Desert National Wildlife Refuge, Nevada
DESERT BIGHORN SHEEP
SPECIES MANAGEMENT PLAN

For the Period: October 1, 2020 to September 30, 2025

Prepared by an Interagency Management Team, including:

U.S. Fish and Wildlife Service: Desert National Wildlife Refuge, Nevada
U.S. Air Force: Nellis Air Force Base, Nevada
Nevada Department of Wildlife
U.S. Geological Survey

August 2020

Bighorn Management Plan Approval Signatures

Tony Wasley 9/3/2020

(Signature) (Date)

Tony Wasley
Director
Nevada Department of Wildlife

PAUL SOUZA Digitally signed by PAUL SOUZA
Date: 2020.09.10 10:46:28 -07'00'

(Signature) (Date)

Paul Souza
Regional Director, Pacific Southwest
U.S. Fish and Wildlife Service

Contents

PLAN SUMMARY

Name:	Desert National Wildlife Refuge: Desert Bighorn Sheep Management Plan
Geographic Scope:	Desert National Wildlife Refuge (Desert NWR), encompassing 1.6 million acres located in southern Nevada, just north of Las Vegas, and giving particular focus to the 49.9% of the Refuge that has been identified as desert bighorn sheep habitat.
Vision:	Desert NWR supports a viable metapopulation of desert bighorn sheep and, by meeting the species' requirements for habitat and ecosystem function, supports ecosystem, species, cultural and economic values of Desert NWR.
Contact Name:	Amy Sprunger, Manager, Desert National Wildlife Refuge
Address:	U.S. Fish & Wildlife Service (USFWS), Desert National Wildlife Refuge Complex, 4701 N. Torrey Pines Drive, Las Vegas, Nevada 89130
Plan Period:	October 1, 2020 to September 30, 2025
Brief Plan Summary:	Desert NWR is one of four refuges in the Desert National Wildlife Refuge Complex. The Refuge was established in 1936 primarily to preserve desert bighorn sheep and their habitat. The Refuge is managed by USFWS, with a portion co-managed with Nellis Air Force Base (Nellis AFB). In support of desert bighorn sheep conservation, USFWS and Nellis AFB work in close collaboration with the U.S. Geological Survey (USGS) and the Nevada Department of Wildlife (NDOW). The staff of Desert NWR recognized the need to address the long term comprehensive management of desert bighorn sheep. This species management plan (SMP) addresses this need and entails the refinement of desert bighorn sheep conservation goals and objectives as well as analysis of critical threats, strategies to address threats, and indicators to measure conservation progress. The SMP is a step down plan from the "Desert National Wildlife Refuge Complex Comprehensive Conservation Plan," which was finalized in 2009. [1] Implementation of the SMP will be coordinated by USFWS, in partnership with Nellis AFB, USGS, and NDOW. Together, these entities jointly developed the SMP (Appendix A) and are represented on an Interagency Management Team that will guide and support its execution. An annual work plan and a monitoring plan will be developed to lay out how the SMP will be implemented.

[1] The final CCP can be found at: https://www.fws.gov/refuge/Desert/what_we_do/planning.html

INTRODUCTION

Plan Purpose

Mature male (ram) desert bighorn sheep (*Ovis canadensis nelsoni*) (Photo: NDOW – Cameron Waithman)

The desert bighorn sheep (*Ovis canadensis nelsoni*) has long been a majestic and iconic symbol of the west, sacred to the Nuwuvi (Southern Paiutes),[2] and valued by sportspeople. Desert National Wildlife Refuge (Desert NWR or Refuge), the largest NWR in the contiguous United States (U.S.), was originally created in 1936 to conserve the desert bighorn sheep and its dwindling habitat. President Franklin D. Roosevelt signed Executive Order (EO) 7373 on May 20, 1936 for "the conservation and development of natural wildlife resources" (Appendix B). The area was generally considered the last stronghold of desert bighorn sheep and thought to hold at least 1000 animals. Today, Desert NWR continues to support a critically important population of desert bighorn sheep, under the management authority of the United States Fish and Wildlife Service (USFWS), in coordination with Nellis Air Force Base (Nellis AFB) and the Nevada Department of Wildlife (NDOW) and with the support of the United States Geological Survey (USGS).

The "Desert National Wildlife Refuge Complex Comprehensive Conservation Plan" (CCP; U.S. Fish and Wildlife Service, 2009) is the most recent guiding document for the management of Desert NWR and other refuges in the Desert NWR Refuge Complex (DNWRC). The CCP broadly defines five goals for the Refuge, the first of which states, "Maintain and, where necessary, restore healthy population levels of bighorn sheep on Desert NWR within each of the six major mountain ranges" (Box 1). The CCP also provides long-range guidance and management direction to achieve Refuge purposes. Resource management goals and objectives in the CCP are consistent with Desert NWR's status as a proposed wilderness and its management as *de facto* wilderness (Service Policy 610 FW 1).

To ensure that Desert NWR Goal 1 is achieved, Refuge staff recognized the need for a more detailed analysis of the threats and other factors affecting Desert NWR's bighorn sheep population, refinement of refuge goals and objectives regarding sheep, refinement of management strategies, and monitoring to track sheep conservation progress. These needs have been addressed through the development of this desert bighorn sheep Species Management Plan (SMP). As a step-down management plan from the CCP, the SMP serves as the Refuge's management plan for desert bighorn sheep and their habitat (Service Policy 620 FW 1). It lays out objectives and strategies to achieve Refuge Goal 1, given a limited set of resources. This SMP will have two supporting documents; the first is an annual work plan which

[2] The Nuwuvi (Southern Paiute) have had a connection to the Bighorn sheep and the lands they roam from time immemorial. Nuwuvi oral history states that the Nuwuvi have been in the Southern Great Basin and Northern Mojave deserts since the beginning of time when the world was new (Spoon et al. 2013). In this ancestral homeland, the flora, fauna, and natural resources are sentient, interconnected, and have a purpose (Spoon and Arnold 2020). A Nuwuvi Elder stated, "One of our most sacred animals is the Nah'gah (mountain sheep). Legend tells us that they stepped forward to sacrifice their lives so we could survive when times were tough and food was scarce. They were one of the main food sources for the Nuwu. They are our protectors who watch over us through sickness, droughts, and the beauty of song they have gifted us through their power and energy" (Campbell 2018).

will detail specific activities to deliver on planned objectives and the second is a monitoring plan for tracking progress on the annual work plan and the SMP overall.

Box 1. The five goals for Desert NWR as described in the USFWS CCP.

Bighorn Sheep (Goal 1). Maintain and, where necessary, restore healthy population levels of bighorn sheep on Desert NWR within each of the six major mountain ranges.

Wildlife Diversity (Goal 2). Maintain the existing natural diversity of native wildlife and plants, including special-status species, at Desert NWR.

Specially designated Areas (Goal 3). Manage specially designated areas such that they augment the purposes of the Desert NWR.

Visitor Services (Goal 4). Provide visitors with opportunities to understand, appreciate, and enjoy the fragile Mojave/Great Basin Desert ecosystem.

Cultural Resources (Goal 5). Manage cultural resources for their educational, scientific, and traditional cultural values for the benefit of present and future generations of refuge users, communities, and culturally affiliated tribes.

The Interagency Management Team

Based upon their shared responsibility for and commitment to maintaining a healthy population of desert bighorn sheep on Desert NWR, four key agencies worked together to develop this management plan. These agencies play important roles in ensuring the effective management of Desert NWR and its bighorn sheep during this plan period and beyond. These agencies include:

- **USFWS**, represented by the Desert NWR Manager and the Wildlife Biologist as well as the Project Leader for the Complex (four national wildlife refuges in Southern Nevada). USFWS is the lead agency in this process with a primary role of ensuring the protection of habitat for all wildlife and the effective management of the Refuge as a whole, per legislative authorities.
- **NDOW,** represented by the southern Nevada bighorn sheep biologist. NDOW has primary jurisdiction over management of the desert bighorn sheep population in Nevada. Although this jurisdiction supersedes that of USFWS, bighorn sheep management activities are planned and carried out in close cooperation with USFWS.
- **Nellis AFB,** represented by the Environmental Assessments Section Chief and Natural Resources Manager(s). Nellis AFB environmental staff work to ensure natural resources are managed, effectively enabling the military mission. Natural resource programs at Department of Defense (DoD) installations are authorized by the Sikes Act, 16 United States Code (USC) 670. As a result, Nellis AFB developed an Integrated Natural Resource Management Plan (INRMP) for ecosystem and natural resource management (Nellis AFB 2019). USFWS, Desert NWR, and NDOW were cooperating agencies in the development of and are signatories to the INRMP.
- **USGS**, represented by the Research Wildlife Biologist from the Western Ecological Research Center. The mission of the USGS is to provide science support to Department of Interior (DOI) agencies. The wildlife biologist supports desert bighorn sheep research and monitoring activities, in collaboration with NDOW and USFWS.

While USFWS has primary responsibility for coordinating activities necessary to fully implement this plan, attainment of the objectives laid out herein will require integrated action by all involved agencies.

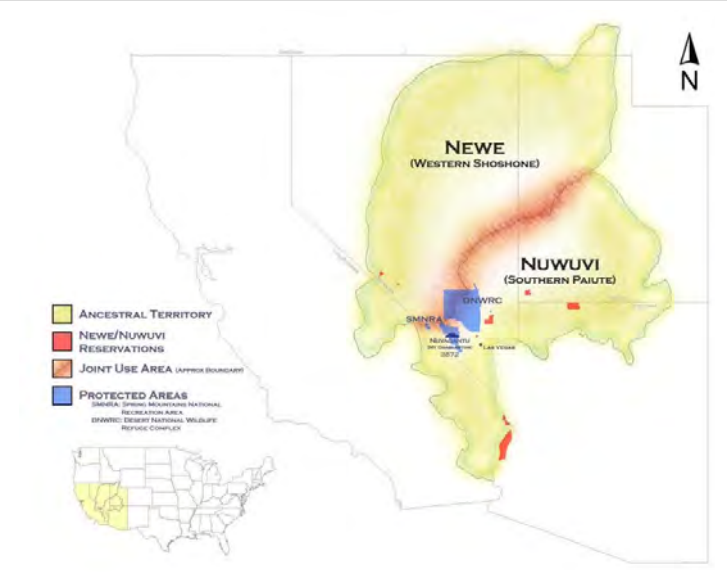
This plan therefore includes the full suite of management strategies required to maintain the desert bighorn sheep population and indicates which agency will take the lead on which elements. Additionally, a first milestone in the advancement of the strategies outlined herein is convening multi-stakeholder coordination teams.

Additionally, the successful implementation of this plan will rely on the buy-in and support of an array of other stakeholders, including leadership and technical support departments of the coordinating agencies and the Fraternity of the Desert Bighorn, which supports water provisioning on the Refuge. As such, the draft of this SMP was shared with DOI Unified Interior Region 8 and 10 leadership, NDOW, expert advisors, Nuwuvi, and other stakeholders for their input. Stakeholders were individuals, groups, or institutions with a vested interest in the natural resources of the Desert NWR or who may be affected by Refuge management activities or changes to Refuge conditions. The plan will be approved by the Director of the Nevada Department of Wildlife and the Regional Chief of the National Wildlife Refuge System, DOI Unified Interior Region 8 and 10.

BACKGROUND

A Brief History of Desert NWR

Desert NWR is one of 568 national wildlife refuges of the USFWS National Wildlife Refuge System (Refuge System), and one of four refuges in the DNWRC. The Refuge is located within the ancestral territory of Newe and Nuwuvi people (Map 1) and encompasses 1.6 million acres of rugged mountain ranges and panoramic valleys in Clark and Lincoln counties (Figure 1). Desert NWR includes six distinct mountain ranges and varies in elevation from 2,515 feet to 9,911 feet. These include, from west to east, the Spotted Range, the Pintwater Range, the Desert Range, the East Desert Range, the Sheep Range, and the Las Vegas Range (Map 2). Broad gradients in elevation, temperature and precipitation give rise to seven life zones that support diverse plant and animal communities within the Mojave and Great Basin Desert ecosystems.

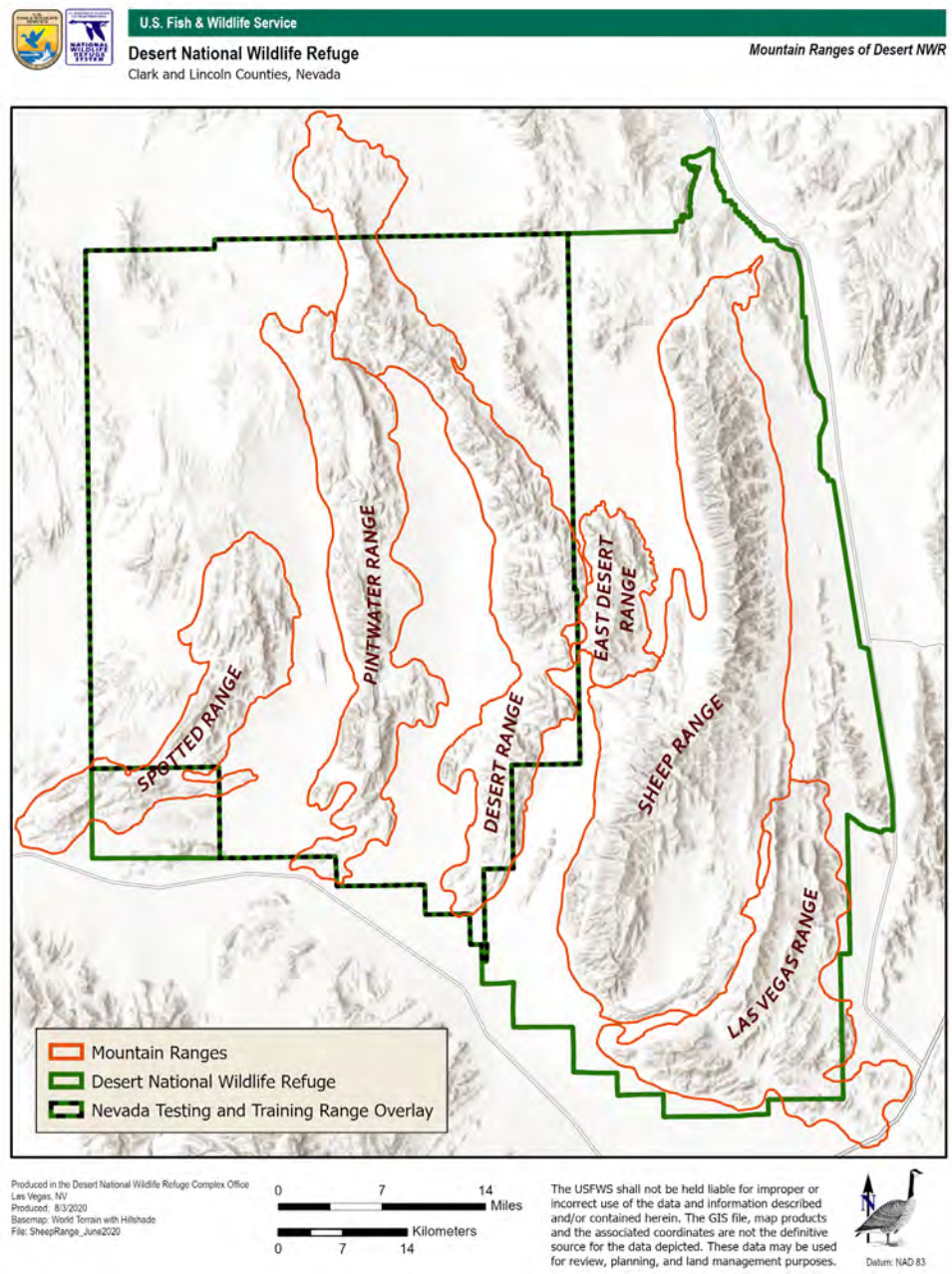


Map 1. The ancestral territory of the Newe and Nuwuvi (map: Spoon 2014).

Established in 1936, the Desert Game Range (the Range), as it was originally called, encompassed 2.25 million acres and was originally under the joint administration of the Bureau of Sport Fisheries and Wildlife (the USFWS predecessor) and the Bureau of Land Management (BLM). It included most of the lands within the current Refuge boundary but stretched south and west to include part of the Spring Mountains and present-day Red Rock Canyon National Conservation Area. The Range was reduced to its current size in Public Land Order (PLO) 4079, and through this reduction renamed the Desert National Wildlife Range (still the official name, although it is typically referred to as the Refuge). From 1936-1966,

cattle grazing was permitted in coordination with BLM; however, there were many disputes between the two agencies due to conflicting missions. Additionally, Las Vegas was rapidly growing, and recreation-based conflicts with the USFWS mission were abundant in the Spring Mountains. Through PLO 4079, the USFWS divested itself of incompatible recreational and grazing uses on approximately 1.6 million acres.

In 1940, through Executive Order 8578, President Roosevelt established the Las Vegas Bombing and Gunnery Range, now known as the Nevada Test and Training Range (NTTR, since 2003), for use as an armament and high hazard testing area; for training for aerial gunnery, rocketry, electronic warfare, and tactical maneuvering and air support; for equipment and tactics development and testing; and for other defense-related purposes. Approximately 2.9 million acres of public land were withdrawn from public



Map 2. Desert NWR, showing the six mountain ranges and the NTTR (map: USFWS)

use, including approximately 846,000-acres located within the Desert NWR. That area is co-managed by USFWS and the U.S. Air Force and is referred to as the Joint-Use Area (JUA). The most recent NTTR withdrawal was authorized in October 1999 by Title III, Subtitle A Sec. 3011(b)(3) of Public Law 106-65, the National Defense Authorization Act for Fiscal Year 2000 and was extended through November 2021 by the Military Lands Withdrawal Act of 1999 (Pub. L. 106-65).

Under the Act, the Service retained primary jurisdiction over the JUA except for 112,000 acres of bombing impact areas, where primary jurisdiction was transferred to USAF. The NTTR is the largest military training complex in the western hemisphere, and the South Range, or "Desert NWR overlay," as it is sometimes called, has remained largely undisturbed over all but the 112,000 acres of bombing area. The USAF restricts access to the JUA for safety and security purposes, although public access is provided to approximately 500,000 acres for a two-week bighorn sheep hunt (managed by NDOW). Nellis AFB, per the 1999 Military Lands Withdrawal Act, also provides helicopter time to USFWS annually in support of desert bighorn sheep surveys, in coordination with the Nevada Department of Wildlife (NDOW).

