U.S. Fish & Wildlife Service

Hart Mountain

National Antelope Refuge

Final Bighorn Sheep Management Plan
Environmental Impact Statement

November 2021

HART MOUNTAIN NATIONAL ANTELOPE REFUGE FINAL BIGHORN SHEEP MANAGEMENT PLAN AND ENVIRONMENTAL IMPACT STATEMENT LAKE COUNTY, OREGON

LEAD AGENCY: U.S. Department of the Interior, U.S. Fish and Wildlife Service, Columbia Pacific Northwest Interior Region 9

COOPERATING AGENCIES: Oregon Department of Fish and Wildlife; U.S. Department of Agriculture, Animal and Plant Health Inspection Service, Wildlife Services

ABSTRACT: The California bighorn sheep (*Ovis canadensis* ssp. *californiana*) herd on Hart Mountain National Antelope Refuge in southeastern Oregon has declined from approximately 150 animals in 2017 to as few as 48 in 2020. Consequently, the herd is at risk of extirpation in the next few years without prompt management intervention. In response to the decline, the U.S. Fish and Wildlife Service has developed a bighorn sheep management plan and environmental impact statement to analyze existing data and identify alternatives and actions needed to restore the herd to a sustainable population level. The alternatives reflect the urgency to implement short-term management actions that are based on the best available science, in combination with mid- to long-term management and monitoring. The plan contains four alternatives: continuing current management; a habitat management focus; a predator control focus; and a preferred alternative, which is a combination of habitat management and predator control.

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EXECUTIVE SUMMARY

The U.S. Fish and Wildlife Service (Service) is developing a California bighorn sheep (*Ovis canadensis* ssp. *californiana*) management plan and associated environmental impact statement (EIS) for Hart Mountain National Antelope Refuge (Hart Mountain NAR, Refuge) in south-central Oregon. The bighorn sheep herd has declined by almost 70% since 2017 to a potentially unsustainable population level and is at risk of extirpation without management intervention. This management plan and EIS analyze the foreseeable effects on the human environment as a result of four possible management alternatives.

The California bighorn sheep herd on the Refuge in southeastern Oregon has declined from approximately 150 animals in 2017 to as few as 48 in 2020. Consequently, the herd is at risk of extirpation in the next few years without prompt management intervention. In response to the decline, the Service has developed a bighorn sheep management plan and EIS to analyze existing data and identify alternatives and actions needed to restore the herd to a sustainable population level. The alternatives reflect the urgency to implement short-term management actions that are based on the best available science, in combination with mid- to long-term management and monitoring. The EIS analyzes four alternatives: continuing current management; a habitat management focus; a predator control focus; and a preferred alternative, which is a combination of habitat management and predator control.

The purpose for the proposed actions analyzed in this EIS is to restore a sustainable herd of bighorn sheep on the Refuge. The California bighorn sheep, an iconic species native to Oregon and the Refuge, was extirpated from the state by 1912. The species was successfully reintroduced in 1954 when 20 bighorn sheep were translocated to the Refuge. The Refuge herd has since been the source of other sheep that have been translocated to other areas.

Action is needed to address the rapidly declining sheep numbers that place the herd in significant risk of extirpation from the Hart Mountain NAR in the next few years if the trend continues. The loss of the Refuge bighorn sheep population would represent a disturbance to historical ecological interactions between other species, would represent the loss of a species native to the Refuge, would be a significant loss to the natural quality of the Poker Jim Ridge Proposed Wilderness Area, and ultimately would be detrimental to associated predator populations over the long term.

Under Alternative A, the No Action Alternative, the alternative that continues current management practices, the bighorn sheep herd would continue to be managed as it has been in the past (i.e., without an integrated comprehensive bighorn sheep management plan). This is considered the baseline, or status quo. The range and numbers of bighorn sheep on the Hart Mountain NAR would be driven by recruitment and mortality factors, could rise or fall above or below management criteria, and extirpation could occur.

Alternative B, Bighorn Sheep Habitat Improvement Alternative, would entail continuing actions listed under Alternative A and conducting habitat management activities that are specifically targeted to benefit bighorn sheep in order to support a sustainable bighorn sheep herd. Actions would increase habitat quality by reducing western juniper (*Juniperus occidentalis*) that has invaded bighorn sheep habitat. These actions would increase the sheep's horizontal site distance and decrease predator-hiding cover.

Alternative C, Population Management Only Alternative, focuses on direct management of the bighorn sheep population by addressing predation mortality, risks associated with small population size (e.g., inbreeding depression), low resilience to environmental stressors, and high probability of extirpation. Under Alternative C, the Service would take immediate action to protect the bighorn sheep herd from both direct and indirect impacts from cougars (*Puma concolor*) by temporarily and strategically conducting administrative lethal removal of cougars to allow the herd size to recover to a sustainable level as defined by bighorn sheep population performance criteria. The intent of cougar removal would be to decrease bighorn sheep adult mortality and increase lamb survival and recruitment. The precarious status of the herd means that any losses are likely an existential threat.

Alternative D, the Comprehensive Integrated Management Alternative, is the Service's Preferred Alternative. It is a combination of management actions proposed in Alternatives B and C. An integrated management approach is preferred considering the complex interactions between habitat features and demographic factors that ultimately determine sustainability.

By definition, actions would be beneficial to bighorn sheep when they have a direct or indirect positive influence on the critical vital rates of the bighorn sheep population. In accord with the goals and objectives of this bighorn sheep management plan, all actions under Alternatives B, C, and D are intended and expected to have minor, intermediate, or major long-term positive effects on the bighorn sheep herd on the Hart Mountain NAR compared to Alternative A, which would likely have short- and long-term negative effects. The Preferred Alternative, Alternative D, would have the greatest positive effects compared to Alternatives A, B, and C because it represents a comprehensive approach integrating multiple strategies with the greatest chance of sustaining a healthy bighorn herd.

Under Alternatives A and B, cougars would not be removed or otherwise managed on the Refuge, but the Refuge subpopulation would be indirectly affected by Oregon Department of Fish and Wildlife management policies pertaining to the regional population within Cougar Management Zone F, which contains the Refuge. Cougars on the Refuge would likely continue preying on bighorn sheep and other prey species at rates similar to those in recent years, unless or until the prey base changes.

Alternatives C and D would result in a short-term moderate to major effect (as intended) and a long-term (post-removal program) negligible direct effect on the cougars. In addition, there would be a short- and long-term negligible effect on the regional cougar population. To the extent that a healthy, sustainable bighorn herd provides additional prey for cougars in the future, Alternatives B, C, and D would have a long-term positive indirect effect on the cougar population once the administrative removal program is suspended. Alternative D would have the greatest potential of restoring a balanced predator-prey interaction between cougars and the bighorn sheep herd on the Refuge.

