the large ears and grayish fur.

4.4 Constructed Water Source Monitoring

Eight constructed water sources were monitored with motion-activated cameras to document the presence of mountain lions and other wildlife during 2022. These included one well pond (Camp 17 Pond), five water troughs installed to mitigate the loss of well ponds, and two radiologically-contaminated sumps (Figure 4-9).

A total of 53 species (9 mammals, 43 birds, 1 invertebrate) were detected at Camp 17 Pond (#6) in 5,358 images (Table 6-3). Turkey vultures (*Cathartes aura*) (1,036 images), mourning doves (1,025 images), feral horses (907 images), common ravens (*Corvus corax*) (441 images), red-tailed hawks (*Buteo jamaicensis*) (353 images), mule deer (347 images), and house finches (*Haemorhous mexicanus*) were the dominant species. Thirty-eight images of peregrine falcons (*Falco peregrinus*) were photographed between May 5 and July 23, including a peregrine and a turkey vulture in the same frame (Figure 4-10). Two images of a rare NNSS visitor, the common blackhawk (*Buteogallus anthracinus*), were taken on June 30 (Figure 4-11) and July 13. This is only the third record of this species on the NNSS. A phainopepla (*Phainopepla nitens*) was photographed on June 2. This is only the sixth record of this species on the NNSS. Several species of waterfowl and shorebirds and a belted kingfisher (*Megaceryle alcyon*) were also documented including 137 images of a great blue heron (*Ardea herodias*) taken from July through November, with many images taken at night.

4.4.1 Mitigating Water Loss for Wildlife

Water conservation measures were implemented on the NNSS in 2012 at four sites: Area 6 Construction Yard (Area 6 LANL Pond), Well C1 Pond, Well 5B Pond, and J11 Pond. 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. The drying of these ponds resulted in the loss of valuable wildlife habitat, so water troughs were installed to help mitigate the loss. 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 (Area 6 Construction Yard) 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 in Area 25. 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 2022 are included in Table 6-3 (see Section 6.7.1, Motion-Activated Cameras).

Wildlife use at Well 5C trough (#24) was heavy with 612 images of 18 species (8 mammals, 8 birds, and 2 reptiles). Horned larks (*Eremophila alpestris*) (188 images) and common ravens (111 images) were the dominant species. Kit foxes, badgers, antelope, and feral burros were also recorded. Wildlife use at Topopah Spring Trough (#23) was moderate with 393 images of 6 mammal species, 6 birds, and 1 reptile species. Mourning doves (256 images) were the dominant species. Four photographs of mountain lions were also taken; two together on March 30 (Figure 4-12), one on April 2, and one on September 3.

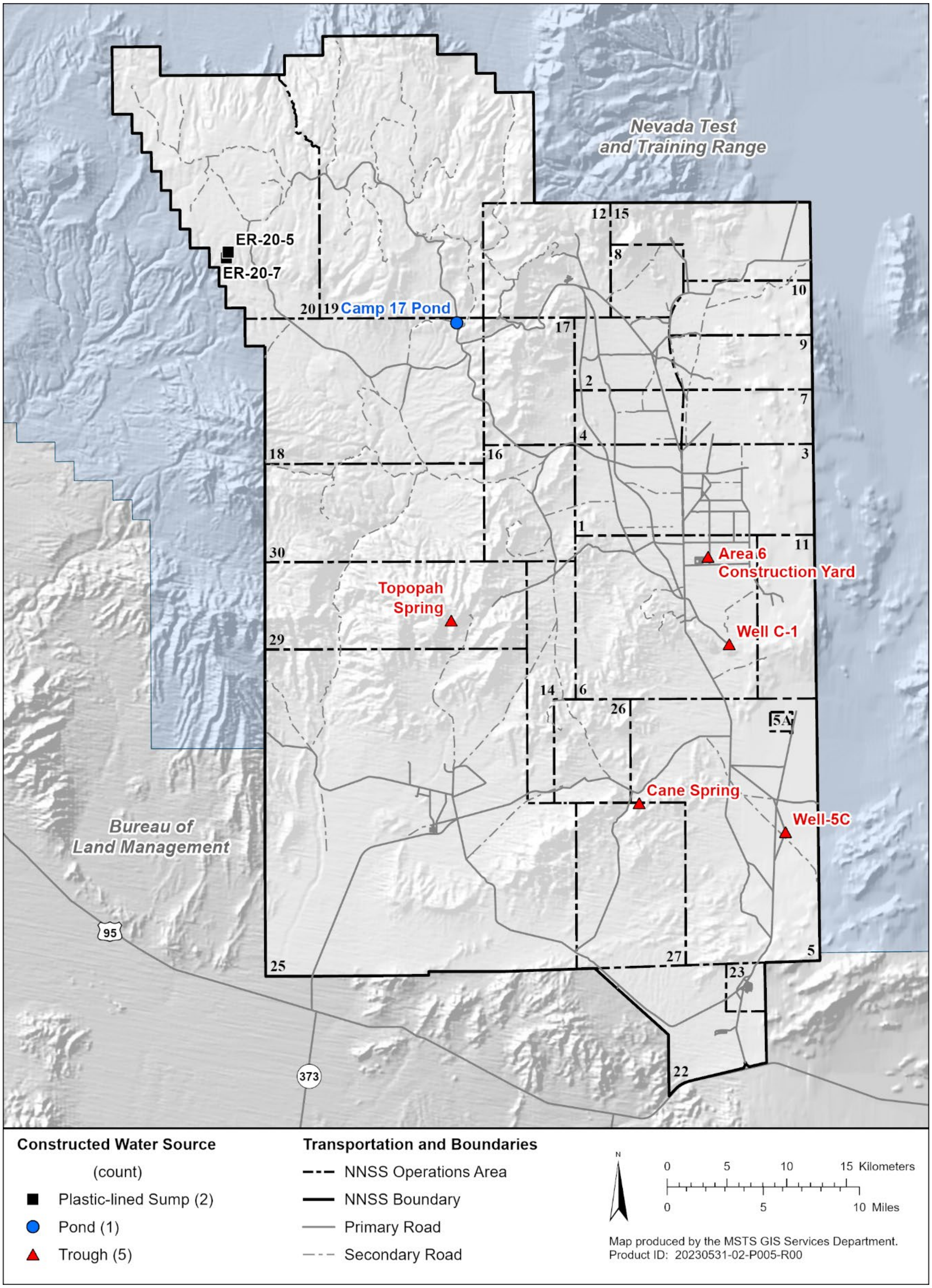

Figure 4-9. Constructed water sources monitored with motion-activated cameras for wildlife use during 2022.

Figure 4-10. A peregrine falcon and turkey vulture flying above Camp 17 Pond (#6).

(Photo by motion-activated camera, May 19, 2022)

Figure 4-11. A rare NNSS visitor, the common blackhawk at Camp 17 Pond (#6).

(Photo by motion-activated camera, June 30, 2022)

Wildlife use at Well C1 Trough (#10) was moderate with 128 images of 6 species (4 mammals, 2 birds). Pronghorn antelope and feral burrows were the most commonly photographed species, 73 and 41 images, respectively. Wildlife use at Area 6 LANL Pond Trough (#14) was light with 20 images of feral burros. Wildlife use of the trough has decreased drastically over the last couple of years due to the abundance of overflow water from the adjacent fillstand. Surface water extends at least 50 m past the fillstand where wildlife can drink from. For the second year in a row, no wildlife images were taken at Cane Spring Trough (#8) even though the camera was operational the entire year. This was likely due to the trough being dry most of the time, especially during the summer.

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

Figure 4-12. Two mountain lions at Topopah Spring Trough (#23).

(Photo by motion-activated camera, March 30, 2022)

4.4.2 Monitoring Wildlife Use at Potentially Contaminated Water Sources

During 2022, motion-activated cameras were set up at two 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 Environmental Restoration (ER) 20-5 (#25) and ER 20-7 (#13) (Figure 4-9). The cameras were also added to the network of cameras used for mountain lion monitoring (see Section 6.7.1, Motion-Activated Cameras) (Table 6-3). Typically, discharge water and drilling fluids having ≥400,000 picocuries/liter (pCi/L) of tritium are diverted to plastic-lined sumps to evaporate; otherwise, they are diverted to unlined sumps. Inactive well sumps can also retain precipitation, which can become contaminated from accumulated sediments. The cameras were set up to document which wildlife species were using the sumps and their frequency of use to assess the potential off-site transport of radionuclides by wildlife as well as the potential impact to the wildlife themselves.

Overall, wildlife use at the contaminated sumps was light with ER 20-5 (#25) having 28 wildlife images and ER 20-7 (#13) having 8 images. Common ravens were photographed at both sites. One turkey vulture, a couple of passerines, and some unknown birds were also photographed at ER 20-5 (#25) and 7 images of unknown bird species were photographed at ER 20-7 (#13).

Important species are using these sites and are potentially up-taking radiological contaminants. Protected birds such as turkey vultures, common ravens, and most passerines may also be impacted. Contaminated water sources will continue to be monitored to determine their level of use by various wildlife species, calculate the potential dose someone eating contaminated wildlife may receive, and determine if the dose is harmful to the animal. More information about potential dose to humans and wildlife can be found in the annual Nevada National Security Site Environmental Reports (e.g., MSTS 2022) available at https://nnss.gov/publication-library/environmental-publications/.

4.5 Coordination with Scientists and Ecosystem Management Agencies

MSTS biologists interfaced with other scientists and ecosystem management agencies in 2022 for the following activities:

- Participated in multiple conference calls for the Mojave Native Plant and Seeds of Success Program.
- Participated in multiple conference calls for the DOE Invasive and Endangered Species Working Group.
- Participated in a meeting with the Eastern Mojave Wildlife Working Group.
- Collaborated with Sasha Reed (United States Geological Survey [USGS]) and Sam Jordan (Arizona State University) to collect data from a study site on the NNSS for a Strategic Environmental Research and Development Program funded project entitled "Forecasting Dryland Ecosystem Vulnerability to Climate Change: A Cross-Systems Assessment of Vegetation and Process Responses to Disturbance and Climate Variability on Department of Defense (DoD)/DOE Lands."
- Accompanied U.S. Forest Service personnel in October to sample two long-term plots for the Interior West Forest Inventory and Analysis Program.
- Attended a workshop where updates were given on various projects associated with the Clark County Multiple Species Habitat Conservation Plan.

5.0 SENSITIVE AND PROTECTED/REGULATED PLANT MONITORING

The list of sensitive and protected/regulated plants on the NNSS (see Table 2-1) is reviewed annually to ensure the appropriate species are included in the NNSS sensitive plant monitoring program. The working list of over 850 plant species identified on the NNSS was reviewed alongside the 2023 NDNH At-Risk Plant and Animal Tracking List (NDNH List) and no updates to the NNSS sensitive plant monitoring program were needed. Currently there are 19 vascular plants and one non-vascular plant considered sensitive and warrant inclusion in the NNSS sensitive plant monitoring program (see Table 2-1).

5.1 Species Evaluations

5.1.1 Lahontan beardtongue (*Penstemon palmeri* var. *macranthus*)

There are three varieties (var.) of *Penstemon palmeri* found in the western United States: scented beardtongue (*P. palmeri* var. *eglandulosus*), Palmer's penstemon (*P. palmeri* var. *palmeri*), and Lahontan beardtongue (*P. palmeri* var. *macranthus*). Scented beardtongue is not found in Nevada, while the other two varieties are. The two varieties found in Nevada are very similar and overlap in distribution. A key to the three varieties can be found in Cronquist et al. (1984).

Lahontan beardtongue is a Nevada endemic perennial subshrub with large, pale lavender tubular flowers. It is listed on the NDNH List and has been found in Churchill, Nye, Pershing, and White Pine counties. It has been observed between 1,045 to 2,300 m elevation. Palmer's penstemon, on the other hand, is wide spread throughout the western United States from lower to upper elevations (300-2,600 m) and is currently not considered an at-risk, rare, or sensitive plant. Lahontan beardtongue is distinguished from Palmer's penstemon by its longer corolla tube (cylindrical, hollow base of the flower measuring 7-8 mm for Lahontan beardtongue and 4-6 mm for Palmer's penstemon) and its often sessile (not fused surrounding the stem) upper leaves.

It has been confirmed that both Lahontan beardtongue and Palmer's penstemon grow on the NNSS and overlap in distribution. A Lahontan beardtongue population was confirmed along the 19-01 Road in Area 19 on September 19, not too far from a Palmer's penstemon population found in 2021 along the same road (UTM NAD83 566217mE, 4120090mN). The two species appear to have different color corollas (flowers) with Lahontan beardtongue being a lighter shade of pink and Palmer's penstemon being a deeper shade of pink (Figure 5-1).

The *Penstemon palmeri* plant location found at the southern base of Skull Mountain at 1,228 feet was revisited on April 5 (UTM NAD83 576360mE, 4066161mN). Previous year's stalks were unrooted, lying on the ground, with no new growth. Burro tracks disturbed the area. The variety of the Skull Mountain population has not been identified.

More surveys are needed to determine this plant's distribution on the NNSS as well as threats. It is recommended that known locations identified from ELU mapping surveys (Ostler et al. 2000) are visited and identified to variety.

5.2 Long-Term Monitoring

As part of the Adaptive Management Plan for Sensitive Plant Species (Bechtel Nevada 2001), the status of each sensitive plant is monitored periodically. Field surveys are conducted to verify previously

Figure 5-1. ***Penstemon palmeri*** **plants found along the 19-01 Road in Area 19 with Palmer's penstemon showing a deep pink flower color (left) and Lahontan beardtongue with a light pink flower color (right).**

(Photos by D.B. Hall, June 17, 2021 [left] and September 13, 2022 [right]) reported locations, better define population boundaries, and identify existing or potential threats to populations. Long-term monitoring was scheduled for Black woollypod (*Astragalus funereus*), Clokey eggvetch (*Astragalus oophorus* var. *clokeyanus*), and Darin buckwheat (*Eriogonum concinnum*). Opportunistic encounters were documented for Pahute green gentian (*Frasera pahutensis*), Pahute Mesa Beardtongue (*Penstemon pahutensis*), and Sanicle biscuitroot (*Cymopterus ripleyi* var. *saniculoides*).

5.2.1 Black woollypod (*Astragalus funereus*)

Black woollypod is a small, low growing milkvetch in the Fabaceae (pea) family. It is also known as Funeral Mountain milkvetch, identified from the Funeral Mountains in Death Valley, California. It is distinguished by dense, sometimes wavy, short hairs covering the leaves and fruit as well as black hairs covering the base of the flowers. A rare plant, its distribution ranges from "Nevada to California, along the east-west corridor of the transition desert" (Blomquist et al. 1995). Black woollypod grows on "steep hillsides composed of ash-flow volcanic tuff that is typically light gray to reddish-brown" (Blomquist et al. 1995, Hinrichs and McKay 1965). On the NNSS it is known from two locations: Shoshone Mountain in Area 25 and French Peak in Areas 6 and 11.

Five locations were visited on Shoshone Mountain on May 9 with no plants being located at three of the locations, five fruiting plants found at one location (UTM NAD83 568891, 4084593), and one fruiting plant at another location (UTM NAD83 568496, 4083701) (Figure 5-2). The locations were very remote, along steep upper slopes, and in talus, gravelly substrate (Figure 5-3). There were no threats to the plants, besides drought, which was likely the reason only six plants were found across a large area that was surveyed.

5.2.2 Clokey eggvetch (*Astragalus oophorus* var. *clokeyanus*)

Clokey eggvetch is a small, grey-green to dark green perennial herb first collected in 1938 in the Spring Mountains in Southern Nevada (Anderson 1998). The name *Astragalus artipes* was misapplied to the 1938 collection by Clokey and later applied the name *A. oophorus* var. *clokeyanus* by Barneby "in honor of Clokey's honest mistake" (Smith 2002). The plant's pea flowers are bicolored, bright reddish-purple and white. The fruit, or seed pod, was described in Anderson's 1998 report *Distribution of Clokey's Eggvetch on the Nevada Test Site* as "strongly inflated, mottled reddish, unilocular pod with 23-28 ovules per pod".

To our knowledge, there are six varieties of egg milkvetch, all which occur in Nevada except Wilken's egg milkvetch, which is endemic to Colorado. Clokey and Egg milkvetch occur on the NNSS. Clokey eggvetch, Lavin's milkvetch, and Pink egg milkvetch are listed on the NDNH List. The six egg milkvetch varieties are below with associated state distributions:

- Pallid egg milkvetch (*A. oophorus* var. *caulescens*) – AZ, CO, NV, UT
- Clokey eggvetch (*A. oophorus* var. *clokeyanus*) – NV
- Lavin's milkvetch (*A. oophorus* var. *lavinii*) – CA, NV
- Pink egg milkvetch (*A. oophorus* var. *lonchocalyx*) – CA, NV
- Egg milkvetch (*A. oophorus* var. *oophorus*) – CA, NV
- Wilken's egg milkvetch (*A. oophorus* var. *wilkenii*) - CO

Clokey eggvetch was thought to have been restricted to the Spring Mountains until 1996 when intensive surveys began on the NNSS locating it on Pahute Mesa, in the Eleana Range, in the southern Belted Range, on Timber Mountain, and on Shoshone Mountain (Anderson 1998). The species was identified as

Figure 5-2. Black woollypod plant found on Shoshone Mountain.

(Photo by J.A. Perry, May 9, 2022)

a candidate plant under the ESA from 1980 through 1997, when the designation was dropped (Anderson 1998). The plant is not currently protected under federal or state law.

The species occurs in areas where natural periodic fires occur in single-leaf pinyon and Utah juniper habitat. Smith (2002) explained "[t]he species has been found in old burns" and "[w]hen fires do occur, some of the *Astragalus oophorus* var. *clokeyanus* sites may also occupy places attractive for staging suppression operations". The Cherrywood Fire, caused by a lightning strike, burned 21,022 acres on the NNSS and 5,391 acres on the Nevada Test and Training Range (NTTR) in 2021. The fire burned through Clokey eggvetch habitat on Timber Mountain. In a continued effort to document the plant's resilience to

Figure 5-3. Black woollypod habitat on Shoshone Mountain.

(Photo by J.A. Perry, May 9, 2022)

the fire, one of the locations on Timber Mountain (UTM NAD83 549805, 4100779) was visited on May 26. Several plants were found with mature fruit and seeds dispersed despite the invasion of cheatgrass post-fire (Figure 5-4).

The Shoshone Mountain population along old Shoshone Trail (UTM NAD83 566366, 4089300) was visited on May 5. Thirty-eight fruiting or flowering plants were found. The trail had been reclaimed by nature and no threats were identified to the habitat or plants.

Figure 5-4. Clokey eggvetch in the foreground with cheatgrass in the background.

(Photo by J.A. Perry, May 26, 2022)

5.2.3 Darin buckwheat (*Eriogonum concinnum*)

Darin buckwheat is an annual herb with erect stems reaching 76 cm high. It is endemic to Nye County, Nevada and its type locality is located on the NNSS. It has relatively large bright green basal leaves and small greenish white flowers. The plant flowers and sets seed in late summer. The plant was included in the NNSS's sensitive plant monitoring plan in 2002.

Darin buckwheat has received little monitoring attention since 2010. Six out of the forteen known locations were visited between August 16–18: two along Buckboard Mesa Road (Areas 18 and 30) and four along the southeast base of Pahute Mesa near Thirsty Canyon (Area 20: two along north Buckboard Mesa Road and two at existing well). No plants were found along the road cuts at any of the locations along Buckboard Mesa Road. Over 300 plants were found at well ER-20-5 on the manmade drill pad (UTM NAD83 546305, 4116405) and along a manmade berm next to the sumps for wells ER-20-5 and ER-20-7 (UTM NAD83 546147, 4119046). The plant does well in disturbed areas and despite little annual germination due to below average winter precipitation, the populations visited at ER-20-5 were healthy. The plants on the drill pad are disturbed regularly in an effort to maintain the drill pad, but this does not appear to impact the plant's annual germination. Water sprayed during maintenance of the drill pad promotes annual growth.

5.2.4 Pahute green gentian (*Frasera pahutensis*)

Pahute green gentian is a small perennial with noteworthy greenish/white to pale blue flowers, flecked with dark purple and bluish stripes. Its leaves are long oblanceolate basal leaves with a white margin that can be wavy to scalloped. It grows in open sagebrush shrubland and single-leaf pinyon-Utah juniper woodlands. It is endemic to Nye County, Nevada, with its type locality on the NNSS on Pahute Mesa. Its taxonomy has been previously synonymized with *Frasera albicaulis* var. *modocensis* in the U. S. Department of Agriculture (USDA) Plants Database (USDA 2020) but appears to be without justification (NNPS 2000). Participants of the Nevada Rare Plant Workshop discussed the taxonomy in 2000, agreeing Pahute green gentian is a valid taxon and no knowledge of published or unpublished support was found for the synonymy with *F. albicaulis* var. *modocensis* which grows primarily in northeastern California (NNPS 2000).

Study Plot 1 in Gold Meadows in Area 12 (UTM NAD83 569169, 4119424) was opportunistically visited on June 15. Approximately 150 plants were found in fruit, dispersing seed, or in senescence. It was determined the population's boundary currently mapped in the database excluded Study Plot 1. The area was adjusted and updated to include the study plot in the database.

5.2.5 Pahute Mesa beardtongue (*Penstemon pahutensis*)

Pahute Mesa beardtongue, a perennial forb/herb, is known for its large, showy pinkish-lavender to bluish-lavender flowers with a unique beard on the upper inner portion of the corolla (flower). It has been found in Nye and Esmeralda counties in Nevada, with a small population in Inyo county (Grapevine Mountains) in California. It is widely distributed on the NNSS throughout Rainier Mesa, Pahute Mesa, and Shoshone Mountain, with a small population at Oak Spring Butte. Intense surveys in the 1990's revealed the plant was more widely distributed than previously known, growing in a range of habitats on the mesas.

