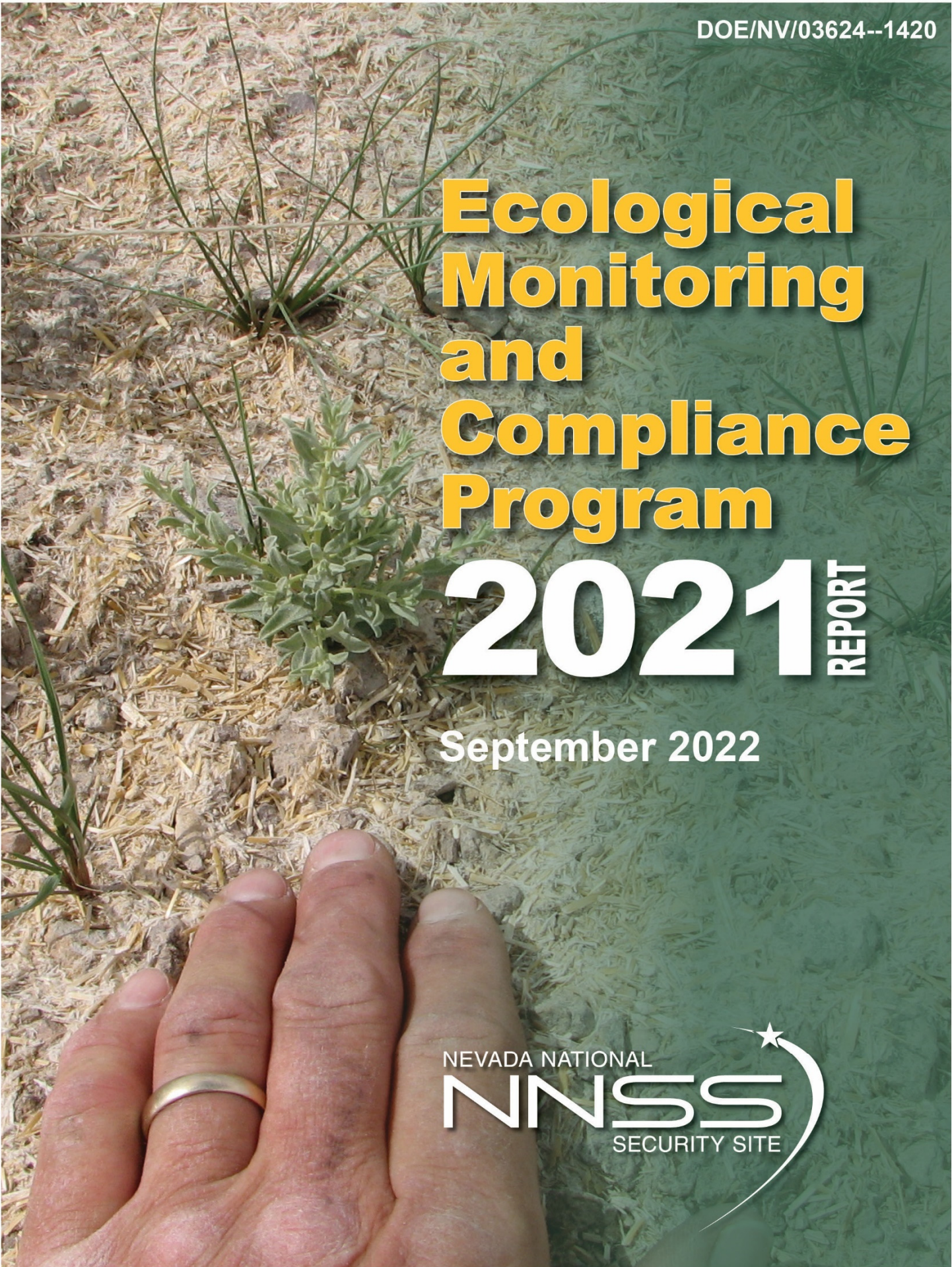


# Ecological Monitoring and Compliance Program

# 2021 REPORT

September 2022



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# Ecological Monitoring and Compliance Program

# 2021 **REPORT**

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**September 2022**

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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 2021. 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 2021, all applicable laws, regulations, and permit requirements were met, except for one instance of unapproved off-road driving during one project.

Sensitive and protected/regulated species of the NNSS include 43 plants, 1 mollusk, 2 reptiles, 240 birds, and 23 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 29 projects. A total of 102.8 hectares 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*); tortoise sign; a tortoise in the juvenile translocation study was hibernating within a project area and was monitored during the project; bat sign; inactive bird nests; breeding bird habitat; 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*); and multiple cactus species. Scientists communicated with ground crews and provided written summary reports to project managers of survey findings and mitigation recommendations when applicable.

Fourteen tortoise clearance surveys were conducted by biologists in 2021. No desert tortoises were observed or reported injured or killed during projects. A total of 22.1 ha of tortoise habitat was disturbed. All projects that were monitored within tortoise habitat remained within the surveyed project area. One project involving driving off-road was completed without the required tortoise clearance survey. A post activity survey was completed and it was determined there was no impact to the tortoise.

There were 41 reported desert tortoise roadside sightings. Of the 41 tortoises, two were roadkills. Thirty-one tortoises were determined to be in harm's way and moved off the road in accordance with U.S. Fish and Wildlife-approved tortoise handling procedures.

Juvenile tortoises continued to be monitored as part of a collaborative effort to study survival of translocated animals. After 112 months post-release, 12 of the 60 juveniles were still alive (20% survival) which is comparable to an estimated 22.7% (14 of 60 alive) survival in a natural population (Turner et al. 1987). Four tortoises (1 female, 3 male) were found dead during 2021. Three mortalities were suspected coyote and kit fox predation and one was due to an unknown cause.

From 1978 to 2021, there has been an average of 10.2 wildland fires per year on the NNSS with an average of about 121.1 ha per fire. Most wildland fires are caused by lightning and do not occur randomly across the NNSS, but occur more often in particular vegetation types (e.g., blackbrush [*Coleogyne ramosissima*] and pinyon pine/Utah juniper/sagebrush [*Pinus monophylla*/*Juniperus*

*osteosperma/Artemisia* spp.] plant communities). These types have sufficient woody and fine-textured fuels that are conducive to ignition and spread of wildland fires. Once a site burns, it is much more likely to burn again because of the invasive annual plants that quickly colonize these areas (Brooks and Lusk 2008).

Nine wildland fires were reported on the NNSS in 2021, all of which were caused by lightning. The largest fire, named the Cherrywood Fire, burned a total of 7,967 ha on the NNSS and an additional 2,729 ha on the adjacent Nevada Test and Training Range. The fire burned much of Timber Mountain including previously burned areas in several vegetation associations, primarily those dominated by pinyon pine, Utah juniper, and sagebrush species. This fire started in mid-May which was earlier than usual. Drought conditions, annual grass dominance from previous fires, and high, erratic winds contributed to the large size and rapid spread of this fire. The Area 19 Southern Bench Fire ignited by lightning on August 25, burned 365.8 ha on the NNSS in the Kawich Canyon area and another 7,494.0 ha on the adjacent NTTR. The Black Glass Canyon Fire started July 18 and burned 348.4 ha in the remote area west of Fortymile Canyon. The Area 16 East Fire was ignited by lightning on June 29 and burned 64.7 ha. The remaining five fires burned less than 10 ha.

Wildlife use at nine natural water sources (six springs, three rock tanks) and nine constructed water sources (one well pond, five water troughs, and three radiologically contaminated sumps) was documented using motion-activated cameras.

There are currently 19 vascular plants and one non-vascular plant included in the NNSS sensitive plant monitoring program. Species evaluations continued for Clokey's cryptantha (*Cryptantha clokeyi*), Lahontan beardtongue (*Penstemon palmeri* var. *macranthus*), and Nye milkvetch (*Astragalus nyensis*). Long-term monitoring continued for Beatley milkvetch (*Astragalus beatleyae*), Cane Spring suncup (*Chylismia megalantha*), Clokey eggvetch (*Astragalus oophorus* var. *clokeyanus*), Inyo hulsea (*Hulsea vestita* ssp. *inyoensis*), Kingston Mountains bedstraw (*Galium hilendiae* ssp. *kingstonense*), Pahute green gentian (*Frasera pahutensis*), and Pahute Mesa beardtongue (*Penstemon pahutensis*).

Surveys of sensitive and protected/regulated animals in 2021 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, shrews, nuisance animals and their control, and increasing populations of feral burros.

A total of eight dead birds were documented on the NNSS in 2021. This is the same number as last year which was the lowest number of recorded mortalities since 2012. Two common ravens (*Corvus corax*) were electrocuted, two owls (one long-eared [*Asio otus*] and one great-horned [*Bubo virginianus*]) were killed by vehicles, one red-tailed hawk apparently died from a collision with an unknown object, and three birds (two Cooper's hawks [*Accipiter cooperii*] and one green-winged teal [*Anas crecca*]) were found dead due to unknown causes. No golden eagle (*Aquila chrysaetos*) deaths were recorded. Only three raptor species were detected during winter raptor surveys in 2021. The red-tailed hawk was the most common species detected on both routes, comprising 50% of all raptor sightings. Common ravens were more prevalent on the southern route this year than in Yucca Flat with most of them observed near the Mercury Sewage Lagoons.

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 71 deer were observed during spotlight surveys, which equates to an average of 11.8 deer per night. This is more than three times fewer deer per night than what was observed in 2020, when an average of 37 deer per night were recorded. This is the lowest number of deer per night since 2006 and the second lowest ever recorded. Eleven marked desert bighorn sheep (7 ewes, 4 rams) and at least 12 unmarked sheep (6 ewes, 4 lambs, one young ram, and one adult ram) were documented with camera traps at water sources in the

Shoshone Mountain, Yucca Mountain, and Fortymile Canyon areas. Combined, a minimum of 23 sheep were documented at monitored water sources on the NNSS in 2021.

A total of 97 mountain lion images (i.e., photographs or video clips) were taken during 178,796 camera hours at 10 of 25 sites sampled. An additional 16,283 images of at least 81 species other than mountain lions were documented. A minimum of four individual mountain lions (adult male and adult female with two subadults) were known to occur on the NNSS in 2021.

Habitat restoration activities conducted in 2021 included 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 Radioactive Waste Management Complex [RWMC]), revegetating CAU 577 East and West Cover Caps (Area 5 RWMC), transplanting creosote bush (*Larrea tridentata*) and white bursage (*Ambrosia dumosa*) and evaluating revegetation success from fall 2020 seeding on Cell 18 (Area 5 RWMC), and implementing a research study to evaluate the effectiveness of different herbicide and seeding treatments to control cheatgrass (*Bromus tectorum*) after the Cherrywood Fire.

## TABLE OF CONTENTS

	Page
ACRONYMS AND ABBREVIATIONS.....	xv
1.0 INTRODUCTION .....	1
2.0 BIOLOGICAL SURVEYS.....	2
2.1 Sites Surveyed and Sensitive and Protected/Regulated Species Observed .....	2
2.2 Potential Habitat Disturbance .....	2
3.0 DESERT TORTOISE COMPLIANCE .....	11
3.1 Project Surveys and Compliance Documentation .....	11
3.1.1 Mitigation for Loss of Tortoise Habitat.....	17
3.2 Conservation Recommendations.....	18
3.2.1 Road Study.....	18
3.2.2 Juvenile Translocation Study .....	19
3.2.3 Rock Valley Circular Pens.....	30
3.2.4 Coordination with Other Biologists and Wildlife Agencies .....	31
4.0 ECOSYSTEM MONITORING.....	33
4.1 Wildland Fire Fuel Surveys and Recovery Plans.....	33
4.1.1 Wildland Fires in 2021.....	33
4.1.2 Wildland Fire Recovery Plans .....	35
4.1.3 Fuel Survey Methods .....	35
4.1.4 Fuel Survey Results .....	35
4.2 Reptile Studies.....	44
4.3 Natural Water Source Monitoring .....	44
4.4 Constructed Water Source Monitoring.....	47
4.4.1 Mitigating Water Loss for Wildlife .....	47
4.4.2 Monitoring Wildlife Use at Potentially Contaminated Water Sources.....	51
4.5 Coordination with Scientists and Ecosystem Management Agencies .....	52
5.0 SENSITIVE AND PROTECTED/REGULATED PLANT MONITORING .....	53
5.1 Species Evaluations .....	53
5.1.1 Clokey's cryptantha ( <i>Cryptantha clokeyi</i> ).....	53
5.1.2 Lahontan beardtongue ( <i>Penstemon palmeri</i> var. <i>macranthus</i> ).....	53
5.1.3 Nye milkvetch ( <i>Astragalus nyensis</i> ) .....	54
5.2 Long-Term Monitoring .....	55
5.2.1 Beatley milkvetch ( <i>Astragalus beatleyae</i> ) .....	55
5.2.2 Cane Spring suncup ( <i>Chylismia megalantha</i> ).....	56
5.2.3 Clokey eggvetch ( <i>Astragalus oophorus</i> var. <i>clokeyanus</i> ) .....	59
5.2.4 Inyo hulsea ( <i>Hulsea vestita</i> ssp. <i>inyoensis</i> ) .....	63
5.2.5 Kingston Mountains bedstraw ( <i>Galium hilendiae</i> ssp. <i>kingstonense</i> ) .....	64
5.2.6 Pahute green gentian ( <i>Frasera pahutensis</i> ).....	65
5.2.7 Pahute Mesa beardtongue ( <i>Penstemon pahutensis</i> ).....	68
5.3 Coordination with Other Scientists.....	68
6.0 SENSITIVE AND PROTECTED/REGULATED ANIMAL MONITORING .....	69
6.1 Birds.....	69
6.1.1 Migratory Bird Treaty Act Compliance.....	69
6.1.2 Bird Mortalities.....	70

6.1.3 Implementing the NNSS Avian Protection Plan ..... 71

6.1.4 Winter Raptor Surveys ..... 71

6.1.5 Western Burrowing Owl Radio-tracking Study ..... 72

6.2 Shrews of the NNSS ..... 72

6.3 Bat Monitoring..... 74

6.3.1 Documenting Bat Locations ..... 75

6.3.2 16B Tunnel ..... 75

6.3.3 NABat Acoustic Sampling ..... 76

6.4 Feral Horse Surveys ..... 77

6.5 Mule Deer ..... 81

6.5.1 Trends in Mule Deer Abundance..... 81

6.5.2 Sex and Fawn/Doe Ratios..... 83

6.6 Mule Deer and Pronghorn Antelope Distribution study..... 85

6.7 Desert Bighorn Sheep ..... 88

6.7.1 Camera Trap Results ..... 88

6.8 Mountain Lion Monitoring ..... 88

6.8.1 Motion-Activated Cameras ..... 88

6.9 Radiological Sampling ..... 97

6.10 Nuisance and Potentially Dangerous Wildlife ..... 99

6.11 Elk and Feral Burros ..... 99

6.12 Coordination with Biologists and Wildlife Agencies ..... 100

7.0 HABITAT RESTORATION IMPLEMENTATION AND MONITORING..... 101

7.1 CAU 110, U-3ax/bl, Closure Cover ..... 101

7.2 CAU 111, “92-Acre Site,” Closure Covers ..... 102

7.3 CAU 577 East and West Cover Cap revegetation and monitoring ..... 104

7.3.1 Site Preparation..... 104

7.3.2 Seeding and Hydromulching ..... 105

7.3.3 Irrigation ..... 105

7.3.4 Monitoring..... 108

7.3.5 Wildlife Use ..... 112

7.3.6 Reference Area ..... 112

7.3.7 Plastic Mulch Trial ..... 114

7.4 Area 5 RWMC, Cell 18 Revegetation and monitoring ..... 115

7.4.1 Transplants..... 116

7.4.2 Seeding Success..... 117

7.5 Cheatgrass Control Research Trial ..... 122

8.0 ACKNOWLEDGMENTS ..... 125

9.0 REFERENCES ..... 126

10.0 DISTRIBUTION ..... 131

## LIST OF FIGURES

Figure 2-1.	Biological surveys conducted in 2021. Projects with an asterisk (*) also had a post-activity survey completed in 2021. ....	7
Figure 3-1.	Locations of tortoise roadside observations on the NNSS (n=39) and off site (n=1) with associated size classes (large tortoises are >180 mm MCL and small are ≤180 mm MCL) from January 1, 2021 through December 31, 2021. Coordinates in UTM NAD83 (Zone 11, meters).....	16
Figure 3-2.	Juvenile tortoise observed foraging on a dirt road, but not handled. ....	17
Figure 3-3.	Relationship between mean annual (2013-2018) spring (March-May) core use area (50% MCP) and winter-spring (December-April) precipitation. ....	20
Figure 3-4.	Mercury Valley along Jackass Flats Road where 15 of 30 study animals were monitored, revealing overlap in home range (95% AKDE) of male and female tortoises. ....	20
Figure 3-5.	Release locations for 60 tortoises, September 2012 (blue dots, 20 at each site) and last known locations for 18 tortoises monitored during 2021 (red dot = living tortoise [n = 12]; red cross = dead tortoise[n = 4] with tortoise number in black text; and green triangle = missing [n = 2]). ....	23
Figure 3-6.	Percentage of observations (n = 475) of 18 juvenile tortoises by location, January 2021–January 2022. ....	25
Figure 3-7.	Percentage of observations (n = 54) of 18 juvenile tortoises found under vegetation by species, January 2021–January 2022. ....	25
Figure 3-8.	Percentage of new juvenile tortoise burrows by topographic position, January 2021–January 2022 (n = 24). ....	26
Figure 3-9.	Percentage of new juvenile tortoise burrows by vegetation cover at the burrow, January 2021–January 2022 (n = 20). ....	26
Figure 3-10.	Percentage of juvenile tortoise burrows by substrate, January 2021–January 2022 (n = 24). ....	27
Figure 3-11.	Number of times evidence of foraging was detected by month for 24 juvenile tortoises, January 2021–January 2022 (n = 17) (no evidence of foraging was detected in January, February, October, November or December). ....	28
Figure 3-12.	Male tortoise (#4048) eating shadscale saltbush, August 2021. ....	28
Figure 3-13.	Locations of juvenile tortoises observed in the circular Rock Valley pens. Coordinates in UTM NAD83 (Zone 11, meters).....	32
Figure 4-1.	Number of acres burned by vegetation association in the Cherrywood Fire on the NNSS, May 2021. ....	34
Figure 4-2.	Average precipitation from December (previous year) through April for the years 2004 through 2021 (long-term average 104.6 mm). ....	36
Figure 4-3.	Index of fine fuels for 104 survey stations on the NNSS during 2021.....	39
Figure 4-4.	Index of woody fuels for 104 survey stations on the NNSS during 2021. ....	40
Figure 4-5.	Index of combined fine fuels and woody fuels for 104 survey stations on the NNSS during 2021. ....	41
Figure 4-6.	Site 99 on the west side of Yucca Flat in 2018, 2019, 2020, and 2021. ....	42
Figure 4-7.	Natural water sources on the NNSS, including those monitored in 2021. ....	45
Figure 4-8.	Hairy woodpecker at Captain Jack Spring (#12).....	46
Figure 4-9.	Doe and young buck mule deer at South Pah Canyon Tanks (#15).....	47
Figure 4-10.	Constructed water sources monitored with motion-activated cameras for wildlife use during 2021. ....	48
Figure 4-11.	First-year summer tanager at Camp 17 Pond.....	49
Figure 4-12.	Two peregrine falcons at Camp 17 Pond (#6). ....	49

Figure 4-13.	LeConte’s thrasher at Well 5C Trough (#24). .....	50
Figure 5-1.	Beatley milkvetch plant. ....	56
Figure 5-2.	Beatley milkvetch type locality in Area 20 surveyed July 12, 2021. Coordinates in UTM NAD83 (Zone 11, meters). ....	57
Figure 5-3.	News article distributed by EG&G in their <i>Life Sciences News</i> newsletter in 1981. A similar article was printed in the <i>Las Vegas Sun</i> August 24, 1980. ....	58
Figure 5-4.	Clokey eggvetch plant with flowers (left) and plant with seed pods (right). ....	60
Figure 5-5.	Map showing the burned area for the Cherrywood Fire and known sensitive plant populations in or near the burn. Coordinates in UTM NAD83 (Zone 11, meters). ....	61
Figure 5-6.	Clokey eggvetch burned habitat on Timber Mountain, east of south Timber Peak, in Area 30. ....	62
Figure 5-7.	Clokey eggvetch burned habitat with a hand line fire break constructed during the Cherrywood Fire for fire suppression. ....	62
Figure 5-8.	Clokey eggvetch burned seed pods with leaf regrowth post-burn on Timber Mountain, east of south Timber Peak, in Area 30. ....	63
Figure 5-9.	Inyo hulsea plant (background, shrub with yellow flowers) found at a new location along the 19-01 Road within a Pahute Mesa beardtongue (foreground, stalk with purple flowers) population. ....	64
Figure 5-10.	Pahute green gentian. ....	66
Figure 5-11.	Pahute Green gentian surveyed locations June 3, 2021 on Pahute Mesa. Coordinates in UTM NAD83 (Zone 11, meters). ....	67
Figure 6-1.	Records of reported bird deaths on the NNSS, 1990–2021. ....	70
Figure 6-2.	Winter raptor survey routes (red lines) on the NNSS. ....	73
Figure 6-3.	Desert shrew captured on top of Shoshone Mountain, Skink Plot 156. ....	75
Figure 6-4.	North American Bat Monitoring Program priority grid cells with four quadrants (colored numbered rectangles) and sampling locations (maroon dots). ....	76
Figure 6-5.	Bat detector at Rock Valley Tank, Grid Cell 10662. ....	78
Figure 6-6.	Bat detector in a typical Mojave Desert wash north of Little Skull Mountain, Grid Cell 10662. ....	78
Figure 6-7.	Bat detector at wash in blackbrush habitat near Papoose Lake Road, Grid Cell 18854. ....	79
Figure 6-8.	Bat detector south of Sedan Crater, Grid Cell 18854. ....	79
Figure 6-9.	Bat detector in Columbine Canyon, Grid Cell 7590. ....	80
Figure 6-10.	Bat detector location at ER 20-6 Sumps, Grid Cell 7590. ....	80
Figure 6-11.	Two horses foraging on cattails and “cooling off” at Camp 17 Pond. ....	81
Figure 6-12.	Road routes and sub-routes of two NNSS regions driven in 2021 to count deer and section removed due to road closure. ....	82
Figure 6-13.	Trends in total deer count per night from 1989 to 2021 on the NNSS (surveys were not conducted during 1995–1998 or 2001–2005). Standard deviation values above bars. ....	84
Figure 6-14.	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 2015–2021). ....	84
Figure 6-15.	Locations of collared mule deer (brown dots) and pronghorn antelope (yellow dots) during 2021. ....	87
Figure 6-16.	Ram 686322 (left) and unmarked ram (right) at Cottonwood Spring. ....	89
Figure 6-17.	Locations of mountain lion photographic detections and camera traps on the NNSS during 2021. ....	90
Figure 6-18.	Mountain lion with recently killed mule deer in its mouth at Camp 17 Pond. ....	96

Figure 6-19. Mountain lion at Delirium Canyon Tanks (#5)..... 96

Figure 6-20. Number of mountain lion images by month for camera sites where mountain lions were detected from 2006 through 2021 (n = 1,133). ..... 98

Figure 6-21. Number of mountain lion images by time of day (Pacific Standard Time) for camera sites where mountain lions were detected from 2006 through 2021 (n = 1,128). ..... 98

Figure 6-22. Bull elk drinking at Gold Meadows Spring. .... 100

Figure 7-1. Overview of plant community that has established on the CAU 110 over the last 21 years. Shadscale and Nevada jointfir are the two most dominant plants found on the closure cover. .... 102

Figure 7-2. North North Cover on the “92-acre Site.” ..... 103

Figure 7-3. Ripping CAU 577 East Cover Cap with bulldozer to alleviate soil compaction. .... 104

Figure 7-4. Broadcast seeding CAU 577 West Cover Cap with drill seeder and chain harrow. .... 106

Figure 7-5. Applying hydromulch on CAU 577 West Cover Cap..... 106

Figure 7-6. Schematic of irrigation systems for CAU 577 West Cover Cap (left) and East Cover Cap (right); two wheel lines per cap..... 107

Figure 7-7. Watermaster filling water tanks at CAU 577 East Cover Cap..... 107

Figure 7-8. Irrigation system in operation at CAU 577 East Cover Cap. Note the abundance of seeded perennial shrubs (light green vegetation) with minimal saltlover and prickly Russian thistle (brown vegetation)..... 108

Figure 7-9. Snow cover on Cell 18 Cover Cap..... 111

Figure 7-10. Herd of five antelope foraging on West Cover Cap. .... 112

Figure 7-11. Area 5 Radioactive Waste Management Complex reference area..... 113

Figure 7-12. Plastic mulch trial plot, East Cover Cap..... 114

Figure 7-13. Plastic mulch trial plot with plastic removed (green, vegetated square marked by orange pin flags) and surrounding non-mulched area. .... 115

Figure 7-14. Dense saltlover on Cell 18 Cover Cap, July 2021. .... 122

Figure 7-15. Final plot layout for cheatgrass control research trial. .... 124

## LIST OF TABLES

Table 2-1.	List of sensitive and protected/regulated species known to occur on the NNSS.....	3
Table 2-2.	Summary of biological surveys conducted on the NNSS during 2021.....	8
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 2021 (TCS = Tortoise clearance survey, DTM = Desert tortoise monitor).....	12
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, 2021. ....	14
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 – 2021.....	15
Table 3-4.	Mortality, sex, distance in meters (m) between release site and January 2022 burrow, distance between January 2021 burrow and January 2022 burrow, total distance between monitored locations (January 2021 to January 2022), and total number of burrows and new burrows occupied by 18 juvenile desert tortoises monitored during 2021. ....	22
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 2014–2021.....	24
Table 3-6.	Midline carapace length (MCL) (mm) and body condition score in fall 2012, spring 2021, and fall 2021; weight without transmitters (gram [g]) in fall 2012 and fall 2021; MCL growth and weight gain from fall 2012 to fall 2021; and MCL growth spring 2021 to fall 2021 for 18 tortoises monitored in 2021. ....	29
Table 4-1.	Woody fuels, fine fuels and combined fuels index values for 2004–2021. ....	38
Table 4-2.	Precipitation history and percent presence of key plant species contributing to fine fuels at surveyed sites. ....	43
Table 6-1.	Results of winter 2021 raptor surveys on the NNSS.....	74
Table 6-2.	Mule deer classified by sex and age, with sex ratios, and fawn to doe ratios from 2006 to 2021 on the NNSS (12 survey nights for 2012, 8 for 2013, 6 for 2015–2021, 9 for all other years).....	85
Table 6-3.	Results of mountain lion camera surveys during 2021 (a = non-continuous operation due to camera problems, dead batteries, full memory cards, etc.; b = camera hours not known for some time periods).....	91
Table 6-4.	Number of mountain lion images taken with camera traps by month and location, December 2020 through December 2021 (orange = number of mountain lion images; yellow = camera operational, no mountain lion images; green = camera not operational). ....	95
Table 7-1.	Seedmix used to revegetate CAU 577 East and West Cover Caps including species, number of pure live seeds per square meter and number of pounds of pure live seed per acre. ....	105
Table 7-2.	Amounts of irrigation applied and natural precipitation (mm) received at CAU 577 East and West Cover Caps in 2021. ....	109

Table 7-3.	Average number of seedlings per square meter by lifeform and species for CAU 577 East and West Cover Caps and Reference Area, May/June 2021.....	110
Table 7-4.	Average percent cover by species and category on the Area 5 RWMC Reference Area, June 2021.....	113
Table 7-5.	Average number of seedlings per square meter by species for plastic mulch trial and control, April 15, 2021 and June 1, 2021.....	116
Table 7-6.	Results from transplant success monitoring including total number of plants evaluated, percent survival, average vigor and flowering/fruitleting information for Cell 18, May and October 2021.....	118
Table 7-7.	Average number of seedlings per square meter by lifeform and species for Cell 18, May 2021.....	119
Table 7-8.	Amounts (mm) of supplemental irrigation applied and natural precipitation received on Cell 18 Cover Cap, November 2020 through October 2021. Numbers in parentheses in irrigation column represent increments of irrigation (i.e., a total of 25.4 mm was applied in 6.4- or 12.7-mm increments).....	121
Table 7-9.	Seed mix used in cheatgrass control research trial.....	124

## ACRONYMS AND ABBREVIATIONS

AKDE	autocorrelated kernel density estimate
APP	Avian Protection Plan
BCS	Body Condition Score
BYU	Brigham Young University
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
ha	hectare(s)
ICR	San Diego Zoo Institute for Conservation Research
km	kilometer(s)
kV	kilovolt
LANL	Los Alamos National Laboratory
m	meter(s)
M	average
MBTA	Migratory Bird Treaty Act
MCL	midline carapace length
MCP	minimum convex polygon
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
NDOT	Nevada Department of Transportation
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)
P	probability
pCi/L	picocuries per liter
PLS	pure live seed
PTT	platform transmitter terminal
R, R <sup>2</sup>	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

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In accordance with U.S. Department of Energy (DOE) Order DOE O 231.1B, “Environment, Safety, and Health Reporting,” the Office of the Assistant Manager for Mission and Infrastructure of the U.S. Department of Energy, National Nuclear Security Administration Nevada Field Office (NNSA/NFO) requires ecological monitoring and biological compliance support for activities and programs conducted at the Nevada National Security Site (NNSS). 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 2021, all applicable laws and regulations were followed and the permit requirements were met except for one instance of unapproved off-road driving during one project.

This report summarizes the EMAC activities conducted by MSTS during calendar year 2021. Monitoring tasks during 2021 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

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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 2022). 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 2021, biological surveys were conducted for 29 projects on the NNSS (Figure 2-1, Table 2-2). Several projects had multiple survey locations and post-activity surveys were conducted for projects completed before 2021 as well as projects completed during 2021 (Figure 2-1, Table 2-2). Scientists surveyed a total of 102.8 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. Sensitive and protected/regulated wildlife species and important biological resources found during the surveys included western burrowing owl sites (*Athene cunicularia hypugaea*); tortoise (*Gopherus agassizii*) sign (scat, two old carcasses, and burrows); a tortoise in the juvenile translocation study (see Section 3.2.2) was hibernating within the 19-47 project area and was monitored during the project; bat sign; several inactive bird nests; breeding bird habitat; 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*); 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 <sup>a</sup>
<b>Moss Species</b>		
<i>Entosthodon planoconvexus</i>	Planoconvex cordmoss	S, H
<b>Flowering Plant Species</b>		
<i>Arctomecon merriamii</i>	White bearpoppy	S, M
<i>Astragalus beatleyae</i>	Beatley's milkvetch	S, H
<i>Astragalus funereus</i>	Black woollypod	S, H
<i>Astragalus oophorus</i> var. <i>clokeyanus</i>	Clokey eggvetch	S, W
<i>Chylismia megalantha</i>	Cane Spring suncup	S, M
<i>Cryptantha clokeyi</i>	Clokey's cryptantha	S, E
<i>Cymopterus ripleyi</i> var. <i>saniculoides</i>	Sanicle biscuitroot	S, W
<i>Eriogonum concinnum</i>	Darin buckwheat	S, M
<i>Eriogonum heermannii</i> var. <i>clokeyi</i>	Clokey buckwheat	S, W
<i>Frasera pahutensis</i>	Pahute green gentian	S, M
<i>Galium hilendiae</i> ssp. <i>kingstonense</i>	Kingston Mountains bedstraw	S, H
<i>Hulsea vestita</i> ssp. <i>inyoensis</i>	Inyo hulsea	S, W
<i>Ivesia arizonica</i> var. <i>saxosa</i>	Rock purpusia	S, H
<i>Penstemon fruticiformis</i> ssp. <i>amargosae</i>	Death Valley beardtongue	S, M
<i>Penstemon pahutensis</i>	Pahute Mesa beardtongue	S, W
<i>Penstemon palmeri</i> var. <i>macranthus</i>	Lahontan beardtongue	S, E
<i>Phacelia beatleyae</i>	Beatley scorpionflower	S, M
<i>Phacelia filiae</i>	Clarke phacelia	S, W
<i>Phacelia mustelina</i>	Weasel phacelia	S, W
<i>Agavaceae</i>	Yucca (3 species), Agave (1 species)	CY
<i>Cactaceae</i>	Cacti (17 species)	CY
<i>Juniperus osteosperma</i>	Utah juniper	CY
<i>Pinus monophylla</i>	Single-leaf pinyon	CY

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

<b>Animal Species</b>	<b>Common Name</b>	<b>Status<sup>a</sup></b>
<b>Mollusk Species</b>		
<i>Pyrgulopsis turbatrix</i>	Southwest Nevada pyrg	S, A
<b>Reptile Species</b>		
<i>Plestiodon gilberti rubricaudatus</i>	Western red-tailed skink	S, IA
<i>Gopherus agassizii</i>	Desert tortoise	LT, S, NPT, A
<b>Bird Species<sup>b</sup></b>		
<i>Accipiter gentilis</i>	Northern goshawk	S, NPS, A
<i>Alectoris chukar</i>	Chukar	G, IA
<i>Aquila chrysaetos</i>	Golden eagle	EA, NP, A
<i>Asio flammeus</i>	Short-eared owl	S, NP, A
<i>Asio otus</i>	Long-eared owl	S, NP, A
<i>Callipepla gambelii</i>	Gambel's quail	G, IA
<i>Coccyzus americanus</i>	Western yellow-billed cuckoo	LT, S, NPS, IA
<i>Corvus brachyrhynchos</i>	American crow	G, IA
<i>Falco peregrinus</i>	Peregrine falcon	S, NPE, A
<i>Gymnorhinus cyanocephalus</i>	Pinyon jay	S, NP, IA
<i>Haliaeetus leucocephalus</i>	Bald eagle	EA, S, NPE, A
<i>Ixobrychus exilis</i>	Least bittern	S, NP, IA
<i>Lanius ludovicianus</i>	Loggerhead shrike	NPS, A
<i>Melanerpes lewis</i>	Lewis's woodpecker	S, NP, IA
<i>Oreoscoptes montanus</i>	Sage thrasher	NPS, IA
<i>Riparia riparia</i>	Bank swallow	S, NP, IA
<i>Spinus pinus</i>	Pine siskin	S, NP, IA
<i>Spizella breweri</i>	Brewer's sparrow	NPS, IA
<i>Toxostoma lecontei</i>	LeConte's thrasher	S, NP, IA
<b>Mammal Species</b>		
<i>Antilocapra Americana</i>	Pronghorn antelope	G, A
<i>Antrozous pallidus</i>	Pallid bat	NP, A
<i>Cervus elaphus nelsoni</i>	Rocky Mountain elk	G, IA
<i>Corynorhinus townsendii</i>	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).**

<b>Animal Species</b>	<b>Common Name</b>	<b>Status<sup>a</sup></b>
<i>Equus asinus</i>	Burro	H&B, A
<i>Equus caballus</i>	Horse	H&B, A
<i>Euderma maculatum</i>	Spotted bat	S, NPT, A
<i>Lasiorycteris noctivagans</i>	Silver-haired bat	S, A
<i>Lasiurus blossevillii</i>	Western red bat	S, NPS, A
<i>Lasiurus cinereus</i>	Hoary bat	S, A
<i>Lynx rufus</i>	Bobcat	F, IA
<i>Microdipodops megacephalus</i>	Dark kangaroo mouse	NP, A
<i>Microdipodops pallidus</i>	Pale kangaroo mouse	S, NP, A
<i>Myotis thysanodes</i>	Fringed myotis	S, NP, A
<i>Ovis canadensis nelsoni</i>	Desert bighorn sheep	G, A
<i>Odocoileus hemionus</i>	Mule deer	G, A
<i>Puma concolor</i>	Mountain lion	G, A
<i>Sorex tenellus</i>	Inyo shrew	S, IA
<i>Sylvilagus audubonii</i>	Desert cottontail	G, IA
<i>Sylvilagus nuttallii</i>	Nuttall's cottontail	G, IA
<i>Tadarida brasiliensis</i>	Brazilian free-tailed bat	NP, A
<i>Urocyon cinereoargenteus</i>	Gray fox	F, IA
<i>Vulpes macrotis</i>	Kit fox	F, IA

<sup>a</sup> **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*

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

NPE Nevada Protected-Endangered, species protected under Nevada Administrative Code (NAC) 503

NPT Nevada Protected-Threatened, species protected under NAC 503

NPS Nevada Protected-Sensitive, species protected under NAC 503

NP Nevada Protected, species protected under NAC 503

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

G	Regulated as game species under NAC 503
F	Regulated as fur bearer species under NAC 503
<u>State of Nevada – Plants</u>	
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
<u>NNSS Sensitive Plant Ranking</u>	
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)
<u>Long-term Animal Monitoring Status for the NNSS</u>	
A	Active
IA	Inactive
<sup>b</sup> All bird species on the NNSS are protected by the <i>Migratory Bird Treaty Act</i> except for chukar, Gambel’s quail, English house sparrow ( <i>Passer domesticus</i> ), Rock dove ( <i>Columba livia</i> ), Eurasian collared dove ( <i>Streptopelia decaocto</i> ), and European starling ( <i>Sturnus vulgaris</i> ). Most bird species are also protected under NAC503.	