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ACRONYMS AND ABBREVIATIONS

Acronym/Abbreviation	**Extended Word, Term, or Phrase**
°	degree
APHIS	Animal and Plant Health Inspection Service
ASR	Area Solar Radiation
AVMA	American Veterinary Medical Association
biocrust	biological soil crust
BLM	Bureau of Land Management
BMPs	best management practices
CEQ	Council on Environmental Quality
CFR	Code of Federal Regulations
CH_4	methane
CMP	*1994 Hart Mountain National Antelope Refuge Comprehensive Management Plan*
CO_2	carbon dioxide
DM	Departmental Manual (U.S. Department of the Interior)
DNA	deoxyribonucleic acid
EIS	environmental impact statement
EO	Executive Order
EPA	Environmental Protection Agency
F	Fahrenheit
FR	*Federal Register*
FSoC	federal species of concern
FW	U.S. Fish and Wildlife Service Manual
GIS	geographic information system
GHG	greenhouse gas
GPS	global positioning system
HUC	hydrologic unit code
I&E	immobilization and euthanizing
IAF	invasive annual forb
IAG	invasive annual grass
IMP	inventory and monitoring plan
IPM	integrated pest management
Improvement Act	National Wildlife Refuge System Improvement Act of 1997
LFM	live fuel moisture

Acronym/Abbreviation	**Extended Word, Term, or Phrase**
M. ovi	*Mycoplasma ovipneumoniae*
MFSL	Missoula Fire Sciences Laboratory
MRA	Minimum Requirements Analysis
NAIP	National Agriculture Imagery Program
NAR	National Antelope Refuge
NEPA	National Environmental Policy Act
NOAA	National Oceanic and Atmospheric Administration
NOI	notice of intent
NWRSAA	National Wildlife Refuge System Administration Act of 1966
ODEQ	Oregon Department of Environmental Quality
ODFW	Oregon Department of Fish and Wildlife
PJRPWA	Poker Jim Ridge Proposed Wilderness Area
PUP	pesticide use proposal
R&R	resistance and resilience
Refuge	Hart Mountain National Antelope Refuge
Refuge System	National Wildlife Refuge System
RNA	research natural area
Se	selenium
Service	U.S. Fish and Wildlife Service
SGI	Sage Grouse Initiative
SMU	species management unit
SOP	standard operating procedure
SRI	solar radiation index
USC	United States Code
USDA	U.S. Department of Agriculture
USGS	U.S. Geological Survey
VRM	vector ruggedness measure

CHAPTER 1. INTRODUCTION

The U.S. Fish and Wildlife Service (Service) is developing this California bighorn sheep (*Ovis canadensis* ssp. *californiana*) management plan and associated environmental impact statement (EIS) for Hart Mountain National Antelope Refuge (Hart Mountain NAR, Refuge) in south-central Oregon (Figure C-1; all maps referenced in this EIS are included below or in Appendix C). The bighorn sheep herd has declined by approximately 70% between 2017 and 2020 to a potentially unsustainable population level and is at risk of extirpation without management intervention. This EIS analyzes the foreseeable effects on the human environment related to four management alternatives.[1]

National Wildlife Refuge System

National wildlife refuges are guided by the mission and goals of the National Wildlife Refuge System (Refuge System), the purposes of an individual refuge, Service policy, and laws and international treaties. Relevant guidance includes the National Wildlife Refuge System Administration Act of 1966 (NWRSAA), as amended by the National Wildlife Refuge System Improvement Act of 1997 (Improvement Act), Refuge Recreation Act of 1962, and selected portions of the Code of Federal Regulations (CFR) and the Service Manual (FW). The mission of the Refuge System, as outlined by the NWRSAA, as amended, is

> to administer a national network of lands and waters for the conservation, management, and, where appropriate, restoration of the fish, wildlife, and plant resources and their habitats within the United States for the benefit of present and future generations of Americans.

1.1 Refuge Purpose

Although the Refuge System mission guides management of refuges as a national network, the highest priority for resource management and conservation comes from an individual refuge's establishing purpose. The purpose must form the basis for planning and management decisions on units of the Refuge System. The NWRSAA states that the purposes of a refuge are "specified in or derived from the law, proclamation, executive order, agreement, public land order, donation document, or administrative memorandum establishing, authorizing, or expanding a refuge, refuge unit, or refuge subunit." 16 United States Code (USC) 668ee(10).

Hart Mountain NAR was established by Executive Order (EO) 7523 (December 21, 1936):

> The public lands in the following-described area in Lake County, Oregon, [Hart Mountain NAR] are hereby withdrawn from settlement, location, sale, or entry and reserved and set apart for the use of the Department of [Interior], subject to existing valid rights, as a range and breeding ground for antelope and other species of wildlife.

The NWRSAA, as amended, also legally mandates the maintenance, and where feasible, restoration of biological integrity, diversity, and environmental health on an established refuge within the Refuge System (16 USC 668dd). Biological integrity is the "biotic composition, structure, and functioning at genetic, organism, and community levels comparable with historic conditions, including the natural biological processes that shape genomes, organisms, and communities" (601 FW 3).

1.2 Need for Action

The California bighorn sheep, an iconic species native to Oregon and Hart Mountain NAR, was extirpated from the state by 1912. The species was successfully reintroduced in 1954 when 20 bighorn sheep were translocated to the Refuge. Since then, Refuge and Oregon Department of Fish and Wildlife (ODFW) staff

[1] Revisions to the Council on Environmental Quality National Environmental Policy Act regulations became effective on September 14, 2020, and apply only to National Environmental Policy Act documents that commenced on or after that date. Because the Service published a notice of intent to prepare an EIS in the *Federal Register* on May 8, 2020, the revised regulations do not apply to this EIS.

have conducted cooperative annual surveys to assess population trends and measure demographic parameters, including the number of sheep, lamb recruitment, and ram size and age class. The observed number of sheep counted results directly from surveys and is regarded as the minimum number of sheep. Estimated bighorn sheep populations are derived from observed bighorn sheep counts using detectability rates (Section 3.3.1.3). The observed number of sheep counted on the Refuge increased yearly from 1954 as the herd expanded into available habitat to a peak range of approximately 350 to 415 between 1982 and 1992 (Figure 1.1); however, sheep numbers have steadily declined since the mid-1990s. Surveys over the past 3 years reflect the most significant declines with the number of sheep counted dropping from 149 (2017) to 100 (2018), then to 68 (2019) and 48 (2020). Based on these minimum counts, the current bighorn sheep density is approximately 1 per square mile, which is considered very low, according to Van Dyke et al. (1983), who recommended at least 5 bighorn sheep per square mile as a sustainable density (full references for this and all citations are presented in Appendix A). Lamb recruitment (number of lambs to 100 ewes) is also below levels necessary to maintain a stable herd size (from 54.4 in 2017 to 22.7 in 2019).

