NEVADA TEST AND TRAINING RANGE (NTTR)

Land Withdrawal Application Packages/
Case File and Legislative EIS

LARGE MAMMAL REPORT FOR THE NEVADA TEST AND TRAINING RANGE AND PROPOSED EXPANSION AREAS

FINAL
June 2017

LARGE MAMMAL REPORT
FOR THE NEVADA TEST AND TRAINING RANGE
AND PROPOSED EXPANSION ALTERNATIVES
Final Report

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Abbreviations

99 CES/CEIEA	99th Civil Engineering Squadron, Asset Management Flight, Environmental Section, Conservation Element
ACC	Air Combat Command
AFI	Air Force Instruction
AML	Appropriate Management Level
BLM	Bureau of Land Management
CAFB	Creech Air Force Base
CFR	Code of Federal Regulations
CWA	Clean Water Act
DNWR	Desert National Wildlife Range
DOD	U.S. Department of Defense
DOE	U.S. Department of Energy
DOI	U.S. Department of the Interior
ESA	Endangered Species Act
GIS	Geographic Information Systems
GPS	Global Positioning System
INRMP	Integrated Natural Resources Management Plan
LEIS	Legislative Environmental Impact Statement
MLMA	Military Land Withdrawal Act
MSL	Mean Sea Level
NDF	Nevada Division of Forestry
NDCNR	Nevada Department of Conservation and Natural Resources
NDOW	Nevada Department of Wildlife
NAFB	Nellis Air Force Base
NEPA	National Environmental Policy Act
NHPA	National Historic Preservation Act
NNRP	Nellis Natural Resources Program
NNSS	Nevada National Security Site, formerly the Nevada Test Site
NRCS	Natural Resources Conservation Service
NTTR	Nevada Test and Training Range. Also, the new name for 98th Range Wing
NWAP	Nevada Wildlife Action Plan
NWHR	Nevada Wild Horse Range
SAR	Small Arms Range
USACE	U.S. Army Corps of Engineers
USAF	United States Air Force
USAHA	United States Animal Health Association
USDA	U.S. Department of Agriculture
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey

INTRODUCTION

The United States Air Force (USAF) is in the process of extending the withdrawal of land for military operations and training on the Nevada Test and Training Range (NTTR). In addition to extending the current withdrawal, the Air Force is evaluating several potential expansion alternatives. The current withdrawal will expire on November 6, 2021, unless Congress enacts legislation to extend it. In accordance with Section 3016 of the Military Land Withdrawal Act (MLWA), the USAF, in coordination with the Department of Defense (DOD), has notified Congress of a continuing military need for the NTTR withdrawal. Furthermore, the Air Force plans to submit a Legislative Environmental Impact Statement (LEIS) that supports a legislative withdrawal proposal which will be submitted through the Department of the Interior (DOI) to extend the withdrawal.

As part of the LEIS process, the Air Force is preparing documentation required to support the Application Package, Case File, and legislative language to successfully accomplish the NTTR land withdrawal by November 2021. To maintain critical test and training capabilities at the NTTR, the Air Force must complete all required studies in compliance with the National Environmental Policy Act (NEPA), the *Engle Act*, *Federal Land Policy and Management Act*, the MLWA, and Land Withdrawals regulations set forth in Title 43 Code of Federal Regulations (CFR) Part 2300. The analysis and results of the road-less area study are needed in order to comply with NEPA and Land Withdrawals regulations and support submittal of an application to the Bureau of Land Management (BLM), provision of a Case File to the DOI, and development of draft legislation for Congressional approval of the withdrawal in accordance with applicable rules and regulations.

The scope of this report is to summarize historic and recent surveys and projects involving large mammals, desert bighorn sheep (*Ovis canadensis nelsoni*), pronghorn (*Antilocapra americana*), mule deer (*Odocoileus hemionus)*, wild horses (*Equus ferus*), and burros (*Equus asinus*). The land withdrawal renewa l includes actions that present potential impacts to large mammals and this report provides information pertaining to the current health of the large mammal populations as well as areas where the animals have been observed. As the author of the previous reports, the USAF is using much of the information from previous reports written for support of the military mission in this report, often verbatim. Table 1 provides a list of the previous reports used to prepare this summary report.

On the study area, large mammal surveys have been a historical focus of natural resources management for the Nellis Natural Resources Program (NNRP) and the Desert National Wildlife Refuge (DNWR). Large mammals are periodically surveyed to determine general condition of the species, distribution and size of the population, and key habitats where the species resides. This information is used to develop management strategies to conserve these important species and to ensure that the species are not significantly impacted by military activities on the NTTR as documented in the Integrated Natural Resources Management Plan for NTTR and Nellis Air Force Base (NAFB) (Nellis Natural Resources Program, 2010).

Historical surveys have been conducted in and around the NTTR since the 1970s to locate and monitor populations of large mammals. Beginning in 2005, extensive surveys were initiated on the NTTR to monitor the distribution and disposition of large mammal populations as required by the Nellis AFB INRMP (Nellis Natural Resources Program, 2010). Bighorn sheep surveys have been conducted on Stonewall Mountain, Desert Range, Spotted Range, Pintwater Range, and Sheep Range by the Nevada Department of Wildlife (NDOW) since 1978. This report is a summary of the historical surveys conducted for large mammals on the study area. Most of the information provided in this report is a summary of data that has been previously reported in NNRP Annual Large Mammal Reports with additional information from the DNWR. Most of the statistical data was derived from analysis of data in the NTTR Geodatabase, DNWR data, and NDOW bighorn sheep data. Table 1 provides a list of the reports that have been prepared over the years for large mammal studies conducted on the study area.

Table 1. List of reports prepared for Nellis AFB and used to compile data and background information for this report.

Reports Pertaining to Large Mammal Studies on the Study Area
Nevada Department of Wildlife. 1990. Compilation of Aerial Antelope Surveys 1960-1990.
Nevada Department of Wildlife. 1998. Compilation of Aerial Bighorn Sheep Surveys 1975-1998.
Science Applications International Corp. 1999. Range Condition Survey and Appropriate Management Level of Wild Horses on the Nevada Wild Horse Range, Nye County, Nevada. Final report. U.S. Army Corps of Engineers, Ft. Worth District. 99 Pages.
Nellis Natural Resources Program. 2007. Large Mammal Section of the 2006 Annual Report for the Nellis Natural Resources Program. Nellis AFB, NV.
Nellis Natural Resources Program. 2008. Large Mammal Section of the 2007 Annual Report for the Nellis Natural Resources Program. Nellis AFB, NV.
Nellis Natural Resources Program. 2009. Large Mammal Section of the 2008 Annual Report for the Nellis Natural Resources Program. Nellis AFB, NV.
Nellis Natural Resources Program. 2010. Large Mammal Section of the 2009 Annual Report for the Nellis Natural Resources Program. Nellis AFB, NV.
Nellis Natural Resources Program. 2011. Large Mammal Section of the 2010 Annual Report for the Nellis Natural Resources Program. Nellis AFB, NV.
Nellis Natural Resources Program. 2014. 2013 Final Report for Species at Risk—Large Mammals. Nellis AFB, NV.
Nellis Natural Resources Program. 2013. 2011 Final Report for Species at Risk—Large Mammals. Nellis AFB, NV.
Nellis Natural Resources Program. 2013. 2012 Final Report for Species at Risk—Large Mammals. Nellis AFB, NV.
Nellis Natural Resources Program. 2013. 2012 Final Report for Species at Risk—Furbearers and Carnivores. Nellis AFB, NV.
Nellis Natural Resources Program. 2014. 2013 Final Report for Species at Risk—Large Mammals. Nellis AFB, NV.
Nellis Natural Resources Program. 2014. 2013 Final Report for Species at Risk—Furbearers and Carnivores. Nellis AFB, NV.
Nellis Natural Resources Program. 2015. 2014 Large Mammal Database Final Project Report. Nellis AFB, NV.
Nellis Natural Resources Program. 2015. 2014 Final Report for Large Mammal Species, Surveys and Monitoring. Nellis AFB, NV.
Nellis Natural Resources Program. 2016. Nellis Natural Resources Program Geodatabase.

DESCRIPTION OF THE PROJECT AREA

The study area for this report includes the NTTR and potential expansion areas designated as Alternatives 3A, 3B, and 3C. The NTTR consists of 2,919,980 acres, in rural portions of Nye, Lincoln, and Clark Counties, Nevada (Figure 1). The potential expansion areas are shown in Figure 1 and consist of about 302,000 acres. Alternative 3A is 18,000 acres lying along the southwest boundary of the North Range of the NTTR. Alternative 3B is 57,000 acres located immediately south of the South Range of the NTTR. Alternative 3C is 227,000 acres immediately east of the South Range of the NTTR in the Desert National Wildlife Refuge (DNWR). Geology varies from limestone/dolomite in the south to volcanic fields in the north. The South Range Study Area lies in the eastern Mojave Desert, and the North Range Study Area lies in the southern Great Basin (Figure 2).

Natural sources of water are scarce across most of the study area. Annual precipitation ranges from 3 to 5 inches in the basins to 16 inches in upper elevations of mountains. Vegetation composition is strongly influenced by the levels of precipitation. Most of the active springs are found in the North Range Study Area, especially in the Kawich, Belted, and Cactus Mountain Ranges and Stonewall Mountain. Only five springs are found in the South Range Study Area. Most water sources for wildlife in the South Range Study Area are provided by wildlife water developments, which collect water from storm events and store it in water tanks.

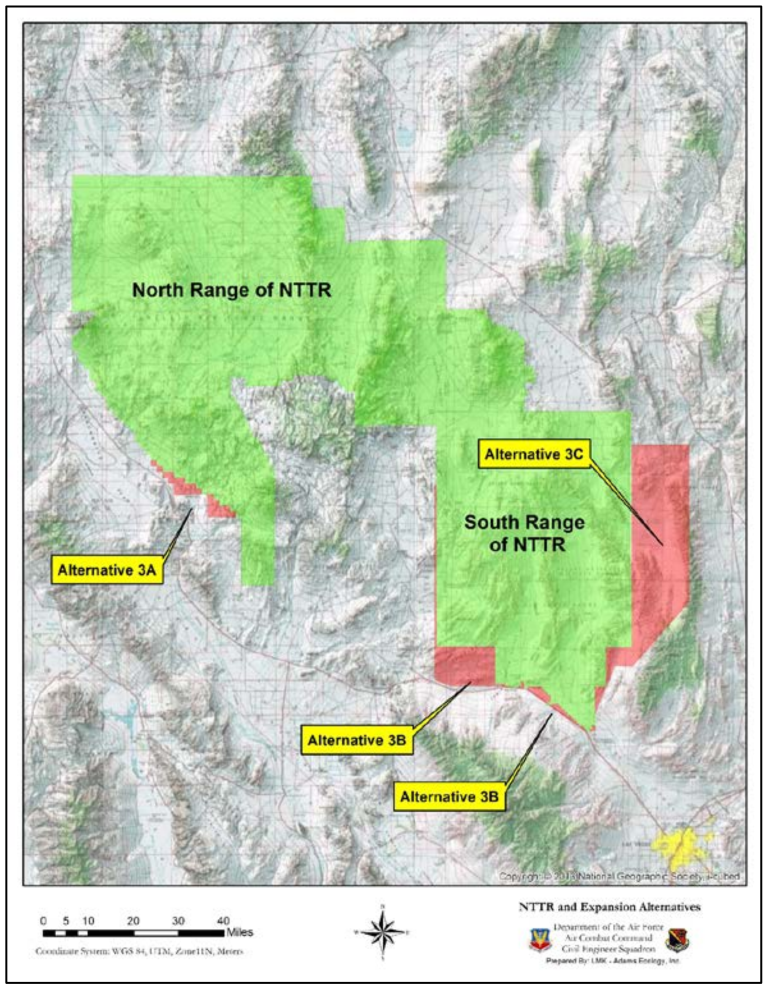

Figure 1. Location of the North and South Ranges of the NTTR as well as Alternatives 3A, 3B, and 3C.

The South Range Study Area is typical of the Mojave Desert. Except for the higher elevations, most of the mountains are covered by scattered populations of various desert brush and cactus species. Typical physiography of the area consists of mountain ranges which drain into bajadas (collections of alluvial fans) that eventually drain into playas. Most of these areas are considered basins which are self-contained and do not drain into any of the major rivers in the area. Playas tend to have little or no vegetation while bajadas are often dominated by creosote bush (*Larrea tridentata*) and bursage (*Ambrosia dumosa*) in the lower bajadas and blackbrush (*Coleogyne ramosissima*) and Joshua tree (*Yucca brevifolia*) in the upper bajadas. Mountain ranges support scattered populations of bitterbrush (*Purshia spp.*), matchweed (*Gutierrezia spp.)*, and shadscale

(*Atriplex confertifolia*). At higher elevations, plant communities may be dominated by Utah juniper (*Juniperus osteosperma*) and pinyon pine (*Pinus monophylla*).

The North Range Study Area is typical of the southern portions of the Great Basin Desert. Again, the physiography of the area is comprised of mountains and closed basins, similar to the South Range Study Area. However, rainfall is slightly higher in the North Range Study Area resulting in denser plant communities. Like the South Range Study Area, playas in the North Range Study Area contain little or no vegetation. From the boundaries of the playas to the base of mountains, plant communities are typically dominated by greasewood (*Sarcobatus spp.*) and shadscale (*Atriplex spp.*) in lower elevations and sagebrush (*Artemisia spp.*) in higher elevations. The upper elevations in the mountains are dominated by Utah juniper (*Juniperus osteosperma*) and pinyon pine (*Pinus monophylla*).

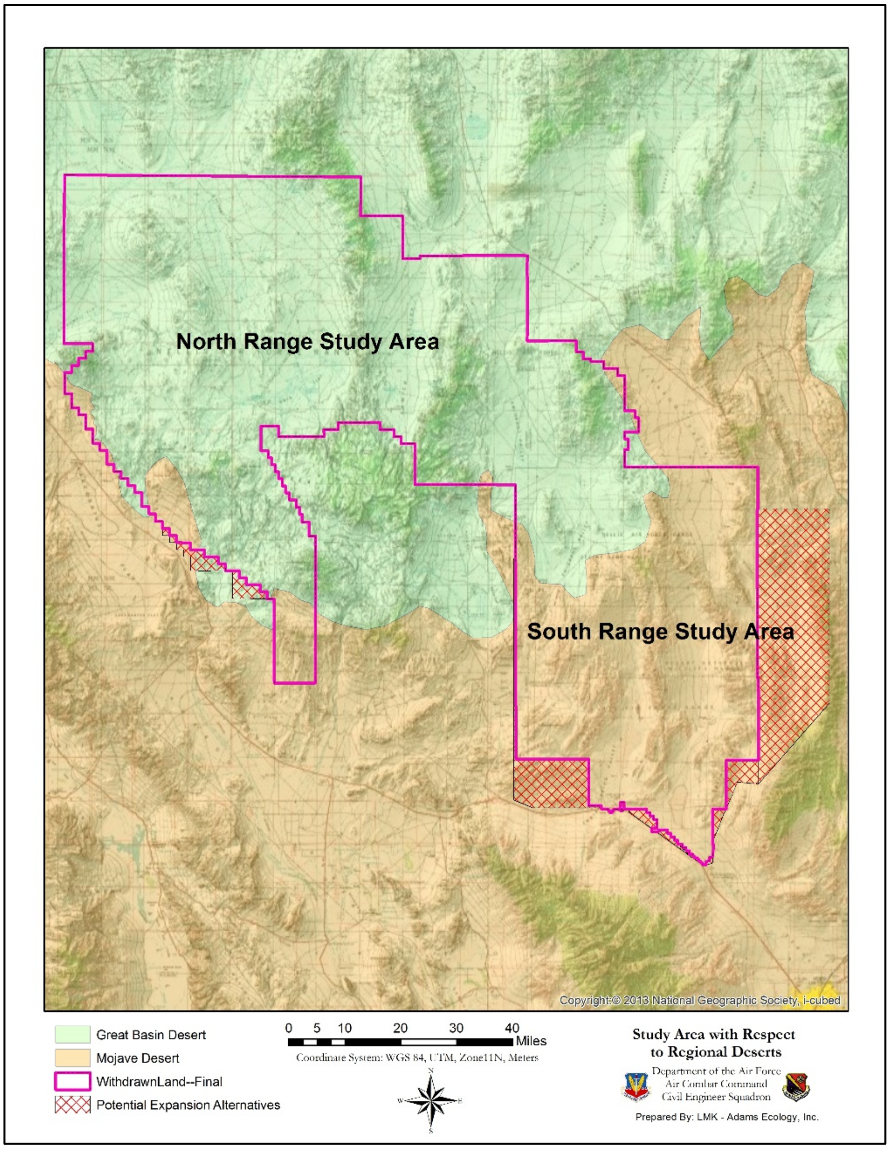

Figure 2. Location of the study area with respect to the Great Basin Desert and the Mojave Desert.

BIGHORN SHEEP

BACKGROUND INFORMATION

Desert bighorn sheep (*Ovis canadensis nelsoni*) refers to one of seven subspecies of the bighorn sheep found within North America (San Diego Zoo, 2002). The common name "desert bighorn" is sometimes arbitrarily used for the bighorns inhabiting the entire arid, sparsely vegetated desert environment of the extreme western and southwestern parts of the U.S. and northern Mexico. This designation may encompass different geographically isolated populations including *O. c. cremnobates*, *O. c. mexicana*, and *O. c. weems* (Manville, 1980). The validity of separation of the species into these subspecies has been questioned and reassessed on the basis of additional morphological and genetic analysis (U.S. Fish and Wildlife Service, 2000). It is apparent that desert bighorn herds have become increasingly isolated geographically, and, as a result, there is less gene flow between populations. It is possible that genetic and endocrine-immune deficiencies, which do not favor survival, have resulted from isolation-induced inbreeding (U.S. Fish and Wildlife Service, 2000). For the purpose of this report, the term "desert bighorn" will be used for the subspecies referred to as *O. c. nelsoni*.

Desert bighorn sheep RAM on the North Range Study Area.

The desert bighorn is a medium sized bovid with a muscular body and thick neck. The upper body ranges in color from dark brown in the northern mountains to pale tan in the southwest deserts. Their belly, rump patch, back of legs, muzzle, and eye patch are white (U.S. Fish & Wildlife Service, 2011). Males have heavy, tapering, curled brown horns; while females have smaller, less curled horns. When a ram reaches 7 to 8 years of age, he may display horns with a full curl, a spread of 33 inches and weighing as much as 30 lbs. (Digital West Media, Inc, 2016). The average weight of rams ranges 165 to 330 lbs., while ewes average 100 to 145 lbs. The compact and muscular body, short legs, spongiform hooves, and low center of gravity support the agile movement of bighorn sheep on steep rocky terrain.

Historically, bighorn sheep were distributed from Baja California to Texas in the south to the Canadian Rockies in the north, with the eastern boundary reaching western Nebraska and the western boundary in California (Wehausen J. D., 1999). Cowan (Cowan, 1940) divided bighorn sheep from the southwest deserts into isolated subspecies, and the desert bighorn (subspecies *nelsoni*) found within Nevada, California, Northern Arizona, and Utah was recognized as a separate subspecies. The desert bighorn currently ranges from Nevada and California to west Texas and south into Mexico. Within Nevada, they inhabit the southern portion of the state and are found in the rough terrain of the mountain ranges throughout the South Range Study Area and much of the western half of the North Range Study Area.

The life history, characteristics, and behavior of desert bighorns generally follow those of other bighorn sheep subspecies. However, desert bighorns are more dependent on access to free standing water and mineral licks, especially during the spring (Nevada Department of Wildlife, 2013) compared to bighorn sheep in other regions. Water availability is the single most important limiting factor for desert bighorn populations (Turner & Weaver, 1980) living within these arid climates. Because of this constraint, they have employed behavioral adaptations such as drinking water as infrequently as every 5 to 15 days (San Diego Zoo, 2002). Typically, desert bighorns will consume large volumes of water at a time, usually in the early morning; and ingest foods, such as cactus, that are high in water content (Turner & Weaver, 1980). The desert bighorn also retains physiological mechanisms that allow them to exist in dry climates with limited water. These include decreased water to body weight ratios, decreased evaporative water loss, and greater kidney efficiency (Turner & Weaver, 1980).

Group of ewes and lambs on a cliff on the North Range Study Area.

The importance of free standing water to bighorn sheep in general has been questioned (Broyles, 1995), and some biologists believe that a few small populations can exist without standing water (Krausman P. a., 1986; Krausman P. S., 1985). This concept is not widely accepted (Broyles, 1995), and most desert bighorn will drink standing water regularly when it is available. Therefore, herds of bighorn sheep often concentrate near water during dry, summer months (U.S. Fish and Wildlife Service, 2000). During periods of high rainfall, sheep distribution is not concentrated around permanent water sources (Leslie & Douglas, 1979) because temporary accumulations of surface water are also available. Studies have shown that desert bighorn populations will be concentrated within a 2-3 mile radius of water sources during the summer months (Leslie & Douglas, 1979; Jones, 1957; Cunningham & Ohmart, 1986). Specifically in Nevada, Leslie and Douglas (1979) reported that 84% of the desert bighorn in their study area were found within 1.18 miles of a water source. Water sources are most valuable to bighorn sheep if they occur in proximity to adequate escape terrain with good visibility (U.S. Fish and Wildlife Service, 2000). Escape terrain is defined as an area with at least a 60% slope and rocky outcroppings (McQuivey, 1978). Desert bighorn sheep prefer to drink from water sources that are not surrounded by brush or other obstructions, where their vision could be obscured (Turner & Weaver, 1980). They are also wary of areas of dense trees, large boulders, or cliffs adjacent to a water source due to the threat of predation (Turner & Weaver, 1980).

Although the construction and maintenance of artificial water developments is controversial (Dolan, 2006), this practice appears to aid in the conservation of isolated populations throughout the west. Historically, the ranges of the desert bighorn were said to be much wetter than the arid, rocky, poorly vegetated, and poorly watered habitat where they currently reside. Grassland habitats were more prevalent, and water was historically more abundant (McColm, 1963).

Many of the natural water sources previously used by desert bighorns have been degraded or eliminated by human development and livestock use. Some sources have been eliminated by the pumping of the ground water for agriculture and/or urban development (Nevada Department of Wildlife, 2001). Wild horse herds often compete with the desert bighorns for water sources and may damage or degrade springs, making them unattractive for use by bighorn sheep. A cooperative project between NDOW, the Fraternity of the Desert Bighorn, the Wild Sheep Foundation, and the USAF involved the construction of several wildlife water developments on the South Range of the NTTR for the management and conservation of existing populations of desert bighorn. Many of the natural springs on the North Range Study Area have been protected from wild horse damage by construction of fences and placement of watering troughs for the horses outside of the natural springs. In addition to increased predation around these developments, other concerns include drowning or starvation as a result of being trapped in the water development (Mensch, 1969; Allen, 1980).

Ram on the North Range Study Area.

Desert bighorn sheep are opportunistic herbivores and ruminant ungulates having a 4-chambered stomach that can digest most of the thick cellulose in vegetation. Their efficient digestive system can breakdown the dry abrasive forage dominant in the deserts of the southwest (San Diego Zoo, 2002). Bighorns typically consume grasses, sedges, and forbs; but will also consume young twigs, leaves, and shoots when preferred food is scarce (especially in the winter) (Digital West Media, Inc, 2016). During the summer, desert bighorns rely heavily on green vegetation for food and moisture. They will often use their hooves and horns to remove spines from cacti and succulents to obtain the water. Indications are that the bighorn's diet reflects the seasonal changes in vegetation, showing an increase in grass and forbs during the spring growing season and after summer rains. As the new spring growth of forbs and grasses dries up, the bighorn reverts to "dry rations" at lower ranges, or in some areas, move to higher elevations to find green feed. The fall and winter feed is comprised of primarily browse (Browning & Monson, 1980).

A variety of plant communities are used by bighorn sheep across the southwest. In the lowest elevations of the Mojave, plant communities associated with bighorns are dominated by white bursage, creosote bush, and saltbush. At the highest elevations of the Mojave, pinyon-juniper and sagebrush-juniper plant communities supply forage. In between these elevations, blackbrush-needlegrass and blackbrush-galleta plant communities are used extensively. Conflicting reports exist regarding the significance of desert washes, drainages, and ephemeral vegetation in the bighorn diet (Browning & Monson, 1980). Winter annuals are an important part of the bighorn sheep diet during the lambing season. Crude protein and digestible energy is higher in "early green-up species" of plants, especially during the critical late gestation, lambing, and rearing seasons of the bighorn sheep. These plant species contribute important nutritional value during these critical life stages (Wagner G. , 2000). Recorded diet of the desert bighorn within the Mojave Desert includes the following species:

- <u>Grasses:</u> *Hilaria jamesii, Hilaria rigida, Stipa spp., Tridens pulchella, Bouteloua spp., Sporobolus airoides, Poa spp., Andropogon spp., Festuca spp., Distichlis stricata, Achnatherum spp.*
- <u>Browse:</u> (Bighorn feed on a large variety of browse plants with no one or two plants preferred). *Artemisia tridentata, Cercocarpus intricatus, Ephedra spp., Krascheninnikovia lanata, Atriplex sp., Purshia stansuriana, Eriogonum fasciculatum, Rhus trilobata, Bebbia juncea,* and *Grayia spinosa.*

Flowering buds of *Yucca brevifolia, Yucca shidigera,* and *Yucca baccata* are eaten in April and May, as are berries and green foliage of *Juniperus sp.*

Two ewes standing on a high bluff on the North Range Study Area.

Breeding season (rutting season for rams or estrous season for ewes) in the Mojave Desert typically begins in early July and lasts through September (Nevada Department of Wildlife, 2010). Breeding season varies by geographical elevation and latitude. Generally, the length of the season is longest in the lower southern elevations and shortest at higher northern elevations (Monson & Sumner, 1980), possibly due to unpredictability of rain and food supply in the lower elevations (San Diego Zoo, 2002). Gestation can last up to six months, with one or two lambs generally born in early spring. However, lambing season within southern Nevada shows considerably more variation from year to year than the more northern races (Turner & Hansen, 1980), likely due to variation in climate conditions within the desert environment. Ten to fourteen days prior to parturition, pregnant ewes leave the herds to become solitary. Traditional lambing areas are chosen on the basis of isolation, shelter, and unobstructed view (Simmons, Levy, & Levy, 1963). Preferred lambing areas located on the NTTR appear to be Mt. Helen and northern portions of Thirsty Canyon. Within a few weeks of birth, the lambs will form herds of their own, seeking out their mothers only to suckle (San Diego Zoo, 2002). Mortality is high for lambs within the first few months of life (Digital West Media, Inc, 2016). Studies of mortality and natality on various desert bighorn herds suggest that only ewes of at least 18 months of age, and more commonly 21 months of age, are capable of pregnancy. However, copulations between mature rams and ewes younger than 18 months without resulting in pregnancy have been recorded (Monson & Sumner, 1980). Males have been documented as breeding successfully as young as 6 months of age (Turner & Hansen, 1980). However, due to competition (where dominant males gain priority over females), males may not have the opportunity to breed until seven years of age (Digital West Media, Inc, 2016)**.**

Habitat preferences by desert bighorns vary somewhat, but certain aspects are common among populations. Escape terrain is important because bighorn sheep typically do not have the speed to outrun their predators, rather, they use their climbing abilities to escape (Geist, 1971; McQuivey, 1978). The presence of steep terrain for predator evasion during lambing is a crucial component of sheep habitat (U.S. Fish and Wildlife Service, 2000). Variation in slope and aspect also help bighorn sheep to survive in harsh climates by seeking shade under boulders, cliffs, and north facing slopes (U.S. Fish and Wildlife Service, 2000; Merritt, 1974; Andrew, 1994). Other areas where bighrons may be found include alluvial fans, desert washes, and flat terrain in between mountain ranges (Krausman P. a., 1986; Bleich, Wehausen, & Holl, 1990; Bleich, Wehausen, Ramey, & Rechel, 1996). Low rolling terrain and washes seasonally provide an important source of high quality forage, with a greater diversity of browse species than in steeper terrain (Leslie & Douglas, 1979). The importance of this habitat component increases during periods of limited forage availability.

General health issues that impact desert bighorns include bacterial diseases, viral diseases, internal and external parasites, tumors, mineral and dietary deficiencies, poisonous plants, and inbreeding. Bighorn sheep of various races are susceptible to lung diseases and lesions. Helive & Smith (Helive & Smith, 1970) and Johnson (Johnson, 1957) recorded that *Pastuerella* and *Corynebacterium* were causes of pneumonia in Nevada bighorn on several occasions. Necropsy reports have listed pneumonia as the cause of death of lambs. These bacterial diseases have also been recorded as causes of malformation of the bones within bighorns on Desert National Wildlife Refuge (Allred & Bradley, 1965).

Group of bighorn sheep on the North Range Study Area.

Recently, NDOW partnered with the Wild Sheep Foundation and the Fraternity of the Desert Bighorn to determine if pathogens known to cause pneumonia in bighorn sheep were present in populations within the McCullough, Spring, and El Dorado Mountain Ranges in Nevada. Lab results from an investigation by the Notional Park Service at the Mojave National Preserve in San Bernardino County, California, confirmed the presence of *Mycoplasma ovipneaumoniae* and *Pasteurella spp.* in dead and distressed bighorn sheep (Nevada Department of Wildlife, 2013). NDOW is also working with the NTTR in determining if an outbreak of the disease is causing a drop in the lamb population on Stonewall Mountain.

The viral disease known as “blue tongue” has the possibility of being partially responsible for the disappearance of the desert bighorn from the Trans-Pecos region of Texas, where the bighorn sheep population was historically eradicated (Robinson, Hailey, Livingston, & Thomas, 1967). No instances of blue tongue have been confirmed within Nevada. However, *myxovirus parainfluenza-3* which is associated with “shipping fever” has been historically documented (Taylor, 1976).

Internal and external parasites have also been found to affect desert bighorn rangewide. Gastrointestinal nematodes, such as *Haemonchus contortus, Trichostrongylus extenuatus,* and *Trichuris ovis,* as well as ticks, such as *Dermacentor hunteri* and *Otobius megnini,* have been reported. The predominant external parasites found in Nevada are hard ticks, *Dermacentor albipictus* and *D. hunteri*. Becklund and Senger (Becklund & Senger, 1967) published a comprehensive checklist of parasites reported from *Ovis canadensis* including sarcocyst, fringed tapeworms, Wyoming tapeworm, whipworms, pinworms, lungworms, hunter ticks, and scab mites.

Tumors have been found on desert bighorn from the Desert National Wildlife Range and the NTTR (Deming, 1964). Mineral and dietary deficiencies; including phophorus, iodine, calcium, protein, and vitamin A (Allen, 1980), have been recorded in bighorn throughout the U.S.

Poisonous plants have been documented as having adverse affects on bighorn sheep. Nevada specific plants may include Jimsonweed (*Datura sp.*), spineless horsebush (*Tetradymia sp.*), desert almond (*Prunus fasciculata*), locoweed *(Astragalus sp.*), and species of the genera *Oxytropis, Delphinium, Asclepias,* *Nicotiana, Baccharis, Actinea, Aplopappus,* and *Linum.* At present, evidence that plants are poisonous to desert bighorn is largely circumstantial, and precise evaluation of their importance is lacking (Allen, 1980).

Predator relationships with desert bighorn have been a controversial subject within the desert bighorn scientific community. Predators have been accused of depleting bighorn herds throughout the southwest (Kelly, 1980). Predators of the desert bighorn within Nevada have included coyote, gray fox, bobcat, mountain lion, and golden eagles.

Young ram drinking water at a wildlife water development on the South Range Study Area.

Since the late 1980s and early 1990s, mountain lion predation has become a limiting factor for bighorn sheep populations (Wehausen J. D., 1999; U.S. Fish and Wildlife Service, 1999). Mountain lions remain the greatest predation threat to the desert bighorn in areas capable of supporting both populations. Mountain lions appear to be the sole predators capable of causing appreciable mortality in small bighorn sheep populations (<100) that occupy suitable habitats (Sawyer & Lindzey, 2002). Sustained high levels of mountain lion predation may hinder the recovery of bighorn sheep populations (Hayes, Rubin, Jorgensen, & Boyce, 2000), cause populations to decline (Wehausen J. , 1996), or in severe cases, lead to the biological extinction of very small (<40) bighorn sheep populations (Logan & Sweanor, 2001). Mountain lions are thought to affect bighorn sheep indirectly by forcing the sheep to abandon former habitat to avoid predations (Sawyer & Lindzey, 2002). Evidence of desert bighorn mortality by mountain lions has been found on the North Range of the NTTR. Mountain lion populations appear to be scattered throughout many of the mountain ranges of the NTTR.