One location southeast of Gold Meadows in Area 12 was opportunistically documented with a small population expansion (UTM NAD83 569543, 4119552). Nine plants were found flowering east of the currently mapped population boundary. The area was adjusted and updated in the database.

5.2.6 Sanicle biscuitroot (*Cymopterus ripleyi* var. *saniculoides*)

There are two varieties of Sanicle biscuitroot that occur on the NNSS; *Cymopterus ripleyi* var. *saniculoides* listed on the NDNH List and *C. ripleyi* var. *ripleyi*, a more widely distributed species not considered at-risk. *C. ripleyi* var. *saniculoides* has purple flowers and grows along drainages in sandy washes at lower elevations on the NNSS. *C. ripleyi* var. *ripleyi* has white flowers and grows "along sandy slopes, or in shrub interspaces, with no apparent affinity for washes or drainages" at higher elevations on the NNSS (Hansen et al. 2010). Both plants are frequently encountered during surveys or other work.

Sanicle biscuitroot was opportunistically encountered at Fuel Survey Point 127 in Yucca Flat in Area 2 (UTM NAD83 582766, 4111809) on May 11. Eight plants were observed in a known population in a disturbed area adjacent to Rainier Mesa Road. The area had previously been used to dump excess cement.

5.3 Coordination with Other Scientists

- Nevada Native Plant Society meetings occurred virtually by combining the Northern and Southern Chapters. An MSTS biologist attended the February meeting discussing Joshua trees, the March meeting discussing ethnobotany, and presented on plant monitoring on the NNSS in the November meeting.

- An MSTS biologist attended The American Penstemon Society Annual Meeting 2022 in Redmond, Oregon in July. Members of the society gathered to share information and see penstemons in their natural habitat. Lectures and field trips included distribution, taxonomic, and threat status for penstemon plants.

- MSTS biologists participated in the Joshua Tree Biological Working Group. The group is comprised of eight government agencies committed to align research, monitoring, and management goals to protect and collect long-term data on Joshua trees.

6.0 SENSITIVE AND PROTECTED/REGULATED ANIMAL MONITORING

The NDNH At-Risk Plant and Animal Tracking List (NDNH 2023); NAC 503, "Hunting, Fishing and Trapping; Miscellaneous Protective Measures" (NAC 2023); FWS Endangered Species home page (FWS 2023); 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. Several changes were made to NAC 503 on February 28, 2022. The most important change was that all bat species are now state protected. 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 2022 focused on (a) birds, (b) bats, (c) feral horses, (d) mule deer, (e) pronghorn antelope, (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 Birds

Bird monitoring on the NNSS during 2022 focused on Migratory Bird Treaty Act (MBTA) compliance, documenting bird mortalities, implementing the NNSS Avian Protection Plan (APP), conducting winter raptor surveys, and a western burrowing owl radio-tracking study.

6.1.1 Migratory Bird Treaty Act Compliance

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

U.S. Executive Order 13186 *Responsibilities of Federal Agencies to Protect Migratory Birds* directs federal agencies to develop a Memorandum of Understanding (MOU) and work with FWS to promote the conservation of migratory bird populations. An MOU was signed by DOE and FWS in September 2013 regarding implementation of U.S. Executive Order 13186. This MOU is currently being updated.

Actions taken to comply with the MBTA and MOU during 2022 included the following: 1) conducted pre-activity surveys for proposed projects before surface-disturbing work or building demolitions to avoid harming birds or their nests, 2) moved red-tailed hawk nest and two nestlings from energized power pole and released two red-tailed hawks on the NNSS, 3) captured a grounded common loon (*Gavia immer*) and released it at Mercury Sewage Lagoons, 4) removed a juvenile brown-headed cowbird (*Molothrus ater*) from glue trap and released it, 5) implemented the NNSS APP, and 6) reported dead/injured birds to FWS.

6.1.2 Bird Mortalities

Bird mortality is a measure of impacts that NNSA/NFO activities may have on protected bird species. NNSA/NFO activities that have affected birds typically have been of two types: electrocution and vehicle mortalities. Other causes of death include predation, disease, and entrapment and in many instances the cause of death is unknown. Workers and biologists work together to observe and report mortalities. A total of 39 dead birds were documented on the NNSS in 2022 (Figure 6-1). This is the second highest number of mortalities recorded in a single year. Sixteen dead bird carcasses (one barn owl [*Tyto alba*], one loggerhead shrike [*Lanius ludovicianus*], six Say's phoebes [*Sayornis saya*], one house finch, and seven European starlings of varying stages of decay were found inside a fill pipe connected to a baker tank at Area 5 RWMC. This tank had been brought in from an unknown location on the site a few years ago to support revegetation efforts so it is likely many of these birds were killed before it was moved. Cause of death was entrapment. The pipe was modified so no more birds could be trapped. Additionally, all other baker tanks at Area 5 RWMC and elsewhere on the NNSS were checked to make sure the tanks were avian safe. An unknown passerine was rescued from a glue trap but later died of its injuries. Six bird carcasses were found inside the tower at Ice Cap event site in Yucca Flat and included five barn owls (three chicks, two adults) and an adult great-horned owl (*Bubo virginianus*). Cause of death is unknown and not likely due to entrapment because there are numerous openings to the outside unless the birds could not find them. Five birds (four common ravens, one great-horned owl) were electrocuted. Four birds were hit by vehicles including two red-tailed hawks (*Buteo jamaicensis*), one western burrowing owl, and one common poorwill (*Phalaenoptilus nuttallii*). One red-tailed hawk chick died following a nest relocation. One mourning dove (*Zenaida macroura*) was found with a broken wing and had to be euthanized. It was collected and analyzed as part of our program to monitor potential radiation in wildlife (see Section 6.8 Radiological Sampling). A total of 11 birds were found dead due to unknown causes. This included the six dead birds found at the Ice Cap tower (mentioned above), three common ravens, one common goldeneye (*Bucephala clangula*), and one western tanager (*Piranga ludoviciana*).

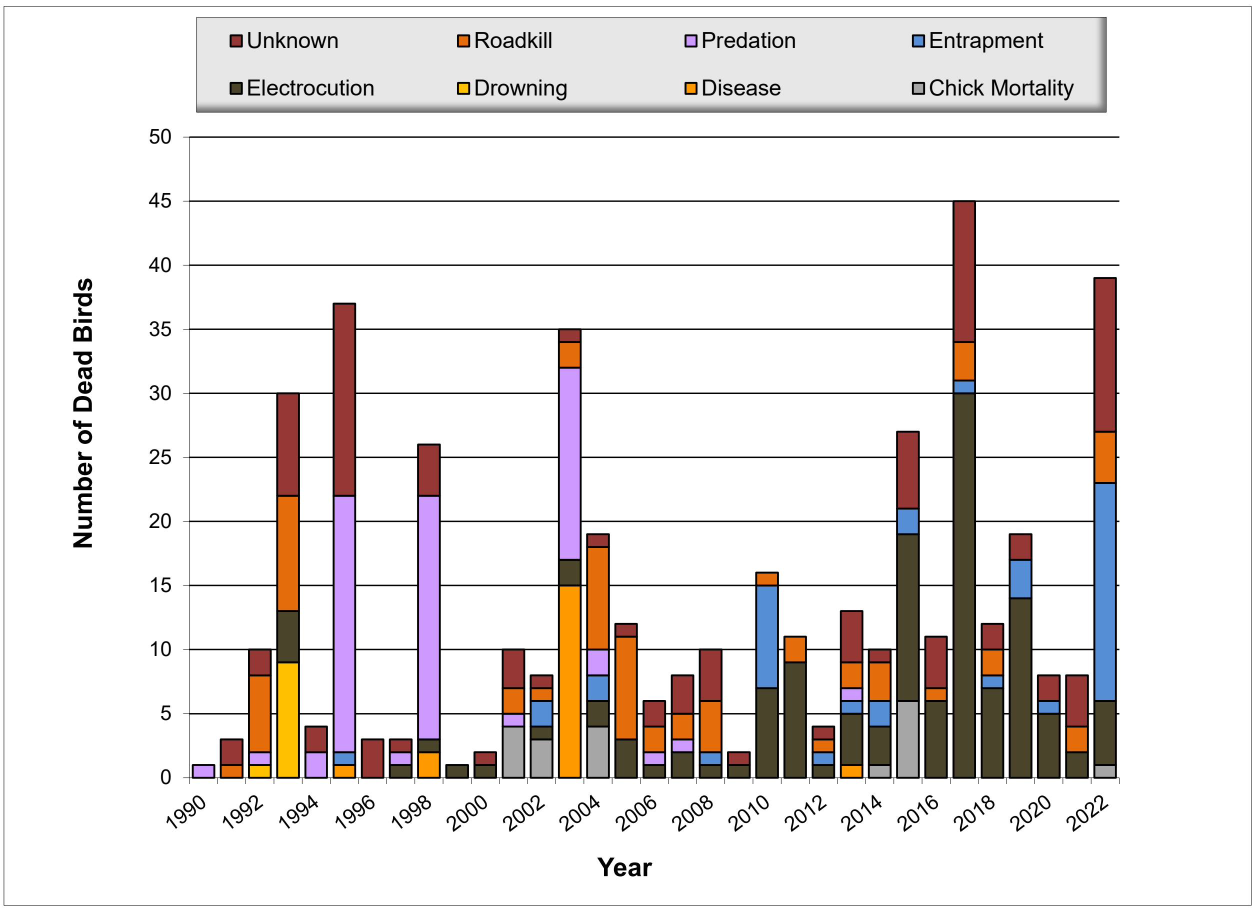

Figure 6-1. Records of reported bird deaths on the NNSS, 1990–2022.

6.1.3 Implementing the NNSS Avian Protection Plan

The NNSS APP was finalized during 2017. Its main purpose is to describe a program intended to reduce the operational and avian risks that result from avian interactions with electric transmission and distribution lines on the NNSS owned by NNSA/NFO as well as other non-electric sources of mortality (e.g., vehicle collisions, habitat disturbance).

At the end of each calendar year the APP is reviewed and the following questions answered: 1) Is the reporting procedure effective at documenting avian mortalities, 2) Are reported mortalities/injuries addressed in a timely manner, 3) Are permit conditions being met, and 4) What mortality reduction measures were taken and are they effective. For 2022 answers to these questions are:

- The reporting procedure was effective at documenting avian mortalities. There is good communication between biologists, the power group, other NNSS workers, and the Operations Command Center to report avian issues. Biologists responded to 33 calls related to avian issues during 2022.

- Reported mortalities/injuries were addressed in a timely manner and were usually investigated the same day or within a few days.

- Currently, there are two federal permits and one state permit pertaining to birds on the NNSS. Federal permit MB008695-2 allows the taking of up to 10 mourning doves each year for radiological analysis and the salvage of dead migratory birds (except species listed under the ESA). All permit conditions were met and an annual report summarizing 2022 activities was submitted to FWS. Five mourning doves were taken, and no bird specimens were salvaged for educational purposes. Federal permit MB60930C-1 is a "Special Purpose Utility Permit – Electric," and was issued November 6, 2018. This permit enables MSTS biologists to remove active nests at project sites in emergency situations and possess and transport carcasses of golden eagles and other bird species. A red-tailed hawk nest and two older chicks were moved from an energized switch pole in Jackass Flats to the rooftop of an abandoned building on June 3. Within an hour one adult was perched near the nest. The nest was checked on June 6, and both chicks were on the ground. They were captured and taken to a licensed raptor rehabilitator in Las Vegas. The smaller male chick died that night, but the bigger female survived. She was released at Captain Jack Spring on the NNSS on July 14 (see cover photos). Another rehabilitated immature red-tailed hawk found near Las Vegas was released at Camp 17 Pond, also on July 14. All permit conditions were met and an annual report summarizing 2022 activities was submitted to FWS. This included entering all bird injuries and mortalities into the Injury and Mortality Reporting system, a FWS electronic database. Nevada Department of Wildlife (NDOW) Scientific Collection Permit 261454 allows for the salvage and possession of migratory birds and the sacrificing of mourning doves, chukar, and Gambel's quail. All permit conditions were met and an annual report summarizing 2022 activities was submitted to NDOW.

- Several mortality reduction measures were taken. These included retrofitting 197 power poles between U1a facility and Valley substation to make them avian-friendly, rescuing a grounded common loon and releasing it at a large pond, removing a juvenile brown-headed cowbird from a glue trap and releasing it, removing a nest and two chicks from a potentially unsafe location, surveying 267 ha at 26 project sites for active bird nests before disturbance, and removing several dead rabbits and snakes from roads to reduce the potential for vehicle mortalities of scavenging birds. These measures were effective at reducing avian mortalities. In fact, there has been a substantial decrease in the number of electrocutions over the last few years (Figure 6-1), which may be due, at least in part, to the hundreds of pole retrofits that have been completed during this timeframe.

6.1.4 Winter Raptor Surveys

Winter raptor surveys were initiated during 2014, to better understand wintering raptors on the NNSS and as a collaborative effort to provide data to the U.S. Army Corps of Engineers' nationwide mid-winter bald eagle survey and NDOW's statewide monitoring effort. Surveys continued in 2022 and were conducted by driving a standard route to identify all raptors observed (i.e., eagles, hawks, owls, and vultures). Two official routes were established on the NNSS: Southern NNSS, Route #60 (83 kilometers [km]), and Yucca Flat, Route #61 (75 km) (Figure 6-2). Data including common name, UTM coordinates (NAD83), time, activity, age class, and perpendicular distance from the road were recorded, and climatic data (i.e., temperature, wind speed, and cloud cover) were taken at the beginning and end of each survey. Surveys for Route #60 were conducted on January 13 and February 9, 2022, and surveys for Route #61 were conducted on January 12 and February 8, 2022.

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 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 found in the 2016 EMAC report (Hall et al. 2017).

Only two raptor species were detected during the surveys in 2022, with a total of 10 red-tailed hawk sightings on the southern NNSS route, 4 red-tailed hawk sightings on the Yucca Flat route, and one prairie falcon (*Falco mexicanus*) sighting on each of the routes (Table 6-1). No golden eagle sightings were documented during any of the surveys which is uncharacteristic. Common ravens were more prevalent on the Yucca Flat route than on the southern route, and no loggerhead shrikes were observed on either route. Data were entered into the Ecological Geographic Information System (EGIS) faunal database and given to NDOW for inclusion in their analyses.

6.1.5 Western Burrowing Owl Radio-tracking Study

The western burrowing owl is a National Species of Conservation Concern that has been declining in certain parts of its range for many years. Western burrowing owls have been studied on the NNSS since 1996 (Steen et al. 1997, Hall et al. 2003, Greger and Hall 2009, Hall et al. 2009, Conway et al. 2010, Hall and Greger 2014) and much has been learned about their natural history and ecology on their summer range. Little is known about their migration ecology including where they spend the winter, migration routes, and stopover sites. This type of information is important to understand threats to this species during migration and on their wintering range.

New technology has recently become available to use satellites and GPS to track western burrowing owls over vast areas to identify specific migration routes, important stopover sites and wintering areas. Lightweight (5 g), solar-powered, Platform Transmitter Terminals (PTT) (Microwave Telemetry, Incorporated) are transmitters that are light enough to attach to western burrowing owls without exceeding the general rule of adding no more than 5% of an animal's body weight when attaching transmitters or other devices. Seven of these PTT's were attached to owls in June 2019 with results summarized in Hall and Perry (2021) and (2022).

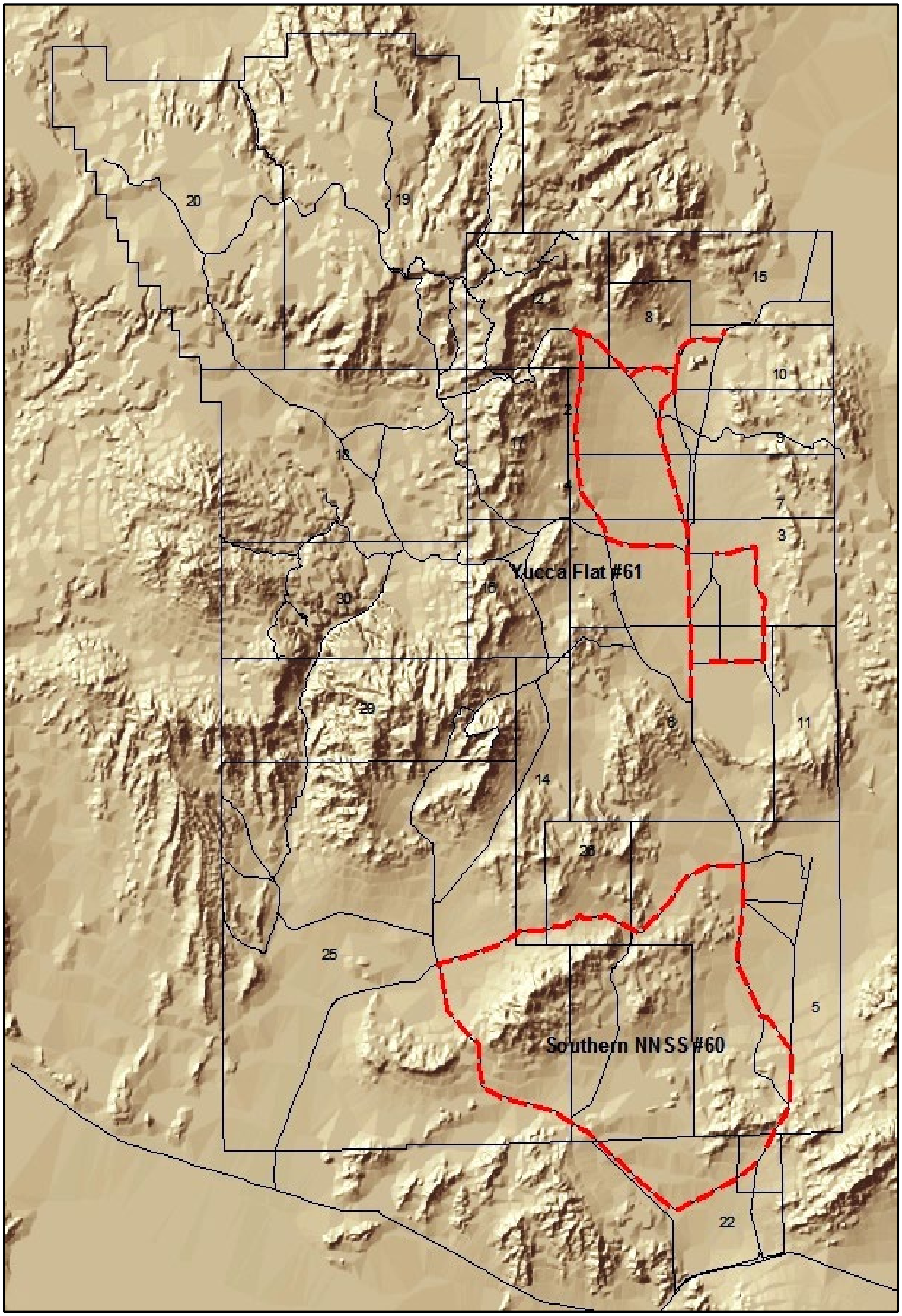

Figure 6-2. Winter raptor survey routes (red lines) on the NNSS.

Table 6-1. Results of winter 2022 raptor surveys on the NNSS.

Species	Southern NNSS (1/13/22)	Southern NNSS (2/9/22)	Yucca Flat (1/12/22)	Yucca Flat (2/8/22)
Red-tailed Hawk (*Buteo jamaicensis*)	7	3	1	3
Praire Falcon (*Falco mexicanus*)	1	0	0	1
Total Raptors	**8**	**3**	**1**	**4**
Common Raven (*Corvus corax*)	2	0	5	3
Loggerhead Shrike (*Lanius ludovicianus*)	0	0	0	0

Seven additional transmitters were purchased with the intent of attaching them to owls in June 2022. Unfortunately, like in 2021, no owls were found during several searches (most likely due to drought conditions) of previously used burrows, so no transmitters were attached. It is anticipated that the transmitters will be attached to owls in 2023.

6.2 Bat Monitoring

Bat monitoring in 2022 consisted of documenting roost sites or locations of bats found around buildings or in other areas and continued long-term acoustic sampling at sites within North American Bat Monitoring Program (NABat) priority grid cells.

6.2.1 Documenting Bat Locations

A dead adult female western small-footed myotis (*Myotis ciliolabrum*), one dead adult female California myotis (*Myotis californicus*), and a dead unknown myotis species were found at U1a. A dead adult female California myotis was found in Area 25 at the EMAD facility. One adult male pallid bat (*Antrozous pallidus*) was moved from the Dense Plasma Focus Facility, a juvenile male canyon bat (*Parastrellus hesperus*) was moved from U1a, and an adult female California myotis was moved from Building 23-460 in Mercury. A dead adult female canyon bat was found on a glue trap in Area 22. Locations where bats were found were entered in the EGIS faunal database. Additionally, 106 images of bats were photographed at 6 of 25 sites monitored for mountain lions, all of which were water sources (Table 6-3).