Action is needed to address the rapidly declining sheep numbers that place the herd at significant risk of extirpation from the Refuge in the next few years if these trends continue. The loss of the Refuge bighorn sheep population would represent a disturbance to historical ecological interactions between other species, would represent the loss of a species native to the Refuge, would be a significant loss to Poker Jim Ridge Proposed Wilderness Area’s (PJRPWA’s) natural quality of wilderness character under the Wilderness Act, and ultimately would be detrimental to associated predator populations over the long term.

The ODFW (Muir 2018) has used a population model based on White and Lubow (2002) that incorporates all available bighorn data collected on the Refuge. This multiple data source model uses data to estimate, or predict, the most likely population parameters. Model results using the most recent bighorn sheep observed population demographic data show a current Hart Mountain NAR population trajectory trending toward 0 (local extirpation). This modeling effort supports the conclusion that the current decline in the number of bighorn sheep counted on the Refuge necessitates management action.

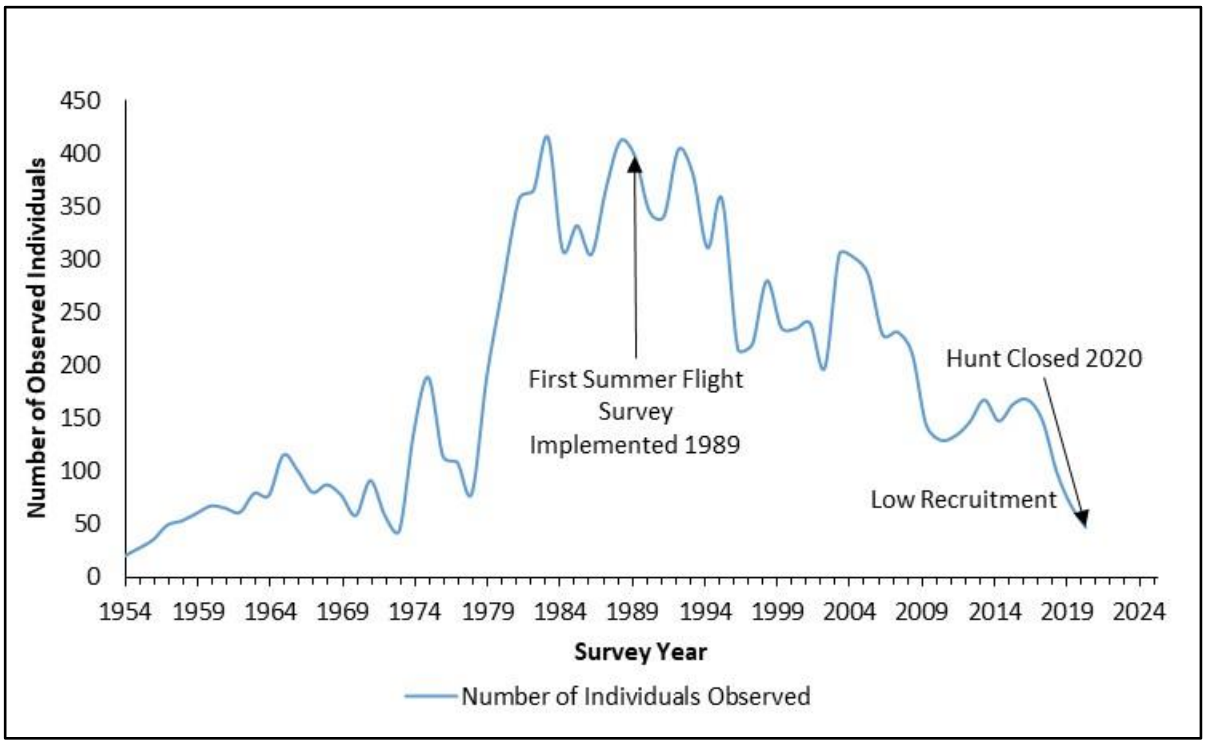

Figure 1.1. Minimum number of individual bighorn sheep observed on Hart Mountain National Antelope Refuge (1954–2020). Number of sheep observed was obtained from fall ground counts until 1988. Beginning in 1989, sheep were counted during summer helicopter flight surveys (Service 2020a).

1.3 Purpose for Action

The purpose for the proposed action is to return bighorn sheep to a sustainable population with demographic characteristics that demonstrate no long-term upward or downward trend, (i.e., a population that fluctuates around a stable average number). This may be termed the *steady state equilibrium* of the population within its habitat. A sustainable population is further characterized by persistence under projected future conditions with minimal management intervention and resilience to the dynamic conditions present at the Refuge (e.g., changes in habitat quality and quantity, disease, fire, drought, severe storms, predation, and forage competition). Based on fundamental population biology concepts and modeling efforts, bighorn sheep populations may be considered healthy when average annual growth rates are equal to or greater than 1.0, average lamb-to-adult ratios are equal to or greater than 30 to 100, and adult survival is at least 80% annually. All indications are that the Refuge's bighorn sheep herd is currently performing well below these performance measures, and its current population size and trend place it at risk of extirpation from potential random (stochastic) and nonrandom (deterministic) events. Therefore, taking aggressive management actions to benefit bighorn sheep under an adaptive management framework is necessary to ensure the growth and ultimate stability of the population on the Refuge.

1.3.1 Bighorn Sheep Population Performance Measures

Several studies suggest that a minimally viable bighorn sheep population consists of at least 125 individuals (Geist 1971; Van Dyke et al. 1983; Smith et al. 1991). In the event that disease enters a population, Cassaigne et al. (2010) suggest that the population should consist of at least 170 animals, assuming that 50 to 70% will succumb to disease and the surviving number of individuals would presumably be large enough to preserve and maintain genetic diversity. Specific to the Refuge, Foster and Whittaker (2010) suggested that, based on available information, Refuge habitats could sustain an estimated population of approximately 400 bighorn sheep over a long period of time. Refuge survey data (see Figure 1.1) indicate that the observed bighorn sheep population was dynamic, but declining, for nearly 20 years between 1989 and 2008 before dropping to approximately 150 observed bighorn sheep from 2009 to 2017. The sudden population crash from 2017 to 2020 suggests that the bighorn sheep population during that period was not sufficient to buffer the population against random natural events and was not sustainable over the long term. Therefore, an observed count of 170 bighorn sheep, based upon Cassaigne et al. (2010), representing an estimated population size of 215 individuals using the detectability rate described in Section 3.3.1.3, represents a population believed to be the minimum necessary to provide opportunity for an adequately performing population to achieve a steady state equilibrium over a long period of time.