Many bighorn sheep management programs have implemented mountain lion control to benefit sheep populations under certain circumstances (U.S. Department of the Interior, 2009; New Mexico Department of Fish and Game, 2002). These methods of management have included removal of “offending” lions by lethal means and through translocations. Mountain lion control may be more readily needed and implemented in small or newly transplanted bighorn herds, rather than well-established populations (Sawyer & Lindzey, 2002). It is doubtful that management of the mountain lion will be required on the NTTR based on current known distribution and density of both populations in the area.

The coyote is the most common predator occupying bighorn ranges (Weaver, 1961), and has the highest population density of all bighorn predators (Kelly, 1980). It is difficult for coyotes to climb the steep rocky slopes favored by bighorn sheep. Thus, predation typically happens when sheep are in valleys. Gray foxes have been recorded to prey on newborn lambs, as they cannot kill an adult. Though not common, bobcats have been known to prey upon ewes and lambs by ambushing from an overhang or vantage point. Escape terrain is vital for escaping most predators.

FIELD METHODOLOGY

Data for this report was collected from annual large mammal reports prepared by the NNRP and from the NTTR Geodatabase. Additional data was collected from NDOW and USFWS, most of which was already documented in the NTTR Geodatabase. Please note that the intent of these surveys was to monitor the desert bighorn sheep population for management of the herd. The methodology was not designed to provide statistical analysis of data. The reader should be aware that results are not meant to be statistical in nature. Results are discussed as trends. Methods described below are the general methodology used over the years. Much of the data has been accumulated over many different years and surveys. However, trends in population growth and composition are valid because most of the surveys were comprehensive and covered most of the habitat. Information was gathered for herd management, not academic research. In the paragraphs that follow, methodology used for field surveys conducted by the NNRP and NDOW is discussed.

NNRP and NDOW Field Surveys

NDOW actively participates in desert bighorn management on the NTTR and DNWR. Historically, NDOW has conducted bighorn sheep helicopter surveys for the Stonewall Mountain, Desert Range, Pintwater Range, Spotted Range, and Sheep Range since 1978. The NTTR and USFWS have cooperated with NDOW on these surveys and often accompanied NDOW during the surveys. The NTTR cooperates with NDOW and USFWS by permitting and facilitating an annual winter hunt on the South Range and Stonewall Mountain. USFWS and NDOW typically conduct periodic helicopter surveys of desert bighorn on the mountain ranges found in the DNWR on the South Range Study Area (Pintwater, Spotted, Sheep, and Desert Ranges). NDOW conducts helicopter surveys every other year to monitor populations on Stonewall Mountain and portions of Pahute Mesa. Beginning in 2007, the NNRP supplemented NDOW surveys by conducting additional surveys on the Cactus Range, Mount Helen, Tolicha Peak, Black Mountain, and Pahute Mesa. Beginning in 2012, the NNRP began to survey additional areas including Thirsty Canyon and the Timber Mountains. Figures 3 and 4 show the location of mountain ranges, basins, and valleys found in the North Range Study Area and South Range Study Area. General coverage of these surveys on the North Range and South Range Study Areas is shown in Figures 5 and 6.

Surveys typically start around 7:00 AM and usually end between 2:00 - 5:00 PM. In most cases, at least two experienced biologists and the pilot were present for spotting and counting populations. Individual flight paths were not pre-determined but were designed to cover 100% of the bighorn sheep habitat. In order to accomplish this goal, the helicopter was flown along mountain slopes and canyons with the lead biologist directing where the pilot should fly. From 2012-2015, flight paths were tracked on a Panasonic Toughbook to allow the lead biologist to ensure that all viable habitat was covered. Good bighorn sheep habitat was determined, generally mapped prior to the surveys, and was based on many factors including topography, historic observations of herds, and experience of the biologists. If bighorn sheep are observed, the following data was collected:

- Total number of animals observed
- Number of males, females, and lambs
- Number and age class of rams based on horn size (Yearling, 2-3 years old, 4-5 years old, and 6+ years old). Age class of the rams was determined by the size and configuration of the horn as described by NDOW (Nevada Department of Wildlife, 2013). Two experienced biologists were always present for the surveys. When a group of rams was observed, the biologists made separate age estimates and then compared results after the observation was made. The age classification for the group of rams was then determined by consensus.
- Any outward signs of poor health or injuries

Surveys covered all accessible and appropriate bighorn sheep habitats. A GPS unit was used to document survey flight paths and locations of bighorn sheep. Data collected by NDOW was processed and checked by NDOW staff and then provided to NNRP. All data, including NDOW data were entered into the NTTR Geodatabase and subjected to a thorough QA/QC process to ensure that observations were correctly entered.

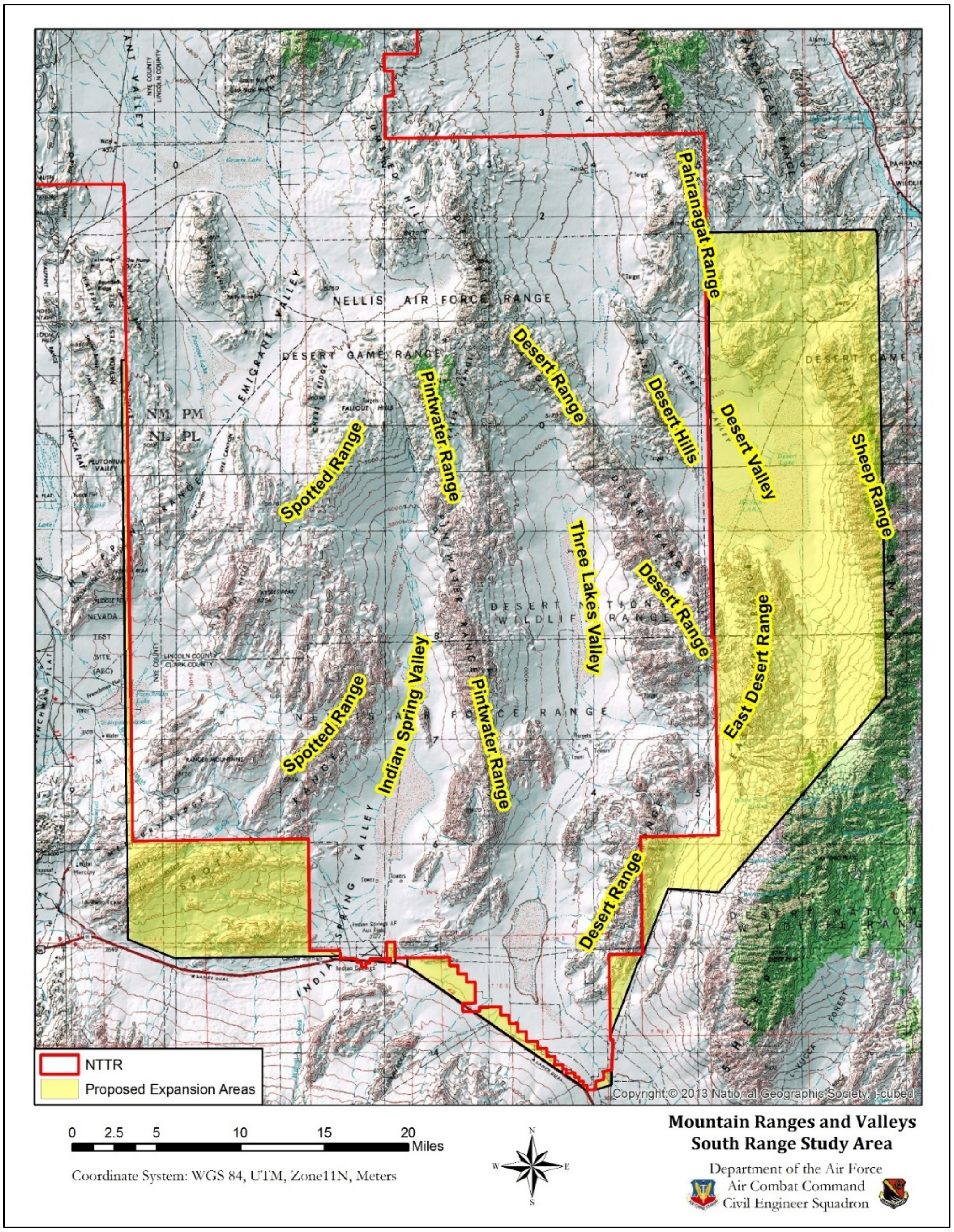

Figure 3. Mountain ranges and valleys found on the South Range Study Area.

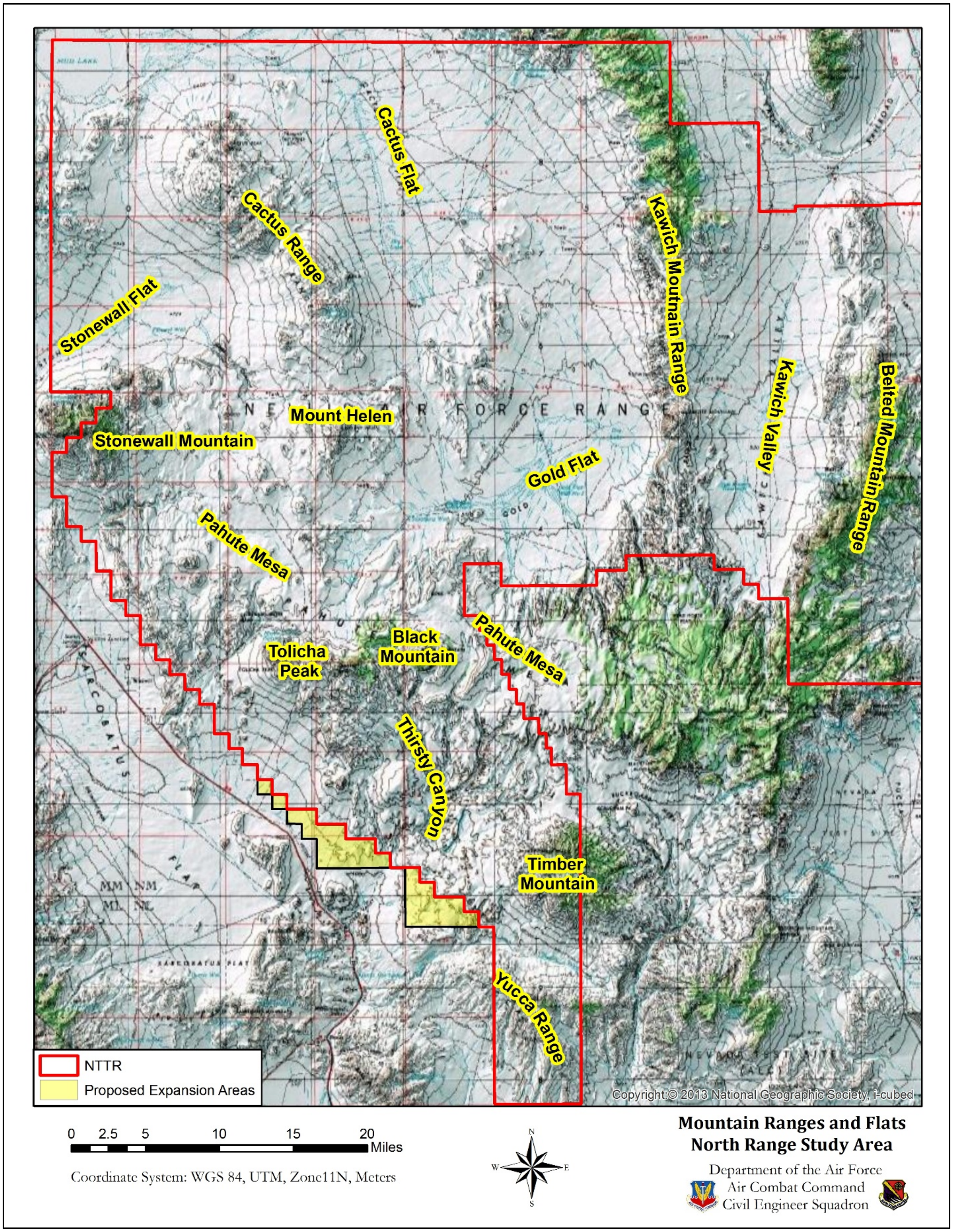

Figure 4. Mountain ranges and valleys found on the North Range Study Area.

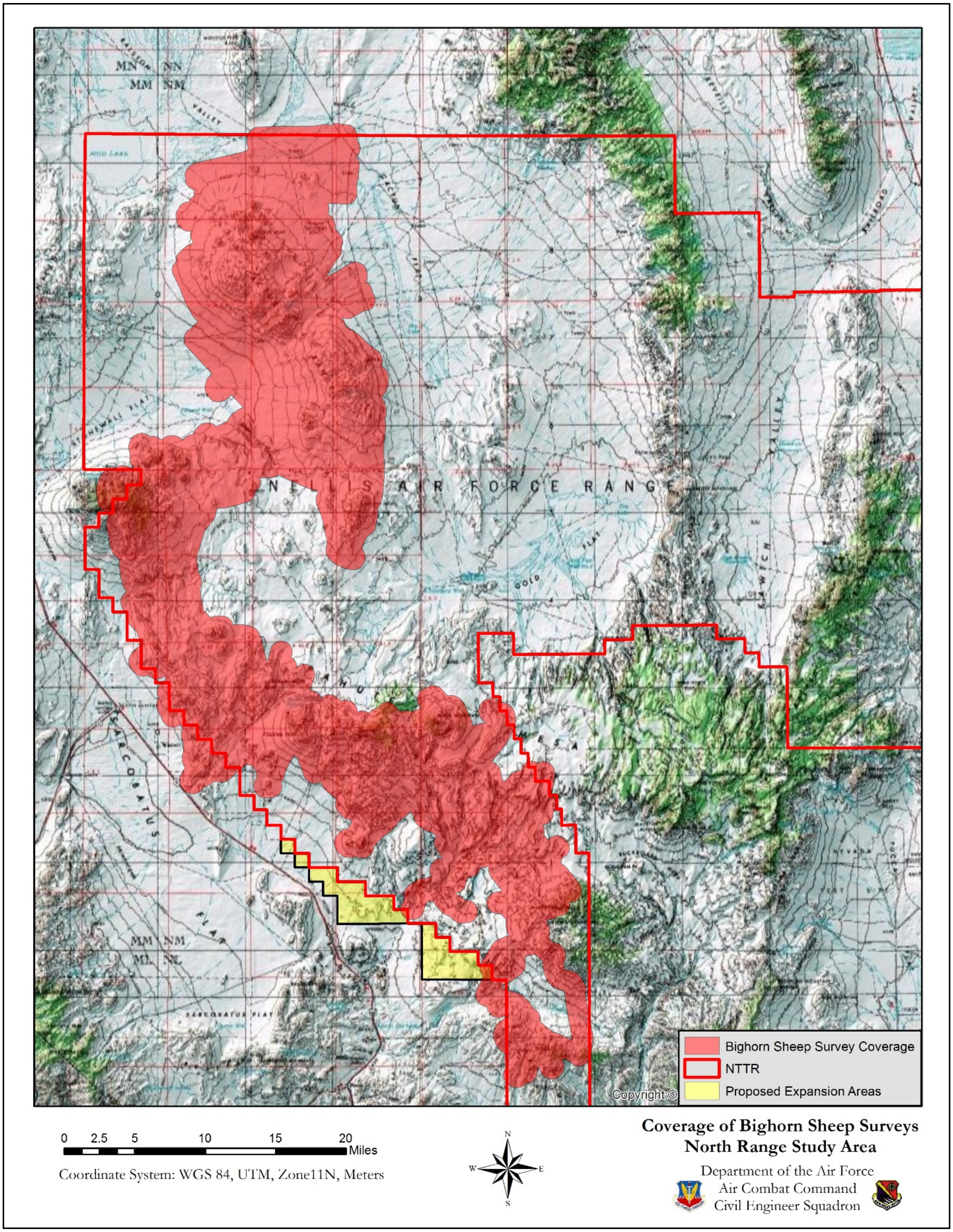

Figure 5. General area covered by desert bighorn sheep surveys conducted on the North Range Study Area.

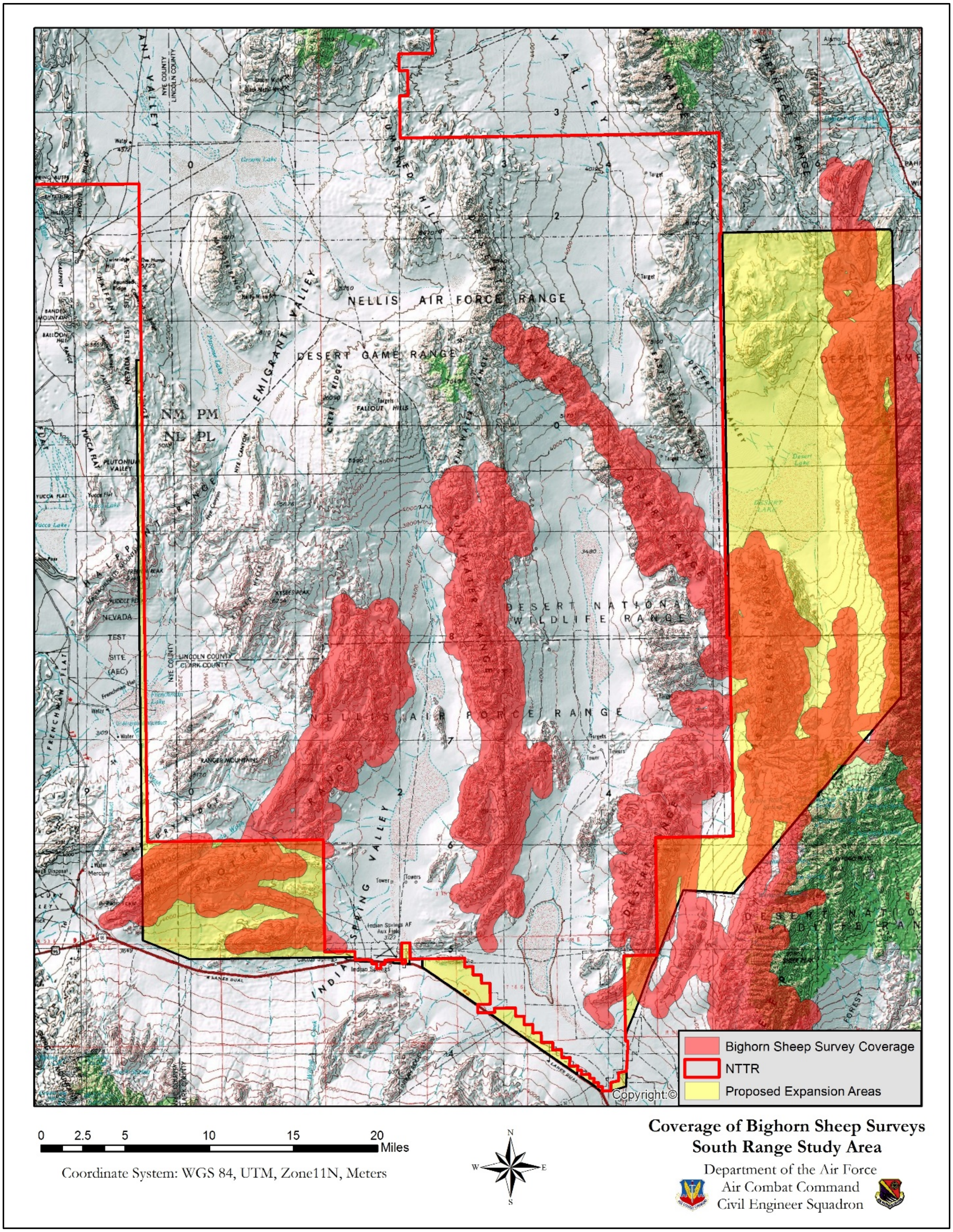

Figure 6. General area covered by desert bighorn sheep surveys conducted on the South Range Study Area.

Summer Lamb Pneumonia Interagency Study

In 2015, a cooperative study was conducted for bighorn sheep on the NTTR to determine if herds were infected with summer lamb pneumonia (*Mycoplasma ovipneumoniae*) and if the source of the disease could be determined. The survey was conducted by a team of biologists from NDOW, USFWS, BLM, USGS, and NNRP. The intent of the study was to determine if pneumonia or any other disease was present. GPS collars were placed on the bighorn sheep to follow daily movements and to determine if the sheep herds on the NTTR were connected to herds on NNSS and other adjacent areas.

Bighorn sheep herd connectivity (intermixing of herds that were separated geographically in the past) is of great concern in Nevada and regionally across multiple jurisdictions. Through the highly successful bighorn restoration efforts, connectivity among adjacent herds has resulted. Thus, herds are now not isolated from each other as in the past and are susceptible to disease transmission and a higher potential for polymicrobial bacterial pneumonia events being contracted across previously separated herds.

Based on the planned bighorn project on the NNSS and extremely low lamb ratio discovered by the 2014 survey on the NTTR, a multi-agency coordination meeting was held on May 4, 2015 in Las Vegas to develop a study plan that would include both the NNSS and the NTTR regarding bighorn herds on adjacent BLM and DNWR lands. The overall goal of the study was to delineate bighorn herds and occupied bighorn habitat on the NNSS and NTTR, identify future herd growth potential for currently occupied and unoccupied bighorn habitat, conduct disease surveillance, and better understand and document seasonal movements and dispersal patterns and distances throughout the NNSS/NTTR complex and adjacent public lands. The committee decided to capture approximately 22 bighorn sheep, place GPS collars on the sheep, and sample the sheep for diseases, etc.

The objectives of the study were the following:

- Determine the presence and estimate the prevalence of pathogens (with emphasis on *Mycoplasma ovipneumoniae* (*M. ovi.*)) known to cause pneumonia leading to all age die-offs and subsequent summer lamb pneumonia mortalities in bighorn sheep.
- Determine the geographic distribution of pathogens among the various bighorn sub-herds across the NTTR, NNSS, and adjacent public lands.
- Identify *M. ovi* strain types and compare them to current regional strains to determine the origin, distribution, and virulence of the identified *M. ovi* strains; as well as past and future disease transmission pathways.
- Use GPS collars to document ram and ewe foray/dispersal distances, direction, timing, and frequency relative to bighorn herd connectivity (gene flow, disease transmission, habitat resource selection) and radionuclide migration pathways.
- Identify key year-round and ephemeral water sources used by bighorn sheep and determine relative bighorn densities at the water sources to estimate present and future resource limitations and predict bighorn dispersal and pioneering events.
- Estimate rates of morbidity and mortality among age classes
- Estimate lamb recruitment for each herd or sub-herd to correlate with pathogen profiles.
- Determine the genetic diversity and lineage of the herds on the NNSS and the NTTR.
- Collect daily locations of collared bighorn to assist in developing resource selection functions for habitat range modeling by the USGS to predict potential and currently occupied bighorn habitats.

Proposed areas on the North Range Study Area for bighorn captures and water source monitoring included Cactus Range, Mt. Helen, Stonewall Mountain, Civet Cat Canyon, Pahute Mesa, Tolicha Wash, Tolicha Peak, Quartz Mountain, Black Mountain, Timber Mountain, and Thirsty Canyon.

NTTR and NDOW conducted helicopter bighorn sheep herd composition surveys on the North Range Study Area and Stonewall Mountain in October 2015. Data collected in 2015 was used to determine location of bighorn sheep herds for capture events in late October/early November.

Helicopter net gun captures and GPS collaring of bighorn sheep were conducted on the NTTR and adjacent lands during the period from October 31 – November 15, 2015. Collaring was conducted on the Pintwater Range on November 11-12, 2016. A total of 22 sheep (11 rams and 11 ewes) were to be captured and collared. The method of capture was as follows:

- Animals were located and pursued by a helicopter;
- Once a specific target was identified, the helicopter approaches the sheep and a net was fired at close range from a net gun to envelop the sheep;
- One or two handlers were let off the helicopter to restrain (hobble and blindfold) and remove the animal from the net. Animals were processed by the capture crew at the point of capture, or flown to a basecamp and processed depending on road access, sensitivity of area, need for sampling precision, animal welfare, and environmental factors.
- Processing involved: a complete physical exam, the collection of standardized vital rates, biometric data, comprehensive samples for pathogen screening, health and genetic evaluation, and marking with uniquely identified ear tags as well as deploying a GPS collar.
- Once sampling was complete, the animal was released at the capture location.

If an animal had clinical signs of disease, the decision was sometimes made to euthanize the animal for diagnostic sampling. In that situation, the animal was humanely euthanized, as per protocol by the attending veterinarian at the base camp. After diagnostic sampling the carcass was removed for proper disposal.

Samples that were collected were screened by the appropriate NTTR personnel and approved for chain of custody transfer off site. Samples were properly stored, processed and shipped to labs as per NDOW protocol. Samples collected included:

- Blood (serum) for respiratory virus titers (PI3, BRSV, EHD, BT, BVDV) M. ovi ELISA and archival banking;
- Whole blood for selenium levels and genetic screening;
- Nasal swabs for *M. ovi* antigen detection via PCR;
- Tonsillar swabs for *Pasteurellaceae* identification and determination of the presence of the *Pasteurella Lkt-A* gene;
- Fecal pellets to screen for the presence of internal parasites including the lung worm *Protostrongylus spp;*.
- Ear canal swabs to screen for the ear mite *Psoroptes ovis.*

Bighorn Sheep Collaring

Twenty-five GPS collars were deployed on bighorn on the NTTR in 2015 and twenty-one collars were deployed in 2016. All collars were real-time satellite collars accessing either Iridium or Globalstar satellite systems. The collars have a battery life of about 2 years based on transmission of collar GPS data every hour. Data is downloaded weekly and converted into Excel Spreadsheets and ArcGIS shapefiles, which are combined into monthly datasets. Data collected from the monitoring of collars will be used to determine the locations and movements of bighorn sheep herds and to provide baseline information for development of a habitat range model by the USGS.

Habitat Models

Computer models were used to delineate potential habitat for bighorn sheep on the study area. Two different models were used—a Habitat Suitability Model and Maxent, a probabilistic model. These models were run for bighorn sheep, mule deer, wild horse, and pronghorn. The model methodology is described below for all species, but details on the parameters used for each species will be provided in their separate sections.

Habitat Suitability Model

For the Habitat Suitability Model, documented habitat parameters for each large mammal species were researched and the limiting range for each parameter was determined. After layer criteria were selected for each model, each of the layers was weighted based on the importance of the layer in determining habitat range. Thus, if a layer was more important in determining habitat range, it was given a higher weighting factor. Weighting factors ranged from one to five with five being very important. Last, if the large mammal species was rarely found outside of a range of parameter limits within a layer, that criterion was considered inclusive and any other criteria used for the model outside of those limits were excluded from the model.

Habitat Suitability for large mammals was modeled using the Habitat Range Prediction Tool (HRPT), which was recently developed by Adams Ecology for natural resources modeling. The HRPT is a script and associated script tool that was created to model and score locations of a species' preferred habitat. To build this tool, environmental layers were used to map suitable habitat for the particular large mammal species. Vector layers were converted to raster files, and all layers were clipped to the boundaries of the NTTR and proposed expansion alternatives. The parameters could only be used if GIS layers were available for the parameter on the study area. Thus, the following GIS layers were selected for the Habitat Suitability Model for large mammals:

- Elevation: USGS Digital Elevation Map (DEM); 10 m resolution. The elevation range for the species was considered the highest score and the score for this layer decreased as one moved away from the lower or upper limit of elevation.
- Slope: Created from 10 m DEM using ArcMap.
- Key Habitat: NDOW Key Habitats: Nevada Wildlife Action Plan (Nevada Department of Wildlife, 2013).
- Ruggedness: Layer was prepared using the procedure described Sappington, et al. (2007).
- Permanent Water Sources: Created from seeps and springs database from NTTR and DNWR and includes only perennial seeps and springs and construction ponds. Scoring was based on distance from the source with 0.5 mi. radius being the highest score and the score decreasing as the radius increased (1.0, 2.0, 3.0, 5.0, and >5.0 mi.).
- Temporary Water Sources: Created from seeps and springs database from NTTR and DNWR and includes all intermittent and ephemeral water features except washes and dry lakes. Scoring was based on distance from the source with 0.5 mi. radius being the highest score and the score decreasing as the radius increased (1.0, 2.0, 3.0, 5.0, and >5.0 mi.).
- Soil Associations: U.S. Natural Resources Conservation Service STATSGO2 Database.
- Plant Alliances: Map developed by Adams Ecology for the documentation of plant alliances on the study area (U.S. Air Force, 2017).
- Mountains: Prepared by Adams Ecology based on digital elevation maps of the area.
- Valleys: Prepared by Adams Ecology based on topographic maps of the area.

The script for the model was created in Python. Using "arcpy.GetParameterAsText," user inputs could be entered for each variable directly through ArcMap or ArcCatalog. For each layer, specific inputs were required to allow the script to proceed. Invalid inputs caused an error in the script and it would no longer process. In layers with ranges, the user-specified range was scored a five (highest), while scores four through one were determined incrementally by ten percent of the range added or subtracted from the upper and lower ends of the range. Layers containing specific types were scored based on presence or absence of the user-input type. After the script created scoring outputs for each of the environmental layers, they were all multiplied by the weighting factor for each layer using the ArcGIS Raster Calculator tool. A simple addition method was used to prepare a total of the resulting scores of all layers.

The final resulting output consisted of a raster file with values from zero (no habitat) to the raster's maximum value (prime habitat). A higher score indicated that more preferred habitat parameters were met at that location. The final model for large mammal species was placed on a topographic map using ArcGIS, with the overlay being color coded to show the varying degree of potential for habitat to be present, based on habitat quality.

Parameters used for bighorn sheep habitat included the following:

- Elevation: 3,500–8,500 ft. MSL (No weighting factor): Potentially can be found at most of the elevations on the South Range Study Area.
- Slope: 60° to 90° (Weighting factor of 3): Escape terrain is described as at least 60° slope and rocky outcrops (McQuivey, 1978).
- Permanent Water Sources (Weighting factor of 3): Studies have shown that desert bighorn sheep populations are usually concentrated within a 2-3 mile radius of a water source during the summer months (Leslie & Douglas, 1979; Jones, 1957; Cunningham & Ohmart, 1986).
- Temporary Water Sources (No Weighting factor): Less emphasis on this parameter because it is only present periodically.
- Key Habitat: Cliffs and Canyons (No weighting factor): Based on slope parameter above.
- Mountains: Included.
- Valleys: Included.
- Plant Communities (No weighting factor):
    - *Ambrosia dumosa* Shrubland Alliance
    - *Artemisia arbuscula* Shrubland Alliance
    - *Artemisia nova* Shrubland Alliance
    - *Artemisia tridentata* Shrubland Alliance
    - *Atriplex canescens* Shrubland Alliance
    - *Atriplex confertifolia* Shrubland Alliance
    - *Coleogyne ramosissima* Shrubland Alliance
    - *Juniperus osteosperma* Woodland Alliance
    - *Larrea tridentata* Shrubland Alliance
    - *Larrea tridentata-Ambrosia dumosa* Shrubland Alliance

Maxent

Maxent is a probabilistic model program that uses the habitat attributes at observation points to delineate areas where a species is likely to be found (Phillips, Anderson, & Schapire, 2006). The model relies on a sufficient number of observation points (no fewer than 30 and preferably greater than 100) to provide a reliable delineation of habitat preferences for a species (Wisz, et al., 2008). The intersection of point observations with available environmental parameter GIS layers is used to create importance values and limits for parameters, which, in turn, are used to create the final habitat map. The model GIS layers used for the Maxent model for large mammals included the following:

- Elevation: USGS Digital Elevation Map (DEM); 10 m resolution. The elevation range for the species was considered the highest score and the score for this layer decreased as one moved away from the lower or upper limit of elevation.
- Slope: Created from 10m DEM using ArcMap.
- Aspect: Created from DEM using ArcMap.
- Roughness: Created according to Sappington et al. (2007).
- Geologic Outcrops: Geologic Map of Nevada (Crafford, 2007).
- NDOW Key Habitats: Nevada Wildlife Action Plan (Nevada Department of Wildlife, 2013).
- Mountains: Prepared by Adams Ecology based on digital elevation maps of the area.
- Permanent Water Sources: Created from seeps and springs database from NTTR and DNWR and includes only perennial seeps and springs and construction ponds. Scoring was based on distance from the source with 0.5 mi. radius being the highest score and the score decreasing as the radius increased (1.0, 2.0, 3.0, 5.0, and > 5.0 mi.).
- Soil Associations: U.S. Natural Resources Conservation Service STATSGO2 Database.
- Temporary Water Sources: Created from seeps and springs database from NTTR and DNWR and includes all intermittent and ephemeral water features except washes and dry lakes. Scoring was based on distance from the source with 0.5 mi. radius being the highest score and the score decreasing as the radius increased (1.0, 2.0, 3.0, 5.0, and > 5.0 mi.).
- Valleys: Prepared by Adams Ecology based on topographic maps of the area.
- Plant Communities: Map developed by Adams Ecology for the documentation of plant alliances on the study area (U.S. Air Force, 2017).