Sources used: NDNH 2022, NAC 2022, U.S. Fish and Wildlife Service (FWS) 2022

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 certain projects to determine the total amount of habitat disturbed and ensure the project followed all applicable biological compliance. Table 2-1 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

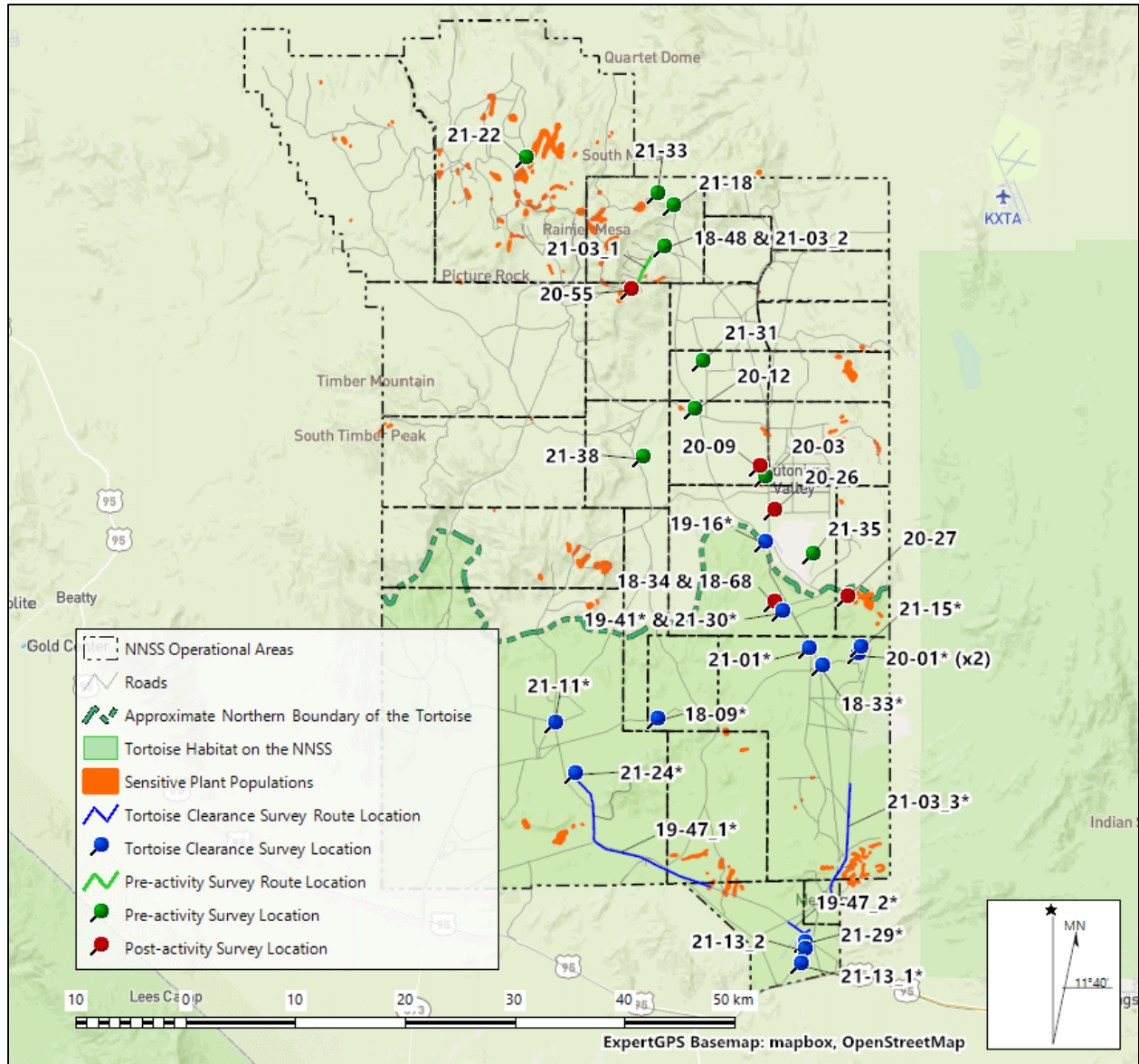


Figure 2-1. Biological surveys conducted in 2021. Projects with an asterisk (\*) also had a post-activity survey completed in 2021.

Table 2-2. Summary of biological surveys conducted on the NNSS during 2021.

Project No.	Project Name	Important Species/Resources Found	Area Surveyed (ha)	Project area in Undisturbed Habitat (ha)	Mitigation in 2021
18-09	Test Bed South	Yucca, cacti	0.34	0.16	TCS <sup>a</sup> , DTM <sup>b</sup> , Post-activity Survey
18-33	Frenchman Flat Transformer Replacement	Predator burrow, raven nest, ungulate sign, yucca	2.90	0.70	TCS <sup>a</sup> , DTM <sup>b</sup> , Post-activity Survey
18-34	Device Assembly Facility Substation Upgrade	Yucca, cacti, 1 sensitive plant species, predator burrow	1.89	0.16	Post-activity Survey <sup>c</sup>
18-48	Area 12 Trailer Disposal	3 inactive bird nests, bat sign	NA	NA	Pre-activity Survey for Buildings
18-68	Device Assembly Facility Uninterruptible Power Supply Upgrade and Trailer	NA	NA <sup>c</sup>	0	Post-activity Survey <sup>c</sup>
19-16	Area 6 Tippetah Batch Plant	Yucca, cacti	0.89	0.40	TCS <sup>a</sup> , Post-activity Survey
19-41	Powerline at Device Assembly Facility	Yucca, cacti, ungulate sign	2.60	0.20	TCS <sup>a</sup> , Post-activity Survey
19-47	NV Energy Pole Replacements	Yucca, cacti, predator burrows, 2 old tortoise carcasses, ungulate sign, translocated monitored tortoise, tortoise burrow	11.50	0	TCS <sup>a</sup> , DTM <sup>b</sup> , Post-activity Survey
20-01	RWMC Expansion	Yucca, cacti, predator burrows, ungulate sign	21.6	16.63	TCS <sup>a</sup> , DTM <sup>b</sup> , Post-activity Survey
20-03	U1a Modernization Sewage Lagoon	Yucca, ungulate sign, breeding bird habitat	17.1	Project in Progress	Pre-activity Survey
20-09	U1a Modernization Power Distribution	Yucca, ungulate sign, cottontail rabbit	NA <sup>c</sup>	5.95	Post-activity Survey <sup>c</sup>
20-12	Demolition 01-101 and 102	2 inactive bird nests	NA	NA	Pre-activity Survey for Buildings
20-26	U1a Communications	NA	NA <sup>c</sup>	2.10	Post-activity Survey <sup>c</sup>
20-27	Blading Area 11 Explosive Ordnance Disposal Unit	NA	NA <sup>c</sup>	0	Post-activity Survey <sup>c</sup>
20-55	Emergency FAJ Power Line Reroute	NA	NA <sup>c</sup>	0.60	Post-activity Survey <sup>c</sup>
21-01	Emergency Waterline Repair Area 5	None	0.40	0	TCS <sup>a</sup> , Post-activity Survey
21-03	Blading Maintenance Roads and Grounds Activities 2021	Yucca, cacti, possible burrowing owl burrows, pine trees, pinyon jays, inactive bird nest, ungulate sign	19.50	0	Pre-activity Survey, TCS <sup>a</sup> , DTM <sup>b</sup> , Post-activity Survey
21-11	Project 300 Shade Structure	Cacti	1.57	0.50	TCS <sup>a</sup> , Post-activity Survey
21-13	Aerial Distributed Acoustic Sensing Infrasonic Test	Yucca, cacti, tortoise scat	3.88	0.89	TCS <sup>a</sup> , DTM <sup>b</sup> , Post-activity Survey

Table 2-2. Summary of biological surveys conducted on the NNSS during 2021 (continued).

Project No.	Project Name	Important Species/Resources Found	Area Surveyed (ha)	Project area in Undisturbed Habitat (ha)	Mitigation in 2021
21-15	Cell 29 Construction	Yucca, cacti, predator burrow, ungulate sign	4.50	2.30	TCS <sup>a</sup> , DTM <sup>b</sup> , Post-activity Survey
21-18	Balloon System Launch Location	Pine trees, cacti, ungulate sign	0.60	Project in progress	Pre-activity Survey
21-22	Arrays	Pine trees, cacti, blue jays, ungulate sign	0.12	0.14	Pre-activity survey
21-24	Antelope Ridge House Power Test Bed 1	Yucca, cacti	1.60	0.12	TCS <sup>a</sup> , DTM <sup>b</sup> , Post-activity Survey
21-29	Cherrywood Fire Mobilization	Tortoise burrow, tortoise scat	1.39	0	TCS <sup>a</sup> , DTM <sup>b</sup> , Post-activity Survey
21-30	Device Assembly Facility Road Culvert Clean Out	Yucca, ungulate sign	2.55	0	TCS <sup>a</sup> , Post-activity Survey
21-31	Big Explosives Experimental Facility New Road	Yucca, cacti, ungulate sign, inactive bird nest	1.10	Project in progress	Pre-activity Survey
21-33	Array Off Roading	Pine trees, cacti, predator burrows, ungulate sign	1.35	Project in progress	Pre-activity Survey
21-35	Desert Eagle Road Grading	Yucca, cacti, ungulate sign, predator burrow	5.40	Project in progress	Pre-activity Survey
21-38	Tunnel U16b Reactivation	Bat sign, bird sign	NA	NA	Pre-activity Exit Survey for Tunnels
		<b>Total</b>	<b>102.78</b>	<b>30.85</b>	

<sup>a</sup> Tortoise Clearance Survey

<sup>b</sup> Desert Tortoise Monitor

<sup>c</sup> Post activity survey completed in 2021. Area surveyed during TCSs or pre-activity surveys was reported in previous years' EMAC reports.

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).

Projects 18-09, 18-33, 19-16, and 20-09 disturbed 7.21 ha of *Sensitive Habitat*. Project 20-55 disturbed 0.60 ha of habitat considered *Sensitive* and *Unique*. The total area disturbed (ha) of important habitat types tracked since 1999 comprises 11.01 (*Pristine*), 22.32 (*Unique*), 397.80 (*Sensitive*) (should have been 389.99 in 2020), and 87.05 (*Diverse*). Projects in 2021 disturbed a total of 30.85 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).

### 3.0 DESERT TORTOISE COMPLIANCE

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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 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 (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 staff biologists in 2021, including (a) conducting 100% 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

Thirty-four projects occurring within the range of the tortoise were reviewed by biologists in 2021 and seven 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).

Fourteen TCSs were completed by biologists in 2021 (Figure 2-1, Table 2-2). No tortoises were observed or reported injured or killed during projects. A total of 22.1 ha of tortoise habitat was disturbed during 2021. Project 21-07, Geotech boring preparation work for the new 138 kilovolt (kV) power line, submitted the project for review but completed the work without TCSs or a DTM. The project was within the range of the tortoise and drove off-road to access boring locations. A post-activity survey was completed revealing off road tracks at several locations, but no impact to the tortoise. Noncompliance was addressed internally.

In January 2022, the annual report summarizing tortoise compliance activities conducted on the NNSS from January 1 through December 31, 2021 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 2021 (TCS = Tortoise clearance survey, DTM = Desert tortoise monitor).**

Project No.	Project Name	Description of Compliance Activity Required	TCS Completed During 2021	Tortoise Habitat Disturbed During 2021 (ha)
17-12 (18-43) <sup>a</sup>	Power Pole Weed Abatement	Formal Consultation, TCS, DTM		0
18-05 <sup>a</sup>	RWMC Expansion	Formal Consultation, TCS, DTM		0
18-09 <sup>a</sup>	Test Bed South	No Activities in 2020	✓	0.2
18-33	Frenchman Flat Transformer Replacement	TCS, DTM	✓	0.7
18-34 <sup>a</sup>	DAF Substation Upgrade	TCS, DTM		0.2
18-68 <sup>a</sup>	Area 6 Uninterruptible Power Supply Upgrade & Trailer	TCS, DTM		0
19-16 <sup>a</sup>	Area 6 Tippipah Batch Plant	Formal Consultation, TCS, DTM	✓	0.4
19-41	Area 6 Power Line	TCS, DTM	✓	0.2
19-47	NV Energy Pole Replacements	TCS, DTM	✓	0
20-01 <sup>a</sup>	RWMC Westward Expansion	Formal Consultation, TCS, DTM	✓	16.6
20-17	Area 25 Criminal Site Investigation	None		0
20-42	138 kV Power Transmission System Replacement	Formal Consultation, TCS, DTM		0
20-64	Mercury Cabling	None		0
20-65	Mercury Storm Drain	None		0
21-01	Emergency Water Line Repair Area 5	TCS	✓	0
21-03	Blading Maintenance Roads and Grounds Activities 2021	TCS, DTM	✓	0
21-04	Pole Inspection and Treatment	None		0
21-05	Seismic and Diagnostic Monitoring	None		0
21-07	Geotech Boring 138 kV Power Line	TCS, DTM	Out of compliance	0
21-08	Baker 27-5310 Building Modification	None		0
21-09	Seismic and Diagnostic Monitoring – Rock Valley	None		0
21-11	P300 Shade Structure	TCS	✓	0.5
21-13	Aerial Distributed Acoustic Sensing Infrasonic Test	TCS, DTM	✓	0.9
21-15	Cell 29 Construction	TCS, DTM	✓	2.3

**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 2021 (continued).**

Project No.	Project Name	Description of Compliance Activity Required	Survey Completed During 2021	Tortoise Habitat Disturbed During 2021 (ha)
21-16	Well Site Clean-up Phase I	None		0
21-17	Baker Electrical Upgrade	None		0
21-21	Mercury Roads Project	None		0
21-23	Area 27 Sidewalk	None		0
21-24	Antelope Ridge House Power Test Bed 1	TCS, DTM	✓	0.1
21-26	Rockets Test 1	None		0
21-28	Lightning Protection System	None		0
21-29	Cherrywood Fire Mobilization	TCS, DTM	✓	0
21-30	Area 6 Culvert Clean Out	TCS	✓	0
21-32	Area 27 Power Poles	None		0
21-36	Mercury New Building 2 Contractor Support	None		0
21-40	Counter Terrorism Operations Support	None		0
21-45	Restore Area 6 Range Signs	None		0
21-49	Mercury New Building 23-461	None		0
21-50	Mercury New Building 23-462	None		0
21-52	Will Site Clean-up Phase II	None		0
21-54	Mercury Concrete Cores & Anchor Testing	None		0
			<b>Total</b>	<b>22.1</b>

<sup>a</sup> Project carried over from previous year.

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 represented in Table 3-2. Cumulative totals tracked since 1992 are represented in Table 3-3.

There were 41 reported tortoise roadside observations on the NNSS and one observation on the I-95 Highway offramp at the Mercury exit, an area managed by Nevada Department of Transportation (NDOT) (Figure 3-1). The tortoise observed on the I-95 offramp was approximately 203 mm MCL. It was moved off the ramp and reported to NDOT. Of the 41 tortoises observed on NNSS roads, two were roadkills and one was a predation (Figure 3-1). The two roadkill tortoises were small ( $\leq 180$  mm MCL); therefore, did not count as incidental take, but were detected and reported to FWS. Both roadkill tortoises were found dead upon arrival. The tortoise predation observation was a juvenile tortoise 99 mm MCL. The carcass was found abandoned on the road, intact, hollowed out, with some exposed bone from a possible predation.

**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, 2021.**

Program	Actual No. of Hectares Impacted (Limit Allowed)	No. of Tortoises Incidentally Taken (Maximum Allowed)	
		Non-injury or Non-mortality <sup>a</sup>	Detected Injury or Mortality
1) Continued Use of Existing Roads	NA	55 (350) <sup>b</sup>	0 (15) <sup>c</sup>
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 <sup>e</sup>	1.2 (405)	0 (20)	0 (4)
6) Work-for-Others	0 (202)	0 (20)	0 (2)
7) Infrastructure	9.2 (202)	0 (20)	0 (4) <sup>d</sup>
<b>Totals</b>	<b>32 (1,213)</b>	<b>55 (440)</b>	<b>0 (31)</b>

<sup>a</sup> All tortoises observed in harm’s way may be moved to a safe location

<sup>b</sup> No more than 35 non-injury or non-mortality tortoises in a given year.

<sup>c</sup> No more than 4 tortoises killed in a given year and no more than 15 killed during the term of the Opinion.

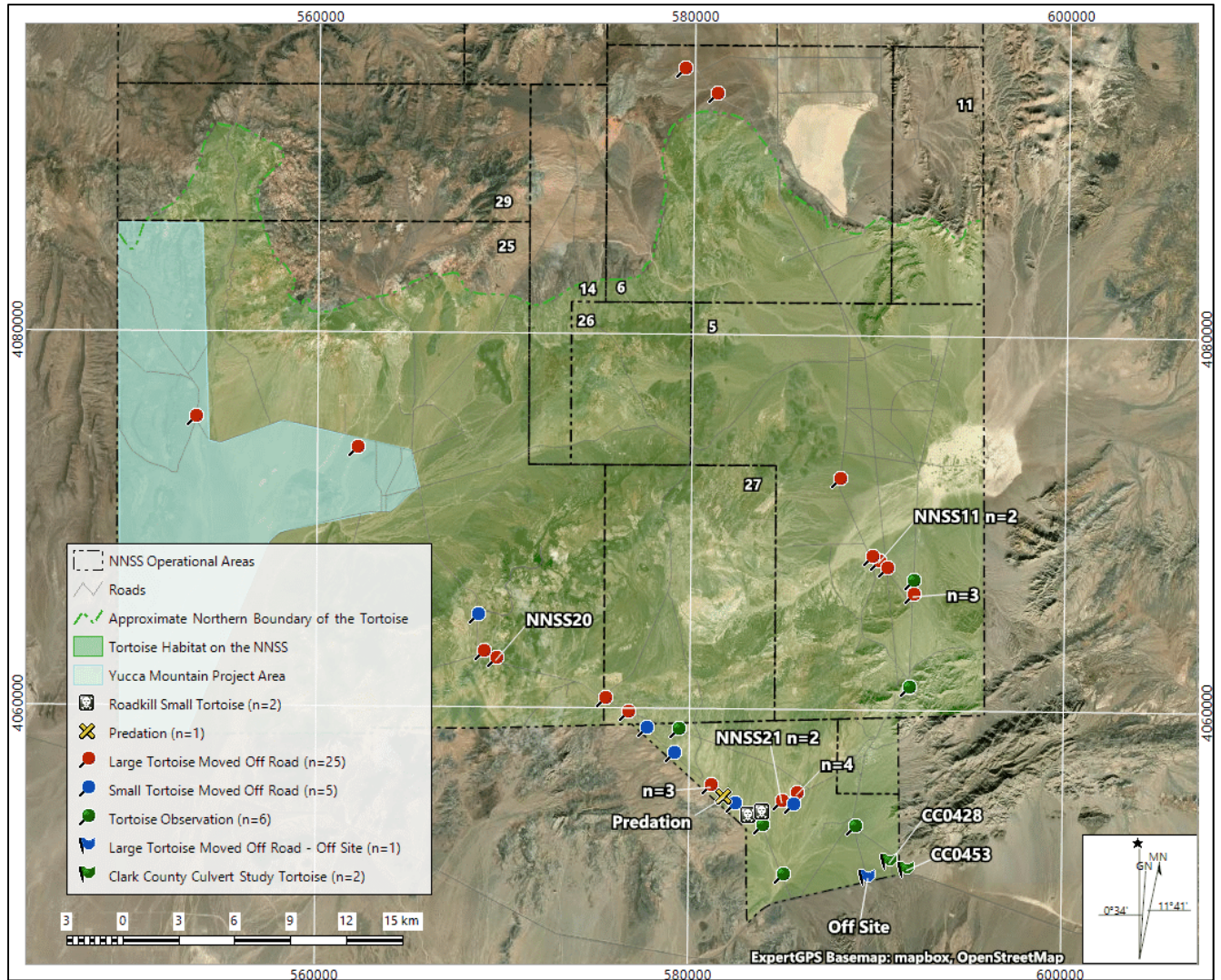
<sup>d</sup> No more than 2 tortoises killed in a given year and no more than 4 killed during the term of the Opinion.

<sup>e</sup> Research and Development

**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 – 2021.**

Calendar Year	Hectares Disturbed	Total Roadside Observations	Non-injury or Non-mortality Roadside Observations <sup>a</sup>	Detected Injury or Mortality
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
<b>Total</b>	<b>185.8</b>	<b>882</b>	<b>777</b>	<b>28</b>

<sup>a</sup> 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 3-1. Locations of tortoise roadside observations on the NNSS (n=39) and off site (n=1) with associated size classes (large tortoises are >180 mm MCL and small are ≤180 mm MCL) from January 1, 2021 through December 31, 2021. Coordinates in UTM NAD83 (Zone 11, meters).**

Thirty-one tortoises were determined to be in harm's way and moved off the road following FWS-approved protocol. Six tortoises were not handled and allowed to move themselves off the road (Figure 3-2). Five of the tortoises moved off roads were small ( $\leq 180$  mm MCL) and although were detected, did not count as incidental take. Large tortoises ( $>180$  mm MCL) were moved 26 times off roads, but one tortoise was moved twice within an hour; therefore, 25 were reported non-injury/non-mortality incidental take. Of the 25 large tortoises that were moved off roads, previously marked tortoises were encountered five times: NNSS11 and NNSS21 were both encountered twice and NNSS20 was encountered once. No tortoises were paper-tagged this year by MSTs biologists (see Conservation Recommendations), but two tortoises were paper-tagged by Clark County on the NNSS along the I-95 during their surveys for a culvert study in March: CC0428 and CC0453 (Figure 3-1).

Five of the roadside observations occurred during a rainstorm on the morning of October 5th. Biologists monitored roads during the rainstorm and provided "all nets" radio announcements to increase awareness during the storm and throughout the day.



**Figure 3-2. Juvenile tortoise observed foraging on a dirt road, but not handled.**

(Photos by J.A. Perry, June 7, 2021).

### 3.1.1 Mitigation for Loss of Tortoise Habitat

Prior to land-disturbing activities associated with any projects of the Work-for-Others 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 Desert Tortoise Sub-Account through the National Fish and Wildlife Foundation Chief Financial Officer for all Work-for-Others projects at the rate of \$936 per acre of disturbance. All other projects are able to 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 \$936 per acre of disturbance.

Ten projects disturbed habitat in 2021. Three were framework programmatic actions: 18-09, 19-16, and 20-01 and seven were programmatic actions: 18-33, 18-34, 19-41, 21-11, 21-13, 21-15, and 21-24. Projects 18-09 and 19-16 prepaid remuneration fees under previous Opinion File No. 84320-2008-F-0416. Project 20-01 prepaid remuneration fees under the current Opinion in 2020. Lastly, project 20-42 was appended to the Opinion in September and, although did not start work this year, a deduction of \$140,400 for the potential disturbance of 150 acres was applied.

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

- 18-33 disturbed 1.7 acres (a); therefore, fees cost \$1,591 (1.7 a x \$936)
- 18-34 disturbed 0.4 a; therefore, fees cost \$374 (0.4 a x \$936)
- 19-41 disturbed 0.6 a; therefore, fees cost \$562 (0.6 a x \$936)
- 21-11 disturbed 1.2 a; therefore, fees cost \$1,123 (1.2 a x \$936)
- 21-13 disturbed 2.2 a; therefore, fees cost \$2,059 (2.2 a x \$936)
- 21-15 disturbed 5.6 a; therefore, fees cost \$5,242 (5.6 a x \$936)
- 21-24 disturbed 0.3 a; therefore, fees cost \$281 (0.3 a x \$936)

## **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.

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 2021. There are currently ten tortoise carcasses approved by FWS to be processed and tested. They will be tested after Los Alamos National Laboratory 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 tortoise 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 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. Highlights include:

- Twenty-two of the study animals crossed roads with 1,206 road-crossing events. Vehicle encounters were reported at 13 of these events. No marked tortoises were killed or injured by vehicles during the study.
- Male tortoises averaged 13.1 (standard deviation [sd] = 15.5) paved road-crossing events per year, while females averaged 6.3 (sd = 7.7; two-sample t-test,  $P = 0.252$ ).
- Road-crossing events increased during the nesting season for females and during mating season for males.
- Tortoises crossed higher traffic volume roads (average [M] =  $21.5 \pm 14.7$ ) significantly less frequently than lower traffic volume roads ( $M = 60.3 \pm 55.2$ ; two-sample t-test,  $P = 0.018$ ).
- Road avoidance behaviors were observed with five tortoises not returning to or crossing roads.
- Spring core use area (areas of intense use) (minimum convex polygon estimator [50% MCP], 50% isopleth, 95% confidence interval) increased significantly as winter-spring (December-April) precipitation increased ( $R^2 = .951$ ,  $P = .0047$ ) (Figure 3-3).
- Tortoises spent 58% of time within 400 m of roads with majority of time spent 201-320 m from roads
- As distance increased beyond 320 m from roads, habitat use also decreased.
- Male cumulative home range (autocorrelated kernel density estimate [AKDE], 95% isopleth, 95% confidence interval) and core use area (areas of intense use [AKDE], 50% isopleth, 95% confidence interval) averaged 59% and 135% larger than those of females, respectively.
- Considerable overlap occurred between male and female home ranges (Figure 3-4).

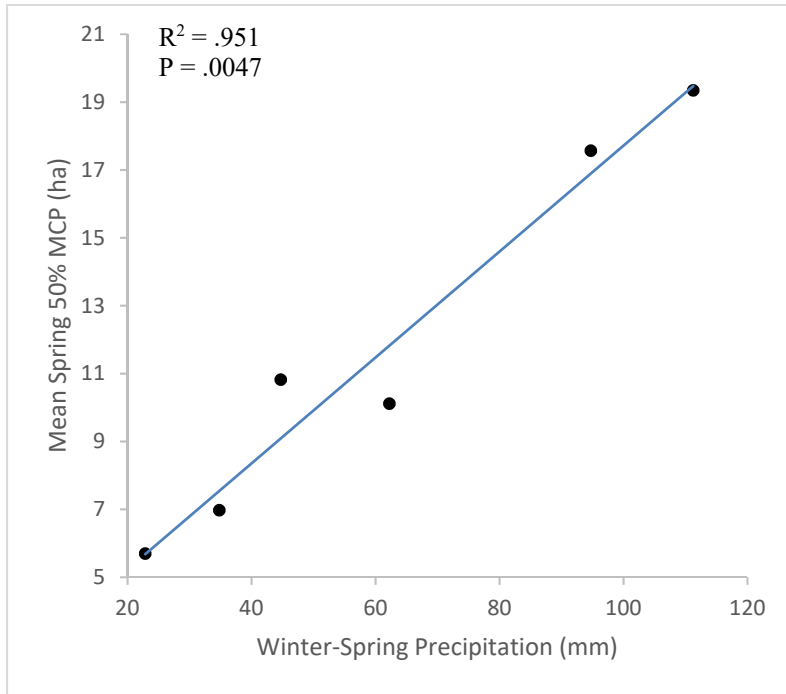
Results indicated tortoises utilize resources on both sides of roads and that exclusion fencing, although a necessity in decreasing roadkills along high trafficked roads, can be avoided when traffic is low and educational outreach is available on land removed from public domain. The results also concluded that seasonal activities and precipitation can be used to predict road-crossing events. Results and full discussion will be published.

Because the largest threat to the tortoise on the NNSS is the continued use of roads, research will continue on this topic. 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). No tortoises were marked in 2021 by MSTs biologists, but two were paper-tagged by Clark County on the NNSS along the I-95 during their surveys for a culvert study in March: CC0428 and CC0453 (Figure 3-1).

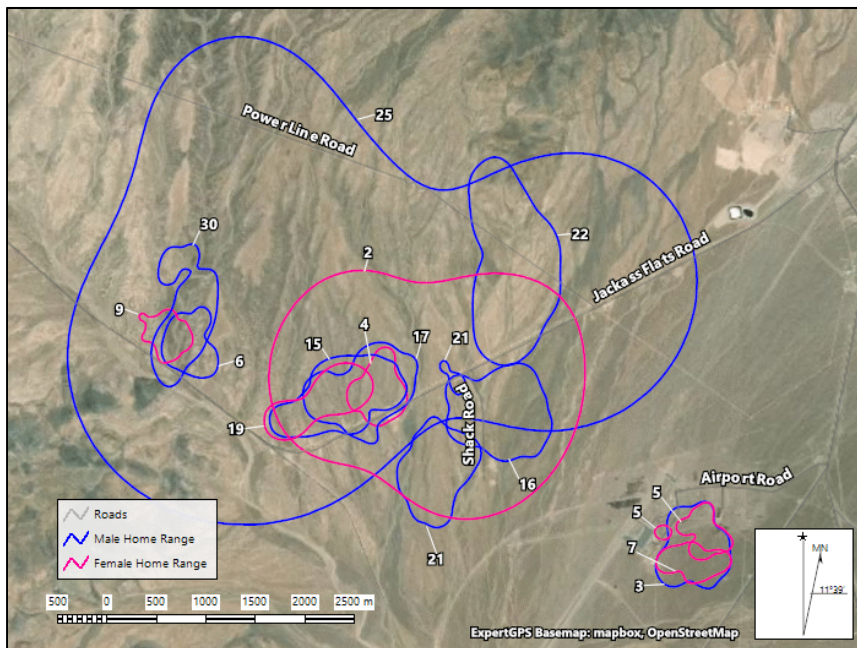
### **3.2.2 Juvenile Translocation Study**

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.



**Figure 3-3. Relationship between mean annual (2013-2018) spring (March-May) core use area (50% MCP) and winter-spring (December-April) precipitation.**



**Figure 3-4. Mercury Valley along Jackass Flats Road where 15 of 30 study animals were monitored, revealing overlap in home range (95% AKDE) of male and female tortoises.**

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 2021. During 2021, monitoring occurred once in January and February; weekly in March, April and May; twice in June, July and August; weekly in September and October; three times in November; and once in December. Additional monitoring was conducted in early January 2022 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 2021, 18 tortoises were known or assumed to be alive, including two missing tortoises with failed transmitters (Table 3-4; Figure 3-5). By the end of 2021, 12 of the 60 tortoises (20.0%) (5 female, 7 male) were known to be alive. This does not include 4040 and 4041 which were not found during many search attempts in 2021, and are assumed to be missing due to transmitter failure. Four tortoises (1 female, 3 male) were found dead during 2021 (Table 3-4; Figure 3-5). Although no carcass was found, Female 4014 was assumed to be dead due to predation on March 29<sup>th</sup> after its burrow was found mostly collapsed with disturbed soil and vegetation in the area along with coyote tracks. On June 21<sup>st</sup> Male 4053 was found dead due to predation. The burrow it was using previously was dug up by a predator. On August 23<sup>rd</sup> Male 4005 was found flipped over on its back with no sign of predation. Cause of death is unknown but may have been due to being flipped by another tortoise. On September 7<sup>th</sup> Male 4038 was found in pieces with disturbed soil and vegetation and coyote tracks in the area. Cause of death was predation.

Our survival rate of 20.0% (12 of 60 alive) after nine years is a little lower but comparable to an estimated 22.7% (14 of 60 alive) survival based on an annual survival rate of 85.0% calculated for a natural population (Turner et al. 1987). Excluding the three missing males (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 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 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 18 juvenile tortoises monitored during 2021. On average, the distance between the release location and winter 2021-2022 burrow (i.e., the burrow a juvenile was in during the first part of January 2022) was 528 m (range = 27 – 2,377 m, sd = 651) which is nearly half the distance reported in 2020. On average, tortoises used winter burrows in 2021, 62 m away from their 2022 winter burrows, which is 10 times less than in 2020. Two-thirds (8 of 12) of the tortoises wintered in burrows within 100 m of their last year's winter burrow, and half (6 of 12) of them used the same winter burrow as the previous year. The average distance moved between monitoring checks was 1,618 m (range = 417 – 6,533 m; sd = 1,724 m) which is substantially less than 2,388 m moved during 2020. 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.

**Table 3-4. Mortality, sex, distance in meters (m) between release site and January 2022 burrow, distance between January 2021 burrow and January 2022 burrow, total distance between monitored locations (January 2021 to January 2022), and total number of burrows and new burrows occupied by 18 juvenile desert tortoises monitored during 2021.**

<b>Tortoise Number</b>	<b>Sex</b>	<b>Distance (m) Release to January 2022 Burrow</b>	<b>Distance (m) between January 2021 and January 2022 Burrows</b>	<b>Total Distance (m) between locations (January 2021 to January 2022)</b>	<b>Number of Burrows Used (New Burrows)</b>
4014 <sup>a</sup>	Female	NA	NA	NA	NA
4030	Female	2377	174	417	3 (0)
4039	Female	150	68	424	4 (3)
4044	Female	227	0	1024	3 (1)
4045	Female	188	0	1435	2 (1)
4046	Female	376	210	6533	7 (4)
4004	Male	220	63	1087	6 (3)
4005 <sup>b</sup>	Male	NA	NA	NA	4 (0)
4007	Male	27	0	957	6 (1)
4011	Male	637	107	3331	8 (4)
4025	Male	1101	0	779	5 (1)
4034	Male	215	0	1016	7 (3)
4036	Male	575	117	877	3 (0)
4038 <sup>c</sup>	Male	NA	NA	NA	3 (2)
4040 <sup>e</sup>	Male	NA	NA	NA	NA
4041 <sup>e</sup>	Male	NA	NA	NA	NA
4048	Male	240	0	1539	4 (1)
4053 <sup>d</sup>	Male	NA	NA	NA	NA
	Average	528	62	1618	

<sup>a</sup>Found dead on 3/29/21

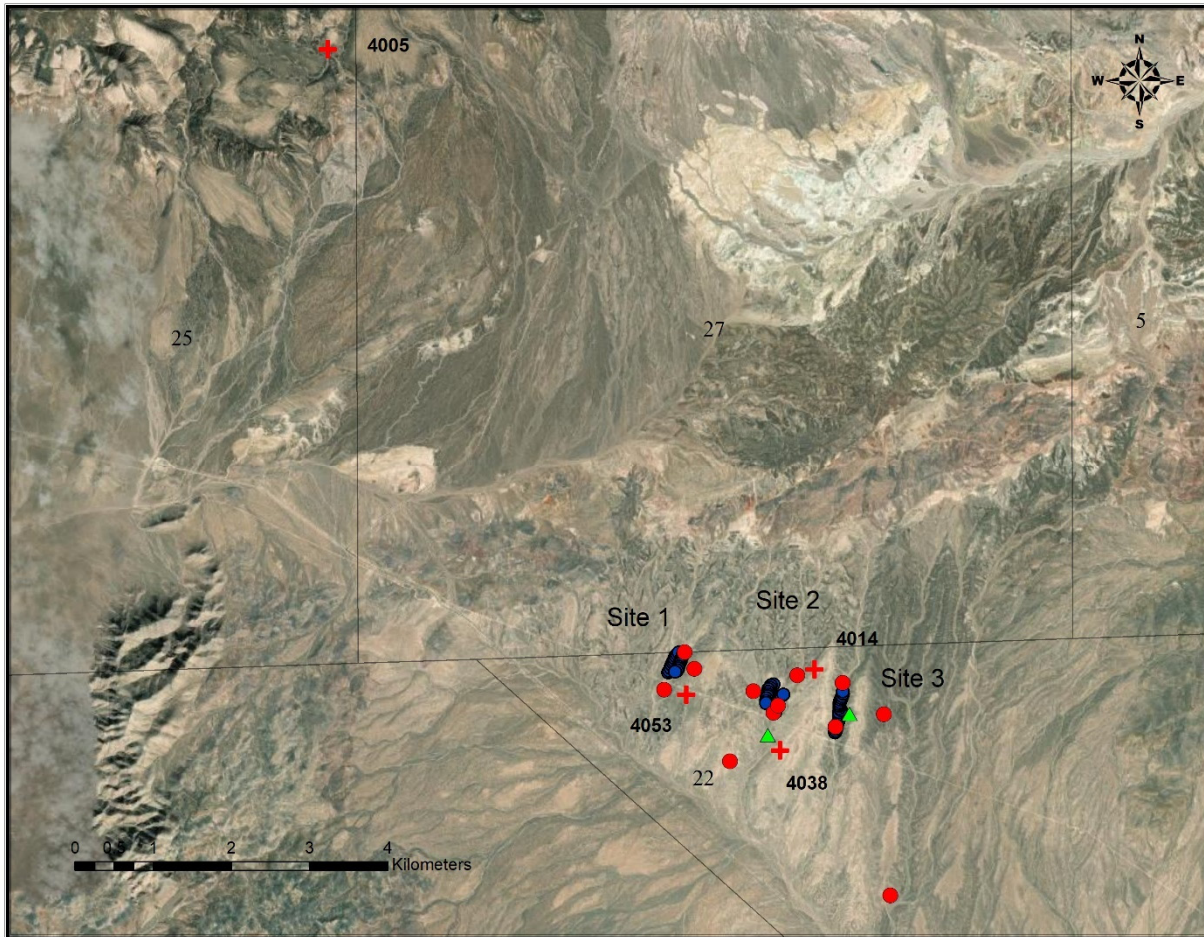
<sup>b</sup>Found dead on 8/23/21

<sup>c</sup>Found dead on 9/7/21

<sup>d</sup>Found dead on 6/21/21

<sup>e</sup>Assumed to be missing

NA = Not Applicable



**Figure 3-5. Release locations for 60 tortoises, September 2012 (blue dots, 20 at each site) and last known locations for 18 tortoises monitored during 2021 (red dot = living tortoise [n = 12]; red cross = dead tortoise [n = 4] with tortoise number in black text; and green triangle = missing [n = 2]).**

During 2021, 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 checks, so it is likely that not all burrows used were documented. A total of 65 unique burrows were used during 2021, including 24 new burrows that were marked and measured. The average height of new burrows was 12.4 mm (range = 8 - 25 mm; sd = 5.0 mm) and average width of burrows was 23.4 mm (range = 15 - 34 mm; sd = 5.3 mm). On average, tortoises used 4.6 unique burrows (range = 2 - 8; sd = 1.9) (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). Precipitation during summer and fall was sparse, resulting in little food for tortoises to eat.