6.2.2 NABat Acoustic Sampling

NABat is a multi-national, multi-agency coordinated bat monitoring program across North America made up of an extensive community of partners who use standardized protocols to gather data that allows for assessing population status and trends, informing responses to stressors, and sustaining viable populations. Basically, a 10 x 10-km grid was overlaid across North America and certain grid cells were strategically selected for sampling. Four priority grid cells are located on the NNSS (Figure 6-3). Grid Cell 10662 is in the Mojave Desert ecoregion, Grid Cell 3494 is in the Fortymile Canyon area, Grid Cell 18854 is in northeastern Yucca Flat in the Transition ecoregion, and Grid Cell 7590 is on Pahute Mesa in the Great Basin Desert ecoregion. The placement of these grid cells is fortuitous because it allows us to

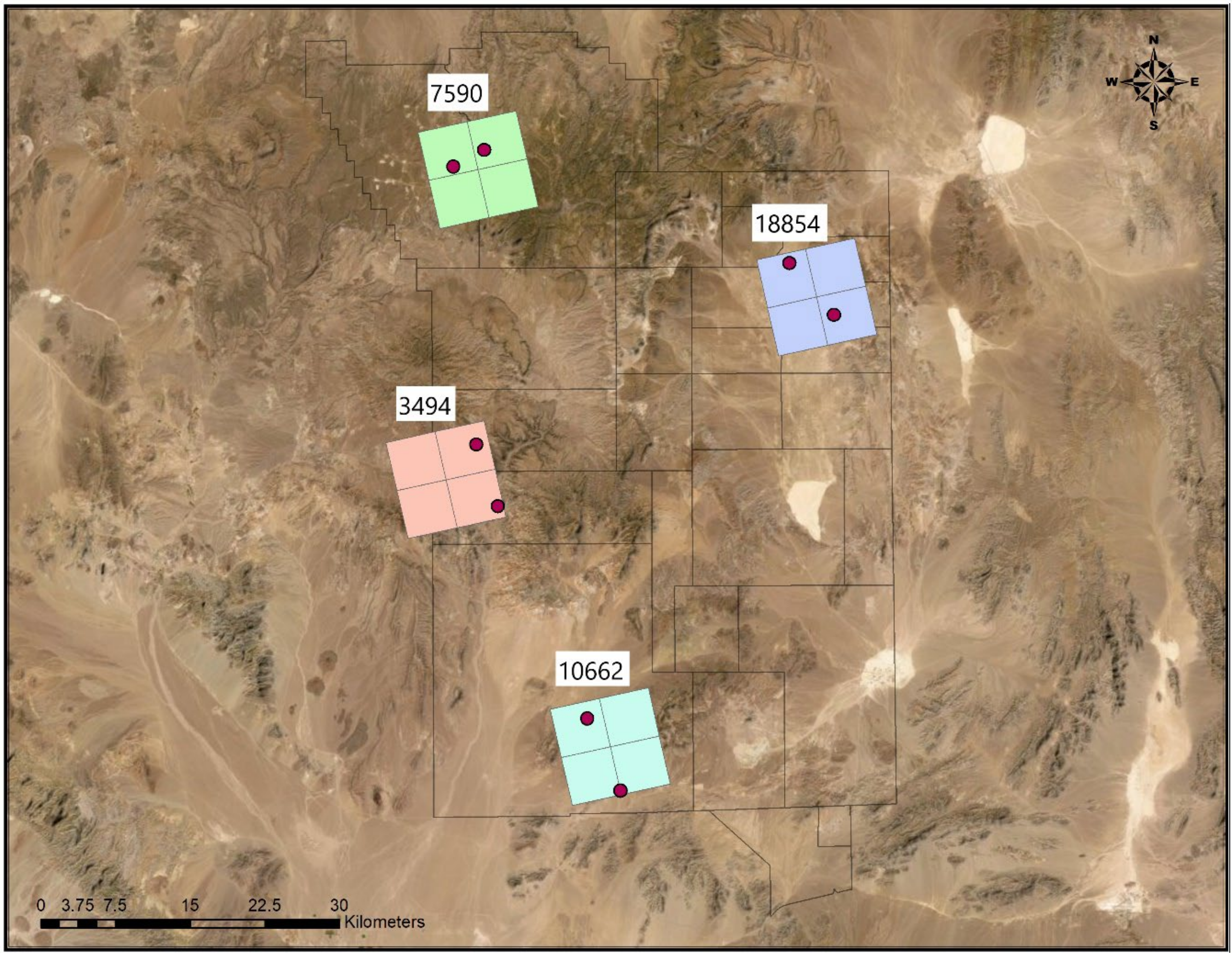

Figure 6-3. North American Bat Monitoring Program priority grid cells with four quadrants (colored numbered rectangles) and sampling locations (maroon dots).

sample a diverse assemblage of habitats, thus maximizing our chance of detecting all bat species that occur on the NNSS. Within each grid cell are four quadrants, and the intent is to sample within at least two of the four quadrants, preferably during May and June before the young become volant. The standard NABat monitoring protocol was followed for grid cell selection and sampling (Rodriguez et al. 2019).

We chose to use stationary acoustic monitoring as our primary sampling technique using Anabat Swift (Titley Scientific, Columbia, Missouri) passive full spectrum bat detectors. These detectors record the ultrasonic echolocation calls of bats which can be analyzed for species identification. One sampling location within two separate quadrants of each grid cell was selected based on specific habitat characteristics (Figure 6-3). The two locations within each grid cell were sampled concurrently with one bat detector per location. Detectors were attached to adjustable poles and raised to a height of 3 m and oriented toward the area of interest where bats were likely to pass through (Figure 6-4). Detectors were left out for a minimum of four consecutive nights. Acoustic files were downloaded and submitted to the NABat Data Processing Lab for analysis.

The two sampling locations for Grid Cell 10662 were Rock Valley Tank (southwest quadrant) (Figure 6-4) and a desert wash on the north side of Little Skull Mountain (northwest quadrant) (Figure 6-5). Both these locations are in creosote bush-white bursage habitat. Rock Valley Tank is a

Figure 6-4. Bat detector at Rock Valley Tank, Grid Cell 10662.

(Photo by D.B. Hall, May 4, 2022)

Figure 6-5. Bat detector in a typical Mojave Desert wash north of Little Skull Mountain, Grid Cell 10662.

(Photo by D.B. Hall, May 4, 2022)

small, natural water source in a limestone formation and the other location is a typical Mojave Desert wash draining off Skull Mountain and Little Skull Mountain. Detectors operated from May 4 to May 10.

The two sampling locations for Grid Cell 18854 were a wash near Papoose Lake Road (southeast quadrant) (Figure 6-6) and south of Sedan Crater (northwest quadrant) (Figure 6-7). The wash location is in a drainage that flows from the west side of the Halfpint Range in blackbrush habitat with scattered Joshua trees. The location south of Sedan Crater is in highly disturbed habitat with sparse perennial vegetation and abundant annual grasses and forbs. There are also some structures in the area that may provide roosting habitat for bats. Detectors operated from May 11 to May 17.

The two sampling locations for Grid Cell 3494 are at Twin Spring (southeast quadrant) (Figure 6-8) and North Chukar Canyon Tanks (northeast quadrant) (Figure 6-9). Twin Spring is a natural spring with perennial water. Nearby is an abandoned mine adit that is a known Townsend's big-eared bat and fringed myotis (*Myotis thysanodes*) maternity colony. North Chukar Canyon Tanks are in a canyon that drains into Fortymile Canyon, surrounded by volcanic rock. It is an ephemeral water source but can hold water for a few months. These locations were not sampled in 2021 because of restricted access due to the Cherrywood Fire but were sampled for the first time in 2022 from May 19 to May 31.

The two sampling locations for Grid Cell 7590 were Columbine Canyon (northeast quadrant) (Figure 6-10) and ER 20-6 sumps (northwest quadrant) (Figure 6-11). Columbine Canyon is in a small, narrow canyon in pinyon pine-Utah juniper-sagebrush habitat with adjacent cliff and rock features that provide potential bat roosting habitat. ER20-6 is a highly disturbed site surrounded by pinyon pine-Utah juniper-sagebrush habitat. There are several plastic-lined sumps that sometimes have water in them. They were dry during sampling this year which occurred from June 15 to June 22.

Results from 2021 detected California myotis, western small-footed myotis and canyon bats at the Mojave Desert wash, California myotis and canyon bats at Rock Valley Tank, western small-footed myotis and canyon bats at Papoose Road wash, and California myotis and canyon bats at south of Sedan Crater. No bats were detected at Columbine Canyon or ER 2-6 Sumps. Twin Spring and North Chukar Canyon tanks were not sampled during 2021. The presence of western small-footed myotis at the Mojave Desert wash location is somewhat surprising because it is typically found at higher elevations. This specie's occurrence at this site will be tracked over time.

6.3 Feral Horse Surveys

Feral horse monitoring in 2022 was limited to opportunistic observations and data from camera traps (see Table 6-3 in Section 6.7.1 Motion-Activated Cameras). The number of horses was not enumerated this year but at least three foals were observed. Gold Meadows Spring and Camp 17 Pond (Figure 6-12) continued to be valuable resources for these animals, especially during the hot, dry summer. A total of 133 and 907 photos of horses were recorded using a motion-activated camera at Gold Meadows Spring and Camp 17 Pond, respectively (Table 6-3). Based on opportunistic sightings and camera results, horses were observed in the same areas as previous years. No horses were documented using Captain Jack Spring for the tenth consecutive year.

Figure 6-6 Bat detector at wash in blackbrush habitat near Papoose Lake Road, Grid Cell 18854.

(Photo by D.B. Hall, May 17, 2022)

Figure 6-7. Bat detector south of Sedan Crater, Grid Cell 18854.

(Photo by D.B. Hall, May 17, 2022)

Figure 6-8. Bat detector location at Twin Spring, Grid Cell 3494.
(Photo by D.B. Hall, May 19, 2022)

Figure 6-9. Bat detector location at North Chukar Canyon Tanks, Grid Cell 3494.
(Photo by D.B. Hall, May 19, 2022)

Figure 6-10. Bat detector in Columbine Canyon, Grid Cell 7590.

(Photo by D.B. Hall, June 15, 2022)

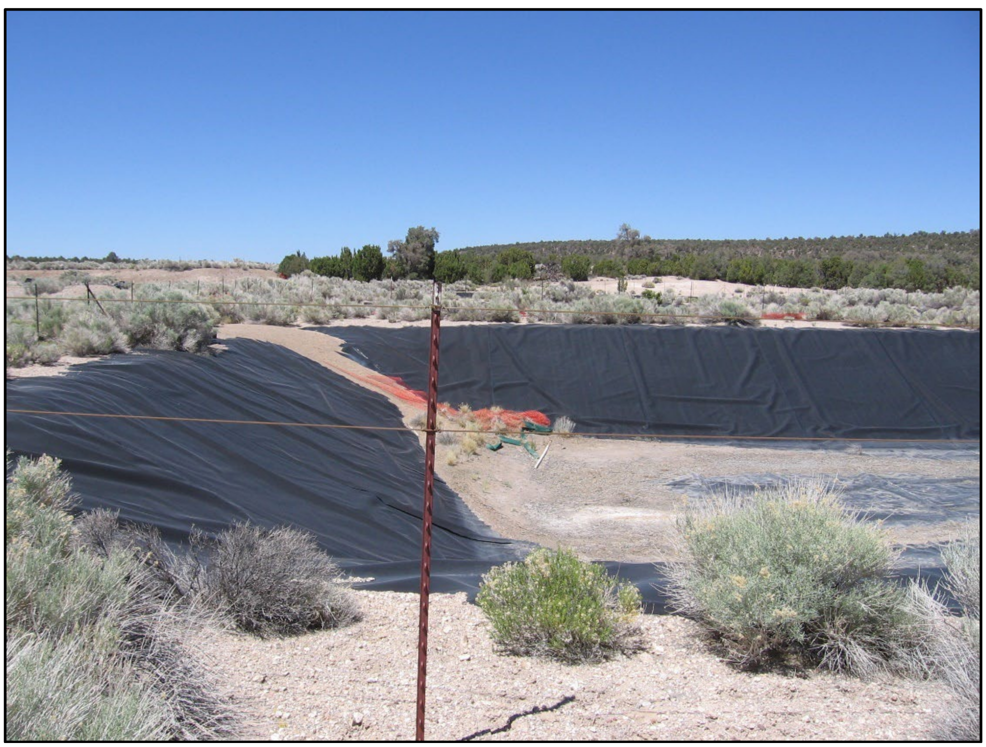

Figure 6-11. Bat detector location at ER 20-6 Sumps, Grid Cell 7590.

(Photo by D.B. Hall, June 15, 2022)

Figure 6-12. Several horses drinking and "cooling off" at Camp 17 Pond.

(Photo by motion-activated camera, August 7, 2022)

6.4 Mule Deer

Initial studies of mule deer at the NNSS were conducted by Giles and Cooper (1985) from 1977 to 1982 when they performed mark and recapture studies on about 100 marked deer. They estimated the population to be about 1,500–2,000 deer. Spotlighting surveys for deer on the NNSS were conducted during 1989–1994, 1999–2000, and 2006–2021. In past years, the monitoring effort has emphasized estimating relative abundance and density but since 2016 survey efforts have focused solely on relative abundance.

6.4.1 Trends in Mule Deer Abundance

Mule deer abundance on the NNSS was measured by driving two standardized (59 km total length) road courses to count and identify mule deer. One route (29 km) was centered around Rainier Mesa, and the second (30 km) was centered around the eastern portion of Pahute Mesa (Figure 6-13). 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 handheld GPS unit from the road centerline. Perpendicular distance from the road to each deer group was measured with a laser range finder.

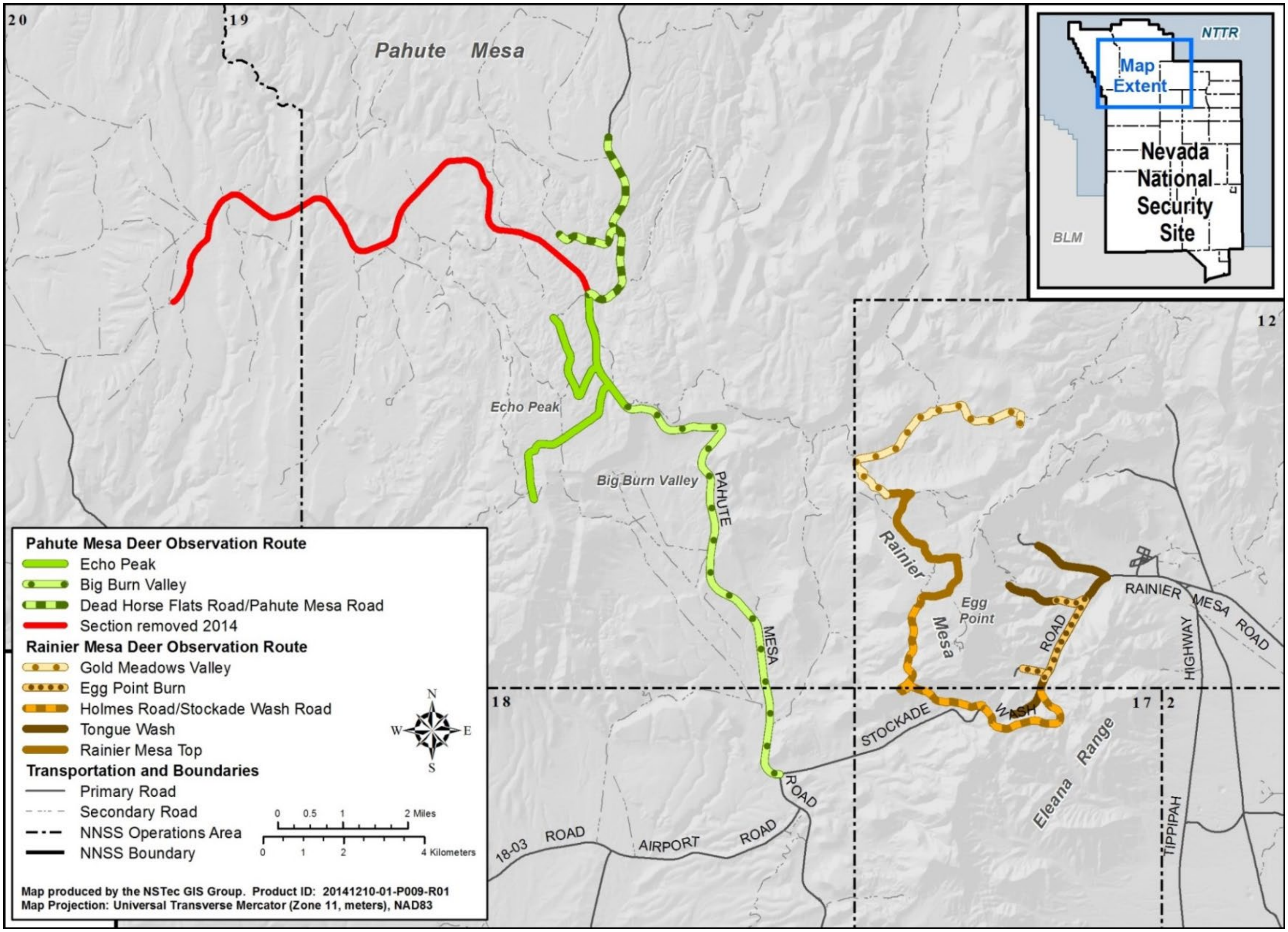

Figure 6-13. Road routes and sub-routes of two NNSS regions driven in 2022 to count deer and section removed due to road closure.

During six surveys conducted September 19-21 and October 3-5, 2022, a total of 26 deer were observed on both routes combined, which equates to an average of 4.3 deer per night. This is less than half the number of deer per night observed in 2021, when an average of 11.8 deer per night were recorded. This is the lowest number of deer per night ever recorded. There has been a decreasing trend ($y = -2.0292x + 47.15$, $r^2 = 0.54$) the last 17 years with counts fluctuating widely (Figure 6-14). The trend for the entire study period (1989-2021, excluding 1995-1998 and 2001-2005) is nearly flat ($y = -0.2678x + 33.201$, $r^2 = 0.05$). Specific causes for the fluctuation in deer numbers is unknown and requires further investigation. Mountain lion predation and drought are likely candidates for the decrease during 2021 and 2022. Eight of 11 (73%) radio-collared mule deer that died during 2021 and 2022 were apparently killed by mountain lions and no fawns were observed on the deer surveys during 2021 and 2022.

Like last year, the number of deer per 10 km was higher on Pahute Mesa than Rainier Mesa in 2022 (Figure 6-15). A total of 22 deer groups were detected, and group size varied from one to two animals. The average group size was nearly equal between the Pahute Mesa and Rainier Mesa routes (1.2 and 1.1, respectively).

6.4.2 Sex and Fawn/Doe Ratios

A disproportionate number of bucks were observed during the 2022 deer surveys; 17 bucks, 2 does, 0 fawns, and 7 unknown. The deer sex ratio (number of bucks per 100 does) increased from 511 in 2021 to 850 in 2022, which is by far the highest recorded since 2006 (Table 6-2). 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) was zero in 2022 as it was in 2021 (Table 6-2). The only other year with zero fawns detected was 2007, which was an extremely dry year like 2021 and 2022. The buck to doe ratio was also much higher in 2007 than in other years, like our results in 2021 and 2022 (Table 6-2). This suggests that perhaps bucks are more drought hardy than does, and fawns are either not born or don't survive the summer during drought conditions. A few fawns have been observed in photographs taken with our motion-activated cameras but it is unknown how long they survive.

The percentage of individuals unclassified to sex in 2022 was 26.9% which is higher than the average percentage of unclassified sex since 2006 (18.8%). When deer are observed at long distances (150-200 m) from the vehicle, it can be difficult to determine if individuals are bucks, does, or fawns due to spotlight limitations.

6.5 Mule Deer and Pronghorn Antelope Distribution study

Mule deer and pronghorn antelope are mobile game animals that inhabit the NNSS. Both are generally considered to be migratory with distinct winter and summer ranges. Mule deer typically prefer the forested, mountainous habitats in the northern and western portions of the NNSS while pronghorn generally prefer the open valleys in the southern and eastern portions of the NNSS. Gold Meadows on the northern NNSS boundary is one of the few places where mule deer and pronghorn regularly occur together during the summer. Mule deer are much more abundant than pronghorn on the NNSS. Mule deer movements on the NNSS were studied more than 30 years ago (Giles and Cooper 1985) using radio-collars that required triangulating locations that lacked the accuracy of current GPS radio-collars. They identified summer and winter ranges and a couple of long-distance movements of mule deer into areas where hunting is allowed on public land. Mule deer in their study were not necessarily those known to be using radioactively contaminated locations.