The GIS layers were converted into raster files having the exact same resolution and clipped to the exact same size and shape. The raster files were converted into ASCII format as required for the model with each record being comprised of the attribute value, an x coordinate and a y coordinate. Once the layers were properly converted, Maxent was run in four different formats including Cloglog, Raw, Cumulative, and Logistic formats. The format showing the most realistic results based on the location of point observations was shown in the results section of this report.

Results

Field Surveys

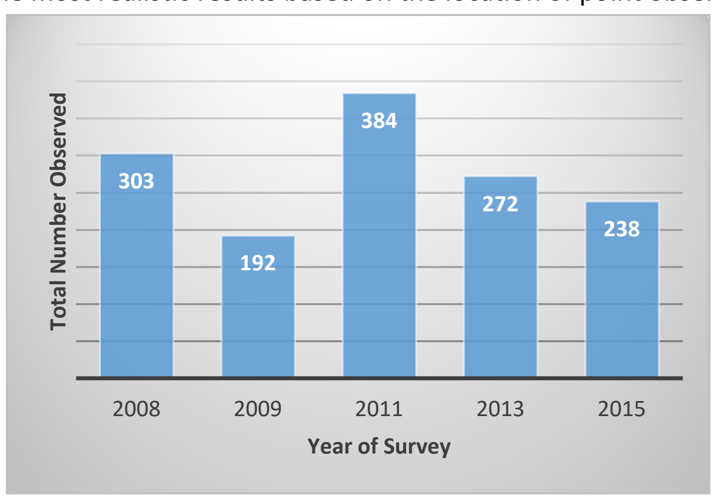

Figure 7. Total number of bighorn sheep observed during surveys of Stonewall Mountain on the North Range Study Area.

The total number of bighorn sheep observed during helicopter census surveys within the management boundaries of the NTTR each year from 2003-2015 is variable due to several factors. The area covered by surveys was not consistent across years on the North Range Study Area. Stonewall Mountain was surveyed every other year and usually comprised a significant part of the sheep population. Also, from 2012-2014, the NNRP surveys overlapped with the NDOW surveys in the North Range Study Area. Thus, a graph showing the total number of sheep observed on NTTR is not provided because it can be misleading to the reader. Total sheep observed will only be discussed for those areas where the methodology and size of survey area was consistent across the survey years. Incidental observations were recorded during other surveys and limited data was collected at each observational point. This data was only included in figures showing locations of sheep observations over the years.

Data for Stonewall Mountain includes only those observations made by NDOW biologists. Overlap with any NNRP surveys was removed. Additionally, the population data for Pahute Mesa and Thirsty Canyon was spatially separated from any NNRP surveys that encroached into the area surveyed by NDOW for Stonewall Mountain. This does not ensure that the population data does not have overlap because herds from both areas could mix since surveys were not conducted at the same time, except in 2015. In 2015, the NDOW surveys and NNRP surveys were conducted the same day and overlap was avoided by coordinating survey areas covered by each entity. The survey results for the North Range Study Area should be fairly accurate because of these precautions, but the results should not be considered definitive for population size but are only counts of animals observed. Numbers were not adjusted for standard errors and omissions. Surveys were not designed for statistical analysis. Only raw data (animal counts) results are discussed.

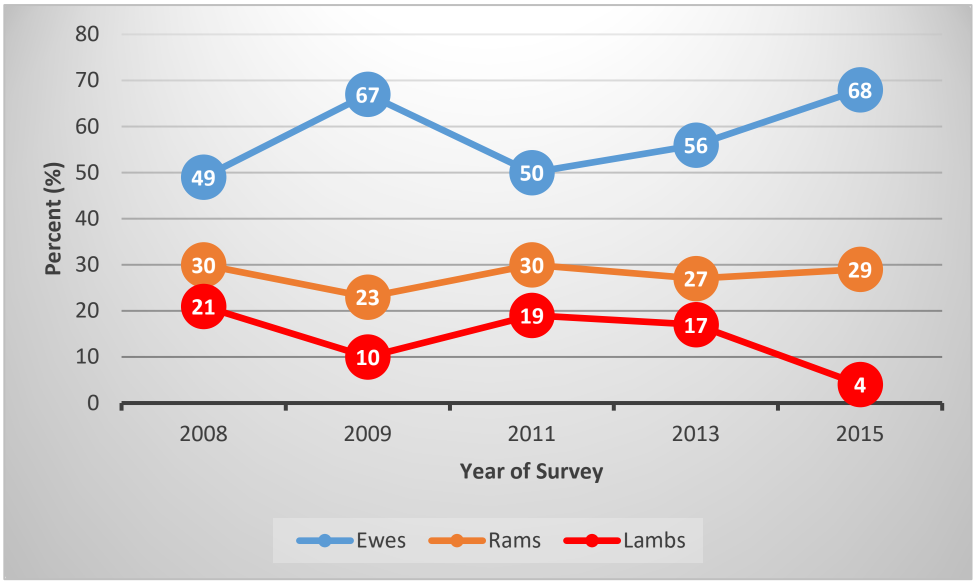

Figure 8. Percent ewes, rams and lambs comprising the bighorn sheep population on Stonewall Mountain during the surveys conducted from 2008 to 2015.

On Stonewall Mountain, bighorn sheep counts ranged from a low of 192 in 2009 to a high of 384 in 2011 (Figure 7). The population counts showed a steady decline from 2011 to 2015, possibly due to disease or drought. During that same period of time, the percent of the population that was female increased from 50% to 68% while the lamb percentage dropped from 19% to 4% (Figure 8). The percent of rams in the population was relatively constant from 2008 to 2015. The drop in the lamb population was suspected to be a result of summer lamb pneumonia, which had been reported in the area.

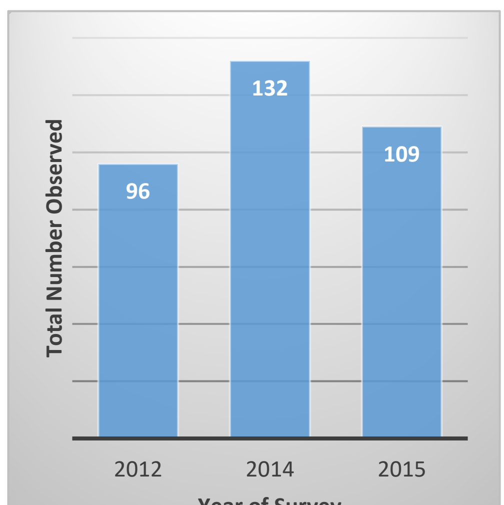

Figure 9. Total number of bighorn sheep observed during surveys of Pahute Mesa and Thirsty Canyon on the North Range Study Area.

Surveys were conducted in 2012, 2014, and 2015 on Pahute Mesa and Thirsty Canyon (Figure 9). The sheep counts appeared to be relatively stable during this period, although a slight drop from 132 sheep in 2014 to 109 sheep in 2015 was observed. The bighorn sheep counts indicated a healthy population in 2012 with 51% ewes, 22% rams, and 27% lambs (Figure 10). However, no lambs were observed in 2014 and the percent lambs in 2015 remained low at 7%. Again, this may be a result of the occurrence of summer lamb pneumonia in the herd in 2014 and 2015 that was confirmed in 2016.

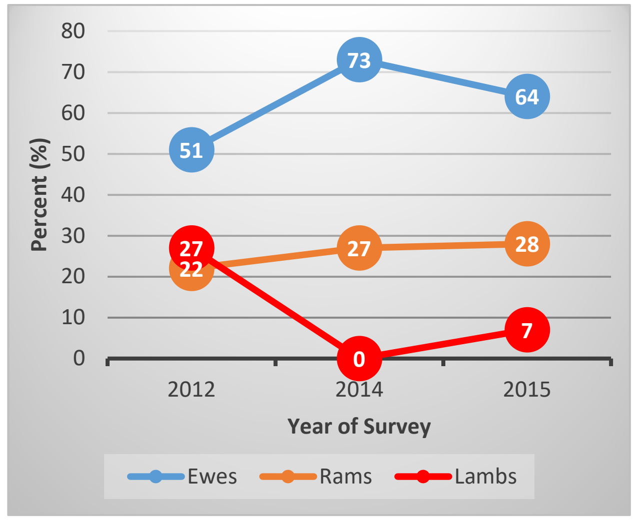

Figure 10. Percent ewes, rams, and lambs comprising the bighorn sheep population on Pahute Mesa and Thirsty Canyon during the surveys conducted from 2012 to 2015.

Surveys of bighorn sheep on the Cactus Range indicate a drop in the population count in 2015 (Figure 11). As with other bighorn populations on the North Range Study Area, the population counts on Cactus Peak showed a decrease in percentage of lambs in 2014 with 16% in 2012, 3% in 2014, and 10% in 2015 (Figure 12). Overall, on the Cactus Range, the percent of the population that was lambs is much lower than that observed on the other mountain ranges. The percent of the population attributed to rams was much higher in the Cactus Range compared to other ranges with the percent rams ranging from 42-47% across the surveys.

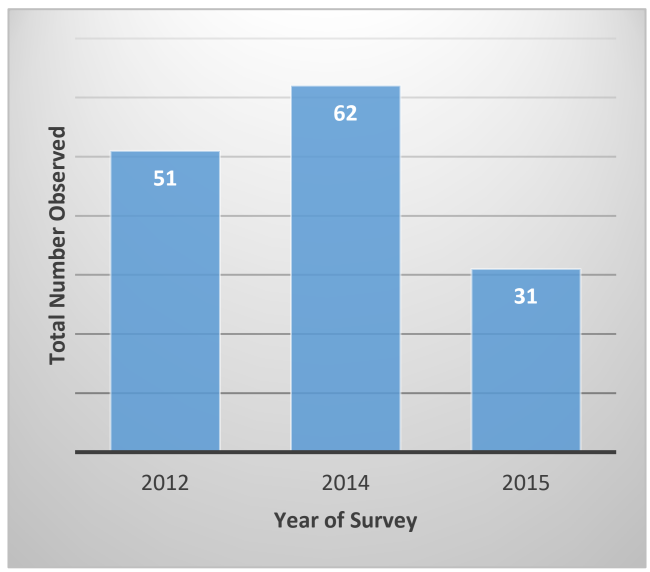

Figure 11. Total number of bighorn sheep observed during surveys of the Cactus Range on the North Range Study Area.

The total number of sheep observed on Mount Helen was relatively low in 2014 and 2015 (Figure 13). Mount Helen is believed to be a lambing area and relatively large herds of ewes and lambs have been observed in the area in late winter and early spring during the lambing season. Additionally, the Pahute and Shoshone tribes in the area consider this sacred ground because it is considered a lambing area. However, no studies have been conducted to confirm that it is a lambing area. The surveys presented in this report were conducted in the fall outside of the lambing season, which may explain the low numbers of sheep counted.

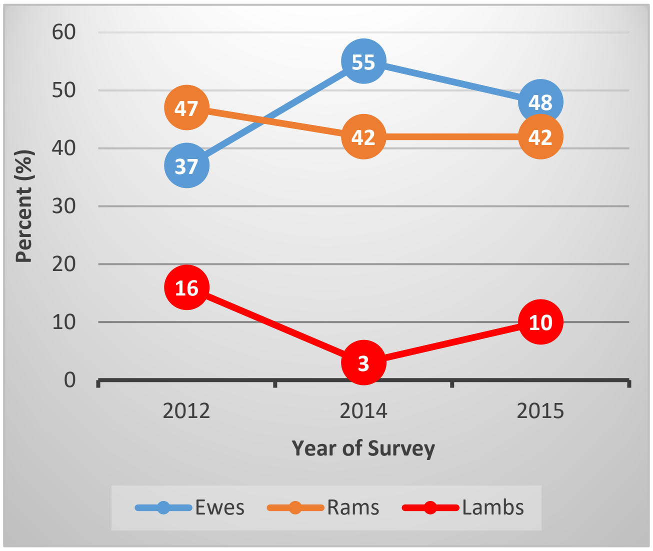

Figure 12. Percent ewes, rams, and lambs comprising the bighorn sheep population on the Cactus Range during the surveys conducted from 2012 to 2015.

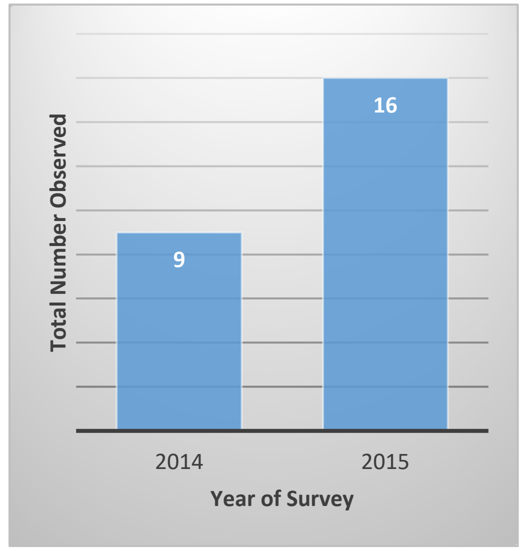

Figure 13. Total number of bighorn sheep observed during surveys of Mount Helen on the North Range Study Area.

On the South Range Study Area, bighorn sheep surveys were conducted almost every year from 2003 to 2015. Data was not available for the Sheep Range for 2008-2013. On the Spotted Range, bighorn sheep counts were relatively low in 2003 and 2004, increased to 111 in 2006, and then varied from 60 to 102 in the years that followed (Figure 14). The average count across all years was 77. Counts for the Pintwater Range were also variable, ranging from a low of 29 in 2004 to a high of 107 in 2009 (Figure 15). The average sheep count for the Pintwater Range across all years was 68. In contrast, the Desert Range experienced the lowest counts of sheep in 2005 (13 sheep) and 2009 (9 sheep). The highest count was in 2015 with a total of 134 sheep (Figure 16). The average count across all years for the Desert Range was 69, comparable to the other ranges. Sheep counts on the Sheep Range included a low of 34 in 2003 and highs of 162 in 2005 and 176 in 2015 (Figure 17). The average count for the Sheep Range across all dates was 108 sheep. Please note that this average did not include 2008-

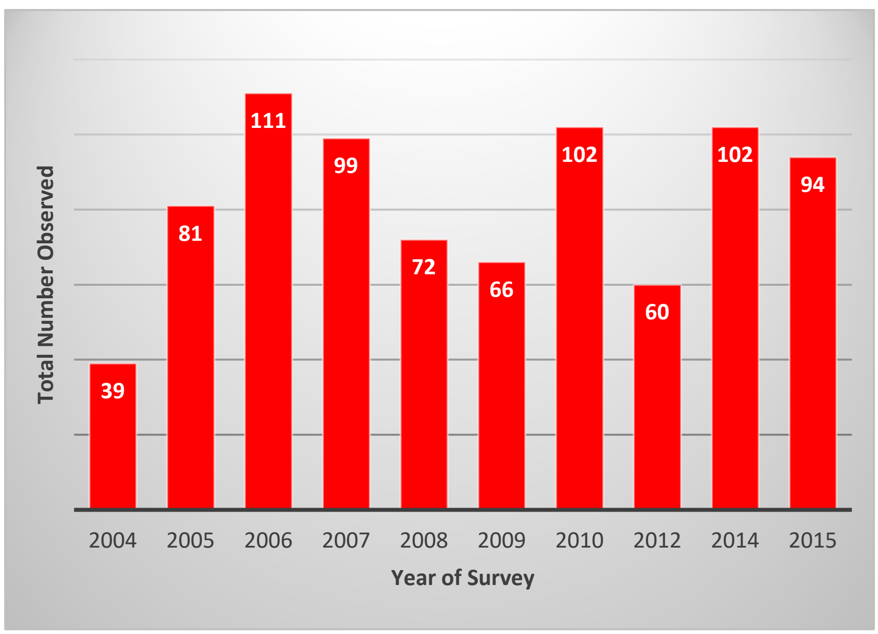

Figure 14. Total number of bighorn sheep counted on surveys for the Spotted Range on the South Range Study Area

2013. Figure 18 shows the total counts for the South Range on dates where all ranges were surveyed. The breakdown by range is included. Basically, the bighorn sheep counts for the South Range indicate a stable population with a trend towards an increase in numbers.

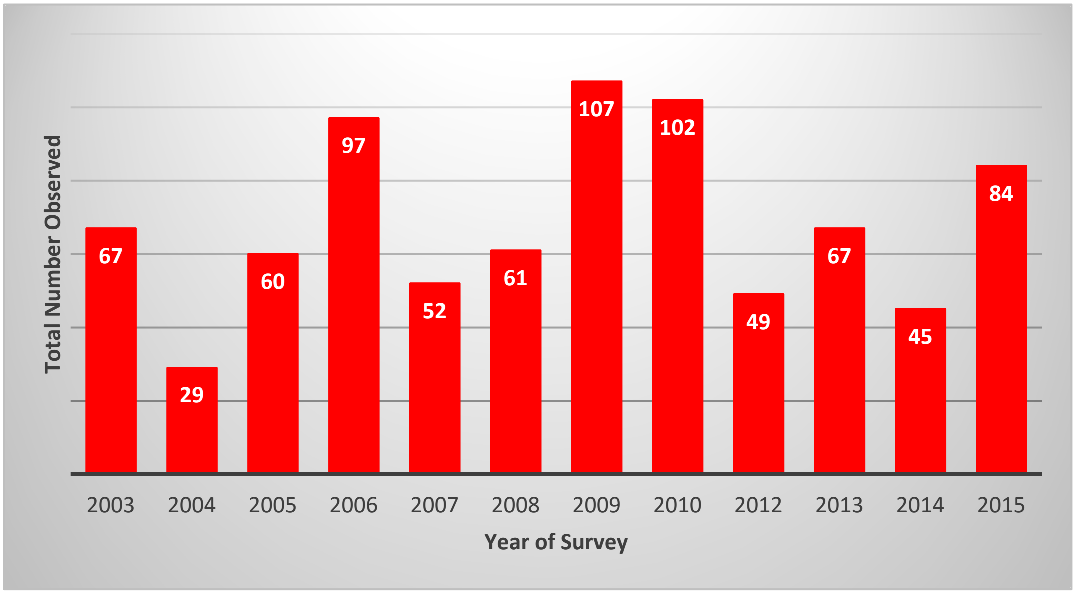

Figure 15. Total number of bighorn sheep counted on surveys for the Pintwater Range on the South Range Study Area.

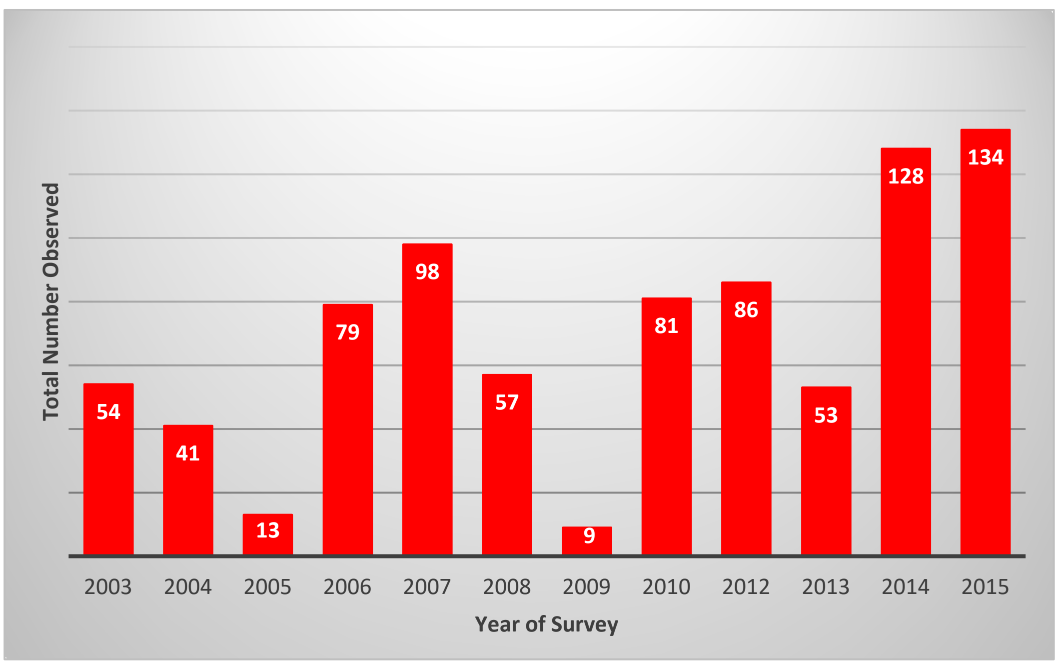

Figure 16. Total number of bighorn sheep counted on surveys for the Desert Range on the South Range Study Area.

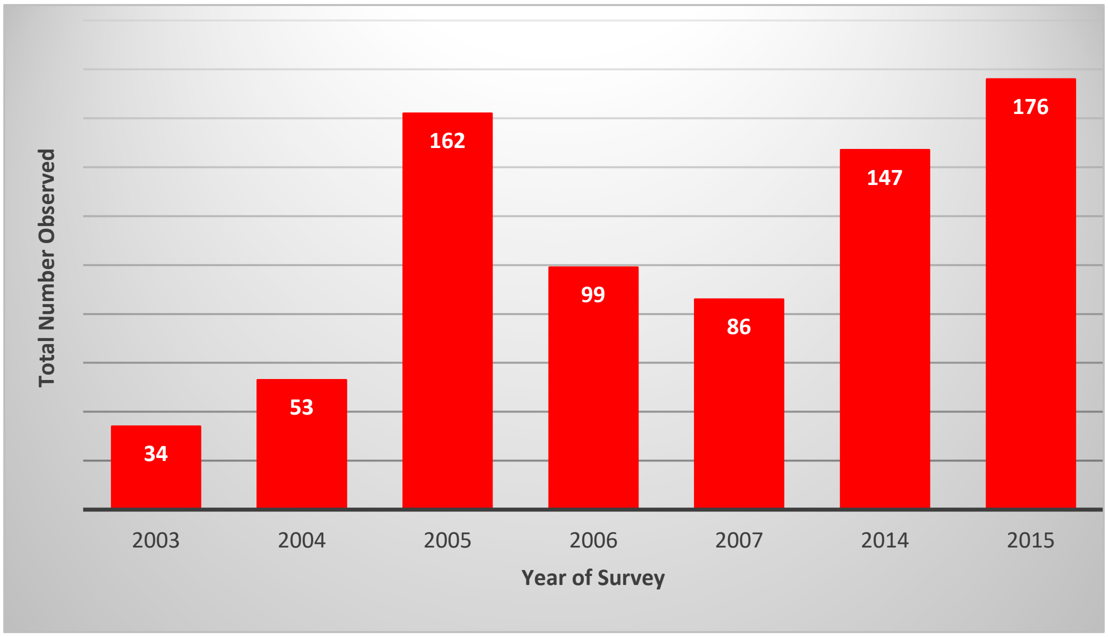

Figure 17. Total number of bighorn sheep counted on surveys for the Sheep Range on the South Range Study Area.

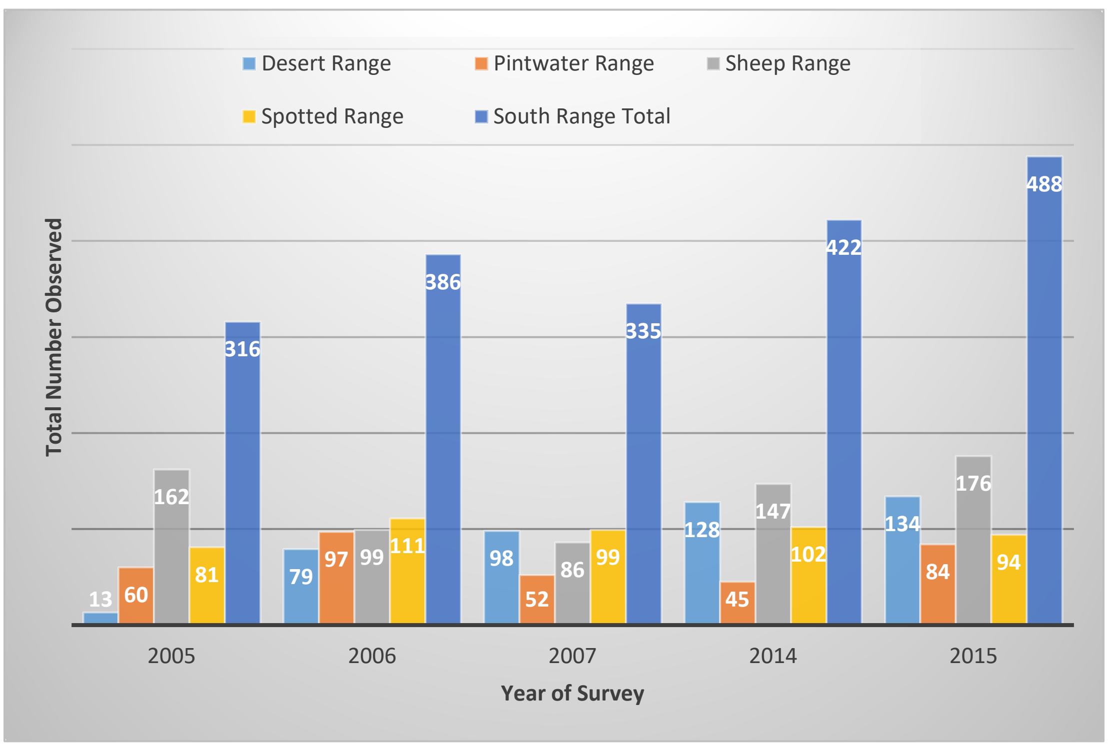

Figure 18. Total number of bighorn sheep counted on surveys for the South Range Study Area when counts were available for all mountain ranges.

Percentage of lambs in the bighorn sheep population on the NTTR has varied over the years. Across all years, lambs have averaged about 16% of the population (Figure 19). From 2006 to 2008, the percent of lambs in the bighorn populations ranged from 18% to 24% (Figure 20). This compares to lows of 11% in 2009 and 8% in 2014. The percentage of lambs in counts increased to 13% in 2015. The percentage of ewes, rams, and lambs in the population counts each year is provided in Figures 21 and 22. The South Range experienced a slight drop in percentage of lambs from 2009 to 2014, but overall, the average contribution to the population count was 53%, 29%, and 18% for ewes, rams, and lambs, respectively. The population appears to be stable over the time period. On the North Range Study Area, the contributions of ewes, rams, and lambs was fairly stable until 2014 when the percent lambs dropped to 1% and then only increased to 6% in 2015 (Figure 22). From 2014 to 2015, the percentage of ewes increased from 56% to 66%. Percentage of rams jumped up to 37% in 2014 when the lamb population was low, but then returned to 29% in 2015. The average percentage contribution of ewes, rams, and lambs to population counts across all survey years for the North Range Study Area was 58%, 29%, and 13% respectively. The average percentages indicate that the South Range population counts tended to have a fewer percentage of ewes and higher percentage of lambs than the North Range populations (Figure 21). Percentage of rams was the same for both study areas. This may be attributed

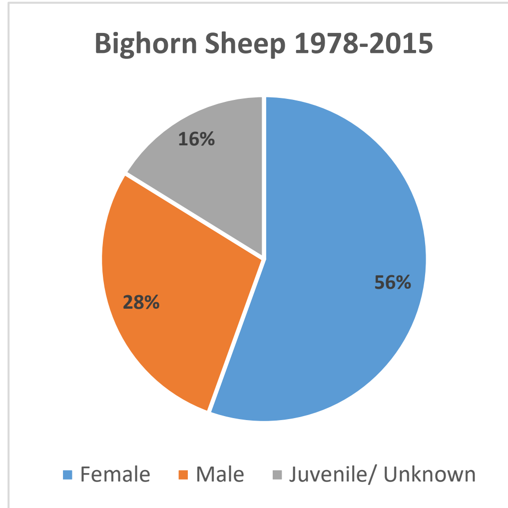

Figure 19. Percentage of male, female and juvenile bighorn sheep across the study area all years.

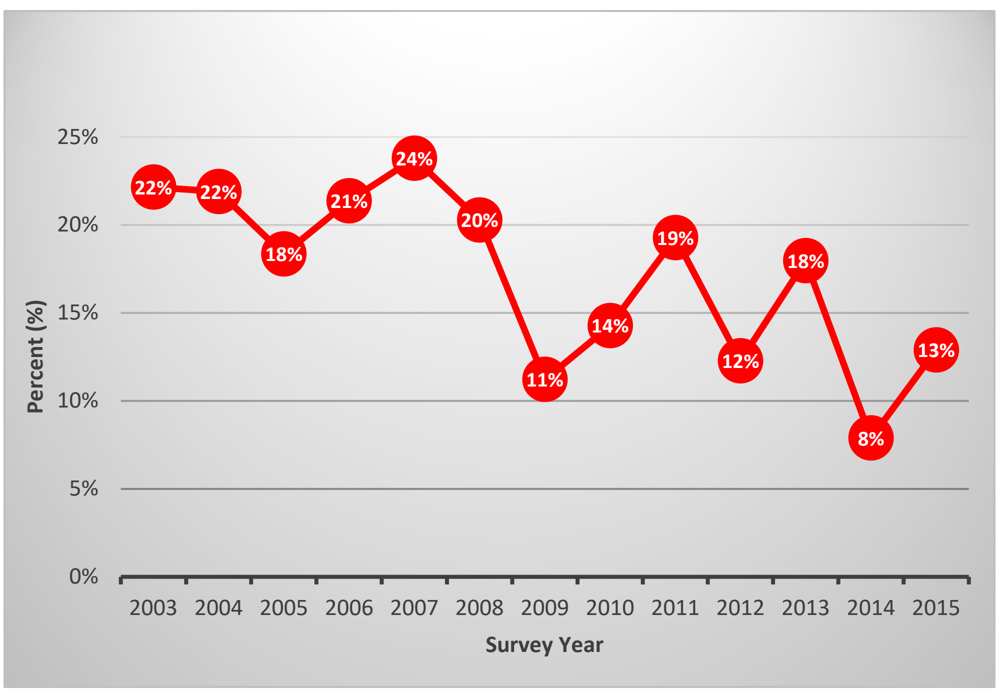

Figure 20. Percentage of lambs contributing to the population of the count of bighorn sheep across the entire study area.

to the summer lamb pneumonia that was discovered to have occurred in the North Range Study Area.

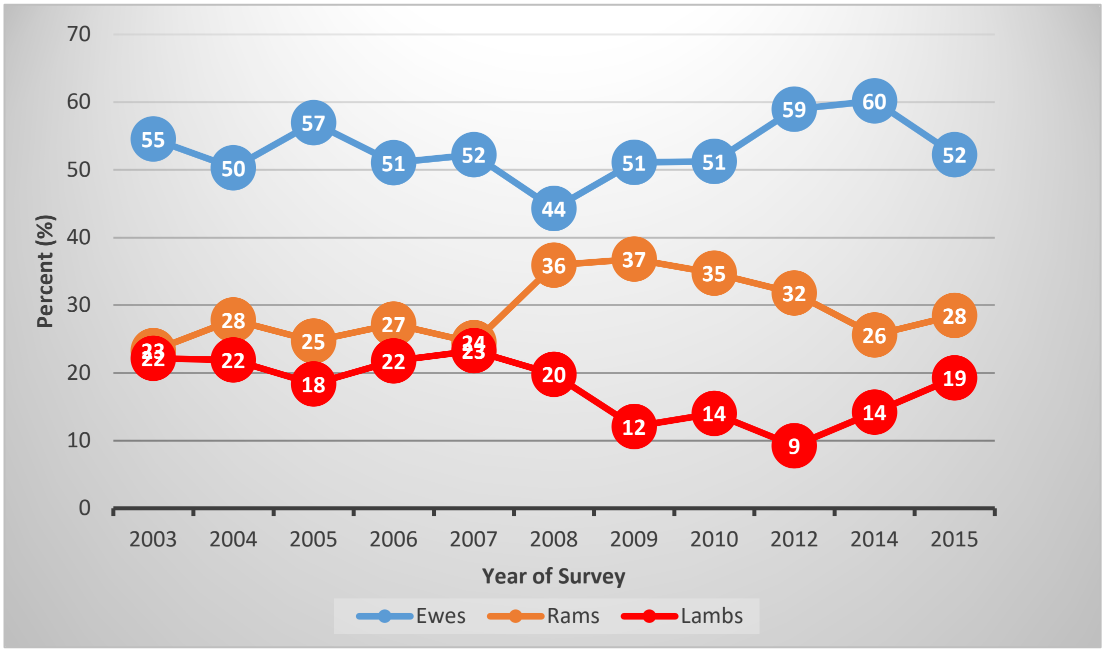

Figure 21. Percentage of the population counts on the South Range Study Area contributed by ewes, rams, and lambs.