**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 2014–2021.**

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

Between early January 2021 and early January 2022, 475 observations were recorded. Tortoises were inside burrows 81% of the time and aboveground 19% of the time including under vegetation (11%), in the open (5%), in the burrow mouth (2%), or on the burrow apron (1%) (Figure 3-6). Of the 54 observations under vegetation, 43% were under blackbrush (*Coleogyne ramosissima*), 11% were under pale desert-thorn (*Lycium pallidum*), 7% were under Nevada jointfir (*Ephedra nevadensis*), 7% were under Fremont’s dalea (*Psorothamnus fremontii*), 18% were under mixed shrub species clumps, and the remaining 14% under six other shrub species including 4% shadscale saltbush (*Atriplex confertifolia*), and 2% each of white bursage (*Ambrosia dumosa*), spiny hopsage (*Grayia spinosa*), littleleaf ratany (*Krameria erecta*), creosote bush (*Larrea tridentata*), and water jacket (*Lycium andersonii*) (Figure 3-7).

For the 24 new burrows, tortoises used burrows on wash slopes 50% of the time followed by burrows in wash bottoms (42%) and equally split between active wash (4%) and ridgetops (4%) (Figure 3-8). Vegetation cover at burrows was found at 83% of the burrows, suggesting this may be an important factor in burrow use for these juveniles. Pale desert thorn was the dominant species (30%) followed by mixed shrub clumps (25%), creosote bush (20%), Nevada jointfir (15%), white bursage (5%), and burrobrush (*Hymenoclea salsola*) (5%) (Figure 3-9).

Gravel was the dominant substrate at over 40% of all new juvenile tortoise burrows followed by gravel/cobble (21%), cobble (17%), sandy/gravel (13%), sandy/cobble (4%), and sandy (4%) (Figure 3-10). 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 10 tortoises, 17 times between March 29 and September 7, 2021, with a foraging peak in April (6 times) (Figure 3-11). This was a substantial decrease from previous years. The most commonly observed species eaten was red brome (*Bromus rubens*) (17.6%) followed by *Gilia* species (5.9%) and shadscale saltbush (5.9%) (Figure 3-12). Most (71%) of the time, it was not possible to identify what the tortoises had eaten. Winter and spring precipitation were about half of normal and production of annual forbs and grasses, even *Bromus* species, was virtually non-existent. Summer and fall precipitation were also below normal which resulted in low plant production and reduced foraging opportunities during this time period.

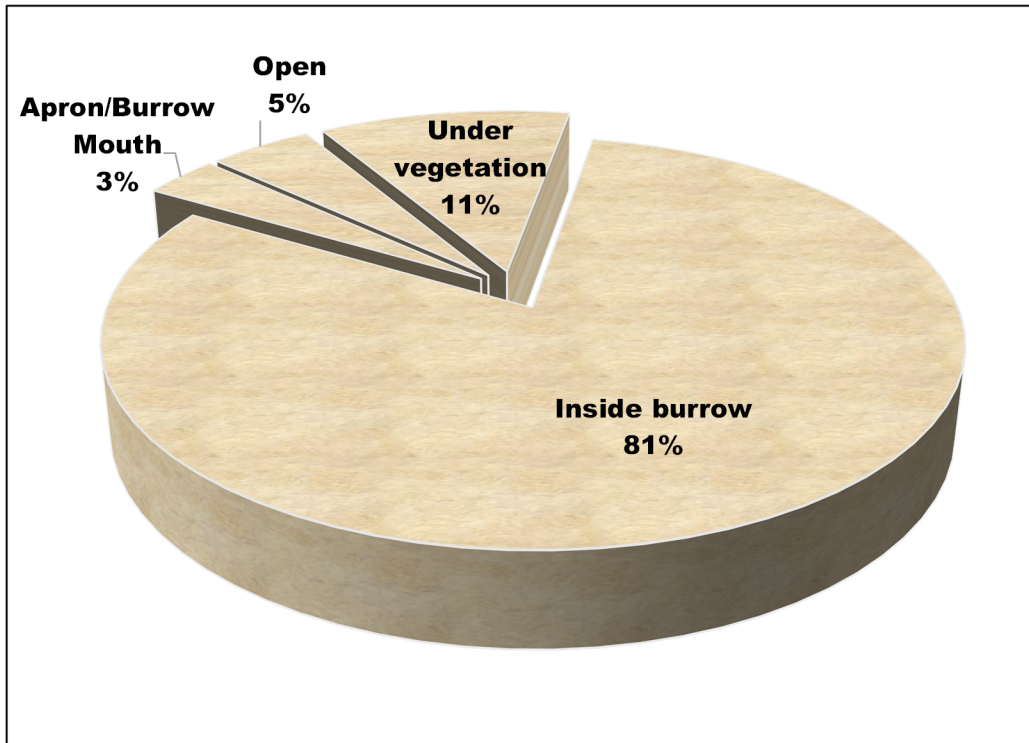


Figure 3-6. Percentage of observations (n = 475) of 18 juvenile tortoises by location, January 2021–January 2022.

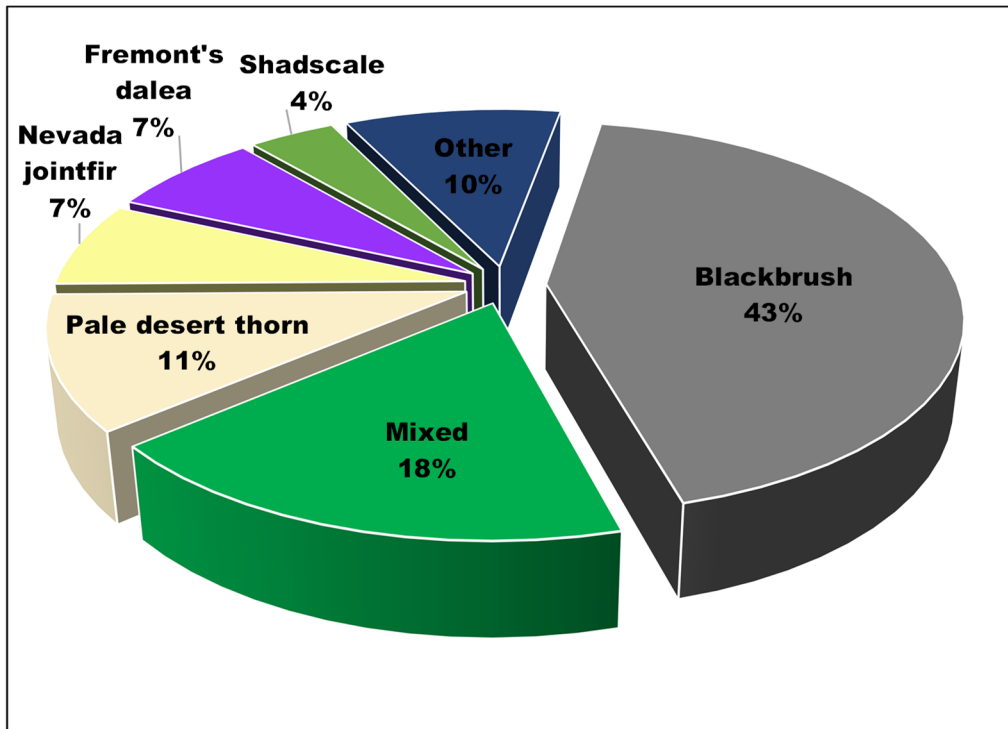


Figure 3-7. Percentage of observations (n = 54) of 18 juvenile tortoises found under vegetation by species, January 2021–January 2022.

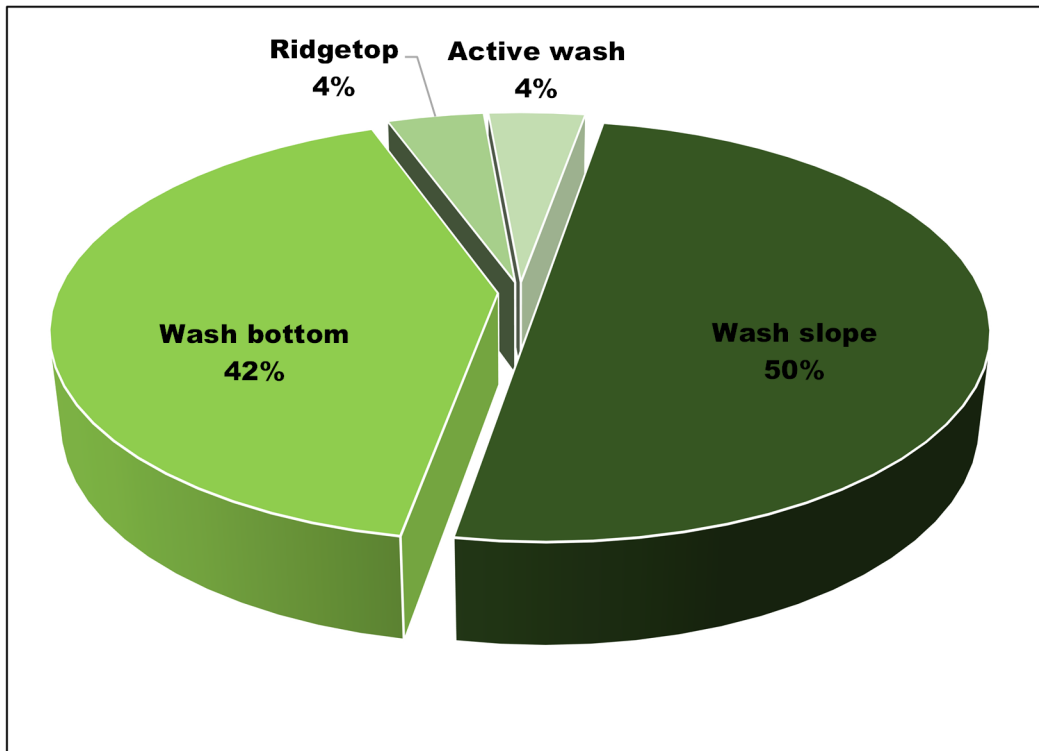


Figure 3-8. Percentage of new juvenile tortoise burrows by topographic position, January 2021–January 2022 (n = 24).

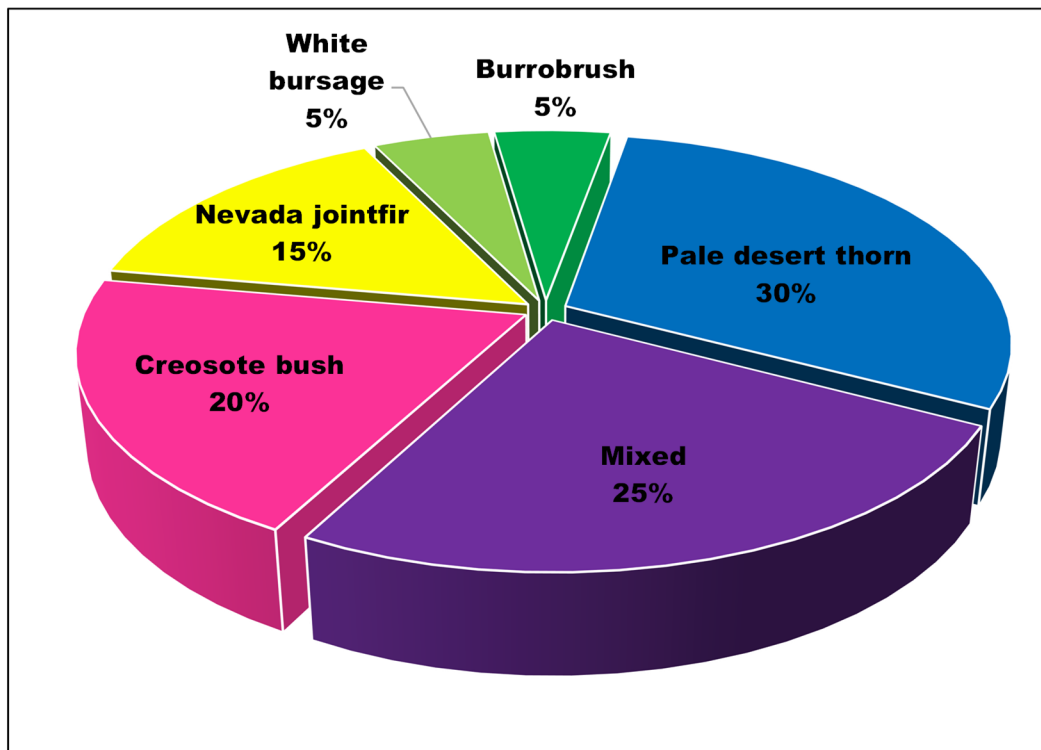
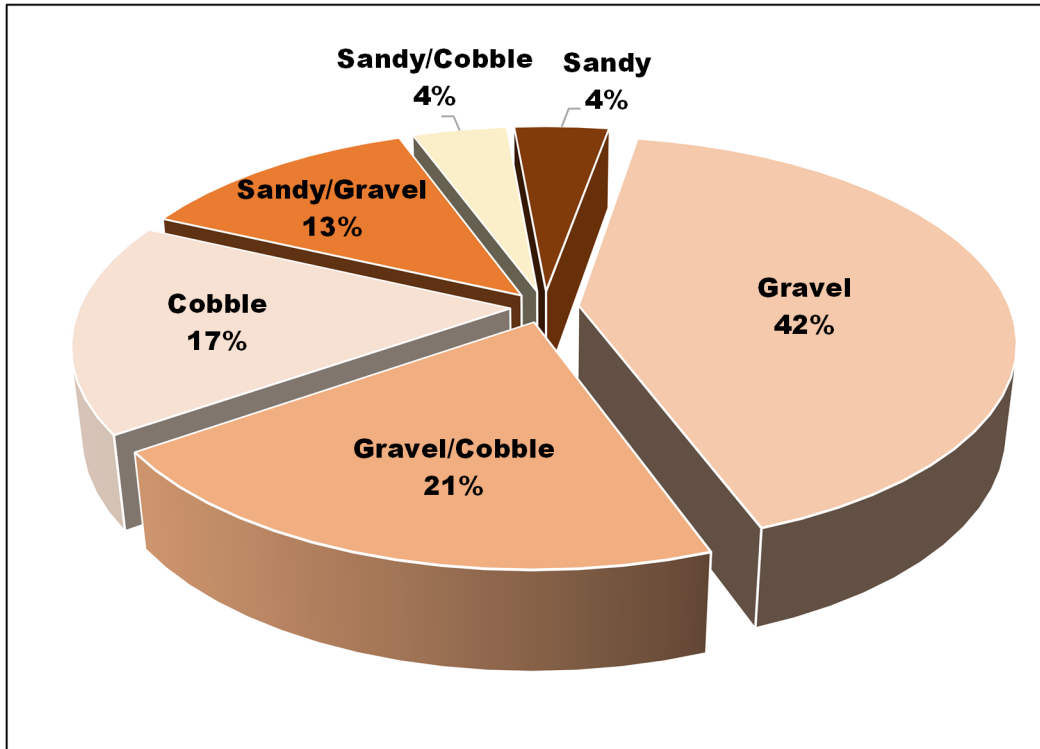
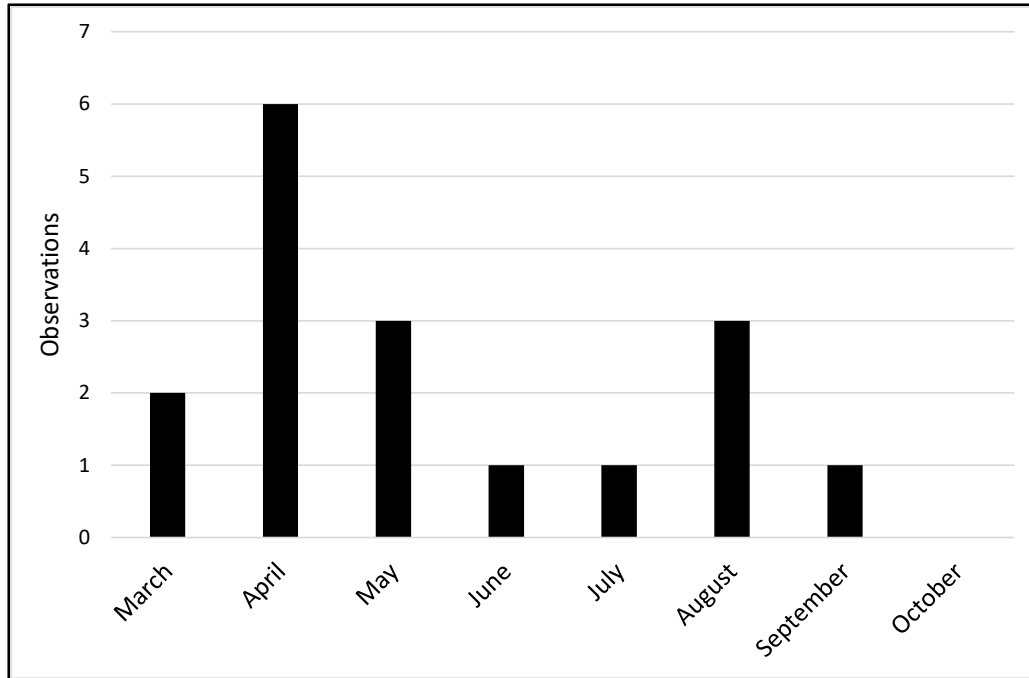


Figure 3-9. Percentage of new juvenile tortoise burrows by vegetation cover at the burrow, January 2021–January 2022 (n = 20).



**Figure 3-10. Percentage of juvenile tortoise burrows by substrate, January 2021–January 2022 (n = 24).**

All transmitters were changed in the fall and health assessments were conducted at the time of transmitter changes except for three tortoises (Female 4039, Female 4044, and Male 4025) which were not found outside of their burrows during the fall, so their transmitters were not changed and health assessments were not completed. Most living tortoises were also measured and weighed and given a Body Condition Score (BCS) (1-3 = under condition, 4-6 = good condition, 7-9 = over condition) in both spring and fall (Table 3-6). Results from health assessments showed that all tortoises were in good condition (BCS4-5). Some observations from the health assessments include: one tortoise had occluded nares (Male 4007); one tortoise (Male 4011) had mild, serous discharge from both eyes; and three had localized trauma to the carapace or plastron. Male 4034 had signs of old trauma from unknown cause on the nuchal and right costal scutes 9-10; Male 4048 had active trauma with whitish flaking on plastron and exposed bone on left costal scutes 1, 3, and 4 and caudal scute 4; and Female 4046 had whitish flaking from transmitter on the right costal scutes 1 and 3 and old damage on the nuchal and right margin scutes 8, 9, and 11. Two tortoises voided during handling. Male 4034 voided during the fall and was rehydrated via saline injection and Female 4030 voided <1 ml during the spring and was rehydrated via oral administration of drinking water.



**Figure 3-11. Number of times evidence of foraging was detected by month for 24 juvenile tortoises, January 2021–January 2022 (n = 17) (no evidence of foraging was detected in January, February, October, November or December).**



**Figure 3-12. Male tortoise (#4048) eating shadscale saltbush, August 2021.**

(Photo by D.B. Hall August 3, 2021).

**Table 3-6. Midline carapace length (MCL) (mm) and body condition score in fall 2012, spring 2021, and fall 2021; weight without transmitters (gram [g]) in fall 2012 and fall 2021; MCL growth and weight gain from fall 2012 to fall 2021; and MCL growth spring 2021 to fall 2021 for 18 tortoises monitored in 2021.**

Tortoise Number	Sex	Pre-release MCL (mm) 2012	MCL (mm) (Spring 2021)	MCL (mm) (Fall 2021)	MCL Growth (mm) 2012-2021	MCL growth (mm) Spring 2021 to Fall 2021	Pre-release Weight (g) (2012)	Weight (g) (Fall 2021)	Weight gain (g) 2012-2021	Pre-release Body Condition (2012)	Body Condition (Spring 2021)	Body Condition (Fall 2021)
4014	Female	136	*	*	*		485	*	*	5	*	*
4030	Female	148	191	192	44	1	562	1350	788	4	4	4
4039	Female	117	162	*	*	*	315	*	*	5	5	*
4044	Female	146	197	*	*	*	484	*	*	4	4.5	*
4045	Female	129	167	168	39	1	400	962	562	4	4	4
4046	Female	126	190	191	65	1	476	1600	1124	4	4	5
4004	Male	117	171	173	56	2	303	923	620	4	4	4
4005	Male	140	187	*	*	*	564	*	*	5	5	*
4007	Male	121	140	140	19	0	363	565	202	5	4	4
4011	Male	144	216	216	72	0	634	1700	1066	4	4	4
4025	Male	127	190	*	*	*	357	*	*	5	4	*
4034	Male	128	187	185	57	-2	407	1250	843	4	4	4
4036	Male	132	183	182	50	-1	455	1200	745	4	4	4
4038	Male	132	212	*	*	*	457	*	*	4	4	*
4048	Male	135	224	224	89	0	480	2000	1520	5	4	4.5
4053	Male	150	173	*	*	*	681	*	*	4	4	*
	<b>Average</b>	133	186	186	55	0.2	464	1283	830			

\* = data not taken due to mortality or unable to tap out of burrow

Table 3-6 contains information on MCL (mm) and BCS for fall 2012 (pre-release), spring 2021 and fall 2021 and weight without transmitter (g) for fall 2012 (pre-release) and fall 2021. Also included is information on growth (mm) from fall 2012 to fall 2021, spring 2021 to fall 2021, and weight gain (g) from fall 2012 to fall 2021. Surviving juvenile tortoises have grown an average of 55 mm and gained an average of 830 g between time of release in fall 2012 and fall 2021. In addition, average growth between spring and fall 2021 was negligible at 0.2 mm. This is most likely due to the drought conditions during 2021 and lack of forage.

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; and 358 days between January and December 2021, for a total of 1,370 days. Results showed 11 coyote images which is about one every 125 days, 13 kit fox images which is about one every 105 days, 12 badger (*Taxidea taxus*) images which is about one every 114 days, and 4 bobcat (*Lynx rufus*) images which is about one every 343 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 (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.

Overall, the remaining 12 translocated tortoises seem to be doing well. A pattern of reduced activity was evident during 2021, likely due to the drought conditions that prevailed through most of the year. Hopefully, additional moisture will fall in 2022 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 Rock Valley Circular Pens

The United States Geological Survey (USGS) in collaboration with FWS, ICR, and Penn State University conducted an epidemiology study in three 9-ha pens in Rock Valley from 2013-2017. Translocated tortoises were placed in the pens during the study resulting in some mating and a few juvenile tortoises were observed within the pens. The translocated tortoises have since been

removed from the pens. FWS considers any offspring within the pens as residents. MSTS biologists surveyed the pens in 2018 and, although one nonviable tortoise egg was found under a shrub, no tortoises were found. On August 26, 2021 the pens were surveyed again during a high humidity event and three juvenile tortoises were found (Figure 3-13). One tortoise approximately 95 mm MCL was found Pen 1 with a BCS 4. Two tortoises were found in Pen 2: 120 mm MCL with a BCS 5 and 95 mm MCL with a BCS 5. The observations in Pen 2 were very close to observations made during the USGS study (Figure 3-13). No tortoises were observed in Pen 3. All three tortoises were healthy with sufficient natural resources within the pens. The pens will continue to be monitored to determine the number of tortoises in each pen and a determination on relocating the tortoises outside the pens will be decided in conjunction with FWS.

### 3.2.4 Coordination with Other Biologists and Wildlife Agencies

- MSTS biologists continued to join the Desert Tortoise Transportation Ecology workshop webinars through March 2021 developed and organized in collaboration with the Center for Large Landscape Conservation, Western Transportation Institute, Federal Highway Administration, NDOT, Bureau of Land Management, Clark County Desert Conservation Program, and Tortoise Group. The collaboration has concluded with a Basecamp website to share data and information addressing issues regarding effects of transportation infrastructure on tortoise recovery and assist with development of management measures to minimize road mortality and increase connectivity for tortoise populations.
- An MSTS biologist attended the 46<sup>th</sup> Annual Desert Tortoise Council Symposium in February. The meeting was held virtually and included numerous presentations on desert tortoise biology, ecology, and recovery efforts.
- 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 five years of the study. It is anticipated that this will be submitted for publication during 2022.
- MSTS biologists are collaborating with Los Alamos National Laboratory (LANL) on a study to determine radiation impacts on tortoises through scute sampling.
- MSTS biologists facilitated access to conduct desert tortoise surveys along the southern NNSS boundary as part of a study by Clark County to assess use of culverts that run under I-95. This study is part of a larger habitat connectivity study to determine effects of transportation corridors on movements of desert tortoises.

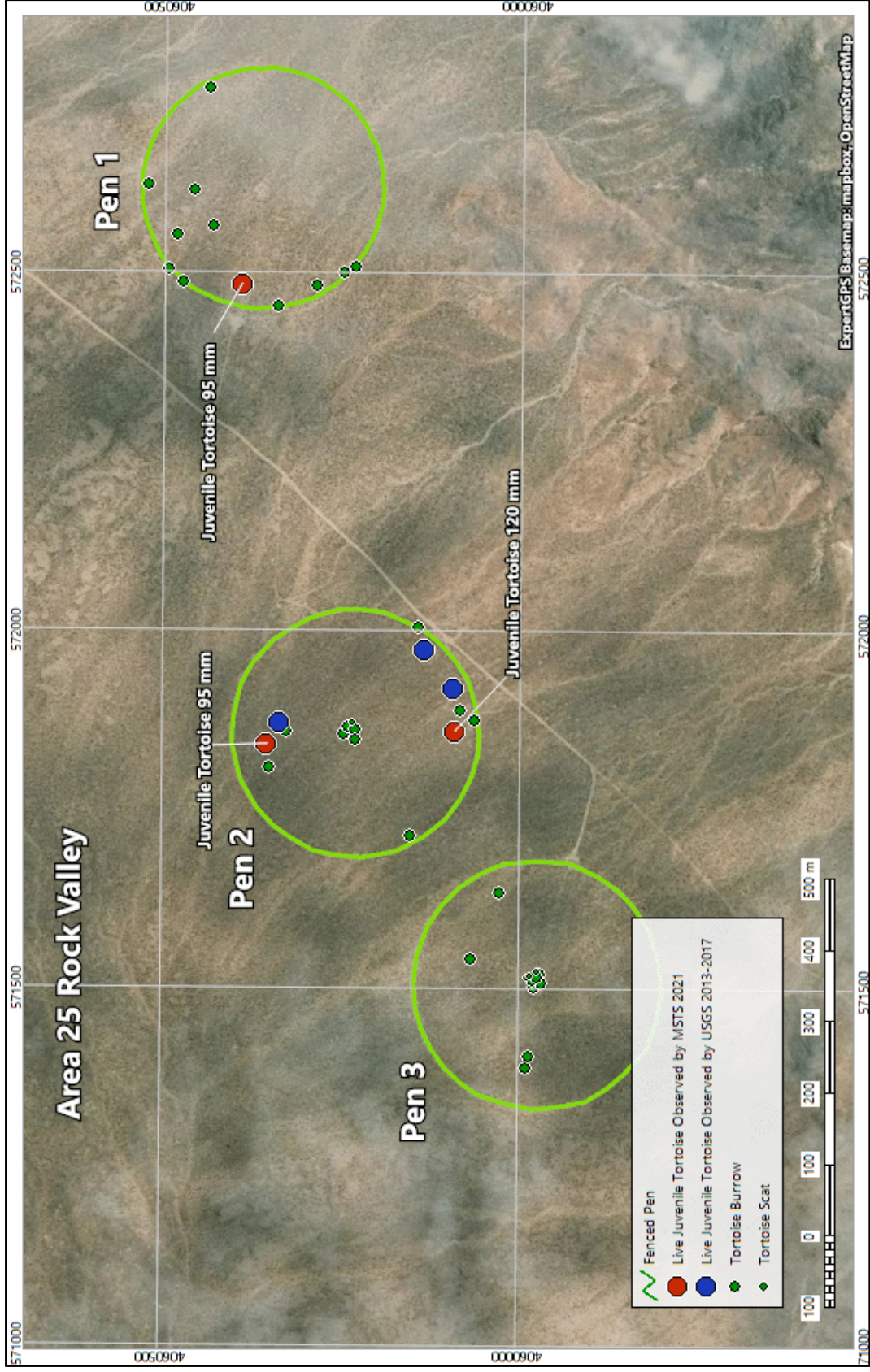


Figure 3-13. Locations of juvenile tortoises observed in the circular Rock Valley pens. Coordinates in UTM NAD83 (Zone 11, meters).

## 4.0 ECOSYSTEM MONITORING

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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 2021 focused on wildland fire fuels surveys, contributing to the development and writing of wildland fire recovery plans, natural water source monitoring, and constructed water source monitoring, including contaminated sumps.

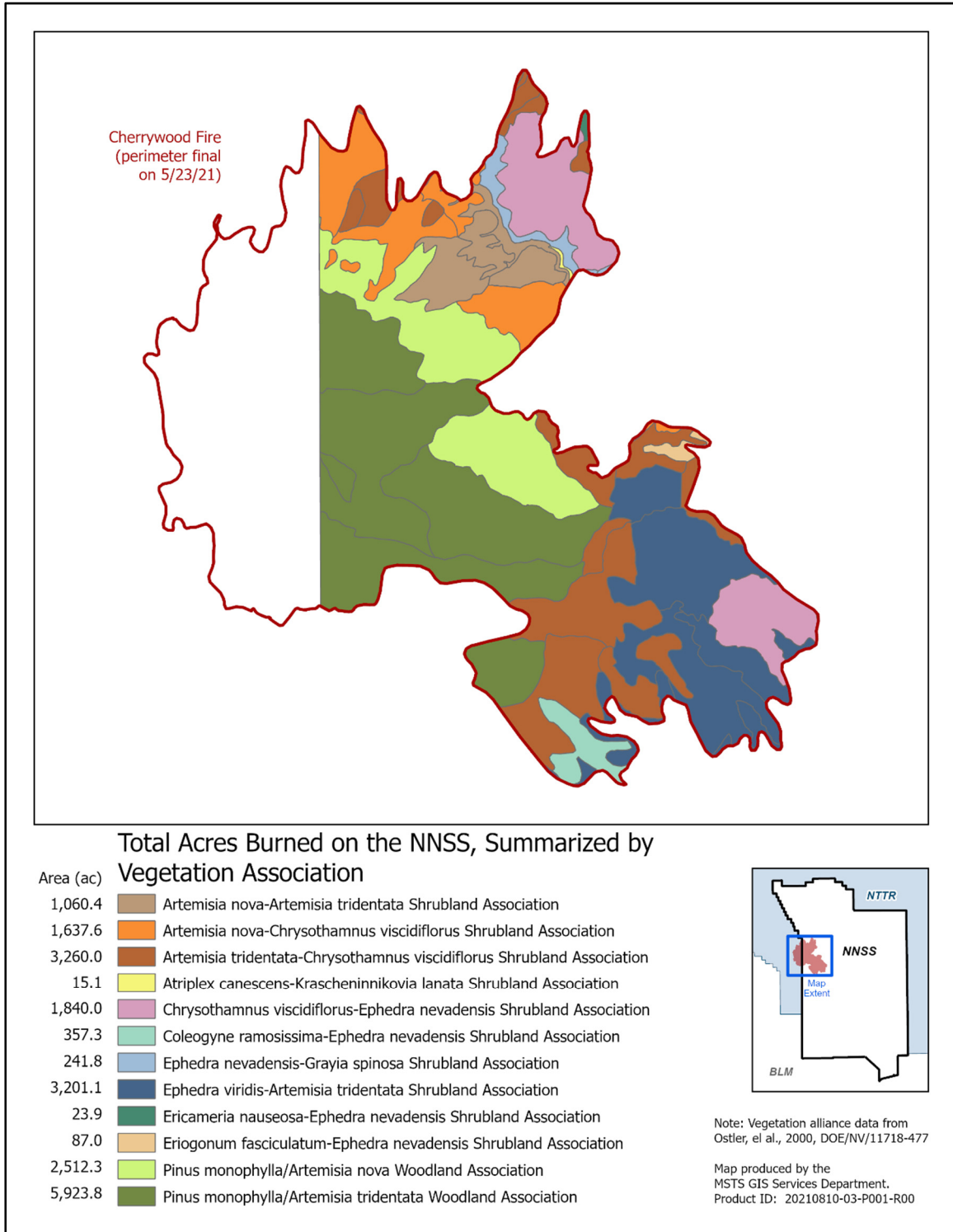
### 4.1 Wildland Fire Fuel Surveys and Recovery Plans

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. 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 2021, wildland fire recovery plans written for specific fires, and methods and results of fuel surveys designed to assess annual wildland fire risk on the NNSS.

#### 4.1.1 Wildland Fires in 2021

From 1978 to 2021, an average of 10.2 wildland fires per year and about 121.1 ha per fire have burned on the NNSS. Most wildland fires are caused by lightning and do not occur randomly across the NNSS, but occur more often in particular vegetation types (e.g., blackbrush 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).

Nine wildland fires were reported on the NNSS in 2021, all of which were caused by lightning. The largest fire, named the Cherrywood Fire, burned a total of 7,967 ha on the NNSS and an additional 2,729 ha on the adjacent Nevada Test and Training Range (NTTR). The fire burned much of Timber Mountain including previously burned areas in several vegetation associations, primarily those dominated by pinyon pine, Utah juniper, and sagebrush species (Figure 4-1). This fire started in mid-May which was earlier than usual. Drought conditions, annual grass dominance from previous fires, and high, erratic winds contributed to the large size and rapid spread of this fire. NNSS Fire and Rescue, BLM and other agencies were brought in to fight the



**Figure 4-1. Number of acres burned by vegetation association in the Cherrywood Fire on the NNSS, May 2021.**

fire, including air support and ground crews. The Area 19 Southern Bench Fire ignited by lightning on August 25, burned 365.8 ha on the NNSS in the Kawich Canyon area and another 7,494.0 ha on the adjacent NTTR. The Black Glass Canyon Fire started July 18 and burned 348.4 ha in the remote area west of Fortymile Canyon. The Area 16 East Fire was ignited by lightning on June 29 and burned 64.7 ha. The remaining five fires burned less than 10 ha.

### **4.1.2 Wildland Fire Recovery Plans**

A relatively new requirement identified in the Consolidated Emergency Management Plan (NFO-EOC-PLN-101) necessitated the development of recovery plans for specified fires based on their impact and magnitude of acreage burnt. Two recovery plans were written during 2021. The first was PLN-2120-CWF for the Cherrywood Fire. The second was PLN-2120-Y21 for the Area 16, Emilie Seep, South Shoshone, Black Glass Canyon, Bushy, and Southern Bench wildland fires. MSTs biologists developed the framework for the biological resources and wind and water erosion sections of the plan and then authored the content of these sections for each plan. The primary objectives were to evaluate the impacts of the fires on: 1) species protected under the ESA (i.e., desert tortoise), 2) sensitive and/or protected/regulated species or important biological resources (e.g., water sources), 3) vegetation changes, potential for conversion to annual grassland, and possible rehabilitation measures, and 4) wind and water erosion potential and possible rehabilitation measures.