A formal renewal process is underway, entitled *Nevada Test and Training Range Land Withdrawal Process and Legislative Environmental Impact Statement.* The process is described here, and includes a Legislative Environmental Impact Statement (LEIS) and a public consultation, among other steps. The request for renewal was submitted to the BLM and the decision on the final action will be made by Congress and written into law. Details concerning the proposal to renew and expand the NTTR are available on nttrleis.com, including Notices of Availability, Intent, BLM Segregation Notice, and maps. A full account of the history of Desert NWR and land use and jurisdictional changes is found in Annex A.

A Brief History of Desert Bighorn Sheep on Desert NWR[3]

In the early decades since Desert NWR was established, it was thought that the desert bighorn sheep population within the Refuge remained stable. Early population estimates, based on empirical observations and waterhole count data (Deming, 1947), were on the order of 1,000 to 1,200. Given the limited number and distribution of water sources, most of the population inhabited the Sheep Range. It was believed that in this early period, bighorn sheep distribution, abundance, and seasonal movements were similar to historic metrics, largely uninfluenced by human presence and activities.

Elsewhere across the western states, numerous desert bighorn sheep population declines and extirpations due to human influences helped shape a common and enduring understanding that the species was in serious decline. This stark reality was the impetus for not only the creation of the Desert Game Range but also for how the Refuge would be managed. Fundamentally, it was thought that the Refuge was underpopulated with sheep, and relatedly, an expectation existed that the population would substantially increase under focused management. Early on, and principally in view of the available water resources, it was felt that the habitat conditions on the Sheep Range and Pintwater Range would support and ensure bighorn viability and persistence on the Refuge. It was recognized that bighorn population size scaled with what was termed "year-long habitat:" areas that included reliable water sources that would support bighorn sheep through summer months, in contrast to cool season use areas. Thus, it was understood that during the cool season, bighorn sheep would disperse from what were termed key areas on the Sheep Range and Pintwater Range to other mountain ranges. Early management concepts, therefore, were to maintain and increase core subpopulations of bighorn sheep

[3] To the extent possible, information in this section is cited. It is complemented by historic records and information and by NDOW federal aid job progress and status reports and USFWS quarterly and annual narratives. In these cases, citations are sometimes not possible.

on the Sheep Range and Pintwater Range, and to continue with a newly initiated spring development program. Also envisioned at this time was construction of catchment basins and reservoirs in the Desert Range and the Spotted Range, with the goal of converting seasonal use areas to year-long habitats to the maximum extent possible (Deming, 1947).

In 1970, field techniques in collecting desert bighorn sheep population data were enhanced using helicopters, which allowed biologists to obtain larger and more accurate bighorn sheep population data sets over larger areas with far less effort and time expended. Based on data from helicopter surveys, the bighorn sheep population on the Sheep Range precipitously declined from 1,133 individuals in 1988 to approximately 217 in 1992 (Tsukamoto 1993). There were two plausible causes for the decline—excessive mountain lion predation or a disease outbreak—although neither cause was supported definitively at that time. In the several years following the decline, the herd failed to show signs of recovery. Nevada sportsmen familiar with the once magnificent herd and dissatisfied with the loss of bighorn sheep hunting opportunities, began to pressure the NDOW and USFWS officials to hasten recovery efforts. This compelled wildlife officials to capture 35 bighorn sheep from northeast Clark County in the Muddy Mountains and the Arrow Canyon Range, and from southern Nye County in the Specter Range, and release them in the mouth of Joe May Canyon on the southwest end of the Sheep Range. The release failed to spark the recovery of the population, as mountain lion predation losses among members in the release contingent were high. Some Nevada hunters who thought mountain lion predation was the original cause of the bighorn sheep population decline were deeply angered by the predation losses sustained by the release contingent and were further angered that no mountain lion control treatments were undertaken. At the time, Refuge and NDOW biologists were mindful that the release complement was comprised of bighorn sheep from lower elevation ranges that neither supported mule deer (*Odocoileus hemionus*) populations, nor resident mountain lions (Wehausen 1996, Kamler et al. 2002), and reasoned that not only were the released bighorn sheep unfamiliar with a very different mountain range but also naïve to mountain lions.

In 2010, a study was initiated to assess factors that may have caused the original population decline in the Sheep Range and to understand the potential causes of the current depressed population numbers. Study results found a large proportion of the animals tested positive for exposure to *Mycoplasma ovipneumoniae*, known to cause high mortality in bighorn sheep populations. At the time of the study, predation by mountain lions did not appear to be having a major effect on the sheep population (Longshore et al. 2014).

Following the desert bighorn sheep die-off on the Sheep Range, progress was made on newer anthropogenic water development upgrades and new construction in the East Desert, Desert, and Spotted Ranges. Formerly, none of these mountain ranges had perennial water sources, and as such were cool season use areas. It has become evident in recent decades that most of the sheep on the Refuge are dependent not on reliable, perennial spring sources but rather on completely artificial systems. Therefore, maintaining the sheep population requires maintaining these systems, which have the inherent and inevitable problem of regular component failures.

Typically, desert bighorn sheep population estimates are generated annually in April and published in May. Estimates for 2020 show that the bighorn sheep population on Desert NWR has returned to approximately 900 individuals, although with noteworthy differences in distribution and abundance (NDOW 2020). The number of bighorn sheep inhabiting the Sheep Range is well below the 1988 estimate of 1,133 sheep (Tsukamoto 1993), with a current estimate of the Sheep Range population at 220 (NDOW 2020). Water developments now support more bighorn sheep in formerly seasonal use areas across the Refuge. Due to the manipulation of water availability, a minor proportion of bighorn sheep that occupy the Sheep Range continue historic cool season movements to adjacent lower

elevation ranges. More information on the seasonal movements of sheep in relation to water sources is found in the Sheep Habitat section under Priority Resources of Concern.

PLAN SCOPE AND VISION

Scope

The geographic scope of this SMP encompasses the entirety of the Desert NWR's 1.6 million acres, including the overlaid portion of the NTTR and giving particular focus to the 49.9% of the Refuge that has been identified as desert bighorn sheep habitat.

Desert NWR is located in a transition zone between the Mojave and Great Basin Deserts. It encompasses typical basin and range topography—a series of six narrow north/south-trending mountain ranges separated by wide valleys. As mentioned previously, the mountain ranges include, from west to east, the Spotted Range, the Pintwater Range, the Desert Range, the East Desert Range, the Sheep Range, and the Las Vegas Range. Elevations of Desert NWR extend from 2,515 feet to 9,911 feet atop Hayford Peak in the Sheep Range. Most of Desert NWR consists of closed hydrographic basins (basins that have interior drainage).

Beyond supporting a vitally important population of desert bighorn sheep, Desert NWR contains diverse flora and fauna found over a wide elevation range that are representative of both deserts. According to the Southwest regional gap analysis, the Refuge holds more than one-third of the 75 different ecological systems mapped in Nevada (Prior-Magee, et al., 2007). The predominant communities are desert shrubland and montane, with a small amount of riparian, wetland, and aquatic habitats along Corn Creek (Ackerman 2003). Ackerman (2003) identified 702 plant species in 80 families within the Desert NWR, including three plant species that are endemic to the Desert NWR. Additionally, approximately 320 bird species, 53 mammal species, 35 reptile species, and four amphibian species have been identified in the different communities on the Desert NWR (USFWS 2009).

USFWS and Nellis AFB recognize, per the Public Trust Doctrine and National Wildlife Refuge System Administration Act (16 U.S. Code § 668dd(m)), the State of Nevada has primary ownership and management jurisdiction over desert bighorn sheep populations, in trust for the people, within the Desert NWR. Nothing within the Desert NWR SMP diminishes those state rights and desert bighorn population management goals herein are in accordance with management goals of the State of Nevada.

Vision

Desert NWR supports a viable metapopulation[4] of desert bighorn sheep and, by meeting the species' requirements for habitat and ecosystem function, supports ecosystem, species, cultural and economic values of Desert NWR.

Desert NWR and the species and ecosystems it supports have remained largely undisturbed by human activity. The Refuge represents the largest intact and largely undisturbed habitat for desert bighorn sheep in the Mojave and Great Basin deserts. Given present and potential future impacts of the highest priority threats identified, including disease, climate change, water scarcity, soil/air/water contamination, and small-holder grazing and ranching, effective management of Desert NWR is

[4] The desert bighorn sheep population is considered a metapopulation because it is comprised of small subpopulations that are connected by sheep movements among the mountain ranges.

fundamental to ensuring the long-term persistence of this intrinsically, culturally, and economically important flagship game species.

Desert's bighorn sheep population is connected to the broader remaining metapopulation of bighorn sheep across its historic range. In the face of climate change, Desert NWR will play a critical role for sheep conservation; as average annual temperatures warm, sheep will require and move to higher elevation areas. Furthermore, given the sheep's role as a landscape species, ongoing efforts to ensure its conservation help maintain the numerous other species that reside in the Refuge. If a healthy sheep population is maintained on Desert NWR, this is a credible indicator of the health of the Refuge as a whole.

PRIORITY RESOURCES OF CONCERN AND CONSERVATION GOALS

Two priority resources of concern have been selected as the focus of this management plan: 1) desert bighorn sheep and 2) habitat that supports desert bighorn sheep. To determine the desired future state of these targets, (i.e., the ultimate goals of this plan), a target viability assessment was conducted to define key characteristics of each target that must be maintained in good condition in order for the target to be conserved. Each target, the viability assessment, and the resulting goals that were defined are described below.

Priority Resources of Concern

Desert bighorn sheep *are the primary conservation target and Resource of Concern (ROC) of Desert NWR. The current Refuge-wide population estimate is 900 and is comprised of six subpopulations: Spotted 160, Pintwater 200, Desert 150, East Desert & Sheep 220, and Las Vegas 170 (Nevada Department of Wildlife 2020, pp. 94-98, A-53).*

Lambs in the safety of rugged terrain (Photo: NDOW – Craig Stevenson)

An overview of the natural history of desert bighorn sheep is provided below.

Taxonomy and Uniqueness

- **Desert bighorn sheep are desert-adapted ungulates that inhabit mountain ranges in arid regions of the western and southwestern U.S. and Mexico (Bleich et al. 1996).** They are habitat specialists that select for steep, rocky terrain with open visibility, i.e., escape terrain, to detect and escape predators (Hanson, 1980; Elenowitz 1984; Gionfriddo and Krausman 1986). Their short, stocky bodies have a low center of gravity that is well adapted for maneuvering quickly on escape terrain. Desert bighorn sheep in southern Nevada occupy mountain ranges as permanent residents where perennial water sources are available. Vegetative associations in bighorn habitat range from upland pinyon (Pinus edulis) - juniper (*Juniperus* spp.) to desert scrub (e.g., creosote [*Larrea tridentata*] - white bursage [*Ambrosia dumosa*]) (Hansen 1980; Krausman et al. 1999).

  Based on morphometric analyses by Cowan (1940), bighorn sheep from the southwest desert region were traditionally divided into four subspecies, *O. c. nelsoni*, *O. c. mexicana*, and *O.c.*

weemsii and *O.c. cremnobates*. However, more recent evidence from genetic analyses and morphometric measures by Wehausen and Ramey (1993), Ramey (1993, 1995), and Gutierrez-Espeleta et al. (2002) found little support for Cowan's (1940) subspecies. Desert bighorn sheep are now considered to be one polytypic subspecies (*Ovis canadensis nelsoni*).

Metapopulation Dynamics

- **Desert bighorn sheep occur across the landscape as small subpopulations that are connected by sheep movements between mountain ranges.** This metapopulation-like distribution is due to the patchy distribution of their preferred habitat and results in frequent extinction and recolonization of populations (Bleich et al., 1990; Schwartz et al., 1986; Epps et al., 2010). The metapopulation approach to population ecology of desert bighorn sheep recognizes the critical nature of gene flow and colonization, and that important dynamics occur at a metapopulation level in addition to individual populations (Schwartz et al., 1986, Bleich et al., 1990). Two types of migration processes occur in metapopulations. One is the migration of genes between populations, which plays an important role in maintenance of genetic diversity. Migration by both sexes contribute to this gene flow, but male movements can be the dominant source. The second migration process involves the colonization of habitat vacated by the extinction of a population (Epps et al., 2010). This requires migration by both sexes, and for the metapopulation to persist, the colonization rate must exceed the extinction rate (Hanski, 1991). The long-term persistence of desert bighorn sheep metapopulations depends upon movement corridors between populations due to the critical nature of gene flow and colonization (Bleich et al., 1990; Epps et al., 2010). An important consideration from a conservation standpoint is the long-term viability of the entire metapopulation rather than that of individual populations. However, sheep movements between mountain ranges may act as a double-edged sword if these movements also increase the spread of disease.

Life History

- **Bighorn sheep are highly polygynous ungulates.** Male reproductive success is related to rank and fighting ability (Geist, 1971; Hogg, 1984, 1987). The sexes loosely segregate during much of the year but come together during the breeding period, or rut (Geist, 1971; Bleich et at. 1997). Males exhibit a highly linear hierarchy based on age (Hass and Jenni, 1991), while females exhibit a stable, non-linear hierarchy correlated with age (Hass, 1991). Movement patterns and habits of ewes are learned by their lambs as they follow their dam across the landscape (Geist, 1971). Ewes that share the same portion of a mountain range are likely to be more closely related to each other than they are to other ewes (Festa-Bianchet, 1991; Boyce et at., 1999). These related ewes are often referred to as "ewe groups". Rams tend to range more widely but may follow the same travel routes year after year (Geist, 1971; Wehausen, 1980; DeForge et at., 1997).
- **Ewes reach sexual maturity at 2.5 years, but under good forage conditions, may occasionally reach sexual maturity as yearlings. Rams reach sexual maturity at the same age but are unlikely to mate until they are older and larger.** Young rams generally stay with ewe groups until they reach two to four years of age, when they follow older rams away from their natal group during the mating season, or rut, and often return after this period (Geist, 1971; Festa-Bianchet, 1991). During the rut, rams join the ewe groups and compete to breed with receptive ewes. The largest, oldest, rams presumably are the most successful breeders, but smaller rams have been reported to breed as well (Hogg, 1984).
- **A recruitment rate of 25-30 lambs/100 ewes is common in static populations, less than 20 lambs/100 ewes is considered a declining population.** Bighorn sheep primarily give birth to single

young and have a low incidence of twins (Buechner, 1960). However, under some conditions, the rate of twinning may be higher than previously recognized (Spalding, 1966; Eccles and Shackleton, 1979). Gestation is 5.5 to 6.0 months. Bighorn sheep occupying warmer desert mountain ranges typically have extended lambing seasons (Hass, 1997; Rubin et al., 2000; Wehausen, 2005). For most desert bighorn populations in southern Nevada, the rut peaks during summer months (Hass, 1997). Most lambs are born from late winter months through spring, but ewes can lamb year-round (Hass, 1997).

Activity Patterns

- **Bighorn sheep are primarily diurnal but may be active at any time of day or night** (Miller et al., 1984; Krausman et al., 1985; Longshore et al., 2009). Daily activity patterns generally consist of short bedding periods that alternate with feeding periods (Chilelli and Krausman, 1981; Krausman et al., 1985). Feeding activity is generally highest during early morning (0500-0700 Pacific Standard Time) and early evening hours (1600-2000), and is lowest during midday (Chilelli and Krausman, 1981; Krausman et al., 1985).

Forage

- **Bighorn sheep physiology allows for a flexible diet.** They are ruminant herbivores that have a large rumen and reticulum relative to their body weight (Krausman et al., 1993). They consume a number of species and types of plants and can digest graminoids (grasses, sedges, and rushes) in all phenological stages (Hanley, 1982). Thus, species composition of the diet varies greatly seasonally and regionally and can range from largely graminoids and forbs to predominantly browse (Krausman et al., 1989).

Mortality Factors

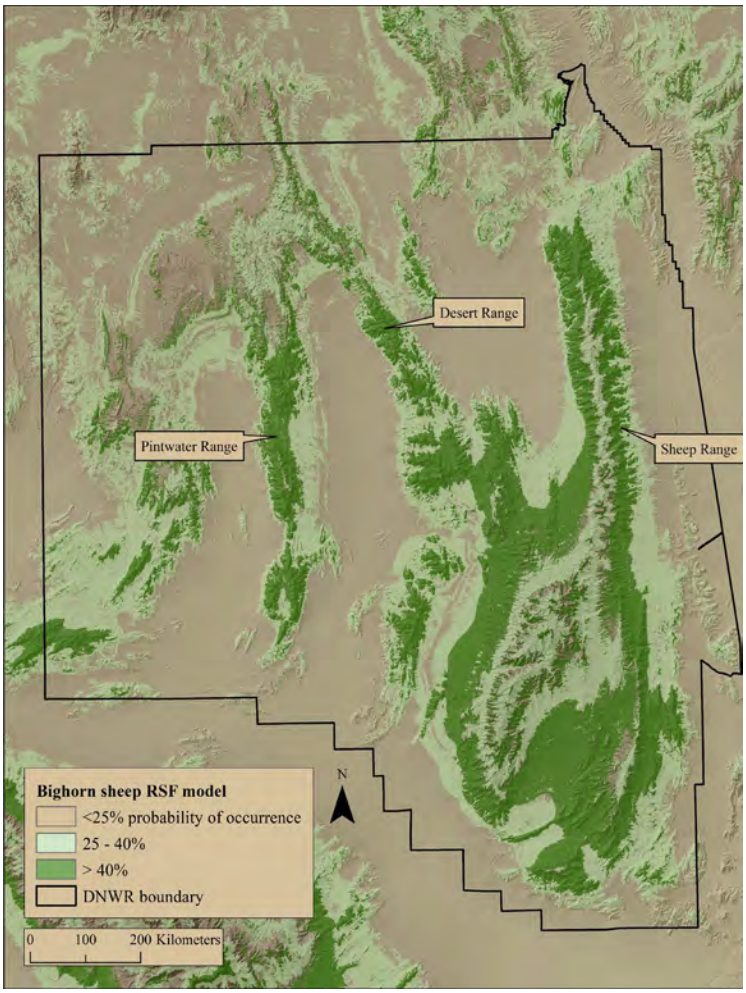
- **Bighorn sheep die from a variety of causes, including disease, predation, and accidents.** Pathogens that impact the health and success of bighorn sheep populations include infectious bovine rhinotracheitis , bovine respiratory syncytial virus , parainfluenza 3 -, leptospirosis, epizootic hemorrhagic disease bluetongue, anaplasmosis, contagious ecthyma, or sore mouth, scabies (caused by infestations of *Psoroptes mites*), sinusitis (infestations of nasal bot fly larvae), malignant catarrhal fever, sinus tumor, keratoconjunctivitis, and respiratory disease (i.e., pneumonia; from a bacterial complex, including, *Bibersteinia trehalosi, Mannheimia haemolytica, and Mycoplasma ovipneumoniae, [M. ovi]*) (Allen, 1980; Dubay et al., 2002; Miller et al., 2012; Fox et al., 2016). Of these pathogens, respiratory disease has had the greatest impact on sheep populations.