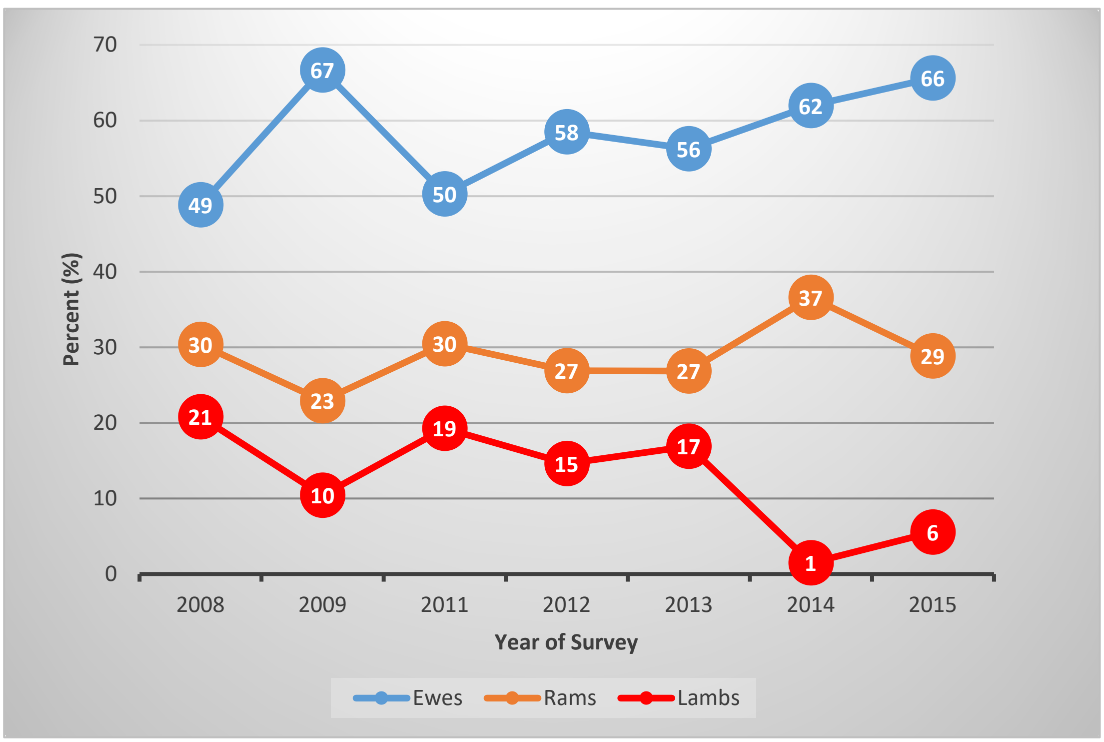

Figure 22. Percentage of the population counts on the North Range Study Area contributed by ewes, rams, and lambs.

The decrease in percentage of lambs counted in 2014 could be attributed to the ongoing drought or the outbreak of *Mycoplasma ovipneumoniae (M. ovi)*. Water is available on the South Range Study Area through wildlife water developments, while only natural springs are available on the North Range Study Area. Many of the North Range springs were dry or nearly dry in 2015. Surveys in 2014 showed that the percentage of lambs in the North Range Study Area was 1%, while in the South Range Study Area the percentage of lambs was 14%. In 2015, the overall lamb population count appeared to be increasing. However, the North Range Study Area still only showed 6% lambs compared to 19% lambs on the South Range Study Area. The low lamb population count in 2014 was reflected in a low yearling population count on the North Range Study Area in 2015 with only 5 yearlings observed in a population of 416 total animals (1.2%). These facts led to the implementation of the cooperative study between NDOW, USFWS, USGS, and NNRP to capture bighorn sheep and inspect the animals for disease symptoms and take samples for pathological analysis.

Population counts classified by ram age and expressed as a percentage of total males shows that the population of rams is fairly consistent in age composition except during the period of 2013-2015 (Figure 23). The percentage of 2-3 year-old rams is very stable across the dates. Interestingly, the 4-5 year-old rams and the 6 and older rams appear to have an inverse relationship with each other and were somewhat variable. Bearing this in mind, the two classifications were added together to form the 4 and older class of rams. This age class percentage shows a gradual increase across time, which is probably in response to the decrease in yearling rams observed 2013-2015. This decrease in the percentage of rams being yearlings and increase in older rams would be an expected change in the event of a disease that impacts lamb populations.

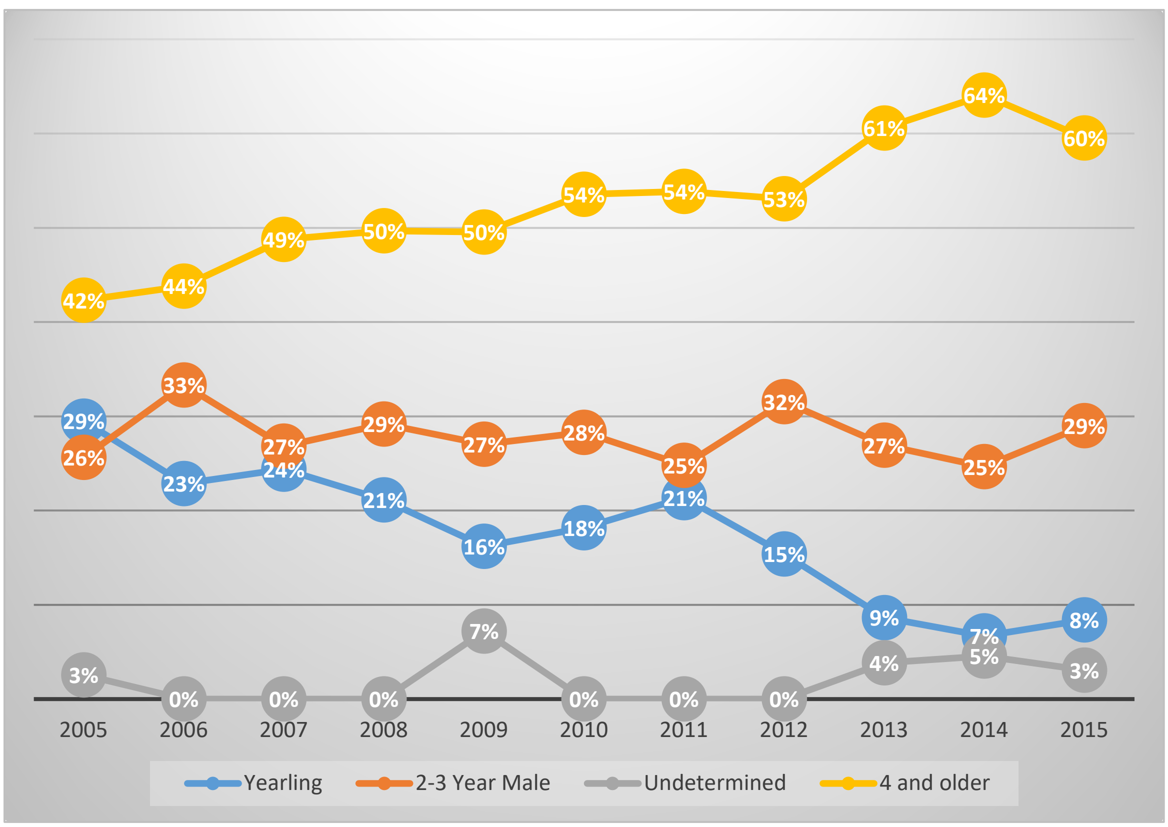

Figure 23. Percentage of the population count of rams broken down by age class each year of surveys 2005 to 2015.

Figures 24-25 show the locations where bighorn sheep have been observed on the study area since 1978. This provides a general concept of where populations of the species may be found on the study area and will be useful developing strategies to avoid impacts to the animals.

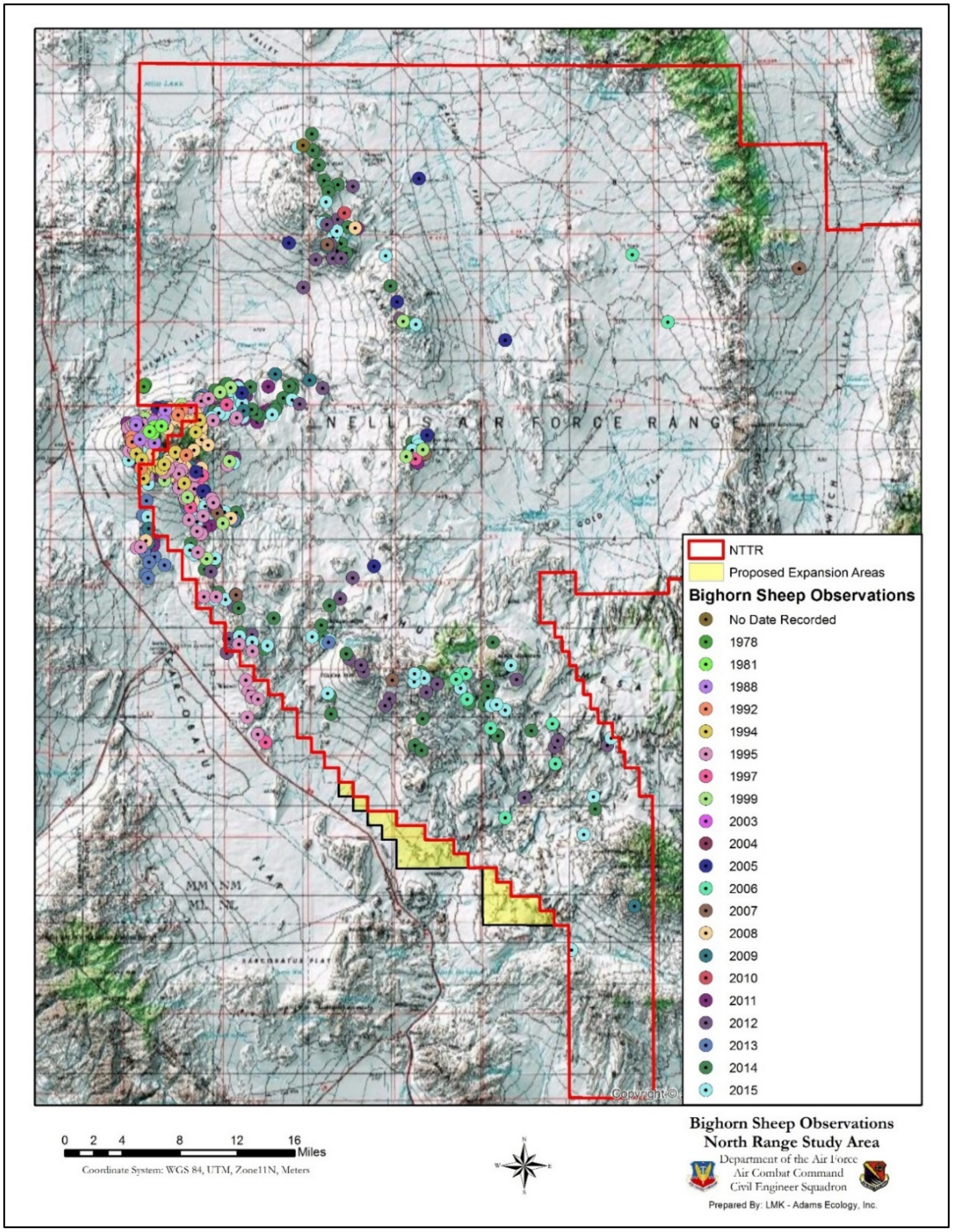

Figure 24. Locations where bighorn sheep have been observed on the North Range Study Area since 1978.

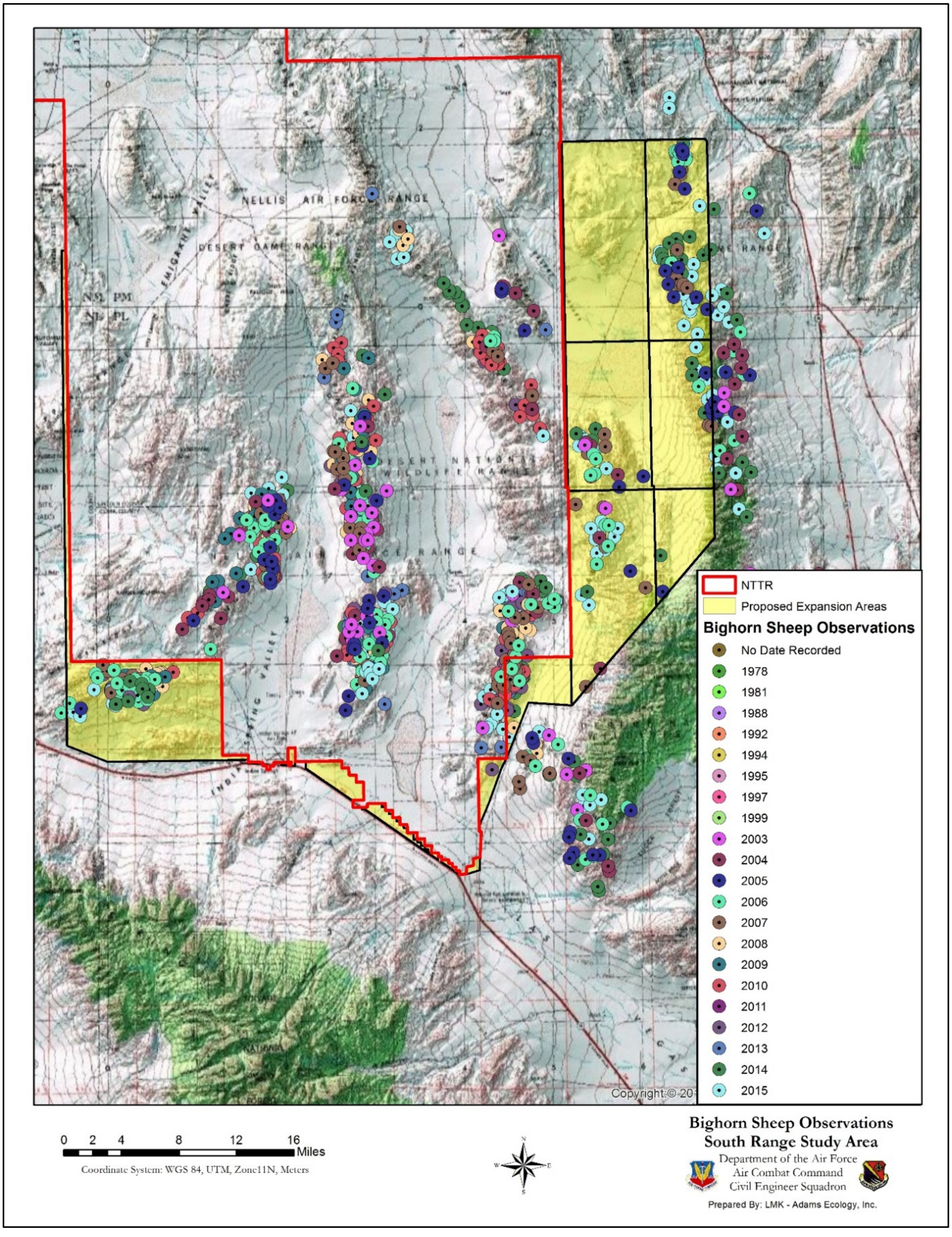

Figure 25. Locations where bighorn sheep have been observed on the South Range Study Area since 1978.

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Collaring Studies

In 2015 and 2016, bighorn sheep were trapped and fitted with GPS collars to monitor the movement and general habitat preferences of the animals. This information is currently being used by the USGS to develop a habitat range model for bighorn sheep. As previously mentioned, twenty-five bighorn sheep were fitted with GPS collars in 2014 on the Cactus Range, Pahute Mesa, Stonewall Mountain, and the Spotted Range. In 2016, twenty-one GPS collars were deployed on 10 rams and 11 ewes on the Pintwater Range on November 11-12. Preliminary data from the Pintwater population for movement from November 11 to December 2, 2016 is shown in Figure 26.

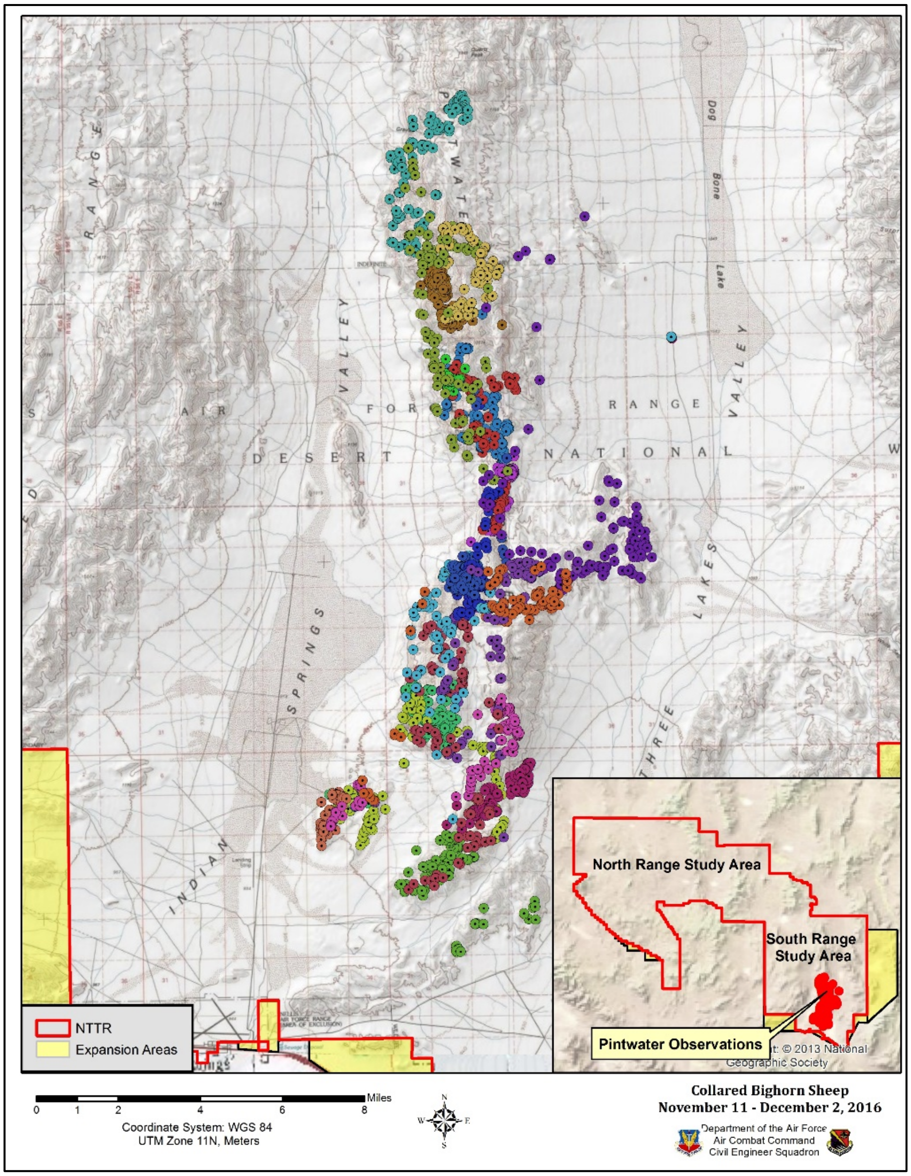

Figure 26. Locations where collared bighorn sheep have been detected from November 11 to December 2, 2016. Different colors of points indicate different individual bighorn sheep.

Potential Pneumonia Outbreak Study

On March 1, 2016, Dr. Peregrine Wolff provided NNRP with preliminary results of serum samples from bighorn sheep found on the NTTR. These were as follows:

- Of the animals sampled in the NTTR, only two were polymerase chain reaction (PCR) positive for *M. ovi* (one from Pahute Mesa (south) and one from Thirsty Canyon).
- In all sub-herds, *M. ovi* enzyme-linked immunosorbent assay (ELISA) positive animals ranging from 40-90% were detected.
- A high percentage of ELISA indeterminate animals which are likely to turn positive was observed.
- All animals were also EHD/BT negative on serology and BRSV and PI3 positive.
- Fecal tests for lung worms were negative.
- From the low % that were PCR positive a post disease event phase is indicated.
- The NTTR/Stonewall strain of *M.ovi* does not appear to match other strains that have been identified in southern Nevada.

Bighorn sheep were sampled and inspected during the November 11-12, 2016, collaring event on the Pintwater Range. Information from that event was not available at the time of this report.

Habitat Models

Habitat models were run for desert bighorn sheep. Results of those models are provided in Figures 27 to 30. The Habitat Suitability Model and the Maxent Model predicted similar habitat ranges for bighorn sheep. Both models showed suitable habitat in the mountain ranges found on the North Range Study Area including the Kawich and Belted Ranges where no bighorn sheep have been observed. The Maxent Model tended to be more conservative and showed more desirable habitat than the Habitat Suitability Model. However, the Habitat Suitability Model showed a wider range of moderately desirable habitat. For management purposes, the potential habitat mapped on the Kawich and Belted Ranges should be removed. On the South Range Study Area, both models provided comparable results with very minor differences in predicted habitat. Either model appears to provide excellent predictions of potential habitat for the desert bighorn sheep on the study area based on locations of current observations. Either model could be used to determine the potential for bighorn sheep to be present in an area that may be impacted by military activities to allow planners to avoid or minimize impacts to bighorn sheep herds.

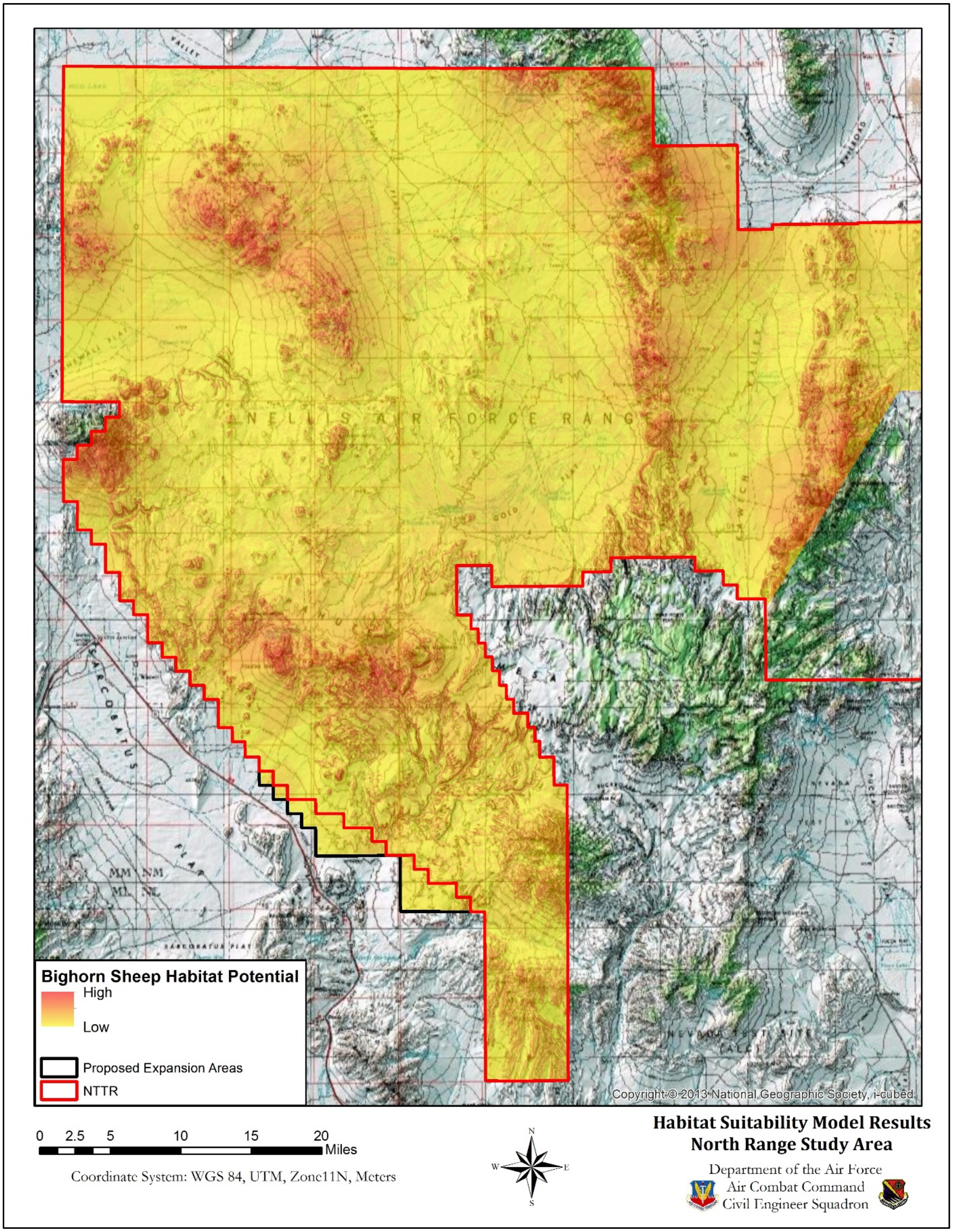

Figure 27. Results of the Habitat Suitability Model for bighorn sheep on the North Range Study Area.

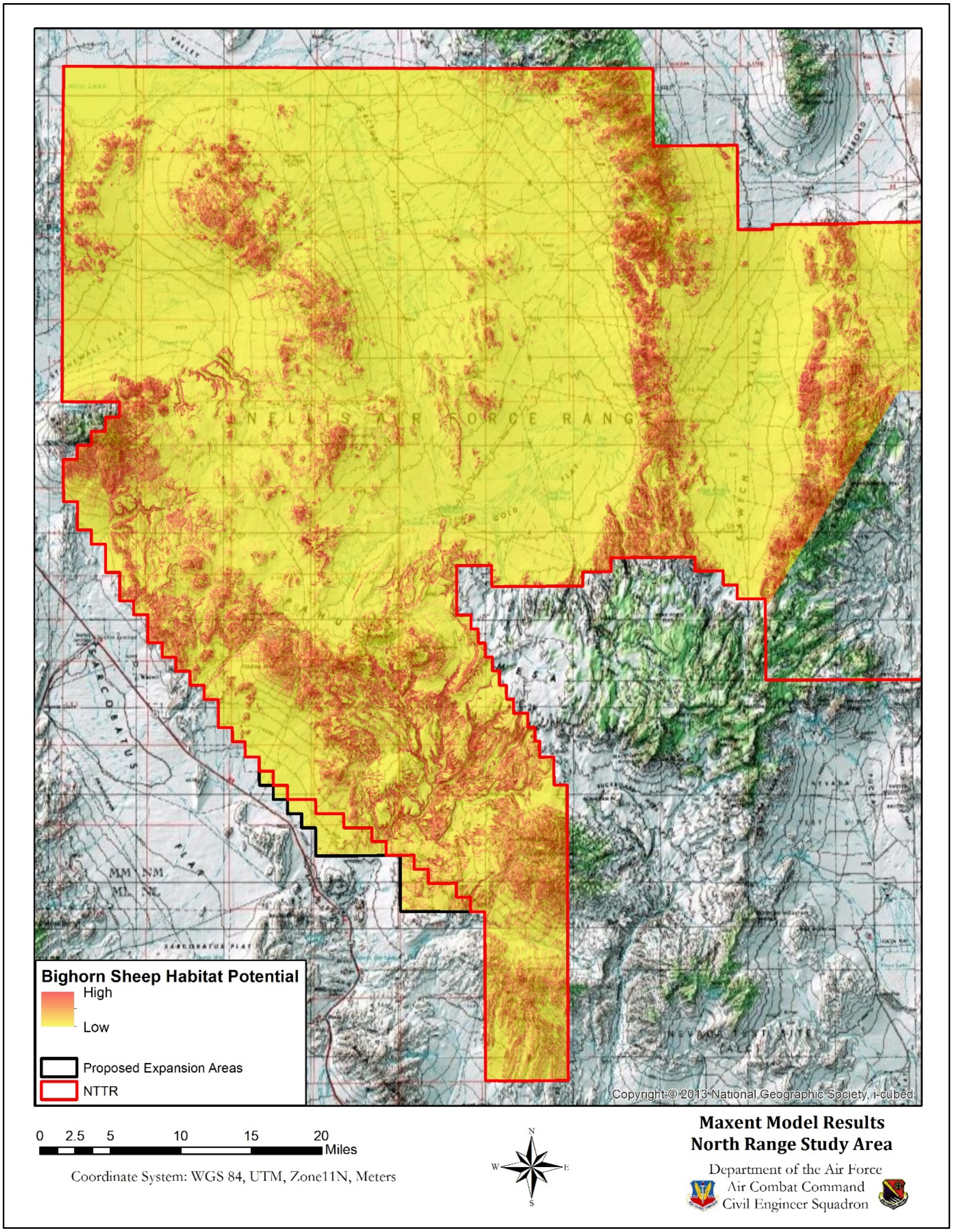

Figure 28. Results of the Maxent Model for bighorn sheep on the North Range Study Area.

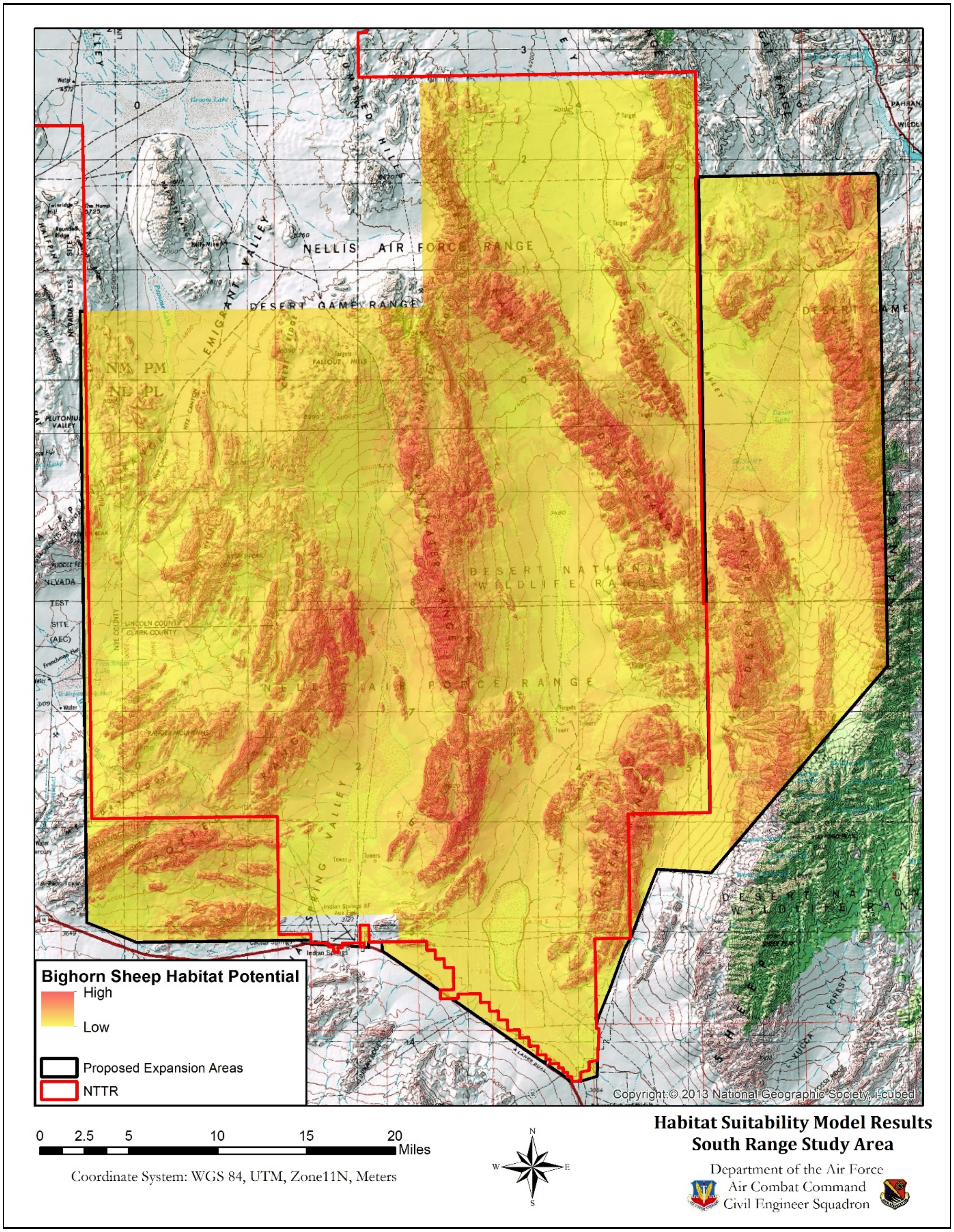

Figure 29. Results of the Habitat Suitability Model for bighorn sheep on the South Range Study Area.