### **4.1.3 Fuel Survey Methods**

Beginning in 2004, and in response to DOE O 231.1B, surveys were initiated on the NNSS to identify wildland fire hazards. Vegetation surveys were conducted between April 20 and June 14, 2021, 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) 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.

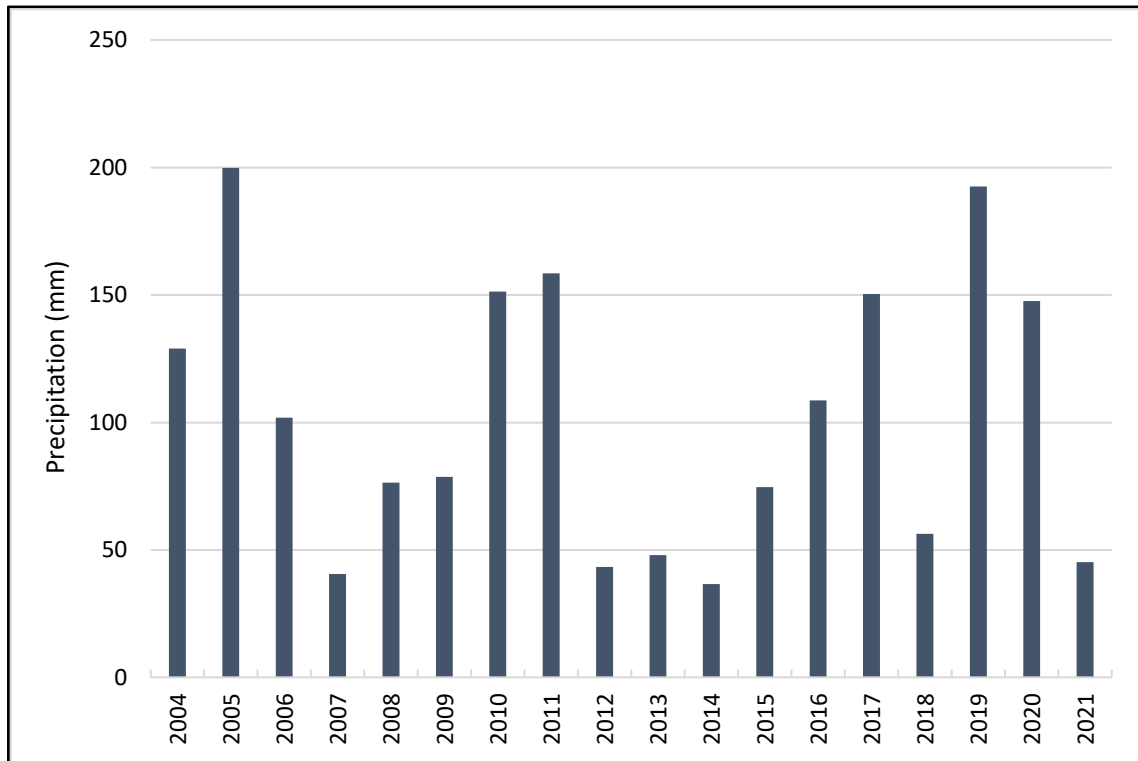
### **4.1.4 Fuel Survey Results**

#### **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. 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 2021 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. 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 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 five months is correlated ( $r = 0.770$ ) with our estimations of the combined fuel loads. During 2021, the average precipitation from the remaining 14 rain gauge stations on the NNSS during December–April was 45.3 mm, which is less than half the average amount of 104.6 mm received on the NNSS (Figure 4-2).



**Figure 4-2. Average precipitation from December (previous year) through April for the years 2004 through 2021 (long-term average 104.6 mm).**

#### **4.1.4.2 Fuels**

Due to the well below-average precipitation received during winter/spring 2020-21, production of annual forbs and grasses was virtually non-existent. 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 last year persisted in large quantities.

The fine fuels index decreased from 2.53 in 2020 to 2.14 in 2021. This was an average value in comparison to the other index values since 2004 (Table 4-1). Most of the fine fuels were from invasive annual grasses such as red brome and cheatgrass (*Bromus tectorum*) with nearly all the biomass persisting from last year's growth rather than from this year's growth. This highlights the wildland fire risk these invasive species create not just in high production (wet) years but for multiple years after wet years even during drought conditions like this year.

The woody fuels index value decreased slightly from 2.60 in 2020 to 2.56 in 2021 (Table 4-1). This was an average value in comparison to the other index values since 2004.

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 5.13 in 2020 to 4.70 in 2021 (Table 4-1). This is an average value in comparison to the other index values since 2004, 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 2021 are shown in Figures 4-3, 4-4, and 4-5, respectively. The highest combined index values (Figure 4-5) and thus the highest potential for wildland fires occurred in Fortymile Canyon, Mid Valley, and southern Yucca Flat. High amounts of fine fuels were found in Fortymile Canyon, Yucca Flat, and Mid Valley (Figure 4-3). High amounts of woody fuels were primarily found in the forested portions of Pahute Mesa, but also occurred along Stockade Wash Road, Cane Spring Road, southern Yucca Flat, and upper Fortymile Canyon (Figure 4-4).

Photographs were taken from permanent locations for all 104 sites during the past 15 years. For example, Figure 4-6 shows photographs of Site 99 in Yucca Flat for the years 2018, 2019, 2020, and 2021. 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.

#### **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). Cheatgrass was the most common invasive plant but only occurred on 24% of the study sites. While it was predominantly found at middle to higher elevations it was found at lower elevation sites as well. Red brome was found at 18% of the sites, mostly at low to moderate elevations. Native annual forbs were sparse this year (Table 4-2). Values in Table 4-2 only reflect plants that germinated this year and do not include residual plants from last year. Precipitation history (Figure 4-2, shown previously) 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

Table 4-1. Woody fuels, fine fuels and combined fuels index values for 2004–2021.

<b>Year</b>	<b>Average Woody Fuels Index</b>	<b>Average Fine Fuels Index</b>	<b>Average Combined Fuels Index</b>
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

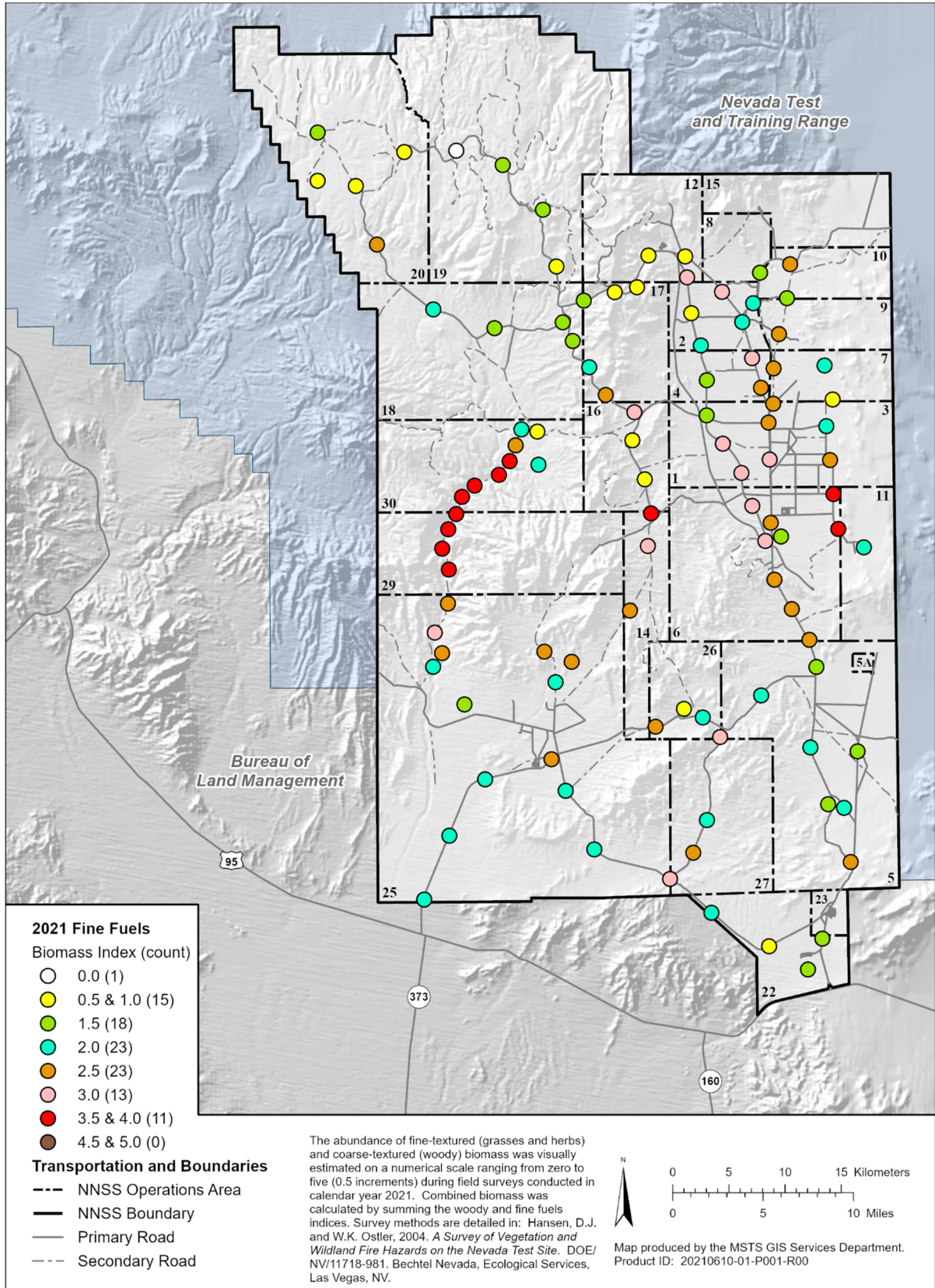


Figure 4-3. Index of fine fuels for 104 survey stations on the NNSS during 2021.

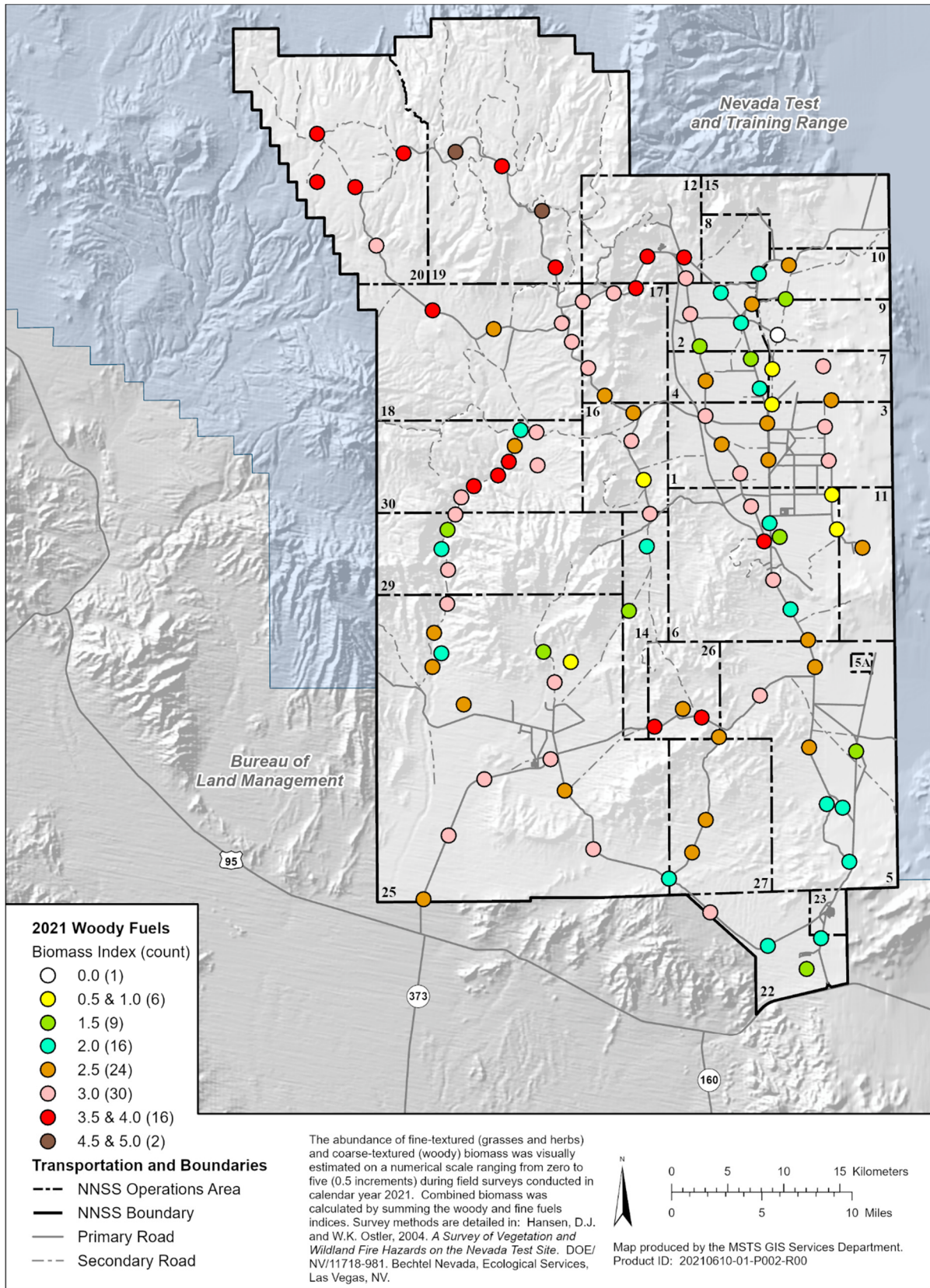


Figure 4-4. Index of woody fuels for 104 survey stations on the NNSS during 2021.

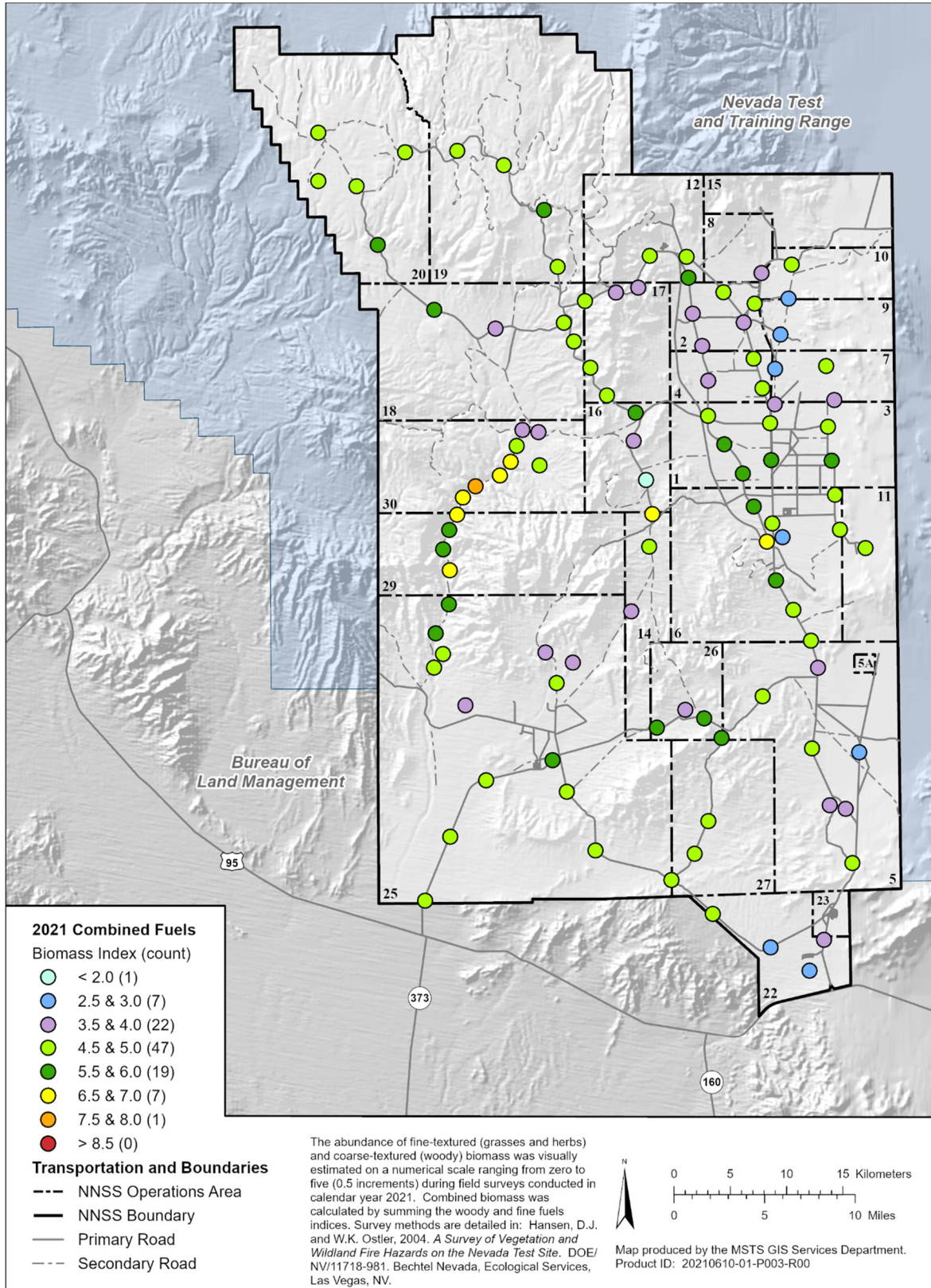
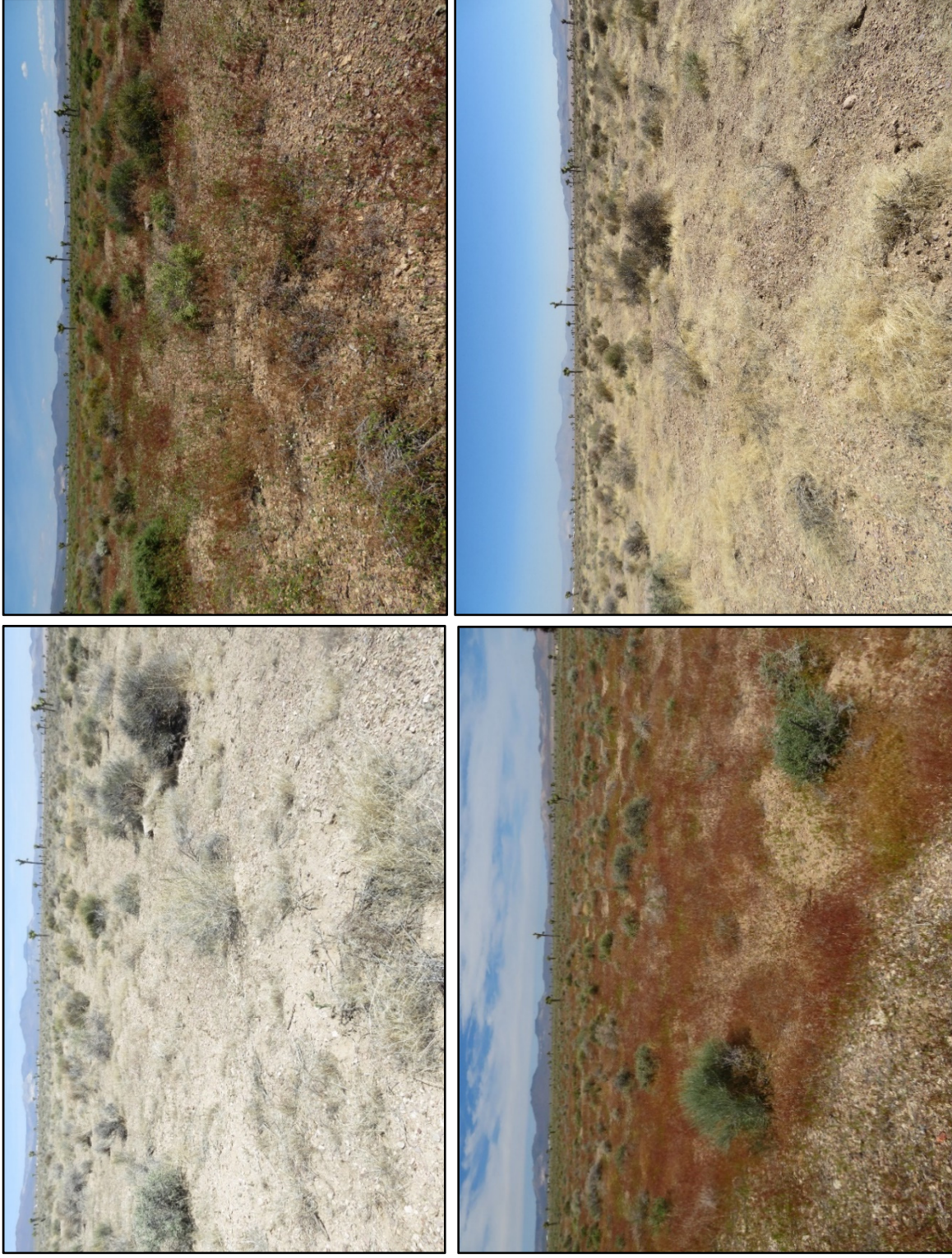


Figure 4-5. Index of combined fine fuels and woody fuels for 104 survey stations on the NNSS during 2021.



**Figure 4-6. Site 99 on the west side of Yucca Flat in 2018, 2019, 2020, and 2021.**  
(Photos by J. Perry, April 24, 2018 [top left], May 14, 2019 [top right], May 6, 2020 [bottom left], and May 20, 2021 [bottom right]).

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	
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	
<b>Invasive Introduced Species</b>																			
<i>Bromus rubens</i> (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	
<i>Bromus tectorum</i> (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	
<i>Erodium cicutarium</i> (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	
<i>Schismus arabicus</i> (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	
<b>Native Species</b>																			
<i>Amsinckia fessellata</i> (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	
<i>Mentzelia albicaulis</i> (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	
<i>Chaenactis fremontii</i> (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	

the plant was observed to be present and growing). Percent presence is generally greatest during periods of high precipitation, and appears to be a good indication of germination. Higher percent presence is also expected to occur when regional storms provide precipitation to a greater number of operational areas across the NNSS. However, the responses of some species, both invasive and native species, suggest that other variables, such as the timing of precipitation or temperatures required for germination, may also be contributing to plant response 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 was about average for 2021. 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.

### 4.2 Reptile Studies

No formal trapping or roadkill studies took place in 2021. 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.

One adult red racer (*Masticophis flagellum*) was found in the bottom of a utility vault in the north end of Frenchman Flat and was safely removed and released back into the desert. Another red racer was found on a glue trap in a building in Yucca Flat and safely removed and released. An adult western fence lizard (*Scleropus occidentalis*) found on a glue trap in northern Yucca Flat was being attacked by a coyote. The coyote was chased off and the lizard was extracted and released alive back into the desert.

### 4.3 Natural Water Source Monitoring

Nine natural water sources (six springs, three rock tanks) were monitored with motion-activated cameras in 2021 to document the presence of mountain lions (*Puma concolor*) and other wildlife (Figure 4-7). 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 2021, Topopah Spring was nearly dry with just a small wet spot in the cave pool. Vegetation was heavily trampled primarily by feral burros and mule deer 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 pretty dense in the absence of feral horses using the perennial spring, and cattails (*Typha domingensis*) were very dense around Cane Spring. Burros continued to use Cottonwood Spring and the area around it was

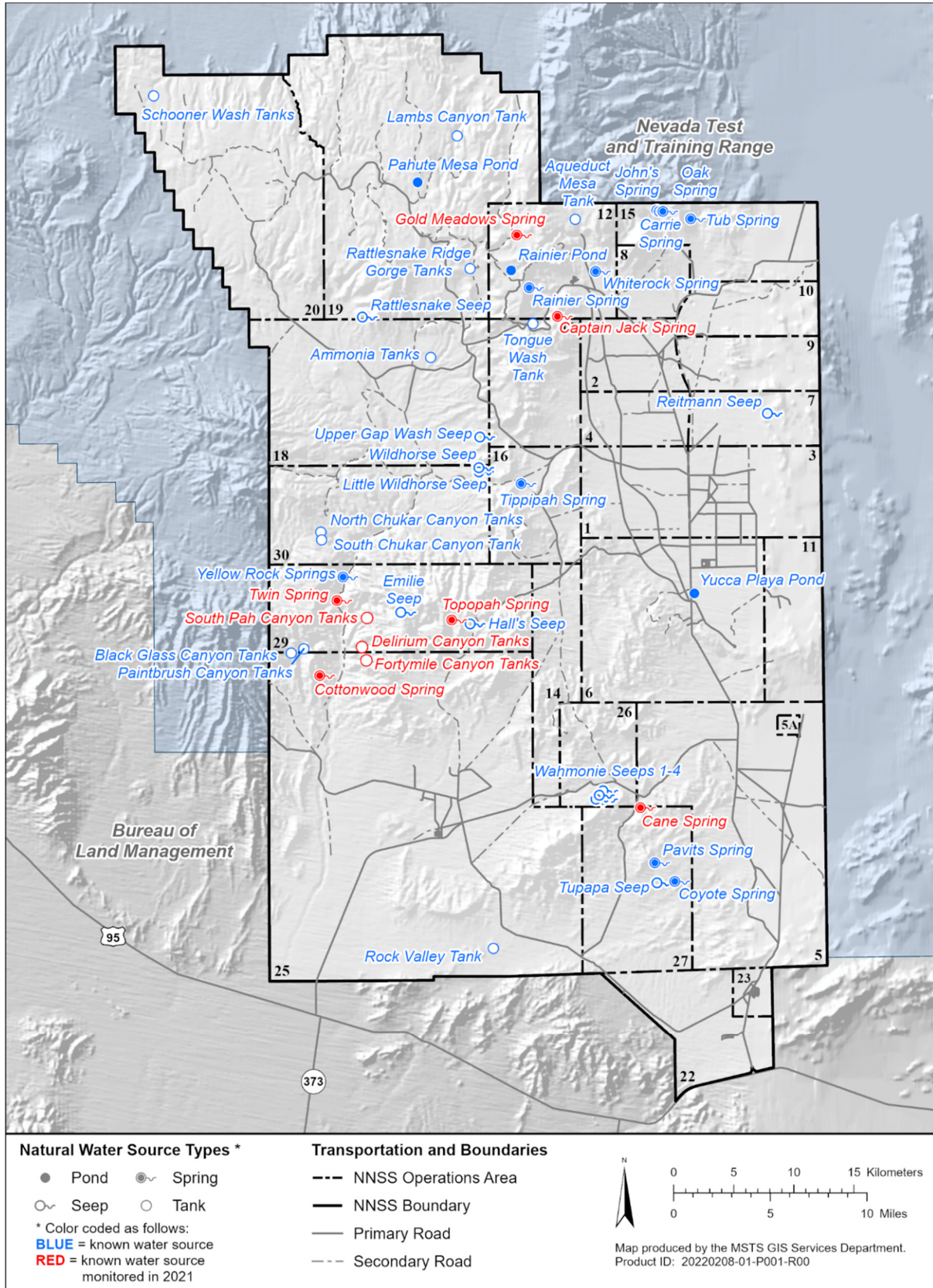


Figure 4-7. Natural water sources on the NNSS, including those monitored in 2021.

heavily trampled with little to no vegetation left. Gold Meadows Spring dried up in early June, filled back up in late July, and dried up again between August 28 and September 27.

Twin Spring (#21) had the most images (3,590; 9 mammals, 8 birds, 2 reptiles) with a majority of them being feral burros (2,964 images). Cottonwood Spring (#4) was a close second with 3,524 images (6 mammals, 2 birds, 1 reptile) with 3,208 images of feral burros. Species richness was much lower at Cottonwood Spring than Twin Spring even though the camera at Twin Spring was only operational about half as long as the camera at Cottonwood Spring.

Captain Jack Spring (#12) had 2,839 images of 8 mammals and 14 birds (Table 6-3). Mule deer were the most commonly photographed (1,799 images) followed by pinyon jays (*Gymnorhinus cyanocephalus*) (813 images). Five images of a hairy woodpecker (*Picoides villosus*) were also recorded on June 26 (Figure 4-8). This is only the sixth record for this species on the NNSS. Gold Meadows Spring (#18) had 281 images of 8 mammals and 9 birds. This is a drastic decline from 2020 when 12,153 images of 8 mammals and 24 birds were recorded (Hall and Perry 2021). Only 5 species (4 mammals, 1 bird) were detected in 27 images at Cane Spring (#7) and 4 species (3 mammals, 1 bird) were detected in 6 images at Topopah Spring (#9).

The highest species richness at any natural water source was documented at South Pah Canyon Tanks (#15) and included 7 mammal species, 17 bird species, 1 reptile species, and 1 invertebrate species in 355 images. Mule deer were documented here for the first time (Figure 4-9). Delirium Canyon Tanks (#5) had 13 species (6 mammals, 6 birds, and 1 invertebrate) in 969 images. Most of these were of desert bighorn sheep (*Ovis canadensis nelsoni*) (889 images). At Fortymile Canyon Tanks (#11) 3 mammal and 1 bird species were detected in 22 images with 18 images of desert bighorn sheep. Interestingly, mountain lions were detected at each of these three ephemeral tanks.



**Figure 4-8. Hairy woodpecker at Captain Jack Spring (#12).**

(Photo by motion-activated camera, June 26, 2021)



**Figure 4-9. Doe and young buck mule deer at South Pah Canyon Tanks (#15).**

(Photo by motion-activated camera, August 17, 2021)

#### **4.4 Constructed Water Source Monitoring**

Nine constructed water sources were monitored with motion-activated cameras to document the presence of mountain lions and other wildlife during 2021. These included one well pond (Camp 17 Pond), five water troughs installed to mitigate the loss of well ponds, and three radiologically-contaminated sumps (Figure 4-10).

A total of 39 species (5 mammals, 33 birds, 1 invertebrate) were detected at Camp 17 Pond (#6) in 3,596 images (Table 6-3). Common ravens (*Corvus corax*) (765 images), turkey vultures (*Cathartes aura*) (619 images), mule deer (498 images), red-tailed hawks (*Buteo jamaicensis*) (405 images), red-shafted common flickers (*Colaptes auratus*) (317 images), feral horses (276 images), and pinyon jays (253 images) were the dominant species. The first record of a summer tanager (*Piranga rubra*) on the NNSS was documented at Camp 17 Pond (#6) (Figure 4-11). Fifteen images of peregrine falcons (*Falco peregrinus*) were photographed between May 1 and June 24, including two birds on June 16 and June 19 (Figure 4-12), which suggests the possibility of a breeding pair. Several species of waterfowl and shorebirds and a belted kingfisher (*Megasceryle alcyon*) (7 images) were also documented.

##### **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. In order to conserve millions of gallons of water being lost to drainage and evaporation, pumping water to fill these ponds was stopped. Wildlife observation data gathered over several decades documented more than 100 species of wildlife

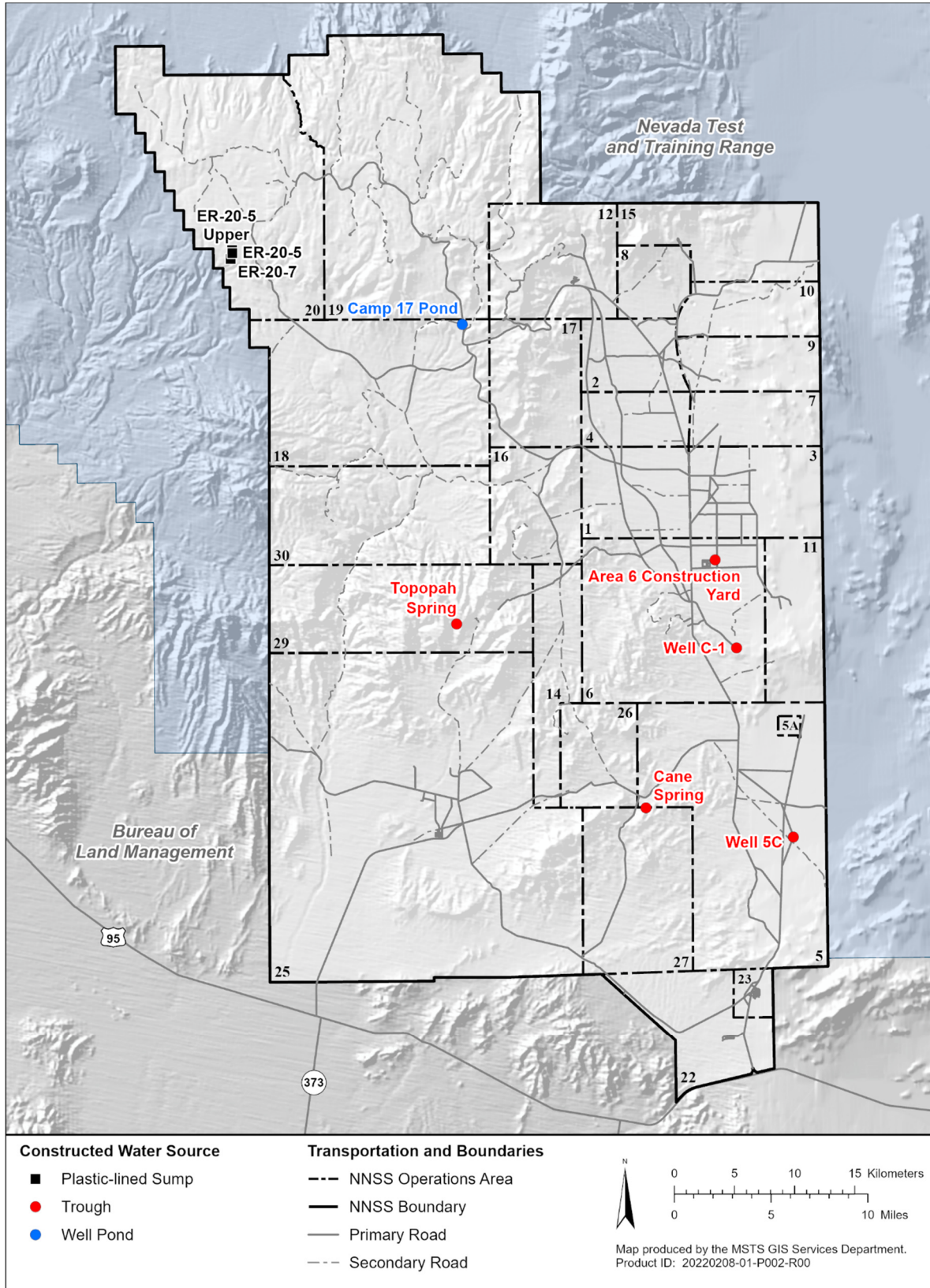


Figure 4-10. Constructed water sources monitored with motion-activated cameras for wildlife use during 2021.



**Figure 4-11. First-year summer tanager at Camp 17 Pond.**

(Photo by motion-activated camera, May 15, 2021)



**Figure 4-12. Two peregrine falcons at Camp 17 Pond (#6).**

(Photo by motion-activated camera, June 19, 2021)

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 Pond) and Well C1 Pond to mitigate the loss of these ponds, at Well 5A (Well 5C) to mitigate the loss of the Well 5B Pond, and at Cane Spring and Topopah Spring to mitigate the loss of the J11 Pond 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 2021 are included in Table 6-3 (see Section 6.7.1, Motion-Activated Cameras).

Wildlife use at Well 5C trough (#24) was heavy with 503 images of 18 species (8 mammals, 10 birds) (Table 6-3). Pronghorn antelope was the dominant species with 103 images, and two images of a LeConte's thrasher (*Toxostoma lecontei*) were taken on August 1 (Figure 4-13).



**Figure 4-13. LeConte's thrasher at Well 5C Trough (#24).**

(Photo by motion-activated camera, August 1, 2021)

Wildlife use at Well C1 Trough (#10) was moderate with 200 images of 7 species (4 mammals, 3 birds). Pronghorn antelope was the most commonly photographed species (141 images). Wildlife use at Area 6 LANL Pond Trough (#14) was light with 29 images of 2 mammal species, pronghorn antelope (17 images), and feral burros (12 images). 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.

Wildlife use at Topopah Spring Trough (#23) was light with 29 images of 7 mammal species and 1 bird species. Three photographs of a mountain lion walking past the trough were taken, one in November and two in December. On January 6, 2022, there was water flowing in the wash between the trough and the spring from snowmelt. 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.