Population size or trends as standalone measures are proven to be insufficient as a base for management goals or objectives because environmental stressors and management actions do not affect population size directly; rather, they directly affect the vital rates of the population, and through vital rates, affect the population size and population trend (Temple and Wiens 1989). Vital rates such as population growth, adult survival, and lamb to adult ratios are measurable rates that can be derived from surveys and field data to determine population performance (DeCesare et al. 2012; Serrouya et al. 2017). These metrics provide the critical input for modelling population performance through time. Generally, a ratio of at least 30 lambs to 100 adults (3-year average) in the spring of the year is important in sustaining a population assuming a 50:50 sex ratio at birth, and annual adult survival of 80% to a breeding age of 2.5 years. Management decisions and actions will be linked to these demographic performance measures. To verify the long-term effectiveness of the management plan, we expect the estimated population size, as a result of successfully meeting or exceeding the population performance measures and implementing actions, to range between 215 and 400 bighorn sheep on Hart Mountain NAR. Based on historical bighorn sheep population growth on Hart Mountain (see Figure 1.1), it could take 15 years or more to reach 170 bighorn sheep through natural recruitment. According to the Kofa National Wildlife Refuge Final Environmental Assessment to reduce cougar predation on desert bighorn sheep (USFWS 2009), declines in bighorn sheep populations can occur relatively quickly, and recovery from those effects can take much longer than the period of decline.

The Service will evaluate alternatives in this EIS and assess their ability to restore and maintain a bighorn sheep population on Hart Mountain NAR, which is characterized by the following:

- 3-year average annual population growth rate ≥1.0
- 3-year average annual adult survival ≥80%
- 3-year average lamb recruitment ratio at or above 30 lambs to 100 adults

Consistently meeting these population performance conditions is necessary for the population to attain a sustainable number that will enable the population to withstand environmental variability and stochastic events inherent on the landscape.

1.4 Planning and Issue identification

1.4.1 Description of the Planning Process

A core planning team, consisting of the Sheldon-Hart Mountain National Wildlife Refuge Complex project leader, deputy project leader, wildlife population biologist, habitat biologist, and the Hart Mountain NAR manager, began developing the bighorn sheep management plan and EIS in 2019. A retired Service wildlife biologist was also hired under a professional services agreement to assist the planning team.

Public scoping began May 8, 2020, with the publication of a notice of intent (NOI) in the *Federal Register* (FR). The NOI notified the affected public of the opportunity to participate in the preparation of the management plan and EIS and encouraged them to comment and make suggestions on the scope of issues to consider in the planning process (602 FW 1). The State of Oregon imposed restrictions on public gatherings and closed public venues because of COVID-19; consequently, two planned in-person public scoping meetings had to be cancelled. As a result, Refuge staff developed and posted detailed information regarding the Refuge, bighorn sheep population, and the National Environmental Policy Act (NEPA) process on the Refuge website and solicited public comment. Public comments were also solicited through notifications sent to three federally recognized tribes, the Lake and Harney County Commissions, 19 neighboring landowners, 23 nongovernmental organizations, and an additional 20 national environmental and sportsman's organizations. A virtual meeting was held with one organization, as requested.

1.4.2 Planning Issues

After the initial public scoping period ended on June 8, 2020, the planning team, other Service personnel, partners, and the public identified significant issues. The planning team then reviewed and evaluated all potential issues, management concerns, problems, and the opportunities to resolve them. The Service defines an issue as "any unsettled matter that requires a management decision, e.g., an initiative, opportunity, resource management problem, threat to the resources of the unit, conflict in uses, public concern, or the presence of an undesirable resource condition." (602 FW 1.6(K)). Significant issues typically are those that are within our jurisdiction, suggest different actions or alternatives, and will influence our decision (602 FW 3.4(C)(3)(b)).

The issues listed below are within the scope of the management plan and EIS and are considered by the Service to be the major issues to address in the planning process.

1.4.2.1 BIGHORN SHEEP POPULATION VIABILITY

What are the population objectives and other demographic metrics for defining a sustainable bighorn sheep herd on Hart Mountain NAR? What are the causes of the bighorn sheep population decline? What management tools can be used to rebound the declining bighorn sheep population? How will augmentation of the sheep population be used? Under what condition can bighorn sheep hunting resume, and how?

1.4.2.2 BIGHORN SHEEP SURVIVAL AND MORTALITY

How have the various sources of mortality (e.g., disease, predation) contributed to the bighorn sheep population decline on Hart Mountain NAR? To what extent is cougar (*Puma concolor*) predation a cause of the observed decline of the bighorn sheep population? Should/can removal of cougars through a cougar hunt and/or administrative removals be used effectively?

1.4.2.3 BIGHORN SHEEP HABITAT MANAGEMENT

What quantity and quality of various components of habitat are available to bighorn sheep on Hart Mountain NAR? What habitat management actions (e.g., improvements to food and cover resources, addressing shrub and juniper (*Juniperus occidentalis*) encroachment, and control of invasive species) and tools (e.g., prescribed fire) can the Service identify and implement to encourage the bighorn sheep population to rebound and move toward a long-term sustainable population defined by population performance and health?

1.4.2.4 WATER AVAILABILITY

Is the availability of water limiting sheep on Hart Mountain NAR? How has water availability changed over time, and how will it change in the future with climate change?

1.4.2.5 DATA COLLECTION, RESEARCH, AND MONITORING

What habitat, demographic, disease, genetic variability, and other scientific data needs to be collected and analyzed over the short and long term relative to both bighorn sheep and cougars? What is an appropriate monitoring strategy and program?

1.4.3 Issues Outside the Scope of the Management Plan and Environmental Impact Statement

No issues outside the scope of the management plan and EIS were identified.

1.5 Cooperating Agencies and Partnerships

In early 2020, the Service and ODFW entered into a memorandum of understanding to formally establish the ODFW as a cooperating agency for the development of this bighorn sheep management plan and EIS because of its special expertise with bighorn sheep management. Two ODFW biologists serve as members of the core planning team and are providing input and reviewing portions of the document.

In October 2020, the Service requested the U.S. Department of Agriculture (USDA) Animal and Plant Health Inspection Service (APHIS)–Wildlife Services to be a cooperating agency for this management plan and EIS based on their special expertise with predator management. Several staff serve as members of the core planning team and are providing input and reviewing portions of the document.

1.5.1 Oregon Department of Fish and Wildlife

ODFW is responsible for managing resident wildlife and is responsible for the maintenance of populations for the benefit of the people of the State of Oregon (Oregon Revised Statutes 496.012).