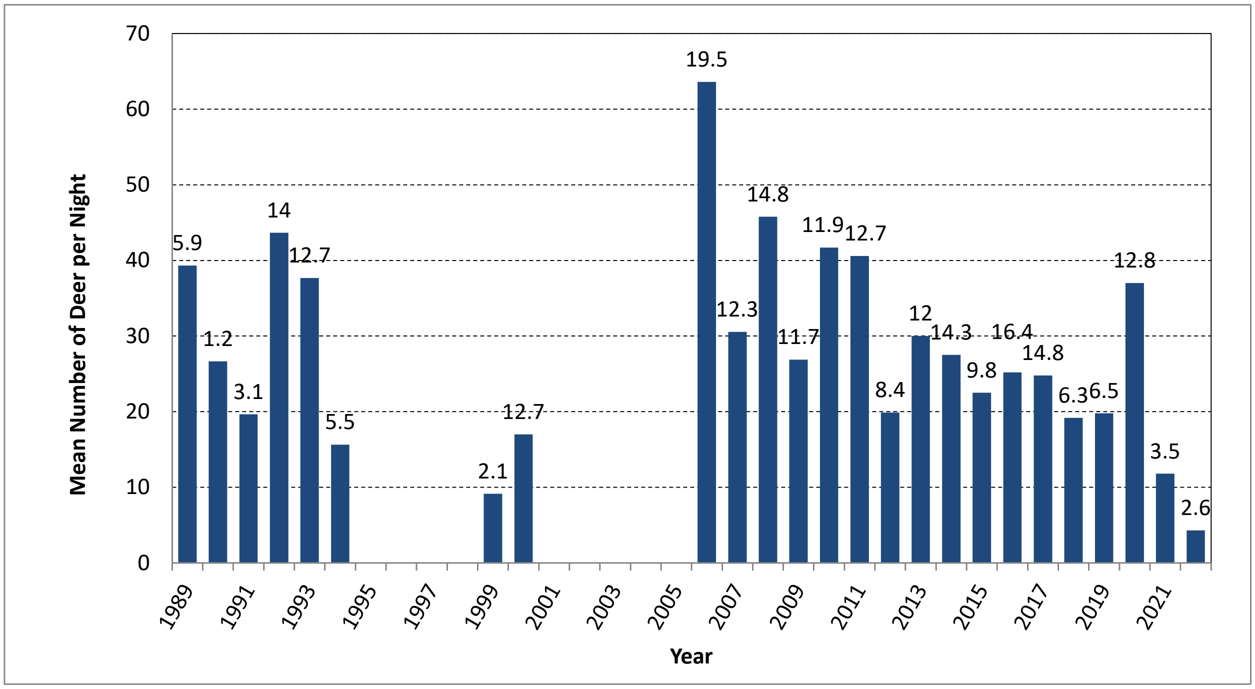

Figure 6-14. Trends in total deer count per night from 1989 to 2022 on the NNSS (surveys were not conducted during 1995–1998 or 2001–2005). Standard deviation values above bars.

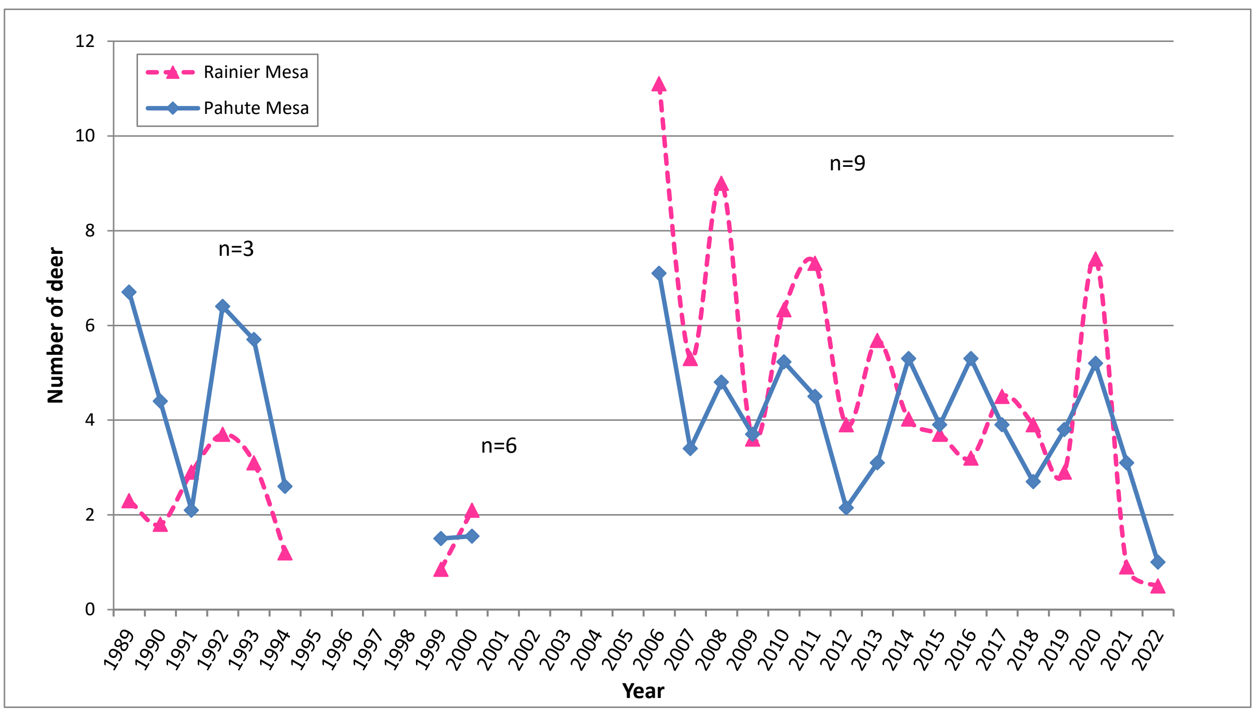

Figure 6-15. Mean number of mule deer per 10 km per night, counted on two routes (n = number of survey nights; exceptions n = 12 for 2012, n = 8 for 2013, n = 6 for 2015–2022).

Table 6-2. Mule deer classified by sex and age, with sex ratios, and fawn to doe ratios from 2006 to 2022 on the NNSS (12 survey nights for 2012, 8 for 2013, 6 for 2015–2022, 9 for all other years).

Year	Total Deer	Bucks	Does	Unclassified Sex	Bucks/100 does	Fawns	Fawns/100 does
2006	573	224	222	96	101	31	14
2007	275	148	68	59	218	0	0
2008	408	164	147	50	112	47	32
2009	242	98	102	35	96	7	7
2010	365	133	150	50	89	32	21
2011	477	189	184	67	103	37	19
2012	179	65	67	28	97	19	30
2013	243	106	68	38	156	31	45
2014	249	76	94	60	81	19	20
2015	135	33	58	19	57	25	43
2016	151	43	58	27	74	23	40
2017	149	52	42	44	124	11	26
2018	115	40	38	27	105	10	26
2019	119	41	47	21	87	10	21
2020	222	63	100	42	63	17	17
2021	71	46	9	16	511	0	0
2022	26	17	2	7	850	0	0

Pronghorn are relatively new residents to the NNSS (first observed in 1991) and their use of the NNSS has never been studied but they are known to be widespread. Tsukamoto et al. (2003) report the distribution of pronghorn in Nevada as of 2002 with the nearest population to the NNSS being just north in Emigrant Valley. The NNSS represents an expansion of pronghorn range in Nevada.

A research study involving the capture and radio-collaring of mule deer and pronghorn antelope on the NNSS was initiated in November 2019 to better understand the potential radiological dose to the off-site public via the hunter pathway. This was a true collaborative effort involving Kathy Longshore (Co-Principal Investigator, USGS), NDOW (Dr. Peregrine Wolff and Chris Morris [veterinarian support]; Joe Bennett, Pat Cummings, and Cody Schroeder [game biologists]), and MSTS biologists. Native Range Capture Services (David Rivers, pilot, and his crew) was contracted to capture the animals using net guns from a helicopter. NNSA/NFO and DOE Environmental Management Nevada Program (DOE EM/NV) graciously provided funding for the study. Study objectives included: 1) determine the distribution, abundance, and range of movements of mule deer and pronghorn, 2) estimate the potential for hunters to harvest mule deer and pronghorn which use the NNSS, 3) evaluate mule deer and pronghorn use of contaminated areas, 4) obtain information on the potential radiological dose to someone consuming deer and pronghorn from the NNSS, 5) determine the potential radiological dose to mule deer and pronghorn on the NNSS, 6) document survival and causes of mortality for both mule deer and pronghorn, 7) refine habitat use patterns for both mule deer and pronghorn using resource selection functions and correlate that with phenological changes in the vegetation, and 8) assess the overall health, disease status, and genetics of NNSS mule deer and pronghorn.

In November 2019, a total of 23 mule deer (16 does, 7 bucks) and 20 pronghorn (14 does, 6 bucks) were captured. All 23 mule deer were radio-collared and ear-tagged, and 18 pronghorn (12 does, 6 bucks) were radio-collared and ear-tagged. One pronghorn doe was ear-tagged only. This animal was excluded from the survival analysis because it was unknown how long it survived. At the beginning of 2022, eight mule deer (7 does, 1 buck) and eight pronghorn (5 does, 3 bucks) were alive. These animals were monitored during 2022.

Similar to 2020 and 2021, pronghorn spent a majority of time in Frenchman Flat and Yucca Flat with no large seasonal migrations (Figure 6-16), although they remained close to water sources and shade during the hot, dry summer. One doe spent some time in Emigrant Valley around mid-June to mid-July. Two bucks spent time around the Ranger Mountains and foothills of the Spotted Range with one location as far east as Indian Springs Valley. One buck spent time around Mercury in July and mid-August. Like previous years, mule deer made seasonal migrations, migrating primarily off the high elevation portions of Rainier and Pahute mesas to lower elevation areas in the CP Hills, Eleana Range, Pahute Mesa, Mine Mountain, and eastern slopes of Rainier Mesa (Figure 6-16). For the third year in a row, a doe (#705940) that wintered on the NNSS moved over 60 km to the north through the Kawich Range to spend the summer in the Kawich Peak area which is open to hunting. She started migrating north in mid-May and headed back south in early October. A few deer also spent time on Shoshone Mountain and Timber Mountain with one doe spending time in Beatty Wash during March and April.

Three pronghorn does (two were lactating) and one buck were found dead in Yucca Flat during 2022. One doe had marks on the hindquarters that may have been from a predator attack. The other two does and buck died of unknown causes. Two does and the buck all died between August 31 and September 10 which suggests heat exposure as a possible cause of death, although more than an inch of rain fell in Yucca Flat during August. Saltlover (*Halogeton glomeratus*) is abundant in many disturbed areas in Yucca Flat and the rain would have stimulated late summer growth of this plant which is known to be toxic to sheep and cattle. It is unknown if it is toxic to pronghorn. Further research is warranted to determine if saltlover may be responsible for pronghorn mortalities. The other doe died on October 20. One mule deer buck was killed by a mountain lion on August 21 in the northern part of Dead Horse Flat. During the latter part of 2021, low voltage messages on several of the pronghorn collars were received, whereas none of the collars on mule deer had this issue. The collars were scheduled to last for three years. The manufacturer was consulted about the problem and they did not have a reason for the battery issues. Due to this issue, large data gaps occur in the pronghorn location dataset. Radio-collars were programmed to drop off the animals on November 1, 2022. Radio-collars were retrieved and data was downloaded directly from each retrieved collar. Collars for two pronghorn bucks (#705963 and #705965) were not found because their batteries died and one collar for a pronghorn doe did not drop off until April 10.

Seven mule deer does, two pronghorn does, and two pronghorn bucks survived to the end of the study. Thus, overall survival of mule deer was 30% (7 of 23) (44% for does, 0% for bucks) and 22% for pronghorn (4 of 18) (17% for does, 33% for bucks). Detailed analyses to answer study objectives will be performed over the next two years and a summary report written.

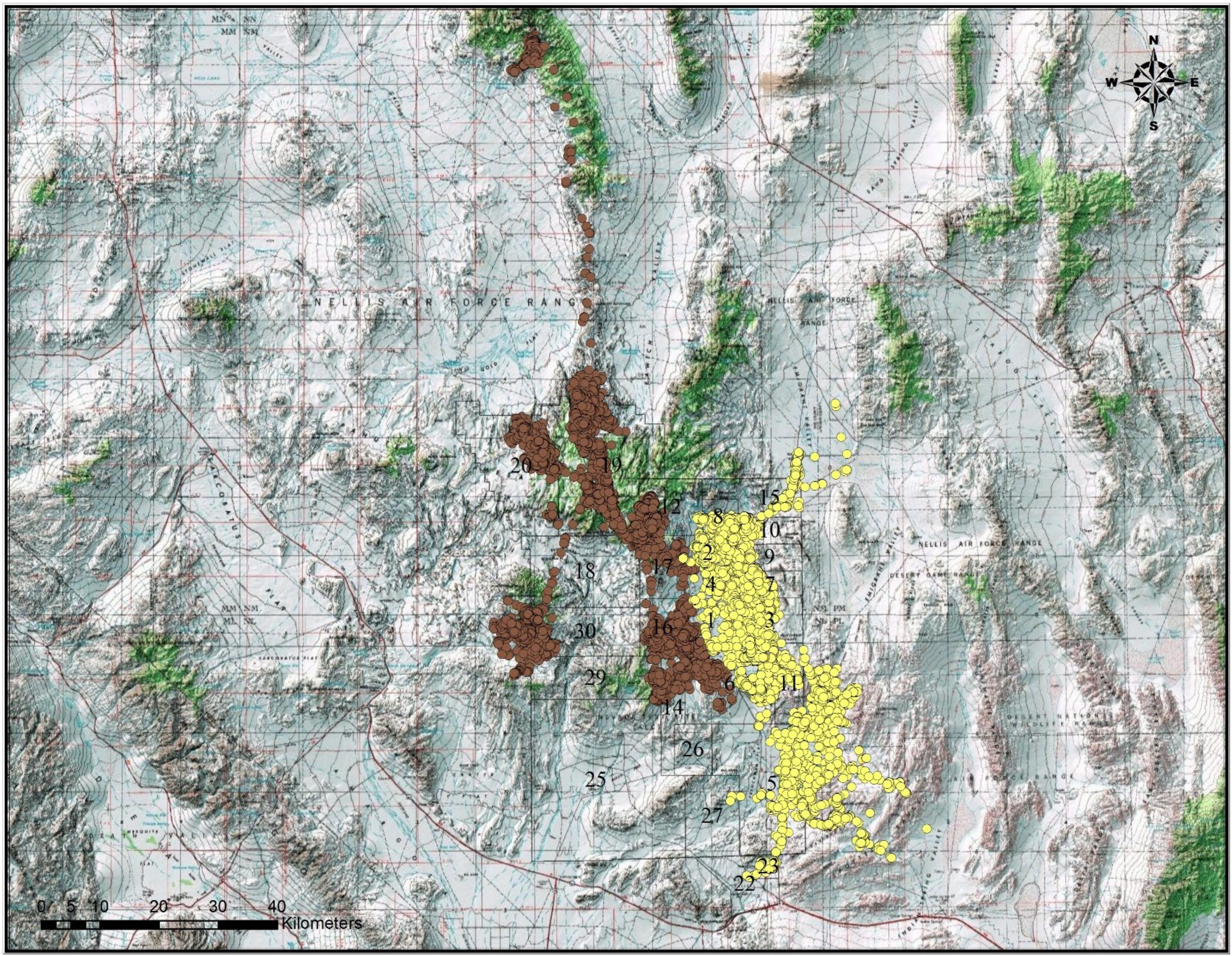

Figure 6-16. Locations of collared mule deer (brown dots) and pronghorn antelope (yellow dots) during 2022.

6.6 Desert Bighorn Sheep

Prior to 2009, desert bighorn sheep (sheep) were rare visitors on the NNSS (Saethre 1994, Wills and Ostler 2001, Hall et al. 2017). Since 2009, numerous observations of sheep and sheep sign (i.e., scat, beds, and remains) have been detected with motion-activated cameras and during a recent mountain lion study, including the discovery of ewes and lambs in the Yucca Mountain/Fortymile Canyon area in 2011. These new data expanded the known distribution of sheep on and near the NNSS and prompted the radio-tracking study from 2015-2018. Results of this study were summarized in the 2018 EMAC Report (Hall and Perry 2019) and a comprehensive USGS Open File Report on the study is being finalized for publication by Kathy Longshore (USGS). Conclusions from the radio-tracking study recommend continued monitoring of the NNSS sheep population. In 2022, this was done by documenting sheep use at several water sources using camera traps. In addition, a joint test and remove study with NDOW occurred in November 2022 as part of a state-wide program for disease surveillance and control.

6.6.1 Camera Trap Results

During 2022, motion-activated cameras detected sheep at Delirium Canyon Tanks (#5) (1,720 images), Cottonwood Spring (#4) (3 images), Rock Valley Tank (#2) (17 images), South Pah Canyon Tanks (#15) (9 images), Fortymile Canyon Tanks (#11) (3 images), and East Cat Canyon (#19) (1 image) (Table 6-3). The ram photographed on August 17, was the first sheep detected at this camera location (Figure 6-17). Four marked sheep (3 ewes, 1 ram) were identified including Ewe 686315 (about 8 years old), Ewe 686316 (collar still attached, about 8 years old), Ewe 686318 or 686319, and Ram 686329 (about 10 years old). At least an additional 12 unmarked sheep were detected (5 unmarked ewes, 1 yearling ewe, 2 lambs, 3 unmarked adult rams, and one young ram) making a total of at least 16 sheep documented on the NNSS during 2022.

6.6.2 NDOW Test and Remove Project

A bacteria, *Mycoplasma ovipneumoniae*, that causes pneumonia in bighorn sheep has drastically reduced several bighorn sheep populations in Southern Nevada. The disease seems to be especially lethal to lambs resulting in low recruitment and declining populations. To try and control this disease, NDOW is conducting a test and remove project to capture several sheep, test them to see if they have the active disease, and remove (i.e., euthanizing) diseased animals from the population. Prior research detected the presence of the disease on and around the NNSS. In November, MSTS biologists collaborated with NDOW to capture several sheep on and around the NNSS (e.g., Bare Mountains, NTTR, Specter Range). Three ewes were captured on or near the NNSS on November 11, 2022 (Figure 6-18). Two ewes were captured near The Prow on the north end of Yucca Mountain ridge and one was captured on the west side of Fortymile Canyon near Comb Peak. Oral, nasal, and blood samples were taken for disease testing, radio collars were attached, and the animals were then released. None of the animals tested positive for the disease. Animals will be tracked, and locations documented over the next few years. Additional sheep may be captured and tested in the future.

Figure 6-17. Unmarked ram at East Cat Canyon (#19); first time this species has been detected at this location.

(Photo by motion-activated camera, August 17, 2022)

Figure 6-18. Desert bighorn sheep ewe being brought to the staging area for processing.

(Photo by J.A. Perry, November 11, 2022)

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, MSTS 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. Remote, motion-activated cameras were used in 2022 at 25 sites (Figure 6-19 and Table 6-3). Sites were selected at locations with previous or new mountain lion sightings or sign, on roads or landform features that are potential movement corridors from one area to another, and in areas of good mule deer habitat (mule deer are a primary prey species for mountain lions). Some sites were also added based on other needs such as documenting the predator community in tortoise habitat or detecting animals at contaminated water sources or water troughs. 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 2021 due to the accessibility and scheduling of camera trap visits.

A total of 142 mountain lion images (i.e., photographs or video clips) were taken during 170,805 camera hours across all sites (Figure 6-19 and Table 6-3). This equates to about 0.8 mountain lion images per 1,000 camera hours. Mountain lions were detected at 11 of the 25 sites, including 9 water sources, 1 road, and 1 canyon (Figure 6-19). Table 6-4 contains the camera trap results by month and location. Figure 6-20 depicts a mountain lion walking along 19-01 Road (#16), and Figure 6-21 shows a mountain lion at South Pah Canyon Tanks (#15) in Fortymile Canyon.

It is difficult to tell individual mountain lions apart from camera trap images and determine the exact number of mountain lions on the NNSS. At least three individuals (adult male, adult female, and subadult) were documented in 2022 from the 25 camera traps. This compares to a minimum of three individuals in 2021, four individuals in 2020, three individuals in 2019 and 2018, four individuals in 2017, five individuals in 2016, three individuals in 2015, four individuals in both 2014 and 2013, and six individuals in 2012.

In order to investigate temporal activity of mountain lions, camera detection data from all 17 years (2006-2022) were combined. Mountain lions were detected every month with peak occurrences during November (n = 194), August (n = 169), and June (n = 164) (Figure 6-22). The number of images taken during summer and fall (June–November) (n = 872) accounted for nearly 70% of all images compared with the number of images taken during winter and spring (December–May) (n = 403) (Figure 6-22). Nearly three-fourths of mountain lion images were taken between 1700 to 0500 hours with peaks between 1900 and 2100 and 0300 to 0400 hours Pacific Standard Time (Figure 6-23). From 2011 to 2022, nearly 1.9 times as many images were taken when it was dark (n = 706) compared with when it was light (n = 378).

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 26,420 images of at least 81 species other than mountain lions were taken during 170,805 camera hours across all sites which is about 155 images per 1,000 camera hours; substantially higher than 91 images per 1,000 camera hours documented in 2021 and closer to 169 images per 1,000 camera hours taken during 2020.