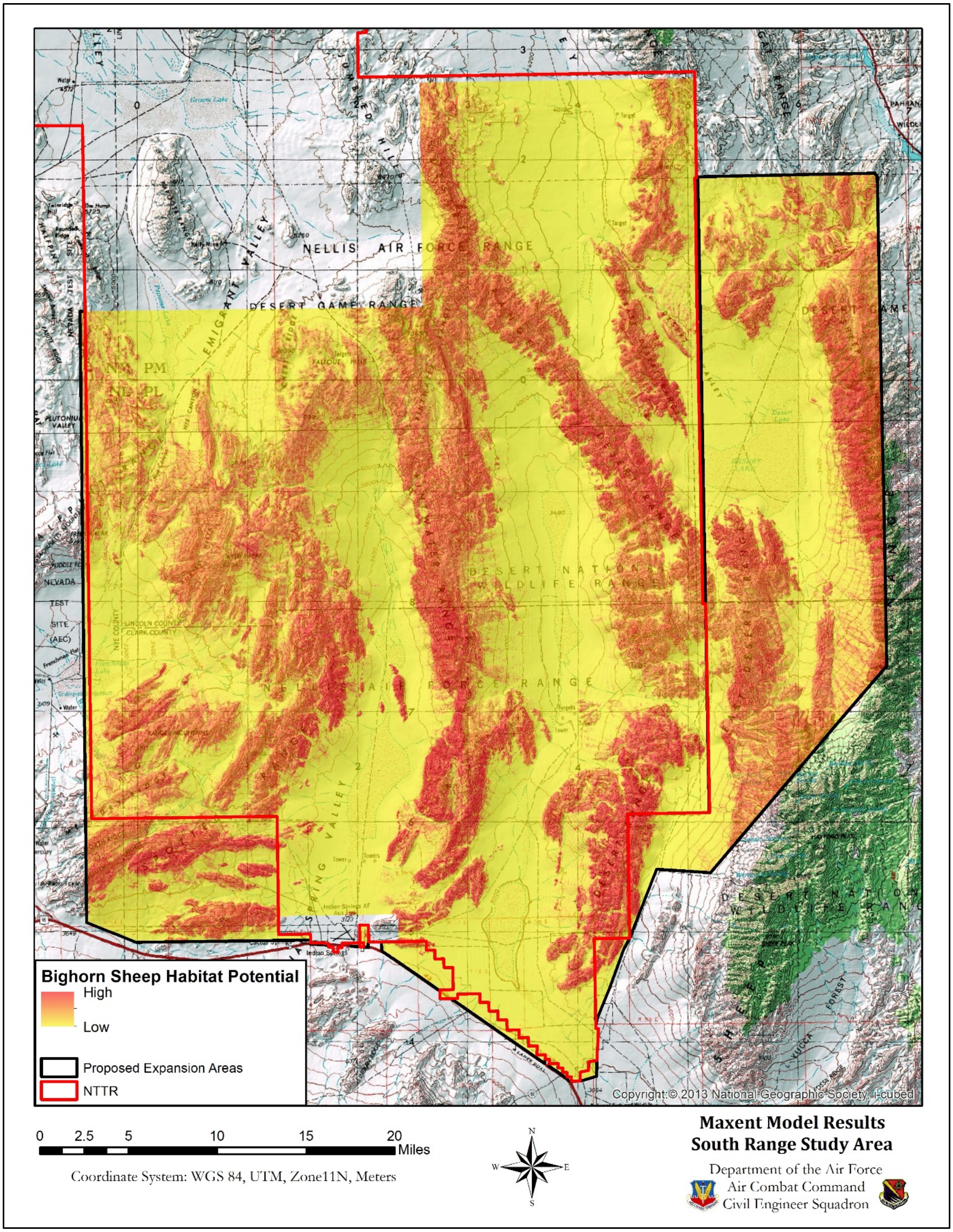

Figure 30. Results of the Maxent Model for bighorn sheep on the South Range Study Area.

PRONGHORN

Background Information

The pronghorn (*Antilocapra americana*) is native only to North America, but is not a true antelope but is in a separate classification family called *Antilocapridae*. Pronghorns have a bright reddish-tan coat marked with white and black. Only the male (buck) has a conspicuous black neck patch below the ears, a diagnostic for identifying males. At a distance, the coat color pattern camouflages the pronghorn by breaking up the outline of their body. Their white rump patch is enlarged and conspicuous when they are alarmed and raise their tail. The flash of white serves as a warning signal to other pronghorns and is visible at long distances (Schemnitz, 1994).

Pronghorn Buck at Log Spring on the North Range Study Area.

An average adult male pronghorn weighs about 125 pounds, and females typically weigh about 95 lbs. Males stand 31-40 inches tall at the shoulders, and females stand 28-36 inches. The overall length, including the body and head, ranges from 40-60 inches (Nevada Department of Wildlife, 2010a).

The pronghorn is the only North American big game animal with branched horns (as opposed to antlers), from which its name is derived. The horns of the pronghorn have an outer sheath of fused, modified hair that covers a permanent, bony core. The outer sheath is shed yearly in October or November and a new outer sheath is grown by July (Schemnitz, 1994). This is different from antlers, which are completely shed annually. Both sexes have horns, but the female horns are not forked and rarely longer than two inches (Tsukamoto, et al., 2003). The average male's horns are approximately 12 inches in length and have a prominent prong on one of the two branches (Nevada Department of Wildlife, 2010b). Pronghorns have exceptionally keen eyesight, using it and their exceptional speed to evade predators (Tsukamoto, et al., 2003). Pronghorns are the swiftest terrestrial mammals in the New World (U.S.Fish and Wildlife Service, 1998). Kitchen and O'Gara (1974) clocked herds moving

A herd of Pronghorn on the North Range Study Area.

at 40-45 miles per hour, with an observed maximum speed of 54 miles per hour. Unlike many of the species of animals that run fast for short distances, the pronghorn can run long distances at high speeds.

Pronghorn buck on the North Range Study Area.

Pronghorns have widespread distribution throughout western North America. There are five recognized subspecies of pronghorn throughout the west (Integrated Taxonomic Information Systems, n.d.). These are *A. a. americana, A. a. oregona, A. a. mexicana, A. a. peninsularis, A. a. sonoriensis*. Of these subspecies, *A. a. sonoriensis* (from southwestern Arizona into Sonora Mexico), *A. a. peninsularis* (from Baja California), *and A. a. mexicana* (from southeast Arizona, southwest New Mexico, Texas, and into Chihuahua, Mexico) are listed as endangered (U.S.Fish and Wildlife Service, 1998), or protected (Digital West Media, Inc., 2016). In the early 1800s, when the Lewis and Clark expedition recorded the presence of large herds of pronghorn, the total population across North America was estimated at 35 million. In fewer than 100 years, however, intensive market hunting brought pronghorn numbers to approximately 13,000. Populations have shown a notable increase in the last 2 decades in North America (Schemnitz, 1994). This notable increase was and is due to the enhanced public interest in wildlife conservation in the United States. In 1917, the Nevada State Legislature closed the hunting season for pronghorn until 1921; and in 1923 Governor James Scrugham was empowered by the state legislature to create 25 State Game Refuges (Tsukamoto, et al., 2003). This was the beginning of pronghorn management in Nevada. Pronghorn management continues to be vitally important to the health of the ecosystem on the NTTR, and throughout Nevada in general. The scattered populations throughout Nevada number approximately 18,000 as of 2002; and suitable pronghorn habitat covers approximately 55,952 square miles of the state, increasing from 21,246 square miles in 1983 (Tsukamoto, et al., 2003). Prior to the population increase of pronghorn throughout Nevada, distribution was limited to the northwestern and central portions of the state.

The quantity of water consumed by pronghorn varies with body size, sex, health, lactation demands, physical activity, the succulence of the forage, as well as humidity and ambient temperatures (Autenrieth, et al., 2006). It has been suggested that drinking free-standing water is not necessary to some populations of pronghorn (Monson G. , 1968; Seton, 1937; O'Connor, 1939; Phelps, 1974). Seton (1937) and O'Connor (1939) attribute such ability to the consumption of succulent plants, plus various physical and physiological adaptations that conserve the water obtained. However, free water is considered a key component and necessary requirement for Nevada populations of

Three does and one buck (center) in the early morning hours at Log Spring on the North Range Study Area.

pronghorn. Research shows that pronghorn cannot survive for extended periods without water during hot summer months in salt desert shrub vegetation, even when forage succulence is above-average (Tsukamoto, et al., 2003). Studies in the southwestern U.S. have shown that pronghorn populations require a minimum of two inches of precipitation during the period of October through March for herd maintenance (Brown, Bayer, & McKinney, 2006). The amount of drinking water required for pronghorns is related both to maximum air temperatures and the amount of moisture in the forage they are consuming (Beale & Holmgren, 1975). Natural surface water sources are not always available due to frequent droughts, heavy use and damage by domestic livestock, wild horses, and other wildlife. Therefore, wildlife water developments have been strategically placed throughout known and potential pronghorn habitat in order to enhance and expand pronghorn and other wildlife populations (Tsukamoto, et al., 2003). A recommended standard spacing for wildlife water development placement for pronghorn populations is one unit every three to five miles (Sundstrom, 1969) to compensate for periods of deficient permanent water sources. Field surveys on the NTTR indicate that most pronghorn herds restrict their activities to within five miles of a permanent water source.

Pronghorn Buck.

Pronghorns feed entirely on vegetation, chiefly shrubs and forbs. They are ruminants with a four-chambered stomach to aid in digestion of roughly textured foods such as cacti and other desert plants. The ruminant stomachs allow for a high level of water retention (Brown, Bayer, & McKinney, 2006), an adaptation especially important to desert ungulates. Food utilized by pronghorn varies seasonally depending upon the availability, palatability, and succulence of vegetation (Pima

Pronghorn bucks fighting on the North Range Study Area.

County Arizona, 2006). In the winter, pronghorns are often seen feeding on wheat and alfalfa fields. Over 150 different species of grasses, forbs, and browse plants are eaten by pronghorn (Schemnitz, 1994); however, succulent plants and sprouts are preferred. Pronghorn will move from relatively dry ranges to more mesic sites in search of succulent vegetation. When forbs are scarce, pronghorns select the most succulent alternative browse available (Pima County Arizona, 2006). All parts of the plants are consumed, including leaves, stems, flowers, and fruit. Summer forage consists of about 62% forbs, 23% browse, and 15% grasses (Nevada Department of Wildlife, 2010b). Desert lands used by pronghorn may have <10% shrub cover with annual grasses and forbs composing <2% of the ground cover. The use of semi-desert and desert habitats with tree cover is usually low, but increases during hot, dry periods when pronghorn use scattered trees or other structural cover for shade (Ockenfels, Alexander, Ticer, & Carrel, 1994). Within Nevada, some of the main components of pronghorn habitat and diet include sagebrush (*Artemisia spp*), antelope bitterbrush (*Purshia tridentata*), four-winged saltbush (*Atriplex canescens*), rubber rabbitbrush (*Ericameria nauseosa*), cheatgrass (*Bromus tectorum*), Indian ricegrass (*Achnatherum hymenoides*), crested wheatgrass (*Agropyron crystatum*), and shadscale (*Atriplex confertifolia*) (56). Ground cover, in shrub steppe and semi-desert grassland habitats occupied by pronghorn, averages 50% or more living vegetation and less than 50% bare ground, rock, litter, etc. (Ockenfels, Alexander, Ticer, & Carrel, 1994). Habitats used by desert pronghorn are often comprised of less than 50% ground cover (Ogara & Yoakum, 2004).

Pronghorn buck on the North Range Study Area.

The breeding season of the pronghorn extends from the last week in August to the first week in October (Schmidly, 2004), with the peak occurring around mid-September (Tsukamoto, et al., 2003). As a polygamous species, bucks gather small harems of 2 to 20 does, which the male must defend and maintain. Aggressive bucks tend to have the larger harems. Young bucks frequently linger on the outskirts of the harem herd and periodically attempt to steal a doe or even to interfere with a mature buck in his mating activities (Schmidly, 2004). Antagonism between bucks begins around July 1 (the onset of harem formation) and is evident by fights

Pronghorn doe on the North Range Study Area.

and chases between bucks, increasing in intensity until breeding commences (Ackerly & Regier, 1956).

Female pronghorns generally mate for the first time in September of their second year (Tsukamoto, et al., 2003). There is however, some indication that young does may breed late in the same year in which they are born (Schmidly, 2004). The gestation period is around 7 to 8 months, with the young fawns appearing in May or June. The female hides her young in dense brush, and the fawns are active only during a short part of the day to nurse. When they are about one week old, they begin to walk and by one month they begin to graze on vegetation. At this time, does and fawns may form small herds that stay together well into and sometimes throughout the winter (Nevada Department of Wildlife, 2010b).

Pronghorn typically inhabit land forms characterized by low rolling, expansive terrain (Autenrieth R. , 1978), grass-shrub valleys, and grasslands (Arizona Game and Fish Department, 2011). Elevation ranges from near sea level to an altitude of 11,000 ft. MSL. However, the majority of the herds are found between 4,000 and 6,000 feet MSL (Ogara & Yoakum, 2004). In some areas, pronghorns use the more mountainous terrain. However, in Nevada, most of the pronghorn population inhabit cold desert shrublands and Great Basin sagebrush/grasslands habitats (Tsukamoto, et al., 2003). Kindschy, et al. (1982) suggested that, overall, areas with less than 5% slope are optimal for pronghorn, but pronghorn will also use sites having slopes of less than 10%. Although pronghorns occupy steeper terrain, slopes greater than 20% are generally avoided (Autenrieth, et al., 2006) due to the risk of predation. Based on studies conducted over the years, the species prefers habitat characterized by the following:

- Ground cover averaging 50% living vegetation and 50% nonliving vegetation (Yoakum, Pronghorn, 1978).
- Vegetation composition of 40-60% grass, 10-30% forbs, and 5-20% browse (Yoakum, Pronghorn, 1978).
- Succulent plants available in spring and wet summers (Yoakum, Pronghorn, 1978).
- Vegetation averaging 15 inches in height (Arizona Game and Fish Department, 2011).

Primarily during the summer and fall seasons, northern desert shrub vegetation is important habitat for pronghorn because it includes the big sagebrush habitat. Pronghorn inhabit pinyon-juniper woodlands to a limited extent dependent upon the density of the forest canopy (Tsukamoto, et al., 2003). The relative carrying capacities of the various habitats that pronghorn utilize in Nevada are markedly variable, with the highest densities found in sagebrush-grass association (Tsukamoto, et al., 2003).

Pronghorn Buck in the snow on the North Range Study Area.

The size of pronghorn home range is dependent upon topography, the presence of physical barriers, and the amount of forage available in the area (Yoakum, Pronghorn, 1978). The area required per individual depends upon how well the range provides each habitat requirement in sufficient quality and quantity for all seasons of the year (Yoakum, 1972). Natural barriers can curtail movements and exclude the occupancy of otherwise suitable habitat. Natural barriers include abrupt escarpments, mountain ranges, deep canyons, thick shrubs or trees, and densely wooded areas (Autenrieth, et al., 2006). Fences are also detrimental to pronghorn movement because they are not good jumpers. It is recommended that barbed-wire fences be built with the lowest strand as smooth wire approximately 18 inches above the ground to allow pronghorn to squeeze underneath while still containing livestock (James & Crouse, 2011).

Predation has been documented as the primary source of mortality for pronghorn (Yoakum, Pronghorn, 1978). Predators of pronghorn include coyotes (*Canis latrans*), bobcats (*Lynx rufus*), mountain lions (*Puma concolor*) and golden eagles (*Aquila chrysaetos*). Pronghorn are gregarious in nature, and primarily gather in herds for protection from predation (Ogara & Yoakum, 2004). Losses of pronghorn due to predation vary regionally and seasonally with age, sex, and density of the pronghorn population (Jacques & Jenks, 2007). Speed and exceptional eyesight are the main defense mechanisms used by pronghorn for predators. They can detect predator movement up to 4 miles away (Arizona Game and Fish Department, 2011). Fawns are especially vulnerable to predation and lie motionless in dense cover to avoid predation. The most critical period of fawns is the first two months of life when they are at the greatest risk of predation. If fawns can survive the first 60 days of life, their chances of survival increase dramatically (Texas Parks and Wildlife, 2007).

Predation by coyotes is common in the west. Coyotes have been known to herd pronghorns toward fences, where pronghorns will instinctively slow down to crawl under a fence rather than jump it, thus making them vulnerable (Texas Parks and Wildlife, 2007). Golden eagles, although large in size and stature, typically only prey upon fawns. Direct observation of golden eagle predation on an adult pronghorn is rare; however, eagle predation of pronghorn may be a more significant mortality factor than previously thought (Goodwin, 1976).

Extensive epizootics controlling pronghorn populations are uncommon. However, 33 species of roundworms, 21 genera of bacteria, fourteen viral diseases, eight species of protozoa, five species of tapeworms, and four species of ticks, one fluke, and one louse fly have been reported in or on pronghorn (Ogara & Yoakum, 2004; Lance & Pojar, 1984). The impact of most of these agents on free-ranging populations is unknown (Autenrieth, et al., 2006). Blue tongue is the most serious disease affecting pronghorn in the west, and is generally spread by domestic sheep and cattle. Blue tongue virus is transmitted by biting midges and can spread rapidly throughout herds, making pronghorn populations especially vulnerable and susceptible (Utah Division of Wildlife Resources, 2009).

FIELD METHODOLOGY

Since 2009, annual comprehensive population census surveys have been conducted for pronghorn on the North Range of the NTTR. Pronghorns have only been observed in significant numbers on the North Range Study Area. Very few observations have been made elsewhere. In 2005, and from 2009 to 2015, helicopter surveys were initiated to monitor pronghorn population distribution and health on the North Range of the NTTR. From 2006 to 2008, no formal comprehensive census surveys for pronghorn were undertaken by the NNRP. However, location coordinates were documented for pronghorn that were incidentally observed during other field surveys and entered in the Nellis geodatabase.

From 2009-2015, surveys were conducted during the July 4 weekend. In 2005, the survey was conducted in early February. Surveys in 2006, 2007, 2008, and 2012 were not comprehensive due to scheduling issues and their data is not included in this report. Surveys typically start around 7:00 AM and usually end between 2:00 - 5:00 PM. Transects were flown by helicopter in the basins between mountain ranges and continued upslope until pinyon-juniper habitat was encountered. Figure 31 shows the basins where pronghorn surveys were conducted. Helicopters flew at about 100 – 200 ft. above the ground surface in parallel transects usually running east to west and about 0.5 miles apart. In areas typically not supporting pronghorn populations, transects were flown 1-2 miles apart, depending on the sight limits of the observers. The surveys were conducted in separate basins each day to ensure that herds were geographically separated and count overlap would be minimal. The surveys were completed in 3-4 consecutive days and covered approximately 852,800 acres. During each census survey, sex and age class (adult/juvenile) of individual pronghorns were recorded. Also, any observations of wild horses or other wildlife were recorded.

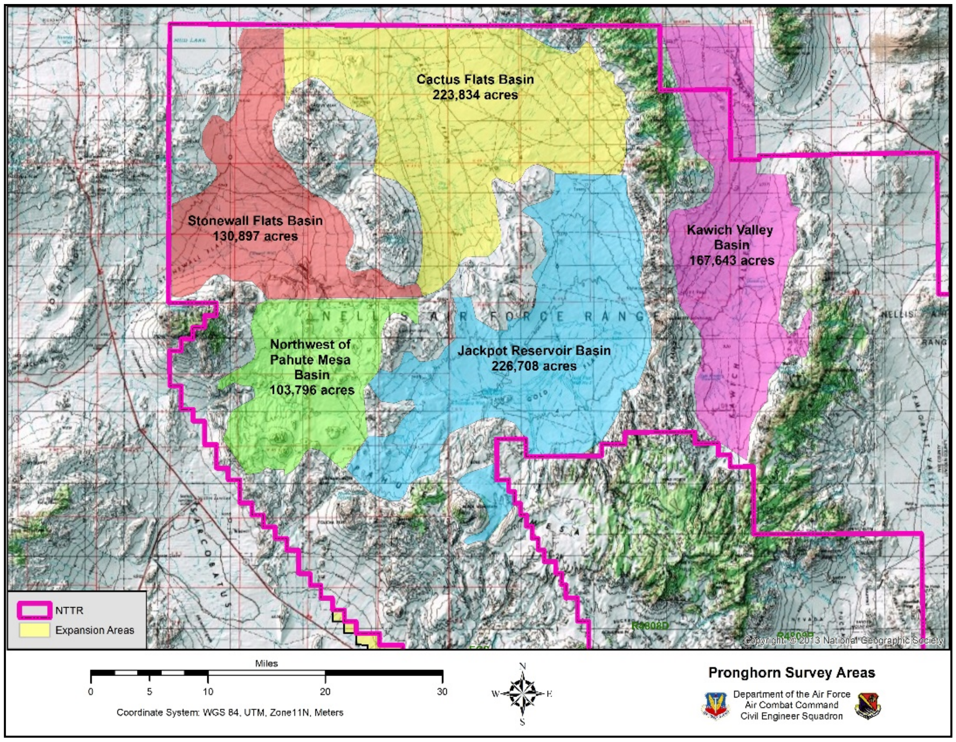

Figure 31. Separate basins where pronghorn surveys are conducted.

No formal pronghorn surveys have been conducted on the proposed expansion alternatives due to the fact no populations have been observed in those areas. One pronghorn buck has been observed in the South Range Study Area in Ranges 64C and 64B. This buck was always alone and no other pronghorns were ever observed with him. This is the only observation of pronghorn in the South Range Study Area.

Habitat models were also run for pronghorn using the same methodology that was discussed in the bighorn sheep habitat model section. The habitat parameters used for the Habitat Suitability Model were the following:

- Elevation: 4,000 ft. MSL–6,000 ft. MSL (Weighting factor of 2). Elevation ranges from near sea level to an altitude of 11,000 ft. MSL, but pronghorn appear to prefer between 4,000 and 6,000 feet MSL (Ogara & Yoakum, 2004).
- Slope: O° to 12° (Weighting factor of 3). Kindschy, et al. (1982) suggested that, overall, areas with less than 3° slope are optimal for pronghorn, but pronghorn will also use sites having slopes up to 6°. Although pronghorn occupy steeper terrain; slopes greater than 12° are generally avoided due to the risk of predation (Autenrieth, et al., 2006).

- Aspect: No preference.
- Permanent Water Sources (Weighting factor of 5). Surface water is considered a key component and necessary requirement for Nevada populations of pronghorn. Research shows that pronghorn cannot survive for extended periods without water during hot summer months in salt desert-shrub vegetation, even when forage succulence is above-average (Tsukamoto, et al., 2003).
- Temporary Water Sources (Weighting factor of 2). Same reasoning as for permanent water sources, but a lower weighting factor because they are only present during wet seasons.
- Geologic outcrop: Not a limiting factor.
- NDOW Key Habitat: Pronghorn typically inhabit land forms characterized by low rolling, expansive terrain (Autenrieth R. , 1978), grass-shrub valleys, and grasslands (Arizona Game and Fish Department, 2011). However, in Nevada, most pronghorns inhabit the cold desert shrub lands and the Great Basin sagebrush/grasslands habitat types (Tsukamoto, et al., 2003).
    - Grasslands and Meadows
    - Intermountain Cold Desert Scrub
    - Sagebrush
- Soil Associations: Not a limiting factor.
- Mountains: Excluded.
- Valleys: Included.
- Vegetation (Weighting factor of 3). Within Nevada, some of the main components of pronghorn habitat and diet include sagebrush (*Artemisia spp.*), antelope bitterbrush (*Purshia tridentata*), four-winged saltbush (*Atriplex canescens*), rubber rabbitbrush (*Ericameria nauseosa*), cheatgrass (*Bromus tectorum*), Indian ricegrass (*Achnatherum hymenoides*), crested wheatgrass (*Agropyron crystatum*), and shadscale (*Atriplex confertifolia*) (Digital West Media, Inc., 2016).
    - *Artemisia arbuscula* Shrubland Alliance
    - *Artemisia nova* Shrubland Alliance
    - *Artemisia tridentata* Shrubland Alliance
    - *Atriplex canescens* Shrubland Alliance
    - *Atriplex confertifolia* Shrubland Alliance
    - *Picrothamnus desertorum* Shrubland Alliance
    - *Purshia (stansburiana,mexicana)* Shrubland Alliance

The Maxent Model was run using all pronghorn observation points and the layers listed for the bighorn sheep Maxent Model.

RESULTS

Pronghorn populations were recorded as 12,700 statewide in Nevada in 1937 and began a gradual drop to 3,000-4,000 in 1954. From 1960-1970, the pronghorn population in Nevada remained at about 3,000 animals through 1970. Through intensive management of the herds and more accurate surveying, the estimated population increased to 14,850 by 1990 and continued to increase to 18,000 by 2002 (Tsukamoto, et al., 2003). Correspondence from NDOW concerning the INRMP for the NTTR (undated correspondence) stated that the pronghorn population on the North Range of NTTR experienced a de-crease in size most likely due to the feral horse population (Stevenson, Donham, Cummings, &

Hardenbrook, No Date). A grand total of 1,865 pronghorns have been observed across all years that formal surveys were conducted. Of these 1,865 pronghorn, 1,546 (82%) were adults (males accounting for 26% while females comprised 56%) and 319 (18%) were juveniles (Figure 32). This is consistent with other populations across the species' range in Nevada (Ogara & Yoakum, 2004).

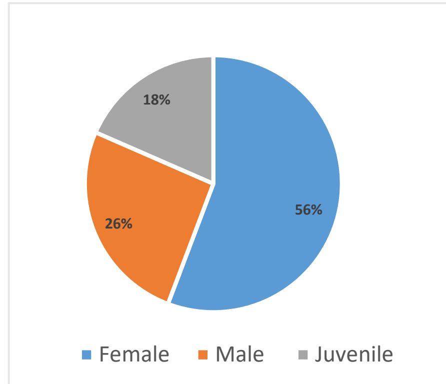

Figure 32. Percent male, female, and juvenile pronghorns as observed during surveys in 2005 and 2009-2015.

The total number of pronghorn observed each year within the management boundaries of the NTTR during formal surveys (2009 - 2014) are shown in Figure 33. The population count in 2009 was 214 animals. Five years later in 2014, the population count for the same survey area was 269 animals, a 26% increase. Counts showed a slight decrease in number of juveniles in 2014, but that was countered by a corresponding increase in number of adults. Total counts for the pronghorn indicate a trend of increasing numbers of pronghorn across survey years.

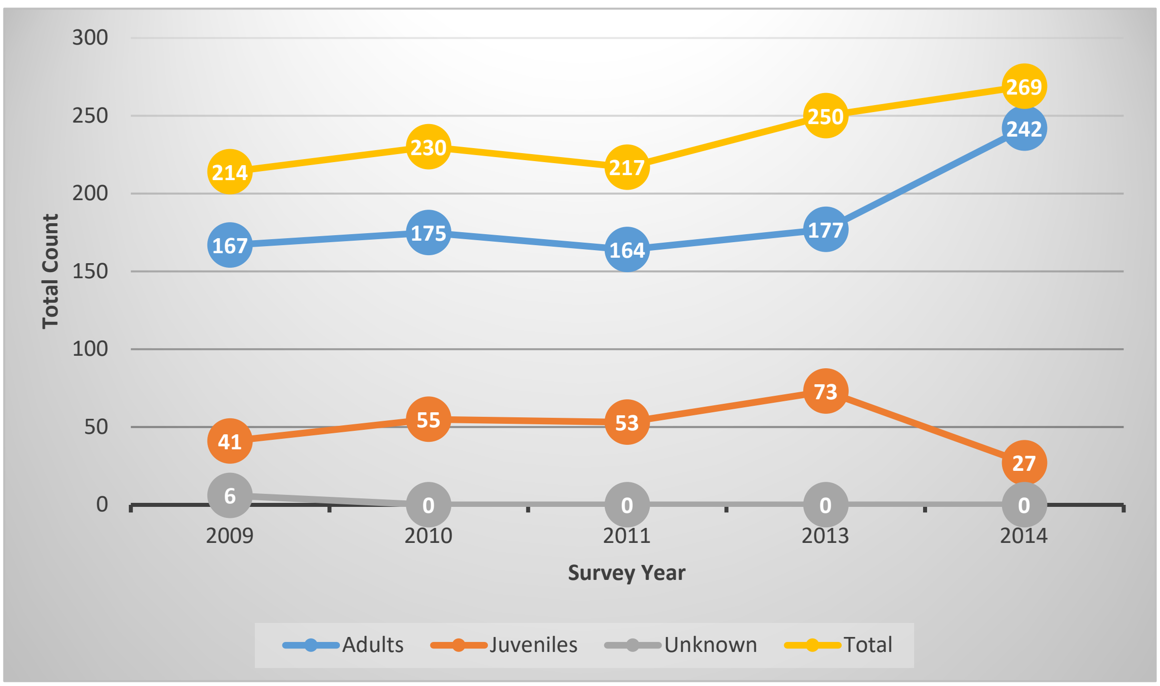

Figure 33. Number of pronghorns observed at each survey showing total count, unknown, adults, and juveniles.

Across all years that formal surveys were conducted (2005, 2009-2015), pronghorn were only observed on the North Range Study Area. As previously mentioned, only one pronghorn has been observed on the South Range and it was a buck observed on a regular basis in Indian Springs Valley. The locations of pronghorn observations within the North Range Study Area each year from 2005-2015 is provided in Figure 34. Most of the pronghorn were observed on Cactus Flats, Kawich Valley, and the west side of the Kawich Range.

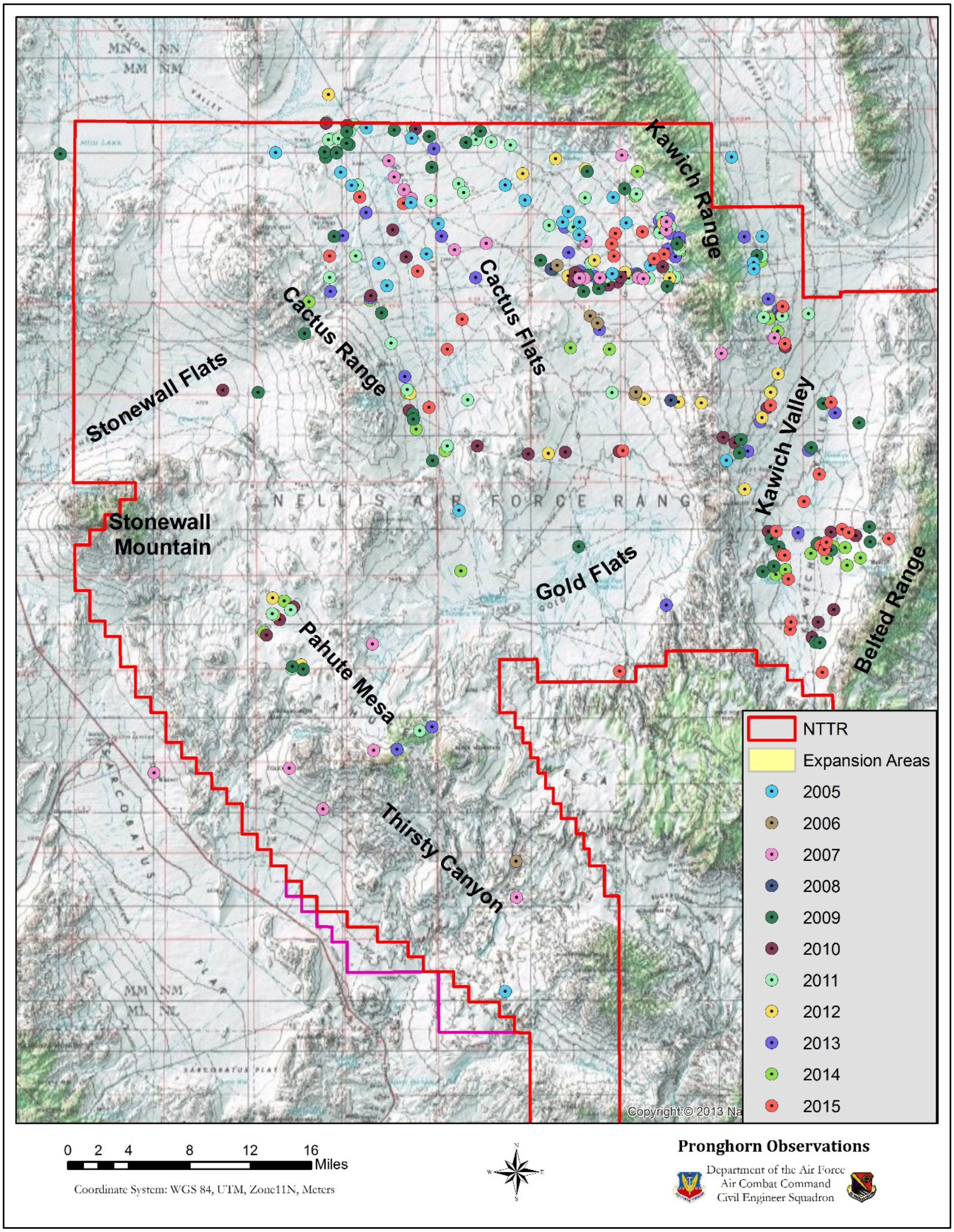

Figure 34. Locations where pronghorn were observed from 2005 to 2015.