Wildlife are managed by ODFW according to management plans, conservation strategy plans, and other documents, including the following, which are pertinent to this EIS:

- Oregon's Bighorn Sheep and Rocky Mountain Goat Management Plan (ODFW 2003)
- Oregon Cougar Management Plan (ODFW 2017)

These plans provide goals and management actions for ensuring sustainable populations in Oregon. Habitat management is under the jurisdiction of private landowners or appropriate state and federal land management agencies such as the U.S. Forest Service, the Bureau of Land Management (BLM), or the Service (Hart Mountain NAR).

1.5.2 U.S. Department of Agriculture Animal and Plant Health Inspection Service–Wildlife Services

Wildlife Services is the federal agency authorized by Congress to protect American resources from damage associated with wildlife. The Act of March 2, 1931 (46 Stat. 1468; 7 USC 426), as amended in the Act of December 22, 1987 (101 Stat. 1329-331, 7 USC 426c), states “The Secretary of Agriculture may conduct a program of wildlife services with respect to injurious animal species and take any action the Secretary considers necessary in conducting the program.”

The Act was amended in 1987 (101 Stat. 1329-331, 7 USC 8353) to allow Wildlife Services “to conduct activities and to enter into agreements with States, local jurisdictions, individuals, and public and private agencies, organizations, and institutions in the control of nuisance mammals and birds . . . .”

The agency is funded by Congressional appropriations and by funds provided by governmental, commercial, private, and other entities that enter into an agreement with Wildlife Services for assistance.

Wildlife Services provides federal professional leadership and expertise to resolve wildlife conflicts to help create a balance that allows people and wildlife to coexist. Wildlife Services applies and recommends a cohesive integrated approach, which incorporates biological, economic, environmental, legal, and other information into a transparent wildlife damage management decision-making process, and includes many methods for managing wildlife damage, including non-lethal and lethal options.

The Wildlife Services’ mission includes resolution of wildlife conflicts in rural and urban areas; conservation of natural resources (including threatened and endangered species and managed wildlife populations); protection of public, private, and commercial property and assets; control of invasive species; and assisting states with wildlife disease surveillance and management efforts.

Wildlife Services would only provide assistance when the appropriate property manager or property owner requested assistance and where authorization for services is granted.

Wildlife Services Directive 3.101 (USDA 2015) states:

> Wildlife Services (WS) is specifically authorized to enter into cooperative programs with Government agencies, public or private institutions, organizations, or associations, and private citizens to manage conflicts with wild animals. By coordinating Federal Government involvement in managing wildlife conflicts and/or damage, WS officials help ensure that wildlife management activities are environmentally sound and conducted in compliance with applicable Federal, State, and local laws and regulations, including two significant Federal environmental laws, the Endangered Species Act and [NEPA].

A detailed review of relevant federal and state laws is presented in Appendix B.

CHAPTER 2. ALTERNATIVES, GOALS, OBJECTIVES, AND STRATEGIES

2.1 Criteria for Alternatives Development

Alternatives represent a range of reasonable management approaches considered to accomplish the purpose and need of the proposed action, which is to restore and maintain a healthy, sustainable bighorn sheep herd on the Refuge. To address the small and rapidly declining herd on the Refuge, the alternatives must appropriately reflect the urgency to implement short-term management actions that are based on the best available science, in coordination with mid- to long-term management, research, and monitoring. Predator control would be considered while also recognizing that predator-prey interactions and population fluctuations are essential parts of a healthy herd and ecosystem. In addition, focusing the long-term management of habitat on meeting the life-history needs of bighorn sheep on the Refuge is considered a key element of this management plan.

This chapter presents a No Action Alternative (current management) and three action alternatives. Descriptions of the resource management goals and objectives for this management plan are also presented in this chapter. For each alternative, we propose management strategies (specific tools and actions) to achieve resource objectives (i.e., maintain a healthy, sustainable herd of bighorn sheep on the Refuge). The proposed management strategies within the alternatives represent the most current range of scientifically based options that are considered reasonable and necessary to accomplish resource objectives. The projected effects are compared among the alternatives in Chapter 4, Environmental Consequences.

2.2 Elements Common to All Alternatives

2.2.1 Coordination with Tribal, State, and County Governments

Regular communication with Native American tribes who are affected or who have an interest in the management of the Refuge would continue. The Service coordinates and consults with tribes on a regular basis regarding issues of shared interest. These tribes include the Burns Paiute Tribe, the Fort Bidwell Indian Community, Summit Lake Paiute Tribe, Cedarville Rancheria of Northern Paiute Indians, Klamath Tribes, Pit River Tribe, Winnemucca Indian Colony of Nevada, and the Fort McDermitt Paiute and Shoshone Tribes.

The Service would maintain regular discussions with Lake County commissioners and agencies of the State of Oregon. Specific state agencies include ODFW, Oregon Department of State Lands, and, in the case of larger landscape-scale concerns, Nevada Department of Wildlife. Key topics discussed include monitoring, research opportunities and needs, big-game management, and hunting and fishing seasons and regulations.

2.2.2 Management of Areas Proposed for Wilderness Designation

In 1972, the president submitted a proposal to Congress for designation of certain lands within the Refuge as the PJRPWA under the Wilderness Act of 1964 (Figure 2.1). The area shown in Figure 2.1 is consistent with the original proposed wilderness boundary description, but also includes several contiguous small parcels of public land now managed by the Service after the 1998 Hart Mountain Transfer Act, which resulted in an exchange of land with the BLM. Congress has taken no action on the 1972 proposal. Until Congress takes additional action, the PJRPWA will continue to be managed per Service policy as designated wilderness, including development of Minimum Requirements Analyses (MRAs). The purposes of the Wilderness Act are within and supplemental to the Refuge purposes for the wilderness portion of the Refuge (610 FW 1.5(X)).