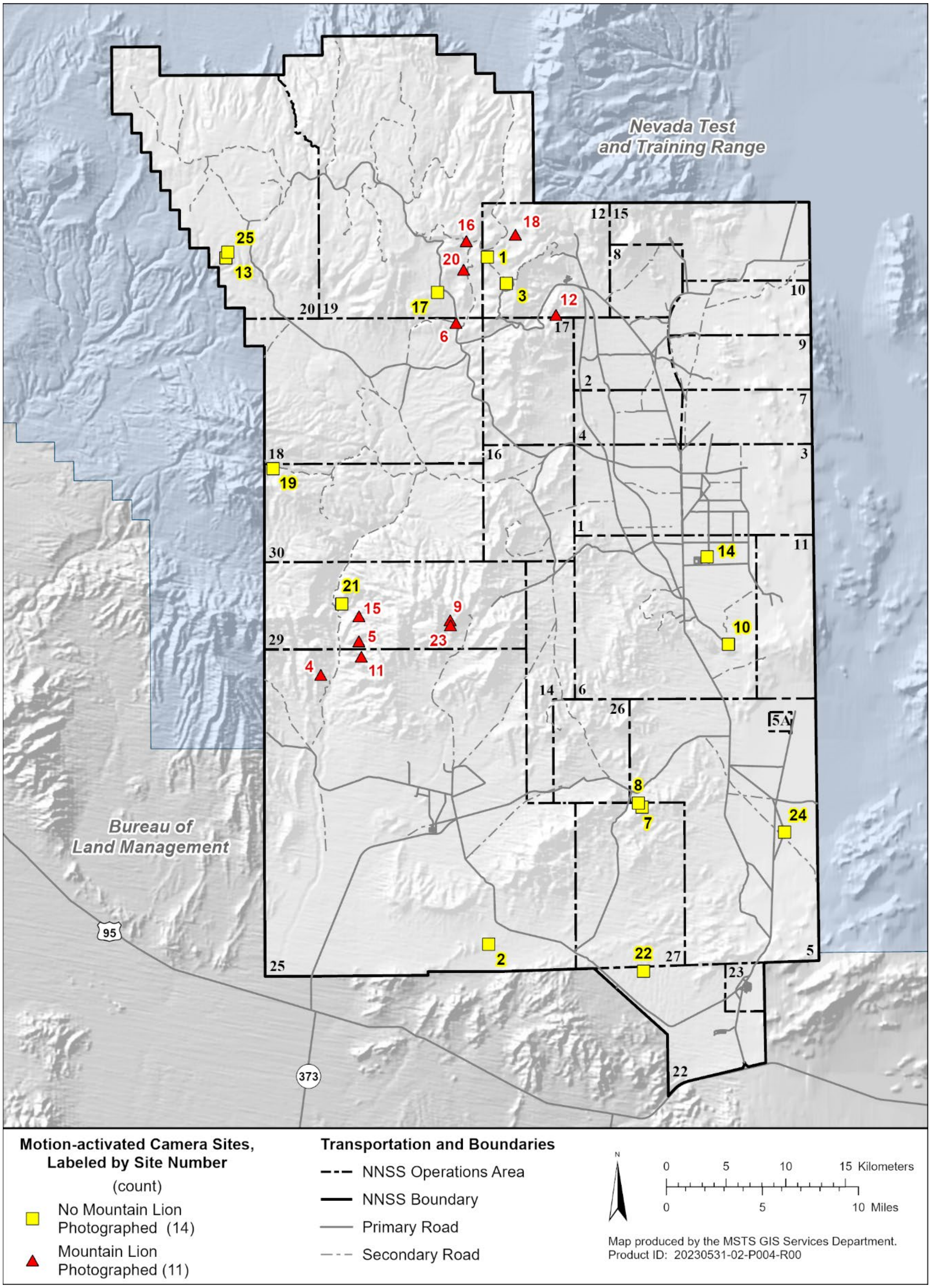

Figure 6-19. Locations of mountain lion photographic detections and camera traps on the NNSS during 2022.

Table 6-3. Results of mountain lion camera surveys during 2022 (a = non-continuous operation due to camera problems, dead batteries, full memory cards, etc.; b = camera hours not known for some time periods).

Location (Site Number)	Dates Sampled	Camera Hours	Mountain Lion Images (Number of Images per 1,000 Camera Hours)	Other Observations (Number of Images)
Delirium Canyon Tanks (#5)	1/13/22-1/12/23	8,736	55 (6.3)	Bobcat (11), gray fox (27), ring-tailed cat (1), desert bighorn sheep (1,720), bats (6), rock squirrel (3) great-horned owl (4), mourning dove (23), turkey vulture (6), red-shafted common flicker (2)
Camp 17 Pond (#6)	12/20/21-12/22/22[a]	9,368	39 (4.2)	Bobcat (7), coyote (39), mule deer (347), feral horse (907), black-tailed jackrabbit (13), desert cottontail rabbit (9), rock squirrel (1), bats (4), peregrine falcon (38), golden eagle (25), common blackhawk (2), Swainson's hawk (1), prairie falcon (13), Cooper's hawk (166), red-tailed hawk (353), great-horned owl (6), turkey vulture (1,036), chukar (177), mourning dove (1025), common raven (441), belted kingfisher (1), great blue heron (137), Canada geese (9), ducks (4), spotted sandpiper (73), solitary sandpiper (11), greater yellowlegs (1), killdeer (4), pinyon jay (35), scrub jay (3), Lewis' woodpecker (28), red-shafted common flicker (13), phainopepla (1), western tanager (1), mountain bluebird (1), Scott's oriole (1), American robin (7), cedar waxwing (7), western kingbird (4), black phoebe (3), yellow warbler (1), northern mockingbird (15), lesser goldfinch (2), house finch (318), evening grosbeak (2), yellow-headed blackbird (3), Townsend's solitaire (10), great-tailed grackle (5), horned lark (1), brown-headed cowbird (1), European starling (6), common green darner (1)
Captain Jack Spring (#12)	12/20/21-1/4/23[a]	7,503	16 (2.1)	Bobcat (2), gray fox (2), mule deer (723), bats (4), Cooper's hawk (23), chukar (22), mourning dove (314), pinyon jay (82), scrub jay (2), common raven (16), black-throated sparrow (2), house finch (9)
Topopah Spring Trough (#23)	1/6/22-1/4/23[a]	3,372	4 (1.2)	Bobcat (1), gray fox (2), coyote (2), rock squirrel (25), white-tailed antelope ground squirrel (7), mourning dove

Table 6-3. Results of mountain lion camera surveys during 2022 (a = non-continuous operation due to camera problems, dead batteries, full memory cards, etc.; b = camera hours not known for some time periods).

Location (Site Number)	Dates Sampled	Camera Hours	Mountain Lion Images (Number of Images per 1,000 Camera Hours)	Other Observations (Number of Images)
				(256), chukar (94), turkey vulture (1), scrub jay (1), common raven (2), house finch (1), lizard (1)
Gold Meadows Spring (#18)	1/1/22-12/31/23[a]	6,903	6 (0.9)	Coyote (1), pronghorn antelope (3), mule deer (6), feral horse (133), black-tailed jackrabbit (54), cliff chipmunk (3), rock squirrel (1), white-tailed antelope ground squirrel (10), rodent (30), turkey vulture (1), mourning dove (4), red-shafted common flicker (1), pinyon jay (5), common raven (2), white-crowned sparrow (17), Say's phoebe (3)
Rattlesnake Ridge Gorge (#20)	1/1/22-1/1/23	8,807	6 (0.7)	None
East 19-01 Road (#16)	1/1/22-1/1/23[a]	4,875	3 (0.6)	Bobcat (1), gray fox (17), coyote (6), mule deer (3), black-tailed jackrabbit (123), cliff chipmunk (14) common raven (1), pinyon jay (3), scrub jay (1), rufous-sided towhee (3), hummingbird (1)
Topopah Spring (#9)	1/6/22-1/4/23[a]	8,227	3 (0.4)	Coyote (1), chukar (4)
South Pah Canyon Tanks (#15)	1/11/22-1/11/23	8,757	3 (0.3)	Bobcat (1), gray fox (10), ring-tailed cat (21), desert bighorn sheep (9), cliff chipmunk (22), rock squirrel (8), kangaroo rat (2), bats (89), great-horned owl (16), turkey vulture (2), mourning dove (32), chukar (9), pinyon jay (5), scrub jay (1), loggerhead shrike (1), red-shafted common flicker (5), common poorwill (1), Costa's hummingbird (1), dark-eyed junco (3), rufous-sided towhee (2), Townsend's solitaire (22), rock wren (1), house finch (36), Say's phoebe (10), western fence lizard (8)
Fortymile Canyon Tanks (#11)	1/13/22-1/12/23[a]	8,254	2 (0.2)	Gray fox (1), desert bighorn sheep (3), golden eagle (1), mourning dove (1), chukar (7)

Table 6-3. Results of mountain lion camera surveys during 2022 (a = non-continuous operation due to camera problems, dead batteries, full memory cards, etc.; b = camera hours not known for some time periods).

Location (Site Number)	Dates Sampled	Camera Hours	Mountain Lion Images (Number of Images per 1,000 Camera Hours)	Other Observations (Number of Images)
12T-26, Rainier Mesa (#1)	1/1/22-8/31/22	5,843	0 (0.0)	None
Dick Adams Cutoff Road, Rainier Mesa (#3)	1/1/22-8/31/22	5,823	0 (0.0)	Mule deer (10)
Water Bottle Canyon (#17)	1/12/22-12/22/22	8,279	0 (0.0)	Unknown mammal (1)
East Cat Canyon (#19)	12/20/21-12/22/22	8,808	0 (0.0)	Bobcat (1), gray fox (2), coyote (18), desert bighorn sheep (1), mule deer (8), feral burro (89), black-tailed jackrabbit (5), pinyon jay (1), northern mockingbird (3), black-throated sparrow (1), house finch (2)
Cottonwood Spring (#4)	1/13/22-1/11/23[b]	5,858	5 (0.9)	Bobcat (13), gray fox (3), coyote (77), desert bighorn sheep (3), mule deer (35), feral burro (8,323), bats (1), red-tailed hawk (46), chukar (43), common raven (16), pinyon jay (36)
Twin Spring (#21)	1/11/22-1/11/23[a]	4,149	0 (0.0)	Coyote (12), mule deer (7), feral burro (7,256), desert woodrat (1), bat (2), mourning dove (5), chukar (1), greater roadrunner (5), rock wren (3), common raven (1), Say's phoebe (1), chuckwalla (1), desert spiny lizard (7), side-blotched lizard (2)
Area 22, Juvenile GOAG [c] Site 2 (#22)	1/10/22-1/3/23[b]	5,733	0 (0.0)	Coyote (1), black-tailed jackrabbit (2), white-tailed antelope ground squirrel (5), kangaroo rat (8), LeConte's thrasher (2), common poorwill (1), zebra-tailed lizard (1)
Cane Spring (#7)	1/6/22-1/4/23[a]	1,769	0 (0.0)	Bobcat (1), mule deer (5)
Cane Spring Trough (#8)	1/6/22-1/4/23[a,b]	4,024	0 (0.0)	None
Area 6 LANL Pond Trough (#14)	1/6/22-1/4/23[a]	7,430	0 (0.0)	Feral burro (20)

Table 6-3. Results of mountain lion camera surveys during 2022 (a = non-continuous operation due to camera problems, dead batteries, full memory cards, etc.; b = camera hours not known for some time periods).

Location (Site Number)	Dates Sampled	Camera Hours	Mountain Lion Images (Number of Images per 1,000 Camera Hours)	Other Observations (Number of Images)
Well C1 Pond Trough (#10)	1/6/22-1/4/23	8,733	0 (0.0)	Coyote (2), pronghorn antelope (73), mule deer (5), feral burro (41), turkey vulture (5), common raven (2)
Well 5C Trough (#24)	1/6/22-1/4/23	8,743	0 (0.0)	Coyote (15), kit fox (11), badger (2), pronghorn antelope (28), feral burro (47), black-tailed jackrabbit (29), white-tailed antelope ground squirrel (76), kangaroo rat (42), red-tailed hawk (31), turkey vulture (2), mourning dove (3), common raven (111), horned lark (188), great-tailed grackle (13), western meadowlark (4), European starling (7), desert spiny lizard (1), western whiptail (2)
Rock Valley Tank (#2)	5/10/22-1/4/23[a]	3,147	0 (0.0)	Bobcat (5), kit fox (10), coyote (9), badger (1), desert bighorn sheep (17), white-tailed antelope ground squirrel (18)
ER 20-7 Plastic-lined Sump (#13)	12/20/21-12/22/22	8,832	0 (0.0)	Common raven (1), unknown birds (7)
ER 20-5 Plastic-lined Sump (#25)	12/20/21-12/22/22	8,832	0 (0.0)	Turkey vulture (1), common raven (21), passerine (2), unknown birds (4)

Table 6-4. Number of mountain lion images taken with camera traps by month and location, December 2021 through December 2022 (orange = number of mountain lion images; yellow = camera operational, no mountain lion images; green = camera not operational).

Camera Location (Site number)	Dec-21	Jan-22	Feb-22	Mar-22	Apr-22	May-22	Jun-22	Jul-22	Aug-22	Sep-22	Oct-22	Nov-22	Dec-22
Cottonwood Spring (#4)													5
Delirium Canyon (#5)			2	2	8	1			10	6		14	12
South Pah Canyon (#15)							3						
Fortymile Canyon Tanks (#11)				1									1
Topopah Spring (#9)			1			1				1			
Topopah Spring Trough (#23)				1	2					1			
Captain Jack Spring (#12)				2								13	1
Camp 17 Pond (#6)	1	1				4	10	8	4		5	5	1
Rattlesnake Ridge Gorge (#20)					1		1	1		1	2		
East 19-01 Road (#16)			1		1		1						
Gold Meadows Spring (#18)					2	1	1	1		1			

Figure 6-20. Mountain lion walking along the east section of the 19-01 Road (#16).
(Photo by motion-activated camera, June 3, 2022)

Figure 6-21. Mountain lion at South Pah Canyon Tanks (#15).
(Photo by motion-activated camera, June 21, 2022)

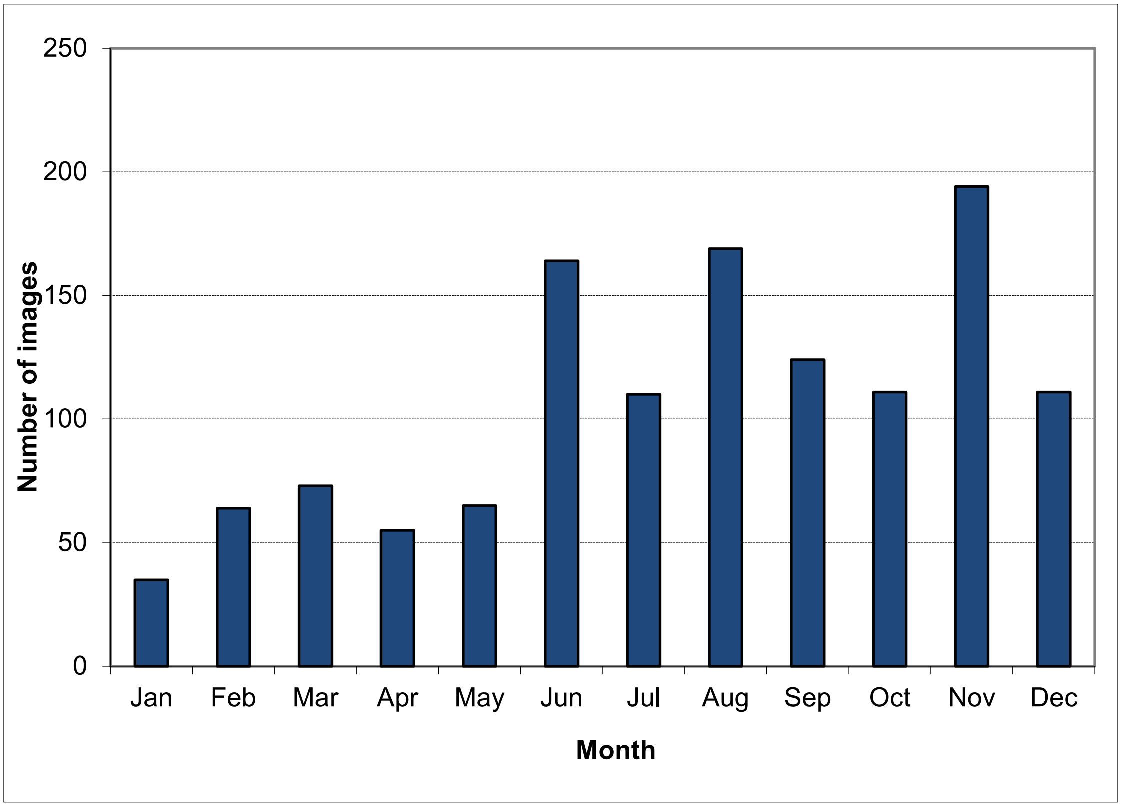

Figure 6-22. Number of mountain lion images by month for camera sites where mountain lions were detected from 2006 through 2022 (n = 1,275).

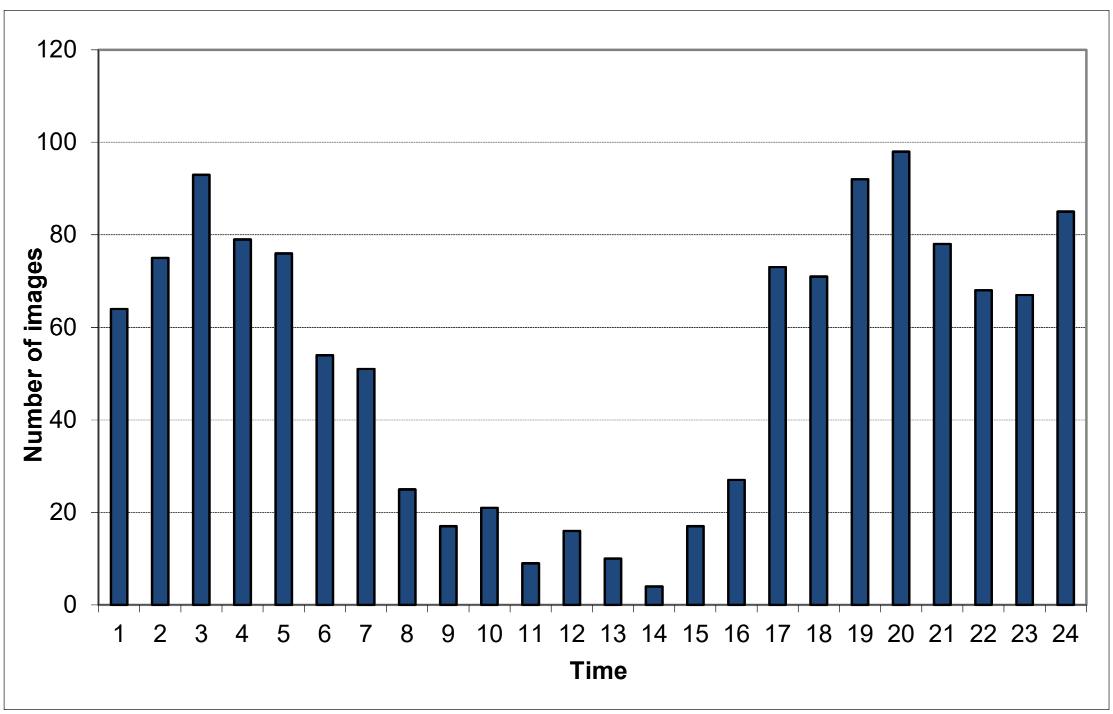

Figure 6-23. Number of mountain lion images by time of day (Pacific Standard Time) for camera sites where mountain lions were detected from 2006 through 2022 (n = 1,270).

The most photographed species (60% of all images) was feral burros (15,774 images at 6 of 25 sites). Mule deer were photographed at 10 of 25 sites with only 1,159 images taken compared to 2,938 images taken (18% of all images) at 13 of 25 sites in 2021. Captain Jack Spring (#12) and Camp 17 Pond (#6) were important water sources for mule deer during 2022. Some of the rarer, more elusive species documented from camera surveys were desert bighorn sheep (see Section 6.6.1), bobcat (found at 10 of 25 sites), gray fox (*Urocyon cinereoargenteus*) (found at 7 of 25 sites), golden eagle (found at 2 of 25 sites), badger (found at 2 of 25 sites), ring-tailed cat (found at 2 of 25 sites), peregrine falcon (found at 1 of 25 sites), and pinyon jay (found at 7 of 25 sites) (Table 6-3). Red-shafted common flickers were only found at 4 of 25 sites (21 images), a decrease from 2021 when 332 images were taken at 6 of 25 sites. Kit foxes were detected at Well C Trough (#24) (11 images) and Rock Valley Tank (#2) (10 images). Noteworthy observations of some of the more common species included 598 images of common ravens at 10 of 25 sites, and 183 images of coyotes at 12 of 25 sites. Number of mourning dove images increased from 69 images at 7 of 25 sites in 2021 to 1,349 images at 8 of 25 sites in 2022 with a majority of images (1,025) taken at Camp 17 Pond (#6). Greatest use and highest species richness were documented at water sources (both natural and constructed) which emphasizes the importance of various water sources for several wildlife species, particularly during the drier months.

6.8 Radiological Sampling

Sampling for radionuclides in game species (e.g., mule deer, pronghorn antelope, waterfowl, mourning doves) was performed to 1) determine uptake of radionuclides left over from previous nuclear testing on the NNSS, 2) estimate the potential dose to a human consuming a contaminated animal, and 3) estimate the dose to the animal. Sampling is to ensure dose limits, set to protect human and animal health, are not exceeded. These species are known to have large home ranges and may leave the NNSS and move into areas where hunting is allowed. This is a potential pathway for humans to receive a dose from radionuclides found on the NNSS and must be accounted for.

In 2022, 15 tissue samples were collected and analyzed from three mule deer (one doe, two bucks), six pronghorn (three does, three bucks), five mourning doves, and one common goldeneye (*Bucephala clangula*). Water was distilled from the tissue samples and submitted to a laboratory for tritium analysis. The remaining tissue samples were submitted for Strontium-90, Plutonium-238, Plutonium-239+240, Americium-241, and gamma spectroscopy analysis.

Results revealed elevated concentrations of tritium in the dove and pronghorn found near Area 5 RWMC and Strontium-90 in the same pronghorn. Plutonium-238 was found in one of the pronghorn found in Area 4. No man-made radionuclides were detected in any of the other animals sampled. Concentrations are low and do not present a hazard to the animal or a person eating them. For a more detailed analysis of specific radionuclides and dose assessments see MSTS (2022).