  Predators of desert bighorn sheep in the Mojave Desert include mountain lions (*Puma concolar*), coyotes (*Canis latrans*), bobcats (*Lynx rufus*), and golden eagles (*Aquila chrysaetos*) (see review: Sawyer and Linzey 2002). Coyotes and eagles primarily prey on young bighorn (Harrison and Hebert 1988, Hass 1989), mountain lions prey on both adults and young (Sawyer and Linzey 2002). Mountain lions can be the primary predator where sheep range overlaps, or is immediately adjacent to, mule deer habitat (Wehausen 1996, Kamler et al. 2002). Significant losses of bighorn sheep have been attributed to relatively few mountain lions that may have shifted their prey selection to focus more on bighorn sheep (Ross et al. 1997, Ernest et al. 2002, McKinney et al. 2010). When this occurs, mountain lions can cause population-level declines by greatly depressing annual adult survivorship (Wehausen 1996, Hayes et al. 2000, Rominger et al. 2004). In healthy populations of bighorn sheep, adult survival is stable and characteristically high (Gaillard et al. 1998). Where population dynamics are impacted by mountain lion predation, adult survival is much lower. For example, in Arizona, adult survival of bighorn sheep populations impacted by mountain lion predation ranged from 0.42 to 0.83, with lowest survival occurring during drought years

(Kamler et al 2002). In the Sheep Range, adult survival for 30 adult bighorn sheep radiomarked from 2010 to 2012 was relatively high (0.92, unpublished data), suggesting that during this time, mountain lions were not a major cause of mortality.

Desert bighorn sheep habitat. *The second conservation target of this management plan is desert bighorn sheep habitat, which encompasses approximately 50% (816,930 acres of the Desert NWR (Map 3). Currently, the desert bighorn sheep's habitat across the Refuge is extensive, largely intact, in good condition, and stable, which makes it a very high value location for conservation of the species within its remaining range.*

- **Escape terrain is considered one of the most critical habitat requirements**, and has been quantified using various measures of slope (minimum of 60% slope; Holl and Bleich 1983, Smith et al. 1991, Turner et al. 2004), ruggedness (Bleich et al. 1997, Andrews et al. 1999, Sappington et al. 2007), or a combination of both (McKinney et al. 2003; Sappington et al. 2007, Longshore et al. 2009). Use of escape terrain varies between the sexes, with ewes preferring steeper, more rugged terrain than do rams. Use of escape terrain by ewes is most critical during the lambing period (Bangs et al. 2005). During much of the year male and female desert bighorn sheep are mostly found in separate groups and often select different habitats (Wehausen 1980, Bleich et al. 1997, Ruckstuhl 1998; Mooring et al. 2003). Female desert bighorn select habitat with more escape terrain than males, but males are often in habitat with better quality forage (Bleich et al. 1997).



Map 3. Probability of occurrence of desert bighorn sheep across Desert NWR. Map is based upon a resource selection function (RSF) model constructed from a logistic regression model that describes sheep habitat use on the Refuge. The model is based on GPS locations from 30 sheep (15 females, 15 males) radiomarked from 2010-2012 (see Longshore et al. 2014 for detailed methods).

Before parturition, and for a few days after giving birth, desert bighorn sheep females sequester themselves on escape terrain (Bangs et al. 2005, Karsh et al. 2016). Following the birthing period, ewes remain on escape terrain with their lambs. Steeper terrain used during the early lamb rearing period is often referred to as lambing habitat. Groups of ewes with young lambs may congregate in

nursery groups; ewes leave groups of lambs on escape terrain while they feed nearby in less steep terrain with higher forage quality. Habitat selection by males is for less steep and rugged terrain, but overlaps habitat used by females during the breeding season in summer and early fall (Bleich et al. 1997).

- **Water is a critical habitat component for bighorn sheep in the Mojave Desert, particularly during dry summer months** (Bleich et al.1997, Turner et al. 2004, Longshore et al. 2009). The presence of permanent water sources is strongly correlated with the persistence of bighorn sheep populations (Epps et al. 2004). In southern Nevada, bighorn sheep occupy mountain ranges as permanent residents only where perennial water sources are available. During cooler months of the year, desert bighorn sheep meet their water needs from the forage they consume and may seldom drink water (Turner 1973, Bleich et al. 1997). During hot, dry summer months, they regularly visit springs and other sources of water to drink. They typically begin shifting their distribution toward areas with surface water in May or June, depending on temperature, elevation, and the abundance and persistence of spring forage. Full use of water typically begins when daily maximum temperatures reach about 38º C (100º F) and then declines at the end of the hot season coincident with declining high temperatures and rainfall (Leslie and Douglas 1980). Summer home ranges typically include only habitat within a relatively short distance (within 2-3 miles) from water (Blong and Pollard 1968, Leslie and Douglas 1979, Cunningham and Ohmart 1986, Krausman et al. 1999, Longshore et al. 2009). During the heat of summer, females typically come to water to drink about once every three days, but that can vary with temperature and some ewes, particularly those with lambs, may drink every day. Water use may continue into winter if forage remains dry due to lack of rain (Leslie and Douglas 1979).
- **Visibility has long been recognized as an important characteristic of bighorn habitat** because predator evasion behavior depends on the ability to visually detect predators at a distance (Risenhoover and Bailey 1985). Areas of high visibility (i.e., poor predator concealment cover) are associated with increased foraging efficiency, while areas where dense vegetation reduces visibility are generally avoided (Risenhoover and Bailey 1985, Etchberger et al. 1989). Bighorn sheep under conditions of low visibility are found to have increased heart rates (Hayes et al. 1994).

Target Viability Assessment

Target viability assessment measures the status of a priority ROC over time in terms of specific key ecological attributes (KEAs) of that ROC. Each KEA represents a characteristic of the ROC such as population size or habitat extent. The viability assessment then defines indicators of status of each KEA, the range of likely variation for each indicator, and the desired state of each indicator. In more general terms, such an assessment helps to establish a description of the current and desired status of an ROC, which informs the setting of conservation goals and measurement of progress.

A viability assessment of the priority ROCs, desert bighorn sheep and sheep habitat, was conducted to identify and describe: 1) what poor to very good state of these ROCs would look like, 2) their current state, and 3) their goal state on Desert NWR. Tables 1 and 2 present the target viability assessments for the priority ROCs of desert bighorn sheep and sheep habitat. We note that the KEA lists are not exhaustive but reflect the priority characteristics of each ROC that would best indicate the state of sheep and their habitat.

We identified KEAs and related indicators for each ROC and used this information to develop viability scales. Viability scales indicate ROC health, in terms of indicators, on a scale of Poor to Very Good:

- **Very Good**: ecologically desirable status; requires little intervention for maintenance

- **Good**: indicator within acceptable range of variation; requires some investigation, or intervention, for maintenance
- **Fair**: outside acceptable range of variation; triggers investigation or human intervention
- **Poor**: restoration increasingly difficult; may result in extirpation of target

Recognizing that important information gaps remain regarding assessing and monitoring the health of desert bighorn sheep and their habitat, several viability scale measures have been denoted as "To Be Determined (TBD)." The Team will strive to gather information and conduct research as needed to resolve these in the next several years.

Table 1. Key Viability Analysis for the Resource of Concern of DESERT BIGHORN SHEEP
(Note: Herein ranges are abbreviated as Pintwater (PW), Spotted (SP), Desert (Des), Sheep (SH), and Las Vegas (VEG))[5]

Key Ecological Attribute	Indicator[6]	Methodology	Poor State	Fair State	Good State	Very Good State	Baseline (2020 estimates)	Source & Date
Population Size	# (total) metapopulation	Aerial surveys and population modeling	Less than viable[7] = 1 subpopulation with <50 individuals	Minimal viable[8]= 1 subpopulation with at least 50 individuals	1020-1609	1610-1940	900	
	# in each subpopulation	Aerial surveys and population modeling	PW: 50 -99 SP: 50-99 DES: 50-99 SH: 100-199 VEG: 50-99	PW: 100-199 SP: 100-159 DES: 100-139 SH: 200-399 VEG: 100-119	PW: 200-279 SP: 160-179 DES: 140-179 SH: 400-799 VEG: 120-169	PW: 280-320 SP: 180-200[9] DES: 180-220 SH: 800-1000 VEG: 170-200	PW: ~200 SP: ~160 DES: ~150 SH: ~220 VEG: ~170	
Rate of Change	Adult Survival (annual)	Collaring sheep	≤79%	80-89%	90-95%	>95%	SH: 92% ± 4.9%	
	Recruitment (10-yr average)	Aerial surveys	<26 lambs/100 ewes	≥26-29 lambs/100 ewes	~30-33 lambs/100 ewes	≥34 lambs/100 ewes	PW: 39 ± 14.9 (SD)[10] SP: 26 ± 7.4 (SD) DES: 26 ± 10.6 (SD) SH: 23 ± 10.7 (SD) VEG: 34± 11.8 (SD)	
Connectivity/ Genetic heterogeneity	Allelic richness	Collecting and analysis of blood and pellet samples.	<4	<4 (relative to each subpopulation)	Current level (baseline)	Higher than baseline	PW: 5.3 SP: 4.2 DES/SH: 6.2 VEG: N/A (need more samples/data)	Wehausen and Jaeger 2012
	Gene flow/connectivity	Combination of measures of gene flow and corridors for animal movements between all populations	TBD: need to develop connectivity metric	TBD: need to develop connectivity metric	TBD: need to develop connectivity metric	TBD: need to develop connectivity metric	TBD: need to develop connectivity metric	Wehausen and Jaeger 2012

[5] This is a deviation from the CCP as it separates the East Desert and Desert Mountain Ranges. Within this SMP, the East Desert and Desert are grouped together as one mountain range. Recent sheep movement data has shown sheep do not use East Desert exclusively as other subpopulations on other mountain ranges do.

[6] The Interagency Management Team hopes to monitor all or most of these indicators, however, the top priorities that will serve as "vital signs" of population health are overall population and recruitment and water availability. If any of these were to fall into a "fair" state, that would trigger increased effort around investigation, research, and potentially management interventions.

[7] Except for Sheep range in which less than viable is <100 individuals and minimal viability is at least 200 individuals.

[8] Defined as having at 1 subpopulation with at least 100 individuals, except for Sheep range in which minimal viability is at least 200 individuals.

[9] V. Good range for Spotted range can increase maximum if a new water development is built.

[10] Recruitment data determined from 2010-2019 average.

Key Ecological Attribute	Indicator[11]	Methodology	Poor State	Fair State	Good State	Very Good State	Baseline	Source & Date
Health Status	Body Condition-pelage, illness, behavior, weight	Possible cooperative w/ hunters to collect data from harvested rams. Cameras to look at live animals.	TBD: need to develop health metric	TBD: need to develop health metric	TBD: need to develop health metric	TBD: need to develop health metric	TBD[12]	
	Disease-overall & *M. ovi*; parasite load	*M. ovi*. Using a combination of PCR and ELISA results.[13]	Polymerase chain reaction (PCR): ≥1% Enzyme-linked immunosorbent assay (ELISA): >50%	PCR: ≥1% ELISA: 40-50%	PCR: 0% ELISA: ≤40%	PCR: 0% ELISA: 0%	Sh PCR: 3.33% ELISA: 70%[14]	

*to be defined through CC analysis

[11] The Interagency Management Team hopes to monitor all or most of these indicators, however, the top priorities that will serve as "vital signs" of population health are overall population and recruitment and water availability. If any of these were to fall into a "fair" state, that would trigger increased effort around investigation, research, and potentially management interventions.

[12] Identified a need to create a body condition index or health matrix which will then populate this section.

[13] *M. ovi*. PCR and ELISA ranges based on Mojave *M. ovi*. strain, which is extremely virulent.

[14] Based on testing 30 individuals in 2010.

Table 2. Key Viability Analysis for the Resource of Concern of Desert Bighorn Sheep HABITAT

Key Ecological Attribute	Indicator	Methodology	Poor State	Fair State	Good State	V. Good State	Baseline	Source & Date
Forage Quality	Change of Plant Cover	Develop an index based on NDVI (Normalized Difference Vegetation Index) and GIS across mountain ranges.	TBD- based on index	TBD- based on index	TBD- based on index	Upper percentile of the curve based on the baseline.	Average variance over a 20 year period.	
	Index of Invasive plant species	Surveying key areas e.g. areas around water sources, disturbed areas, burns and sites across each mountain range	TBD- based on index	TBD- based on index	TBD- based on index	TBD- based on index	Determined by 2013 project by David Charlet, et al.	Charlet, D., Leary, P. J., Westenburg, C. 2013. Vegetation and Floristic Survey Desert National Wildlife Refuge, Clark and Lincoln Counties, Nevada.
	Time and length of green up	Develop an index based on NDVI (Normalized Difference Vegetation Index) and GIS across mountain ranges.	TBD- based on index	TBD- based on index	TBD- based on index	TBD- based on index	Average variance over a 20 year period.	
Water resources [15]	Density of active springs and manmade water catchments (guzzlers*) based on Water Management Plan	GIS location to measure distance between water sources Construction and maintenance of guzzlers	≤⅓ of all mountain ranges are in compliance with Water Management Plan	½ of all mountain ranges are in compliance with Water Management Plan	4/6 of all mountain ranges are in compliance with Water Management Plan	100% of mountain ranges are in compliance with Water Management Plan	Current status of water resources- Fair	
	Recharge and capacity of guzzlers and springs	Presence/depth measure of water in guzzlers via visual assessments and remote sensors. Build upon database of water resources to include recharge, capacity, condition, etc.	TBD	TBD	TBD	TBD	Current status	

[15] This KEA is based on dryer conditions, not meant to address extreme drought conditions. Need to develop a definition of drought based on drought indexes.

Key Ecological Attribute	Indicator	Methodology	Poor State	Fair State	Good State	V. Good State	Baseline	Source & Date
Intactness/Connectivity Vertical & horizontal movement corridors	Fragmentation index	GIS (e.g. Fragmentation index) development Circuit Scape and other methods Compile list of known corridors and identify corridors in use. Develop movement disturbance index that includes roads, trails, military activities	TBD for each mountain range- based on analysis of methodology	TBD for each mountain range- based on analysis of methodology	TBD for each mountain range- based on analysis of methodology	TBD for each mountain range- based on analysis of methodology	TBD for each mountain range- based on analysis of methodology	
	Presence of Infrastructure	Satellite data, GIS and (possibly) INRMP	TBD- based on analysis of methodology	TBD- based on analysis of methodology	TBD- based on analysis of methodology	TBD- based on analysis of methodology	Current Condition	
Intactness/Lambing Areas	Disturbance rates in key habitat for important lambing stages [16]	Develop necessary habitat modeling and back-dating for each stage (if possible) Identify potential sources of anthropogenic disturbances	TBD- based on methodology	TBD- based on methodology	TBD- based on methodology	TBD- based on methodology	Current Condition	

#Consider monitoring growth of invasives/monoculture; impact of climate and fire
*Are there any perverse effects of guzzlers, e.g. increased concentration of sheep or other wildlife, erosion of habitat where they exist

[16] Key lambing stages were determined to be pregnancy, parturition, 0-2 week-old neonate, lamb-rearing (end of spring).

Goals

Goals specify the desired state of a refuge ROC, in terms of their KEAs, over a specific unit of time. Goals also consider past patterns, current measures, and expectations of how environmental conditions will change over the next 15 years. Refuge goals are to be reviewed on an annual basis and refined, if needed, as new information becomes available or environmental conditions change (such as species range shifts in response to climate change).

Given the target viability assessment, the following 5-year goals have been set for this management plan. Effectiveness of management of sheep and their habitat will be tracked and ultimately assessed given the extent to which these goals are realized.

- **Sheep Goal:** Desert NWR supports a healthy, viable and thriving population of desert bighorn sheep, in perpetuity.[17]
    - Attainment of this goal requires maintaining a "good" or better population size, rate of change, extent of connectivity, and overall health, as per the indicators defined in the viability assessment.
- **Habitat Goal:** Sheep habitat quality and extent (*49.9% of the Refuge, approximately 815,000 acres or 3,306 km²)* are maintained at or better than the 2019 condition, in perpetuity.
    - Attainment of this goal requires maintaining a "good" or better plant diversity, water resources supply, and intactness for connectivity and lambing areas, as per the indicators defined in the viability assessment.

CONTEXT AND OBJECTIVES

Direct Threats

Direct threats are forces that presently or are likely to degrade a resource of concern and therefore require a management response to avoid or mitigate the threat. We identified current or potential direct threats to desert bighorn sheep and their habitat within Desert NWR (Table 3). We rated each threat based upon its current and likely future scope of influence and severity of impact on each target and given the results of that analysis, derived a summary ranking of the threats. Current and projected threats of greatest concern to desert bighorn sheep and their habitat on Desert NWR are disease, climate change, water scarcity, and contamination of soils, water, and air (Table 3). Brief summaries of the most critical threats are provided below. Additionally, Box 2 discusses two forces, predation and

[17] This goal differs somewhat from the Bighorn Sheep Goal in the CCP, which reads, "Bighorn Sheep (Goal 1). Maintain and, where necessary, restore healthy population levels of bighorn sheep on Desert National Wildlife Refuge within each of the six major mountain ranges." An associated objective reads, "Objective 1.1: Increase the bighorn sheep (Ovis canadensis nelsoni) populations in the Sheep Range up to 1,000 individuals, increase the East Desert Range up to 100 individuals, increase the Desert and Pintwater Range subpopulations up to 250 and 300 individuals each and maintain the remaining subpopulations at or near their current levels over the next 15 years." The population targets set in this SMP differ from those in the CCP because: 1) the CCP was written in 2009 using the data available at the time while the SMP is based on data available in 2020; 2) the subpopulation ranges for each "state" are based on water availability on each mountain range, with the assumption that an individual water development can support 40 sheep; and 3) the subpopulation estimates for each mountain range are based on water availability in a non-drought year, with the Spotted and Desert Ranges being the exceptions; the estimates for these ranges were lowered because the water sources available are all artificial.

hunting, that in fact cause bighorn sheep mortality but are not threats currently or in the foreseeable future.