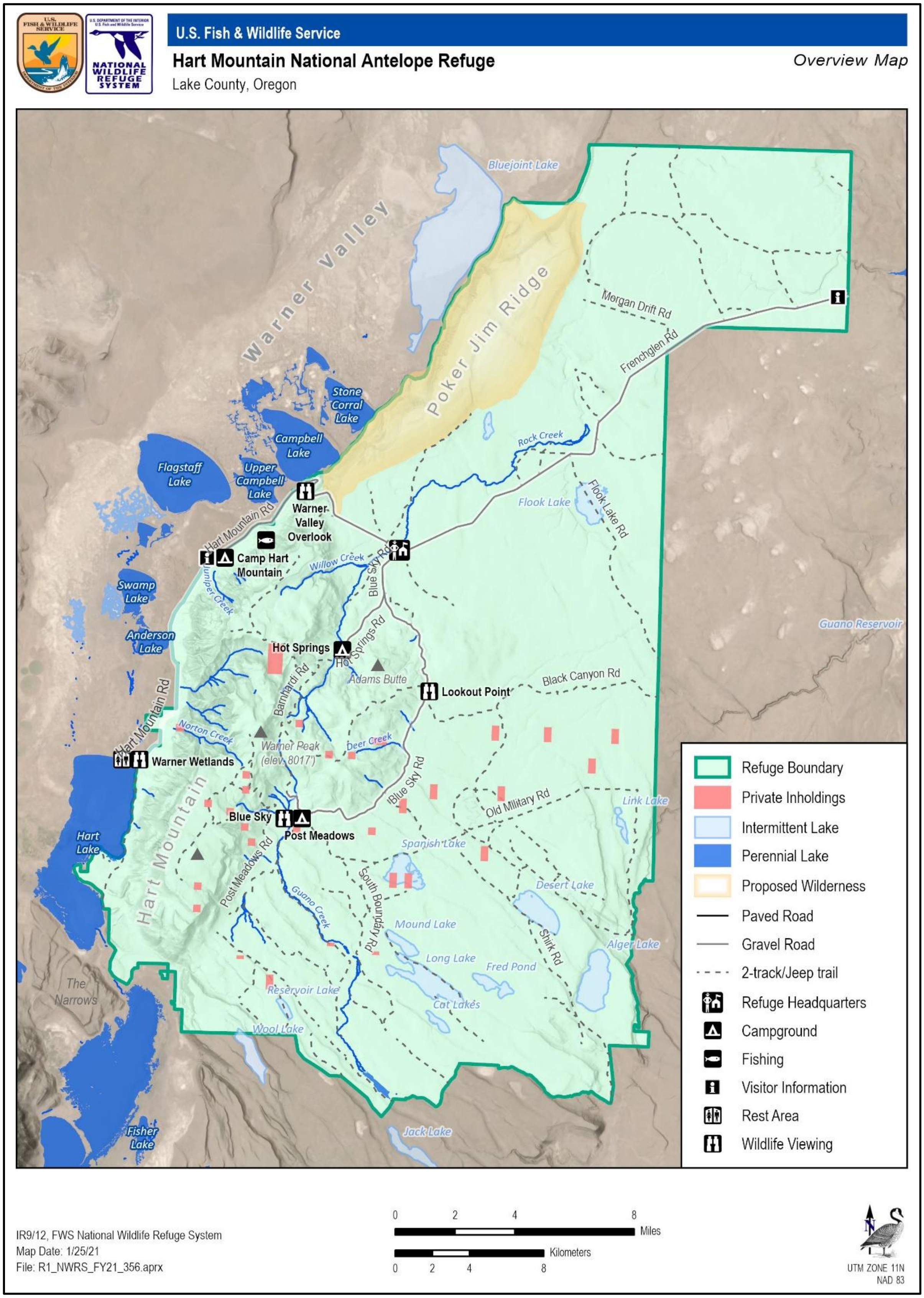

Figure 2.1. Overview map of Hart Mountain National Antelope Refuge.

2.2.3 Integrated Pest Management Strategies

In accordance with 517 U.S. Department of the Interior Departmental Manual (DM) 1 and 569 FW 1, an integrated pest management (IPM) approach would be followed, where practical, to eradicate, control, contain, or prevent pest and invasive species on the Refuge. Vegetation management actions described in the alternatives include controlling invasive plants and reducing shrub cover for the benefit of bighorn sheep. IPM would involve systematic prevention, monitoring, and intervention using methods based upon effectiveness, cost, and minimal ecological disruption, considering potential impacts to non-target species and the Refuge environment. Regional management direction for implementing IPM strategies has been adopted as part of this management plan (Appendix D). Biological, cultural, chemical, and physical methods are commonly used techniques to control invasive and encroaching plants in a variety of habitats. Herbicides may be used where biological, cultural, and physical methods or combinations thereof are impractical or incapable of providing adequate control, eradication, or containment. Where applicable, Refuge staff would continue to develop pesticide use proposals (PUPs) consistent with this IPM guidance. If an herbicide is needed on the Refuge, the most specific (selective) and effective chemical(s) available for the target species would be used unless considerations of persistence or other environmental and biotic concerns would preclude it.

PUPs would be prepared and approved before any herbicide is used on the Refuge. PUPs require site-specific analysis, evaluation of chemical profiles, and evaluation of likely environmental impacts (risks). Based on scientific information and analyses documented in chemical profiles, herbicides would be approved for use on Refuge lands where the potential impacts to biological resources and physical environment are likely to be only minor, temporary, or localized in nature, and would be of relatively low risk to non-target organisms as a result of low toxicity or short persistence in the environment; however, herbicides may be used on Refuge lands where substantial impacts to species and the environment are possible in order to protect human health and safety.

In addition to the generally responsive IPM strategies described in Appendix D, this management plan would also employ invasive species prevention guidelines (Appendix E) developed by the Service to implement EO 13112, amended by EO 13751, Safeguarding the Nation from the Impacts of Invasive Species, to minimize the introduction of invasive species.

2.2.4 Development of Step-Down Plans

Step-down management planning is the process of developing detailed plans for meeting the goals and objectives identified in a parent document, such as the *1994 Hart Mountain National Antelope Refuge Comprehensive Management Plan* (CMP), as needed to implement management actions (see 602 FW 4). Step-down plans typically include standard operating procedures (SOPs) detailing how the proposed strategies would be implemented, including field methods and equipment for data collection, data record quality control, analyses, archival procedures, roles of personnel involved, and reporting requirements. The SOPs for surveys would be integrated into the Refuge inventory and monitoring plan (IMP), which identifies and selects surveys to inform management decisions or assess the status of resources in accordance with 701 FW 2. The IMP for the Refuge would include habitat surveys, health screenings for disease in bighorn sheep as well as herd composition and population surveys using aerial counts. Global positioning system (GPS) collar data would aid in determining adult survival and distribution.

2.2.5 Public Use Management

The current management direction would continue to provide existing opportunities for compatible wildlife observation, wildlife photography, and hunting on the Refuge, with the staff continuing to coordinate harvest seasons and tags with ODFW.

2.2.6 Implementation Subject to Funding Availability

Management actions and strategies detailed in this chapter would be implemented based upon the availability of funding.

2.3 Proposed Alternatives

2.3.1 Alternative A: No Action (Current Management)

Under the No Action Alternative, the bighorn sheep herd on the Refuge would continue to be managed as it has been in the past (i.e., without an integrated comprehensive bighorn sheep management plan). This is considered the baseline, or status quo. The range and numbers of bighorn sheep on the Refuge would be driven by recruitment and mortality factors and could rise or fall above or below management criteria stated in Objective 2.1.