Results of the habit models are provided in Figures 35 and 36. The Habitat Suitability Model was much more liberal than the Maxent Model, showing more habitat with a moderate potential than the Maxent Model. Both models show high potential habitat in Cactus Flats and the Kawich Valley. Either model would be acceptable to use for management purposes. Ideally, a combination of the two models would be preferred.

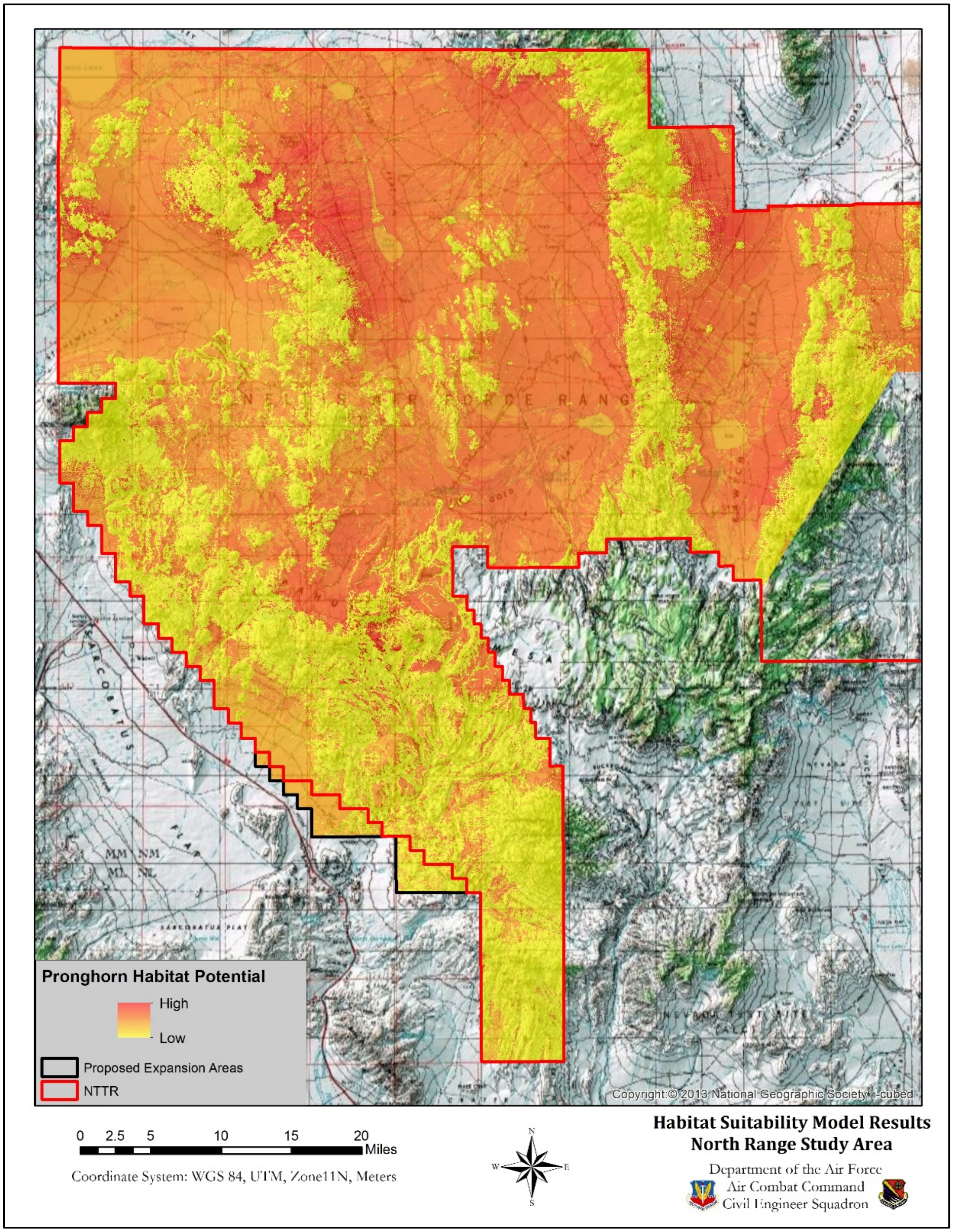

Figure 35. Habitat Suitability Model showing the potential for habitat on the North Range Study Area to accommodate pronghorn populations.

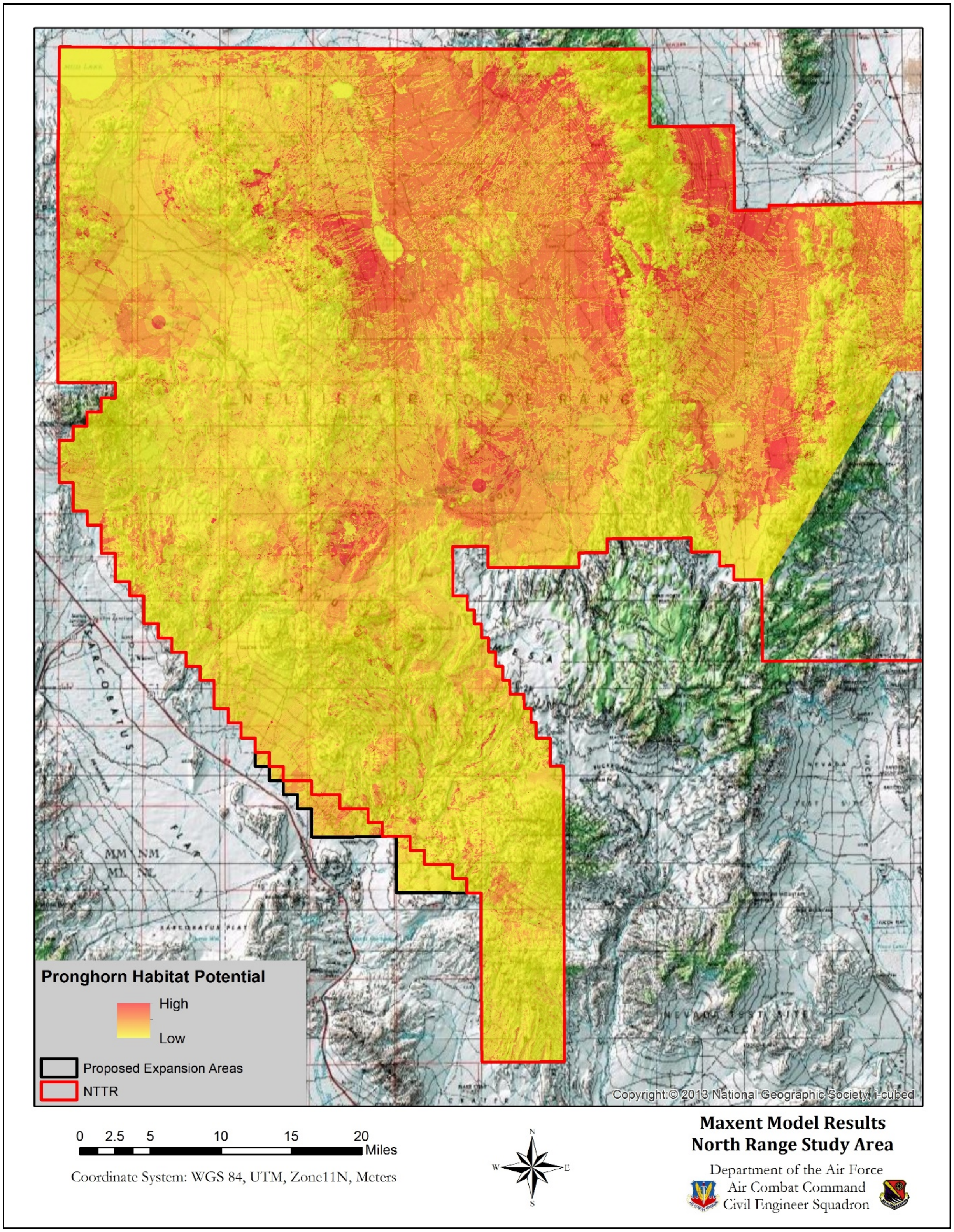

Figure 36. Maxent Model showing the potential for habitat on the North Range Study Area to accommodate pronghorn populations.

The majority of pronghorn on NTTR were observed within Intermountain Cold Desert Scrub and Sagebrush before the transition into Lower Montane Woodlands or Pinyon-Juniper. This appears to be the preferred habitat of pronghorn. Throughout the years, most of the pronghorn herd consistently resided in and around Cactus Flats and Kawich Valley. In addition to habitat preference continuity, the ratio of adult males to adult females has been consistent at 1:2 over the years, which is consistent with other populations throughout the North American pronghorn population (Yoakum, Pronghorn, 1978).

Survey observations as well as photographs taken with wildlife motion detection cameras indicate that the pronghorn appear to be in good condition. Survey data suggests that the herd is stable and showing a trend towards an increase in number. Thus, it is doubtful that military mission activities are having negative impacts on the herd. In fact, isolation of the herd from hunting and other public activities appears to be a positive impact on the population.

MULE DEER

BACKGROUND INFORMATION

The mule deer (*Odocoileus hemionus)* is a large deer with ears similar to a mule, hence the name “Mule” or “Burro Deer.” The upper parts of the ears are usually dark gray-brown with long guard hairs covering a dense under fur. The coat is shed in the spring for a lighter reddish-tan coat (Utah Division of Wildlife Resources, 1999). A small white patch on the rump and a white tail with a black tip are also present. Mule deer hold their tails down when they run, unlike the white-tailed deer which raise their tails when in flight (Utah Division of Wildlife Resources, 1999). The average weight of a mule deer ranges from 135 to 224 lbs. with heavier weights being associated with males (Utah Division of Wildlife Resources, 1999). As many as seven subspecies have been suggested for the mule deer, with the rocky mountain mule deer (*O. h. hemionus*) being the common subspecies in Nevada (Feldhamer, Thomspon, & Chapman, 2003). The antlers on mule deer are typically dichotomously branched and restricted to males (Utah Division of Wildlife Resources, 1999). They begin growing in late winter, reaching full growth by late summer. The antlers are usually covered in velvet until late summer when the velvet is rubbed off. Antlers remain in place until late December when they are shed (Utah Division of Wildlife Resources, 1999). Although equipped with acute sight and hearing, these deer rely largely on the sense of smell in detecting danger. Stationary objects are easily overlooked by mule deer, but they readily detect any predators that are in motion (Utah Division of Wildlife Resources, 1999).

Young mule deer getting a drink at Sumner Spring on the North Range Study Area.

Mule deer have sturdy legs, grow to be 3.5 feet tall at the shoulders and are known for their peculiar, high-bouncing gait (Digital West Media, Inc, 2016). This makes the mule deer well equipped for running in rugged country with rocks, brush, and other obstructions. If necessary, mule deer can turn or completely reverse direction in the course of a single bound (Digital West Media, Inc, 2016).

Mule deer buck in velvet at Antelope Spring on the North Range Study Area.

Mule deer are found scattered throughout the Western United States, moving from the forest edges at higher elevations to the desert floor at lower elevations (Digital West Media, Inc, 2016). Within Nevada some mule deer populations remain in one area year-round, while other populations are migratory. Within the higher elevations of the north, mule deer appear to have distinct summer and winter ranges. The more southern populations appear to be year-round residents (Utah State University Extension, 2005), but may travel short distances to relocate locally along elevation gradients. Some mule deer herds in Nevada have been found to migrate 100 miles or more (Wasley, 2004). The mule deer population on the NTTR appears to be transient with populations migrating through the range, but not remaining as resident populations. Migration of mule deer on the NTTR is not clearly understood but may be influenced by water availability, weather, local habitat quality, physical terrain, etc.

Although some populations of mule deer inhabit areas lacking free standing water (McLean, 1930), water appears to be a limiting factor within the desert ecosystems. Mule deer probably drink more frequently than desert bighorn sheep and must drink to replace their evaporative water loss especially during the summer. Range-wide, mule deer typically require about 3 quarts of water per day per 100 lbs. of body weight (Feller, n.d.). Mule deer have been recorded visiting water sources in the desert an average of once every 24 hours and consume 4-6 liters per visit (Hazam & Krausman, 1988). Therefore, it is likely that mule deer will be found within the vicinity of a water source.

Mule deer buck at Wild Horse Spring on the North Range Study Area.

Mule deer, like bighorn sheep, are ruminants with a four-chambered stomach that is used for micro-fermentation of otherwise indigestible highly fibrous vegetation. Mule deer prefer secondary successional plant species, which are plant species that become established on areas after some type of disturbance (Wasley, 2004). Woody plants, grasses, and forbs comprise the diet of the mule deer. Specifically, mule deer rely heavily on browse and forbs, which comprise over 90% of their diet, whereas grasses and succulents are generally less than 5% of their diet (Krausman, et al., 1997). Browse species; including sagebrush, bitterbrush, rabbitbrush, and scrub oak, are especially preferred by mule deer within the eco-region of the study area. Mule deer rarely concentrate on any single species, but eat a variety of parts of different plants varying with the time of year. When deer are feeding on browse they prefer the most tender parts, which are the new shoots and tips of "leaders" (Wasley, 2004). Grazing typically takes place at dawn and dusk, though nocturnal and daytime activity is also common (Nevada Department of Wildlife, 2013).

Two does and a fawn at Cliff Spring on the North Range Study Area.

Mule deer habitat can vary throughout the southwestern United States and although they occupy almost all types of habitat within the range, they appear to prefer arid open areas and rocky hillsides (Digital West Media, Inc, 2016). Areas with bitterbrush and sagebrush are often preferred by mule deer, although a mixture of herbaceous openings, dense brush, riparian areas, and edge habitat is also frequented by mule deer (Nevada Department of Wildlife, 2010b). Mature bucks tend to prefer rocky ridges for bedding grounds, while the does and fawns prefer bedding in the open (Nevada Department of Wildlife, 2010b).

Resources that determine the distribution of mule deer within their habitat can include availability of forage (Albert & Krausman, 1993; Marsha, Krausman, & Bleich, 2005), nutritional quality of forage (Albert & Krausman, 1993; Rautenstrauch, Krausman, Whiting, & Brown, 1988; Marshal, Krausman, & Bleich, 2005), cover (Ordway & Krausman, 1986), mating sites (Scarbrough & Krausman, 1988), natal sites (Fox & Krausman, 1994), and sources of water (Hervert & Krausman, 1986). Environmental conditions that can influence mule deer distribution include human disturbance (Krausman & B.Czech, 1998) or terrain characteristics (Ordway & Krausman, 1986).

Large buck in velvet captured by a wildlife camera.

Habitat alterations have negatively impacted the populations of mule deer throughout the southwest. Direct human impact may include oil, gas, and mineral exploration and extraction, urban growth, highway, railroad, fence line development, and other impediments to migration. Indirect factors relative to human population growth include recreational activities such as dispersed camping and off-highway vehicle use.

Doe and fawn on the North Range at Breen Creek on the North Range Study Area.

Vegetative communities important to mule deer are altered by land management practices such as fire suppression, livestock grazing, shrub eradication, and ground disturbances promoting cheatgrass or other plant invasions including pinyon-juniper encroachment (Mule Deer Working Group, 2004).

Breeding season, or "rut", occurs from November through December in Nevada. As bucks prepare to enter the rut, they become more aggressive and hyperactive. Large, aggressive bucks gain dominance over small bucks and will chase them away, or, if challenged, will posture and lock antlers until dominance is established (Utah Division of Wildlife Resources, 1999). Bucks that are evenly matched in size and strength may fight until almost exhausted (Schmidly, 2004). Once a suitable doe is found, chase games are initiated before mating. The duo will remain together for several days before the male leaves to copulate with other does.

After about a 200-day gestation period, the females deliver one or two fawns, typically between May and August. The female sequesters herself and drops her fawn in a protected location, where the fawn remains for a period of a week or 10 days before it is strong enough to follow her (Schmidly, 2004). A doe will usually produce a single fawn the first year she gives birth and twins in subsequent years (Digital West Media, Inc, 2016). Fawns average about eight lbs. at birth and suckle and follow their mother within a short time of being born. Fawns grow rapidly during the summer months, reaching weights of 70 to 80 lbs. by November. The weaning time is critical because, if green forage is not available, the fawns have difficulty transferring from milk to a diet of vegetation. If the fawn is not weaned, both mother and fawn are likely to not survive a severe winter (Schmidly, 2004).

The role of disease and parasites in Nevada's mule deer population is difficult to assess. Typically, diseased animals seek seclusion and die, making detection and collection difficult. Consequently, mule deer disease related literature is largely restricted to large scale die-offs (Krausman & B.Czech, 1998). Although Nevada is not immune to the potential for an epizootic event; Nevada's deer herds are mostly isolated and small in number which would reduce likelihood of such an event (Wasley, 2004).

Isolated cases of epizootic events have been observed and have often been found in close association with agricultural fields (Wasley, 2004). The probable link between disease and agriculture fields is based on nutrition and the mule deer's preference for irrigated alfalfa fields. Mule deer lack the necessary microbes for proper digestion of alfalfa and therefore do not obtain the energy required to complete the digestive process. The weakened condition that results from poor digestion of alfalfa predisposes mule deer to disease pathogens (Wasley, 2004). CWD (Chronic Wasting Disease) has not been identified in deer from Nevada at this time, but some experts believe that CWD will eventually affect all deer populations in the future (Wasley, 2004).

Hemorrhagic (bleeding) diseases have been observed in mule deer; however, no more than 20% mortality rates have been observed. These types of diseases are common only in late summer and fall until the first freeze kills the biting midges, which are the transmitters of the virus. Those deer that die usually do so within 5 to 10 days after being bitten by an infected midge (Mule Deer Working Group, 2003). Other symptoms of hemorrhagic diseases include bleeding from the eyes, ears, mouth and/or nostrils; moderate fever; depression; anorexia; excessive drooling; swelling and ulcers in the cheek or tongue (e.g. blue tongue); swelling of one or more of the linings in the stomachs; and blood in the feces and saliva (Mule Deer Working Group, 2003).

Tuberculosis is caused by bacteria, and spread by direct and indirect contact between animals. Tuberculosis usually affects the lungs causing difficulty breathing, coughing, and discharge from the mouth or nose. The United States Animal Health Association (USAHA) does not currently have evidence of tuberculosis in free ranging populations of mule deer. Tuberculosis; however, is transmitted readily when deer are concentrated, therefore posing a significant threat to both mule deer and humans (Mule Deer Working Group, 2003).

Fibromatosis is a common skin disease of mule deer and other cervids of North America. At this time, it is thought that fibromas or skin tumors are caused by a papilloma virus and can be transmitted between deer but not to humans. They appear as large, warty growths or firm, round, nodular, hairless, pigmented skin abnormalities as a single mass or numerous growths. Most often, fibromas occur in deer less than two years of age, with a higher incidence of disease in bucks (Oregon Department of Fish and Wildlife, 2012).

FIELD METHODOLOGY

No formal comprehensive surveys have been conducted for mule deer within the study area. A formal spotlight survey was conducted in February 2014, but no mule deer were observed. Surveys are difficult due to the secretive nature of mule deer and their preferred habitat having tall brush and trees. All data collected thus far are comprised of incidental observations made during other wildlife and vegetation surveys, or remote camera data. Mule deer prefer the pinyon-juniper woodlands located in the higher elevations of the Kawich and Belted Ranges, although small herds and individuals have also been observed on Stonewall Mountain, Cactus Peak, Tolicha Peak, Thirsty Canyon, Desert Range, and Sheep Range where cover is less dense and the animals are more easily observed. Even with helicopters, observation of mule deer in the pinyon-juniper habitat is very difficult since mule deer prefer to stay still and hide under low branches. Currently, the NNRP relies on incidental observations and trail cameras to determine herd locations and habitat preferences. Photos of mule deer taken by trail cameras are carefully studied to determine the general health of individuals and the size of herds utilizing springs and other wildlife water developments. However, true census surveys have not been conducted and the actual size of the mule deer herd cannot be estimated at this time.

Habitat models were prepared to predict potential habitat for mule deer on the study area. Both models were prepared as discussed in the bighorn sheep model methodology section. The Maxent Model was run using the 98 observation locations of mule deer on the study area and the same GIS layers as the bighorn sheep model. Habitat parameters used for mule deer in the Habitat Suitability Model were the following:

- Elevation: 5,500 ft. MSL to 7,500 Ft. MSL (Weighting factor of 1): A study on the NNSS shows populations locally inhabiting pinyon-juniper habitat near 6,000 ft. MSL to sagebrush habitat in the lower reaches (Giles & Cooper, 1984). Additionally, mule deer have been observed on the NTTR at elevations between 6,000 and 7,500 ft. MSL.
- Slope: Not a limiting factor.
- Aspect: Not a limiting factor.
- Permanent Water Sources (Weighting factor of 5). Mule deer have been recorded visiting water sources in the desert an average of once every 24 hours and consume 4-6 liters per visit (Hazam & Krausman, 1988).
- Temporary Water Sources (Weighting factor of 3). Same as permanent water sources only a lower weighting because they are not always present.
- Geology: Not a limiting factor.
- NDOW Key Habitat (Weighting factor of 2): Based fully on vegetation requirements for habitat.
    - Intermountain Cold Desert Scrub
    - Lower Montane Woodlands
    - Sagebrush
- Soil Associations: Not a limiting factor.

  Plant Communities (Weighting factor of 2). Browse species are especially preferred by mule deer; including sagebrush, bitterbrush, rabbitbrush, and scrub oak within the eco-regions associated with the study area (Wasley, 2004). Areas with bitterbrush and sagebrush provide common habitat, although a mosaic of vegetation providing an interspersion of herbaceous openings, dense brush or tree thickets, riparian areas, and abundant edges are also common (Nevada Department of Wildlife, 2010b).
    - *Artemisia arbuscula* Shrubland Alliance
    - *Artemisia nova* Shrubland Alliance
    - *Artemisia tridentata* Shrubland Alliance
    - *Chrysothamnus (greenei or viscidiflorus)* Shrubland Alliance – Proposed
    - *Ericameria nauseosa* Shrubland Alliance
    - *Fallugia paradoxa* Shrubland Alliance -- Proposed
    - *Purshia (stansburiana,mexicana)* Shrubland Alliance
    - *Juniperus osteosperma* Woodland Alliance
    - *Pinus monophylla - (Juniperus osteosperma)* Woodland Alliance
    - *Pinus monophylla* Woodland Alliance

RESULTS

From 2005-2016, a total of 98 mule deer observations have been recorded on the study area. This information provides insight as to the general location and habitat preferences of mule deer. However, the total number of deer observed each year is influenced more by the location of other surveys and is not indicative of a trend in population size. In 2005, five mule deer were observed as compared to six in 2006, fifty in 2007, five in 2009, eight in 2011, one in 2012, eight in 2014, eleven in 2015 and one in 2016. Six additional mule deer were observed and entered in the database with unknown dates and are included in the total number. The large number of deer observed in 2007 was an artifact of the types of surveys conducted that year. Intensive helicopter surveys of vegetation were conducted in good mule deer habitat and a large number of deer were subsequently observed. A large herd of about 40 deer was observed grazing in an area that had recently experienced a brush fire and was recovering with lush vegetation following a spring rain.

Locations of mule deer incidentally observed on the study area from 2005-2016 are provided in Figure 37. Two does and one yearling mule deer were observed in the South Range of the NTTR in 2011 during a rare plant survey on the Desert Range. The one male mule deer was observed in 2016 north of the study area on the Pahranagat Range during aerial vegetation surveys using a helicopter. Over 50% of the mule deer observed from 2005-2016 were found on Tolicha Peak, Black Mountain, and the Kawich Range. Substantial numbers of mule deer were also observed on the Belted Range, Thirsty Canyon, and the Cactus Range.

No meaningful conclusions can be made by analyzing the demographics of incidental observations, and therefore, age or sex ratios are not included here. Additionally, many observations recorded in the database did not include age or sex determinations.

Very few mule deer have been observed on the study area because no formal surveys have been conducted and all the observations were incidental. The data do not necessarily reflect the dynamics or distribution of the mule deer population on the study area, but are a factor of where other field surveys took place. Currently, no information has been gathered to access population movements, habitat use or preferences, population size, or reproductive potential. Only non-quantitative methods, such as trail cameras have been used to assess health in the species. These photographs and field observations indicate that the mule deer on NTTR are in good condition.

The results of the habitat models for mule deer are provided in Figures 38 to 41. As with the other models, the Maxent Model tended to show smaller areas as good mule deer habitat. In contrast, the habitat suitability model was much more liberal and showed a much wider range of habitat for the species. For mule deer management purposes, the Habitat Suitability Model is recommended to avoid or minimize impacts to mule deer because it is more conservative and because the Maxent Model is based on a small number of observation points.

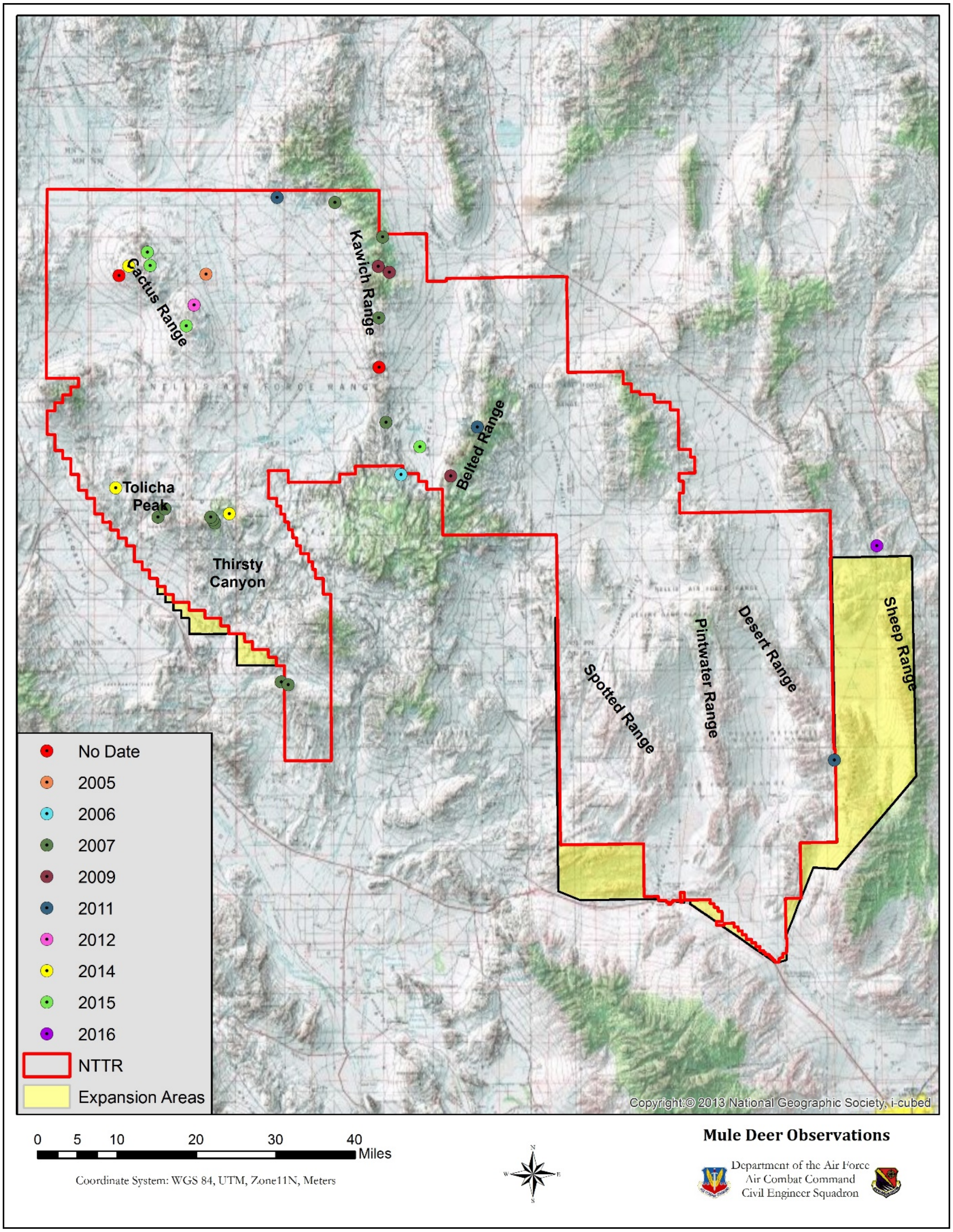

Figure 37. Locations where mule deer have been observed on the study area from 2005-2016.

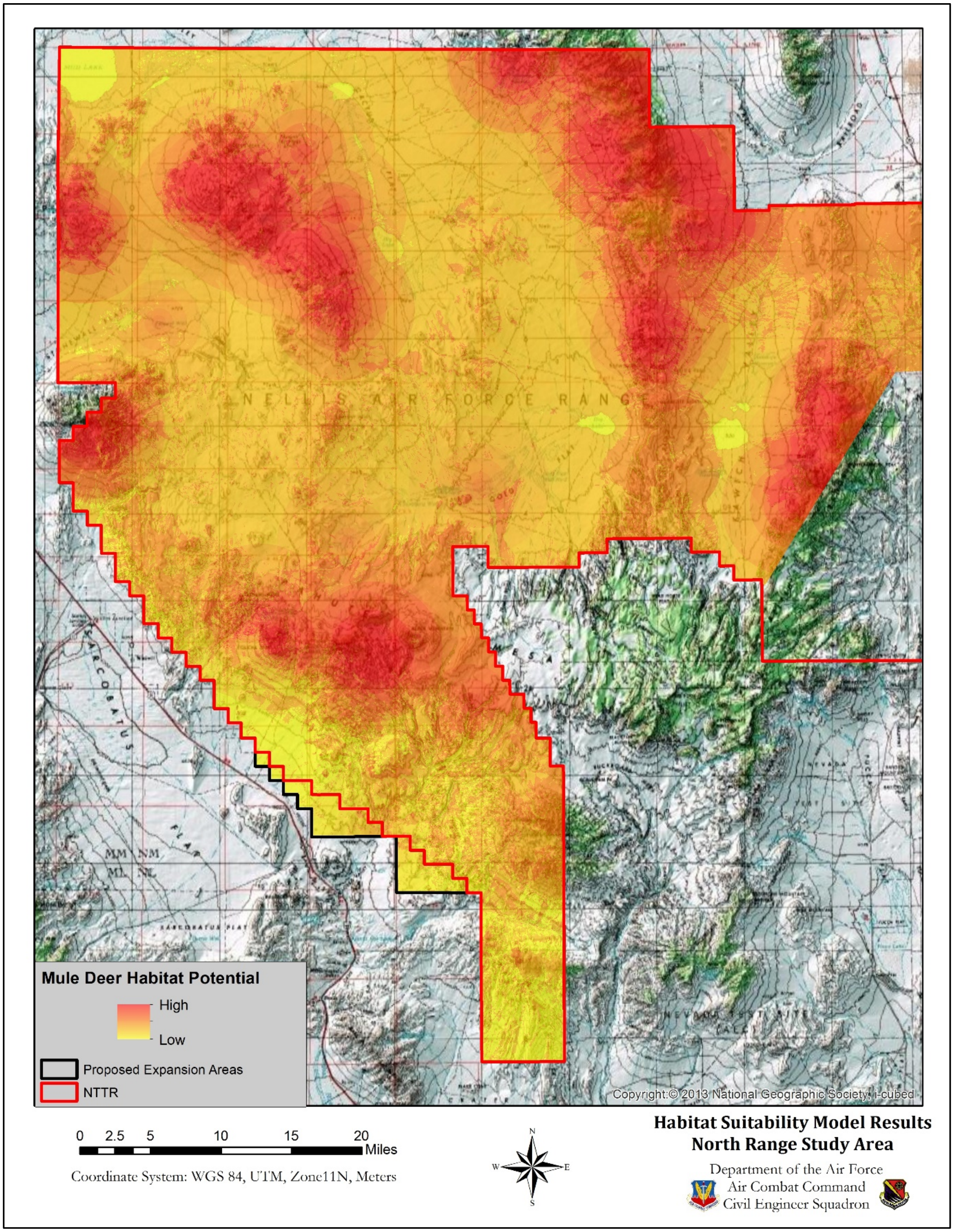

Figure 38. Habitat Suitability Model showing the potential for habitat on the North Range Study Area to accommodate mule deer populations.