This threats assessment was based upon the situation as of November 2019. The Interagency Management Team notes that should management authority change on the Refuge, in particular via the proposed NTTR withdrawal extension and expansion on Desert NWR, the severity of several threats would likely increase, negatively impacting the sheep population and its habitat. In such a case, this assessment, and the SMP overall, would need to be revised.

Table 3. Rating of key threats to bighorn sheep and their habitat in Desert NWR.

CONSERVATION TARGETS THREATS	Desert Bighorn Sheep	Sheep Habitat	Overall Rating of Threat
Disease (*M. ovi*)	HIGH	N/A	HIGH
Climate change (habitat change, decreased precipitation/drought, storms & flooding	MEDIUM	MEDIUM	MEDIUM
Water scarcity	MEDIUM	MEDIUM	MEDIUM
Soil/water/air contamination	MEDIUM	MEDIUM	MEDIUM
Small-holder grazing, ranching (disease)	MEDIUM	N/A	MEDIUM
Disruptions to connectivity (roads, fences, solar fields, permanent structures, impacts of military activities on movement patterns)	LOW	LOW	LOW
Fragmentation (roads, trails, fire)	LOW	LOW	LOW
Military waste, airborne waste, rec waste	LOW	LOW	LOW
Light pollution	LOW	LOW	LOW
Behavioral disturbance (from recreation, military activities (maneuvers, overflights, bombing, strafing)	LOW	N/A	LOW
Non-native species (Bromus sp., non-native grasses)	N/A	LOW	LOW
Predation	LOW	N/A	LOW
Overall Threat Level of Target	HIGH	MEDIUM	

- **Disease:** Of the various diseases that impact the health of bighorn sheep (see above), respiratory disease has had the greatest impact on bighorn sheep populations, contributing to massive declines and extinctions (Dassanayake et al. 2010, Besser et al. 2012). *M. ovi* is a primary causative agent driving epidemic respiratory disease (i.e., pneumonia) in bighorn sheep (Besser et al. 2013) and represents the most significant threat to desert bighorn sheep within Desert NWR and more broadly, across the range of the species. *M. ovi* is considered responsible for the severe population decline on the Sheep Range in the 1980's (Longshore et al. 2014). The primary pathogens involved in this pneumonia complex have been identified (Besser et al. 2013), but there is wide variability in herd response following infection that is not well understood (Cassirer et al. 2018). Anecdotal and experimental evidence suggests that pathogens associated with epizootic pneumonia (*M. ovi* in particular) may be introduced into bighorn sheep populations through contact with infected bighorn or domestic sheep or goats (Besser et al 2012). Mortality occurs as the result of pneumonia epizootics that affect all ages of bighorn sheep and from enzootic pneumonia that is characterized by sporadic or persistent high rates of pneumonia, primarily affecting lambs (Besser et al. 2008). After a die-off, 10-20% of the survivors may remain positive for *M. ovi*. These animals can become chronic shedders of the bacteria, passing it to other sheep. Evidence of a *M. ovi* flair-up in a population includes endemic lamb mortality at 30-90 days of age and endemic (sporadic) adult bronchopneumonia. Outcomes following a disease outbreak vary, ranging from little to no impact on health and

recruitment, to all age pneumonia die-offs, followed by years of pneumonia deaths in lambs (Besser et al. 2013). Reasons the severity of impact of disease differs among individuals or herds are largely unknown; key factors may include the strain(s) of *M. ovi* involved, presence of additional bacteria or other respiratory viruses, environmental conditions, and other emerging factors (e.g., paranasal sinus tumors). To date, there is no known cure for *M. ovi*-caused respiratory disease. Determining what impacting factors contribute to variation in herd response to respiratory disease, and how management actions can improve post-disease herd performance, is a key question for management of sheep on the Desert NWR and for sheep managers across North America.

- **Water scarcity:** In the mountain ranges on the DNWR, water availability is limited in distribution and reliability. There are no natural water sources (i.e., springs or seeps) on three of the six mountain ranges. In the late 1930s, the managers on the then Desert Game Range attributed a contracted desert bighorn sheep population principally to dry conditions and very limited water availability due to low flow rates at known springs. At that time, the majority of bighorn sheep on the Refuge inhabited the Sheep Range. Bighorn sheep occupancy in the adjacent, lower elevation ranges was largely seasonal due to either no, or very limited, water availability. In 1939, Refuge Superintendent Joseph Allen in a letter to the Chief of the Bureau of Biological Survey wrote, "the number of sheep now to be found on this refuge is estimated at three hundred, whereas, estimated populations of earlier times vary between eighteen hundred and twenty five hundred." In a late summer/early fall 1939 report, the superintendent described water as the one ecological link or determinant factor that must be managed well to promote the expansion of the bighorn population. To this end, the superintendent wrote, "the development of water and the conservation of supply will always be one of our major activities." Thus, this early time marked the beginning of management actions to address what was understood to be the primary Refuge-wide problem: the lack of water availability.

  Beginning in the late 1930s and extending into the 1970s, much thought and commitment was directed at spring sources to enhance flow rates and to devise means to collect and store water. The earliest efforts to bolster bighorn population segments in the lower elevation ranges entailed modifying natural springs in the Pintwater Range and Las Vegas Range.

  In the 1960s, the concept to enhance water availability for bighorn sheep broadened beyond spring modifications to include anthropogenic water developments. Rapidly, it was realized that water developments, also referred to as guzzlers, could be constructed in many locations. Since inception, the challenges in planning and constructing water developments in remote areas attracted passionate hunters and outdoor enthusiasts. In 1964, the Fraternity of the Desert Bighorn was formed. Since then, the nonprofit organization has provided volunteer and financial support for water development construction and maintenance on Desert NWR.

  Today, Desert bighorn subpopulations inhabiting the Spotted, Desert and East Desert ranges are supported by water developments designed to collect, store, and provide water to wildlife. Each of the few critically important, natural perennial water sources in the Pintwater, Sheep, and Las Vegas ranges were developed to enhance water availability. Many of the water developments and spring developments were constructed decades ago and are antiquated in design, materials and component specifications, storage capacities, and collection efficiencies. Many of the outmoded water developments are prone to component failures and incomplete recharge after annual fall and winter storms. The immediate lack of water availability in the height of summer due to component failure and total discharge of stored water or insufficient recharge in

previous fall and winter months imposes an immediate crisis for bighorn sheep and other wildlife.

- **Climate change:** Considerable modeling efforts have been undertaken the past few decades to determine shifts in regional climate patterns across the Southwest (Weltzin et al. 2003; Seager et al. 2007; Seager et al. 2013). Studies suggest the region will experience decreased precipitation, with upslope shifts in vegetation communities, causing changes in forage quality and reduction of suitable habitat, thus contributing to lower reproductive success of bighorn sheep (Douglas and Leslie 1986; Wehausen et al. 1987), and increasing the probability of population extirpation (Epps et al. 2004). The Sheep Range within Desert NWR exemplifies elevational life zones typical of the desert Southwest (Jaeger 1957). As herbivores' and carnivores' life zones are constricted, and center upon known water sources, greater habitat overlap will occur, potentially causing higher predation rates and possible shifts in prey base. Long-term studies and modeling are necessary to help understand the consequences of climate changes in the Mojave and Great Basin Deserts.
- **Cumulative Effects of Multiple Threats:** The Las Vegas Valley has grown significantly over the past 50 years and continues to rapidly expand. This growth, combined with the military activities that occur on the Refuge, create an array of pressures on Desert NWR's sheep. While presently each of these has limited scope and low severity of impact, their cumulative effect could potentially be significant, particularly when co-occurring with disease or water scarcity, or both. Some research has been conducted on the cumulative effects of poor air and environmental qualities on wildlife, but it is an often-overlooked issue (Newman et al. 1988). Cumulative stressors cannot be overstated or fully accounted for and could be extremely detrimental to herd and habitat health.

Box 2. Other factors that cause desert bighorn sheep mortality but are not deemed threats of concern: predation and hunting

The methodological basis of the threats analysis aims to identify those forces with potential to directly compromise the long-term health and persistence of a priority ROC. For some, this brings to mind predation and hunting, both of which cause desert bighorn sheep mortality but neither of which, based upon best available science and monitoring, are likely to cause a significant decline in the foreseeable future. This plan therefore does not include management interventions regarding these issues.

Predation. In healthy populations of bighorn sheep, adult survival is stable and characteristically high (Gaillard et al. 1998). For populations where population dynamics are impacted by mountain lion predation, adult survival is much lower. In Desert NWR's Sheep Range, adult survival of 30 adult bighorn sheep radiomarked from 2010 to 2012 was relatively high (0.92; unpublished data), suggesting that during this time period, mountain lions were not a major cause of mortality. Should that change in a manner that causes a significant and unsustainable decline in Desert NWR's desert bighorn sheep population, management measures would be considered.

Hunting. Using best available science and monitoring, NDOW carefully manages desert bighorn sheep hunting as a legitimate and desirable use of the bighorn resource. The conservative hunt quota criteria are based on 8% of the estimated total rams not to exceed 50% of the estimated number of mature rams 6 years of age or older respective of each population model for each unit or unit group. The general hunt seasons do not occur during the peak of the rut. The harvest of ewes may be considered as a population management tool if all other options for population control have been exhausted (NV Bighorn Sheep Mgt Plan 2001).

Lower level threats with the potential for a cumulative effect on sheep and their habitat include:

- *Contamination of soils, water, and air.* Local air quality changes are expected to decrease air quality by increasing sulfur dioxide and ozone levels, as well as particulate matter due to construction. Wildlife can become ill or die by inhalation, ingestion and direct contact with contaminants, but ingestion is the most common form of contamination. In addition to urban growth and pollution, the USAF monitors contaminants in the Operational Range Assessment Program.
- *Disruptions to connectivity,* both physical (e.g., due to roads, fences, solar fields, permanent structures) and behavioral, in the form of sheep being deterred from normal movement patterns (e.g., due to noise and other disturbance caused by military activities).
- *Fragmentation/degradation of habitat resulting from fire or new linear infrastructure* (e.g., roads and trails) or permanent structures.
- *Light and air pollution or waste* generated by military and recreational activities.
- *Human activities causing behavioral disturbance* (e.g., recreation, including hikers and drivers on refuge roads, and military activities such as maneuvers, overflights, bombing, and strafing). Military training activities are limited to target areas that are situated on low elevation playa basins.
- *The presence and spread of non-native species* (e.g., *Bromus sp.*, non-native grasses).

Situation Analysis

A situation analysis considered external and internal factors that affect the desert bighorn sheep and its habitat. The purpose of conducting a situation analysis is to map out the most important factors, both positive and challenging, that drive the direct threats in order to develop a collective understanding regarding which critical forces and opportunities should be the focus of limited management resources. Key factors that are particularly challenging or enabling effective management of bighorn sheep and their habitat are briefly summarized below and portrayed graphically in a conceptual model (Appendix C). Through management strategies defined later in this plan, the Interagency Management Team will seek to either mitigate or effectively work in context of the challenges (▲) or leverage and advance factors already enabling conservation (✚).

Key challenges to overcome or work around:

- ▲ **Lack of knowledge about threats and their impacts.** At this time, sheep populations are particularly threatened by respiratory disease but also by connectivity to habitat and corridors, or possible lack thereof. Radiomarked sheep in the Pintwater and Spotted Range have exhibited a high degree of fidelity to the mountains themselves and have not been observed crossing valley floors to other ranges. The reason for lack of movement is unclear; potential reasons include insufficient collaring to understand intermountain movements, natural behavior changes, and disruptive activity in valleys between mountain ranges (Lowrey et al. *In review*).
- ▲ Climate change will certainly play a part in the health of bighorn sheep and other wildlife on Desert NWR. The extent to which this occurs will require on-going monitoring of herds and water sources, as well as vegetative studies.

  Air, soil and vegetative quality, quantity, and type (i.e., spread of invasive species), should be studied on a long-term basis.

- **Public awareness and education.** The USFWS, NDOW, Nuwuvi, hunters' groups and NGOs have been leaders in public awareness campaigns specific to the protection of Desert NWR and its habitat and inhabitants. Despite these efforts, the importance, challenges, and needs for public support and broader constituency are known only locally and typically within small circles of key stakeholders.
- **Limited human and financial resources.** Desert NWR, the largest refuge in the lower 48 states, has a paucity of full-time staff, including only a manager, a wildlife biologist, and a maintenance worker. USFWS's management of Desert NWR is also subject to funding limitations. Together, these resource constraints limit the nature and extent of management activities on the Refuge, including such challenges as advancing basic biological and natural resource knowledge across the landscape and taking a proactive approach rather than emergency response/reactive action.
- **Overlapping mandates and interests of recreation, hunting, species and habitat protection, and military use.** Desert NWR was created for the preservation of desert bighorn sheep habitat. Over its 84-year existence, while habitat has remained largely intact and undisturbed by user groups, challenges continually arise due to competing user priorities. For example, recreation can particularly impact certain sites or potentially cause behavior disturbance to sheep. The 112,000 acres ceded to the military are used for bombing and maneuvers, which can disrupt habitat, sheep movement, and behavior. Ensuring effective coordination and management decision-making consistent with maintaining the values for which Desert NWR was created requires ongoing time and attention of the Interagency Management Team.


Recreation on Desert NWR (Photo: USFWS)

- **Legacy of past management decisions.** Past managers of Desert NWR, operating in good faith and intent and with best available information, established some management practices that today must be maintained, adapted, worked around, or phased out. At times, these decisions were reactive and not carried out with a long-range vision of sustainability. Foremost among these is the construction of watering sources within mountain ranges historically devoid of natural sources, serving to enhance sheep populations; while this led to a more widely distributed metapopulation on Desert NWR, the sheep in many places are now dependent on these water sources, which require regular monitoring and maintenance.

Positive factors to leverage or amplify:

- **Relatively intact habitat across the Refuge.** The Desert NWR forms one of the largest intact blocks of desert bighorn sheep habitat remaining in the Southwest. Even with its proximity to Las Vegas, now a city of over two million inhabitants, the land has remained relatively untouched by all user groups across its landscape. As stewards of this landscape, USFWS and Nellis AFB will continue to protect and maintain this vital habitat.
- **Positive, constructive partnerships with key agencies and stakeholders.** Strong inter- and intra-governmental relationships exist for managing the natural and cultural resources found on

Desert NWR, including the Nellis AFB, USGS, NDOW, Nuwuvi, and a myriad of non-governmental organizations, most notably the Fraternity of the Desert Bighorn. It is through these long-standing relationships that the Refuge has remained intact and wildlife have flourished.

- **Acts, designations, and executive orders supporting the protection and management of bighorn sheep and their habitat.** In May 1936, Executive Order 7373 established the Desert Game Range for the main purpose of conservation and development of natural wildlife resources, of which, desert bighorn sheep are the primary species to be afforded sufficient forage resources to sustain a population in healthy condition. The four purposes of DNWR described in Executive Order 7373 are: 1) protection, enhancement and maintenance of wildlife, including desert bighorn sheep, 2) conservation of fish or wildlife listed as endangered or threatened species, 3) protection and maintenance of habitat suitable for incidental fish and wildlife-oriented recreational development and 4) the Secretary of the DOI may accept the donations of lands to establish National Wildlife Refuges.
- **Historical and ongoing data collection, monitoring, and research.** Because the Refuge has a long history of bighorn sheep management and observations, extensive data exists regarding locations, herd expansions and contractions, baseline vegetation existence and presence/absence of other wildlife species. It might be possible to draw from existing information for modeling future expectations. Nellis AFB has been conducting flora and fauna surveys routinely since 2010. These surveys include bighorn sheep, desert tortoise (a federally threatened species), golden eagles and other migratory birds, bats and other small mammals, reptiles and amphibians, and vegetation truthing and rare plant surveys.

Threat Mitigation Objectives

Successful conservation of bighorn sheep and their habitat in Desert NWR will require management actions that ensure critical threats are mitigated and other potential threats are maintained at low levels. Through this management plan, the Interagency Management Team seeks to work toward the following threat mitigation objectives in the period 2020-2025. While some of these may prove challenging to measure, in terms of baseline and regular monitoring, the Team nonetheless will strive to ensure that management efforts work toward the following objectives.

- By 2025, and per a water management strategy developed under Strategy 1 below, there is sufficient water to maintain the population of sheep supported by the Refuge in good condition (per the KEA tables) in normal precipitation years and to maintain a minimum viable population in drought years.
- By 2025, there is no increase in fragmentation of sheep habitat from 2020 (baseline) levels, and critical barriers to connectivity are identified, and if feasible, eliminated.
- By 2025, disturbances to sheep due to cumulative stressors such as military training activities and public recreation has not increased from 2020 levels.
- By 2025, there is no increase (from 2020 levels) in soil and water contamination on the joint use and public use areas of the Refuge.

MANAGEMENT STRATEGIES

To achieve the goals and threat mitigation objectives outlined above, a suite of complementary management strategies has been defined. These are briefly described below and include:

- Strategy 1: Ensure sufficient water to maintain healthy sheep populations
- Strategy 2: Maintain a viable sheep population
- Strategy 3: Maintain habitat connectivity and integrity and mitigate disturbance
- Strategy 4: Build constituencies and raise awareness to deliver action

Additional detail on strategy execution, such as specific activities and monitoring methodologies, is captured in a separate integrated annual action and monitoring plan, which is still to be developed. As Strategies 1, 2, and 3 all involve some degree of monitoring and other data collection, a priority result under Strategy 4 is to establish data sharing agreements and a platform that can be used to capture data required to support delivery of this SMP.