Current monitoring of bighorn sheep would continue, including aerial herd composition counts, capture and marking of animals with GPS collars, and conducting health screenings for disease. Trials to treat diseased bighorn sheep in captive and free-ranging situations or to attempt to vaccinate them against infectious diseases have not been effective when infection is facilitated by *Mycoplasma ovipneumoniae* (*M. ovi*) bacterium (Raghavan et al. 2017). Incidences of pneumonia-related population crashes are repeatedly associated with the presence of domestic sheep and goats (Alaska Chapter of the Wildlife Society 2015, George et al. 2008, Wehausen et al. 2011). While not all outbreaks of pneumonia in wild sheep have confirmed contact with domestic sheep or goats, the preponderance of scientific evidence shows that association between these species poses a significant threat to wild sheep conservation and recovery (The Wildlife Society 2020). The vulnerability of the Refuge bighorn sheep herd at this time warrants caution, and goats and sheep would both be considered a threat of disease transmission that could result in bighorn sheep die-offs. Therefore, the discovery of a known, suspected, or likely contact between bighorn sheep and domestic sheep or goats would be treated aggressively. A bighorn sheep within a livestock pasture off-Refuge would be immediately live-captured, if feasible, or lethally removed if not, and tested for disease exposure in cooperation with ODFW. When there is known, suspected, or likely contact by stray domestic sheep or goats within Refuge bighorn sheep range, the owner of such livestock would be notified and asked to remove the stray animals immediately. If, for any reason, the livestock owner does not respond and remove the animals, the stray(s) would be removed following Service domestic animal impoundment procedures (50 CFR 28.42). Refuge or ODFW staff would lethally remove all feral (nondomestic, or without identifiable markings) sheep and goats immediately (50 CFR 30.11). Domestic horses used for horseback riding and packing are allowed on the Refuge, but goats and llamas are prohibited.

MRAs for restricted management actions within the PJRPWA are included in Appendix F and include guzzler maintenance and monitoring, juniper treatment, and bighorn sheep capture. An MRA is a decision-making process to determine if proposed management actions or activities are necessary to administer the area as wilderness and if those actions/activities accomplish the mission/purpose of the Refuge, including the Wilderness Act purposes. An MRA is required whenever the Refuge is considering a use prohibited by Wilderness Act of 1964.

Bighorn sheep hunts would continue to be suspended until the herd reaches sustainable numbers. No bighorn sheep translocations or augmentations would be conducted to increase the population.

Bighorn sheep habitat would be managed under objectives outlined in the CMP. The CMP emphasizes the use of prescribed burning as the primary means of restoring and maintaining upland habitats, and passive restoration for rehabilitating riparian areas. Juniper treatment objectives are limited to cutting juniper prior to burning. Recent juniper treatments were focused on assessing and treating low density juniper for sage-grouse habitat improvements and included cut and leave, lop and scatter, and cut, pile, and cover (slash piles) methods. Use of the cut, pile, and cover method to treat low-density juniper is followed up with burning and reseeding piles.

Invasive plants would continue to be treated using IPM methods, but without specific emphasis on invasive species directly affecting the quality of bighorn sheep habitat. There would be no change in fire management and no focused treatment of bighorn sheep habitat. Surveillance of bighorn sheep predation losses and movements would continue within the Refuge using GPS-marked individuals.

2.3.2 Alternative B: Bighorn Sheep Habitat Improvement

Alternative B would entail continuing actions listed in Alternative A plus conducting habitat management activities that are specifically targeted to benefit bighorn sheep in order to support the sustainable bighorn sheep management Objective 2.1. Section 2.5.1 describes specific goals, objectives, and strategies identified to support bighorn sheep habitat management. Bighorn sheep are wide-ranging animals that require a variety of habitat characteristics related to topography, visibility, water availability, and forage quality and quantity. Habitat management would focus on the entire herd range and address life-history needs to expand and enhance habitat conditions (Figure C-2). The Refuge would protect and maintain all bighorn sheep habitat currently in desired conditions; it would also assess and evaluate additional habitat and develop site-specific prescriptions to improve habitats in fair or poor condition. Under this alternative, habitat management actions would focus on addressing deficiencies in lambing, as well as summer and winter habitats in areas with reasonable and safe access for the people doing the management work. As available and relevant, habitat-use information derived from GPS-collared bighorn sheep would be integrated into decisions regarding sites at which to implement habitat-improving actions.

Factors leading to the current bighorn sheep population status are directly or indirectly related to habitat change over recent decades. There have been successional changes in habitat resulting from fire suppression and the establishment of invasive plants that have likely contributed to the bighorn sheep decline. Habitat management actions proposed under this management plan are designed to reverse the ecological trends of recent decades that have reduced bighorn sheep habitat quality and quantity, as described in Section 3.4. Objectives include conserving native species–dominated sagebrush habitats while maintaining a low percent cover of invasive annual grasses (IAGs) (Section 2.5.1). Actions would include

- controlling non-native invasive plants using IPM strategies;
- using management concepts of resistance and resilience (R&R) in assessing and managing habitats;
- suppressing wildfire in habitats vulnerable to non-native species invasion and with low resilience to disturbance (with particular emphasis on IAG species);
- judicious use of prescribed fire, wildfire, and wildfire response in habitats with higher resilience to disturbance;
- reseeding and replanting with native plants as necessary;
- improving horizontal visibility in escape terrain and foraging habitats where needed and possible; and
- reducing density, canopy closure, and canopy cover of native post-settlement western juniper trees (<150 years old), while maintaining juniper woodlands, old-growth juniper trees (>150 years old) and mountain mahogany (*Cercocarpus* spp.) stands.

All actions would follow principles and policies in the Service's Biological Integrity, Diversity, and Environmental Health Policy (BIDEH; see 601 FW 3). Upland shrubland with canopy closure >25%, >4 encroaching juniper stems per acre, >10% herbaceous cover of non-native invasives, or mean shrub height over 2 feet may be targeted for treatment to bring these metrics back to desired sheep habitat characteristics. Initial focus would be to treat areas in accessible core habitat to be identified using the geographic information system (GIS) habitat model and field reconnaissance. Efforts to remove encroaching juniper would primarily focus on approximately 11,275 acres of accessible areas in core bighorn sheep habitats, the vast majority of which are shrubland communities. Approximately 1,500 acres may be treated per year by work crews on foot using chainsaws and hand tools. Old-growth juniper (over 150 years old) would be conserved and not be directly managed or affected.