### 4.4.2 Monitoring Wildlife Use at Potentially Contaminated Water Sources

During 2021, motion-activated cameras were set up at three 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) 20-7 (#13), ER 20-5 Upper (#2), and ER 20-5 (#25) (Figure 4-10). 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  $\geq 400,000$  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 17 wildlife images, ER 20-7 (#13) having 11 images, and ER 20-5 Upper (#2) having 5 images (Table 6-3). Common ravens were the most commonly photographed species at each site. One golden eagle (*Aquila chrysaetos*) and one turkey vulture were photographed at ER 20-7 (#13) and one mourning dove (*Zenaidura macroura*) was photographed at ER 20-5 (#25). Photographs of house finches (*Carpodacus mexicanus*) were taken at ER 20-7 (#13) (4 images) and ER 20-5 (#25) (1 image). A desert bighorn sheep ram was also photographed at ER 20-7 on November 25 as part of another project (Ron Warren, personal communication).

A motion-activated camera was also set at E Tunnel Ponds, a perennial source of contaminated water flowing from E Tunnel, as part of another project (Ron Warren, personal communication). Several species including mule deer (1,799 images), mountain lions (83 images), golden eagles (15 images), bobcats (2 images), coyotes (110 images) and bird species, including turkey vultures, mourning doves, pinyon jays, and chukar were documented.

Important species are using these sites and are potentially up-taking radiological contaminants. Hunt-able species such as chukar and mourning doves are a potential pathway of exposure to the general public. Protected birds such as golden eagles, 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 2021) available at <https://www.nnss.gov/pages/resources/library/NNSSER.html>

#### **4.5 Coordination with Scientists and Ecosystem Management Agencies**

MSTs biologists interfaced with other scientists and ecosystem management agencies in 2021 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 (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.”
- Published an article entitled, “Mosquito Distribution and West Nile Surveillance Results on the Nevada National Security Site in South Central Nevada” in the *Western North American Naturalist* (Hall and Raman 2021) in August, 2021.
- Accompanied U.S. Forest Service personnel in October to sample three long-term plots for the Interior West Forest Inventory and Analysis Program.

## 5.0 SENSITIVE AND PROTECTED/REGULATED PLANT MONITORING

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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 2022 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 Clokey's cryptantha (*Cryptantha clokeyi*)

Clokey's cryptantha was added to the NDNH List in January 2019. Previously known to be endemic to California, this species was found in Nevada in 2016 in Perlite Canyon just east of Beatty by Dr. James M. André and again by MSTs biologists in 2020. This species grows alongside several other *Cryptantha* species as well as being very similar morphologically with *C. nevadensis*, making it difficult to identify in the field. Clokey's cryptantha differs from *C. nevadensis* in that *C. nevadensis* is more sprawling in structure and differs from other *Cryptantha* species based on its triangular nutlets with translucent tubercles. Positive identification can be accomplished by collecting nutlets, allowing them to dry if they are fresh, and observing them under a microscope. The key in *The Jepson Manual: Higher Plants of California* (Baldwin et al. 2012), alongside Simpson and Hasenstab's 2009 publication "Cryptantha of Southern California" can be used for positive identification, with one adjustment: Dr. André found nutlets collected from plants in Perlite Canyon were typically 2-2.5 mm, as opposed to 3 mm listed in published keys.

MSTs biologists identified Clokey's cryptantha at Yellow Rock Springs in Fortymile Canyon on the NNSS in 2020. The plant was added to the NNSS sensitive plant monitoring program in 2021 with a ranking of evaluate. Habitat similar to Perlite Canyon, which was a light-colored rocky outcrop with rhyolitic tuff at 1,264 m elevation, is throughout Fortymile Canyon. With well below average winter precipitation and little *Cryptantha* germination this year, only one survey was scheduled at Yellow Rock Springs this year with exploratory surveys rescheduled during better precipitation years. No plants were found at Yellow Rock Springs during the survey on May 4<sup>th</sup>. Very few annuals were observed with only one *Cryptantha* species, *C. confertiflora*. Cheatgrass and red brome dominate Fortymile Canyon and had very little germination as well.

There were very few plants originally located over a large area at Yellow Rock Springs in 2020. This alongside a continued drought has limited surveys. With few surveys conducted in Nevada for this species and its challenging field identification, it is possible it is more widely distributed than currently known in southern Nevada.

#### 5.1.2 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.

Palmer's penstemon continued to be spotted throughout the NNSS with a large population found along the 19-01 Road in June at 2,164 m elevation (UTM NAD83 566217mE, 4120090mN). Lahontan beardtongue was not observed this year. The unidentified population found at the southern base of Skull Mountain at 1,228 feet in 2020 was revisited on April 27 (UTM NAD83 576360mE, 4066161mN). Basal leaves of two of seven plants were barely vegetative. The Jackass Flats Road population (UTM NAD83 588343mE, 4056843mN) of Palmer's penstemon at 1,089 feet did not bloom this year; therefore, the Skull Mountain population was not revisited later in the season with the assumption they also did not bloom. The variety of the Skull Mountain population has not been identified. The one confirmed location of Lahontan beardtongue, just northwest of Gold Meadows in southern Kawich Canyon (UTM NAD83 568945mE, 4121647mN), was revisited June 14. The population could not be relocated and no new plants were observed along Kawich Valley Road.

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 down to the variety.

### 5.1.3 Nye milkvetch (*Astragalus nyensis*)

Nye milkvetch is a small, herbaceous annual thought to be extirpated from southern Frenchman Flat in Area 5 by construction of several borrow/gravel pits (Beatley 1977). The plant is listed on the NDNH List and is found in Clark, Lincoln, and Nye counties in Nevada. The species has also been documented in eastern California, southwestern Utah, and northwestern Arizona. The plant was first identified and collected in 1941 in southern Frenchman Flat on the NNSS, its type locality. Surveys conducted in April and May in 1978 by EG&G Energy Measurements Group found Nye milkvetch in two areas of southern Frenchman Flat, one of which was at the existing gravel pits. These findings were reported in January 1979 in an addendum to a report published in 1977 (Rhoads and Williams 1977, Rhoads et al. 1979). A survey data sheet from May 1995 stated, "some Nye milkvetch plants" were found during a survey for a different sensitive plant species at the Area 5 gravel pits. This was the last documented survey for Nye milkvetch that could be found on the NNSS.

It was determined there are possibly two locations of Nye milkvetch on the NNSS in Area 5: at the gravel pits (UTM NAD83 591982mE, 4068456mN) and approximately two kilometers (km) east at the type locality (UTM NAD83 593803mE, 4069151mN). Both locations were surveyed in 2020 with no plants found. The gravel pits were surveyed again in 2021 with the same results. There were little to no annuals in the area.

Nye milkvetch has been removed from the NNSS's sensitive plant monitoring program until it can be confirmed to occur on the NNSS. Locations in Area 5 will continue to be surveyed, especially during good precipitation years.

## 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 reported locations, better define population boundaries, and identify existing or potential threats to populations. The primary focus in 2021 was to continue evaluation of Clokey's cryptantha, Lahontan beardtongue, and Nye milkvetch as well as restart long-term monitoring of several species which had yet to be surveyed during assigned monitoring periods. Long-term monitoring was scheduled for Beatley milkvetch (*Astragalus beatleyae*), Beatley scorpionflower (*Phacelia beatleyae*), Clarke phacelia (*P. filiae*), Clokey eggvetch (*Astragalus oophorus* var. *clokeyanus*), Darin buckwheat (*Eriogonum concinnum*), Kingston Mountains bedstraw (*Galium hilendiae* spp. *kingstonense*), and Pahute green gentian (*Frasera pahutensis*). Due to well below average winter precipitation the two *Phacelia* species were not surveyed based on reconnaissance to several areas determining little to no *Phacelia* germination this year. Darin's buckwheat was also not able to be monitored. Opportunistic encounters were documented for Cane Spring suncup (*Chylismia megalantha*), Inyo hulsea (*Hulsea vestita* subspecies [ssp.] *inyoensis*), and Pahute Mesa beardtongue (*Penstemon pahutensis*).

### 5.2.1 Beatley milkvetch (*Astragalus beatleyae*)

Beatley milkvetch is a small, short-lived perennial herb which forms circular mats five to 20 cm in diameter with blue-violet pea flowers which bloom April through mid-July (Figure 5-1). The pods, an identifying characteristic of milk vetch species, are bladderly-inflated, incurved, pale green with reddish speckles (Figure 5-1). Endemic to Nye county in Nevada, it has only been found on the NNSS and NTTR. Its type locality is on Pahute Mesa (UTM NAD83 545651mE, 4126312mN) in an area designated in 1986 as Beatley milkvetch critical habitat (Figure 5-2). As a candidate for listing under the ESA in the 1970's, habitat on the NNSS was intensely surveyed in the 1970's and 80's to determine its distribution. In 1979 the species was listed by the state as critically endangered under NAC 527. Threats during this time included habitat clearing, ground-motion effects, and off-road driving, all associated with underground nuclear testing. These threats since have been eliminated with very few NNSS activities occurring in Beatley milkvetch habitat.

Beatley milkvetch hit the press in 1980 in the *Las Vegas Sun* and 1981 in *Life Sciences News* (Figure 5-3). Three-year duration conservation agreements were signed in 1983 and 1988 in lieu of listing under the ESA by DOE and FWS identifying the significance of the species and providing removal of NNSS threats. Populations were monitored into the 1990's and early 2000's with seven permanent monitoring plots established. DOE's efforts to study and monitor Beatley milkvetch have been summarized in several publications: Rhoads et al. (1980), Hunter et al. (1988), and Blomquist et al. (1992). Due to the extensive monitoring from the 1970's through 2000's and the moratorium on underground nuclear testing, the plant is currently not designated as requiring protection under federal or state law.

There were several visits to Beatley milkvetch populations in 2010 and 2014, but long-term monitoring has not been conducted since 2005. With hopes of conducting transect monitoring this year, five locations were selected at the type locality in Area 20 on Pahute Mesa for sampling (Figure 5-2). Four of the locations were visited on July 12. Only eight immature plants were observed at one location with 49 senescent plants from previous years found throughout all locations. With no vegetative plants found at three of the four locations, the fifth location was not visited. Low precipitation had a significant impact this year not only on annual germination, but on perennial biomass as well. No threats were observed to the populations, with the areas being untouched for years. Pahute Mesa Road, which is a dirt road through this area, is driven occasionally by employees and segments two locations (Figure 5-2). Observing 49



**Figure 5-1. Beatley milkvetch plant.**

(Photo by W.K. Ostler, July 17, 2010)

plants from previous years was promising and transect surveys will be rescheduled during better precipitation years.

### **5.2.2 Cane Spring suncup (*Chylismia megalantha*)**

The Cane Spring suncup (*Chylismia megalantha*, formerly *Camissonia megalantha*) is a large annual that blooms in the fall with a showy pink flower and large foliage. The plant grows well on steep slopes and disturbances, including manmade disturbances. A population located on a manmade berm at the Area 5 Radioactive Waste Management Complex (RWMC) (UTM NAD83 593471mE, 4080590mN) is adjacent to the Cell 18 revegetation project (see section 7.4 Area 5 RWMC, Cell 18 Revegetation). One Cane Spring suncup plant was found in July within the revegetation project on a flat, disturbed area along the northern perimeter of the revegetation plot. It is likely the plant will colonize within the revegetated area due to wind-dispersed seeds from the adjacent berm population.

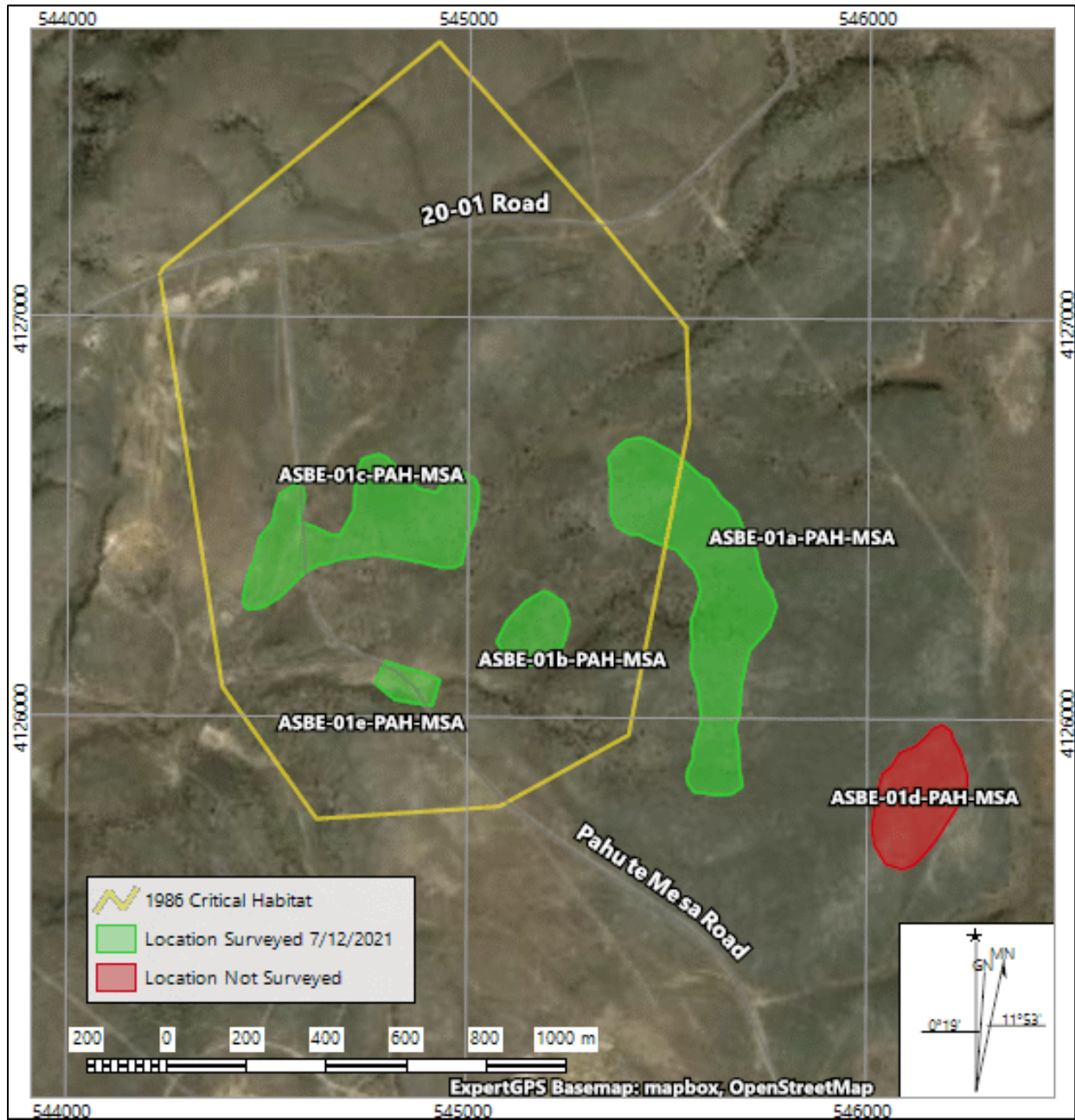


Figure 5-2. Beatley milkvetch type locality in Area 20 surveyed July 12, 2021. Coordinates in UTM NAD83 (Zone 11, meters).

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## Beatley's Milk Vetch

To almost 3,500 Las Vegans, the huge, federally owned Nevada Test Site (NTS) is their workplace. But to the tiny gray-green plant whose species name is *Astagalus beatleyae*, the test site is home. It has no other known habitat.

Beatley's milk vetch, as it is commonly called, grows on Pahute Mesa, a wide, windswept area at the extreme northwestern corner of the NTS and is protected with the help of Mary Sauls, a plant taxonomist with the EG&G Energy Measurements Group, headquartered in Las Vegas.

The miniature plant hovers close to the ground, rising no more than two or three inches above the surface. Its enemies are the clawing Nevada winds, extreme temperatures, insects, and grazing animals – and the underground nuclear weapons testing program at NTS.

Ironically, those who might endanger the plant — the administrators of the testing programs — are also those who wish to prevent its extinction.



The rare milk vetch in its desert environment.

As early as 1957, intensive studies of on-site plant and animal life were begun. The NTS governing agency, then called the Atomic Energy Commission, was concerned about the effects of atmospheric testing on plant and animal species. That concern has continued to the present, although atmospheric testing ended at the NTS on July 17, 1962.

Intensive collection, classification, and documentation of plants at the site started in 1959, when Dr. Janice Beatley began her 16-year tenure as the site's resident botanist. Later, her successor, Susan Cochrane, proposed the milk vetch for protection under the Endangered Species Act of 1973. Today, the plant is carefully monitored and protected by the DOE, although it is not yet officially designated as an endangered species.

Mary Sauls took over Susan Cochrane's job in 1980. She spends much of her time searching for the milk vetch and has found four new populations of the plant on Pahute Mesa — bringing the total of known populations to seven.

The greatest present danger to the milk vetch is the construction work associated with underground nuclear tests. Can the plant survive nuclear weapons

testing? Resident botanists believe that it can. Once the plant is designated as endangered, its critical habitat will be off limits to all disturbances from testing or traffic.

Will the tiny plant clinging tenaciously to the windswept mesa significantly curtail nuclear weapons testing or other research projects at the site? Not likely. Roughly three square miles of the test site's 1,350 are required to protect the milk vetch's critical habitat — hardly restrictive. It would seem that the tiny plant, and the nuclear tests will coexist.

*(Adapted from an article which appeared in the "Las Vegas Sun", August 24, 1980. Photos courtesy of Laura Lyon.)*



Mary Sauls of EG&G cradles with her hands the delicate milk vetch.

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Figure 5-3. News article distributed by EG&G in their *Life Sciences News* newsletter in 1981. A similar article was printed in the *Las Vegas Sun* August 24, 1980.

### 5.2.3 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 (Figure 5-4). 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” (Figure 5-4).

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 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 NTTR this year (Figure 5-5). The fire burned through Clokey eggvetch habitat on Timber Mountain from May through June during its bloom season (Figure 5-6). Five known Clokey eggvetch locations within the burned area were visited on July 20 to determine impacts. Some habitat was utilized by NNSS Fire and Rescue for suppression activities like hand line fire breaks (Figure 5-7). No plants were observed at two of the locations and approximately 44 plants observed at three of the locations. A majority of plants had vegetated prior to the fire with a few fruiting. Some plants were burnt (Figure 5-8) with others dried out. Most plants were sprouting leaves post-fire (Figure 5-8). Although the locations were not able to be revisited later in the season to determine if they fruited post-fire, July is very late in the season for Clokey eggvetch to bloom; therefore, the plants most likely did not bloom post-fire. The plants showed resilience to the fire by re-sprouting leaves after the burn.



**Figure 5-4. Clokey eggvetch plant with flowers (left) and plant with seed pods (right).**

(Photos by W.K. Ostler, June 2, 2010)

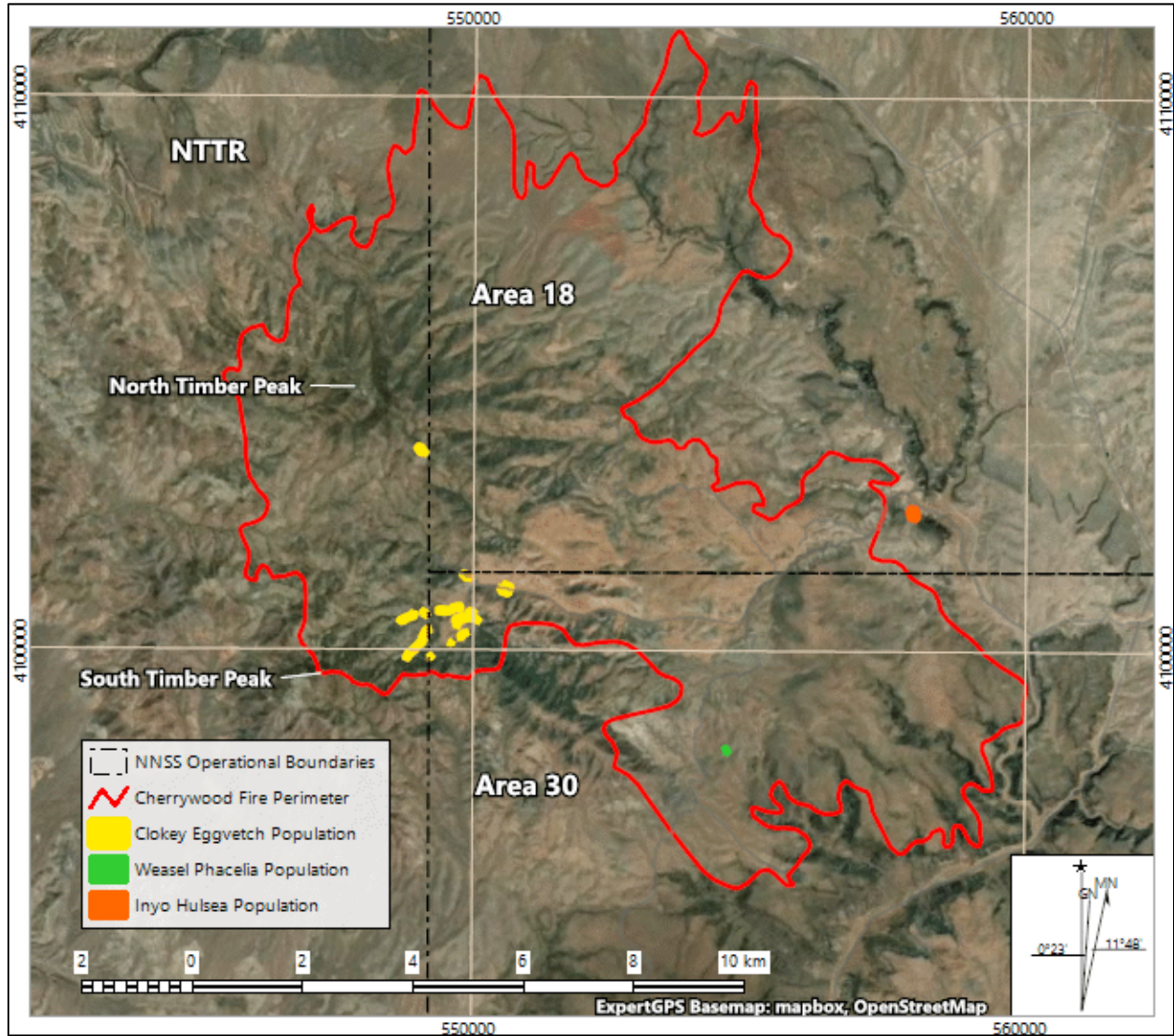


Figure 5-5. Map showing the burned area for the Cherrywood Fire and known sensitive plant populations in or near the burn. Coordinates in UTM NAD83 (Zone 11, meters).



**Figure 5-6. Clokey eggvetch burned habitat on Timber Mountain, east of south Timber Peak, in Area 30.**

(Photo by J.A. Perry, July 20, 2021)



**Figure 5-7. Clokey eggvetch burned habitat with a hand line fire break constructed during the Cherrywood Fire for fire suppression.**

(Photo by J.A. Perry, July 20, 2021)



**Figure 5-8. Clokey eggvetch burned seed pods with leaf regrowth post-burn on Timber Mountain, east of south Timber Peak, in Area 30.**

(Photo by J.A. Perry, July 20, 2021)

#### **5.2.4 Inyo hulsea (*Hulsea vestita* ssp. *inyoensis*)**

Inyo hulsea, an herbaceous perennial in the Asteraceae family, occurs primarily on steep, unstable sandy or rocky slopes in single-leaf pinyon and Utah juniper habitat (Figure 5-9). It grows well on road cuts or other manmade disturbances. When the leaves are crushed, it has an odor somewhat reminiscent of pine resin (Rhoads et al. 1978). Its yellow flowers are showy and can be distinguished from other subspecies by its greater number of ray flowers (18-32) which are longer and completely yellow (Rhoads et al. 1978). Rhodes et al. (1978) explained “[o]ther subspecies usually have an orange or red hue to the entire or underside of the ray flower”. *Hulsea* species are able to grow in nutrient-poor soils. Threats to Inyo hulsea on the NNSS have greatly reduced with the absence of underground nuclear testing and its associated disturbances. Current threats include maintenance of power lines which cross through populations and installment of seismic monitoring equipment.



**Figure 5-9. Inyo hulsea plant (background, shrub with yellow flowers) found at a new location along the 19-01 Road within a Pahute Mesa beardtongue (foreground, stalk with purple flowers) population.**

(Photo by D.B. Hall, June 17, 2021)

A new location was found June 17 along the 19-01 road cut in Area 19 on Pahute Mesa (UTM NAD83 564800mE, 4120448mN). Plants were found on a steep slope along the road within a Pahute Mesa beardtongue population (Figure 5-9). The location will be re-visited to obtain population size and abundance.

### **5.2.5 Kingston Mountains bedstraw (*Galium hilendiae* ssp. *kingstonense*)**

Kingston Mountains bedstraw is a small, slender perennial with pink, bell-shaped flowers found on steep slopes typically beneath the canopies of single-leaf pinyon, Utah juniper, Gambel oak (*Quercus gambelii*), and Sumac (*Rhus*) species. Kingston Mountains bedstraw can be distinguished from others in the genus by its large, bell-shaped, narrow throated, pink flowers in dense terminal clusters. Stems and leaves are covered in long, stiff, bristly hairs.

The newly identified population of *Galium hilendiae* located on Yucca Mountain (UTM NAD83 549348mE, 4087880mN) in 2018 was reviewed and determined not to be Kingston Mountains bedstraw.

Photos of the plants revealed they were entirely glabrous (hairless). Although the plants could not be keyed out by photos, the population has been ruled out as Kingston Mountains bedstraw.

On June 14, a known population was visited in Gold Meadows (UTM NAD83 571358mE, 4119534mN) to become familiarized with identification of *Galium*. Many plants were found in bloom. There were no threats to the population which was remote and accessed by foot.

An undocumented *Galium* species population was found opportunistically September 18 in the Eleana Range, south of Stockage Wash Road (UTM NAD83 570566mE, 4111539mN). Approximately 20 plants in senescence were found under the canopies of single-leaf pinyon and Utah juniper at 2,112 feet. No plants were in flower and little data was collected. The population should be revisited during blooming season to determine species.

### **5.2.6 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 (Figure 5-10). Its leaves are long oblanceolate basal leaves with a white margin that can be wavy to scalloped (Figure 5-10). 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 (UTM NAD83 569106mE, 4119355mN). 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).

Four populations were visited June 3<sup>rd</sup> on Pahute Mesa for long-term monitoring (Figure 5-11). Two of the locations were within the Area 19 Fire burned area (01a and 01c; Figure 5-11), which ignited by lightning strike in 2018 burning 1,012 ha. The fire burned through four out of seven Pahute green gentian populations on the NNSS. Almost 200 healthy plants were observed in these two populations. Most of the plants were vegetative with a handful in bloom. Although pine trees in the burned area had not rebounded from the fire, annuals, small perennials, and shrubs were abundant, including Pahute Mesa beardtongue, which was a new location found in population 01a.

The other two locations surveyed (02a and 01b; Figure 5-11) were along the 19-01 Road. Population 02a was very healthy with over 200 plants counted. It was noted that most of the plants were not flowering and already showing signs of stress; implying many of the vegetative plants were not going to bloom due to it being too late in the season. Plants in population 01b were rare, with only two vegetative plants observed over a 6-ac area. Population 01b covers approximately 12.2 ac.



**Figure 5-10. Pahute green gentian.**

(Photo by J.A. Perry, June 3, 2021)

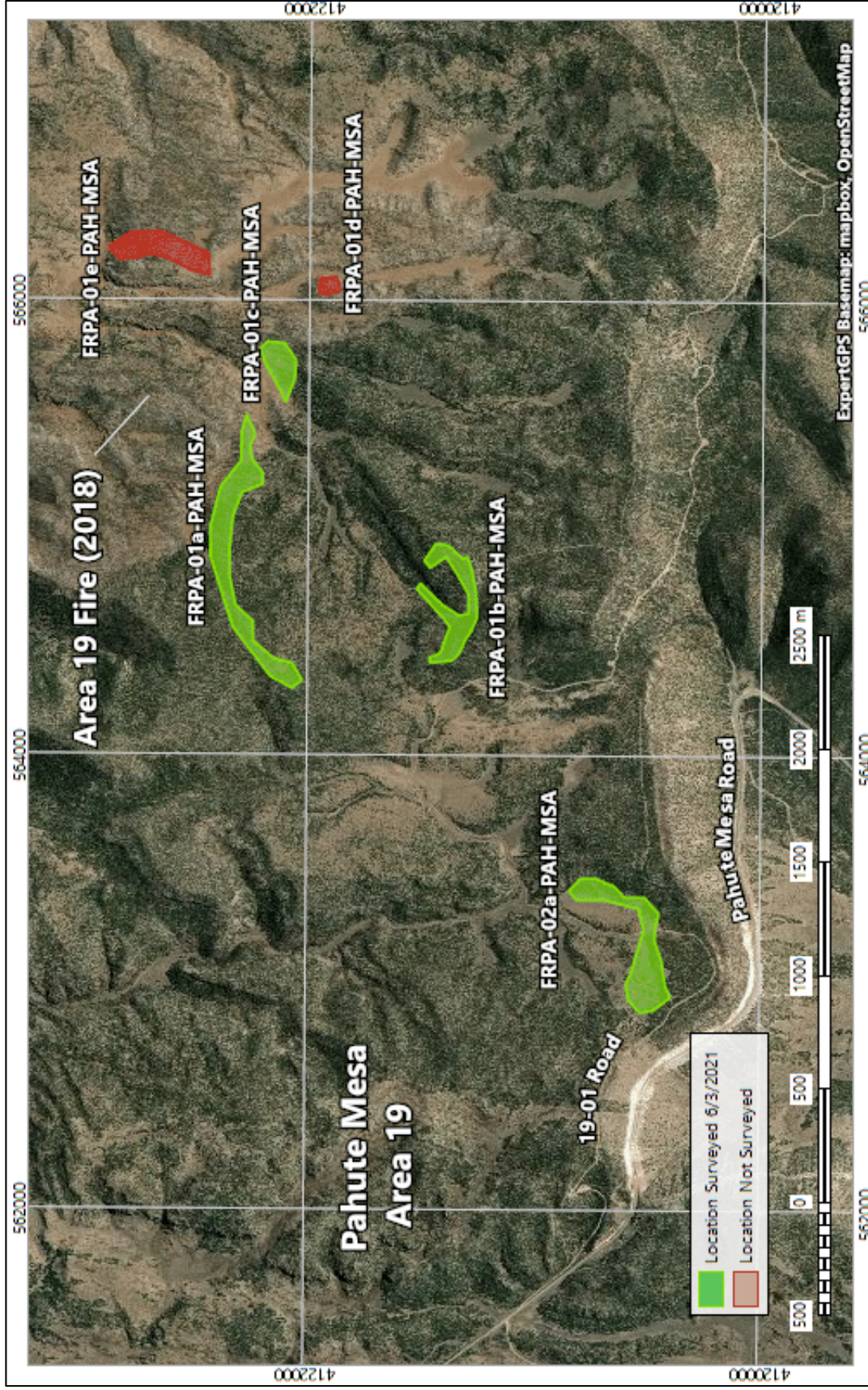


Figure 5-11. Pahute Green gentian surveyed locations June 3, 2021 on Pahute Mesa. Coordinates in UTM NAD83 (Zone 11, meters).

### 5.2.7 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. Long-term monitoring of this plant has not occurred since 1993, but plants are frequently encountered throughout the year during other work.

Two new locations were recorded while surveying for other sensitive plant species: one in Gold Meadows within a Kingston Mountains bedstraw population (UTM NAD83 571357, 4119533) and another in the Area 19 Fire scar, which burned in 2018, within a Pahute green gentian population (UTM NAD83 565361, 4122268). Another population was opportunistically visited while documenting a new location of Inyo hulsea, which lead to a population expansion of a known location along the 19-01 Road (see Figure 5-9) (UTM NAD83 564800, 4120445). The plant is more widely distributed on the NNSS than currently mapped, as shown by recent documented population expansions and new population locations.

### 5.3 Coordination with Other Scientists

- Nevada Native Plant Society meetings occurred virtually by combining the Northern and Southern Chapters. An MSTS biologist attended meetings in April and September. During meetings, the preservation of Nevada native flora was discussed.
- A photo of Pahute green gentian taken June 3, 2021 (see Figure 5-10) on Pahute Mesa was featured in the Nevada Native Plant Society 2022 Wildflower Calendar.
- An MSTS biologist attended two virtual Jepson Workshops: one in October which discussed identification of lichens and the other in December on identification of moss. The Jepson Herbarium hosts educational outreach programs like these to help close the gap between the scientific community and the public by providing virtual and in-person workshops on identifying vascular and nonvascular plants.

## 6.0 SENSITIVE AND PROTECTED/REGULATED ANIMAL MONITORING

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The NDNH At-Risk Plant and Animal Tracking List (NDNH 2022); NAC 503, “Hunting, Fishing and Trapping; Miscellaneous Protective Measures” (NAC 2022); FWS Endangered Species home page (FWS 2022); and other sources were reviewed to determine if any changes had been made to the status of animal species known to occur on the NNSS. The complete list with current designations is found in the Sensitive and Protected/Regulated Animal Species List (Table 2-1).

Surveys of sensitive and protected/regulated animals during 2021 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 shrews, 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 2021 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. A new bird species for the NNSS, the summer tanager, was photographed twice at Camp 17 Pond on May 15. The plumage is consistent with a first-year bird. The bird was likely just migrating through, as they are known to breed at lower elevations in southern Nevada (Jeanne Tinsman, personal communication, February 2022). One bird species, Baltimore oriole (*Icterus galbula*), was deleted from our database and all seven records of this species were changed to Bullock’s oriole (*Icterus bullockii*) due to a taxonomic change that occurred back in the 1990’s. There are now 246 known bird species on the NNSS.

#### 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. The chukar and Gambel’s quail (*Callipepla gambelii*) are also not protected under the MBTA but are regulated by Nevada state law as gamebirds. A change in the way the MBTA has been interpreted was written in FWS Memorandum M-37050 on December 22, 2017. Up until then, the MBTA prohibited the intentional and incidental take of migratory birds. M-37050 changed that interpretation to state, “the Migratory Bird Treaty Act does not prohibit incidental take.” On January 7, 2021, FWS published a final rule (86 FR 1134; hereafter “the January 7 rule”) that officially defined the MBTA’s prohibitions on pursuing, hunting, taking, capturing, killing, or attempting to do the same, to apply only to actions directed at migratory birds, their nest, or their eggs. However, on October 4, 2021, a final rule (86 FR 54667; hereafter “the October 4 rule”) was published that revokes the January 7 rule, thus returning the FWS to interpreting the MBTA as prohibiting incidental take and applying enforcement discretion, consistent with judicial precedent and longstanding agency practice prior to 2017. Nonetheless, the revocation of the January 7 rule does not include codification of the current interpretation of the MBTA as it applies to incidental take, it simply revokes the prior rule codifying the former interpretation and nothing more. With the advanced notice of proposed rulemaking in the October 4 rule, the FWS is initiating the process to codify the interpretation that the MBTA prohibits incidental take and develop an approach to authorizing incidental take of migratory birds. This may require NNSA/NFO to acquire a permit in the future for incidental take of birds protected by the MBTA.

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 2021 included the following: 1) conducted pre-activity surveys for proposed projects before surface-disturbing work to avoid harming birds or their nests, 2) removed a pinyon jay from glue trap and released it, 3) captured a barn owl (*Tyto alba*) from an underground facility and released it at Cane Spring, and 4) 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 and disease, and in many instances the cause of death is unknown. Workers and biologists work together to observe and report mortalities. A total of eight dead birds were documented on the NNSS in 2021 (Figure 6-1). This is the same number as last year which was the lowest number of recorded mortalities since 2012. Two common ravens were electrocuted, two owls (one long-eared [*Asio otus*] and one great-horned [*Bubo virginianus*]) were killed by vehicles, one red-tailed hawk apparently died from a collision with an unknown object, and three birds (two Cooper’s hawks [*Accipiter cooperii*] and one green-winged teal [*Anas crecca*]) were found dead due to unknown causes.