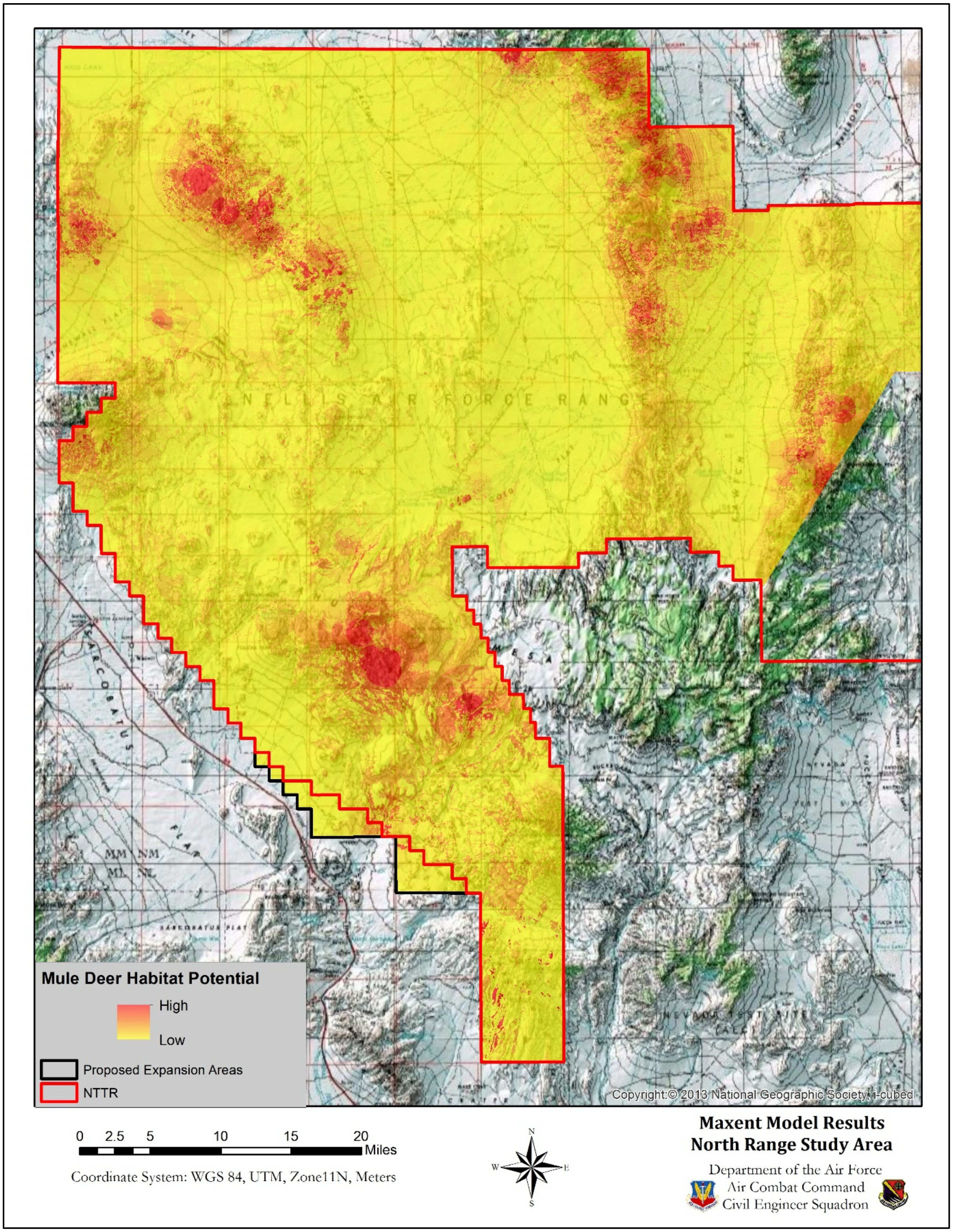

Figure 39. Maxent Model showing the potential for habitat on the North Range Study Area to accommodate mule deer populations.

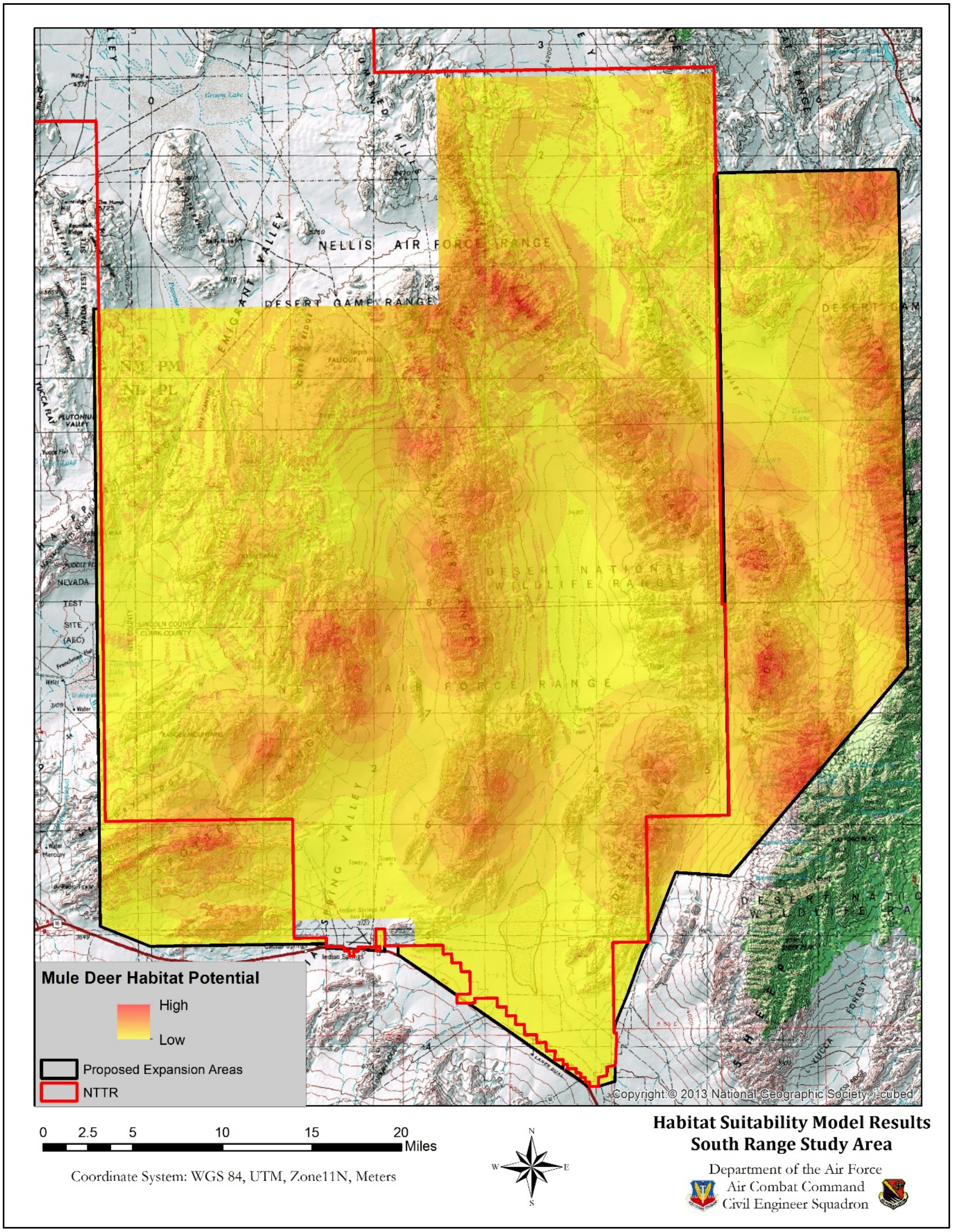

Figure 40. Habitat Suitability Model showing the potential for habitat on the South Range Study Area to accommodate mule deer populations.

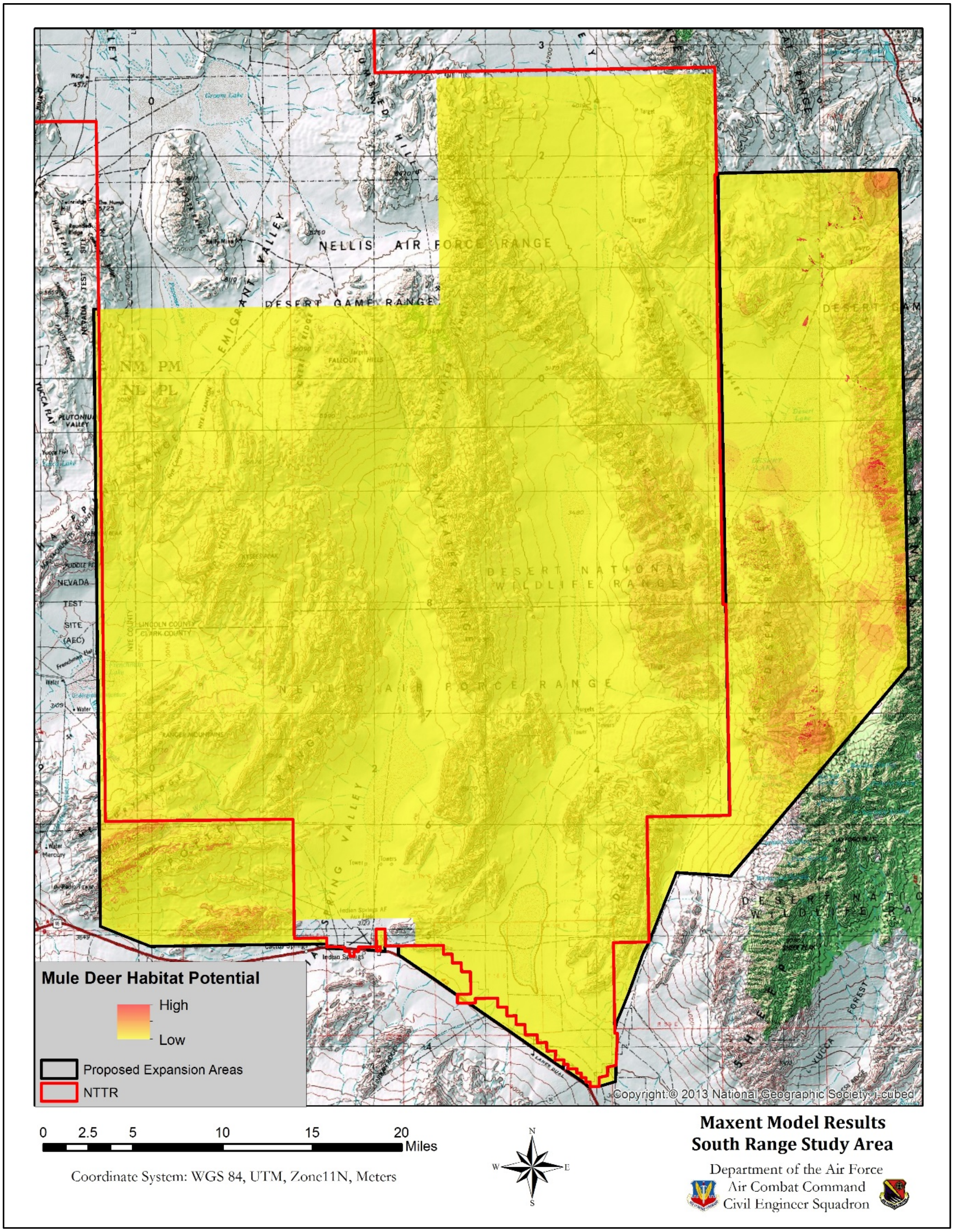

Figure 41. Maxent Model showing the potential for habitat on the South Range Study Area to accommodate mule deer populations.

WILD HORSES and BURROS

BACKGROUND INFORMATION

The modern horse and burro are not native to North America, but have become an important component of the desert ecosystem in Nevada. Horses were absent from North America for 10,000 years after going extinct during the Pleistocene epoch. Since then, the western United States has become more arid and many of the horses' earlier predators, like the American lion and saber-tooth cat, have disappeared, changing the ecosystem and the role horses play (Wagner F. H., 1983).

Mare and colt on the North Range Study Area.

Several authors have suggested that current populations of wild horses in the western United States are not the result of a single European introduction, but rather the amalgamation of repeated introductions of domestic horses (Beebe & Johnson, 1964; Bowling, 1994). Similarly, Beebe and Johnson (1964) suggested that due to repeated interbreeding with released or abandoned domestic horses, the wild horse of the western United States differs little from other domestic horse breeds. Bowling (Bowling, 1994) compared blood samples of 975 wild horses from seven Great Basin sites with samples from 16 domestic horse breeds and found no significant differences. From comparisons of genetic makeup, Bowling (1994) concluded that the Great Basin horse originated from Iberian, American saddle horse, and draft horse breeds.

Reductions in predator numbers, increasing availability of water due to the construction of "wildlife guzzlers", and increased mobility facilitated by fences in disrepair have resulted in the number of wild horses in the United States increasing to an estimated 2 to 7 million during the 20th century (Ryden, 1978; Thomas, 1979). Given these selective forces, many herds have exhibited annual population growth rates of 20% or higher (Eberhardt, Majormicz, & Wilcox, 1982; Wolfe, 1980).

Wild horses on the North Range.

Over-population of wild horses can alter plant communities, thus altering where they graze and compete with native large mammals such as mule deer, pronghorn, and desert bighorn sheep for water and vegetation. The small reptiles and mammals that depend on burrows and brush cover to survive and breed are less abundant in horse occupied sites (except for deer mice, a species known to thrive in disturbed landscapes). Desert snakes, lizards, and amphibians occupy a wide range of ecological and trophic niches, and often serve as a link between trophic levels. If their populations are severely reduced by dense horse populations, larger ecosystem degradation may follow (Beever & Brussard, 2004).

Wild horse on the North Range.

Wild burros are not in the spotlight as often as the wild horses, but they are still an important part of the ecosystem. Wild burros differ from wild horses in many ways. Wild burros have 62 chromosomes while horses have 64 (Werdelin & Sanders, 2010). They have very narrow and small hooves which enable them to fight off predators and to be sure footed on rocky, uneven terrain. They have larger ears which allows them to resist the extreme heat of deserts by releasing heat through the ears. Mules also have the ability to raise their body temperature by 11.7°F without damage to their biological functions (Moehlman, 1998). The hair along the neck, the mane, stands upright with long, thin hairs.

Research has found a distant relative of the modern burro buried in the tombs of Abydos, Egypt (Churcher, 1982). The skeletons were aged to be approximately 5,000 years old and signs of domestication (load-bearing) were evident (Churcher, 1982). It was also found that during this time in Africa, donkeys became domesticated due to the struggles facing humans with the development of the Sahara Desert. After genetics were compared, it was found that domestic and wild donkeys and burros in North America are descendants of these African donkeys (Churcher, 1982).

The wild burros found in America today were originally from arid Africa (Jaco Weinstock, 2005). They were introduced to the Americas by the Spanish in the 1500s (Jaco Weinstock, 2005). The burros were used as pack animals as well as guard animals. Burros have no natural predators and can fight off any predator with their sharp hooves and group instincts. Today, burros and donkeys are still used as pack animals and guardians of farms and ranches.

Wild burros on the North Range Study Area.

Management of wild horses and burros in western North America has proven to be an ongoing political debate. The methods of management have remained controversial throughout time. Wild horse population explosions have created a need for scientifically based management to maintain the ecological integrity of the land, as well as to maintain populations at sustainable levels. When populations spike, not only does the landscape suffer, but so do the individual horses. Without adequate vegetation and water sources these horses decline in health leaving them susceptible to disease, starvation, and death.

The wild horse population on the NTTR is an example of management for ecological integrity and land stewardship responsibilities. In 1962, the USAF and BLM worked together and agreed to create the Nevada Wild Horse Range (NWHR) on the north-central portion of the NTTR. BLM was given the task of managing horses on NWHR. In 1972, Public Law 92-195, the Wild Free-Roaming Horse and Burro Act, was created to protect the horses on the NWHR. A Cooperative Agreement between the BLM and USAF in 1974 (Appendix B of the Record of Decision for the BLM Range Management Plan) gave BLM the responsibility of conducting an annual census of the horses and determining the condition of vegetative resources.

Wild Horse at the O&M Pond on the North Range Study Area.

Prior to initiation of an Appropriate Management Level (AML) by the Nevada Wild Horse Range Herd Management Plan, the wild horse population on the NTTR reached a peak of approximately 10,000 animals in 1993. The AML was set by the Record of Decision for the NTTR Resource Management Plan EIS in 2004 and was determined to be 300-500 horses. This was determined by the amount of forage and water available to the horses, as monitored annually by the BLM. Since the establishment of the AML, wild horse herds on the NTTR have been maintained at a level of 200 to 1,200. In addition, many of the seeps and springs on the NTTR have been protected from wild horses by fences. The wild horses have been provided water near the springs in troughs or dugouts. Subsequently, wild horses on the NTTR have improved significantly in health and damage to seeps and springs has decreased.

Wild burro populations do not have a significant presence on the study area. NNRP has not conducted any formal wild burro surveys; incidental sightings were recorded by GPS. The wild burro herds that occur on the study area travel on and off the study area throughout the year. These herds are found on the southern part of the North Range Study Area near Beatty and on the north side of Stonewall Mountain around Stonewall Spring.

Measuring the utilization of forage that is available to mammals is an excellent means of determining range condition and carrying capacity. Most mammals can co-exist in moderate populations, but many of the large mammals on the NTTR consume the same forage and compete for the same water, which creates problems when mammal populations are high and available forage is low.

In contrast to ruminants of the Intermountain West, horses are cecal digesters (digest food in the large intestines); whereas mule deer, pronghorn and bighorn sheep digest food in four compartments of the stomach or rumen) (Janis, 1976; Hanley & Hanley, 1982). Combined with their large body size, this type of digestion forces the wild horse to be less selective of the plant species compared to other large herbivores across most of western North America (Hanley & Hanley, 1982). Thus, fewer plant species may remain ungrazed in areas occupied by large populations of wild horses compared to areas grazed by other ungulates. This use of a lower-quality diet requires that horses consume 20-65% more forage than a cow of equivalent body mass (Hanley, 1982; Wagner F. H., 1983; Menard, Duncan, Fleurance, Georges, & Lila, 2002). Compared to other ungulates on the NTTR, horses possess a more elongated head, upper front incisors, and flexible lips. Consequently, they can trim vegetation more closely to the ground than mule deer, pronghorn, and bighorn sheep. This can cause serious damage to the plants sometimes impeding their recovery (Menard, Duncan, Fleurance, Georges, & Lila, 2002; Symanski, 1994).

Over-population of wild horses can alter plant communities where they graze and compete with native large mammals such as mule deer, pronghorn, and desert bighorn sheep for water and vegetation. Large populations of wild horses can stress and even alter the composition of the ecosystem they colonize; endangering the existence of native plants and animals by trampling vegetation, hard-packing the soil, and over-grazing (Beever & Brussard, 2004). Areas inhabited by large populations of wild horses tend to have less diverse plant communities, less plant cover, and more invasive grass species, which significantly influence the desert ecosystem (Beever, Tausch, & Thogmartin, 2008).

Wild horses grazing on the North Range Study Area.

Studies have found that the presence of wild horses at water sources reduces utilization by other wildlife. One such study found that bighorn sheep avoid water sources when wild horses are present (Ostermann-Kelm, Atwill, Rubin, Horgensen, & Boyce, 2008). In fact, a study by Ostermann-Kelm (Ostermann-Kelm, Atwill, Rubin, Horgensen, & Boyce, 2008) found a 76% reduction in the number of groups of bighorn sheep using a typically preferred water source when horses were present. However, pronghorns and wild horses have been observed sharing water sources on the North Range Study Area. Wild horses tend to establish their population around water sources during the dry summer season, and when populations are dense, impacts to vegetation are visible for 8-10 miles from accessible water. Degradation of seeps and springs by large populations of wild horses on the North Range Study Area can impact the use of these water sources by other wildlife species, thus altering the landscape. As a result, some seeps and springs on the North Range have been fenced to prevent damage by horses; subsequently allowing the vegetation to recover, improve, and become more palatable for other wildlife.

FIELD METHODOLOGY

BLM typically conducts formal wild horse surveys using a standard protocol developed by the USGS (USGS, 2017). Data was only obtained from the BLM for their 2009 and 2012 surveys. Beginning in 2014, pronghorn surveys by the NNRP were expanded to include the Wild Horse Herd Management Area and wild horses and burros were counted to informally monitor the herd when BLM was unable to conduct formal population census surveys. The pronghorn surveys were expanded to include the foothills of mountain ranges typically supporting sagebrush and pinyon/juniper plant communities. These surveys generally stopped when cover of pinyon pine and Utah juniper exceeded 50%. The surveys conducted by NNRP were not intended to replace or even duplicate BLM surveys. The information gathered was only to be used to supplement BLM results for periods when BLM surveys could not be conducted. In general, transects were flown about a half mile apart. If herds were seen, the helicopter was flown closer to count and classify the horses as adult or juvenile. No other classifications were made because determination of the sex of horses is very difficult and often inaccurate from a helicopter. For population size comparisons, the 2009, 2012, and 2014 surveys will be used. Please note that the methodology used by the NNRP in 2014 was not the same as the BLM methodology used for 2009 and 2012. Therefore, comparison of results should be considered with caution.

Utilization surveys on the North Range were conducted using the Landscape Appearance Method listed in BLM technical reference 1734-3 (Bureau of Land Management, 1999). This technique uses a qualitative visual estimate of forage utilization based on the general appearance of rangeland and relies heavily on the experience of the observer. It is particularly adapted to areas where perennial grasses, forbs, and browse plants are present and should cover large areas using only a few surveyors. Normally, these surveys are conducted along transects at randomly located permanent markers. For the purposes of NNRP work, surveys were conducted in and around active seeps and springs and other wildlife water sources, realizing that utilization would be higher in those locations.

To determine utilization, a biologist walked around the area of each water feature stopping at a minimum of 10 different random points approximately 50 ft. apart to visually estimate utilization. Generally, the biologist would remain within approximately 100 yards of the water feature or determined point of interest. At each point, browse utilization classes were determined as listed below:

- (0-5%). Browse plants show no evidence of grazing use or only negligible use.
- (6-20%). Browse plants have the appearance of very light use. The available leaders of browse plants are little disturbed.
- (21-40%). Obvious evidence of leader use. The available leaders appear cropped or browsed in patches and 60% to 80% of the available leader growth of browse plants remains intact.
- (41-60%). Browse plants appear rather uniformly utilized and 40% to 60% of the available leader growth of browse plants remains intact.
- (61-80%). The use of the browse gives the appearance of complete search. The preferred browse plants are hedged and some plant clumps may be slightly broken. Nearly all available leaders are used and few terminal buds remain on browse plants. Between 20% and 40% of the available leader growth of browse plants remains intact.
- (81-94%). Indications of repeated coverage. No evidence of terminal buds and usually less than 20% of available leader growth on browse plants remains intact. Some patches of second and third year growth may be grazed. Hedging is readily apparent and the browse plants are more frequently broken. Repeated use at this level will produce a definitely hedged or armored growth form.
- (95-100%). Less than 5% of the available leader growth on browse plants remains intact. Some, and often much, of the more accessible second and third year growth of the browse plants has been utilized. All browse plants have major portions broken.

RESULTS

Wild Horse and Burro Census Surveys

In 2005, a total of 880 wild horses were counted by BLM on the NTTR, and in 2008, a large scale round-up was conducted on the North Range to reduce populations to an estimated 230 horses, according to the 2009 census. No official horse surveys were conducted by BLM in 2010 or 2011. In 2012, just over 500 horses were counted on the NTTR by BLM.

The BLM also conducts wild horse utilization surveys on the North Range to determine the level of grazing by wild horses. This assists the BLM in making decisions concerning the scheduling of roundups to remove excess horses from the herds. NNRP field surveys in 2013 and 2014 included horse utilization evaluations to determine the level of grazing in and around seeps and springs. The BLM intends to continue an annual census of the wild horse population and to conduct wild horse gathers when needed to maintain the current AML for the NWHR of 300 to 500 horses. However, because of budget constraints, the BLM has been unable to conduct horse censuses from 2013-2015. NNRP conducted informal wild horse surveys in 2014 and 2015. The 2014 survey was comprehensive and included the entire North Range Horse Management Area. However, the 2015 survey was not a complete survey (scheduling constraints) and the number of animals counted were probably less than the actual population.

The wild horse population on the NTTR has been steadily increasing since the roundup in 2008 (Figure 42). The census by BLM in 2012 showed an increase of 155 animals, or a 67% increase in population, over a three-year period. The 2014 survey by the NNRP was comparable to BLM surveys, but was a raw count, not adjusted for count error. During the two-year period from 2012 to 2014, the herd increased another 173 horses or a 45% increase in population. Although the 2015 count did not cover the entire survey area, it still showed a substantial increase in the number of horses (138 horses, or a 25% increase in the population). Because the survey was not comprehensive, the count is probably less than the actual population. Figure 43 shows all the locations where wild horses were observed during surveys from 2000-2015. This figure indicates that the majority of the wild horse herd resides in Cactus Flats and the Kawich Valley. These areas have several permanent water sources for the horses, which may partially explain the concentration of the herds in these valleys.

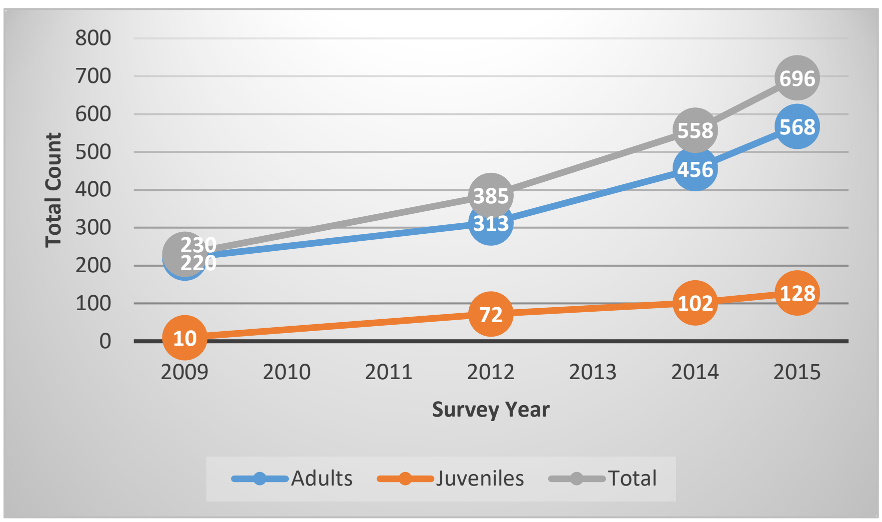

Figure 42. Wild horse population counts as determined by surveys conducted in 2009, 2012, and 2014. Comprehensive surveys were conducted by the NNRP in 2014 and 2015. The 2009 and 2012 surveys were conducted by BLM. The 2015 survey did not cover the entire horse management area.

No formal surveys have been conducted for wild burros. The data that has been collected on the burros cannot be used to draw conclusions on the health or growth of the herds. However, the counts indicate that the burro population on the North Range Survey Area is small. Figure 44 shows the locations in which wild burros have been observed during surveys.

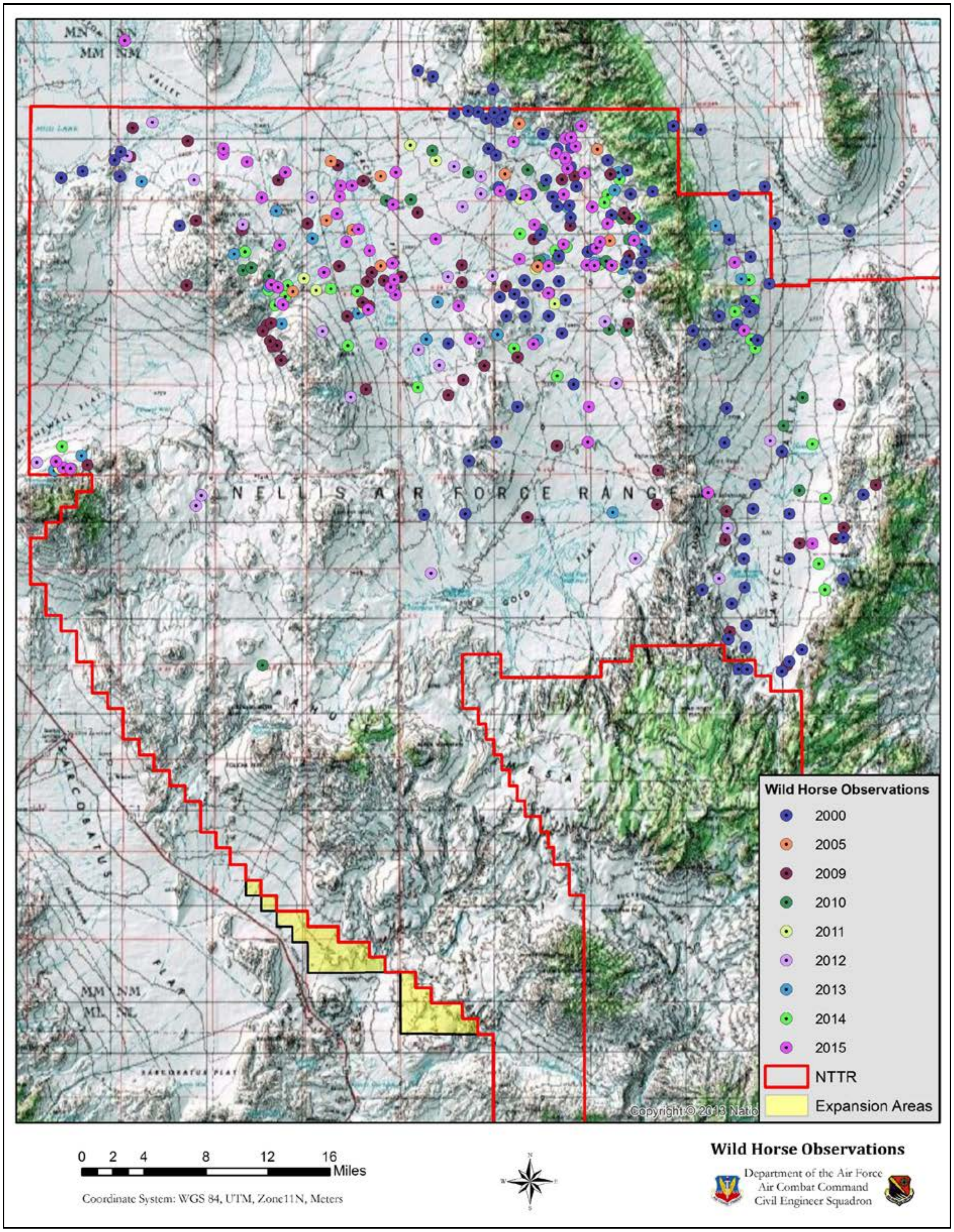

Figure 43. Wild Horse observations during surveys and other activities 2000-2015.

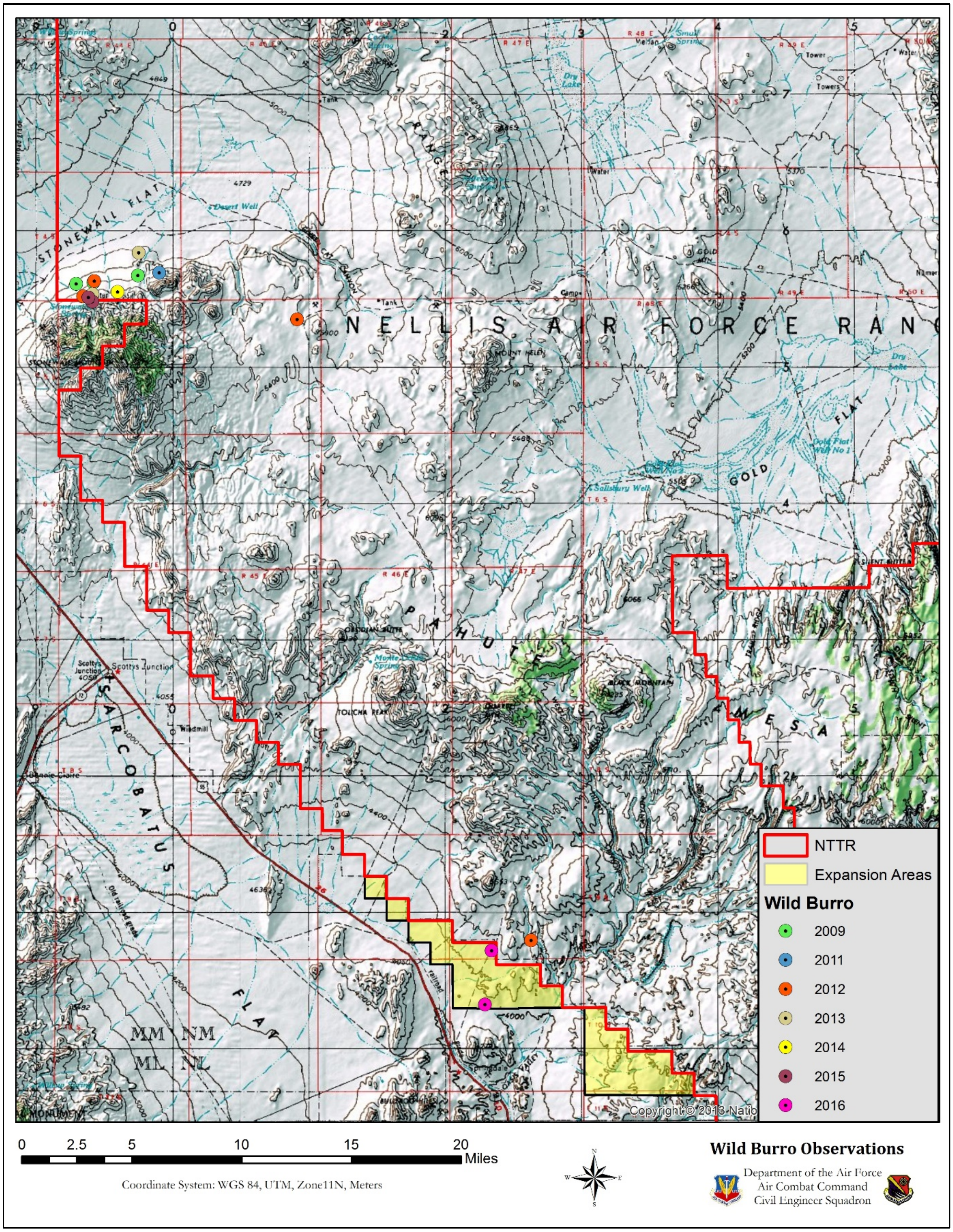

Figure 44. Burro observations during surveys and other activities 2012-2016.