6.9 Nuisance and Potentially Dangerous Wildlife

During 2022, MSTS biologists documented 77 calls regarding nuisance, injured, dead, or potentially dangerous wildlife in or around buildings, power lines, and work areas on the NNSS. Problem, injured, or dead animals included birds (33 calls), bats (10 calls), other mammals (18 calls), reptiles (12 calls), and invertebrates (4 calls). Mitigation measures taken typically involved relocating the animals away from people, instructing workers to leave the animal in place, or disposing of dead animals. On three separate occasions, MSTS biologists trapped a badger at the Mercury landfill after it was found digging up the waste. It is likely that small mammal (preferred prey items of badgers) densities were so low after two years of drought that the badger(s) were desperate and resorted to digging in the landfill to find food. It is unknown if it was the same individual or different ones. A badger was trapped on May 11 and again on July 7 and relocated to the Cane Spring area. On August 18, a badger was trapped and moved to

Camp 17 Pond.

Safety presentations were also given and sent out via employee communications to educate NNSS workers about some of the potential hazards NNSS wildlife pose and how to safely work to protect themselves and the animals that call the NNSS their home.

6.10 Elk and Feral Burros

Historic studies on the NNSS do not mention the presence of Rocky Mountain elk (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 documented burros and elk 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. Since 2009, there have been a few transient bull elk seen and photographed around Rainier Mesa and Pahute Mesa. Young bull elk are known to disperse from their natal range, and it is likely that the source population for the bulls is to the north, possibly in the Groom or Kawich Range. During 2022, no elk were documented on the NNSS.

Feral burros appear to be increasing in number and expanding their range on the NNSS. Thousands of photos were taken at six camera trap locations in Frenchman Flat, Yucca Flat, Fortymile Canyon, and for the first time in East Cat Canyon (#19). Ten individuals were observed along the road during camera checks and 87 images were taken of burros by the camera trap. Burros have also been observed the last few years in Mercury Valley. A total of 8,323 images of burros was taken at Cottonwood Spring (#4) in 2022 compared to 3,208 in 2021, and 7,256 images of burros were taken at Twin Spring (#21) in 2022 compared to 2,964 in 2021 (Table 6-3). They are causing heavy damage to both springs which may require fencing to maintain the integrity of the springs.

6.11 Coordination with Biologists and Wildlife Agencies

MSTS biologists interfaced with other biologists and wildlife agencies in 2022 for the following activities:

- Contributed to the draft version of the Nevada Bat Conservation Plan.
- Participated on the Springsnail Conservation Team.
- Gave multiple “hands-on” wildlife presentations using taxidermied animal specimens to school children at the Nevada Atomic Testing Museum and local elementary schools.

7.0 HABITAT RESTORATION IMPLEMENTATION AND MONITORING

MSTS biologists conduct revegetation activities at disturbances on and off the NNSS in support of NNSA/NFO and DOE EM/NV activities and continue to evaluate those efforts. The objectives of revegetation include: 1) establish a perennial vegetation community on waste cover caps to prevent water from infiltrating into buried waste through evapotranspiration, 2) establish a perennial vegetation community in disturbed areas (e.g., burned areas) to outcompete invasive annual grasses, reduce the risk of wildland fires, restore ecosystem function, and create wildlife habitat, 3) support the intent of U.S. Executive Order 13112, "Invasive Species," to prevent the introduction and spread of non-native species and restore native species to disturbed sites, and 4) revegetation may qualify as mitigation for the loss of desert tortoise habitat under the current Opinion.

Activities conducted in 2022 included: 1) visually assessing the vegetation at the U-3ax/bl closure cover (Corrective Action Unit [CAU] 110) (Area 3 Radioactive Waste Management Site) and the "92-Acre Site" (CAU 111) (Area 5 RWMC), 2) revegetating and monitoring seeding success at CAU 577 Cells 19/20, 3) assessing revegetation success at CAU 577 East and West Cover Caps (Area 5 RWMC), 4) transplanting creosote bush and white bursage and evaluating revegetation success on Cell 18 (Area 5 RWMC), and 4) monitoring results from a research study to evaluate the effectiveness of different herbicide and seeding treatments to control cheatgrass after the Cherrywood Fire.

7.1 CAU 110, U-3ax/bl, Closure Cover

The installation of an evapotranspiration cover on CAU 110, U-3ax/bl closure site, located in Area 3 of the NNSS, was completed in the fall of 2000. Once the evapotranspiration cover was in place, action was taken to establish a cover of native vegetation. Revegetation activities were completed in December 2000. The plant community on the closure cover has been monitored annually since the spring of 2001 to document the vigor of the plant community that has established on the cover and to identify any remedial actions that may be necessary to ensure that it persists.

A qualitative vegetation assessment was conducted on July 20, 2022. Shadscale saltbush (*Atriplex confertifolia*) continues to be the most abundant shrub species on the closure cover (Figure 7-1). Most of the plants observed showed signs of stress due to the drought conditions and some dead shadscale saltbush plants were noted. Nevada jointfir, the second most common perennial species, was doing better than shadscale saltbush but also showed some signs of stress. Some Nevada jointfir plants set seed this year but it is not known if the seed was viable or not. No perennial plant seedlings were seen. No perennial grasses have been found on the closure cover for several years and none were found again this year. No annual plants from this year were documented, not even cheatgrass due to the poor growing conditions caused by the drought. Some residual dead cheatgrass from two years ago was found amongst the shadscale saltbush and Nevada jointfir plants. Old saltlover, Russian thistle (*Salsola tragus*) and flatcrown buckwheat (*Eriogonum deflexum*) plants were found in large numbers on the unseeded portion on the periphery of the cover cap (Figure 7-2), highlighting the importance of seeding to establish a perennial vegetation community. Only a few living saltlover and Russian thistle plants that had germinated this year were observed on the periphery.

7.1.1 Wildlife Use

During the vegetation surveys, small mammal activity on the CAU 110, U-3ax/bl closure cover was evaluated. Some burrow complexes were noted with most of these apparently inactive. The number of

Figure 7-1. Overview of shadscale saltbush and Nevada jointfir plant community that has established on CAU 110 from the original seeding in 2000.

(Photo taken by D.B. Hall July 20, 2022)

Figure 7-2. Unseeded area that is occupied by invasive weeds and flatcrown buckwheat (left). Revegetated cover cap is on the right.

(Photo taken by D.B. Hall July 20, 2022) burrows on the cover cap is substantially less than in the native undisturbed areas in Yucca Flat. Trapping for small mammal removal is not recommended at this time. No rabbits were observed or evidence of herbivory on the vegetation.

7.2 CAU 111, “92-Acre Site,” Closure Covers

CAU 111 consists of four closure cover caps: South Cover, North South Cover, North North Cover, and West Cover. A qualitative assessment of vegetation at the four cover caps was conducted on July 20, 2022. Precipitation received at the 92-Acre Site for the period December 2021 to April 2022 was about half the normal amount, resulting in poor growing conditions.

South Cover. Several perennial shrubs (47 fourwing saltbush [*Atriplex canescens*], 35 shadscale saltbush, one white bursage, and one desert pepperweed (*Lepidium fremontii*) were found widely scattered on the cover cap. The desert pepperweed had been browsed by pronghorn antelope. Some saltlover and a few Russian thistle plants that had germinated this year were found on the cover but most of the plant biomass was from remnant saltlover plants from previous years (Figure 7-3). A few active rodent burrows and four ant mounds were found on the cap. A zebra-tailed lizard (*Callisaurus draconoides*) was also observed on the cap and several piles of antelope scat.

North South Cover. This site was used for a revegetation trial over the last few years and has several plants remaining from the seeding and transplants, mostly fourwing saltbush. There are also some large fourwing saltbush and numerous shadscale saltbush plants alive from revegetation efforts completed several years ago. Shadscale saltbush seed is known to remain viable for several years after being seeded and will germinate when conditions are right. It is estimated that about 25% of this cover has sufficient perennial plant density and cover. It is recommended that the remaining 75% be revegetated. There are some old saltlover plants remaining from previous years across the whole cover and abundant old Arabian schismus plants in the recent revegetated areas that were irrigated. Some saltlover and a few Russian thistle plants that had germinated this year were found on the cover but most of the plant biomass was from remnant saltlover plants from previous years. There were a few active rodent burrows on the cap, an ant mound, and a few piles of antelope scat.

North North Cover. No perennial plants were observed but there were some saltlover and Russian thistle plants that had germinated this year. However, most of the plants were old saltlover plants from previous years. Several rodent burrows and four ant mounds were documented. Two zebra-tailed lizards and a couple of piles of antelope scat were also observed. This site is scheduled to be revegetated in February 2023, which will entail adding an additional 9-12 inches of topsoil on top of the existing cover, seeding, and hydromulching the site.

West Cover. This site had a lot of recent construction activity to fix subsidence issues, so a lot of the cover cap was void of vegetation. Active subsidence was noted near the northernmost monitoring station. The undisturbed areas were dominated by old saltlover plants from previous years. There were some saltlover and Russian thistle plants that had germinated this year, and a few rodent burrows and one ant mound were found. A flock of 10-15 horned larks and 10 piles of antelope scat were also observed.

Overall, the integrity of the cover caps was very good. Due to the drought conditions, germination of new weeds this year was limited. Vegetation was dominated by old saltlover plants remaining from previous years with some new germination of saltlover and prickly Russian thistle plants. No rabbits or rabbit sign were observed. Some rodent burrowing and ant activity were detected but do not appear to be impacting the integrity of the covers. A relatively new discovery of several piles of antelope scat and reported

Figure 7-3. South Cover on the "92-Acre Site" with an abundance of weeds, primarily old saltlover plants from previous years and some new plants from this year.

(Photo taken by D.B. Hall July 20, 2022)

antelope sightings in the compound reveal that antelope are utilizing many of the cover caps within Area 5 RWMC but currently do not pose any harm to the covers.

7.3 Reference Area

A reference area was established approximately 800 m east of the Area 5 RWMC (Figure 7-4). Plant data from this area will be used as a standard to compare revegetation success on all cover caps in Area 5 RWMC. Ten, 100-m long, permanent transects were established in this area. Seedling density was monitored during early June 2021 to evaluate seeding success. Ten transects (100-m long) were established uniformly across the area and sampled using 1-m x 1-m sampling quadrats placed at 5-m intervals along the transect for a total of 20 square meters sampled per transect. All plant species, seeded and unseeded, found inside the quadrat were counted and summed by species. Average number of plants per square meter by species were then calculated (Table 7-3, 7-4). In addition, plant cover was measured using an optical cover scope that projects a point straight downward on the ground and whatever that point intercepts (plant species, litter, bare ground, gravel [0.5-8 cm], cobble [8-25 cm], or rock [>25 cm]) gets recorded. Data from four points (45, 135, 225, and 315 degrees), every four meters, for a total of 100 points were recorded for each transect. These data were summarized, and average percent cover was calculated (Table 7-5).

Figure 7-4. Area 5 Radioactive Waste Management Complex reference area.

(Photo taken June 8, 2021, by D.B. Hall)

7.4 CAU 577 Cells 19/20 Revegetation and Monitoring

Revegetation of CAU 577 Cells 19/20 (4.8 ha) was accomplished during the spring of 2022, and included site preparation, seeding, hydromulching, and supplemental irrigation. The original intent was to include Cell 21 which would have added an additional 2.8 ha, but it was not ready so it will be revegetated in spring 2023.

7.4.1 Site Preparation

Site preparation entailed adding 23-30 cm of topsoil on top of the constructed cover cap to bury any existing weed seedbank and provide a good growing medium for seedlings. The soil was ripped perpendicular to the predominant slope to a depth of approximately 30-45 cm to alleviate soil compaction (Figure 7-5). A rabbit-proof fence was also erected around each cover cap to prevent herbivory, especially on young seedlings (Figure 7-6).

Figure 7-5. Ripping CAU 577 Cells 19/20 with road grader to alleviate soil compaction.
(Photo taken March 3, 2022, by D.B. Hall)

Figure 7-6. Rabbit-proof fence erected around CAU 577 Cells 19/20 to prevent herbivory.
(Photo taken April 19, 2022, by D.B. Hall)

7.4.2 Seeding and Hydromulching

The sites were seeded in early March, a month later than planned, with a native seedmix comprised of seven shrub, two grass, and three forb species at a rate of 30 pounds of pure live seed per acre (PLS/ac) (Table 7-1). Prior to seeding, all white bursage and creosote bush seeds were rinsed with water for about 24 hours to "prime" the seed and remove a chemical germination inhibitor to enhance germination (Ostler et al. 2002). The seed was broadcast seeded onto the ground using a drill seeder that had been calibrated to apply the specified rate of seed and a custom-built, chain harrow was dragged behind the seeder to cover the seed to an appropriate depth (Figure 7-7). Small (10 cm x 10 cm), cloth, mesh bags were filled with seed and buried just below the surface shortly after seeding. These were retrieved in the spring to assess germination status, seed viability, and provide an indication of what was happening to the seed sown with the seeder. Following seeding, a straw mulch plus soil binder product (HydroStraw Guar Plus Formulation) was applied over the site (Figure 7-8) at a rate of 2,240 kilograms/ha for soil moisture retention, organic matter additive, and erosion control. Seeding and hydromulching were done by SoilTech, a subcontractor to Canyon Electric who was the main revegetation subcontractor.

7.4.3 Irrigation

Wheel line irrigation systems as designed by Cascade Earth Sciences (subcontractor to Canyon Electric) were installed in March by JTS Farmstore, another subcontractor to Canyon Electric. The irrigation system had four large water tanks with an approximate capacity of 79,500 L each, a diesel-powered engine and pump, and two wheel lines of equal length (22 sprinklers per line and 12 stations on the main line). Water was delivered to the tanks utilizing watermaster trucks capable of hauling nearly 38,000 L per load (Figure 7-9). Water stored in the tanks was then pumped and uniformly distributed across the site through the wheel lines and sprinkler heads (Figure 7-10). The systems were designed to apply 6.4 mm of irrigation per hour. The irrigation objectives were two-fold; provide suitable moisture for seed germination and keep the soil profile as moist and deep as possible to promote root growth and development to establish the seedlings.

Table 7-1. Seedmix used to revegetate CAU 577 Cells 19/20 including species, number of pure live seeds per square meter and number of pounds of pure live seed per acre.

Lifeform	Common Name	Species (Variety)	Number of pure live seeds/m2	Pounds of pure live seed/acre
Shrub	White bursage	*Ambrosia dumosa*	74	3.5
Shrub	Fourwing saltbush	*Atriplex canescens*	34	2.5
Shrub	Shadscale saltbush	*Atriplex confertifolia*	77	4.8
Shrub	Cattle saltbush	*Atriplex polycarpa*	99	0.5
Shrub	Nevada jointfir	*Ephedra nevadensis*	32	6.5
Shrub	Winterfat	*Krascheninnikovia lanata*	42	1.5
Shrub	Creosote bush	*Larrea tridentata*	99	5.0
Grass	Indian ricegrass	*Achnatherum hymenoides (Paloma)*	80	2.0
Grass	Squirreltail	*Elymus elymoides (Toe Jam)*	57	1.2
Forb	Desert marigold	*Baileya multiradiata*	183	0.7
Forb	Palmer's penstemon	*Penstemon palmeri (Cedar)*	151	1.0
Forb	Desert globemallow	*Sphaeralcea ambigua*	99	0.8
		TOTAL	1026	30.0

Figure 7-7. Broadcast seeding CAU 577 Cells 19/20 with drill seeder and chain harrow.

(Photo taken March 3, 2022, by D.B. Hall)

Figure 7-8. Applying hydromulch on CAU 577 Cells 19/20.

(Photo taken March 8, 2022, by D.B. Hall)

Figure 7-9. Watermaster filling water tanks at CAU 577 East Cover Cap.
(Photo taken March 24, 2021, by D.B. Hall)

Figure 7-10. Irrigation system in operation at CAU 577 Cells 19/20.
(Photo taken March 17, 2022, by D.B. Hall)

Germination irrigation was applied in March and April and establishment irrigation was applied in early June and August (Table 7-2). To optimize germination success during germination irrigation, the top 5 cm of the soil was kept as moist as possible for as long as possible by moving the wheel lines every one to two hours. This way the soil surface where the seed was located stayed moist for multiple, consecutive days. Natural precipitation was negligible during spring 2022.The early June establishment irrigation applied water for 7.5 hours (47.8 mm) at each station with the intent to maximize soil moisture as deep as possible in the soil profile to aid in seedling survival and establishment. An added benefit may have been an increase in creosote bush germination. The August irrigation served two purposes: first to stimulate creosote bush germination during a period of warm summer rains and second to increase soil moisture for seedling growth and establishment. To study the effects of additional irrigation versus natural precipitation, only the eastern half was irrigated with 38.1 mm of irrigation in 12.7 mm increments while the western half received no irrigation. Results will be measured by recording and comparing plant density, primarily creosote bush density, in the two portions of the cover cap. Summer rains in August (24.4 mm) and September (16.3 mm) provided much needed moisture to establishing plants.

Table 7-2. Amounts of irrigation applied and natural precipitation (mm) received at CAU 577 Cells 19/20 in 2022. Numbers in parentheses in irrigation column represent increments of irrigation (e.g., a total of 44.5 mm was applied in 6.4-mm increments in April).

Month(s)	Irrigation (mm)	Natural Precipitation (mm)
March 2022	57.2 (12.7)	0.5
April 2022	44.5 (6.4)	2.8
June 2022	47.8	0
August 2022	38.1[a] (12.7)	24.4
Total	**187.6**	**27.7**

[a]Applied to eastern half only

7.4.4 Monitoring

In 2022, mesh seedbags were retrieved on April 6, May 4, June 20, and August 16, including three bags with fluffy seed and three bags with hard seed at each collection date. Number of germinated seeds (i.e., seed with radicle at least 1.0 mm long) were counted by species and averaged across the three replicates. Counts were made on the day of retrieval which indicated what species' germination requirements had been met. Un-germinated seeds were placed in petri dishes on top of moist blotter paper and left out at room temperature. Counts were made periodically for seven days to determine seed viability of remaining seeds. Results revealed minimal germination of winterfat and Nevada jointfir in spring and creosote bush in summer and good viability for all species except Indian ricegrass, shadscale saltbush, Palmer's penstemon, and desert globemallow. The germination requirements may not have been met for these species or viability may have been low.

Seedling density was monitored during early June 2022 to evaluate seeding success. Thirteen transects (100-m long) were established uniformly across the cover cap and sampled in a similar manner as the reference area. Results are found in Table 7-3. Percent mulch within each quadrat was also visually estimated and recorded.

Seedling density results revealed 6.17 seeded seedlings per m^2 compared to 0.94 perennial plants per m^2 in the reference area (May/June 2021). (Table 7-3). These results are impressive given the drought

Table 7-3. Average number of seedlings per square meter by lifeform and species for CAU 577 19/20 Cells (June 2022) and Reference Area, May/June 2021.

Lifeform	19/20 Cells	Reference Area
Perennial Shrubs		
White bursage	0.004	0.080
Fourwing saltbush	0.004	0.000
Shadscale saltbush	0.000	0.190
Cattle saltbush	0.004	0.000
Nevada jointfir	0.762	0.060
Winterfat	0.008	0.010
Creosote bush	0.008	0.040
Littleleaf ratany (not seeded)	0.000	0.430
Shockley's goldenhead (not seeded)	0.000	0.010
Water jacket (not seeded)	0.000	0.020
SUM	**0.790**	**0.840**
Perennial Grasses		
Indian ricegrass	0.935	0.100
Squirreltail	4.442	0.000
SUM	**5.377**	**0.100**
Perennial Forbs		
Desert marigold	0.000	0.000
Palmer's penstemon	0.000	0.000
Desert globemallow	0.000	0.000
SUM	**0.000**	**0.000**
TOTAL PERENNIALS	**6.167**	**0.940**
Annual Grasses		
Arabian schismus	1.631	0.000
Cheatgrass	0.004	0.010
Red brome	0.004	0.000
Unknown brome	0.004	0.000
Common wheat	0.008	0.000
SUM	**1.651**	**0.010**
Annual Forbs		
Saltlover	0.004	0.000
Russian thistle	0.004	0.000
Roundleaf oxytheca	0.000	0.160
Others	0.000	0.000
SUM	**0.008**	**0.160**

conditions, with less than half the normal winter/spring precipitation received which validates the use of irrigation. In many areas surrounding the Area 5 RWMC, bromes and other annuals did not even germinate. Nevada jointfir was the dominant shrub found with five other shrub species found in low densities. Shadscale saltbush was the only shrub not found. Both perennial grasses germinated well and made up the bulk of total seeded species found (squirreltail [*Elymus elymoides*] 4.44 seedlings/m^2 and Indian ricegrass [*Achnatherum hymenoides*] (0.94 seedlings/m^2). None of the three seeded perennial forbs were documented in the sampled area (Table 7-3). Anecdotal observations during the summer noted several creosote bush seedlings that had germinated presumably from the June irrigation. Sampling during 2023 should help determine if summer irrigation and/or summer rains increased creosote bush germination.

Arabian schismus was the dominant invasive annual (1.63 plants/m^2) documented with minimal saltlover, Russian thistle, and *Bromus* species found during sampling (Table 7-3). The Arabian schismus does not seem to have negatively impacted seeded plant densities. Perhaps because of its shallow root system, low biomass, and tendency to go dormant quickly it does not deplete soil moisture like saltlover and annual bromes do. During the summer, saltlover and Russian thistle started to establish in greater numbers. While irrigating in August, the entire cover cap was hand weeded to reduce these invasive weeds.

Overall, plant densities were lower than expected based on results from East and West Cover Caps but still well above those found in the reference area. Seeding occurred a month later than planned which may have impacted germination. Also, although irrigation was applied at similar times in March and April as was applied at East and West Cover Caps, perhaps soil temperature was different enough to impact germination. Although plant density was not measured in the fall, visual observations indicated high seedling survival over the hot, dry summer and excellent growth, especially for cattle and fourwing saltbush. Average percent mulch was 37% on the cover caps compared to 19% litter in the reference area.