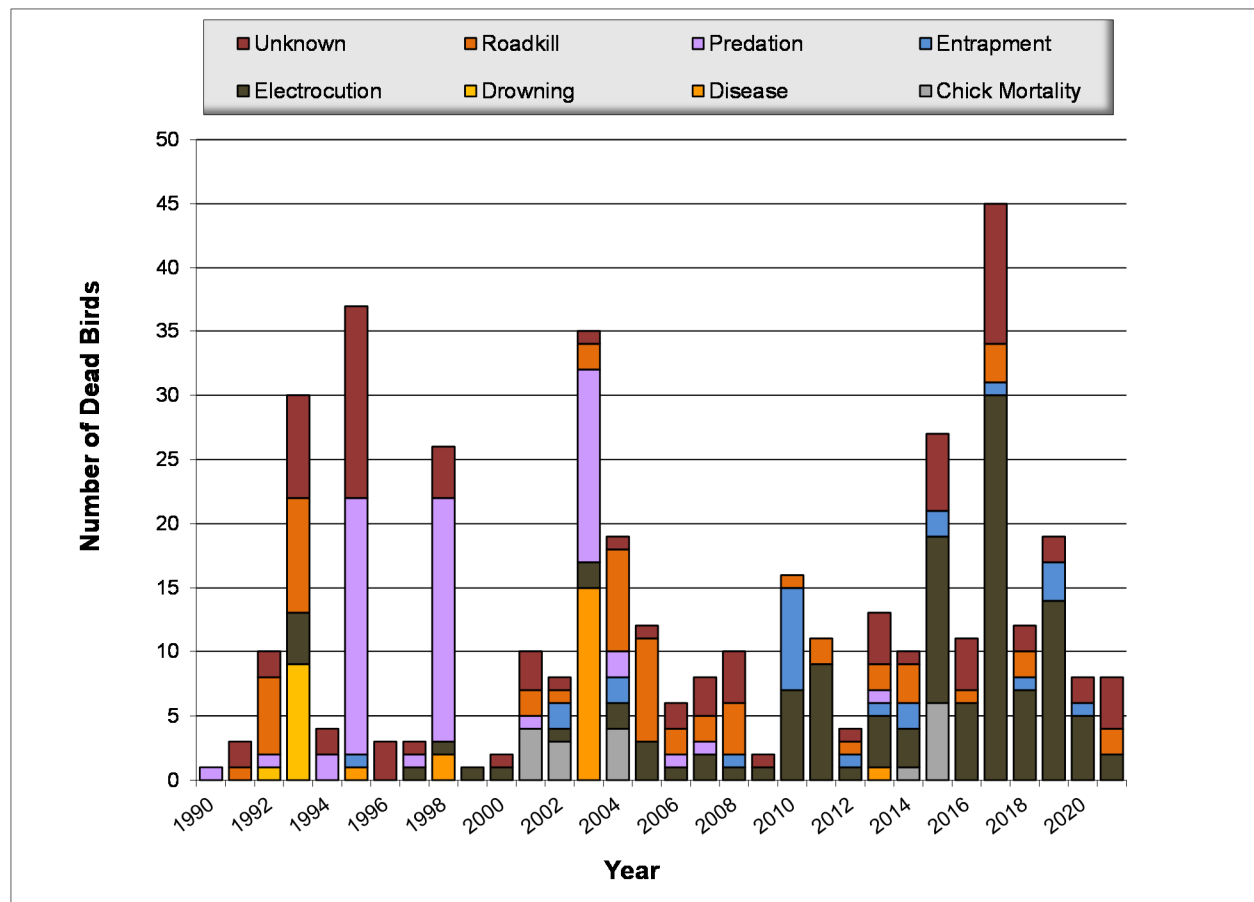


Figure 6-1. Records of reported bird deaths on the NNSS, 1990–2021.

### 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 2021 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. We responded to 17 calls related to avian issues during 2021.
- 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 2021 activities was submitted to FWS. No 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. All permit conditions were met and an annual report summarizing 2021 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 2021 activities was submitted to NDOW.
- Several mortality reduction measures were taken. These include rescuing a barn owl from an underground facility, removing a pinyon jay from a glue trap and releasing it, removing three inactive nests in potentially unsafe locations, surveying 103 ha at 29 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 couple of years (Figure 6-1) which may be due, at least in part, to the hundreds of pole retrofits that have been completed over the last several years.

### 6.1.4 Winter Raptor Surveys

Winter raptor surveys were initiated during 2014, in an effort to better understand wintering raptors on the NNSS and as a collaborative effort to provide data to the U.S. Army Corps of Engineers’ nationwide mid-winter bald eagle survey and NDOW’s statewide monitoring effort. Surveys continued in 2021, 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 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 both routes were only conducted once during 2021 on January 30.

The intent is for these surveys to be conducted each year for numerous years to look at long-term trends in winter raptor occurrence on the NNSS. Much is known about raptors on the NNSS in the summer, but winter data are lacking. Winter data may be important to detect changes in species composition related to climate change. Data on common ravens and loggerhead shrikes (*Lanius ludovicianus*) were also recorded because ravens are known desert tortoise predators, and the loggerhead shrike is a sensitive species. The southern route is located primarily in the Mojave Desert portion of the NNSS while the Yucca Flat route is located in the transition zone between the Mojave Desert and Great Basin Desert. Detailed driving directions for each route are found in the 2016 EMAC report (Hall et al. 2017).

Only three raptor species were detected during the surveys in 2021 (Table 6-1). No golden eagle sightings were documented during any of the surveys which is uncharacteristic. Typically, at least a few sightings are documented especially on the Yucca Flat Route. As in previous years, the red-tailed hawk was the most common species detected on both routes, comprising half of all raptor sightings (Table 6-1). Common ravens were more prevalent on the southern route this year than in Yucca Flat with most of them observed near the Mercury Sewage Lagoons. 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 Global Positioning Systems (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 transmitters were purchased with the intent of attaching them to owls in June. Unfortunately, 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 June 2022.

## 6.2 Shrews of the NNSS

Little information is available about shrew abundance and distribution in Nevada, even though one species (Inyo shrew [*Sorex tenellus*]) is on the NDNH List and three species (Merriam's shrew [*Sorex merriami*], desert shrew [*Notiosorex crawfordi*] and Trowbridge's shrew [*Sorex trowbridgii*]) are on their Watch List. Over the last few years, NDOW has been conducting studies and reviewing museum specimens to learn more about the distribution of shrew species in Nevada.

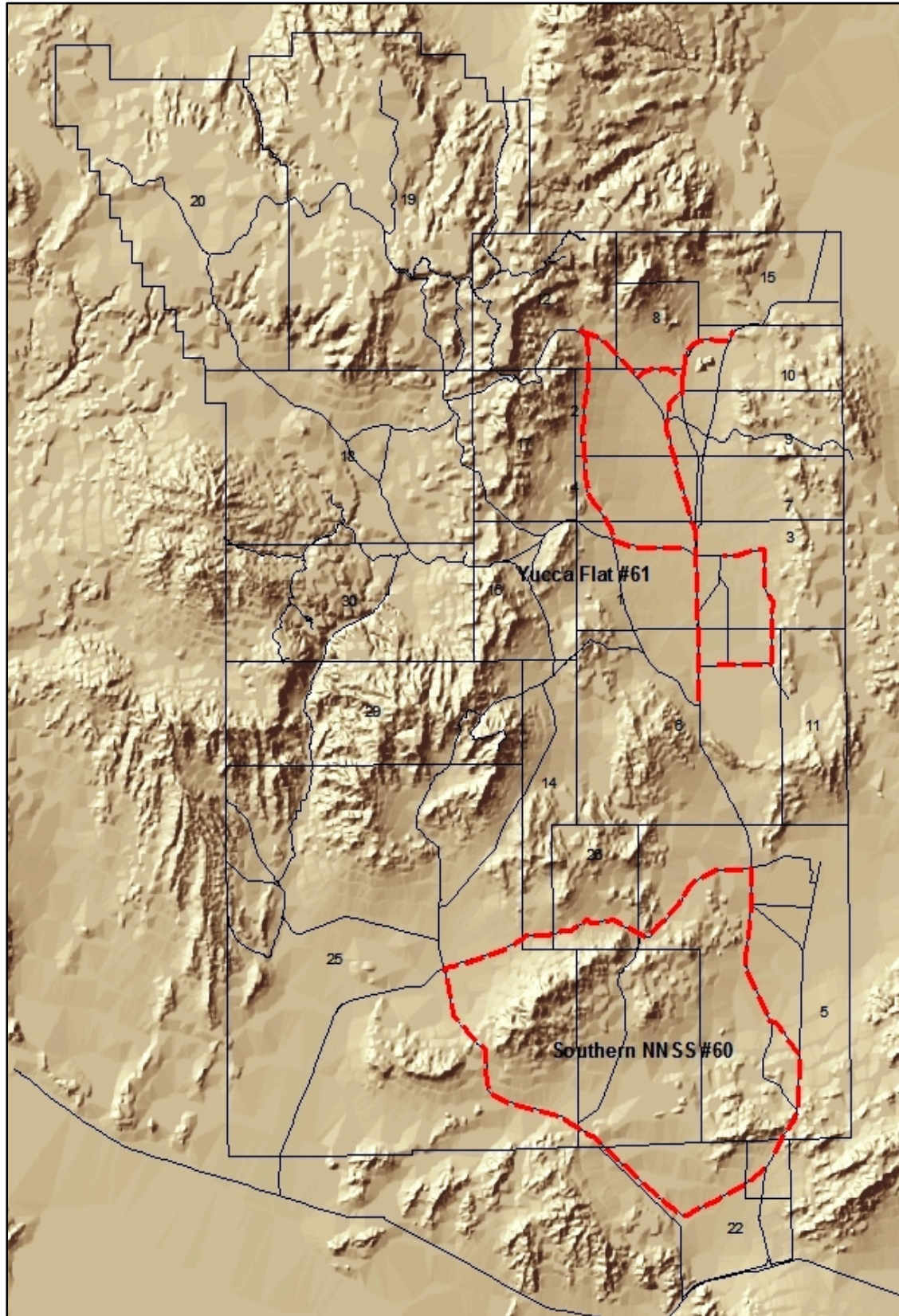


Figure 6-2. Winter raptor survey routes (red lines) on the NNSS.

Table 6-1. Results of winter 2021 raptor surveys on the NNSS.

<b>Species</b>	<b>Southern NNSS (1/30/21)</b>	<b>Yucca Flat (1/30/21)</b>
Red-tailed Hawk ( <i>Buteo jamaicensis</i> )	2	4
Praire Falcon ( <i>Falco mexicanus</i> )	1	2
American Kestrel ( <i>Falco sparverius</i> )	0	3
<b>Total Raptors</b>	<b>3</b>	<b>9</b>
Common Raven ( <i>Corvus corax</i> )	7	3
Loggerhead Shrike ( <i>Lanius ludovicianus</i> )	1	0

NDOW has also collaborated with Dr. Lisette Waits and her colleagues at the University of Idaho, Laboratory for Ecological, Evolutionary, and Conservation Genetics to identify shrew species, given they can be difficult to identify based on morphological characteristics only.

Only nine shrews have been captured on the NNSS, including three Inyo shrews, two Merriam’s shrews, and four desert shrews based on morphological characteristics. In order to confirm species identification, tissue from six specimens was sent to University of Idaho for genetic testing. These included tissue from three Inyo shrews (specimen #'s 4225, 4711, and 4216) collected from unspecified locations in pinyon pine-Utah juniper habitat and one Merriam’s shrew (#4226) collected from Rainier Mesa in Area 12, housed at the Monte L. Bean Museum at Brigham Young University (BYU). These specimens were collected in the 1960’s by BYU researchers who had a contract with the U.S. Atomic Energy Commission to study and inventory the flora and fauna of the NNSS. Dr. Duke Rogers (BYU) graciously provided tissue samples from these specimens. The other two tissue samples came from desert shrew specimens collected by Derek Hall and Paul Greger during a western red-tailed skink (*Plestiodon gilberti rubricaudatus*) distribution study. Specimen Derek Hall1 was collected in the northern part of Dead Horse Flat in Area 19, and Derek Hall2 (Figure 6-3) was collected on top of Shoshone Mountain in Area 29 at Plot 156. Genetic analysis confirmed the species identification for all specimens except for Inyo shrew #4216 which didn’t have enough DNA for species confirmation. Another specimen (Derek Hall3) collected near Austin Summit in central Nevada by Derek Hall was identified as desert shrew by Derek and as vagrant shrew (*Sorex vagrans*) by Jim Dines at the Los Angeles County Museum. Unfortunately, not enough DNA was extracted to confirm species identification. Either way, this specimen would show a range extension; about 150 km north if desert shrew and about 50 km east if vagrant shrew.

### 6.3 Bat Monitoring

Bat monitoring in 2021 consisted of documenting roost sites or locations of bats found around buildings or in other areas, conducting an exit survey at 16B Tunnel, and inaugural acoustic sampling at North American Bat Monitoring Program (NABat) priority grid cells.



**Figure 6-3. Desert shrew captured on top of Shoshone Mountain, Skink Plot 156.**

(Photo by D.B. Hall, June 16, 2011)

### **6.3.1 Documenting Bat Locations**

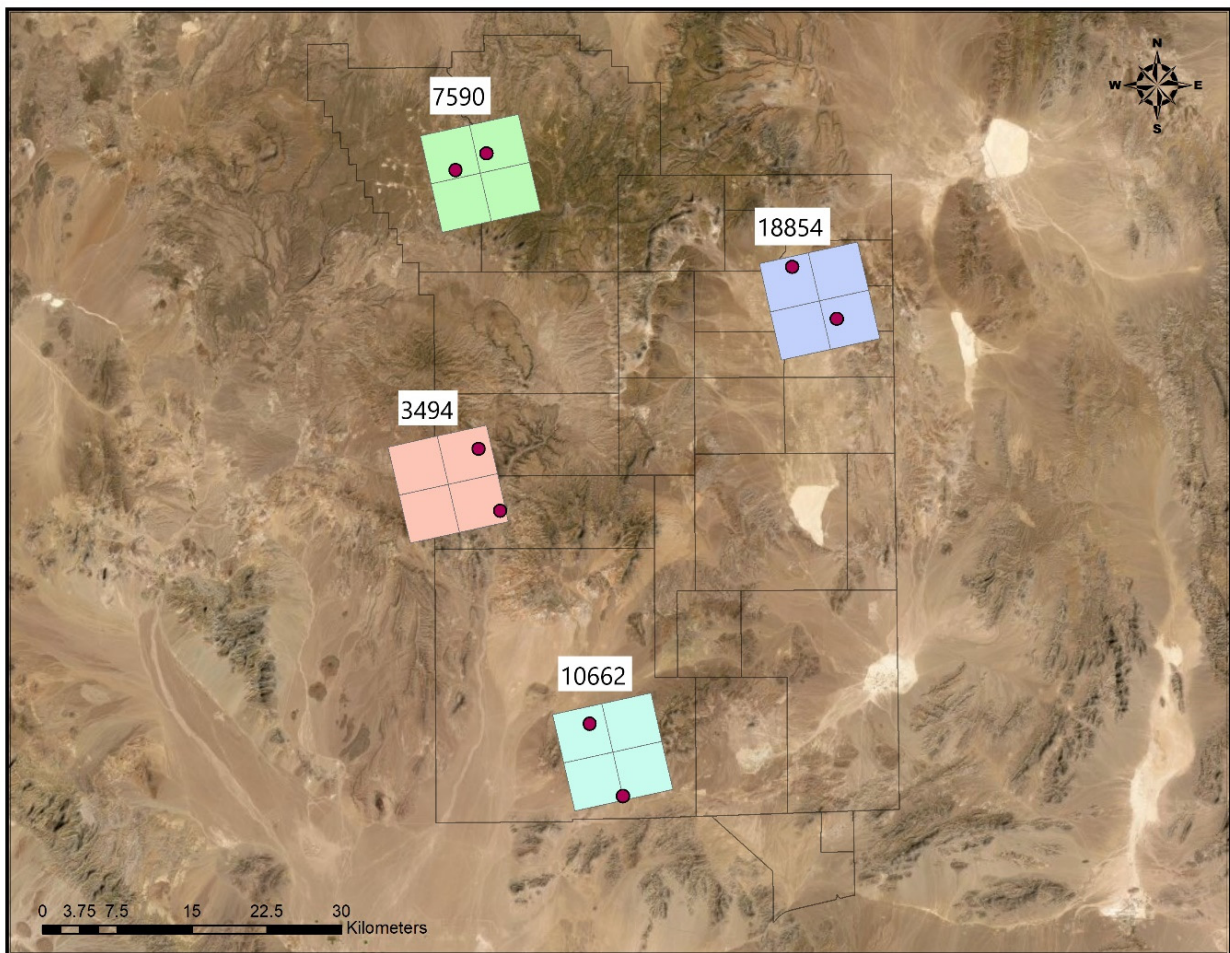
A dead adult canyon bat (*Parastrellus hesperus*) was found floating in Delirium Canyon Tanks. One adult California myotis (*Myotis californicus*) was found dead near the entrance to 23-652 in Mercury. An adult canyon bat was observed on the outside wall of 23-1001 in Mercury and a week later an adult male California myotis was removed from the same wall and released south of Mercury. Locations where bats were found were entered in the EGIS faunal database. Additionally, 65 images of bats were photographed at 5 of 25 sites monitored for mountain lions, all of which were water sources (Table 6-3).

### **6.3.2 16B Tunnel**

An exit survey was conducted at 16B Tunnel on August 30 to document bat use of the tunnel. Both portals (East Portal and Main Portal) were monitored for about two hours after sunset using a combination of acoustic detectors, artificial lights, and a thermal imaging camera. No mist nets were set. Preliminary results of about 97 acoustic bat files collected using Anabat Swifts show a majority of canyon bat activity with possibly some California myotis activity as well. Results from the thermal imaging recording at the East Portal reveal 8 bat entries and 10 bat exits with several bats flying around both inside and outside the entrance. Using a head lamp, a couple of bats were observed flying around the entrance at the Main Portal between 2010 and 2040 hours. Two common ravens were seen flying out of the entrance at the Main Portal around 1920 hours. Flying insects (e.g., moths, flying ants, and beetles) were observed flying around lights outside both portal entrances which likely attracted bats. Cool air was flowing out of the tunnel and mixing with the hot air outside. Based on the limited data, it is possible the tunnel is being used as a day roost for a few bats but appears to be used primarily as a foraging site.

### 6.3.3 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 6-4). Grid Cell 10662 is in the Mojave Desert ecoregion, Grid Cell 3494 is located in the Fortymile Canyon area, Grid Cell 18854 is located in northeastern Yucca Flat in the Transition ecoregion, and Grid Cell 7590 is located on Pahute Mesa in the Great Basin Desert ecoregion. The placement of these grid cells is fortuitous because it allows us to 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).



**Figure 6-4. North American Bat Monitoring Program priority grid cells with four quadrants (colored numbered rectangles) and sampling locations (maroon dots).**

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 6-4). 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 6-5). 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. Results are still forthcoming.

The two sampling locations for Grid Cell 10662 were Rock Valley Tank (southwest quadrant) (Figure 6-5) and a desert wash on the north side of Little Skull Mountain (northwest quadrant) (Figure 6-6). Both of these locations are in creosote bush-white bursage habitat. Rock Valley Tank is a 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 12 to May 17.

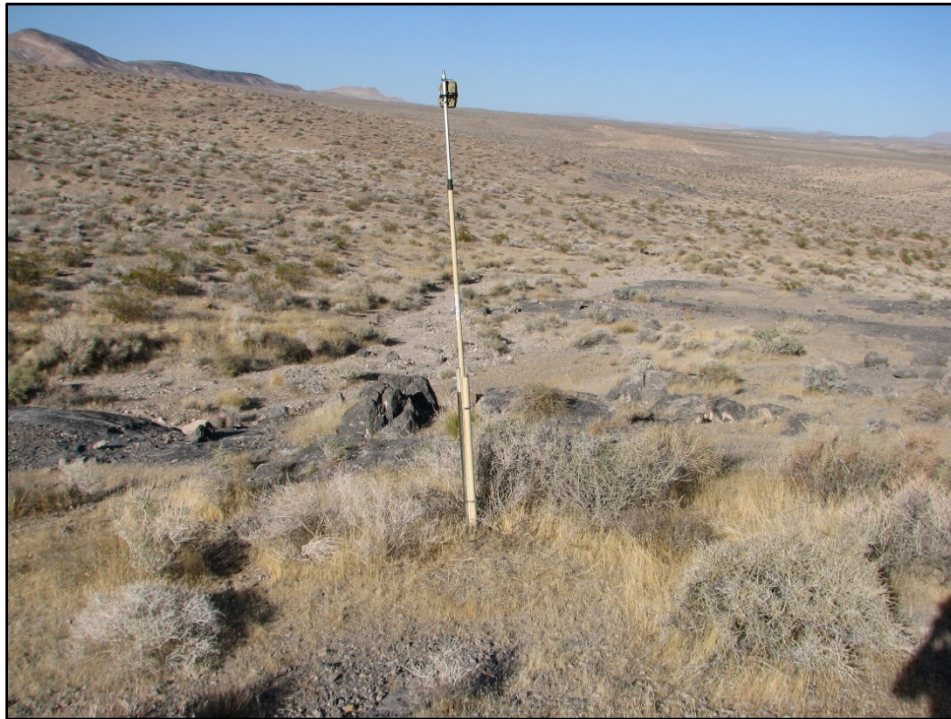
The two sampling locations for Grid Cell 18854 were a wash near Papoose Lake Road (southeast quadrant) (Figure 6-7) and south of Sedan Crater (northwest quadrant) (Figure 6-8). The wash location is in a drainage that flows from the west side of the Halfpint Range in blackbrush habitat with scattered Joshua trees (*Yucca brevifolia*). 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 20 to May 27.

The two sampling locations for Grid Cell 7590 were Columbine Canyon (northeast quadrant) (Figure 6-9) and ER 20-6 sumps (northwest quadrant) (Figure 6-10). 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 9 to June 17.

The two sampling locations for Grid Cell 3494 are at Twin Spring (southeast quadrant) and North Chukar Canyon Tanks (northeast quadrant). Twin Spring is a natural spring with perennial water. Nearby is an abandoned mine adit that is a known Townsend big-eared bat (*Corynorhinus townsendii*) 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 is capable of holding water for several months. These locations were not sampled this year because of restricted access due to the Cherrywood Fire but should be sampled in 2022.

### 6.4 Feral Horse Surveys

Feral horse monitoring in 2021 was limited to opportunistic observations and data from camera traps (see Table 6-3 in Section 6.7.1 Motion-Activated Cameras). At least 24 individual horses were observed including one juvenile and zero foals. Gold Meadows Spring and Camp 17 Pond continued to be valuable resources for these animals, especially during the hot, dry summer. A total of 115 and 276 photos of horses were recorded using a motion-activated camera at Gold Meadows Spring and Camp 17 Pond (Figure 6-11), respectively (Table 6-3). Surprisingly, the number of horse photos taken dropped substantially from 3,644 in 2020 to 115 in 2021 and from 1,716 in 2020 to 276 in 2021 at Gold Meadows Spring and Camp 17 Pond, respectively. Given the drought conditions, we would expect to see more use at these water sources. Fourteen images of three horses were also taken by the camera trap located on east 19-01 Road. This was the first time horses had been photographed using the road. However, horses frequently move between Camp 17 Pond and Gold Meadows Spring and this is a logical route for them to



**Figure 6-5. Bat detector at Rock Valley Tank, Grid Cell 10662.**

(Photo by D.B. Hall, May 12, 2021)



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

(Photo by D.B. Hall, May 12, 2021)



**Figure 6-7. Bat detector at wash in blackbrush habitat near Papoose Lake Road, Grid Cell 18854.**

(Photo by D.B. Hall, May 20, 2021)



**Figure 6-8. Bat detector south of Sedan Crater, Grid Cell 18854.**

(Photo by D.B. Hall, May 20, 2021)



**Figure 6-9. Bat detector in Columbine Canyon, Grid Cell 7590.**

(Photo by D.B. Hall, June 9, 2021)



**Figure 6-10. Bat detector location at ER 20-6 Sumps, Grid Cell 7590.**

(Photo by D.B. Hall, June 9, 2021)



**Figure 6-11. Two horses foraging on cattails and “cooling off” at Camp 17 Pond.**

(Photo by motion-activated camera, June 22, 2021)

take. 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 ninth consecutive year.

## **6.5 Mule Deer**

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

### **6.5.1 Trends in Mule Deer Abundance**

Mule deer abundance on the NNSS was measured by driving two standardized (59 km total length) road courses 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 6-12). Selection of the

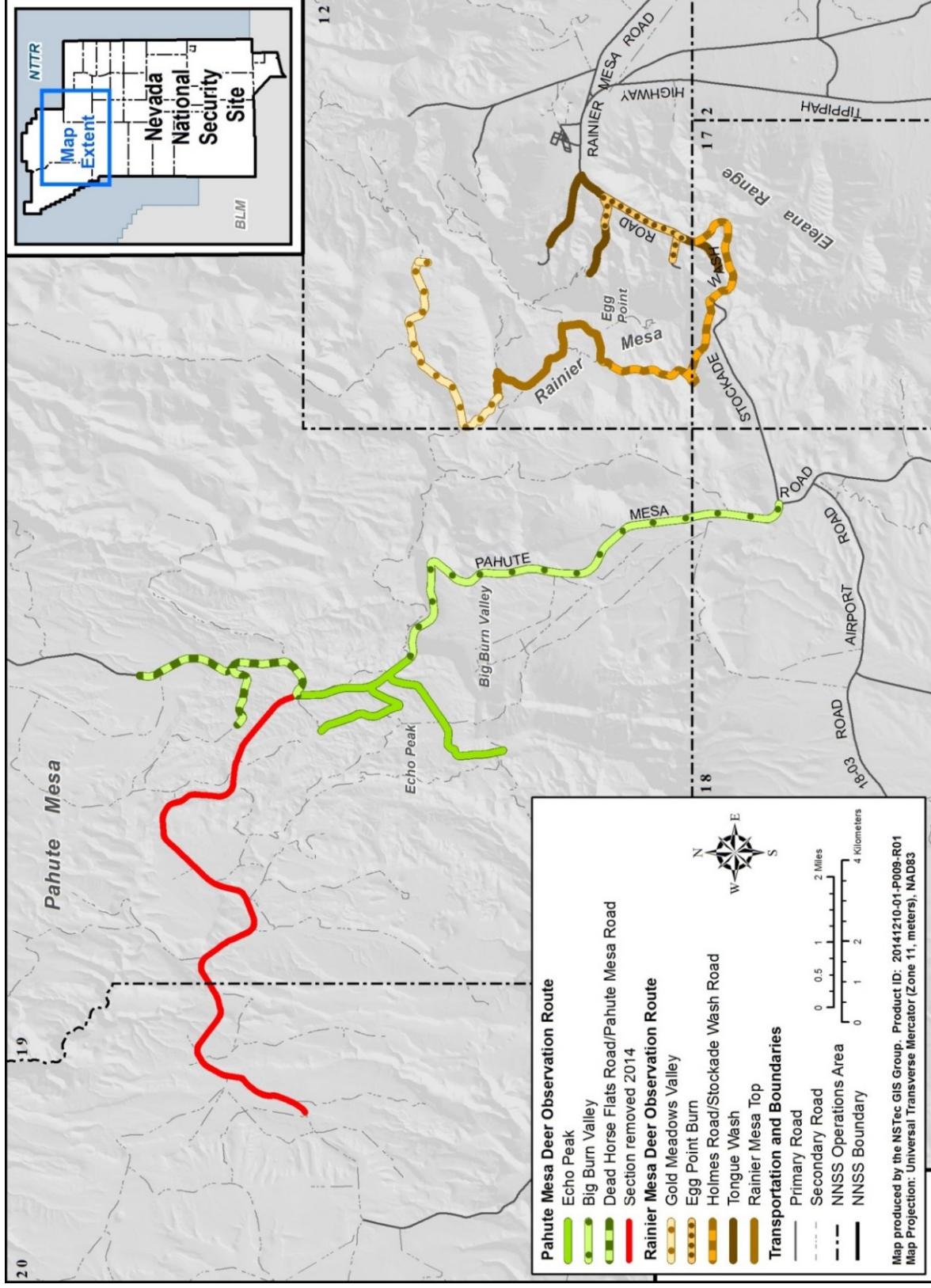


Figure 6-12. Road routes and sub-routes of two NNSS regions driven in 2021 to count deer and section removed due to road closure.

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.

During six surveys conducted September 27-29 and October 12-14, 2021, a total of 71 deer were observed on both routes combined, which equates to an average of 11.8 deer per night. This is more than three times fewer deer per night than what was observed in 2020, when an average of 37 deer per night were recorded. This is the lowest number of deer per night since 2006 when deer surveys resumed and the second lowest ever recorded. There has been a decreasing trend ( $y = -1.8204x + 45.897$ ,  $r^2 = 0.46$ ) the last 16 years with counts fluctuating widely (Figure 6-13). The trend for the entire study period (1989-2021, excluding 1995-1998 and 2001-2005) is nearly flat ( $y = -0.1518x + 31.84$ ,  $r^2 = 0.02$ ). 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. Seven of 18 (39%) radio-collared mule deer were killed by mountain lions during 2021.

Unlike last year, the number of deer per 10 km was higher on Pahute Mesa than Rainier Mesa in 2021 (Figure 6-14). This may be due to the lack of water at Gold Meadows Spring. The number of deer per 10 km (0.9) on Rainier Mesa is the lowest value recorded since 2006 and one of the lowest for the entire study period, while 3.1 deer per 10 km on the Pahute Mesa route is well within the range seen before. A total of 49 (half of 2020) deer groups were detected, and group size varied from one to four animals. The average group size was nearly equal between the Pahute Mesa and Rainier Mesa routes (1.4 and 1.5, respectively).

### 6.5.2 Sex and Fawn/Doe Ratios

A disproportionate number of bucks were observed during the 2021 deer surveys; 46 bucks, 9 does, 0 fawns, and 16 unknown. The deer sex ratio (number of bucks per 100 does) increased from 63 in 2020 to 511 in 2021, 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 2021, down from 17 in 2020 (Table 6-2). The only other year with zero fawns detected was 2007, which was an extremely dry year like 2021. The buck to doe ratio was also much higher in 2007 than in other years, similar to our results in 2021 (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.

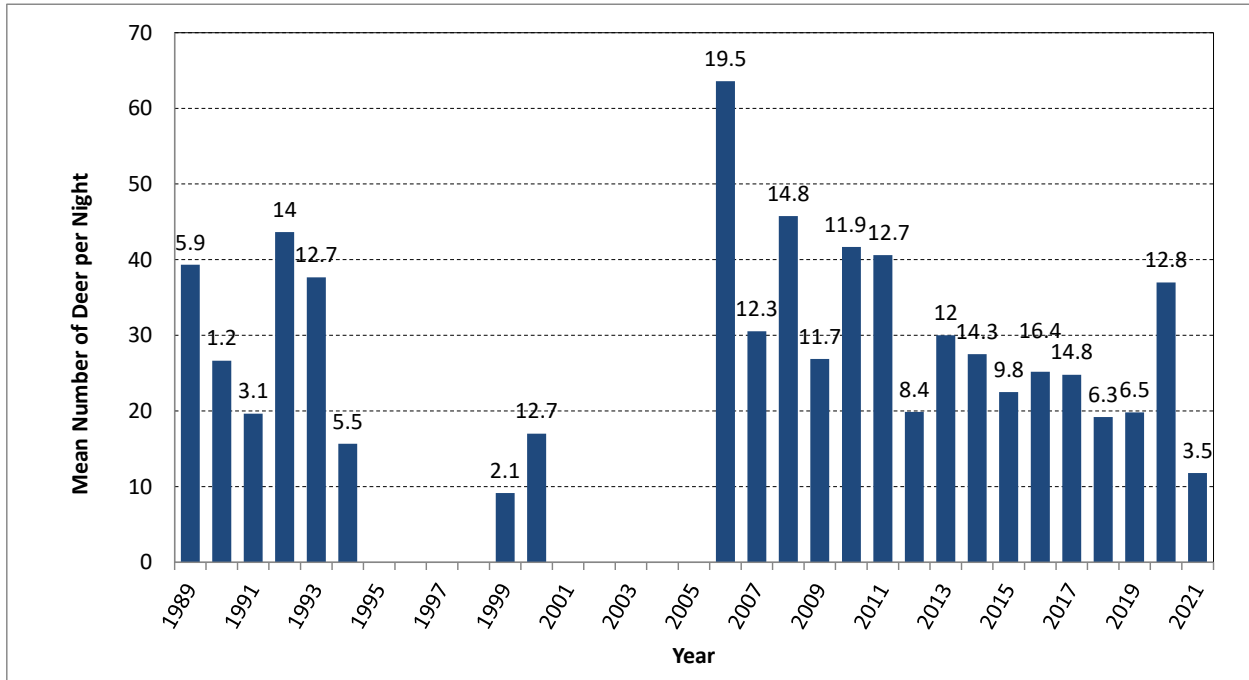


Figure 6-13. Trends in total deer count per night from 1989 to 2021 on the NNSS (surveys were not conducted during 1995–1998 or 2001–2005). Standard deviation values above bars.

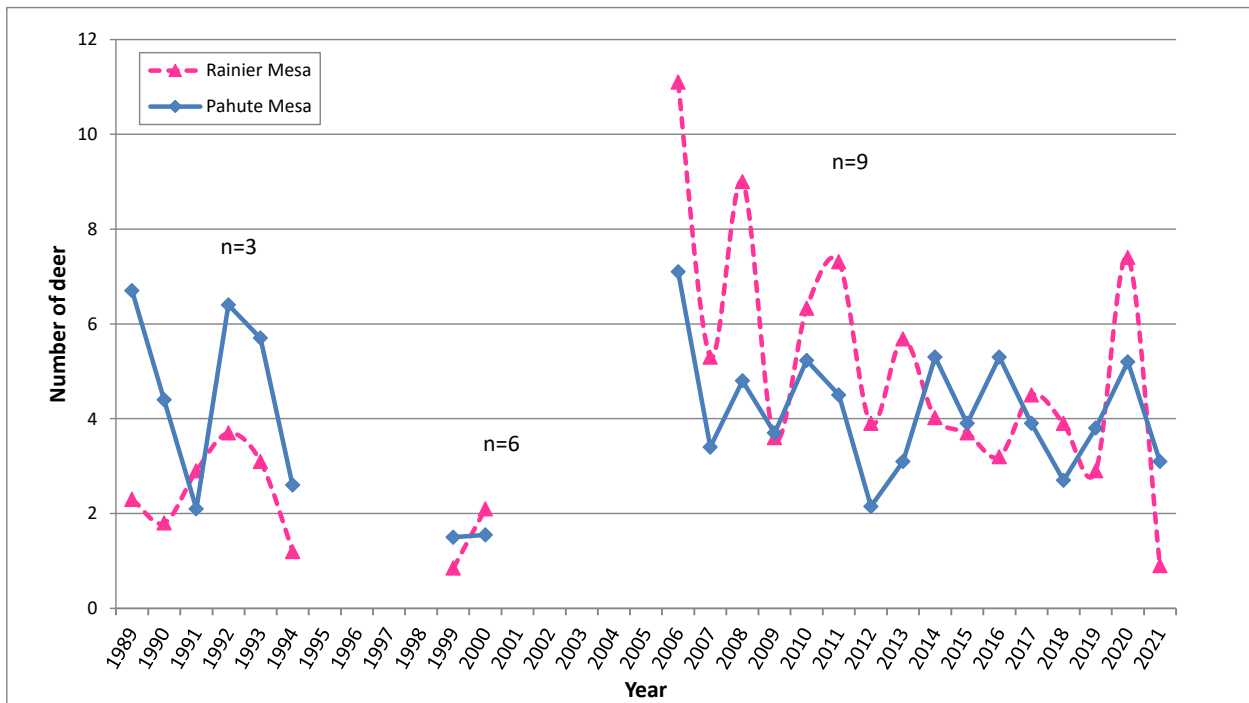


Figure 6-14. Mean number of mule deer per 10 km per night, counted on two routes (n = number of survey nights; exceptions n = 12 for 2012, n = 8 for 2013, n = 6 for 2015–2021).

**Table 6-2. Mule deer classified by sex and age, with sex ratios, and fawn to doe ratios from 2006 to 2021 on the NNSS (12 survey nights for 2012, 8 for 2013, 6 for 2015–2021, 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

The percentage of individuals unclassified to sex in 2021 was 22.5% which is higher than the average percentage of unclassified sex since 2006 (18.3%). 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.

## 6.6 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. 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. At the beginning of 2021, 18 mule deer and 10 pronghorn were still alive. These animals were monitored during 2021. Similar to 2020, pronghorn spent a majority of time in Frenchman Flat and Yucca Flat with no large seasonal migrations (Figure 6-15), although they remained close to water sources and shade during the hot, dry summer. One doe made two short forays (1-2 days) into Emigrant Valley in mid-June and mid-July. One buck spent a good portion of July and August in the foothills of the Spotted Range. One doe stayed in Mercury Valley from late April to June and one buck spent a few days in Mercury Valley in late August/early September. Similar to 2020, 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, and eastern slopes of Rainier Mesa (Figure 6-15). For the second year in a row, a doe (#705940) that wintered on the NNSS moved over 80 km to the north through the Kawich Range to spend the summer in the Kawich Peak area which is open to hunting. A few deer also spent time on Shoshone Mountain and Timber Mountain. One doe made a short foray across Yucca Flat into Plutonium Valley and into Scarp Canyon in late January.