Strategy 1: Ensure sufficient water to maintain healthy desert bighorn sheep populations


Desert bighorn sheep at a water development (image: USFWS)

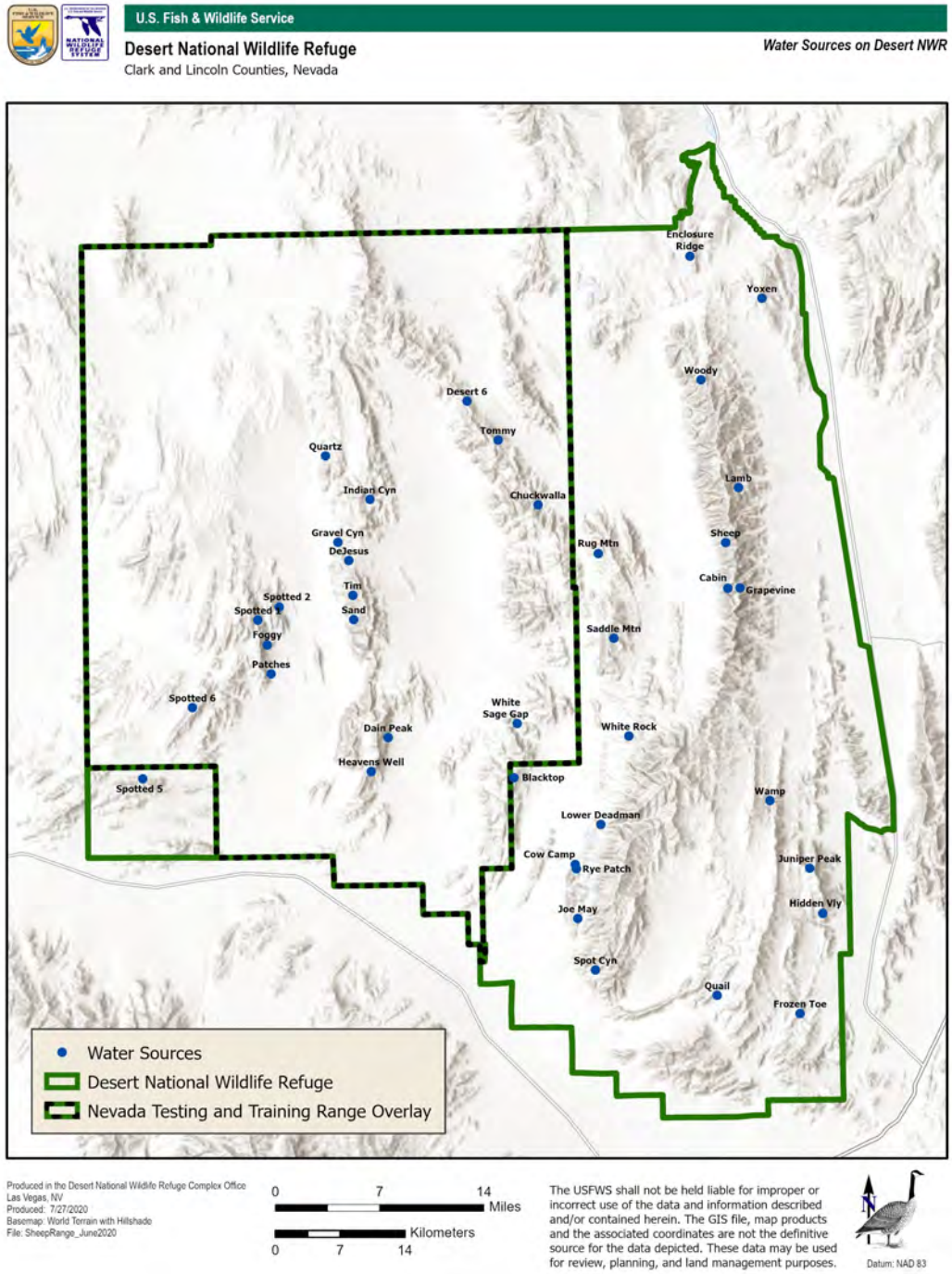
Desert bighorn sheep require reliable water sources. On Desert NWR, water sources consist of developed springs and anthropogenic water developments (also referred to as "guzzlers") (Map 4). Many of the existing water developments and spring developments have exceeded operational life expectancies. Much of the decades old water infrastructure is obsolete in design, materials, and component specifications. Like any equipment that has reached or exceeded useful life expectancy, these older water developments have recurring failures in parts and materials that result in diminished water collection efficiency and water loss. The abrupt loss of water availability in the height of summer imposes a critical situation on dependent bighorn sheep and other wildlife species. Under such austere conditions, animals without the knowledge of or ability to move to an alternate water source have little chance for survival. Currently, many of the water developments do not have the storage capacity to ensure water availability through protracted dry conditions that span two consecutive summers.

The SMP identifies water scarcity as a key threat to bighorn sheep. Maintaining viable sheep populations necessitates development and implementation of a comprehensive water management strategy. The strategy to maintain water availability is needed to minimize water scarcity due to component failures, lack of long term planning and drought conditions. The overall focus of the strategy is to maintain water availability at managed sources throughout the year and employ data analyses to inform decision making. The strategy identifies activities in managing water resources along three axes: maintenance, upgrades, and new construction. The strategy will identify measures to minimize water scarcity due to component failures, lack of or poor planning, and drought conditions. A novel aspect of the management strategy entails installation of remote monitoring subsystems on select water sources.

Implementation of this strategy will produce the following outcomes:

- Minimize the lack of water availability.
- Reduce the need to haul water during periods of drought.
- Decrease the maintenance burden requirements on water developments.

Map 4. Locations of sheep water sources on Desert NWR (map: USFWS)



Strategic Objective 1.1: Interagency Sheep Water Strategy. To ensure adequate water availability, USFWS, NDOW and Nellis AFB will work collaboratively to identify deficiencies and set priorities. An interagency strategy to meet sheep water requirements is agreed to by USFWS, NDOW, and Nellis AFB and has the buy-in of key partners such as the Fraternity of the Desert Bighorn.

Priority Results:

- By end of 2021, form working group: NDOW-Game and Habitat Divisions, Desert NWR, Nellis AFB, and Fraternity of the Desert Bighorn.

    - *Regular time commitment required.*
- By end of 2022, key analyses are completed, compiled, and available in usable format(s) (e.g., sheep movement and distribution, and water developments inventoried for location suitability, capacity, efficiency, and maintenance status).
- By the end of 2023, fund a hydrological study of existing spring hydrology, assess condition and weaknesses of developed spring infrastructures, and learn what options are available to improve water capabilities.
- By spring 2023, key analyses inform the development of a draft Comprehensive Water Management Strategy (CWMS), including provisions for meeting water requirements in average and drought years and identify funding sources. This CWMS is a living document that will be updated every 5 years to incorporate new information from programmed studies, annual surveys, etc.
    - *This action will require regularly scheduled time commitments.*
- By end of 2023, CWMS finalized.
- By the end of 2024, through analyzing the climate data available in 2020, fund studies to address knowledge gaps in climate change.

Strategic Objective 1.2: Water Developments (guzzlers). By the end of 2030, water developments are providing sufficient water to meet sheep water needs. The priority activities will inform the CWMS updates to ensure priorities stay relevant.

Priority Results:

- Annually perform monitoring and maintenance.
- Annually assess winter water storage levels.
- During the period 2025-2030, complete one major upgrade to existing infrastructure or new development per year.

Strategic Objective 1.3: Natural water sources. By the end of 2025, natural water sources on Desert NWR are providing sufficient water to complement water developments in meeting overall sheep water requirements. This objective will be informed by the hydrology study described above under Objective 1.1.

Priority Results:

- By end of 2021, inventory and prioritize springs/seeps based on the level of sheep use.
- Conduct annual maintenance or upgrading of spring/seep developments, per the Interagency Water Strategy generated via Objective 1.1, above.
- Conduct annual monitoring of priority springs and seeps.
- By 2030, return developed spring/seeps to proper functioning condition, per the Comprehensive Water Management Strategy.

Strategy 2: Maintain a viable desert bighorn sheep population

Maintaining a viable bighorn sheep population will rely largely on ensuring there is sufficient water and adequate undisturbed habitat for sheep. Additionally, action is needed to minimize impacts of disease and to maintain sustainable levels of harvest. Disease remains the greatest threat of concern to Desert NWR's desert bighorn sheep population. Unfortunately, little progress has been made to date on guarding against and mitigating the impacts of disease including, principally, *M. ovi*, as well as other

diseases of concern (see list under Critical Threats). For instance, there are significant gaps in knowledge regarding identification of *M. ovi*'s impacting factors that contribute to variation in herd response to respiratory disease and the occurrence of devastating lamb die offs in some years, but not others.

At Desert NWR, efforts will be made to address knowledge gaps, mitigate the transmission of disease to desert bighorn sheep, and maintain sustainable harvest levels. To implement this strategy, USFWS relies heavily on the efforts of NDOW for sheep harvest management and population research and monitoring. They also rely on USGS for population and disease research and monitoring. Refuge staff, (i.e., biologist and manager), work cohesively with partners to achieve this strategy by seeking outside funding for research. Additionally, Nellis AFB has contributed field and logistics support since 2016 in support of the team effort to learn more about desert bighorn sheep distribution, movements, physical well-being, and disease assessment. Thus far, research has been conducted on the Pintwater and Spotted Range herds. Planning is in place to conduct similar studies on the Desert Range herd beginning in 2021.

Strategic objective 2.1: Sheep monitoring. By 2025, reliable and consistent data are being gathered regarding the size, movements, and health indicators of Desert NWR's desert bighorn sheep populations.

Priority Results:

- Annually, we will derive population estimates for each mountain range.
- By 2023, we will have baseline information on herd health for each population on the Desert NWR.
- By 2023, the frequency of lamb die-offs is understood using data from camera traps at water sources.

USFWS biologists assessing the body condition of an adult female (ewe) desert bighorn sheep. (Photo: USFWS)

- By 2023, causes for variability in herd performance after exposure to *M. ovi* are better understood via periodic disease testing of populations, with a focus on those with poor herd performance and those with high herd performance.
- By 2023, a regular practice of monitoring heterozygosity and gene flow is established, involving genetic analysis of all Desert NWR populations, ideally every 4-5 generations (1 generation = 4 years), and monitoring of movements between mountain ranges.

Strategic Objective 2.2: Disease mitigation. By 2025, measures have been put in place to better understand and mitigate disease transmission and impacts.

Priority Results:

- By 2025, environmental and biotic conditions that contribute to lamb die-offs are better understood.
- By 2030, known environmental stressors that contribute to herd response to *M. ovi* have been minimized.
- (Ongoing) Domestic stock, including pack goats and llamas, continue to be prohibited on Desert NWR to prevent disease exposure.

- (Ongoing) Advances regarding *M. ovi* research are tracked, consolidated, and shared with the Interagency Management Team, as needed to ensure effective disease mitigation measures are adopted.

Strategic Objective 2.3: Controlled harvest. Annually, desert bighorn sheep harvest is maintained at sustainable levels.

Priority Results:

- Annually and in agreement with USFWS, NDOW designates sustainable harvest levels using best available science and information and ensures harvest is managed in accordance with those levels.

Strategy 3: Maintain habitat connectivity and integrity and mitigate disturbance

Fundamentally, this strategy aims to maintain or reduce the levels of disturbance and fragmentation resulting from current and potential future anthropogenic activities on sheep habitat, including physical fragmentation, behavioral disturbance, and contamination. Additionally, it is imperative to improve the understanding and identification of critical barriers to connectivity and sheep movements so these can be mitigated wherever possible. The Interagency Management Team recognizes that there are unknowns with identifying barriers to connectivity and to understanding the levels and sources of disturbance that affect sheep movements. This strategy aims to improve our knowledge and understanding of these factors; avoiding or mitigating any negative impacts will continue to be informed by the National Environmental Protection Act (NEPA)[18] compliance for federal agency action.

Presently Las Vegas is one of the fastest growing cities in the country and a byproduct of this rapid expansion is the increase of air pollution and other contaminants. Regarding the public use area of the Refuge, there is potential for increased public usage, although use of the backcountry roads is somewhat restricted to visitors driving high-clearance vehicles.

To implement this strategy, Desert NWR relies heavily on the Nellis AFB's efforts to minimize disruption and fragmentation of habitat on the NTTR. Nellis AFB, in coordination with USFWS, conducts flora surveys to collect baseline data on vegetation communities following international and National Vegetation Classification standards. Nellis AFB flora surveys also focus on invasive plant species to monitor the condition of sheep habitat. Nellis AFB also funds projects, such as sheep collaring, to collect data that are then analyzed by the USGS. With better information available on corridors, connectivity requirements, and disturbance impacts, Nellis AFB and USFWS will be more informed on considering proposed military activity.

USFWS is responsible for minimizing disturbance on the public use portions of the Refuge, although its effectiveness is constrained by limited resources to conduct research and monitoring. In both the public use and the military areas of Desert NWR, continued effort will seek to address disturbance knowledge gaps, share information, and install appropriate protection and management protocols to eliminate or mitigate the disruption and fragmentation of bighorn sheep habitat.

Strategic Objective 3.1: Research & Monitoring. By 2025, the status of connectivity (fragmentation & movement corridors) and other physical disruptions, critical barriers to connectivity, and bighorn sheep

[18] The habitat and species data collected since 2010, and into the foreseeable future, is used to evaluate projects for potential environmental impacts. The NEPA process could, for example, influence a change of location for certain types of activities that could limit fragmentation or other disruptions to the habitat.

habitat connectivity requirements within the Desert NWR are documented through research and monitoring.

Priority Results:

- By 2022, develop indices for forage quality KEA to address TBD's in KEA Viability table
- By 2023, develop fragmentation index which will then address adequacy of current sheep connectivity
- By the end of 2024, the adequacy of current sheep connectivity is assessed
    - By 2024, potential corridors are identified and ranked (note: many have been identified)
- By 2025, develop plan for determining impacts of pollution on sheep.
- By the end of 2025, viability assessment of desert bighorn sheep habitat
- (Ongoing) Research on sheep habitat connectivity requirements and sheep behavioral responses to anthropogenic activities
- (Ongoing) Monitoring of key habitat changes and sheep movements
- (Ongoing) Use data to make management and protection decisions

Strategic Objective 3.2: Alignment and Compliance. By 2025, there is a marked increase in the public's [and military's] understanding of bighorn sheep and their habitat, creating an increased alignment to and compliance with protection and management measures put in place by USFWS to mitigate/eliminate fragmentation and disruption.

Priority Results:

- By 2025, consolidate baseline data on the extent to which public and military activities follow management guidelines meant to mitigate disturbance and fragmentation.
- By the end of 2025, design and implement an awareness strategy that targets priority issues and audiences identified via the baseline assessment.
- Annually meet with Nellis AFB leadership for updates and educational purposes.

Strategic objective 3.3: Protection and Management. By 2025, key protection and management measures are in place to maintain (at 2019 levels) and improve habitat connectivity and integrity.

Priority Results:

- (Ongoing) Assess current protection/management measures against needs indicated by research.
- By 2025, delineate public use areas and signage to clarify land access.
- By 2025, the Interagency Management Team works together to identify, assess and subsequently, minimize barriers to connectivity.
- By 2022, a decision is made regarding the need for public access limitations and a permit plan.

Strategy 4: Build constituencies and raise awareness to deliver action

Execution of this SMP requires seamless and dedicated collective action by member agencies of the Interagency Management Team, in coordination with an array of key partners and other relevant stakeholder groups. These include state agencies (e.g., Nevada Board of Wildlife Commissioners), conservation groups, hunters, educators, Native Americans, corporate sponsors, other government agencies, the public, and agency personnel beyond those who participate on the Interagency

Management Team. Focused strategic action is necessary to ensure the engagement, information sharing, and shared planning needed to drive effective joint work.

Attainment of the SMP's goals, effective implementation of the plan, and abatement of some specific threats such as behavioral disturbance also requires focused outreach and education. USFWS's National Outreach Strategy and Desert NWR CCP serve as a basis for SMP Strategy 4. USFWS has defined outreach as, "Any effort designed to communicate information to, impart knowledge to, promote involvement by, or create behavioral change in the public regarding fish and wildlife resource issues." Goal 4 (Visitor Services) of the CCP for Desert NWR addresses outreach efforts: Provide visitors with opportunities to understand, appreciate, and enjoy the fragile Mojave and Great Basin Desert ecosystem. This strategy will build on outreach and educational opportunities already available for visitors, schools, and groups of many kinds. For example, the Visitor Center at Corn Creek has interpretive exhibits, interpretive walking trails, and offers wildlife viewing and occasional Ranger-led programming. The Desert NWR team, led by visitor services staff, participates in at least two events per year, on-site or off-site. Implementing this strategy may mean adapting ongoing outreach activities and programs to reflect the goals for desert bighorn sheep both within the Refuge and as part of the greater context. A needs assessment will identify the status of current outreach products/messages and ensure consistent quality, continuity, and quantities of future products. Linkages with other efforts (e.g., endangered species, ecosystem teams, etc.) will be important.

Strategic Objective 4.1: Constituency Building. By 2025, strengthen and build relationships within the Interagency Management Team and with key partners for effective implementation of the SMP.

Priority Results:

- (Ongoing) On a yearly basis, identify, organize, and participate in at least two key partner/ stakeholder events and priorities and elaborate collaborative activities with external stakeholders/partners that directly contribute to SMP Strategies 1, 2, and 3, such as research, surveys, and monitoring.
- (Ongoing) On a yearly/biyearly basis, the Interagency Management Team reviews information needs and collaboratively defines and delivers key messages about desert bighorn sheep conservation. The Team assesses and affirms the tools and approaches being used to strengthen both the Team itself, and its broader interest and support groups, to lead to greater success in implementation of the DBHS plan.
- Starting in 2021, provide an annual status report on desert bighorn sheep (including water management status) to key partners and stakeholders such as the Fraternity of Desert Bighorn, Nevada Wildlife Commission and Nuwuvi, to strengthen the credibility of the Interagency Management Team and to ensure continual commitment to the management plan's implementation.
- By 2021, assess human resource needs to deliver the management plan, and explore ways to engage partners more fully in filling needs, as well as consider revisions to the volunteer program to help minimize resource challenges and habitat damages.
- By end 2021, the Interagency Management Team has established data sharing and storage agreements and has started to populate a shared data platform with data needed to support implementation of this SMP, including data gathered under Strategies 1 through 3.

Strategic Objective 4.2: Education and Outreach. By 2025, desert bighorn sheep management is improved by collaboratively developing outreach, educational, and interpretive initiatives that mitigate

anthropogenic activities that result in cumulative stressors and support the long-term survival of bighorn sheep.

Priority Results:

- By end 2021, develop priority messages about threats to desert bighorn sheep and its habitat.
- Every six to twelve months, using collaboratively produced (SO 4.1) information to create posts for the Refuge Facebook page, Refuge website, and other forms of outreach (e.g., classrooms, interpretative trails), to educate and motivate visitors, school children and officials, other groups, and the public to do something positive for bighorn sheep.
- By 2021, involve Nuwuvi with interpretive desert bighorn sheep messaging. Plan and implement any revisions and additions to visitor facilities with a special focus on improved understanding and engagement in the significance of desert bighorn sheep to Native Americans.
- [Ongoing] Ensure that the public is aware of changes in allowed recreational uses or hunting so that disturbance to desert bighorn sheep and their habitat is minimized.
- By 2022, Develop and implement targeted campaigns (one every two years) that educate, increase advocacy, volunteerism, and other support to reduce and eliminate persistent threats to desert bighorn sheep.