7.4.5 Wildlife Use

Opportunistic wildlife observations were also recorded to assess wildlife use of the revegetated areas. Flocks of horned larks were observed on multiple occasions. Approximately 100 yellow-headed blackbirds (*Xanthocephalus xanthocephalus*) were observed on the cap in late April while irrigating. A few rabbit pellets were observed, and some plants had been browsed. A couple of ant hills were also observed on the cover cap.

7.5 CAU 577 East and West Cover Cap Monitoring

Revegetation of CAU 577 East (5.2 ha) and West (7.0 ha) Cover Caps was accomplished during the spring of 2021. Activities during 2022 focused on sampling seedling density and percent cover on these cover caps. Percent cover is not usually done until the third year when plants have had time to grow but because of the high plant densities and good growth, percent cover was measured one year after seeding. No additional irrigation was applied in 2022. Sampling occurred during the first part of June. Seedling density sampling followed the same protocol as in 2021 (Hall and Perry 2022), except for Arabian schismus density (see below), and the same transects were sampled. Percent cover was also measured on the same transects as seedling density following the same methods described above in Section 7.3 Reference Area. Only live plants or current year's annual plants were recorded for both density and cover. This was difficult to determine for the invasive annual grass, Arabian schismus, because plants had began senescence. Only plants that were purplish in color were counted on the West Cover Cap even though dark amber plants were likely current year plants. Thus, reported values are underestimates of actual values. Both purplish and dark amber plants were counted on the East Cover Cap. Densities were so high that only plants in the upper right quadrant (0.25m^2) were counted. Totals were then multiplied by four and are reported as plants/m^2.

Results from seedling density counts on the East Cover Cap (Table 7-4) showed a decline in overall seeded plant densities (19.12 to 7.28 plants/m^2) which is to be expected due to competition from the high number of plants that had germinated the first year. Even with the decrease, seeded plant density was still

Table 7-4. Average number of seedlings per square meter by lifeform and species for CAU 577 East and West Cover Caps (May/June 2021 and June 2022) and Reference Area (May/June 2021).

Perennial Shrubs	East Cover (2021)	East Cover (2022)	West-west Cover (2021)	West-west Cover (2022)	West-east Cover (2021)	West-east Cover (2022)	Reference Area (2021)
White bursage	0.32	0.16	0.08	0.06	0.33	0.16	0.08
Fourwing saltbush	0.71	0.62	0.43	0.35	0.72	0.51	0.00
Shadscale saltbush	0.02	0.01	0.01	0.02	0.03	0.01	0.19
Cattle saltbush	4.45	4.34	1.96	1.67	3.20	2.70	0.00
Nevada jointfir	2.00	1.36	2.06	1.47	2.24	1.68	0.06
Winterfat	0.14	0.06	0.06	0.03	0.10	0.03	0.01
Creosote bush	0.01	0.01	0.02	0.02	0.05	0.02	0.04
Littleleaf ratany (Not seeded)	0.00	0.00	0.00	0.00	0.00	0.00	0.43
Shockley's goldenhead (Not seeded)	0.00	0.00	0.00	0.00	0.00	0.00	0.01
Water jacket (Not seeded)	0.00	0.00	0.00	0.00	0.00	0.00	0.02
TOTAL	**7.65**	**6.56**	**4.60**	**3.61**	**6.65**	**5.10**	**0.84**
Perennial Grasses							
Indian ricegrass	4.32	0.13	11.17	1.36	10.99	2.39	0.10
Squirreltail	3.14	0.00	1.02	0.09	3.23	0.01	0.00
TOTAL	**7.46**	**0.13**	**12.19**	**1.45**	**14.21**	**2.40**	**0.10**
Perennial Forbs							
Desert marigold	4.01	0.59	1.07	0.30	3.64	0.53	0.00
Palmer's penstemon	0.00	0.00	0.00	0.00	0.06	0.00	0.00
Desert globemallow	0.00	0.00	0.01	0.01	0.03	0.02	0.00
Desert pepperweed	0.00	0.00	0.00	0.00	0.01	0.01	0.00
TOTAL	**4.01**	**0.59**	**1.08**	**0.31**	**3.73**	**0.55**	**0.00**
TOTAL SEEDED	**19.12**	**7.28**	**17.86**	**5.37**	**24.59**	**8.04**	**0.94**
Annual Grasses							
Arabian schismus	25.89	139.60	2.37	0.26	39.39	0.75	0.00
Cheatgrass	0.59	0.00	0.06	0.00	0.68	0.19	0.01
Red brome	0.11	0.00	0.04	0.00	0.23	0.11	0.00
Unknown brome	0.00	0.02	0.00	0.00	0.00	0.14	0.00
Sixweeks fescue	1.03	0.00	0.01	0.00	0.61	0.00	0.00
Common wheat	0.00	0.00	0.00	0.00	0.02	0.00	0.00
TOTAL	**27.62**	**139.62**	**2.47**	**0.26**	**40.92**	**1.18**	**0.01**
Annual Forbs							
Saltlover	0.20	0.55	0.69	10.61	0.61	2.46	0.00
Roundleaf oxytheca	0.00	0.00	0.00	0.00	0.00	0.00	0.16
Others	0.16	0.01	0.17	0.09	0.18	0.07	0.00
TOTAL	**0.36**	**0.56**	**0.86**	**10.70**	**0.79**	**2.53**	**0.16**

much higher than perennial plant density in the reference area (0.94 plants/m^2). The most significant declines were seen in perennial grasses (7.46 to 0.13 plants/m^2) and desert marigold (*Baileya multiradiata*) (4.01 to 0.59 plants/m^2) with little change in perennial shrubs (7.65 to 6.56 plants/m^2). There was also a large increase in the number of Arabian schismus plants (25.89 to 139.60 plants/m^2). Most of these plants were very small and it does not appear that the high density negatively impacted seeded plant density. It has a very shallow root system, low biomass, and tends to go dormant quickly so it does not deplete soil moisture like other invasives such as bromes and saltlover. In addition, roots of the seeded plants occurred deeper in the soil profile than roots of Arabian schismus and thus were not competing for the same soil moisture. Density of white bursage on the cover cap was still twice that found in the reference area (0.16 versus 0.08 plants/m^2).

The West Cover Cap was divided into the west-east and west-west portions due to different germination irrigation treatments during March 2021. The west-east and west-west received 50.8 mm and 31.8 mm of irrigation, respectively. Similar to results from East Cover Cap, results from the 2022 seedling density counts for the west-east portion (Table 7-4) showed a decline in overall seeded plant density (24.59 to 8.04 plants/m^2) which is to be expected due to competition from the high number of plants that had germinated the first year. Even with the decrease, seeded plant density was still much higher than perennial plant density in the reference area (0.94 plants/m^2). The most significant declines were seen in perennial grasses (14.21 to 2.40 plants/m^2), especially Indian ricegrass, and desert marigold (3.64 to 0.53 plants/m^2) with little change in perennial shrubs (6.65 to 5.10 plants/m^2). Interestingly, there was a large decrease in the number of Arabian schismus plants (39.39 to 0.75 plants/m^2) but as explained above this might be due to the difficulty in determining current year plants. Results from the 2022 seedling density counts for the west-west portion (Table 7-4) also showed a decline in overall seeded plant density (17.86 to 5.37 plants/m^2) which is to be expected due to competition from the high number of plants that had germinated the first year. Even with the decrease, seeded plant density was still higher than perennial plant density in the reference area (0.94 plants/m^2). The most significant declines were seen in perennial grasses (12.19 to 1.45 plants/m^2), especially Indian ricegrass, with little change in perennial shrubs (4.60 to 3.61 plants/m^2) and perennial forbs (1.08 to 0.31 plants/m^2). Saltlover density was high (10.61 plants/m^2) on the west-west portion.

Percent cover for the East Cover Cap (Table 7-5) for seeded species exceeds that for the reference area. However, if the non-seeded shrub species are included (all perennial species) then percent cover for the East Cover Cap is about 70% of what is found in the reference area (6.2% versus 8.9%). Cattle saltbush provides most of the perennial cover on the East Cover Cap while shadscale saltbush and littleleaf ratany provide most of the perennial cover in the reference area. Total vegetative cover, including both perennial and annual plant species, is about 2.5 times greater on the East Cover Cap than in the reference area. The invasive annual grass, Arabian schismus, accounts for the greatest portion of total vegetative cover. Rock and cobble make up a small percentage of overall cover on both the cap and the reference area. Percent cover of straw mulch on the cap is about the same as percent cover of litter in the reference area. Visual estimates of percent straw cover made during seedling density counts were slightly higher than percent cover measured with the cover scope (24% versus 19%).

Percent cover of seeded species for the west-east and west-west portions of the West Cover Cap was higher than percent cover of seeded species in the reference area and similar to each other (Table 7-5). However, when all perennial species are included then percent cover for the west-east and west-west portions is about 65% and 64% of what is found in the reference area, respectively. Cattle saltbush provides most of the perennial cover on the West Cover Cap while shadscale saltbush and littleleaf ratany provide most of the perennial cover in the reference area. Indian ricegrass has higher percent cover in the west-east portion while Nevada jointfir has higher percent cover in the west-west portion. Total vegetative cover, including both perennial and annual plant species, is about twice as high on the west-east than on the west-west portion and is also higher than in the reference area, largely due to the invasive annual grass, Arabian schismus. Total vegetative cover is somewhat lower in the west-west portion of the cap compared to the reference area (6.5% versus 8.9%). Rock and cobble make up a small percentage of overall cover on both the West Cover Cap and the reference area. Percent cover of straw mulch on the cap is higher than percent cover of litter in the reference area. Visual estimates of percent straw cover made during seedling density counts were on average about 20% higher than percent cover measured with the cover scope.

Table 7-5. Percent cover by species and category for CAU 577 East and West Cover Caps (June 2022) and Reference Area (May/June 2021).

Species/Category	East Cover (% Cover)	West-east Cover (% Cover)	West-west Cover (% Cover)	Reference Area (2021)
White bursage	0.00	0.00	0.10	0.40
Fourwing saltbush	0.53	0.80	0.80	0.00
Cattle saltbush	5.53	2.60	3.50	0.00
Shadscale saltbush	0.00	0.10	0.00	2.40
Nevada jointfir	0.07	0.20	0.50	1.10
Winterfat	0.00	0.00	0.00	0.10
Creosote bush	0.00	0.00	0.00	1.10
Indian ricegrass	0.00	2.00	0.80	0.10
Desert marigold	0.07	0.10	0.00	0.00
Total Seeded	**6.20**	**5.80**	**5.70**	**5.20**
Littleleaf ratany (Shrub)	0.00	0.00	0.00	3.30
Water jacket (Shrub)	0.00	0.00	0.00	0.30
Spiny hopsage (Shrub)	0.00	0.00	0.00	0.10
Arabian schismus (Annual grass)	16.47	8.70	0.20	0.00
Red brome (Annual grass)	0.00	0.10	0.00	0.00
Saltlover (Annual forb)	0.13	0.10	0.60	0.00
Total Perennial	**6.20**	**5.80**	**5.70**	**8.90**
Total Non-seeded	**16.60**	**8.90**	**0.80**	**3.70**
Total Vegetative	**22.80**	**14.70**	**6.50**	**8.90**
Rock (>25 cm)	0.00	0.00	0.20	0.00
Cobble (8-25 cm)	0.33	0.60	0.20	0.20
Gravel (0.5-8 cm)	31.53	27.90	45.50	38.50
Bare ground	16.47	16.50	14.40	33.80
Straw mulch	19.00	30.60	24.80	0.00
Litter	4.33	9.70	8.40	18.60
Total Abiotic	**71.67**	**85.30**	**93.50**	**91.10**

7.5.1 Wildlife Use

Pronghorn antelope have been observed foraging on both the East Cover Cap and West Cover Cap and their scat was recorded in some of the seedling density count quadrats. On the East Cover Cap, nearly all white bursage plants observed showed signs of herbivory, presumably from antelope browsing. No rabbit pellets were documented which suggests the protective fencing is working to keep them out.

7.6 Area 5 RWMC, Cell 18 Revegetation and Monitoring

Revegetation of Cell 18 Cover Cap was done in fall 2020. Activities in 2022 included transplanting white bursage and creosote bush plants in April, plant sampling to assess seeding success and transplant survival, and additional irrigation for germination and establishment of seedlings and transplants.

7.6.1 Transplants

During the first few weeks in April 2021, approximately 3,850 plants were transplanted including 2,389 white bursage and 1,461 creosote bush plants. Due to relatively low survival (<20%), an additional 4,500 plants (1,200 creosote bush, 3,300 white bursage) were planted during the first week of April 2022. Plants were grown by the Nevada Division of Forestry nursery from seed MSTS biologists collected from Frenchman Flat (Area 5) in 2018 and 2019. Planting consisted of digging a hole about 25 cm deep, planting the plant, firmly packing the soil around it, and adding 3.8 L of irrigation to hydrate the plant and settle the soil around the plant to remove any air pockets. The area was divided into six separate parcels with various treatments. These included North Acre Cap, South Acre Cap, East Cap, North Edge, South Edge, and Southeast Triangle. North Acre Cap is a one-acre parcel on the north side of the cap that was fully irrigated. South Acre Cap is a one-acre parcel on the south side of the cap that was fully irrigated. These two areas were originally seeded with slightly different seed mixes to compare germination and establishment of locally collected white bursage and creosote bush seed (North Acre) with commercially purchased seed (South Acre). Otherwise, these two areas were alike. East Cap is a 0.8-acre parcel on the east edge of the cap and was fully irrigated. North Edge is on the side slope of the cap on the north side that was partially irrigated on the southern-third portion of the slope. South Edge is on the side slope of the cap on the southern side that was partially irrigated using a water truck spraying the side slope opportunistically. Southeast Triangle is in the southeastern corner of the site, mostly off the cap, that was partially irrigated. North Acre Cap, South Acre Cap, and East Cap are all considered to be on the cover cap while North Edge, South Edge, and Southeast Triangle are off the cap. Several hundred plants were marked with stake chasers to evaluate survival during both years. Transplants in 2022 were only planted on the cap.

Transplant survival was assessed in early June 2022. Plants were counted as either dead or alive, a vigor rating (0 – Dead, 1 – Barely alive, 2 – Moderate, 3- Thriving, and 4 – Excellent) was assigned, and any flowering or fruiting was noted. Percent survival by species and an average vigor rating were calculated and number of flowering or fruiting plants were tallied (Table 7-6). Due to being drought-deciduous, it was difficult to determine if white bursage was dead or just dormant, whereas creosote bush is evergreen which made it easier to distinguish dead from living plants.

Results from transplant success monitoring by year, area, and species are found in Table 7-6. For plants planted in 2021 on the cap, survival was determined by comparing live plants that survived from April to June 2022. Many (not quantified) new plants in 2022 were planted in the same hole as dead plants from 2021, so survival for 2021 plants is not a true measure of how many plants survived from the original April 2021 planting, except for the areas off the cap where no plants were planted in 2022. For plants planted in 2021, survival for creosote bush and white bursage off the cap was 17.3% and 11.9%, respectively. Spring 2022 survival (April to June) for creosote bush and white bursage on the cap was 75.6% and 63.8%, respectively. Average vigor was also higher for plants on the cap (1.8 and 1.9) versus off the cap (1.0 and 1.2). The lower survival and vigor of transplants off the cap is attributed to the reduced irrigation applied to these areas.

For plants planted in 2022, average percent survival was 69.4% and 82.9% for creosote bush and white bursage, respectively, and overall survival was 79.3% for both species. Average vigor rating was 1.4 and 1.5 for creosote bush and white bursage, respectively. No plants were observed flowering or fruiting. Survival will be assessed again during spring 2023.

Table 7-6. Results from transplant success monitoring including total number of plants evaluated, number of live plants, percent survival, and average vigor information by area and species for Cell 18, June 2022. Blue shaded columns represent data from transplants planted in 2021 and green shaded columns represent data from transplants planted in 2022. NA = Not applicable because transplants were only planted on the cap area in 2022.

Area/Species	Total #Plants (2021)	#Live Plants (2021)	% Survival (2021)	Average Vigor (2021)	Total #Plants (2022)	#Live Plants (2022)	% Survival (2022)	Average Vigor (2022)
North Acre (Creosote bush)	19	12	63.2	2	28	6	21.4	1.7
North Acre (White bursage)	25	8	32	2.5	234	54	23.1	1.8
South Acre (Creosote bush)	7	3	42.9	2	47	10	21.3	2
South Acre (White bursage)	12	3	25	1.7	179	11	6.1	1.7
East Cap (Creosote bush)	15	12	80	2.4	28	6	21.4	2
East Cap (White bursage)	18	9	50	1.8	231	39	16.9	1.8
North Edge (Creosote bush)	33	7	21.2	1.9	NA	NA	NA	NA
North Edge (White bursage)	23	0	0	0	NA	NA	NA	NA
South Edge (Creosote bush)	6	0	0	0	NA	NA	NA	NA
South Edge (White bursage)	26	4	15.4	1	NA	NA	NA	NA
Southeast Triangle (Creosote bush)	56	5	8.9	2.4	NA	NA	NA	NA
Southeast Triangle (White bursage)	27	4	14.8	1.8	NA	NA	NA	NA
TOTAL								
Creosote bush	136	39	28.7	1.8	103	22	21.4	1.9
White bursage	131	28	21.4	1.5	644	104	16.1	1.8
Cap	96	47	49.0	2.1	747	126	16.9	1.8
Off Cap	171	20	11.7	1.2	NA	NA	NA	NA
Creosote bush (Cap)	41	27	65.9	2.1	NA	NA	NA	NA
Creosote bush (Off Cap)	95	12	12.6	1.4	NA	NA	NA	NA
White bursage (Cap)	55	20	36.4	2.0	NA	NA	NA	NA
White bursage (Off Cap)	76	8	10.5	0.9	NA	NA	NA	NA

7.6.2 Seeding Success

Seeding success was evaluated in March 2022 by measuring plant density and plant cover. Multiple 40-m long permanent transects were established in each of the six aforementioned areas. A 1-m x 1-m quadrat was then placed at seven locations, every five meters, on alternating sides of each transect and the number of plants, including from seed and transplants planted in 2021, by species were counted. An average number of plants per square meter by species was then calculated for each area and summed for the areas on the cover cap and areas off the cover cap (Table 7-7). Percent cover was also measured with the optical cover scope as described in Section 7.3 Reference Area. Data from four points (45, 135, 225, and 315 degrees), every four meters, for a total of 40 points were recorded for each transect. Average percent cover by species and category are reported in Table 7-8.

Perennial plant density, including from seed and transplants planted in 2021, on the cap dropped significantly, especially Indian ricegrass and Palmer's penstemon. Even with the declines, perennial plant density on the cap was 93% of perennial plant density recorded in the reference area (0.87 versus 0.94 plants/m^2). Reasons for the decline are likely due to competition from saltlover, found in high density, and natural attrition of perennial seedlings. It appears that Palmer's penstemon germinates readily from a fall seeding but does not persist. The only place it has survived is where the sprinklers drain, so it may require more water than is practical to apply from irrigation. Indian ricegrass also declined but persisted in comparable densities to the reference area. Overall plant density should be higher on the cap with the addition of 4,500 transplants planted in April 2022. Perennial plant densities were higher on the cap than off the cap for both years (Table 7-7) which is attributed to the much lower amounts of irrigation applied off the cap. Only portions of the areas off the cap received irrigation.

No perennials were recorded during plant cover sampling on the cap or off the cap. This compares to 8.9% perennial plant cover on the reference area. Hopefully, perennial plant cover will increase as seedlings and transplants grow and become established on the cover cap. Percent cover of bare ground, gravel, and cobble was much greater on the reference area (72.5%) compared to on the cap (44.5%) and off the cap (46.1%). Conversely, percent cover of straw mulch, litter, and dead saltlover combined was much higher on the cap (54.9%) and off the cap (53.9%) than on the reference area (18.6%).

Typically, dead saltlover would be considered litter. Due to its competitive nature and prevalence, especially on the cap (Figure 7-11), it was recorded as a separate category. Most of the dead saltlover plants were left over from fall 2020 and 2021 when 289 mm of irrigation was applied. The added water helped the seedlings and transplants as the data show higher seedling density and higher transplant survival on the cover cap than off the cover cap (Table 7-6, 7-7) which only received partial irrigation. However, the added water also greatly benefited saltlover (22.9% cover) which may have been responsible, at least in part, for decreased seedling success and low transplant survival on the cap from 2021 to 2022. Irrigation applied in 2022 was designed to help increase transplant survival. A total of 48 mm was applied in late March to increase soil moisture just prior to planting. An additional 48 mm was applied in late April soon after planting.

Table 7-7. Average number of seedlings per square meter by lifeform and species on and off the cover cap for Cell 18 (May 2021 and March 2022) and Reference Area (May/June 2021). S = seeded, T = transplant, Total = seeded and transplanted combined.