Two pronghorn does and no bucks were found dead during 2021 compared to the three bucks and three does found dead during 2020. One was either killed or scavenged by coyotes based on the sign around the carcass and was found on the eastern edge of Yucca Playa. The other one was either killed or scavenged by an unknown predator and was found east of Area 5 RWMC. A total of 10 mule deer (4 bucks, 6 does) were found dead during 2021 compared to five (2 bucks, 3 does) found dead during 2020. Seven mule deer (2 bucks, 5 does) were killed by mountain lions, two bucks were killed or scavenged by coyotes, and one doe was struck by a vehicle. 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 supposed to last for three years. The manufacturer was consulted about the problem and they did not have a reason for the battery issues. We will continue to monitor the remaining animals until November 1, 2022 when the collars are programmed to automatically drop off the animals.

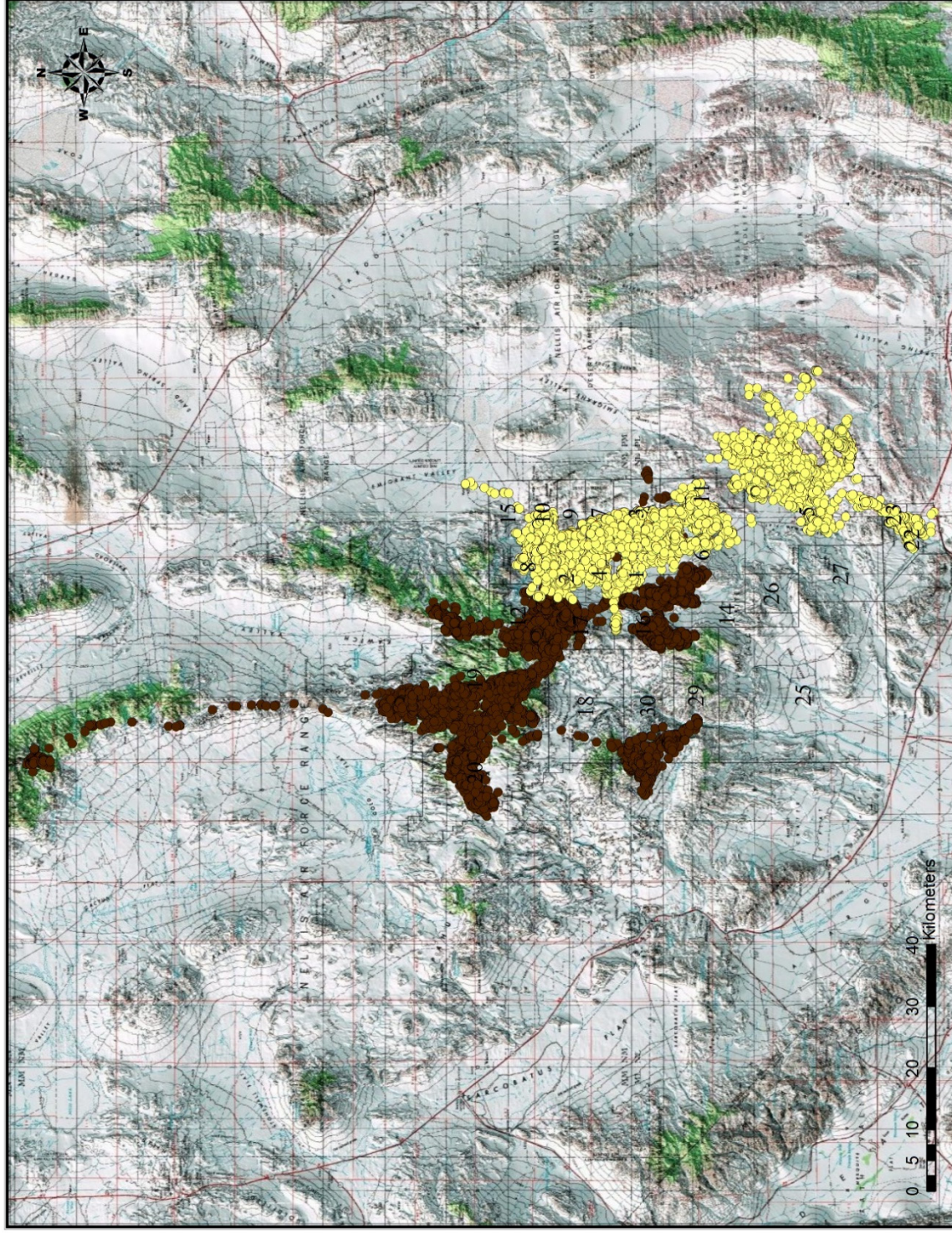


Figure 6-15. Locations of collared mule deer (brown dots) and pronghorn antelope (yellow dots) during 2021.

## 6.7 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 2021, this was done by documenting sheep use at several water sources using camera traps. In addition, 10 rams were opportunistically observed by a helicopter pilot in late May while flying over Skull Mountain during fire suppression activities for the Cherrywood Fire on Timber Mountain and a ram was seen in Mercury in late January. Remains of a mature ram was discovered near the mouth of South Pah Canyon in October. It was likely killed by a mountain lion in early August based on photos from the South Pah Canyon (#15) camera of a mountain lion, common ravens, and turkey vultures in the area. Old remains of a mature ewe were also found in Topopah Valley in November.

### 6.7.1 Camera Trap Results

During 2021, motion-activated cameras detected sheep at Delirium Canyon Tanks (#5) (889 images), Cottonwood Spring (#4) (91 images), South Pah Canyon Tanks (#15) (35 images), Fortymile Canyon Tanks (#11) (18 images), and Twin Spring (#21) (8 images) (Table 6-3). Eleven marked sheep (7 ewes, 4 rams) were identified including Ewe 686314, Ewe 686313 or 686315, Ewe 686316, Ewe 686317, Ewe 686318, Ewe 686319, Ewe 686320, Ram 686322, Ram 686329, Ram D, and Ram 123. Eight marked sheep (all but Ewe 686313 or 686315, Ram D, and Ram 123) were detected at Cottonwood Spring (#4) (Figure 6-16), four marked sheep (Ewe 686313 or 686315, Ewe 686314, Ram D, and Ram 123) were detected at South Pah Canyon Tanks (#15), three marked sheep (Ewe 686313 or 686315, Ewe 686314, and Ewe 686316) were detected at Fortymile Canyon Tanks (#11), three marked sheep (Ewe 686316, Ewe, 686318, and Ewe 686320) were detected at Delirium Canyon Tanks (#5), and one marked sheep (Ram 123) was detected at Twin Spring (#21). At least an additional 12 unmarked sheep were detected (six unmarked ewes, four lambs, one young ram, and one adult ram) making a total of at least 23 sheep documented on the NNSS during 2021. As in previous years, only rams were detected at Twin Spring. Also, Ewe 686316 still had its radiocollar attached, and at least four of our collared ewes were observed with lambs beside them. A mature ram was also photographed at ER 20-7 (#13) in November as part of another project.

## 6.8 Mountain Lion Monitoring

### 6.8.1 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 2021 at 25 sites (Figure 6-17 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



**Figure 6-16. Ram 686322 (left) and unmarked ram (right) at Cottonwood Spring.**

(Photo taken by motion-activated camera, August 20, 2021)

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 2020 due to the accessibility and scheduling of camera trap visits.

A total of 97 mountain lion images (i.e., photographs or video clips) were taken during 178,796 camera hours across all sites (Figure 6-11 and Table 6-3). This equates to about 0.5 mountain lion images per 1,000 camera hours. Mountain lions were detected at 10 of the 25 sites, including 8 water sources, 1 road, and 1 canyon (Figure 6-17). Table 6-4 contains the camera trap results by month and location. Figure 6-18 depicts a mountain lion with a recently killed deer in its jaws at Camp 17 Pond (#6), and Figure 6-19 shows a mountain lion at Delirium Canyon Tanks (#5).

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 with subadult) were documented in 2021 from the 25 camera traps. Photos from another project showed a female and two subadults on a mule deer kill at E Tunnel Ponds in June. Including these there is a minimum of four individuals (adult male, adult female with two subadults). This compares to a minimum of 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.

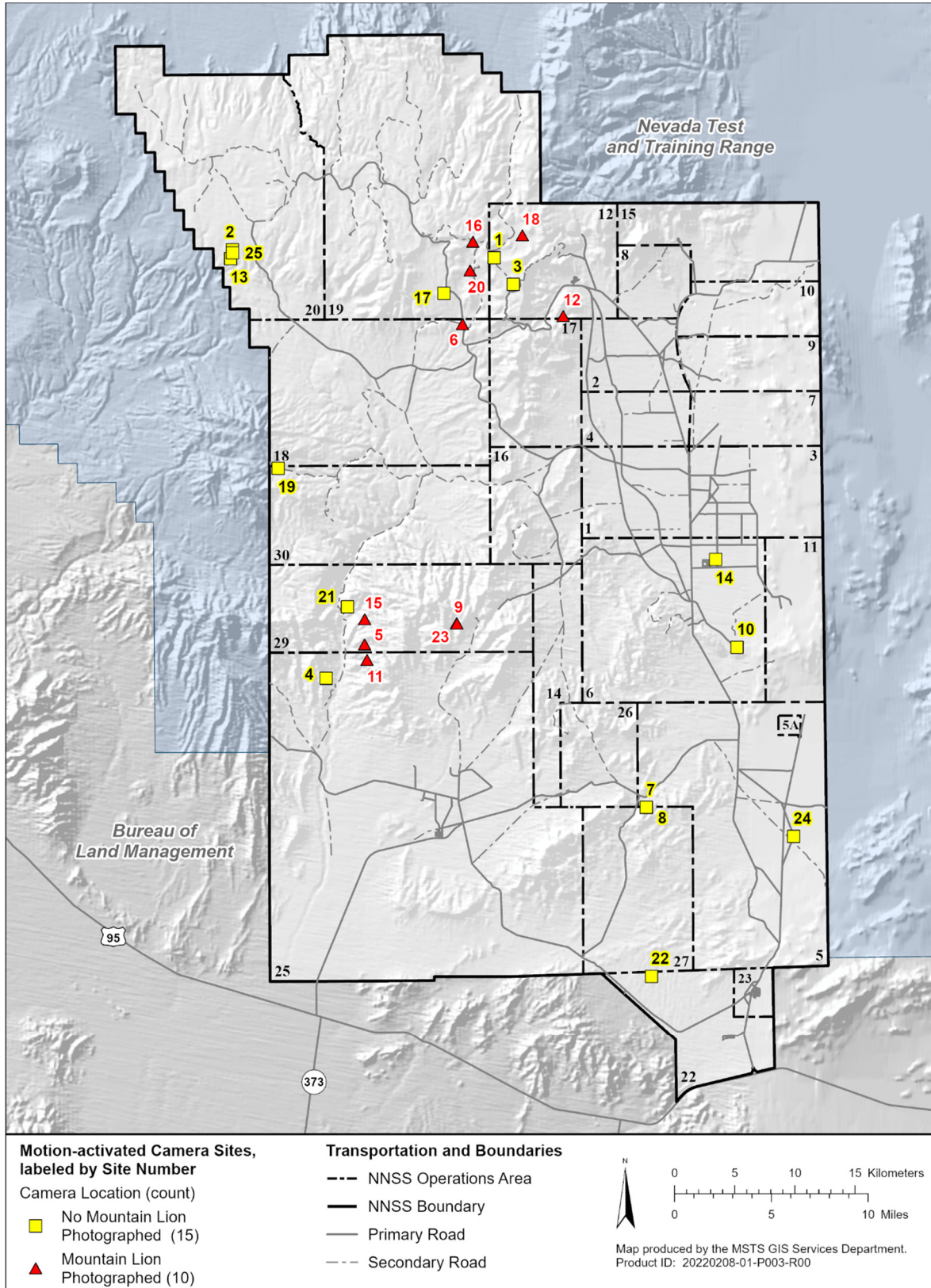


Figure 6-17. Locations of mountain lion photographic detections and camera traps on the NNSS during 2021.

**Table 6-3. Results of mountain lion camera surveys during 2021 (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)
Camp 17 Pond (#6)	1/1/21-12/20/21 <sup>a</sup>	7,362	40 (5.4)	Bobcat (3), coyote (85), mule deer (498), feral horse (276), peregrine falcon (15), golden eagle (7), Cooper's hawk (92), red-tailed hawk (405), great-horned owl (2), turkey vulture (619), chukar (10), mourning dove (40), common raven (765), belted kingfisher (7), green heron (1), great blue heron (22), willet (5), American wigeon (18), mallard duck (19), green-winged teal (2), common snipe (2), black-necked stilt (4), greater yellowlegs (5), pinyon jay (253), scrub jay (3), red-shafted common flicker (317), American robin (13), olive-sided flycatcher (25), Cassin's kingbird (1), black phoebe (30), summer tanager (2), northern mockingbird (19), dark-eyed junco (18), yellow-rumped warbler (1), black-billed magpie (9), house finch (2), European starling (1), dragonfly (1)
Captain Jack Spring (#12)	1/1/21-12/20/21 <sup>a</sup>	5,550	12 (2.2)	Bobcat (37), coyote (12), mule deer (1,799), desert cottontail (2), rock squirrel (2), cliff chipmunk (2), bats (16), Cooper's hawk (31), great-horned owl (1), chukar (84), mourning dove (2), pinyon jay (813), scrub jay (5), common raven (13), red-shafted common flicker (1), hairy woodpecker (5), lazuli bunting (2), Scott's oriole (12), black-headed grosbeak (2), rufous sided towhee (1), black-throated sparrow (1)
Delirium Canyon Tanks (#5)	1/1/21-1/13/22	9,051	16 (1.8)	Bobcat (22), gray fox (26), ring-tailed cat (2), desert bighorn sheep (889), bats (2), golden eagle (3), red-tailed hawk (7), great-horned owl (2), chukar (6), common raven (8), red-shafted common flicker (1), black swallowtail butterfly (1)
East 19-01 Road (#16)	1/1/21-12/31/21 <sup>a</sup>	6,407	7 (1.1)	Bobcat (9), gray fox (2), coyote (23), mule deer (41), feral horse (14), black-tailed jackrabbit (79), great-horned owl (1), mourning dove (2), rufous-sided towhee (1)

**Table 6-3. Results of mountain lion camera surveys during 2021 (a = non-continuous operation due to camera problems, dead batteries, full memory cards, etc.; b = camera hours not known for some time periods) (continued).**

Location (Site Number)	Dates Sampled	Camera Hours	Mountain Lion Images (Number of Images per 1,000 Camera Hours)	Other Observations (Number of Images)
Rattlesnake Ridge Gorge (#20)	1/1/21-12/31/21	8,747	7 (0.8)	Coyote (1)
South Pah Canyon Tanks (#15)	1/1/21-1/11/22	11,415	6 (0.5)	Gray fox (8), coyote (1), desert bighorn sheep (35), mule deer (7), cliff chipmunk (3), bats (44), red-tailed hawk (12), Cooper's hawk (9), great-horned owl (18), chukar (61), turkey vulture (5), common raven (20), pinyon jay (83), scrub jay (1), Clark's nutcracker (5), red-shafted common flicker (9), black-headed grosbeak (10), common poorwill (3), hummingbird (2), rock wren (10), dark-eyed junco (2), white-crowned sparrow (1), house finch (4), western fence lizard (1), red dragonfly (1)
Fortymile Canyon Tanks (#11)	1/1/21-1/13/22 <sup>a</sup>	7,000	3 (0.4)	Gray fox (1), desert bighorn sheep (18), golden eagle (3)
Topopah Spring Trough (#23)	1/1/21-1/6/22 <sup>a</sup>	7,665	3 (0.4)	Bobcat (2), mule deer (16), rock squirrel (4), cliff chipmunk (2), white-tailed antelope ground squirrel (3), rodent (1), red-shafted common flicker (1)
Gold Meadows Spring (#18)	1/1/21-12/31/21 <sup>a</sup>	7,610	2 (0.3)	Coyote (21), Rocky Mountain elk (1), pronghorn antelope (10), mule deer (63), feral horse (115), black-tailed jackrabbit (27), rodent (7), red-tailed hawk (6), turkey vulture (5), mourning dove (6), red-shafted common flicker (3), scrub jay (1), common raven (10), kingbird (2), white-crowned sparrow (2), Say's phoebe (2)
Topopah Spring (#9)	1/1/21-1/6/22 <sup>a</sup>	4,274	1 (0.2)	Rock squirrel (4), rodent (1), western bluebird (1)
12T-26, Rainier Mesa (#1)	1/1/21-12/31/21 <sup>a</sup>	8,463	0 (0.0)	Mule deer (1)
Dick Adams Cutoff Road, Rainier Mesa (#3)	1/1/21-12/31/21	8,726	0 (0.0)	Coyote (1), mule deer (30)

**Table 6-3. Results of mountain lion camera surveys during 2021 (a = non-continuous operation due to camera problems, dead batteries, full memory cards, etc.; b = camera hours not known for some time periods) (continued).**

Location (Site Number)	Dates Sampled	Camera Hours	Mountain Lion Images (Number of Images per 1,000 Camera Hours)	Other Observations (Number of Images)
Water Bottle Canyon (#17)	1/1/21- 1/12/22 <sup>a,b</sup>	unknown	0 (0.0)	None
East Cat Canyon (#19)	1/1/21- 12/20/21 <sup>a</sup>	7,034	0 (0.0)	Coyote (3), mule deer (3), black-tailed jackrabbit (1)
Cottonwood Spring (#4)	1/1/21- 1/13/22	9,065	0 (0.0)	Bobcat (17), coyote (34), desert bighorn sheep (91), mule deer (120), feral burro (3,208), bats (2), golden eagle (1), chukar (50), desert spiny lizard (1)
Twin Spring (#21)	1/1/21- 1/11/22 <sup>a</sup>	4,903	0 (0.0)	Gray fox (6), coyote (52), badger (2), desert bighorn sheep (8), mule deer (332), feral burro (2,964), desert woodrat (3), white-tailed antelope ground squirrel (8), rodents (40), golden eagle (19), chukar (110), common raven (15), sagebrush sparrow (3), Bullock's oriole (1), rock wren (4), white-crowned sparrow (1), Say's phoebe (2), desert spiny lizard (2), side-blotched lizard (18)
Area 22, Juvenile GOAG <sup>c</sup> Site 2 (#22)	1/1/21- 1/10/22 <sup>a</sup>	8,828	0 (0.0)	Kit fox (3), black-tailed jackrabbit (21), white-tailed antelope ground squirrel (6), kangaroo rat (29), passerine (1), zebra-tailed lizard (2)
Cane Spring (#7)	1/1/21- 1/6/22 <sup>a</sup>	2,111	0 (0.0)	Coyote (1), mule deer (6), bats (1), rodent (3), mourning dove (16)
Cane Spring Trough (#8)	1/1/21- 1/6/22	8,904	0 (0.0)	None
Area 6 LANL Pond Trough (#14)	1/1/21- 1/6/22	8,889	0 (0.0)	Pronghorn antelope (17), feral burro (12)
Well C1 Pond Trough (#10)	1/1/21- 1/6/22 <sup>a</sup>	8,655	0 (0.0)	Coyote (8), pronghorn antelope (141), mule deer (22), feral burro (19), golden eagle (1), turkey vulture (5), common raven (4)

**Table 6-3. Results of mountain lion camera surveys during 2021 (a = non-continuous operation due to camera problems, dead batteries, full memory cards, etc.; b = camera hours not known for some time periods) (continued).**

Location (Site Number)	Dates Sampled	Camera Hours	Mountain Lion Images (Number of Images per 1,000 Camera Hours)	Other Observations (Number of Images)
Well 5C Trough (#24)	1/1/21- 1/6/22 <sup>a</sup>	7,136.	0 (0.0)	Bobcat (40), coyote (39), badger (3), pronghorn antelope (103), feral burro (60), black-tailed jackrabbit (19), white-tailed antelope ground squirrel (7), kangaroo rat (29), turkey vulture (1), mourning dove (2), LeConte's thrasher (2), common raven (59), red-winged blackbird (1), horned lark (97), great-tailed grackle (26), common poorwill (4), Eurasian collared dove (3), European starling (8)
ER 20-5 Upper Plastic-lined Sump (#2)	1/1/21- 6/17/21	4,029	0 (0.0)	Common raven (4), passerine (1)
ER 20-7 Plastic-lined Sump (#13)	1/1/21- 12/20/21	8,488	0 (0.0)	Golden eagle (1), turkey vulture (1), common raven (5), house finch (4)
ER 20-5 Plastic-lined Sump (#25)	1/1/21- 12/20/21	8,484	0 (0.0)	Mourning dove (1), common raven (15), house finch (1)





**Figure 6-18. Mountain lion with recently killed mule deer in its mouth at Camp 17 Pond.**

(Photo taken September 3, 2021 by motion-activated camera)



**Figure 6-19. Mountain lion at Delirium Canyon Tanks (#5).**

(Photo taken April 21, 2021 by motion-activated camera)

In order to investigate temporal activity of mountain lions, camera detection data from all 16 years (2006-2021) were combined. Mountain lions were detected every month with peak occurrences during November (n = 162), August (n = 155), and June (n = 148) (Figure 6-20). The number of images taken during summer and fall (June–November) (n = 783) accounted for nearly 70% of all images compared with the number of images taken during winter and spring (December–May) (n = 350) (Figure 6-20). Nearly three-fourths of mountain lion images were taken between 1700 to 0500 hours with a peak between 2000 and 2100 hours Pacific Standard Time (Figure 6-21). From 2011 to 2021, nearly 1.8 times as many images were taken when it was dark (n = 603) compared with when it was light (n = 339).

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 16,283 images of at least 81 species other than mountain lions were taken during 178,796 camera hours across all sites which is about 91 images per 1,000 camera hours. This is almost half as few images as were taken during 2020 (169 images per 1,000 camera hours). However, 81 species were detected in both 2021 and 2020 which is the greatest species richness documented using camera traps in a given year.

The most photographed species (38% of all images) was feral burros (6,263 images at 5 of 25 sites). Mule deer were fairly prevalent (18% of all images) with 2,938 images at 13 of 25 sites. Captain Jack Spring (#12), Camp 17 Pond (#6), Twin Spring (#221), and Cottonwood Spring (#4) were important water sources for mule deer during 2021. Some of the rarer, more elusive species documented from camera surveys were desert bighorn sheep (see Section 6.7.1), Rocky Mountain elk (*Cervus elaphus*) (see Section 6.11), bobcat (found at 7 of 25 sites), gray fox (*Urocyon cinereoargenteus*) (found at 5 of 25 sites), golden eagle (found at 7 of 25 sites), badger (found at 2 of 25 sites), ring-tailed cat (found at 1 of 25 sites), peregrine falcon (found at 1 of 25 sites), and pinyon jay (found at 3 of 25 sites) (Table 6-3). Red-shafted common flickers were surprisingly common with 332 images taken at 6 of 25 sites. Three images of kit fox were taken at the Area 22, Juvenile GOAG Site 2 (#22) location. Noteworthy observations of some of the more common species included 913 images of common ravens at 11 of 25 sites, and 281 images of coyotes at 12 of 25 sites. Like many other species, number of mourning dove photographs drastically declined from 3,306 images at 12 of 26 sites in 2020 to 69 images at 7 of 25 sites in 2021. 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.

### 6.9 Radiological Sampling

Sampling for radionuclides in game species (e.g., mule deer, pronghorn antelope, waterfowl) was performed in order 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 2021, 12 tissue samples were collected opportunistically and analyzed from 10 mule deer (7 does, 3 bucks), one pronghorn doe, and one green-winged teal. One mule deer doe was killed by a vehicle on Tippah Highway in Area 2, the green-winged teal died of unknown causes, and the remaining 10 animals were all collared as part of the mule deer and pronghorn distribution study and died of various causes, mostly due to mountain lion predation. 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.

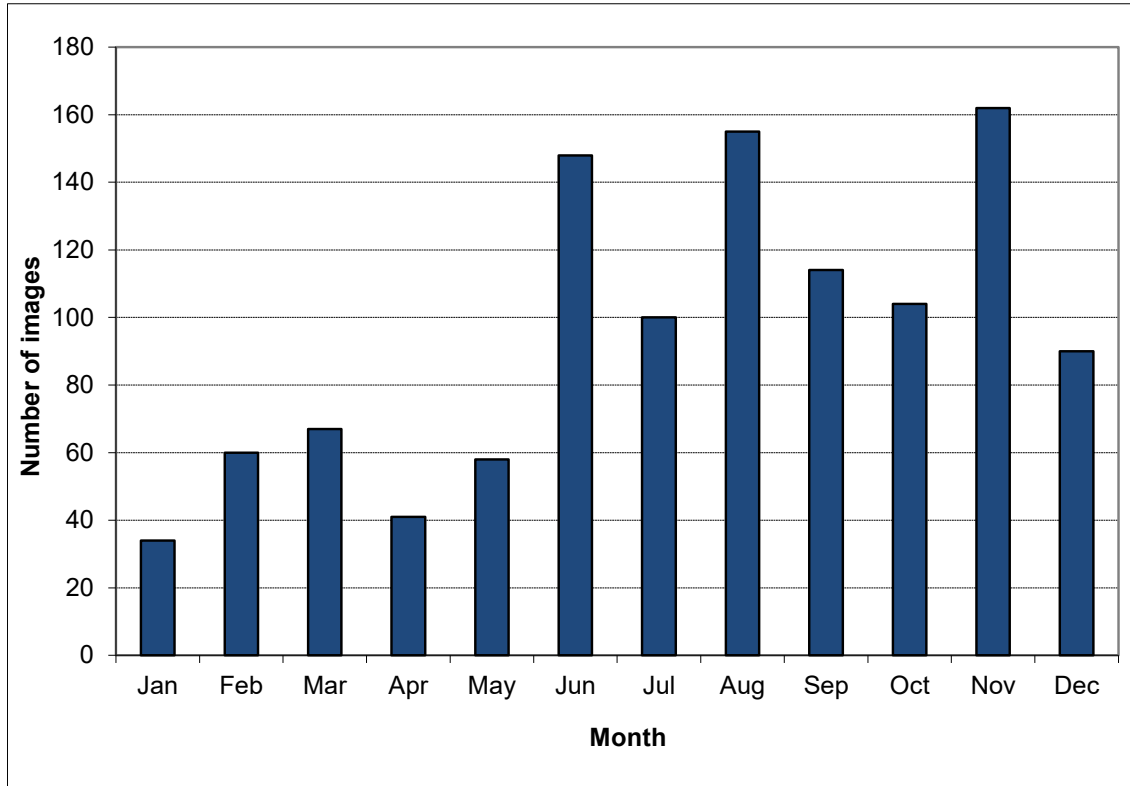


Figure 6-20. Number of mountain lion images by month for camera sites where mountain lions were detected from 2006 through 2021 (n = 1,133).

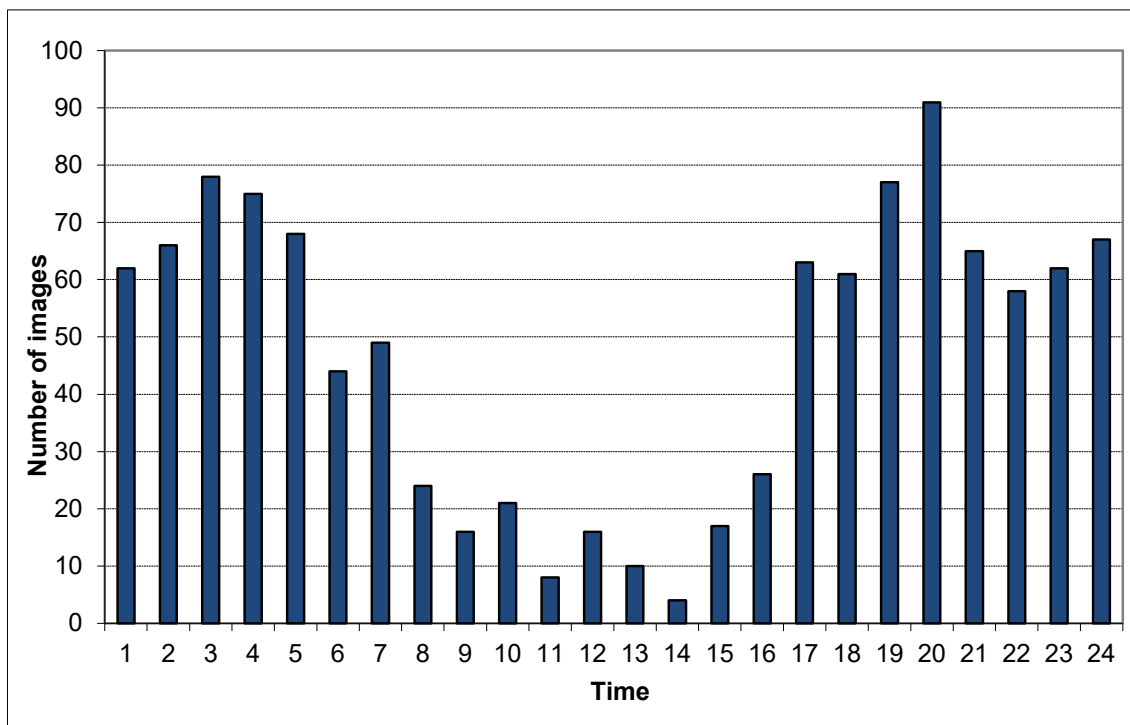


Figure 6-21. Number of mountain lion images by time of day (Pacific Standard Time) for camera sites where mountain lions were detected from 2006 through 2021 (n = 1,128).

Results revealed low concentrations of tritium in five of the mule deer. 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 (2021).

## **6.10 Nuisance and Potentially Dangerous Wildlife**

During 2021, MSTs biologists documented 39 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 (17 calls), bats (4 calls), other mammals (14 calls), reptiles (3 calls), and invertebrates (flying ants, 1 call). Mitigation measures taken typically involved relocating the animals away from people, instructing workers to leave the animal in place, or disposing of dead animals.

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.

## **6.11 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 2021, only one photo of elk was taken. It was a single bull elk photographed drinking at Gold Meadows Spring on May 27 (Figure 6-22).

Feral burros appear to be increasing in number and expanding their range on the NNSS. During 2021, burros were documented with camera traps at Twin Spring (#21) (2,964 images, more than double last year), Cottonwood Spring (#4) (3,208 images compared to 52 images in 2020), Well 5C trough (#24) (60 images), Well C1 Pond Trough (#10) (19 images), and Area 6 LANL Pond Trough (#14) (12 images) (Table 6-3). The area around Twin Spring and Cottonwood Spring was heavily disturbed from burro use with numerous trails on the hillslopes around the springs.



**Figure 6-22. Bull elk drinking at Gold Meadows Spring.**

(Photo taken by motion-activated camera, May 27, 2021)

## **6.12 Coordination with Biologists and Wildlife Agencies**

MSTS biologists interfaced with other biologists and wildlife agencies in 2021 for the following activities:

- Upon NNSA/NFO request, gave presentation on bats and bat monitoring on the NNSS at the Consolidated Group of Tribes and Organizations annual meeting in August.
- Contributed to the draft version of the Nevada Bat Conservation Plan.
- Participated on the Springsnail Conservation Team.
- Gave multiple “hands-on” wildlife presentations using our taxidermied animal specimens to school children at the Nevada Atomic Testing Museum.
- Gave presentation entitled, “Plants and Animals of the Nevada National Security Site” as part of the Distinguished Lecture Series at the Nevada Atomic Testing Museum in April.

## 7.0 HABITAT RESTORATION IMPLEMENTATION AND MONITORING

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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 2021 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 CAU 577 East and West Cover Caps (Area 5 RWMC), 3) transplanting creosote bush and white bursage and evaluating revegetation success from fall 2020 seeding on Cell 18 (Area 5 RWMC), and 4) implementing 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 assessment of the vegetation on CAU 110, U3-ax/bl closure cover was made on July 27, 2021. A meandering transect covering the entire cap was walked. The vigor of perennial plant species was assessed based on current year’s growth, whether plants were flowering, and if any showed signs of stress (i.e. dead stems or leaves). Shadscale saltbush continues to be the most abundant shrub species on the closure cover (Figure 7-1). Many of the plants observed showed signs of stress due to the drought conditions and some dead shadscale plants were noted. Nevada jointfir, the second most common perennial species, was doing well, although no evidence of seed production was observed. No perennial plant seedlings were seen although a few young shadscale plants were observed, especially on the eastern portion of the cover cap. 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. Residual cheatgrass from last year was found amongst the shadscale and Nevada jointfir plants. Old saltlover (*Halogeton glomeratus*), 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, highlighting the importance of seeding to establish a perennial vegetation community.

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 burrows on the cover cap is substantially less than in the native undisturbed areas in Yucca Flat. Trapping



**Figure 7-1. Overview of plant community that has established on the CAU 110 over the last 21 years. Shadscale and Nevada jointfir are the two most dominant plants found on the closure cover.**

(Photo by D.B. Hall, July 27, 2021)

for small mammal removal is not recommended at this time. No rabbits were observed or evidence of herbivory on the vegetation. Several horned larks (*Eremophila alpestris*) were observed on the cover cap.

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

Corrective Action Unit (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 27, 2021. Precipitation received at the 92-Acre Site for the period December 2020 to April 2021 was less than half the normal amount, resulting in poor growing conditions.

**South Cover.** Several perennial shrubs (16 fourwing saltbush [*Atriplex canescens*], 5 shadscale saltbush, and 1 white bursage) were found widely scattered on the cover cap. Some noxious weeds (i.e., saltlover and Russian thistle) and flatcrown buckwheat were found on the cover as well. Most of the biomass was from remnant saltlover plants from last year. There were a few active rodent burrows in the soil berm on the east side of the cover and only a few burrows on top of the cover. One active ant mound was also found on top of the cover.

**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. There are also some large fourwing saltbush plants alive from revegetation efforts completed several years ago. Six shadscale plants were also observed from those same revegetation efforts years ago. Shadscale 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 cap has sufficient perennial plant density and cover. It is recommended that the remaining 75% be revegetated. There is a lot of old saltlover plants remaining from last year across the whole cover and abundant old Arabian schismus plants in the recent revegetated areas that were irrigated.

**North North Cover.** Five white bursage plants were found on this cover that appeared to have germinated over the last couple of years. There were some saltlover and Russian thistle plants that had germinated this year but most of the plants were old saltlover plants from last year (Figure 7-2). Some rodent burrows and an active ant mound were observed but don't appear to be impacting the integrity of the cover. There had been active construction to deal with subsidence issues in the northeast corner.

**West Cover.** This site had a lot of recent construction activity to fix subsidence issues. The undisturbed areas were dominated by old saltlover plants from last year. There were some saltlover and Russian thistle plants that had germinated this year. Two young shadscale plants were also documented. A few rodent burrows were found.



**Figure 7-2. North North Cover on the “92-acre Site.”**

(Photo taken July 27, 2021, by D.B. Hall)

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 last year. No rabbits or fresh rabbit sign were observed. Light rodent burrowing and ant activity were detected but don't appear to be impacting the integrity of the covers.

### **7.3 CAU 577 East and West Cover Cap revegetation and monitoring**

Revegetation of CAU 577 East (5.2 ha) and West (7.0 ha) Cover Caps was accomplished during the spring of 2021, and included site preparation, seeding, hydromulching, and supplemental irrigation. A plastic mulch trial was also conducted on the East Cover Cap to evaluate if covering the ground with plastic (similar to a greenhouse) after revegetation and irrigation would increase germination success.

#### **7.3.1 Site Preparation**

Site preparation entailed adding 23-30 cm of topsoil on top of the constructed cover cap and ripping the soil perpendicular to the predominant slope to a depth of approximately 30-45 cm to alleviate soil compaction using a low, load-bearing bulldozer with a ripper bar (Figure 7-3). A rabbit-proof fence was also erected around each cover cap to prevent herbivory.



**Figure 7-3. Ripping CAU 577 East Cover Cap with bulldozer to alleviate soil compaction.**

(Photo taken February 22, 2021, by D.B. Hall)

### 7.3.2 Seeding and Hydromulching

The sites were seeded in February with a native seedmix comprised of seven shrub, two grass, and four 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 in order to prime the seed and remove a chemical germination inhibitor to enhance germination (Ostler et al. 2002). The desert pepperweed (*Lepidium fremontii*) and almost one-third of the desert globemallow seed was hand-collected from around Mercury (Area 23) and Jackass Flats Road (Area 27), respectively. 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 7-4). 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 and seed viability and give us an indication of what was happening to the seed across both cover caps. Following seeding, a straw mulch plus soil binder product (HydroStraw Guar Plus Formulation) was applied over the site (Figure 7-5) at a rate of 2,240 kg/ha for soil moisture retention, organic matter additive, and erosion control. Seeding and hydromulching were done by SoilTech who was a subcontractor to Canyon Electric, the main revegetation subcontractor.