ADAPTIVE MANAGEMENT

Adaptive Management Questions and Monitoring Data Requirements

Throughout the year, the Interagency Management Team will gather, analyze, and reflect on relevant data and information to answer a range of strategic and management questions based upon five "industry-standard" conservation evaluation criteria. Additionally, focal questions have been derived from writings and thinking regarding "key ingredients for collective impact," which reflects the nature of our interagency management approach to optimize our collective impact (Box 3). Answering this set of questions will help us review what we have set out to achieve, the progress we have made, what has helped or impeded progress, whether we have been efficient, whether our results and work is likely to be sustained and ultimately, and most importantly, how we can improve to have the greatest possible impact.

The Five Conditions of Collective Impact	
Common Agenda	All participants have a shared vision for change including a common understanding of the problem and a joint approach to solving it through agreed upon actions.
Shared Measurement	Collecting data and measuring results consistently across all participants ensures efforts remain aligned and participants hold each other accountable.
Mutually Reinforcing Activities	Participant activities must be differentiated while still being coordinated through a mutually reinforcing plan of action.
Continuous Communication	Consistent and open communication is needed across the many players to build trust, assure mutual objectives, and create common motivation.
Backbone Support	Creating and managing collective impact requires a separate organization(s) with staff and a specific set of skills to serve as the backbone for the entire initiative and coordinate participating organizations and agencies.

Box 3. Key ingredients to collective impact (from: Hanleybrown et al. 2012)

Criterion 1—Strategic design: Are we collectively doing the right things to have the results and impact we want?

Adaptive Management Questions:

- Is the Interagency Management Team looking to a shared strategic vision for success (Collective Impact Indicator 1)?
- Are we still confident that our set of strategies represents the "highest and best" use of our collective resources and effort to promote progress toward the SMP goals?
- Has anything changed in the operating context that suggests we should rethink any of our strategies?
- Should we keep going with each of our strategies given our past effectiveness?
- Is the Interagency Management Team employing and supporting a shared measurement system, such that we are gathering, analyzing, and utilizing sufficient and credible evidence to inform our strategic direction and actions (Collective Impact Indicator 2)?
- Given all of the above, what changes or improvements should be made?

Criterion 2—Effectiveness: Are we on track to achieve our threat mitigation and strategic objectives?

Adaptive Management Questions:

- Are we on track to attain each of our threat mitigation and strategic objectives?
- Where we are not on track with our objectives, what key external and internal factors have been impeding progress?
- With regard to internal factors, to what extent are the involved agencies ensuring alignment of our work such that the whole can be greater than the sum of the parts (Collective Impact Indicator 3)?
- Where we are making progress, what is particularly helping us to advance?
- Are we effectively engaging the right partners and other key stakeholders?

Criterion 3—Impact: Are we on track to achieve our intended impacts (i.e., intended status of desert bighorn sheep and its habitat)?

Adaptive Management Question:

- Are we on track to realize the SMP goals?
- What key external and internal factors have been supporting or impeding progress?

Criterion 4—Efficiency: Are we working well together and making best use of our resources?

Adaptive Management Questions:

- Is there efficient, effective communication among the involved agencies, as well as trust (Collective Impact Indicator 4)?
- Do we have effective "backbone" coordination (Collective Impact Indicator 5)?
- Are roles/responsibilities clear across the Interagency Management Team?
- Are we delivering on our activities as planned?
- Are we making best, most efficient use of the human and financial resources allocated to implementing the SMP?

Criterion 5—Sustainability: Will our work and results persist?

Adaptive Management Questions:

- Are we cultivating the internal and external constituency, capacity, and capital needed a) to ensure that our work can continue as needed and effectively and efficiently, and b) to sustain results achieved?

Our Adaptive Management Approach

The Interagency Management Team will gather and analyze the monitoring data (Table 4) to periodically assess progress toward attainment of our strategic objectives, conservation objectives, and ultimately of our goals to inform decisions regarding strategic direction and overall strengthening of our work. It will be the responsibility of each representative on the Interagency Management Team and their agency to track data relevant to their role in executing this SMP; however, aggregation of these data from across the Team as well as analysis will be coordinated by the Desert NWR Biologist, in close collaboration with relevant staff from NDOW, USGS, and Nellis AFB.

Using these data as well as individual experience and anecdotal and qualitative evidence, the Interagency Management Team will convene twice per year to conduct a systematic assessment structured around our adaptive management questions. While the convenor of the Interagency Management Team may rotate, initially this will be the responsibility of the Desert NWR Biologist. We will record the results of our discussions as well as any decisions taken, including adjustments to planned activities, outputs, and milestones. These reviews will be complemented by any monitoring and reviews each agency carries out, including against programmatic and individual work plans.

Table 4. Data and information needed to support reflection against each criterion.

Reflection Criteria	Data and Information Needs
Strategic design	▪ Extent to which the Interagency Management Team looks to the shared strategy to guide individual and joint work. ▪ Ambient monitoring to track changes in the operating context. ▪ Existence, quality, and utilization of a shared adaptive management system and approach.
Effectiveness	▪ Data on indicators for threat mitigation and strategic objectives and associated milestones.
Impact	▪ Data on indicators defined for goals.
Efficiency	▪ Tracking of execution of activities and outputs.
Sustainability	▪ Sustainability metrics (TBD). ▪ Financial forecasting.

OPERATIONS OVERVIEW

Delivery of this SMP requires excellent coordination, principally among the Interagency Management Team responsible for its delivery. Effective operations are also dependent on:

- Human resources, including personnel from each agency, volunteers, NGOs, and possibly outside technical experts, and
- Financial resources, including committed funding from each agency to support their participation and fulfillment of their responsibilities regarding the SMP.

Additional infrastructure or technical resources may be required, and these should be reviewed and incorporated into work plans and budgets, as needed.

Effective operations are supported by:

- Knowledge management (e.g., exchanging and archiving data and other key documentation, collaborative work on shared documents),
- Teamwork (e.g., an integrated workplan to complement the SMP and collaborative monitoring and reflection), and
- Communications within the Interagency Management Team and to the public, partners, and decision makers.

These different aspects of operations are briefly elaborated below and will be adapted and improved to improve the enabling operations conditions necessary to implement the desert bighorn sheep management plan.

Interagency Coordination

Good coordination and teamwork ensure smooth interplay among the different responsibilities and tasks of all those involved in implementing, monitoring, and adapting the management plan. To coordinate effectively, there needs to be in-depth understanding of the forces and functions of all players and a culture of, and willingness for, good collaboration.

There are several principles that will be followed to engender a culture of cooperation and collaboration. The first is clearly establishing roles and responsibilities and defining the processes to ensure that coordination runs smoothly. Table 5 presents a summary of the key roles and responsibilities of each member of the Interagency Management Team. For each strategy and strategic objective, specific tasks will be defined and included in annual work plans. Beyond that, coordination of collective efforts will be a continuous and dynamic process, founded on mutual respect, clear definition of authorities, flexibility, commitment to follow through on individual responsibilities, and leadership.

Table 5. Roles and responsibilities in operationalizing the desert bighorn sheep management plan

Strategy	USFWS	NDOW	Nellis AFB	USGS	Partners
S1. Water	Support: staff time & $	Responsible: staff time & $	Support: Monitoring & Range time	Support: Research	Hunter Groups: staff time & $ Conservation NGOs: staff time & $ Nevada NBU: $ Wild Sheep Foundation: $
S2. Sheep	Support: Logistics & staff time	Responsible: staff time & $: Monitoring population, hunting	Support: Logistics, Communications, $ (collars)	Support: Research (disease)	Law Enforcement: staff time State Game Research Collaborators & Volunteers: staff
S3. Habitat	Responsible: staff time & $	Support: staff time	Responsible: staff time & $	Support: Research	Volunteers: staff time Visitor Services: $ & staff time Law Enforcement: staff time NGOs: Advocates
S4. Outreach	Responsible: staff time & $	Responsible: staff time & $	Responsible: staff time & $	Support: Ideas	Visitor Services: staff time & $ Communications Depts: staff time & $
Overall					Tribes, NGOS

All Team partners intend to work collaboratively, which will be evidenced by team engagement, the establishment of commitments and agreements, and regular reflections on the effectiveness of the Team's implementation of the plan. Key activities that will reinforce interagency coordination include, but are not limited to:

- A shared annual workplan/implementation plan generated,
- Agreements (as needed) written up and reviewed and revised regularly,

- Identifying and committing human, technical, and financial resources,
- Regular virtual and face-to-face meetings,
- Collaborative problem solving and joint messaging, as needed, and
- A shared knowledge management platform facilitated by USFWS.

Staffing and Key Partners

To implement the SMP, human resources will primarily be drawn from the four partner agencies, supplemented in targeted ways by other organizations, contractors, and volunteers. The resources needed will vary according to each strategy. Table 6 presents an initial assessment of additional human resources needed to implement the SMP, considering numbers and skills, capacity, and experience. For all strategies, human resourcing is considered to be Fair, on a scale of Poor-Fair-Good. This assessment will need to be reviewed and refined in conjunction with annual work-planning to determine what can and cannot be done in any given year, and how that will affect the plan overall.

Table 6. Human resources assessment

Strategy	Additional Human Resource Needs
S1. Water	▪ Hydrologist (temporary post) ▪ Remote monitoring system specialist
S2. Sheep	▪ Experts for research ▪ USFWS sheep biologist
S3. Habitat	▪ Law enforcement capacity (USFWS) ▪ Contaminants biologist (temporary?)
S4. Outreach	▪ Visitor services (full time) ▪ Archaeologist

Budget

While exact budget estimates are still in development, Table 7 presents the *minimum estimated* cost to implement each strategy and for operationalization of the management plan overall. This budget will be refined further as the Interagency Management Team moves into the implementation phase and will be updated on a yearly basis as part of annual work planning. Each Interagency Management Team representative prepared preliminary estimates of the funding and in-kind contributions their agencies can provide to inform thinking regarding unmet resource needs and, where necessary, prioritization of activities.

As an example, USFWS has = provided its estimated support in terms of staffing (staff salaries and benefits), as well as funding for material, logistics and other operational costs (e.g., water development and spring maintenance, construction, upgrades, and habitat improvements) (Table 8). USFWS staff referred to in Table 5 (concerning roles and responsibilities) include the Desert Refuge Manager and Wildlife Biologist, Visitor Services personnel, Desert NWR Complex Project Leader, Law enforcement, and Deputy Project Leader. In addition, Region 8 Inventory and Monitoring Program personnel and other Service programs (e.g., Hydrologists) may provide support for some activities.

A portion of the USFWS contribution to the operational budget may be used to hire additional personnel through contracts, agreements, and volunteer organizations. Table 6 (regarding human resources assessment) identified additional staff needs; an estimate of associated costs is included in the overall budget, with the caveat that recruitment of permanent staff is currently challenging within federal and state agencies. Other partners (e.g., The Fraternity of the Desert Bighorn) provide financial support to specific activities, such as construction and maintenance of wildlife water developments, and others, such as conservation organizations, offer time and effort in advocacy work. Funds or in-kind

contributions from partners are estimated only for Strategy 1 at this time. The Interagency Management Team and refuge staff members will assess conservation progress regularly and use this information to update the plan, including the budget, as needed.

Table 7. Estimated Minimum Cost to implement the Desert Bighorn Sheep Management Plan (Fiscal Year 2021 through Fiscal Year 2026)

Strategy	Staff cost	Operations cost	Total cost	Observations
S1. Water	$1,245,500	$880,500	$2,1266,000	See Notes below
S2. Sheep	$686,750	$592,700	$1,279,450	
S3. Habitat	$604,000	$202,000	$806,000	
S4. Outreach	$200,000	$75,000	$275,000	
Management team participation	$36,500	$0	$36,500	In kind cost provided by four management team members
		Total	$4,522,950	

Notes: This budget represents a rough estimate of the minimum resources needed to implement this SMP over five years. It is based on information available at the time of writing and involved some approximations and some unknowns, such as new research topics. More details on the budget breakdown are available on request.

Table 8. Estimated Contribution of USFWS to implementation of the Desert Bighorn Sheep Management Plan (Fiscal Year 2021 through Fiscal Year 2026)

Strategy	USFWS staff cost	Operations cost	Total cost
S1. Water	$180,000	$ 121,000	$ 301,000
S2. Sheep	$28,750	$110,000	$138,750
S3. Habitat	250, 000	$50, 000	$300,000
S4. Outreach	$150,000	$25,000	$175,000
		Total	$ 1,164,750

Operational Risks

Several operational risks have the potential to influence the effectiveness of delivery of this SMP (Table 9), including such issues as retirement of key personnel, knowledge gaps, and changes in budget. These have been identified to anticipate what might go wrong and to determine what might be done proactively to either avoid or mitigate significant impact. The Interagency Management Team will regularly reflect on risks and mitigation measures throughout its implementation of this SMP.

Table 9. Key operational risks

What?	Mitigation options	Observations
Retirement of key personnel	▪ Develop transition/succession plans ▪ From NDOW, increase involvement of additional staff, in support of succession ▪ From USFWS, new staff recently recruited; may need to hire and train others	▪ Several members of the Interagency Management Team and designers of this strategy are likely to retire
Knowledge gaps	▪ Establish a shared platform so data are available for those connecting to implementing the plan	
Budget cuts	▪ Find other partners or donors	▪ Develop a resource mobilization plan

Capacity of partners	▪ Help build capacity through engagement	▪ Loss of capacity
Prioritization of DNWR for NDOW	▪ Ensure the plan has compelling argument ▪ Keep the right people regularly informed	▪ Ensure key audiences, messages and methods (products) are developed in outreach

LITERATURE CITED

Ackerman, T.L. 2003. A flora of the Desert National Wildlife Range, Nevada. Mentzelia: The Journal of the Nevada Native Plant Society. 7.

Allen, J.C. "Letter to Chief, Bureau of Biological Survey 9 July 1939." U.S. Department of the Interior, Fish & Wildlife Service. Las Vegas, Nevada, USA.

Allen, J.C. 1940. Desert Game Range: Quarterly narrative report. August-October. U.S. Department of the Interior, Fish & Wildlife Service. Las Vegas, Nevada, USA. p3-4.

Allen, R.W. 1980. Natural mortality and debility. Pages 172-185 in: Monson, G. and L. Sumner, editors, The Desert Bighorn, It's Life History, Ecology, and Management. University of Arizona Press, Tucson Arizona.

Andrews, N.G., Bleich, V.C., August, P.V., 1999. Habitat selection by mountain sheep in the Sonoran Desert: implications for conservation in the United States and Mexico. California Wildlife Conservation Bulletin 12, 1–17.

Bangs, P. D., P. R. Krausman, K. E. Kunkel, and Z. D. Parsons. 2005. Habitat use by desert bighorn sheep during lambing. European Journal of Wildlife Research 51:178-184.

Besser, T. E., E. F. Cassirer, K. A. Potter, J. Vanderschalie, A. Fischer, D. P. Knowles, D. R. Herndon, F. R. Rurangirwa, G. C. Weiser, and S. Srikumaran. 2008. Association of Mycoplasma ovipneumoniae infection with population-limiting respiratory disease in free-ranging Rocky Mountain bighorn sheep (Ovis canadensis canadensis). Journal of Clinical Microbiology 46:423-430

Besser T.E., M.A. Highland, K. Baker, E.F. Cassirer, N.J. Anderson, J.M. Ramsey, K. Mansfield, D.L. Bruning, P. Wolff, J.B. Smith, J.A. Jenks. 2012. Causes of pneumonia epizootics among bighorn sheep, western United States, 2008-2010. Emerging Infectious Diseases www.cdc.gov/eid 18(3):406-414.

Besser, T. E., E.F. Cassirer, M. A. Highland, P, Wolff, A. Justice-Allen, K. Mansfield, M. A. Davis, and W. Foreyt. 2013. Bighorn sheep pneumonia: Sorting out the cause of a polymicrobial disease. Preventive Veterinary Medicine. 108:85-93.

Bleich, V. C., J. D. Wehausen, and S. A. Holl. 1990. Desert-dwelling mountain sheep: conservation implications of a naturally fragmented distribution. Conservation. Biology 4:383-390.

Bleich, V. C., J. D. Wehausen, R. R. Ramey II, and J. L. Rechel. 1996. Metapopulation theory and mountain sheep: implications for conservation. Pages 453-473 in D. R. McCullough, ed. Metapopulations and wildlife conservation management. Island Press, Washington, D.C.

Bleich, V. C., R. T. Bowyer, and J. D. Wehausen. 1997. Sexual segregation in mountain sheep: resources or predation? Wildl. Mongr. No. 134. 50pp.

Bleich, V. C., J. P. Marshall, and N. G. Andrew. 2010. Habitat use by a desert ungulate: predicting effects of water availability on mountain sheep. Journal of Arid Environments 74:638-645.

Blong, B., and W. Pollard. 1968. Summer water requirements of desert bighorn in the Santa Rosa Mountains, California, in 1965. California Fish and Game 54:289-296.

Boyce, W.M., R.R. Ramey II, T.C. Rodwell, E.S. Rubin, and R.S. Singer. 1999. Population subdivision among bighorn sheep (Ovis canadensis) ewes revealed by mitochondrial DNA analysis. Molecular Ecology. 8:99-106.

Buechner, H.K. 1960. The bighorn sheep in the U.S., it past, present, and future. Wildlife Monographs. 4:174.

Campbell, S. 2018. Nah'gah: Legend of the Mountain Sheep. https://www.nevadawilderness.org/nah_gah_legend. Accessed July 21, 2020.

Cassirer, F., Manlove, K., Almberg, E., Kamath, P., Cox, M., Wolff, P., Roug, A., Shannon, J., Robinson, R., Harris, R., Gonzalez, B., Plowright, R., Hudson, P., Cross, P., Dobson, A., Besser, T. (2018) Pneumonia in Bighorn Sheep: Risk and Resilience. Jour. Wild. Mgmt. 82, 32-45.

Chilelli, M. and P. R. Krausman. 1981. Group organization and activity patterns of desert bighorn sheep. Desert Bighorn Sheep Council Transactions 25:17-24.

Conservation Measures Partnership. 2013. Open Standards for the Practice of Conservation. Version 3.0. Creative Commons Attribution. ShareAlike 3.0 Unported License.

Cowan, I.M. 1940. Distribution and variation of the native sheep of North America. The American Midland Naturalist Journal. 24(3):505-580.