The percent of juveniles in the wild horse population is on average 15% of the population across all years, which is normal for most wild horse populations (11-22%) (Wolfe, 1980) (Figure 45). This would indicate that conditions continue to be favorable for wild horse population growth on the North Range Study Area.

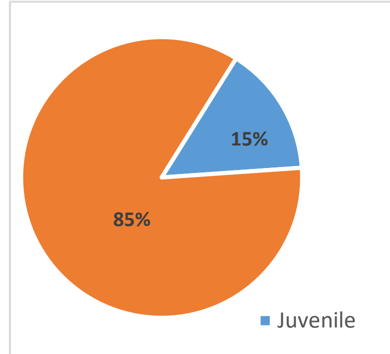

Figure 45. Percent adults and juvenile wild horse population on the NTTR averaged across all the survey years.

Utilization Surveys

Utilization of grasses was measured in 2014 and 2015 to estimate forage use by large mammals in and around active seeps and springs known to be used by large mammals (Figure 46). In general, utilization around the springs and other water sources was either minimal (0% to 5%) or relatively high (80% to 98%). Almost all springs showing minimal utilization appeared to not be used by wild horses (based on tracks, scat, and other sign) and were usually found in higher elevations in pinyon-juniper habitat. Thus, in those areas, usage was restricted to large mammals commonly found in pinyon-juniper habitat, i.e. mule deer and some desert bighorn sheep.

Utilization was highest around those springs and water sources that were heavily used by wild horses. This was especially evident in areas where horse troughs were present. Also, some of the higher quality, unprotected water sources, such as Log Spring, Pillar Spring, and Monte Cristo Spring, showed utilization in the range of 60% to 80% (Table 2). Pillar Spring showed 78% utilization and is rarely frequented by wild horses. Desert bighorn sheep are the prime users of this spring based on wildlife sign. Areas being utilized by large mammals are being carefully monitored each year to ensure that the areas are not becoming dominated by invasive plants such as Halogeton, wild mustard, Russian thistle, salt cedar, and red brome.

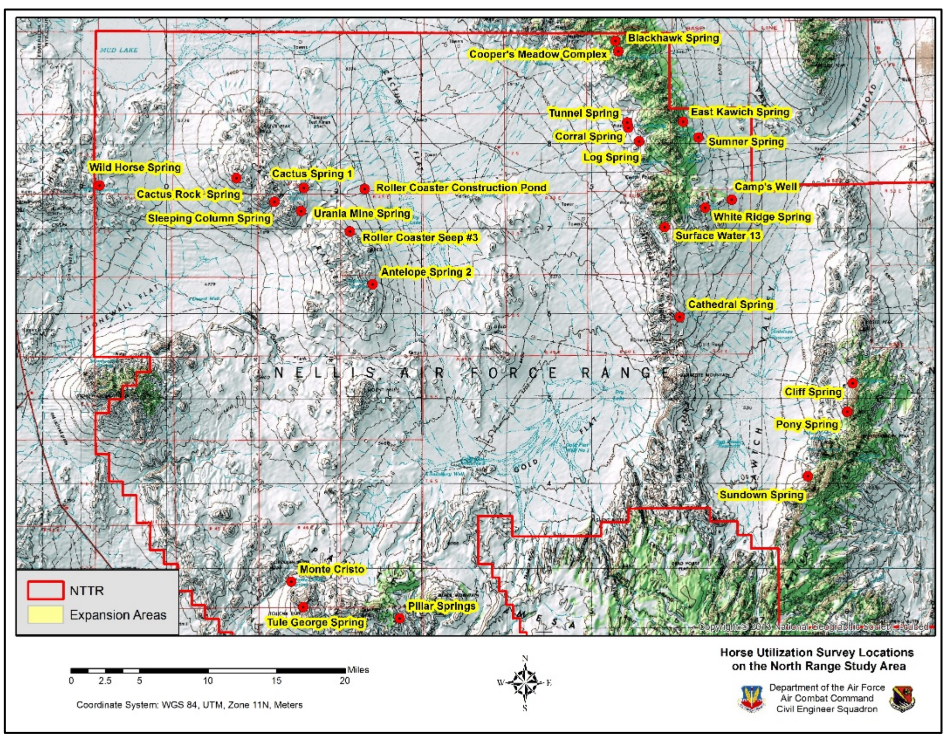

Figure 46. Locations where utilization of forage by large mammals was evaluated in 2014 and 2015.

Many of the areas heavily utilized are already dominated by low quality brush species including rubber rabbitbrush.

Data collected in 2015 indicate that the wild horse population is beginning to increase to a level where utilization in and around water sources is unacceptably high (80% to 100%). Such levels result in encroachment by various invasive plants and loss of desirable forage species.

Table 2. Measurements of forage species at various locations on the North Range to estimate percent utilization.

Sample Site	Dominant Species	2014	2015
Antelope 2 Spring	Atriplex canescens, Gutierrezia sarothrae, Chrysothamnus viscidifilorus, Artemisa tridentata	22%	3%
Blackhawk	Artemisia tridentata	3%	----
Cactus Roadside Seep	Artemisia nova, Aristida purpurea, Leymus triticoides, Pleuraphis jamesii	----	63%
Cactus Rock Spring	Ericameria nauseosa, Salsola tragus	91%	93%
Cactus Rock Spring (upgradient)	Ericameria nauseosa, Salsola tragus	----	77%
Cactus Spring	Ericameria nauseosa, Artemisia nova, Gutierrezia sarothrae	98%	98%
Camp's Well	Elymus elymoides, Bromus tectorum	91%	79%
Cathedral Spring	Elymus elymoides, bromus tectorum	4%	----
Cedar Spring	Bromus tectorum, Sarcobatus vermiculatus, Leymus triticoides, Artemisia tridentata, Atriplex canescens	49%	24%
Cliff Spring	Artemisa tridentata, Achnatherum hymenoides, Bromus tectorum	6%	5%
Cooper Meadows Complex	Artemisia tridentata, Carex capitata, Chrysothamnus viscidiflorus.	3%	----
Corral Spring	Bromus tectorum, Ericameria nauseosa, Descurainia sp.	98%	93%
East Kawich Spring	Artemisia tridentata, Bromus tectorum, Elymus elymoides, Ericameria nauseousa	3%	----
Log Spring	Leymus triticoides, Artemisia tridentata, Bromus tectorum, Ericameria nauseosa	71%	92%
Monte Cristo	Ericameria nauseosa, Atriplex canescens	69%	10%
Pillar Spring	Bromus tectorum	78%	----
Pony Spring	Artemisa tridentata, Acamptopappus shockleyi, Achnatherum speciosum, Juncus balticus	16%	3%
Roller Coaster Construction Pond	Artemisia tridentata, Atriplex canescens, Pleuraphis jamesii	94%	----
Rollercoaster 3	Ericameria nauseosa, Artemisa tridentata, Typha latifolia	60%	----
Sleeping Column	Ericameria nauseosa, Gutierrezia sarothrae, Agrostis pollens	83%	64%

Sleeping Column (outside)	Ericameria nauseosa, Artemisia tridentata, Pleuraphis jamesii, Hesperostipa comata	----	54%
Sumner	Ericameria nauseousa, Artemisia tridentata, Elymus elymoides	5%	90%
Sundown Spring	Ephedra viridis, Purshia mexicana, Ericameria cooperi, Juniperus osteosperma, Pleuraphis jamesii, Bromus tectorum, Achnatherum speciosum, Aristida purpurea	4%	8%
Surface Water 1	Bromus tectorum, Bromus mad. rubens, Leymus triticoides, Poa secunda	----	3%
Surface Water 13	Bromus tectorum, Bouteloua gracilis	3%	----
Tule George	Ericameria nauseosa, Ephedra viridis, Artemisa nova	98%	3%
Tunnel	Descurainia sp., Bromus tectorum, Artemisia tridentata	0%	95%
Urania	Artemisia tridentata, Atriplex confertifolia, Pleuraphis jamesii	85%	4%
White Ridge Spring	Tridens muticus, Bromus tectorum, Elymus elymoides	3%	----
Wildhorse Spring	Pleuraphis jamesii, Artiplex canescens	64%	3%

WORKS CITED

Ackerly, W., & Regier, V. (1956). *Northeastern California Antelope Studies.* California Department of Fish and Game.

Albert, S., & Krausman, P. (1993). Desert mule deer and forage resources in southwestern Arizona. *38*(pp. 198-205).

Allen, R. W. (1980). Natural mortality and debility. In *The desert bighorn: its life history, ecology, and management* (pp. 172-185). Tucson, AZ: University of Arizona.

Allred, L., & Bradley, W. (1965). Necrosis and anomalies of the skull in desert bighorn sheep. *Desert Bighorn Council Transactions*, 9:75-81.

Andrew, N. (1994). Demography and habitat use of desert-dwelling mountains sheep in the east Chocolate Mountains, Imperial County, California. *MS Thesis. University of Rhode Island*, 135 pp.

Arizona Game and Fish Department. (2011). *Pronghorn Antelope.* Phoenix: Heritage Data Management System, AGFD.

Autenrieth, R. (1978). Guidelines for the management of pronghorn antelope. *pp. 473-526*.

Autenrieth, R., Brown, D., J.Cancino, Lee, R., R.A.Ockenfels, O'Gara, B., . . . Yoakum, J. (2006). *Pronghorn Management Guide.* Bismark: 21st Pronghorn Workshop and North Dakota Game and Fish Department.

Beale, D., & Holmgren, R. (1975). *Water Requirements for Pronghorn Antelope Fawn Survival and Growth.* Utah Division of Wildlife Resources.

Becklund, W., & Senger, C. (1967). Parasites of Ovis canadensis in Montana with a checklist of the internal and external parasites of the Rocky Mountain Sheep in North America. *Journal of Parasitology*, 53:157-65.

Beebe, B. F., & Johnson, J. (1964). *American wild horses.* New York: David McKay.

Beever, E. A., & Brussard, P. (2004). Community and landscape level responses of reptiles and small mammals to feral horse grazing in the Great Basin. *59: 271-297*.

Beever, E., Tausch, R., & Thogmartin, W. (2008). Multi-scale responses of vegetation to removal of horse grazing from Great Basin (USA) mountain ranges. *196: 163-184*.

Bleich, V., Wehausen, J., & Holl, S. (1990). Desert-dwelling mountain sheep conservation implications of a natural fragmented distribution. *Conservation Biology, Vol. 4(4)*, Pages 383-390.

Bleich, V., Wehausen, J., Ramey, R., & Rechel, J. (1996). Metapopulation theory and mountain sheep: implications for conservation. In D. McCullough, *Metapopulations and Wildlife Conservation* (p. 429). Washington, D.C.: Island Press.

Bowling, A. T. (1994). Population genetics of Great Basin feral horses. *25(Supplement 1)L 67-74*.

Brown, D., Bayer, D., & McKinney, T. (2006). Measuring the effects of mid-summer drought on doe pronghorn mortality. *81*(2).

Brown, E. (1961). The black-tailed deer of western Washington . *Bull. No. 13*(124 pp).

Browning, B. M., & Monson, G. (1980). Food. In G. Monson, & L. Sumner, *The Desert Bighorn: Its Life History, Ecology and Management* (pp. 80-99). Tucson: University of Arizona Press.

Broyles, B. (1995). Desert wildlife water developments: questioning use in the southwest. *Wildlife Society Bulletin*, 23:663-675.

Bureau of Land Management. (1999). *Utilization Studies and Residual Measurements.* Denver, CO: National Applied Resources Center.

Churcher, C. (1982). Oldest ass recovered from Olduvai Gorge. Tanzania and the orgin of asses. Journal of Paleontology 56: 1124-1132.

Clements, C. D., & Young, J. A. (1997). Rangeland Health and Mule Deer Habitat. *50*(No. 2, pp. 129-138).

Cowan, I. M. (1940). Distribution and variation in the native sheep of North America. *American Mid. Naturalist, 24*(505-580).

Crafford, A. (2007). *Geologic Map of Nevada.* Reston, VA: USGS.

Cunningham, S. C., & Ohmart, R. D. (1986). Aspects of the ecology of desert bighorn sheep in Carrizo Canyon, California. *Desert Bighorn Council Transactions*, 30:14-19.

Dasmann, R., & Taber, R. (1956). Behavior of Columbian Black-tailed Deer with Reference to Population Ecology. *37*(pp. 143-164).

Deming, O. (1964). Bighorn sheep transplants at the Hart Mountain National Antelope Refuge. *Desert Bighorn Council Transactions*, 5:56-57.

Digital West Media, Inc. (2016). *Desert Bighorn*. Retrieved June 13, 2016, from DesertUSA: http://www.desertusa.com/big.html

Digital West Media, Inc. (2016). *Mule Deer*. Retrieved June 30, 2016, from DesertUSA: http://www.desertusa.com/feb97/du_muledeer.html

Digital West Media, Inc. (2016). *Pronghorn Antelope*. Retrieved July 23, 2016, from DesertUSA: http://www.desertusa.com/mag99/may/papr/pronghorn.html

Dolan, B. F. (2006). Water Developments and Desert Bighorn Sheep: Implications for Conservation. *Wildlife Society Bulletin*, Vol. 32, No. 3, pp. 642-646.

Eberhardt, L. E., Hansen, E. E., & Cadwell, L. L. (1984). Movement and Activity Patterns of Mule Deer in the Sagebrush-Steppe Region. *65*(No. 3, pp. 404-409).

Eberhardt, L., Majormicz, A., & Wilcox, J. (1982). Apparent rates of increase for two feral horse herds. *46: 367-374*.

Feldhamer, G. A., Thomspon, B. C., & Chapman, J. A. (2003). *Wildlife mammals of North America: biology management and conservation.* Baltimore, MD: John Hopkins University Press.

Feller, W. (n.d.). *Digital Desert: Mojave Desert*. Retrieved July 2, 2011, from Mule Deer: http://digital-desert.com/wildlife/mule-deer.html

Fox, K., & Krausman, P. (1994). Fawning habitat of desert mule deer. *39*(pp. 269-275).

Geist, V. (1971). *Mountain sheep: a study in behavior and evolution.* Chicago: University of Chicago Press.

Giles, K. R., & Cooper, J. (1984). *Characteristics and Migration Patterns of Mule Deer on the Nevada Test Site.* Las Vegas: Environmental Protection Agency, Department of Energy.

Goodwin, G. A. (1976). Golden Eagle Predation on Pronghorn Antelope. *Auk, 94*, 789-790.

Hanley, T. (1982). The nutritional basis for food selection by ungulates. *35: 152-158*.

Hanley, T., & Hanley, K. (1982). Food resource partitioning by sympatric ungulates on Great Basin rangeland. *35: 152-158*.

Hayes, C., Rubin, E., Jorgensen, M., & Boyce, W. (2000). Mountain lion predation of bighorn sheep in the Peninsular Ranges, California. *Journal of Wildlife Management*, 64:954-959.

Hazam, J. E., & Krausman, P. R. (1988). Measuring Water Consumption of Desert Mule Deer. *52*(No. 3, pp. 528-534).

Helive, J., & Smith, D. (1970). Summary of necropsy findings in desert bighorn sheep. *Desert Bighorn Council Transactions*, 14:47-52.

Hervert, J., & Krausman, P. (1986). Desert mule deer use of water developments in Arizona. *50*(pp. 670-676).

Integrated Taxonomic Information Systems. (n.d.). *ITIS Search*. Retrieved July 20, 2011, from Antilocapra americana: http://www.itis.gov/servlet/SingleRpt/SingleRpt.

Jaco Weinstock, e. a. (2005). *"Evolution, Systematics, and Phylogeography of Pleistocene Horses in the New World: A Molecular Perspective.".* Retrieved 2016, from PLos Biology 3.8 (2005): e241: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC1159165/.

Jacques, C. N., & Jenks, J. A. (2007). Visual Observation of Bobcat Predation on Adult Female Pronghorn in Northwestern South Dakota. *160*.

James, A., & Crouse, B. (2011). *Built for Speed: Pronghorn Migration.* Arlington, VA: The Nature Conservancy. Retrieved from https://www.nature.org/ourinitiatives/regions/northamerica/unitedstates/montana/pronghorn-spring-2011-pdf.pdf.

Janis, C. (1976). The evolutionary strategy of the Equidae and the origins of rumen and cecal digestion. *30: 757-774*.

Johnson, E. (1957). Disease and mechanical injury in desert bighorn sheep. *Desert Bighorn Council Transactions*, 1:38-42.

Jones, G. (1957). *Report on a survey of bighorn sheep in the Santa Rosa Mountains.* Riverside County, California: California Fish and Game.

Kelly, W. E. (1980). Predator Relationships. In G. Monson, & L. Sumner, *The Desert Bighorn: Its Life History, Ecology and Management* (pp. 186-196). Tucson: University of Arizona Press.

Kindschy, R. R., Sundstrom, C., & Yoakum, J. (1982). Wildlife habitats in managed rangelands--the Great Basin of southeastern Oregon. *Gen. Tech Rep. 145*(pp.18).

Kitchen, D., & O'Gara, B. (1974). Social behavior and ecology of the pronghorn. *38*(pp.96).

Krausman, P. a. (1986). The importance of small populations of desert bighorn sheep. *Transactions of the 51st North American Wildlife and Natural Resources Conference*, (pp. 52-61).

Krausman, P. R., Kuenzi, A. J., Etchberger, R. C., Rautenstrauch, K. R., Ordway, L. L., & Hervert, J. J. (1997). Diets of Desert Mule Deer. *50, No. 5, pp. 513-522*.

Krausman, P. S. (1985). Diet activity of ewes in the Little Harquahala Mountains, Arizona. *National Bighorn Council Transactions*, *29*, pp. 24-26.

Krausman, P., & B.Czech. (1998). Water developments and desert ungulates. In J. F. Strouse, *Environmental, economic, and legal issues related to rangeland water developments.* Tempe: College of Law, Arizona State University.

Lance, R., & Pojar, T. (1984). *Diseases and parasites of pronghorn: A review.* Denver, Colorado: Colorado Division of Wildlife.

Leslie, D., & Douglas, C. (1979). Desert bighorn of the River Mountains, Nevada. *Wildlife Monographs*, 66:1-55.

Logan, K., & Sweanor, L. (2001). Desert Puma: evolutionary ecology and conservation of an enduring carnivore. Washington: Island Press.

Manville, R. (1980). The origin and relationships of American wild sheep. In G. M. Summer, *The desert bighorn: its life history, ecology, and management* (pp. 1-6). Tucson: University of Arizona Press.

Marsha, J., Krausman, P., & Bleich, V. (2005). Rainfall, temperature, and forage dynamics affect nutritional quality of desert mule deer forage. *58*(pp.360-365).

Marshal, J., Krausman, P., & Bleich, V. (2005). Dynamics of mule deer forage in the Sonoran Desert. *60*(pp.593-609).

McColm, M. A. (1963). A history of bighorn sheep in central Nevada. *Desert Bighorn Council Transactions*, 7:1-11.

McLean, D. (1930). *The burro deer in California.* California Fish and Game.

McQuivey, R. (1978). The desert bighorn sheep of Nevada. *Nevada Department of Fish and Game*, Biological Bulletin No. 6. 81 pp.

Menard, C., Duncan, P., Fleurance, G., Georges, J., & Lila, M. (2002). Comparative foraging and nutrition of horses and cattle in European wetlands. *39: 120-133*.

Mensch, J. (1969). Desert bighorn (Ovis canadensis nelsoni) losses in a natural trap tank. *California Fish and Game, Vol. 55*, Page 237.

Merritt, M. (1974). Measurement of utilization of bighorn sheep habitat in the Santa Rosa Mountains. *Desert Bighorn Council Transactions*, (pp. 18:4-17).

Moehlman, P. D. (1998, 15 November). *Feral asses (Equus africanus): intraspecific variation in social organization in arid and mesic habitats.* Retrieved 2016, from Applied Animal Behaviour Science 60:171-195: http://www.appliedanimalbehaviour.com/article/S0168-1591(98)00163-4/abstract.life, his

Monson, G. (1968). The desert pronghorn. The desert bighorn sheep council transactions.

Monson, G., & Sumner, L. (1980). *The Desert Bighorn: Its Life History, Ecology and Management.* University of Arizona Press.

Mule Deer Working Group. (2003). *Mule Deer in the West: Changing Landscapes, Changing Perspectives.* Retrieved July 7, 2011, from http://www.createstrat.com/muledeerinthewest/diseases.html.

Mule Deer Working Group. (2004). *North American Mule Deer Conservation Plan.* Western Association of Fish and Wildlife Agencies.

Nellis Natural Resources Program. (2010). *Integrated Natural Resources Management Plan.* Nellis AFB, NV: U.S. Air Force.

Nevada Department of Wildlife. (2001). *Bighorn Sheep Management Plan.* Reno, NV.

Nevada Department of Wildlife. (2010). *Nevada Faunal Facts: Desert Bighorn Sheep*. Retrieved from http://www.ndow.org/Species/Furbearer/Desert_Bighorn_Sheep.

Nevada Department of Wildlife. (2010a). *Nevada Faunal Facts: Pronghorn Antelope*. Retrieved July 20, 2011, from http://ndow.org/wild/animals/facts/antelope.shtm.

Nevada Department of Wildlife. (2010b). *Nevada Faunal Facts: Mule Deer*. Retrieved July 7, 2011, from http://www.ndow.org/wild/animals/facts/mule_deer.shtm.

Nevada Department of Wildlife. (2013). *Bighorn Sheep Management and Hunting Indoctrination.* Reno, NV: NDOW. Retrieved from http://www.ndow.org/uploadedfiles/ndoworg/content/hunt/seasons_and_regulations/big_game/bighorn-indoctrination-2013.pdf.

Nevada Department of Wildlife. (2013). *Nevada Wildlife Action Plan.* Retrieved December 2016, from http://www.ndow.org/Nevada_Wildlife/Conservation/Nevada_Wildlife_Action_Plan/.

Nevada Department of Wildlife. (2013). Partnership Formed to Investigate Bighorn Sheep Disease. Reno, NV: NDOW.

Nevada Department of Wildlife. (2013). *Wildlife Action Plan.* Reno: Nevada Department of Wildliife.

New Mexico Department of Fish and Game. (2002). Mountain Lion Management to Protect the State Endangered Desert Bighorn Sheep. http://mountainlion.org.

Nicholson, M. C., Bowyer, R. T., & Kie, J. G. (1997). Habitat Selection and Survival of Mule Deer: Tradeoffs Associated with Migration. *78*(No. 2, pp. 483-504).

Ockenfels, R., Alexander, A., Ticer, C. D., & Carrel, W. (1994). *Home ranges, movement patterns, and habitat selection of pronghorn in central Arizona.* Phoenix: Arizona Game and Fish Department.

O'Connor, J. (1939). *Game in the Desert.* New York: The Derrydale Press.

Ogara, B., & Yoakum, J. (2004). Pronghorn ecology and management.

Ordway, L., & Krausman, P. (1986). Habitat use by desert mule deer. *50*(pp. 677-683).

Oregon Department of Fish and Wildlife. (2012, January 27). *Wildlife Diseases.* Retrieved May 21, 2013, from Fibromatosis: http://www.dfw.state.or.us/wildlife/health_program/fibromatosis/.

Ostermann-Kelm, S., Atwill, E., Rubin, E., Horgensen, M., & Boyce, W. (2008). Interactions between feral horses and desert bighorn sheep at water. *89 (2): 459-466*.

Phelps, J. (1974). Endangered species investigation: Sonoran pronghorn habitat in Arizona. Proceedings Bien. Pronghorn Workshop.

Phillips, S. J., Anderson, R. P., & Schapire, R. E. (2006). Maximum entropy modeling of species. *Ecological Modeling, 190*, 231-259.

Pima County Arizona. (2006). *Sonoran Desert Conservation Plan*. Retrieved July 22, 2011, from Pronghorn Antelope: http://www.pima.gov/cmo/sdcp/species/fsheets/sp.html.

Rautenstrauch, K., Krausman, P., Whiting, F., & Brown, W. (1988). Nutritional quality of desert mule deer forage in King Valley, Arizona. *8*(pp. 172-174).

Robinson, R., Hailey, T., Livingston, C., & Thomas, J. (1967). Bluetongue in the Desert Bighorn Sheep. *The Journal of Wildlife Management*, Vol. 31, No. 1. pp.165-168.

Ryden, H. (1978). *America's last wild horses.* New York: E.P. Dutton.

San Diego Zoo. (2002). *San Diego Zoo Library*. Retrieved June 12, 2011, from Desert Bighorn Sheep, Ovis canadensis: http://library.sandiegozoo.org/factsheets/bighorn_sheep/bighorn.htm.

Sappington, J. M., Longshore, K. M., & Thompson, D. B. (2007). Quantifying landscape ruggedness for animal habitat analyses: a case study using desert bighorn in the Mohave Desert. *Journal of Wildlife Management, Vol. 71*, Pages 1419-1426.

Sawyer, H., & Lindzey, F. (2002). *A review of predation on bighorn sheep (Ovis canadensis). .* Laramie: Wyoming Cooperative Fish and Wildlife Research Unit.

Scarbrough, D., & Krausman, P. (1988). Sexual segregation by desert mule deer. *33*(pp. 157-165).

Schemnitz, S. D. (1994). *Pronghorn Antelope.* Las Cruces, New Mexico: New Mexico State University.

Schmidly, D. (2004). *The Mammals of Texas.* Texas Parks and Wildlife.

Seton, E. (1937). *Lives of game animals.* New York: The Literary Guild of America, Inc.

Simmons, N., Levy, S., & Levy, J. (1963). Observations of desert bighorn sheep lambing, Kofa Game Range, Arizona. *Journal of Mammalogy*, 44:433.

Stevenson, C., Donham, T., Cummings, P., & Hardenbrook, B. (No Date). Bighorn Sheep/Pronghorn Antelope Memo for the NTTR INRMP. Las Vegas, NV.

Sundstrom, C. (1969). Some Factors Influencing Pronghorn Antelope Distribution in the Red Desert of Wyoming. Western Association of Fish and Game Commissioners.

Symanski, R. (1994). Contested realities: feral horses in outback Australia. *84: 251-269*.

Taylor, R. (1976). Disease losses in Nevada bighorn. *Desert Bighorn Council Transactions*, 20:51-52.

Texas Parks and Wildlife. (2007). *Wildlife Mangagement*. Retrieved July 24, 2011, from Pronghorn Antelope: http://www.tpwd.state.tx.us/landwater/land/habitats/trans_pecos/big_game/pronghorn/.

Thomas, H. (1979). *The wild horse controversy.* New York: A.S. Barnes.

Tsukamoto, G. K. (2003). Nevada's Pronghorn Antelope: Ecology, Management and Conservation. Nevada Department of Wildlife.

Tsukamoto, G. K., Tanner, G., Beckstrand, K., Gilbertson, L., Mortimore, C., & Himes, J. (2003). *Nevada's Pronghorn Antelope: Ecology Management and Conservation.* Reno Nevada: Nevada Department of Wildlife.

Turner, J. C., & Weaver, R. A. (1980). Water. In G. Monson, & L. Sumner, *The Desert Bighorn: Its Life History, Ecology, and Management* (pp. 100-112). Tucson: University of Arizona Press.

Turner, J., & Hansen, C. (1980). Reproduction. In G. Monson, & L. Sumner, *The Desert Bighorn: Its Life History, Ecology and Management* (pp. 145-151). Tucson: The University of Arizona Press.

U.S. Air Force. (2017). Plant Community Mapping for the Nevada Test and Training Range and Proposed Expansion Alternatives. Nellis AFB, NV: U.S. Air Force.

U.S. Department of the Interior. (2009). Environmental Assessment for Limiting Mountain Lion Predation on Desert Bighorn Sheep on the Kofa National Wildlife Refuge. http://mountainlion.org.

U.S. Fish & Wildlife Service. (2011). *Environmental Conservation Online System*. Retrieved June 13, 2016, from Species Profile: Desert Bighorn: http://ecos.fws.gov/speciesProfile/profile/speciesProfile.action?spcode=A0DR.

U.S. Fish and Wildlife Service. (1999). Endangered and threatened wildlife and plants; emergency rule to list the Sierra Nevada distinct populations segment of California bighorn sheep as endangered. Federal Register 64(75): 19300-19309.

U.S. Fish and Wildlife Service. (2000). *Recovery plan for bighorn sheep in the Peninsular Ranges, California.* Portland, OR: U.S. Fish and Wildlife Service.

U.S.Fish and Wildlife Service. (1998). *Final Revised Sonoran Pronghorn Recovery Plan.* Albuquerque, New Mexico.

USGS. (2017). *Alternative Wild Horse and Burro Survey Techniques*. Retrieved from USGS Fort Collins Science Center: https://www.fort.usgs.gov/WildHorsePopulations/AlternativeTech.

Utah Division of Wildlife Resources. (1999). Mule Deer.

Utah Division of Wildlife Resources. (2009). *Utah Pronghorn Statewide Management Plan.* Salt Lake City, UT: Utah Department of Natural Resources.

Utah State University Extension. (2005). *Mule Deer Habitat of the Western United States*. Retrieved June 2, 2017, from RS/GIS Laboratories: https://s3-us-west-2.amazonaws.com/rsgis-public/muledeer05/MuleDeerOfWesternUS.pdf.

Wagner, F. H. (1983). Status of wild horse and burro management on public rangelands. Washington, D.C.: Transactions of the Forty-eighth North American Wildlife and Natural Resource Conference, Wildlife Management Institute.

Wagner, G. (2000). Diet selection, activity patterns, and bioenergerics of bighorn ewes in central Idaho. Moscow, Idaho: University of Idaho.

Wasley, T. (2004). *Mule Deer Population Dynamics: Issues and Influences.* Reno, NV: Nevada Department of Wildlife.

Weaver, R. A. (1961). Bighorns and Coyotes. *Desert Bighorn Council Transactions*, 5:34-37.

Wehausen, J. (1996). Effects of mountain lion predation on bighorn sheep in the Sierra Nevada and Granite Mountains of California. *Wildlife Society Bulletin*, 24:471-479.

Wehausen, J. D. (1999). *Nelson Bighorn Sheep.* Bishop CA: White Mountain Research Station. Retrieved from https://www.blm.gov/ca/pdfs/cdd_pdfs/Bighorn1.PDF.

Werdelin, L., & Sanders, W. J. (2010). *Cenzoic Mammals of Africa.* Los Angeles and London: Univeristy of California Press. Retrieved from https://books.google.com/books?id=6c8lDQAAQBAJ&pg=PA718&lpg=PA718&dq=Churcher,+C.+1982.+Oldest+ass+recovered+from+Olduvai+Gorge.+Tanzania,+and+the+origin+of+asses.+Journal+of+Paleontology+56:1124-1132.&source=bl&ots=Lmwoj9CgON&sig=t_wvcRRZrzml7PFFlk8TXVyd.

Wisz, M. S., Hijmans, R. J., Peterson, A. T., Li, J., Graham, C. H., & Guisan, A. (2008). Effects of sample size on the performance of species distribution models. *Diversity and Distributions, 14*, 763-773.

Wolfe, M. L. (1980). Feral Horse Demography: A Preliminary Report. *Journal of Range Management, Vol. 33(5)*, Pages 354-360.

Yoakum, J. (1972). Antelope-vegetative relationships. Proceedings of the Antelope States Workshop.

Yoakum, J. (1978). Pronghorn. In J. Schmidt, & D. Gilbert, *Big Game of North America, Ecology and Management.* Harrisburg, PA: Stackpole Books.