Perennial Shrubs	ON CAP Total (May 2021)	ON CAP Total (March 2022)	OFF CAP TOTAL (May 2021)	OFF CAP TOTAL (March 2022)	Reference Area
White bursage	0.05 S, 0.16 T, 0.21 Total	0.00 S; 0.03 T; 0.03 Total	0.15 T	0.00	0.08
Fourwing saltbush	0.33	0.06	0.02	0.00	0.00
Shadscale saltbush	0.11	0.02	0.02	0.00	0.19
Cattle saltbush	0.13	0.08	0.23	0.01	0.00
Nevada jointfir	2.05	0.57	0.76	0.18	0.06
Winterfat	0.10	0.00	0.20	0.00	0.01
Creosote bush	.01 S, 0.10 T, 0.11 Total	0.02 T	0.12 T	.06 T	0.04
Littleleaf ratany (Not seeded)	0.00	0.00	0.00	0.00	0.43
Shockley's goldenhead (Not seeded)	0.00	0.00	0.00	0.00	0.01
Water jacket (Not seeded)	0.00	0.00	0.00	0.00	0.02
TOTAL	**2.78 S; 0.26 T; 3.04 Total**	**0.74 S; 0.05 T; 0.79 Total**	**1.23 S; 0.27 T; 1.50 Total**	**0.19 S; .07 T; 0.27 Total**	**0.84**
Perennial Grasses					
Indian ricegrass	7.51	0.08	0.73	0.00	0.10
Squirreltail	2.25	0.00	0.00	0.00	0.00
TOTAL	**9.76**	**0.08**	**0.73**	**0.00**	**0.10**
Perennial Forbs					
Desert marigold	0.21	0.00	0.00	0.00	0.00
Palmer penstemon	6.60	0.00	0.00	0.00	0.00
Desert globemallow	0.05	0.00	0.00	0.00	0.00
Freckled milkvetch (Not seeded)	0.01	0.00	0.00	0.00	0.00
TOTAL	**6.87**	**0.00**	**0.00**	**0.00**	**0.00**
TOTAL SEEDED	**19.40**	**0.82**	**1.96**	**0.19**	**0.38**
TOTAL PERENNIALS	**19.67**	**0.87**	**2.23**	**0.27**	**0.94**
Annual Grasses					
Arabian schismus	1.23	3.31	0.26	0.00	0.00
Cheatgrass	0.02	0.00	0.00	0.00	0.01
Red brome	0.01	0.00	0.00	0.00	0.00
TOTAL	**1.26**	**3.31**	**0.26**	**0.00**	**0.01**
Annual Forbs					
Saltlover (alive)	19.10	23.03	36.28	0.95	0.00
Saltlover (dead)	0.00	16.02	0.00	22.30	0.00
Prickly Russian thistle	0.20	0.09	0.71	0.26	0.00
Other species	0.70	0.13	0.12	0.00	0.16
TOTAL	**20.00**	**39.27**	**37.11**	**23.52**	**0.16**

Table 7-8. Average percent cover by species/category in areas on the cap and off the cap at Cell 18 (March 2022) and the reference area (May/June 2021).

Species/Category	ON CAP	OFF CAP	Reference Area
Total Perennials	0.0	0.0	8.9
Dead saltlover	22.9	5.1	0.0
Prickly Russian thistle	0.3	0.0	0.0
Arabian schismus	0.3	0.0	0.0
Litter	16.6	8.9	18.6
Straw mulch	15.4	39.9	0.0
Bare ground	17.7	14.5	33.8
Gravel	26.6	31.6	38.5
Cobble	0.2	0.0	0.2

Figure 7-11. Cell 18 Cover Cap showing the abundant dead saltlover plants during spring 2022 sampling.

(Photo taken March 21, 2022, by D.B. Hall)

7.7 Cheatgrass Control Research Trial

The Cherrywood Fire burned more than 20,000 acres in the western portion of the NNSS in May 2021. This was the third wildland fire in this area since 2011. One of the major contributing factors to this increased fire frequency is the abundance of cheatgrass, an invasive annual grass. Cheatgrass is problematic for many reasons. It can germinate and grow at colder soil temperatures than many native species; as such, by the time the native species germinate and start growing, the cheatgrass has used up most of the available soil moisture which results in native seedlings struggling to survive. Cheatgrass also has a high germination rate even with little precipitation, grows quickly, and is able to produce a lot of biomass in a short amount of time. Because it is an annual, it dries out early in the season when the soil moisture dries out, resulting in an abundant, highly flammable fine fuel that is easily ignited and carries fire readily. It thrives in areas of disturbance, especially previously burned areas. The cheatgrass biomass is problematic not just for the year in which it germinates but also because the residual biomass can persist for multiple years. The best way to control cheatgrass in the long term is to establish a perennial vegetative community that will outcompete cheatgrass. For short-term control, herbicides such as imazapic (e.g., Panoramic) (1-year control) or indaziflam (e.g., Rejuvra) (2-3 year control) work best. The optimal strategy is to use a combination of herbicide treatments followed by seeding.

We conducted a research trial to evaluate the effectiveness of different herbicide and seeding treatments to control cheatgrass and establish a perennial vegetative community within the Cherrywood Fire burned area. It is anticipated that results will be used to guide future fire rehabilitation efforts and/or proactively protect important areas from burning. The study location is near the East Cat Canyon Road/North Timber Peak spur road (southeast corner post 555553mE, 4101365mN, UTM, NAD83).

Five treatments were implemented and a control, with three replicates of each in a completely randomized design for a total of 18 plots (Figure 7-12). Treatments included: 1) Rejuvra (liquid Indaziflam) applied by hand at 5.0 ounces (oz)/ac plus 8 oz/ac Efficax (surfactant) plus 25 gallons water/acre, 2) Panoramic (liquid imazapic) applied by hand at 8 oz/ac plus 8 oz/ac Efficax (surfactant) plus 10 gallons water/acre, 3) Open Range G (granular imazapic) applied with hand spreader at 10 lbs/ac, 4) seeding a wildland seed mix by hand at a rate of 20 pounds PLS/ac (Table 7-9) and covering the seed with hand rakes, and 5) seeding the same wildland seed mix as previous by hand at a rate of 20 PLS pounds/ac and not covering the seed. Control plots had no treatment. An additional fire-resistant vegetation treatment (i.e., greenstrip) was implemented in a different but nearby area and entailed seeding a mix of Immigrant forage kochia (*Kochia prostrata*) at a rate of 0.5 PLS pounds/ac and Siberian wheatgrass (*Agropyron fragile*) at a rate of 10 PLS pounds/ac. Plot size was 20 m by 20 m (400 m^2 or ~0.1 ac). Plots were staked on November 10, 2021, seeded on November 15, 2021, and herbicide was applied on November 16, 2021.

A follow-up seeding treatment was applied to the herbicide treated and control plots on October 31, 2022, to evaluate if there were residual herbicide effects on seedling germination. The first eight meters of each herbicide-treated and control plot were hand seeded with the same seedmix used before (Table 7-9) at a rate of 14.3 PLS lbs per acre. Seed was then covered using hand rakes.

Plots were monitored in late May for plant density (Table 7-10) and percent cover (Table 7-11) using the same techniques described above. Five, 20-m long, permanent transects were established. Plant density by species was recorded in five, 1-m^2 quadrats on each transect. Due to the high densities of cheatgrass, individual cheatgrass plants were counted only in the upper right quadrant of the 1-m^2 quadrat, thus cheatgrass density is expressed as number of cheatgrass plants per 0.25m^2. Percent cover by species and category was recorded at nine locations every two meters starting at the 2-m mark, with four points at each location for a total of 36 points per transect. Photographs of each plot were taken during sampling, and on June 16, 2022, a drone was used to take aerial photographs of the plot area (Figure 7-13).

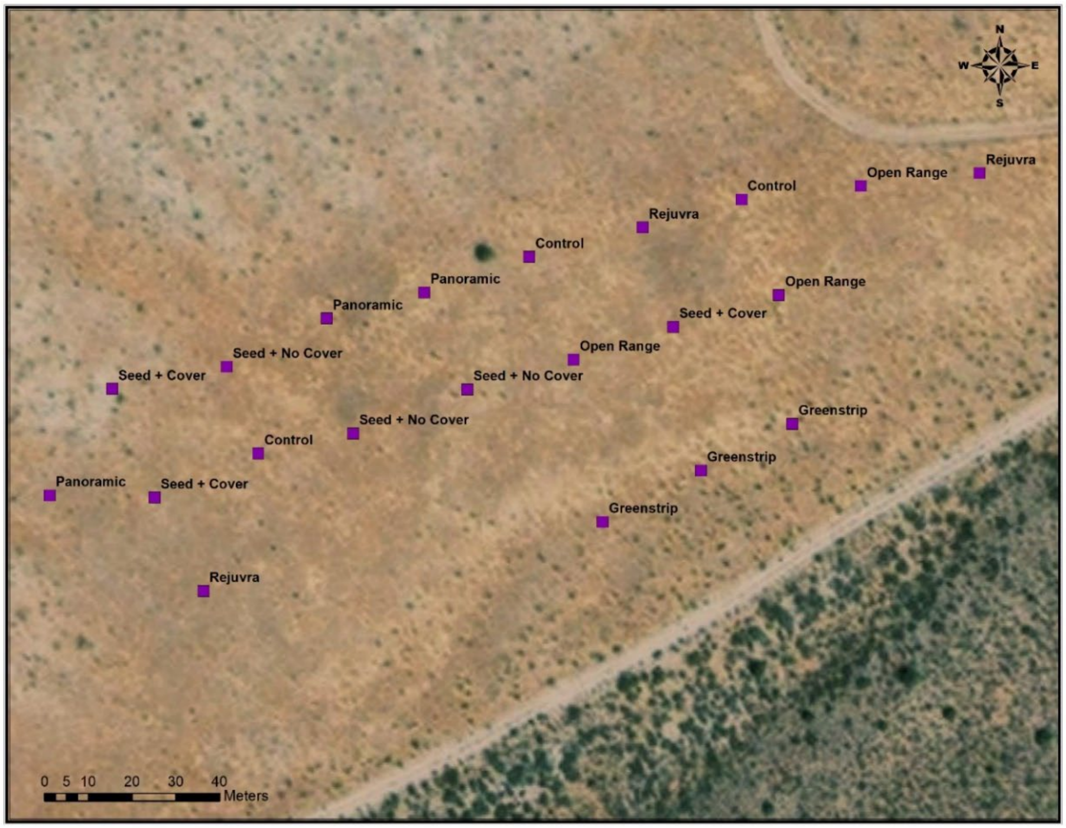

Figure 7-12. Final plot layout for cheatgrass control research trial.

Table 7-9. Seed mix used in cheatgrass control research trial.

Lifeform	Species	PLS lbs/acre	PLS seeds/m2
Shrub	*Artemisia nova*	0.2	45
Shrub	*Artemisia tridentata tridentata*	0.1	62
Shrub	*Atriplex canescens*	2.0	27
Shrub	*Chrysothamnus viscidiflorus*	0.2	39
Shrub	*Ephedra nevadensis*	4.6	23
Shrub	Ephedra viridis	3.6	22
Shrub	*Ericameria nauseosa leiosperma*	0.2	34
Shrub	*Purshia glandulosa*	4.5	23
Grass	*Achnatherum hymenoides Paloma*	1.1	44
Grass	*Achnatherum speciosa*	1.0	43
Grass	*Elymus elymoides Toe Jam*	1.0	47
Grass	*Poa secunda sandbergii*	0.3	78
Forb	*Linum perenne*	0.5	36
Forb	*Penstemon palmeri Cedar*	0.3	45
Forb	*Sphaeralcea ambigua*	0.4	49
	TOTAL	20.0	617

Table 7-10. Plant density (cheatgrass plants/0.25m^2, all other plants/m^2) by species and lifeform by treatment, May 2022.

Species/Lifeform	Panoramic	Open Range	Rejuvra	Seed+Cover	Seed	Greenstrip	Control
Perennial shrubs	0.03	0.00	0.08	0.05	0.01	0.19	0.05
James' galleta	0.91	1.28	0.63	1.08	0.05	0.00	0.88
Desert globemallow	0.07	0.04	0.23	0.03	0.01	0.11	0.04
Whitemargin sandmat	7.24	3.40	8.21	0.33	0.33	1.37	0.69
Perennial forbs	7.32	3.47	8.59	0.36	0.35	1.79	0.83
Cheatgrass	5.71	9.28	19.63	105.55	155.79	96.59	129.60
Bristly fiddleneck	3.93	0.44	0.69	41.48	47.80	2.03	39.91
Annual forbs	3.93	1.01	1.29	43.84	48.03	6.35	42.47

Table 7-11. Percent plant cover by species and lifeform by treatment, May 2022.

Species/Lifeform	Panoramic	Open Range	Rejuvra	Seed+Cover	Seed	Greenstrip	Control
Perennial Shrubs	0.6	1.1	0.9	0.4	0.4	3.2	1.3
James' galleta	1.0	1.1	0.0	0.4	0.2	0.0	0.2
Whitemargin sandmat	2.1	0.2	1.8	0.2	0.2	0.0	0.2
Perennial forbs	2.1	0.2	1.8	0.2	0.2	0.2	0.2
Cheatgrass	0.6	1.3	12.2	29.3	23.4	38.3	24.8
Bristly fiddleneck	0.9	0.4	0.8	5.2	5.0	0.6	3.9
Annual forbs	3.0	0.6	3.3	5.4	5.2	1.0	4.3
Litter	47.6	56.5	38.2	30.6	36.3	24.1	39.1
Total Abiotic	95.0	95.9	83.6	64.7	70.9	57.4	69.4

Figure 7-13. Aerial view of cheatgrass control research trial study plots taken with a drone. (Note the bare areas showing the lack of cheatgrass in the herbicide treated plots and the cheatgrass in the control plots.)

(Photo taken by M. Madlener, June 16, 2022)

Data were analyzed by Dr. Charles Davis who used a nested analysis-of-variance, with treatment as a fixed factor and plot as a random factor nested under treatment. Results yielded significant differences (p-value <0.001) among treatments with cheatgrass densities in Open Range, Panoramic, and Rejuvra plots significantly less than the control (Figure 7-14). A similar pattern was seen with percent cheatgrass cover, although cheatgrass cover in the Rejuvra plots was higher than in the Open Range and Panoramic plots but lower than in the control plots (Figure 7-15). We are not sure if this is due to an application error or lack of efficacy of the herbicide. The herbicide applicator calibrated the backpack sprayer on a test plot, but no tracer dye was used to verify uniform coverage. Analysis of other species has not been completed yet but of significance is the positive response of some of the native annual and perennial plants. For instance, James' galleta (*Pleuraphis jamesii*) plants in the herbicide treated plots were lush, green, and many were flowering whereas they were dry and non-reproductive in the control plots. The competitive release from not having to compete for limited soil moisture with cheatgrass apparently benefited this native perennial grass and some other species as well (e.g., bristly fiddleneck).

No seeded seedlings were documented. Because of the lack of germination it was not possible to test the difference between covering the seed or leaving it on the surface uncovered. The lack of germination demonstrates the difficulty and unpredictability of establishing vegetation from seed in this arid environment. Not even the forage kochia and Siberian wheatgrass, both adapted for arid environments, germinated. Both imazapic and indaziflam need some moisture to activate the chemical that prevents cheatgrass germination, so it was promising to see that even in a dry year (about half normal precipitation) there was enough moisture to activate the chemicals.

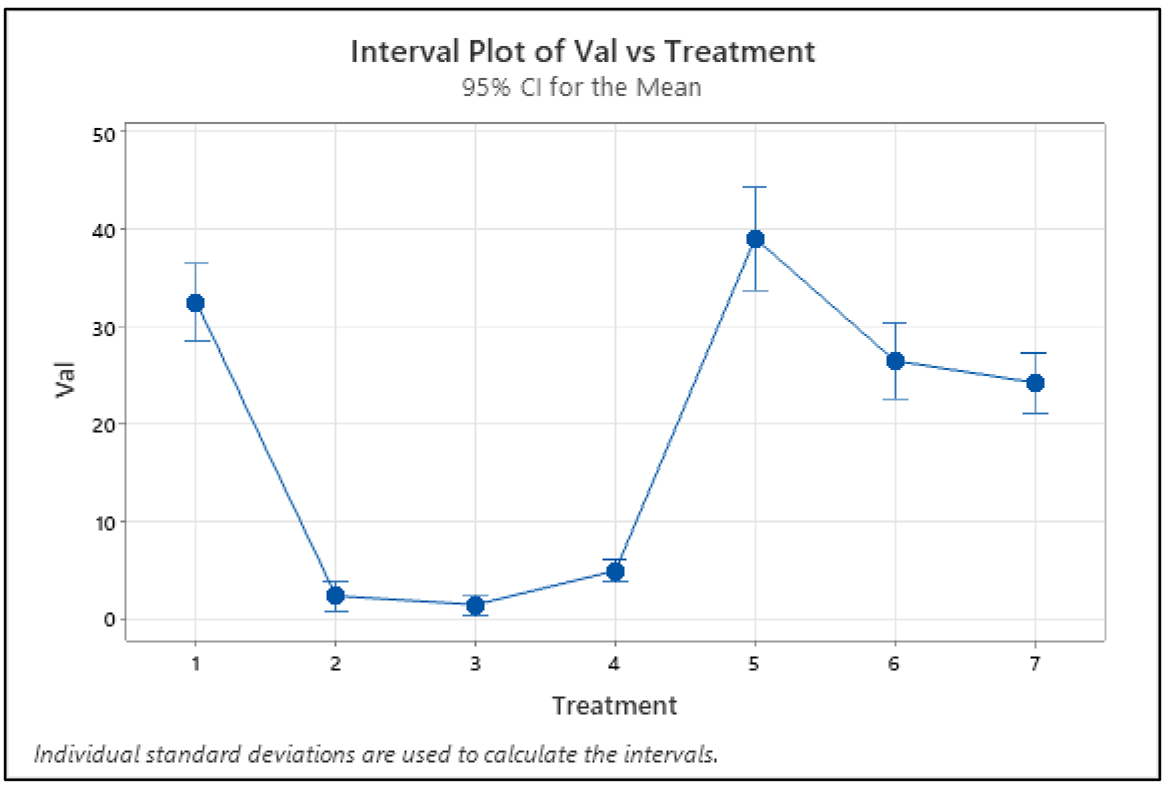

Figure 7-14. Graph showing mean cheatgrass density (plants/0.25m^2) (Val on y-axis) by treatment (x-axis); 1 = Control, 2 = Open Range, 3 = Panoramic, 4 = Rejuvra, 5 = Seed, no cover, 6 = Seed, plus cover, and 7 = Greenstrip. Error bars represent 95% confidence intervals for each treatment mean.

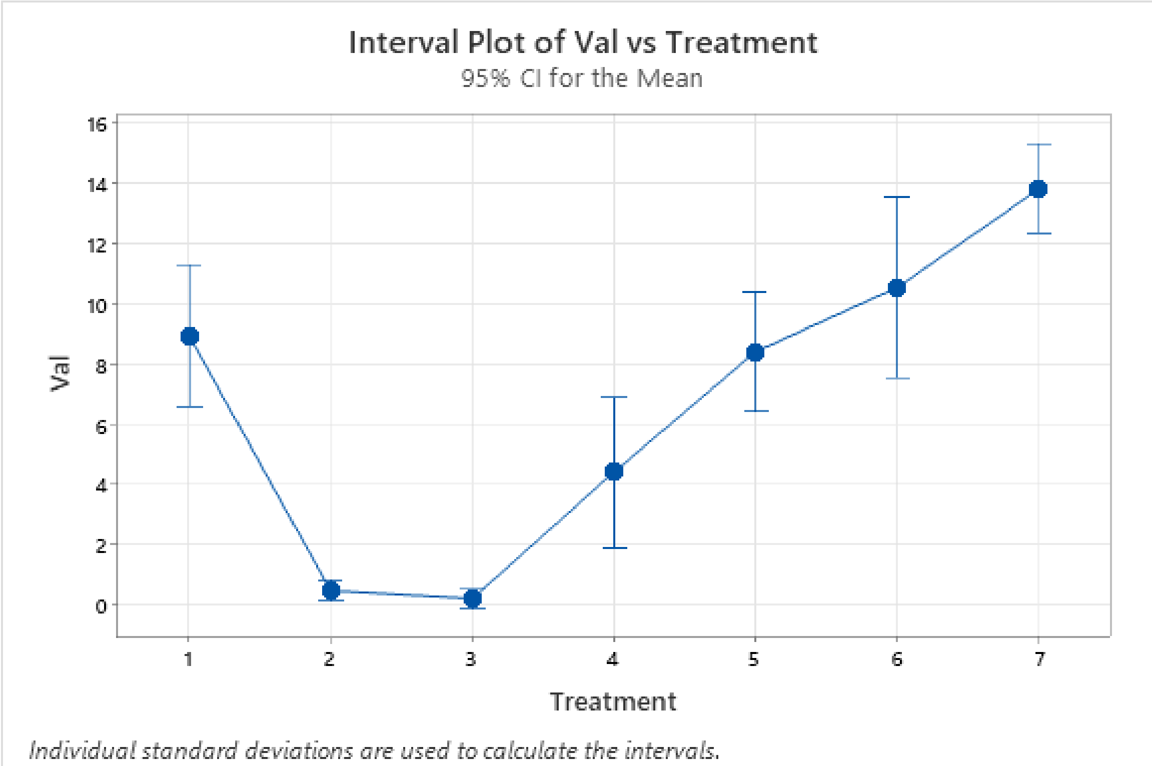

Figure 7-15. Graph showing percent cheatgrass cover (Val on y-axis) by treatment (x-axis); 1 = Control, 2 = Open Range, 3 = Panoramic, 4 = Rejuvra, 5 = Seed not covered, 6 = Seed covered, and 7 = Greenstrip. Error bars represent 95% confidence intervals for each treatment mean.

Overall results indicate that any of the herbicides are effective in controlling cheatgrass for at least one growing season. Open Range may be the preferred herbicide because no water is needed to apply it. However, Rejuvra has been proven to control cheatgrass for three to four years, so it is too early to definitively select which herbicide is best. If Rejuvra controls cheatgrass longer than imazapic it may be more cost-effective to use it than applying imazapic every year. Plots will continue to be monitored for at least another two years to test the longevity of cheatgrass control for all herbicides. Further analysis will also be conducted to determine herbicide impacts on native annual and perennial plants.

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