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

Dassanayake, R.P., S. Shanthalingam, C.N. Herndon, R, Subramaniam, P. K. Lawrence J. Bavananthasivam E. Frances Cassirer, G. J. Haldorson, W. J. Foreyt, F.R. Rurangirwa, D.P. Knowles, T. E. Besser S. Srikumaran. 2010. Mycoplasma ovipneumoniae can predispose bighorn sheep to fatal Mannheimia haemolytica pneumonia. Veterinary Microbiology 145(3-4): 354-359.

Deforge, J. R., S. D. Ostermann, C. W. Willmott, K. B. Brennan, S. G. Torres. 1997. The Ecology of Peninsular bighorn sheep in the San Jacinto Mountains, California. Desert Bighorns Council Transactions 41: 8-24.

Deming, O.V. 1947. Desert Game Range: Quarterly narrative report. January-April. U.S. Department of the Interior, Fish & Wildlife Service. Las Vegas, Nevada, USA. p42.

Deming, O.V. 1947. Desert Game Range: Quarterly narrative report. September-December. U.S. Department of the Interior, Fish & Wildlife Service. Las Vegas, Nevada, USA. p62-65.

Douglas, C., and D. Leslie, 1986. Influence of weather and density on lamb survival of desert mountain sheep. Journal of Wildlife Management, 50(1), 153-156. doi:10.2307/3801506

Dubay, S., H. Schwantje, J. Devos, T. McKinney. 2002. Bighorn sheep (Ovis canadensis) diseases: a brief literature review and risk assessment for translocation. Proc. Bienn. Symp. North. Wild Sheep and Goat Counc. 13:134-152.

Etchberger, R. C., P. R. Krausman, and R. Mazaika. 1989. Mountain sheep habitat characteristics in the Pusch Ridge Wilderness, Arizona. Journal of Wildlife Management 53:902-907.

Eccles, T. R., and D. M. Shackleton. 1979. Recent records of twinning in North American mountain sheep. J. Wildlife Management 43:974-976.

Elenowitz, A. 1984. Group dynamics and habitat use of transplanted desert bighorn sheep in the Peloncillo Mountains, New Mexico. Desert Bighorn Council Transactions 28:1-8.

Epps, C. W. 2004. Population processes in a changing climate: extinction, dispersal, and metapopulation dynamics of desert bighorn sheep in California. Ph.D. dissertation. Univ. of California, Berkeley.

Epps, C. W., D. R. McCullough, J. D. Wehausen, V. C. Bleich, and J. L. Rechel. 2004. Effects of climate change on population persistence of desert-dwelling mountain sheep in California. Conservation Biology 18:102-113

Epps, C. W., J. D. Wehausen, V. C. Bleich, S. G. Torres and J. S. Brashares. 2007. Optimizing dispersal and corridor models using landscape genetics. Journal of Applied Ecology 44:714-724.

Epps, C. W., J. D. Wehausen, P. J. Palsbøll, and D. R. McCullough. 2010. Using genetic tools to track desert bighorn sheep colonizations. Journal of Wildlife Management 74(3):522-531.

Festa-Bianchet M, 1991. The social system of bighorn sheep: grouping patterns, kinship and female dominance rank. Animal Behaviour 42: 71-82.

Ernest, H. B., E. S. Rubin, and W. M. Boyce. 2002. Fecal DNA analysis and risk assessment of mountain lion predation of bighorn sheep. Journal of Wildlife Management 66:75–85.

Festa-Bianchet M. 1991. The social system of bighorn sheep: grouping patterns, kinship and female dominance rank. Animal Behaviour 42: 71-82.

Foundations of Success. 2009. Using Conceptual Models to Document a Situation Analysis: An FOS How-To Guide. Foundations of Success, Bethesda, Maryland, USA.

Fox, K. A., N. M. Rouse, K. P. Huyvaert, K. A. Griffin, H. J. Killion, J. Jennings-Gaines, W. H. Edwards, S. L. Quackenbush, and M. l W. Miller. 2015. Bighorn sheep (Ovis canadensis) sinus tumors are associated with coinfections by potentially pathogenic bacteria in the upper respiratory tract. Journal of Wildlife Diseases. 51: 19-27

Gaillard, J.-M., M. Festa-Bianchet, and N. G. Yoccoz. 1998. Population dynamics of large herbivores: variable recruitment with constant adult survival. Trends in Ecology and Evolution 13:58–63

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

Gionfriddo and Krausman, P. 1986. Habitat components for desert bighorn sheep in the Harquahala Mountains, Arizona. Journal of Wildlife Management. 50(3) 504-

Groves, F.W. 1942. Desert Game Range: Quarterly narrative report. August-October. U.S. Department of the Interior, Fish & Wildlife Service. Las Vegas, Nevada, USA.

Groves, F.W. 1945. Desert Game Range: Quarterly narrative report. September-December. U.S. Department of the Interior, Fish & Wildlife Service. Las Vegas, Nevada, USA.

Groves, F.W. 1946. Desert Game Range: Quarterly narrative report. September-December. U.S. Department of the Interior, Fish & Wildlife Service. Las Vegas, Nevada, USA.

Groves, F.W. 1944. Desert Game Range: Quarterly narrative report. September-December. U.S. Department of the Interior, Fish & Wildlife Service. Las Vegas, Nevada, USA.

Groves, F.W. 1943. Desert Game Range: Quarterly narrative report. September-December. U.S. Department of the Interior, Fish & Wildlife Service. Las Vegas, Nevada, USA.

Gutiérrez-Espeleta, G.A., Kalinowski, S.T., Boyce, W.M. 2000. Genetic variation and population structure in desert bighorn sheep: implications for conservation. Conservation Genetics 1, 3–15. https://doi.org/10.1023/A:1010125519304

Hall, E.R. 1946. Mammals of Nevada. University of California Press, Berkeley, California, USA.

Hanleybrown, F., Kania, J., Kramer, M. 2012. Channeling Change: Making Collective Impact Work. Stanford Social Innovation Review (*online*). https://ssir.org/articles/entry/channeling_change_making_collective_impact_work#bio-footer

Hanly, T. A. 1982. The nutritional basis for food selection by ungulates. J. Range Manage. 35:146-151

Hansen, C. G. 1980. Habitat. Pages 64-79 in The Desert Bighorn: Its life history, ecology, and management. G. Monson and L. Sumner eds. The University of Arizona Press. Tucson. 370 pp.

Hanski, I. 1991. Single-species metapopulation dynamics: concepts, models, and observations. Biological Journal of the Linnean Society, 42: 17–38.

Harrison, S., and D. Hebert. 1988. Selective predation by cougar within the Junction Wildlife Management Area. Proceedings of the Biennial Symposium of the Northern Wild Sheep and Goat Council 6:292–306.

Hass, C. C. 1989. Bighorn lamb mortality: predation, inbreeding, and population effects. Canadian Journal of Zoology 67:699–705.

Hass C. C. 1991. Social status in female bighorn sheep (Ovis canadensis): expression, development and reproductive correlates. J. Zool., London, 225:509- 523.

Hass, C. C. 1997. Seasonality of births in bighorn sheep. Journal of Mammalogy 78:1251–1260.

Hass C. C. and D. A. Jenni. 1991. Structure and ontogeny of dominance relationships among bighorn rams Canadian Journal of Zoology 69:471-476.

Hayes, C.L., P. R. Krausman, M. C. Wallace. 1994. Habitat, visibility, heart rate, and vigilance of bighorn sheep. Desert Bighorn Council Transactions 38:6-11.

Hayes, C. L., E. S. Rubin, M. C. Jorgensen, R. A. Botta, and W. M. Boyce. 2000. Mountain lion predation of bighorn sheep in the Peninsular Ranges, California. Journal of Wildlife Management 64:954–959.

Hogg, J. T. (1984). Mating in bighorn sheep: Multiple creative male strategies. Science, 225(4661), 526–528. https://doi.org/10.1126/science.6539948

Hogg, J. T. 1987. Intrasexual competition and mate choice in Rocky Mountain bighorn sheep. Ethology 75(2):119-144.

Holl, S. A., and V. C. Bleich. 1983. San Gabriel mountain sheep: biological and management considerations. Administrative Report, San Bernardino National Forest, San Bernardino, CA.

Jaeger E. C. 1957. The North American deserts. Stanford University Press, Stanford, California.

Karsch, R., Cain III, J., Rominger, E., and Goldstein, E. (2016). Desert Bighorn Sheep Lambing Habitat: Parturition, Nursery, and Predation Sites. Journal of Wildlife Management, 80(6), 1069-1080.

Krausmann, P. R., S. Torres, L. L. Ordway, J. J. Hervert, and M. Brown. 1985. Diel activity of ewes in the Little Harquahala Mountains, Arizona. Desert Bighorn Council Transactions 29:24-26.

Krausman, P. R., B. D. Leopold, R. F. Seegmiller, and S. G. Torres. 1989. Relationships between desert bighorn sheep and habitat in western Arizona. Wildlife Monographs 102:1-66.

Krausman, P. R., J. D. Wehausen, M. C. Wallace, and R. C. Etchberger. 1993. Rumen characteristics of desert races of mountain sheep and desert mule deer. Southwest. Naturalist. 38:172174.

Krausman, P. R., A. V. Sandoval, and R. C. Etchberger. 1999. Natural history of desert bighorn sheep. Pages 139-191 in R. Valdez and P. R. Krausman, eds. Mountain sheep of North America. Univ. of Ariz. Press., Tucson.

Leslie, D. M., Jr., and C. L. Douglas. 1979. Desert bighorn sheep of the River Mountains, Nevada. Wildlife Monographs 66:1-56.

Leslie, D. M. Jr., and C. L. Douglas 1980. Human disturbance at water sources of desert bighorn sheep. Wildlife Society Bulletin 8:284-290.

Light, J.T. 1973. The effects of oxidant air pollution on forest ecosystems of the San Bernardino Mountains, Section B. In O.C. Taylor, ed., Oxidant Air Pollution Effects on a Western Coniferous ForestEcosystem. Task B Report. Air Pollution Research Center, University of California-Riverside, Riverside, CA B1-B14.

Longshore, K. M., C. Lowrey, and D. B. Thompson. 2009. Compensating for diminishing natural water: predicting the impacts of water development on summer habitat of desert bighorn sheep. Journal of Arid Environments 73:280-286.

Longshore, K. M, C. Lowrey, D. B. Thompson, D. Choate, J. Jaeger, J. Wehausen, P. Cummings, P. L. Wolff, S. Kimball, L. Simons, 2014. Accomplishments Report: Assessment of the Desert Bighorn Sheep in the Desert National Wildlife Refuge, SNPLMA Round 9 Conservation Initiatives: Project Number FW 67. Unpublished Report Prepared for the US Fish and Wildlife Service Desert National Wildlife Refuge Complex. 26 pp.

McKinney, T., S. R. Boe and J. C. DeVos Jr. 2003. GIS-based evaluation of escape terrain and desert sheep populations in Arizona. Wildlife Society Bulletin 31(4):1229-1236.

McKinney, T., T. W. Smith, J.C. DeVos Jr. 2010. Evaluation of factors potentially influencing a desert bighorn sheep population. Wildlife Monographs 164: 1-36

McQuivey, R.P. 1978. The desert bighorn sheep of Nevada. Nevada Department of Wildlife. Biological Bulletin No. 6. Reno, Nevada, USA.

Miller, G. D., M. H. Cochran, and E. L. Smith. 1984. Nighttime activity of desert bighorn sheep. Desert Bighorn Council Transactions 28:23-25.

Miller, D. S., E. Hoberg, G. Weiser, K. Aune, M. Atkinson, C. Kimberling. 2012. A review of hypothesized determinants associated with bighorn sheep (Ovis canadensis) die-offs. Veterinary Medicine International. Volume 2012, Article ID 796527, 19 pages doi:10.1155/2012/796527

Mooring, M.S., T.A. Fitzpatrick, J.E. Benjamin, I.C. Fraser, T.T. Nishihira, D.D. Reisig, and E.M. Rominger. 2003. Sexual segregation in desert bighorn sheep (Ovis canadensis mexicana). Behaviour 140: 183-207.

Nellis Air Force Base [NAFB]. 2019. Final Integrated Natural Resource Management Plan. Nellis Air Force Base/ Creech Air Force Base/ Nevada Test and Training Range Plan 125-4. Nevada, USA.

Nevada Department of Wildlife (NDOW). 2020. 2019-2020 Big Game Status Book. Retrieved from http://www.ndow.org/uploadedFiles/ndoworg/Content/Wildlife_Education/Publications/BIG%20GAME%20STATUS%20BOOK%202020%20COMPLETE(1).pdf.

Nevada Department of Wildlife. 2001. Bighorn Sheep Management Plan. Prior-Magee, J.S., K.G. Boykin, D.F. Bradford, W.G. Kepner, J.H. Lowry, D.L. Schrupp, K.A. Thomas, and B.C. Thompson, Editors. 2007. Southwest Regional Gap Analysis Project Final Report. U.S. Geological Survey, Gap Analysis Program, Moscow, ID, USA.

Ramey, R. R. II. 1993. Evolutionary genetics and systematics of North American mountain sheep. Ph.D. Thesis, Cornell Univ., Ithaca, NY.

Ramey, R. R. II. 1995. Mitochondrial DNA variation, population structure, and evolution of mountain sheep in the south-western United States and Mexico. Molecular Ecology 4:429-439.

Risenhoover, K.L. and J. A. Bailey. 1985. Foraging ecology of mountain sheep: implications for habitat management. Journal of Wildlife Management 49:707-804.

Rominger, E. 2018. The Gordian knot of mountain lion predation and bighorn sheep. Journal of Wildlife Management. 82(1): 19-31.

Rominger, E. M., H. A. Whitlaw, D. L. Weybright, W. C. Dunn, and W. B. Ballard. 2004. The influence of mountain lion predation on bighorn sheep translocations. Journal of Wildlife Management 68:993–999.

Ross, P. I., M. G. Jalkotzy, and M. Festa-Bianchet. 1997. Cougar predation on bighorn sheep in southwestern Alberta during winter. Canadian Journal of Zoology 74:771–775.

Rubin, E. S., W. M. Boyce, and V. C. Bleich. 2000. Reproductive strategies of desert bighorn sheep. Journal of Mammalogy 81:769-786.

Ruckstuhl, K. E. 1998. Foraging behavior and sexual segregation in bighorn sheep. An. Behav. 56:99-106.

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

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

Schwartz, O. A., V. C. Bleich, and S. A. Holl. 1986. Genetics and the conservation of mountain sheep Ovis canadensis nelsoni. Biological Conservation 37:179-190.

Seager, R., M.F. Ting, I.M. Held, Y. Kushnir, J. Lu, G. Vecchi, H.-P. Huang, N. Harnik, A. Leetmaa, N.-C. Lau, C. Li, J. Velez, N. Naik, 2007. Model Projections of an Imminent Transition to a More Arid Climate in Southwestern North America. Science, Vol. 316. no. 5828, pp. 1181 - 1184 DOI: 10.1126/science.1139601.

Seager, R., M. Ting, C. Li, N. Naik, B. Cook, J. Nakamura, and H. Liu, 2013: Projections of declining surface-water availability for the southwestern United States. Nature Clim. Change, 3, 582-486, doi:10.1038/nclimate1787.

Smith, T. S., J.T. Flinders, and D. S. Winn. 1991. A habitat evaluation procedure for Rocky Mountain bighorn sheep in the intermountain West. Great Basin Naturalist 51:205-225.

Spalding, D. J. 1966. Twinning in bighorn sheep. J. Wildlife Management 30:207.

Spoon, J. 2014. Quantitative, qualitative, and collaborative methods: approaching indigenous ecological knowledge heterogeneity. Ecology and Society 19(3): 33.

Spoon, J., R. Arnold, B. Lefler, K. Wendel. 2013. Nuwuvi Working Group. Portland, OR: Portland State University; 2013:9-9.

Spoon J., R. Arnold. 2017. Nuwuvi Ancestral Territory. https://csvpa.org/library/nuwuvi-ancestral-territory/. Published February 3, 2017. Accessed July 23, 2020.

Tsukamoto, G. 1993. Status of bighorn sheep in Nevada. Desert Bighorn Council Transactions. 37:54-56.

Turner, J. C. 1973. Water, energy, and electrolyte balance in the desert bighorn sheep, Ovis canadensis. Ph.D. dissertation, Univ. of Calif. Riverside. 138 pp.

Turner, J. C., C. L. Douglas, C. R. Hallum, P. R. Krausman, and P. R. Ramey. 2004. Determination of critical habitat for the endangered Nelson's bighorn sheep in southern California. Wildlife Society Bulletin 32:427-448.

Turner, J. C. and R. A. Weaver. 1980. Water. Pages 100-112 in G. Monson, L. Sumner, editors. The desert bighorn its life history, ecology, and management. The University of Arizona Press, Tucson, Arizona.

U.S. Bureau of Land Management [BLM]. 2001. Draft Nevada test and training range resource management plan and environmental impact statement. U.S. Department of the Interior, U.S. Bureau of Land Management, Las Vegas Field Office, Nevada, USA.

U.S. Fish & Wildlife Service [USFWS]. 2009. Desert National Wildlife Refuge Complex: Final comprehensive conservation plan and environmental impact statement. Volume 1 & 2. U.S. Fish & Wildlife Service, Sacramento, California, USA.

Jake F. Weltzin, Michael E. Loik, Susanne Schwinning, David G. Williams, Philip A. Fay, Brent M. Haddad, John Harte, Travis E. Huxman, Alan K. Knapp, Guanghui Lin, William T. Pockman, Rebecca M. Shaw, Eric E. Small, Melinda D. Smith, Stanley D. Smith, David T. Tissue, John C. Zak, Assessing the Response of Terrestrial Ecosystems to Potential Changes in Precipitation, BioScience, Volume 53, Issue 10, October 2003, Pages 941–952, https://doi.org/10.1641/0006-3568(2003)053[0941:ATROTE]2.0.CO;2

Wehausen, J. D. 1980. Sierra Nevada bighorn sheep: history and population ecology. Ph.D. Thesis, Univ. of Mich., Ann Arbor, MI. 240 pp.

Wehausen, John & Bleich, Vernon & Blong, Bonnar & Russi, Terry. 1987. Recruitment Dynamics in a Southern California Mountain Sheep Population. Journal of Wildlife Management. 51. 86-98. 10.2307/3801636.

Wehausen, J. D., and R. R. Ramey II. 1993. A morphometric reevaluation of the Peninsular bighorn subspecies. Desert Bighorn Council Transactions 37:1-10.

Wehausen, J. D. 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. 2005. Nutrient predictability, birthing season, and lamb recruitment for desert bighorn sheep. Pages 37-50 in J. Goerrissen and J. M André, eds. Sweeney Granite Mountains Desert Research Center 1978-2003: A Quarter Century of Research and Teaching. University of California Natural Reserve Program, Riverside, CA 2005.