### 7.3.3 Irrigation

Wheel line irrigation systems as designed by Cascade Earth Sciences (subcontractor to Canyon Electric) (Figure 7-6) were installed at each site in late February/early March by JTS Farmstore, another subcontractor to Canyon Electric. The irrigation system at the West Cover Cap 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 varying length. The irrigation system at the East Cover Cap had three large water tanks with an approximate capacity of 79,500 L each, a diesel-powered engine and pump, and two wheel lines of the same length. Water was delivered to the tanks utilizing watermaster trucks capable of hauling nearly 38,000 L per load (Figure 7-7). Water stored in the tanks was then pumped and uniformly distributed

**Table 7-1. Seedmix used to revegetate CAU 577 East and West Cover Caps including species, number of pure live seeds per square meter and number of pounds of pure live seed per acre.**

<u>Lifeform</u>	<u>Common Name</u>	<u>Species</u>	<u>Number of pure live seeds/m<sup>2</sup></u>	<u>Pounds of pure live seed/acre</u>
Shrub	White bursage	<i>Ambrosia dumosa</i>	105	5.0
Shrub	Fourwing saltbush	<i>Atriplex canescens</i>	21	1.5
Shrub	Shadscale salbush	<i>Atriplex confertifolia</i>	77	4.8
Shrub	Cattle saltbush	<i>Atriplex polycarpa</i>	99	0.5
Shrub	Nevada jointfir	<i>Ephedra nevadensis</i>	29	6.0
Shrub	Winterfat	<i>Krascheninnikovia lanata</i>	42	1.5
Shrub	Creosote bush	<i>Larrea tridentata</i>	99	5.0
Grass	Indian ricegrass	<i>Achnatherum hymenoides Paloma</i>	80	2.0
Grass	Squirreltail	<i>Elymus elymoides Toe Jam</i>	57	1.2
Forb	Desert marigold	<i>Baileya multiradiata</i>	183	0.7
Forb	Palmer penstemon	<i>Penstemon palmeri Cedar</i>	151	1.0
Forb	Desert globemallow	<i>Sphaeralcea ambigua</i>	92	0.7
Forb	Desert pepperweed	<i>Lepidium fremontii</i>	2	0.04
		<b>TOTAL</b>	<b>1036</b>	<b>30.0</b>



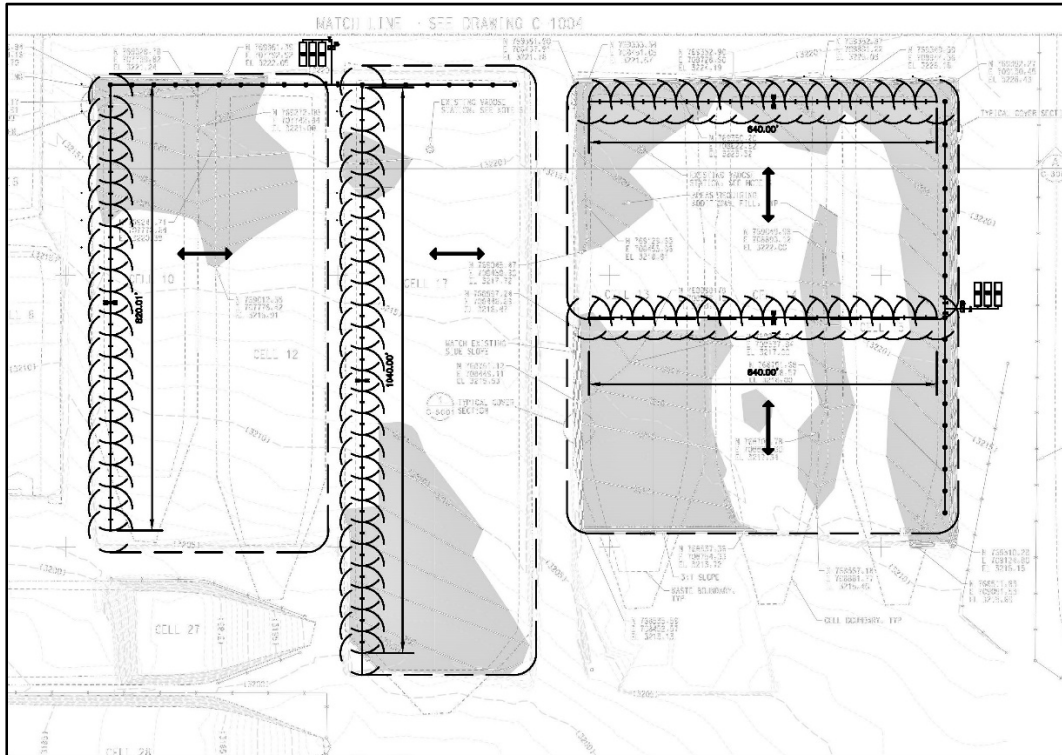
**Figure 7-4. Broadcast seeding CAU 577 West Cover Cap with drill seeder and chain harrow.**

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



**Figure 7-5. Applying hydromulch on CAU 577 West Cover Cap.**

(Photo taken February 11, 2021 by D.B. Hall)



**Figure 7-6. Schematic of irrigation systems for CAU 577 West Cover Cap (left) and East Cover Cap (right); two wheel lines per cap.**

(Drawing P202024141 P1 courtesy of Cascade Earth Sciences, February 18, 2021)



**Figure 7-7. Watermaster filling water tanks at CAU 577 East Cover Cap.**

(Photo taken March 24, 2021 by D.B. Hall)



**Figure 7-8. Irrigation system in operation at CAU 577 East Cover Cap. Note the abundance of seeded perennial shrubs (light green vegetation) with minimal saltlover and prickly Russian thistle (brown vegetation).**

(Photo taken October 5, 2021 by D.B. Hall)

across the site through the wheel lines and sprinkler heads (Figure 7-8). The systems were designed to apply 6.35 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. Germination irrigation was applied in March and April and establishment irrigation was applied in May/early June (Table 7-2). In order to optimize germination success during the March 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 hour. This way the soil surface where the seed was located stayed moist for multiple days. The 10 mm of rainfall in March with associated cool and cloudy conditions also helped keep the soil surface moist which contributed to germination success. The May/early June and September/October establishment irrigation applied water for seven hours (44.5 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.

### **7.3.4 Monitoring**

Mesh seedbags were retrieved on April 14 including three bags with fluffy seed and three bags with hard seed. Number of germinated seeds (i.e., seed with radicle at least 1.0 mm long) were counted by species

**Table 7-2. Amounts of irrigation applied and natural precipitation (mm) received at CAU 577 East and West Cover Caps in 2021.**

<u>Month(s)</u>	<u>Irrigation (mm) East Cover</u>	<u>Irrigation (mm) West Cover-East</u>	<u>Irrigation (mm) West Cover-West</u>	<u>Natural Precipitation (mm)</u>
March 2021	25.4	50.8	31.8	10.2
April 2021	12.7	12.7	12.7	4.1
May 2021	44.5	44.5	44.5	0.5
September-October 2021	44.5	44.5	44.5	15.5

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 moistblotter 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, squirreltail, Indian ricegrass, and shadscale and good viability of white bursage, creosote bush, and squirreltail.

Seedling density was monitored during mid-May to mid-June to evaluate seeding success. Transects (100-m long) were established uniformly across both cover caps 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 by species per square meter were then calculated for the East Cover Cap, eastern portion of West Cover Cap, and western portion of West Cover Cap (Table 7-3). This was done because the eastern portion of the West Cover received 1.6 times more irrigation in March than the western portion of the West Cover Cap due to having fewer stations (8 versus 11) on this longer wheel line, so moving it every hour resulted in more irrigation events at these stations than on the 11 stations on the western portion. It was hypothesized that increased March irrigation would result in increased germination. Percent mulch within each quadrat was also visually estimated and recorded.

Seedling density results revealed that seedling germination was successful in all areas with 19.1, 17.9, and 24.6 seeded seedlings per m<sup>2</sup> on the East Cover Cap, western portion of West Cover Cap, and eastern portion of West Cover Cap, respectively compared to 0.94 perennial plants per m<sup>2</sup> in the reference area. (Table 7-3). These results are even more impressive given the drought 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. Perennial plant densities in all categories exceeded those in the reference area sometimes by two orders of magnitude. Plant densities among the three areas were also different. Not surprising, densities in the western portion of the West Cover Cap were lower than densities in the eastern portion likely due to the increased irrigation applied during March which suggests this is a critical time for plant germination. Interestingly, plant densities on the East Cover Cap were as high or higher for many species than on the West Cover Cap even though it only received 25.4 mm of irrigation in March. These results suggest that 35.6 mm (25.4 mm irrigation plus 10.2 mm precipitation) of water in March is sufficient for excellent seed germination. More perennial shrubs were found on the East Cover Cap than the West Cover Cap but much higher densities of Indian ricegrass (*Achnatherum hymenoides*) were found on the West Cover Cap than on the East Cover Cap (Table 7-3). Cattle saltbush (*Atriplex polycarpa*), Nevada jointfir, fourwing saltbush, Indian ricegrass, squirreltail (*Elymus elymoides*), and desert marigold (*Baileya multiradiata*) all germinated well (Table 7-3). Densities of white bursage on the East Cover Cap and eastern portion of the West Cover Cap exceeded expectations. Desert globemallow did not germinate well, even though some

**Table 7-3. Average number of seedlings per square meter by lifeform and species for CAU 577 East and West Cover Caps and Reference Area, May/June 2021.**

<u>Lifeform</u>	<u>East Cover</u>	<u>West-west</u>	<u>West-east</u>	<u>Reference</u>
		<u>Cover</u>	<u>Cover</u>	<u>Area</u>
<b>Perennial Shrubs</b>				
White bursage	0.32	0.08	0.33	0.08
Fourwing saltbush	0.71	0.43	0.72	0.00
Shadscale saltbush	0.02	0.01	0.03	0.19
Cattle saltbush	4.45	1.96	3.20	0.00
Nevada jointfir	2.00	2.06	2.24	0.06
Winterfat	0.14	0.06	0.10	0.01
Creosote bush	0.01	0.02	0.05	0.04
Littleleaf ratany (not seeded)	0.00	0.00	0.00	0.43
Shockley's goldenhead (not seeded)	0.00	0.00	0.00	0.01
Water jacket (not seeded)	0.00	0.00	0.00	0.02
<b>SUM</b>	<b>7.65</b>	<b>4.60</b>	<b>6.65</b>	<b>0.84</b>
<b>Perennial Grasses</b>				
Indian ricegrass	4.32	11.17	10.99	0.10
Squirreltail	3.14	1.02	3.23	0.00
<b>SUM</b>	<b>7.46</b>	<b>12.19</b>	<b>14.21</b>	<b>0.10</b>
<b>Perennial Forbs</b>				
Desert marigold	4.01	1.07	3.64	0.00
Palmer's penstemon	0.00	0.00	0.06	0.00
Desert globemallow	0.00	0.01	0.03	0.00
Desert pepperweed	0.00	0.00	0.01	0.00
<b>SUM</b>	<b>4.01</b>	<b>1.08</b>	<b>3.73</b>	<b>0.00</b>
<b>TOTAL SEEDED</b>	<b>19.10</b>	<b>17.9</b>	<b>24.6</b>	<b>0.94</b>
<b>Annual Grasses</b>				
Arabian schismus	25.89	2.37	39.39	0.00
Cheatgrass	0.59	0.06	0.68	0.01
Red brome	0.11	0.04	0.23	0.00
Sixweeks fescue	1.03	0.01	0.61	0.00
Common wheat	0.00	0.00	0.02	0.00
<b>SUM</b>	<b>27.62</b>	<b>2.47</b>	<b>40.92</b>	<b>0.01</b>
<b>Annual Forbs</b>				
Saltlover	0.24	0.69	0.61	0.00
Roundleaf oxytheca	0.00	0.00	0.00	0.16
Others	0.16	0.17	0.18	0.00
<b>SUM</b>	<b>0.40</b>	<b>0.86</b>	<b>0.79</b>	<b>0.16</b>

local seed was used. Creosote bush was only found in very small numbers which was disappointing given the seed pretreatment, abundant irrigation during periods of warmer soil temperatures in April and May, and known good seed viability from the seedbags. Shadscale saltbush and Palmer's penstemon (*Penstemon palmeri*) did not germinate well which was expected because they tend to do better from fall seeding.

Arabian schismus was the dominant invasive annual on each area, especially the East Cover Cap and the eastern portion of the West Cover Cap. Interestingly, densities of Arabian schismus were much lower in the western portion of the West Cover Cap than on East Cover Cap even though it received more irrigation (Table 7-2, Table 7-3). The Arabian schismus, although found in high densities, 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. Saltlover densities were low in all areas which is likely due to being outcompeted by the perennial seedlings or perhaps by the Arabian schismus or both. Several native annual plant species were also observed in and out of the sampled area.

Overall, plant densities were higher than expected and well above those found in the reference area. Although plant density was not measured in the fall, visual observations indicated high seedling survival over the hot, dry summer even though no irrigation was used and summer precipitation was lower than normal. A possible explanation or contributing factor for the high seedling survival is the increased soil moisture from an abnormally large snowstorm that dropped 12-15 cm of snow over the entire Area 5 RWMC (Figure 7-9) in late January 2021 (prior to seeding) that stayed on the cover caps for two to three days. As the snow melted it saturated the soil profile several centimeters down which provided suitable moisture for the seedling roots to grow deep into the soil profile that would have enhanced survival. Establishment of seedlings will take several years. This promising preliminary assessment indicates that even if a fraction of the initial seedlings survives, these vegetative cover caps will be comparable to the reference area. It is anticipated that in the next year or two several thousand white bursage and creosote bush plants will be transplanted on both cover caps which will increase the plant density and better reflect the plant community in the reference area. Plant cover was not measured on the cover caps but will be in the next couple of years. Average percent mulch was 77% on the cover caps compared to 19% litter in the reference area.



**Figure 7-9. Snow cover on Cell 18 Cover Cap.**

(Photo taken January 28, 2021 by D. Frenette)

### 7.3.5 Wildlife Use

Opportunistic wildlife observations were also recorded to assess wildlife use of the revegetated areas. Flocks of horned larks and a few common ravens were observed on multiple occasions. Two killdeer (*Charadrius vociferous*) were seen on the West Cover Cap while irrigating. A herd of two to five pronghorn antelope were observed foraging on both cover caps several times during the fall and winter (Figure 7-10). A side-blotched lizard (*Uta stansburiana*) and horned lizard (*Phrynosoma platyrhinos*) were observed on the West Cover Cap. Several ant hills were also observed on the cover caps during plant sampling which may have attracted the horned lizard to the site because their primary prey is ants.

### 7.3.6 Reference Area

A reference area was also established approximately 800 m east of the Area 5 RWMC (Figure 7-11). 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. Plant density was sampled the same way it was on the cover caps and results are found in Table 7-3. 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 then summarized and average percent cover was calculated (Table 7-4).



**Figure 7-10. Herd of five antelope foraging on West Cover Cap.**

(Photo taken November 23, 2021, by D.B. Hall)



**Figure 7-11. Area 5 Radioactive Waste Management Complex reference area.**

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

**Table 7-4. Average percent cover by species and category on the Area 5 RWMC Reference Area, June 2021.**

<u>Species</u>	<u>Average Percent Cover</u>
White bursage	0.4
Shadscale saltbush	2.4
Nevada jointfir	1.1
Spiny hopsage	0.1
Winterfat	0.1
Littleleaf ratany	3.3
Creosote bush	1.1
Water jacket	0.3
Indian ricegrass	0.1
<b>SUM</b>	<b>8.9</b>
Litter	18.6
Bare	33.8
Gravel	38.5
Cobble	0.2
Rock	0
<b>SUM</b>	<b>91.1</b>

### 7.3.7 Plastic Mulch Trial

Results from an earlier study (Bechtel Nevada 2002) suggested that covering the ground with clear plastic sheeting (i.e., plastic mulch) for a few weeks after seeding and irrigating improved germination of certain species. The idea is that the plastic creates a greenhouse effect which creates an environment with warmer soil temperatures and higher soil moisture to enhance germination. This idea was tested on the East Cover Cap in one 6-m x 6-m plot that was covered with clear plastic sheeting with edges sealed to trap warmth and moisture from March 25 to April 15, 2021 (Figure 7-12). An adjacent area was used as the control plot where no plastic sheeting was used. Figure 7-13 depicts the plastic mulch plot and the adjacent control plot almost two weeks (April 27) after the plastic was removed. Seedling density was measured by counting the number of seedlings by species in four, randomly placed 1-m<sup>2</sup> quadrats in the plastic mulch, and control plots on April 15, 2021 and again on June 1, 2021. Total counts by species were divided by four to get an average number of seedlings per square meter and are reported in Table 7-5.

Total seeded seedling density was higher on both dates in the plastic mulch plot versus the control plot as was Arabian schismus density. On June 1, seeded seedling density was 2.6 times higher in the plastic mulch plot versus the control plot (69.25 seedlings per square meter versus 26.50 seedlings per square meter) with desert marigold dominating the density in the plastic mulch plot at 42.00 seedlings per square meter. White bursage was notably higher in the plastic mulch plot compared to the control plot, whereas



**Figure 7-12. Plastic mulch trial plot, East Cover Cap.**

(Photo taken March 25, 2021, by D.B. Hall)



**Figure 7-13. Plastic mulch trial plot with plastic removed (green, vegetated square marked by orange pin flags) and surrounding non-mulched area.**

(Photo taken April 27, 2021, by D.B. Hall)

Nevada jointfir and Indian ricegrass tended to be higher in the control plot compared to the plastic mulch plot. Arabian schismus density was nearly twice as high (60 plants per square meter versus 31 plants per square meter) in the plastic mulch plot compared to the control plot. Based on these results, there appears to be sufficient densities of most seeded species in the control plot, especially when compared to the reference area, so the use of plastic mulch is not justified. It would also be very costly to install the plastic over several acres and then remove it after only a few weeks.

#### **7.4 Area 5 RWMC, Cell 18 Revegetation and monitoring**

Cell 18 Cover Cap was seeded and mulched and an irrigation system installed in late October 2020. 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 periodically through the spring to assess germination status and seed viability and give us an indication of what was happening to the seed that had been planted. A total of 50.8 mm of irrigation was applied in November 2020 to recharge soil moisture as deep as possible in the soil profile. Another 25.4 mm was applied in early December 2020 to provide a moist chill to break dormancy of certain species like shadscale saltbush. Activities in 2021 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.

**Table 7-5. Average number of seedlings per square meter by species for plastic mulch trial and control, April 15, 2021 and June 1, 2021.**

<u>Species</u>	<u>Under Plastic (4/15/21)</u>	<u>Under Plastic (6/1/21)</u>	<u>Control (4/15/21)</u>	<u>Control (6/1/21)</u>
White bursage	2.75	9.00	0.00	0.25
Fourwing saltbush	2.75	2.25	1.25	1.50
Shadscale	2.25	0.00	0.50	0.00
Cattle saltbush	0.25	9.25	0.00	7.25
Nevada jointfir	1.50	0.00	0.50	3.25
Winterfat	0.00	0.00	0.50	0.25
Creosote bush	3.50	0.00	0.00	0.00
Indian ricegrass	3.75	4.75	9.50	7.50
Squirreltail	7.50	1.75	0.75	3.75
Desert marigold	32.25	42.00	0.75	2.75
Desert globemallow	0.00	0.25	0.00	0.00
<b>Total Seeded</b>	<b>56.50</b>	<b>69.25</b>	<b>13.75</b>	<b>26.50</b>
Arabian schismus	39.25	59.50	9.25	29.50
Cheatgrass	0.00	0.00	0.00	0.50
Sixweeks fescue	0.00	0.25	0.00	0.50
Fremont's phacelia	3.25	0.25	0.00	0.00
Saltlover	0.00	0.00	0.00	0.25
Desert tansymustard	0.00	0.00	0.00	0.25
<b>Total Annuals</b>	<b>42.50</b>	<b>60.00</b>	<b>9.25</b>	<b>31.00</b>

### 7.4.1 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. Plants were grown by the Nevada Division of Forestry nursery from seed MSTs biologists collected from Frenchman Flat (Area 5) in 2019. Due to staffing issues related to the coronavirus pandemic, some of the plants, particularly creosote bush, were small with weak root systems. Most of the plants were in gallon containers but several hundred were in smaller supercell containers. 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 was a one-acre parcel on the north side of the cap that was fully irrigated. South Acre Cap was a one-acre parcel on the south side of the cap that was fully irrigated. These two areas were 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 was a 0.8-acre parcel on the east edge of the cap and was fully irrigated. North Edge was 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 was 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 was 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 part of the cover cap while North Edge, South Edge, and Southeast Triangle are considered to be off the cover cap. Several hundred plants were marked with stake chasers to evaluate survival.

Transplant survival was assessed in May and October. 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 actually dead or just dormant, whereas creosote bush is evergreen which made it easier to distinguish dead from living plants.

Table 7-6 contains results from transplant success monitoring by area and species. Across all areas, average percent survival was 94.4% and 83.6% for white bursage and creosote bush, respectively in May and dropped to 13.9% and 24.7%, respectively, in October. Percent survival was higher for plants on the cap versus off the cap in both May and October, most likely due to receiving more irrigation. Overall, transplant success was 89.0% in May and dropped to 19.3% in October with nearly 800 plants assessed. This equates to an estimated 743 plants of the original 3,850 still alive. Average vigor ratings followed similar patterns. No creosote bush plants were observed flowering or fruiting while 41 (34 on cap, 7 off cap) white bursage plants were observed flowering or fruiting in May. As expected, no plants of either species were observed flowering or fruiting in October. Low survival is thought to be caused by high densities of saltlover that outcompeted the transplants for soil moisture. Additionally, some plants sat out for nearly two weeks before being planted which caused some to be drought-stressed. Even though plants were watered twice, many dried out quickly before they were planted.

#### **7.4.2 Seeding Success**

Mesh seedbags were retrieved on February 1 and March 3. Three bags with fluffy seed and three bags with hard seed were retrieved on each 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 six to seven days to determine seed viability of remaining seeds. Results from February showed good germination of Nevada jointfir, squirreltail, and Indian ricegrass and good viability of these three species plus white bursage, cattle saltbush, shadscale, and Palmer's penstemon. March retrieval results showed a similar pattern with the addition of good viability of creosote bush.

Seeding success was also evaluated in May 2021 by establishing multiple 40-m long permanent transects 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 by species were counted. An average number of plants by species per square meter was then calculated for each area and summed for the areas on the cover cap and areas off the cover cap (Table 7-7). Total number of seeded species per square meter was 19.4 on the cover cap with all seeded species being recorded. This was 10 times the number of seeded species in the partially irrigated areas off the cover cap and nearly 20 times more than all perennial species documented in the reference area (0.94 plants per square meter, Table 7-3). Higher densities of white bursage seedlings were found in the North Acre than the South Acre (0.09 versus 0.03 per square meter) but densities of creosote bush seedlings were equal in both areas (0.01 per square meter). It is unknown if the higher densities of white bursage in the North Acre were because it was from locally harvested seed versus commercially bought seed or just following the general pattern of higher densities of most species in the North Acre than the South Acre (Table 7-3). Reasons for this difference

**Table 7-6. Results from transplant success monitoring including total number of plants evaluated, percent survival, percent survival, average vigor and flowering/fruitlet information for Cell 18, May and October 2021.**

Area/Species	Total Number of Plants (May 2021)	Total Number of Plants (October 2021)	% Survival (May 2021)	% Survival (October 2021)	Average Vigor (May 2021)	Average Vigor (October 2021)	# Flower/Fruitlet (May 2021)	# Flower/Fruitlet (October 2021)
North Acre (Creosote bush)	70	68	100.0	41.2	1.94	0.47	0	0
North Acre (White bursage)	130	124	99.2	33.1	2.07	0.35	21	0
South Acre (Creosote bush)	67	67	100.0	19.4	1.73	0.19	0	0
South Acre (White bursage)	137	128	100.0	5.5	1.76	0.05	7	0
East Cap (Creosote bush)	59	61	98.3	29.5	1.63	0.36	0	0
East Cap (White bursage)	121	127	97.5	11.0	1.69	0.11	6	0
North Edge (Creosote bush)	35	36	91.4	38.9	1.6	0.39	0	0
North Edge (White bursage)	34	33	82.4	21.2	1.6	0.21	1	0
South Edge (Creosote bush)	7	7	42.9	0.0	0.43	0.00	0	0
South Edge (White bursage)	39	38	95.9	0.0	1.23	0.00	0	0
Southeast Triangle (Creosote bush)	58	58	69.0	19.0	0.86	0.19	0	0
Southeast Triangle (White bursage)	35	31	91.4	12.9	1.69	0.13	6	0
<b>TOTAL</b>	<b>792</b>	<b>778</b>	<b>89.0</b>	<b>19.3</b>	<b>1.52</b>	<b>0.20</b>	<b>41</b>	<b>0</b>
Creosote bush	296	297	83.6	24.7	1.37	0.27	0	0
White bursage	496	481	94.4	13.9	1.67	0.14	41	0
Cap	584	575	99	23.3	1.80	0.26	34	0
Off Cap	208	203	79	15.3	1.24	0.15	7	0
Creosote bush (Cap)	196	196	99.4	30.0	1.8	0.3	0	0
Creosote bush (Off Cap)	100	101	67.8	19.3	1.0	0.2	0	0
White bursage (Cap)	388	379	98.9	16.5	1.8	0.2	34	0
White bursage (Off Cap)	108	102	89.9	11.4	1.5	0.1	7	0

Table 7-7. Average number of seedlings per square meter by lifeform and species for Cell 18, May 2021.

<u>Lifeform</u>	<u>North Acre</u>	<u>South Acre</u>	<u>East Cap</u>	<u>North Edge</u>	<u>South Edge</u>	<u>SE Triangle</u>	<u>On Cover Cap</u>	<u>Off Cover Cap</u>
<b>Perennial Shrubs</b>								
White bursage	0.09	0.03	0.03	0.00	0.00	0.00	0.05	0.00
Fourwing saltbush	0.37	0.23	0.40	0.05	0.00	0.04	0.33	0.03
Shadscale	0.19	0.09	0.06	0.05	0.00	0.04	0.11	0.03
Cattle saltbush	0.27	0.04	0.09	0.38	0.05	0.25	0.13	0.23
Nevada jointfir	3.50	1.53	1.11	1.43	0.05	0.79	2.05	0.75
Winterfat	0.10	0.01	0.17	0.48	0.00	0.11	0.10	0.19
Creosote bush	0.01	0.01	0.00	0.00	0.00	0.00	0.01	0.00
<b>SUM</b>	<b>4.53</b>	<b>1.94</b>	<b>1.86</b>	<b>2.38</b>	<b>0.10</b>	<b>1.21</b>	<b>2.78</b>	<b>1.23</b>
<b>Perennial Grasses</b>								
Indian ricegrass	9.33	6.99	6.23	1.33	0.00	0.86	7.51	0.73
Squirreltail	3.03	2.17	1.54	0.00	0.00	0.00	2.25	0.00
<b>SUM</b>	<b>12.36</b>	<b>9.16</b>	<b>7.77</b>	<b>1.30</b>	<b>0.00</b>	<b>0.90</b>	<b>9.76</b>	<b>0.73</b>
<b>Perennial Forbs</b>								
Desert marigold	0.07	0.19	0.37	0.00	0.00	0.00	0.21	0.00
Palmer's penstemon	11.00	5.59	3.23	0.00	0.00	0.00	6.60	0.00
Desert globemallow	0.03	0.06	0.06	0.00	0.00	0.00	0.05	0.00
<b>SUM</b>	<b>11.10</b>	<b>5.83</b>	<b>3.66</b>	<b>0.00</b>	<b>0.00</b>	<b>0.00</b>	<b>6.86</b>	<b>0.00</b>
<b>TOTAL SEEDED</b>	<b>27.99</b>	<b>16.93</b>	<b>13.29</b>	<b>3.68</b>	<b>0.10</b>	<b>2.11</b>	<b>19.40</b>	<b>1.96</b>
<b>Annual Grasses</b>								
Arabian schismus	1.06	1.11	1.51	0.38	0.00	0.39	1.23	0.26
Cheatgrass	0.04	0.03	0.00	0.00	0.00	0.00	0.02	0.00
Red brome	0.01	0.01	0.00	0.00	0.00	0.00	0.01	0.00
<b>SUM</b>	<b>1.11</b>	<b>1.16</b>	<b>1.50</b>	<b>0.40</b>	<b>0.00</b>	<b>0.40</b>	<b>1.26</b>	<b>0.27</b>

Table 7-7. Average number of seedlings per square meter by lifeform and species for Cell 18, May 2021 (continued).

<u>Lifeform</u>	<u>North Acre</u>	<u>South Acre</u>	<u>East Cap</u>	<u>North Edge</u>	<u>South Edge</u>	<u>SE Triangle</u>	<u>On Cover Cap</u>	<u>Off Cover Cap</u>
<b>Annual Forbs</b>								
Saltlover	14.99	26.30	16.03	19.05	59.67	30.11	19.11	36.27
Prickly Russian thistle	0.31	0.00	0.00	0.57	1.05	0.57	0.10	0.73
Flatcrown buckwheat	0.33	0.00	0.00	0.00	0.00	0.32	0.11	0.11
Manybranched ipomopsis	0.06	0.00	0.00	0.00	0.00	0.00	0.02	0.00
Lambsquarter	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Small wirelettuce	0.04	0.00	0.00	0.00	0.00	0.00	0.01	0.00
Gilia species	0.03	0.00	0.00	0.00	0.00	0.00	0.01	0.00
Tansy mustard	0.09	0.00	0.00	0.00	0.00	0.00	0.03	0.00
Esteve's pincushion	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00
<b>SUM</b>	<b>15.87</b>	<b>26.90</b>	<b>17.30</b>	<b>19.60</b>	<b>60.70</b>	<b>31.00</b>	<b>20.02</b>	<b>0.00</b>

**Table 7-8. Amounts (mm) of supplemental irrigation applied and natural precipitation received on Cell 18 Cover Cap, November 2020 through October 2021. Numbers in parentheses in irrigation column represent increments of irrigation (i.e., a total of 25.4 mm was applied in 6.4- or 12.7-mm increments).**

<u>Date</u>	<u>Irrigation</u>	<u>Precipitation</u>
Nov. 2020	50.8	2.3
Dec. 2020	22.4	6.6
Jan. 2021	0.0	20.6
Feb. 2021	0.0	0.0
Mar. 2021	25.4 (6.4)	10.2
Apr. 2021	25.4 (12.7)	4.1
May 2021	38.1	0.5
Jun. 2021	0.0	6.1
Jul. 2021	44.5	4.6
Aug. 2021	0.0	4.3
Sep. 2021	44.5	2.8
Oct. 2021	38.1	12.7
<b>Total</b>	<b>289.1</b>	<b>74.7</b>

are unknown. Indian ricegrass, Palmer’s penstemon, squirreltail, and Nevada jointfir had the highest densities of seeded species which was similar to results from the seedbags.

A few native annual plant species were found in low densities (Table 7-7). However, saltlover dominated the annual species (19.11 per square meter), and as the summer progressed it became problematic and took over the site, especially in the irrigated areas. The source of the saltlover seed is unknown and puzzling because saltlover plants were not observed on the stockpiled topsoil which was used to construct the cap. It is possible seeds were in the seedbank but had not germinated on the stockpiled topsoil or blew in from surrounding areas after the cap was built. Saltlover does not grow in the surrounding undisturbed areas. Saltlover is known to thrive in disturbed areas and it appears when soil disturbance occurs, if saltlover seed is present, and irrigation is used it promotes germination and growth. A total of 289 mm of irrigation was applied to Cell 18 from November 2020 through October 2021 (Table 7-8) for seed germination and plant establishment. This was in addition to the 75 mm of natural precipitation received over the same time period (Table 7-8). This included the 12-15 cm of snow that covered the cap for a few days in late January 2021. The snow melted and provided abundant soil moisture deep in the soil profile.

The irrigation strategy was to apply 50 mm of irrigation in November 2020, right after seeding, to increase soil moisture as deep into the soil profile as possible to allow the roots of germinated plants to grow. Nearly 25 mm of irrigation was applied in December to break seed dormancy of certain species like shadscale that appear to require a moist chill for germination. In March and April another 25 mm each month was applied for seed germination. Irrigation was applied in 6 mm and 12 mm increments in March and April, respectively, to try and keep the top 25-50 mm of the soil, where most of the seed was located, wet long enough to promote seed germination. Another 38 mm was applied in late May in order to increase soil moisture as deep as possible to help the plants survive the hot, dry summer and to increase germination of warm season germinators like creosote bush. Observations during the summer revealed many water-stressed perennial plants, so 44 mm of irrigation was applied to increase survival of these

plants. Unfortunately, it had a positive effect on saltlover which thrived with the additional water (Figure 7-14). Plants will continue to be monitored to evaluate seeding and transplant success.



**Figure 7-14. Dense saltlover on Cell 18 Cover Cap, July 2021.**

(Photo taken July 7, 2021 by D.B. Hall)

It is interesting to compare seeding success at Cell 18 which was seeded in the fall and CAU 577 East and West Cover Caps which were seeded in February, especially saltlover densities which were 20 times higher at Cell 18 than at East and West Cover Caps (Tables 7-3 and 7-6). Seeded plant densities were similar during spring 2021, but visual observations in fall 2021 showed low survival of seeded species on Cell 18 (similar to the transplant survival) but excellent survival on East and West Cover Caps. This is believed to be due to the competitiveness of saltlover which outcompeted seeded and transplanted perennials for water. These data suggest that fall seeding is not recommended if saltlover is present. Densities of shadscale and Palmer’s penstemon were higher on Cell 18 than East and West Cover Caps suggesting these species germinate better when seeded in the fall (Tables 7-3 and 7-6).

## **7.5 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 is able to 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 7-15). 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<sup>2</sup> or ~0.1 ac). Plots were staked on November 10, 2021, seeded on November 15, 2021, and herbicide was applied on November 16, 2021.

Plots will be monitored each spring over the next two to three years to evaluate the effectiveness of each treatment and control. Permanent transects will be marked and plant density (number of plants per square meter) and cover by species will be measured. Plots will also be photographed.

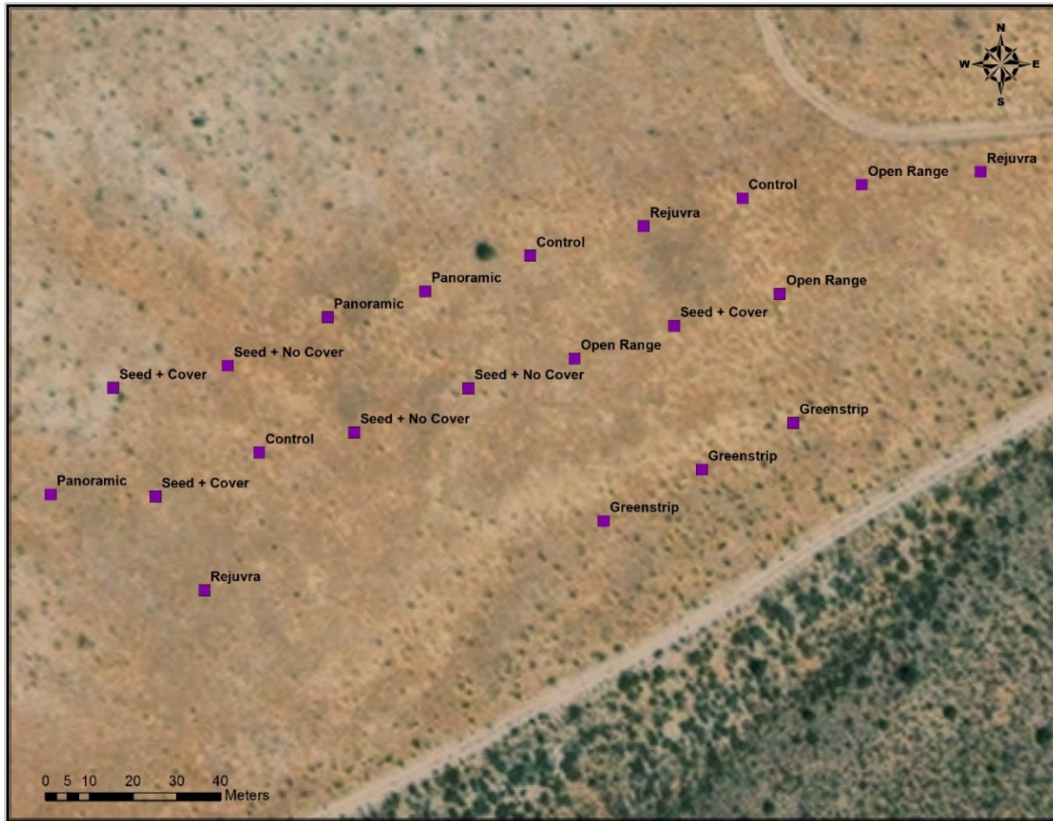


Figure 7-15. Final plot layout for cheatgrass control research trial.

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

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

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