Wehausen, J.D. and J.R. Jaeger. 2012. Genetic population structure of bighorns sheep and mountain lions on the Desert National Wildlife Range. Unpublished report to the USFW. 19 pp.

APPENDICES

Appendix A. Project Team

Desert National Wildlife Refuge Desert Bighorn Sheep Management Plan Project Team			
Name	**Organization**	**Position**	**Role in Project**
USFWS			
Kevin DesRoberts	U.S. Fish & Wildlife Service, National Wildlife Refuge System, Region 8	Project Leader; Desert National Wildlife Refuge Complex	Team Leader, Refuge Expert
Amy Sprunger	U.S. Fish & Wildlife Service, National Wildlife Refuge System, Region 8	Refuge Manager, Desert National Wildlife Refuge	Team Leader, Refuge Expert
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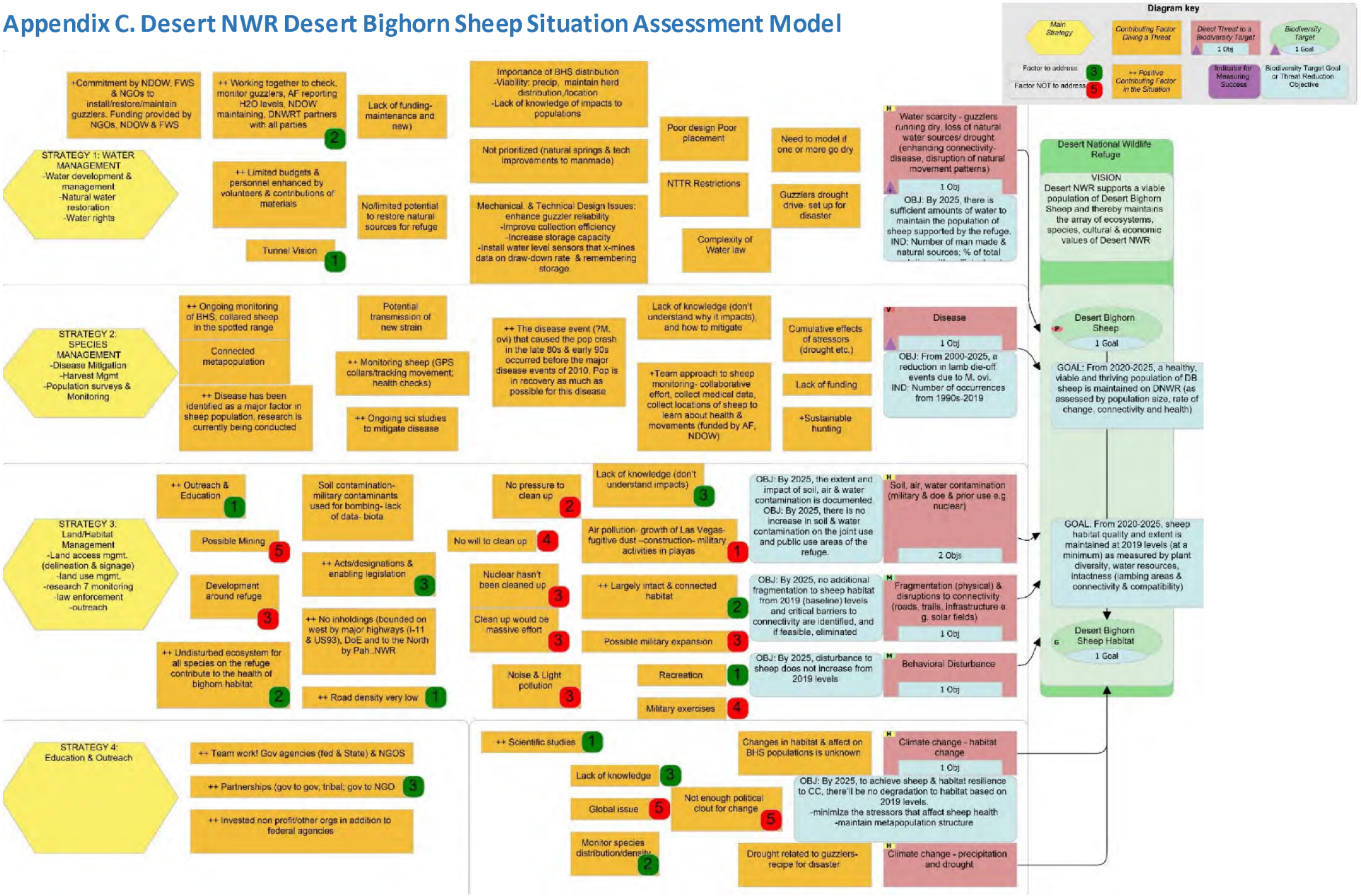
Appendix B. Legal Documents Regarding the Desert NWR

Important legislation, Executive Orders, Public Land Orders, and other documents related to the establishment and management of Desert National Wildlife Refuge.		
Year	**Legal Document**	**Regulatory directive behind document**
1936	Executive Order 7373	Established the 2.25 million–acre Desert Game Range, identified the refuge purpose as "sustaining a healthy condition of Nelson's mountain sheep" and dedicated the range to that species.
1940	Executive Order 8578	Approximately 846,000 acres of the Desert Game Range were reserved/withdrawn for the use of the War Department (U.S. Department of Defense [DOD]) as an aerial bombing and gunnery range (now Nevada Test and Training Range). The USAF's use of a portion of the Desert Game Range was governed by a Memorandum of Understanding (MOU) signed in 1949. The MOU was most recently updated on 2 December 1997.
1966	Public Land Order 4079	Revoked Executive Order 7373, renamed the Desert Game Range as the Desert National Wildlife Range, established administrative jurisdiction under the Bureau of Sport Fisheries and Wildlife (now the USFWS), as well as revised the purpose of the Refuge: "…for the protection, enhancement, and maintenance of wildlife resources, including bighorn sheep…". The Public Law also reduced the size of the range to 1,588,000 acres.
1999	Military Lands Withdrawal Act of 1999 (Public Law 106-65)	Amended Public Land Order 4079 by extending the Air Force's withdrawal on the 2,919,890-acre Nevada Test and Training Range for 20 years. This withdrawal overlay approximately 845,787 acres of the Desert NWR. Additionally, primary jurisdiction of 112,000 acres of bombing impact areas on Desert NWR was transferred from USFWS to DOD. The Service retained secondary jurisdiction over these lands. These lands were reserved for use by the Air Force: ". . . (A) as an armament and high hazard testing area; (B) for training for aerial gunnery, rocketry, electronic warfare, and tactical maneuvering and air support; (C) for equipment and tactics development and testing; and (D) for other defense-related purposes . . ."
2009	Desert National Wildlife Refuge Complex: Final Comprehensive Conservation Plan and Environmental Impact Statement	Provided environmental review of the comprehensive conservation plan, which identified refuge goals and management objectives and complied with the National Wildlife Refuge System Administrative Act of 1966, as amended by Refuge Improvement Act of 1997.

Appendix C. Desert NWR Desert Bighorn Sheep Situation Assessment Model



ANNEX A. Timeline of the Desert National Wildlife Refuge

Timeline of Desert National Wildlife Range

5/20/1936 EO 7373 1 FR 501 **acreage not cited**

Establishment of Desert Game Range

- Subject to valid existing rights, all lands belonging to U.S. withdrawn from settlement, location, or entry.
- For conservation, development of wildlife resources, protection/improvement of public grazing and natural forage resources.
- Does not restrict prospecting, locating, development, mining, entering, leasing, leasing or patenting under applicable laws.
- Any included lands, previously withdrawn for other purposes are impacted only so far as consistent with terms of their withdrawal.
- Any lands released from prior withdrawn lands are included in this order.
- Joint jurisdiction: Interior and Agriculture.
- Surplus game can be hunted at discretion of DOI Secretary.
- Resources managed to provide healthy conditions for 1,800 Nelson's mountain sheep.
- Lands may be included in grazing district and made available to domestic livestock.
- USDA Secretary to regulate land usage for migratory birds and other wildlife.

10/29/1940 EO 8578 5 FR 4313 **3,560,000 acres**

Withdrawal of Public Lands for Use of the War Department as an Aerial Bombing Range and Gunnery Range

- Land withdrawn from all appropriation under public land laws, including mining laws.
- This order takes precedence over but does not revoke EO 7373.
- Partially revoked and modified by EO 9019, 1/12/1942.
- Amended by EO 9526, 2/28/1945, returning land to DOI jurisdiction

11/27/1941 EO 8954 6 FR 6123 **68,533.75 acres**

Withdrawing Public Lands for Use of the War Department

- Land withdrawn from all appropriation under public land laws, including mining laws.
- Two separate tracts.
- Order subject to DOI's grazing district.
- Order subject to Power Site Classification.
- After WWII, order shall be terminated by DOI Secretary informing War Department that lands are needed for DOI purposes.
- Local commander will coordinate with Grazing Service to ensure not less than 2 days a month available for DOI field personnel to maintain range improvements.
- Amended by EO 9526, 2/28/1945, returning land to DOI jurisdiction

1/12/1942 EO 9019 7 FR 238 **2,617,300 acres/483,840 acres**

Revoking in Part and Modifying Executive Order No. 8578 of October 29, 1940, and Reserving Public Land for Use of the War Department as an Aerial Machine-Gun Range

- Paragraph 1: EO 8578 revoked for any lands not in legal cited in paragraph 1 of this EO.
- Paragraph 2: EO 8578 modified: all lands north of 1st Standard Meridian of paragraph 1 reserved for general bombing range; all lands south of said line reserved for aerial machine-gun range; DOI Secretary may coordinate with Secretary of War as necessary to relocate meridian.
- Paragraph 3: Land withdrawn from all appropriation under public land laws, including mining laws.
- Paragraph 4 [pertains to land described in paragraph 3 only]:
- This order takes precedence over, but does not revoke: EO 7373, establishing Desert Range; or other orders establishing a public water reserve, establishment of grazing districts and grazing withdrawals.
- Paragraph 5: Local commander will coordinate with FWS and Grazing Service to ensure not less than 2 days a month available for DOI field personnel to maintain range improvements; DOI personnel will have access to Sheep Valley via Alamo Road for official business.
- Paragraph 6: Land shall be returned to DOI when War Department purpose has been served.
- Amended by EO 9526, 2/28/1945, returning land to DOI jurisdiction

11/12/1942 PLO 58 7 FR 9749 **27, 006.09 acres**

Withdrawing Public Lands for Use of the War Department for Military Purposes

- Land withdrawn from all appropriation under public land laws, including mining laws.
- Modifies EO 7373 and DOI Secretary Order establishing grazing districts as necessary for military purposes.

- FWS personnel will have one day per week available for protection and maintenance of Desert Range.
- Lands will be returned to DOI when no longer needed by War Department.
- Amended by EO 9526, 2/28/1945, returning land to DOI jurisdiction

2/10/1943 PLO 89 8 FR 2294 **66.60 acres**
Withdrawing Public Lands for Use of the War Department for Military Purposes
- Land withdrawn from all appropriation under public land laws, including mining laws.
- Modifies EO 7373 and DOI Secretary Order establishing grazing districts as necessary for military purposes.
- FWS personnel will have one day per week available for protection and maintenance of Desert Range.
- Lands will be returned to DOI when no longer needed by War Department.
- Amended by EO 9526, 2/28/1945, returning land to DOI jurisdiction

8/4/1943 PLO 156 FR 11224 **182,791.53 acres**
Enlarging the Desert Game Range
- Subject to valid existing rights, all lands belonging to U.S. withdrawn from settlement, location, or entry.
- Lands subject to all provisions of EO 7373.
- Lands subject to primary jurisdiction of War Department, per EO 8954.

2/28/1945 EO 9526 10 FR 2423
Amending Certain Executive and Public Lands Orders Withdrawing Public Lands for Purposes Incident to the National Emergency and the Prosecution of the War
- Over 13,000,000 acres of public lands were withdrawn for use by the War Department; much had previously been withdrawn by other federal departments whose jurisdiction was subjugated to the war; now that the war is over the lands are returned to the departments who originally held primary jurisdiction.
- There are 54 EOs listed and 59 PLOs for amendment; including all of the above cited orders pertaining to the military.

3/2/1949 PLO 570 14 FR 1086 **160.00 acres**
Partially Revoking Executive Order No. 7373 of May 20, 1936
- Removes SW ¼ of Sec 35, T21S, R56E from Desert Range.

5/24/1957 PLO 1424 22 FR 3791
Partially Revoking Executive Order No. 7373 of May 20, 1936 **15,785.78 acres/489.91 acres**
- Removes 15,785.78 acres in NE corner of Desert Range
- Patents 489.91 acres in T9S, R62E without reservation of minerals to U.S.
- Describes demographic location and soils of lands removed.
- Lands removed not open for occupancy until they have been classified.
- Non-mineral land applications/selections by previous users or veterans may be filed.
- 1,000 acres of T10S, R62E are not subject to veteran's preference.
- Persons claiming veteran's preference must provide documentation for confirmation of status.

6/7/1961 PLO 2399 26 FR 5314 **25,600 acres**
Partially Revoking Executive Order No. 8954 of November 27, 1971, Which Withdrew Public Lands for Use of the War Department
- E.O. No. 8954 is revoked as it pertains to acreage cited.
- Lands in T18S, R61 & 62E are withdrawn by P/L/O/ No. 156 as part of Desert Game Range.
- Lands in T19S, R61 & 62E are not suitable for agriculture; most of area part of grazing district; all have been cleared of "reasonably able to detect" ordnance.
- Lands subject to public lands law and existing withdrawals.

2/16/1962 PLO 2613 27 FR 1975
Amending Certain Orders Which Withdraw Lands for Use of the War Department for Military Purposes (Nellis Bombing and Gunnery Range; Indian Springs Air Force Base)
- Use of the lands in the Desert Game Range shall be in accordance with the MOU between DOI and USAF.
- DOI retains jurisdiction of the mineral and vegetative resources.
- Authority is changing the land use rests with DOI Secretary.
- Jurisdiction and use granted to USAF for ten years; option to renew for five years; reservation may be terminated at any time upon written notice by DOI Secretary to USAF Secretary, provided that the reservation is no longer needed for military purposes.

2/11/1963 PLO 2936 **28 FR 1477**
Partial Revocation and Amendment of Executive Order No. 8954, Which Withdrew Lands for Use of War Department; Nellis Bombing and Gunnery Range

- Releases 10,758.28 acres in T18S R62 & 63E from EO No. 8954.
- Lands in T18S R62E are withdrawn by PLO 156 for Desert Game Range.
- Released lands subject to existing withdrawals, valid existing rights, mineral laws.
- USAF use of lands in Desert Game Range will be accordance with MOU.
- DOI retains jurisdiction of the mineral and vegetative resources.
- Cites 10,575 acres still withdrawn for USAF use.

3/13/1964 PLO 3348 29 FR 3524 **1,311.41 acres**
Withdrawing Lands for Pahranagat National Wildlife Refuge; Partly Revoking Executive Order No. 7373 of May 20, 1936 (Desert Game Range)

- Lands added to Pahranagat NWR subject to valid existing rights, withdrawn from all forms of appropriation under public land laws, including mining but not mineral leasing.
- EO 7373 revoked as far for all overlapping lands.
- Livestock permitted under BLM license; shall have necessary access to water on refuge; manager shall determine access routes; fencing along routes to be done at expense of grazing permitee; fencing plans approved by manager.

8/26/1966 PLO 4079 31FR 11547 **600,000 acres±**
Withdrawal for Desert National Wildlife Range; Revocation of Executive Order No. 7373

- Subject to existing rights and provisions of existing withdrawals, withdrawn from all appropriation under public land laws; not withdrawn from mining laws or leasing under mineral leasing laws.
- EO 7373 and PLO 156 revoked.
- Reserved for Desert National Wildlife Range, for protection, enhancement and maintenance of wildlife resources, including bighorn sheep.
- All acres in Clark County.

10/17/1987 PL 98-4 **858,503 acres**
Public Lands in Lincoln County, Nevada

- Jurisdictional changes from BLM to FWS as part of Desert NWR and from FWS to BLM.

10/13/1993 PLO 7005 58 FR 54049 **769,543 acres**
Emergency Withdrawal of Public Mineral Estate Within the Desert National Wildlife Refuge; Nevada

- Subject to valid existing rights, withdraws public mineral estate from location and entry under US mining laws.
- Withdrawal remains in effect for one year, unless extended.

7/18/1994 PLO 7070 59 FR 39701 **769,543 acres**
Withdrawal of Public Mineral Estate Within the Desert National Wildlife Range; Nevada

- Subject to valid existing rights, the mineral estate is withdrawn from location and entry under US mining laws.
- Includes lands in Clark and Lincoln Counties.
- Expires in 20 years, unless Secretary determines an extension be approved under FLPMA.

10/5/1999 PL 106-65 **2,919,890 acres**
National Defense Authorization Act for Fiscal Year 2000
TITLE XXX - Military Lands Withdrawal

- Lands withdrawn subject to valid existing rights; withdrawn from all forms of appropriation under public land laws, including mining laws, mineral leasing, geothermal leasing.
- Lands reserved for by Sec AF for training and testing.
- Pahute Mesa reserved for DOE.
- 112,000 acres of lands belonging to DOI, Desert NWR, are now under primary jurisdiction of SecAF. Sec Interior has secondary jurisdiction for wildlife conservation purposes.
- Lands withdrawn for Sec AF and DOE, depicted on map: Nevada Test and Training Range, Proposed Withdrawal Extension, dated April 22, 1999.
- No mineral resources may only be obtained from parts of DNWR not shown as impact areas except in accordance with MOU.
- SecAF has authority to close portions of refuge to public for safety reasons.

11/6/2002 PL 107-282 **26,433 acres**
Clark County Conservation of Public Land and Natural Resources Act of 2002

- Title III - Transfers of Administrative Jurisdiction
- Lands transferred from BLM to FWS for inclusion in Desert NWR as shown on Arrow Canyon map dated October 1, 2002.
- Lands subject to NWRSAA, not FLPMA; and existing cooperative conservation agreements.

11/30/2004 PL 108-424

Lincoln County Conservation, Recreation and Development Act of 2004 (LCCRDA)

- Title VI - Jurisdiction Transfer
- 8,503 acres transferred from BLM to FWS - as identified on map
- 8,382 acres transferred from FWS to BLM - as identified on map
- Map: Lincoln County Conservation, Recreation, and Development Act Map, dated October 1, 2004.