Treatment of encroaching post-settlement juniper is determined by a host of external, internal, and intrinsic factors. External factors are those variables beyond the control of the Service, such as funding, contractor availability, and related market forces (such as contractor workload and worker availability). Internal factors include those variables at least partially within control of the Service, such as personnel availability and project prioritization, administrative access (e.g., seasonal road closures, campground availability, hunting seasons), and administrative support (e.g., development of specific treatment prescriptions, contracting, and planning and communications). Intrinsic factors are those variables that are naturally limiting to the performance and rate of the treatment, such as weather, fire risk, phenology, and climatic patterns; topography and physical access restraints; density and size of targeted juniper; invasive species presence; and cultural features.

Slash resulting from woody plant thinning would be piled for winter burning to minimize soil and root damage and potential fire creep and would be conducted according to an approved prescribed burn plan. Burn pile sites (e.g., ash piles) would be reseeded with locally adapted native seed.

Shrub reduction by physical means or herbicide application could occur on up to approximately 100 acres per year, using ground or aerial methods depending on access and site conditions, primarily to address issues of horizontal visibility. Prescribed burning, to address issues of horizontal visibility, invasives, or to convert late seral shrub cover to grass and forb–dominated cover, may occur on up to approximately 800 acres per year, and would be conducted according to an approved prescribed burn plan.

Invasive grasses and forbs would be treated as necessary and appropriate with hand tools, approved herbicides, and prescribed burns, and reseeded with locally adapted native seed as necessary. Larger infestations would be treated using ground or aerial methods, depending on access and site conditions.

Burned area emergency stabilization, rehabilitation, and restoration projects (see 620 DM 7) would be developed and implemented following wildfire to minimize non-native species invasion and increase and promote recovery of native habitats.

Bighorn sheep water sources are limited on Poker Jim Ridge and are more abundant in North and South Mountain areas of the Refuge. Water sources include natural springs, seeps, creeks, and pools, as well as artificial sources, including three guzzlers, two former stock ponds, and dugouts and impoundments. Artificial water sources require periodic maintenance to function properly. Natural water sources may be enhanced by controlling encroaching juniper in the watershed, increasing water storage capacity and persistence, and reducing concealment cover in the vicinity that may be used by predators. Under this alternative, water source quality, availability (both spatially and seasonally), condition, and proximity to other habitat elements during droughts and critical bighorn sheep life stages would be assessed for potential management actions to improve this critical habitat element. Natural water sources may be rehabilitated using low-complexity techniques, focusing on maintaining or improving water availability (duration) and natural hydrologic function (such as reconnecting down-cut streams to their floodplain and restoring native riparian vegetation and related organic components).

Bighorn sheep habitat management actions would occur in areas where site-specific assessment and monitoring results indicate the habitat is not achieving management objectives optimal for bighorn sheep (see Section 2.5.1). The Refuge would develop an IMP (see 701 FW 2) that would include habitat surveys to assess and monitor effectiveness and efficacy of bighorn sheep habitat management actions.

Habitat management techniques used under this alternative would be similar to those implemented under current management; however, there would be more targeted use of prescribed fire in sagebrush habitats where negative impacts from invasive plant species and other sagebrush-obligate species could be minimized. Use of hand tools, chainsaws, and motor-driven implements to mechanically remove western juniper and rehabilitate native habitats would increase.

Funding is by far one of the largest factors determining the treatment rate for habitat management efforts. As a standard practice, the Service looks for funding sources beyond base allocations (such as grants) to help accomplish goals and objectives. The Service would continue this practice in implementing Alternative B, though successful competition for this funding is not assured. Therefore, the proposed treatment rates (see Section 2.5.1) are based on base funding allocations only (i.e., realistic target levels given a limited funding resource and other commitments within that funding source). Should a significant funding source become available, the Service would attempt to increase the habitat treatment rates (and any requisite follow-up treatments) to the extent practicable.

Under Alternative B, assessment and monitoring would be conducted annually throughout implementation of the habitat management strategies to inform and guide future habitat actions. The Refuge, in consultation with ODFW, would evaluate the progress and efficacy of habitat management actions relative to bighorn sheep habitat objectives every 6 years after implementation begins. This periodic evaluation would determine if habitat management actions were trending toward or meeting habitat objectives and whether changes in habitat management actions are warranted. Assessing strategies applied to achieve bighorn sheep habitat objectives every 6 years generally coincides with the generational span of bighorn sheep.

If 6-year generational monitoring suggests bighorn sheep habitat objectives are not likely to be met, the Refuge will develop appropriate adjustments to management actions. Adjustments to management actions could include amending habitat characteristics or management strategies implemented to meet objectives. Adjustments identified by this process may require a new environmental analysis or decision before implementation.

2.3.3 Alternative C: Population Management Only

Alternative C focuses on direct management of the bighorn sheep population by addressing predation mortality, risks associated with small population size (e.g., inbreeding depression), low resilience to environmental stressors, and high probability of extirpation. It also includes the current management actions (semiannual bighorn sheep aerial surveys to collect demographic data, disease and genetic monitoring, collection and analysis of bighorn sheep movement and habitat use data from GPS-collared sheep, and current levels of habitat work under the CMP) listed under Alternative A. Section 2.5.2 describes specific goals, objectives, and strategies identified to support bighorn sheep population management.

Native predator-prey relationships have coevolved as a natural ecological process that the Service is committed to supporting on national wildlife refuges (see 601 FW 3). After the reintroduction of bighorn sheep on the Refuge, the herd was able to increase and maintain itself for decades through the early 1990s (see Figure 1.1). Cougar sightings were infrequent, and cougars were not documented preying on bighorn sheep during this period. Part of the definition of a healthy bighorn sheep population is one that can sustain mortality pressures from predators over the long term; however, if a bighorn sheep population falls below a certain size, predation by a generalist predator (i.e., one that can sustain itself by preying on multiple species, such as cougars) can overwhelm a herd’s natural ability to replace lost individuals resulting in an irreversible decline that can lead to extirpation (Hogan 1990; Festa-Bianchet et al. 2006).

Data collected over the last 20 years and across multiple collaring events have documented cougars as a significant and primary predator on adult bighorn sheep on the Refuge (see Section 3.3.1.14). Of 19 bighorn sheep fitted with radio collars on the Refuge in January 2019, seven of 10 (70%) documented deaths are likely attributed to cougar predation (Service 2020a). During a 4-year study on the Refuge, Foster and Whittaker (2010) found cougar predation or probable cougar predation accounted for 63.2% of bighorn sheep mortalities. High cougar predation coupled with no indication of disease in live bighorn sheep during Foster and Whittaker’s study led them to conclude that disease was not a substantial mortality factor, and cougar management would benefit the herd. During their study, the annual adult survival rate averaged 83.2% and 89.7% for adult rams and adult ewes, respectively, which were apparently adequate to maintain the herd. In 2019 (May–October) and 2020 (May–September) hair snares and camera traps indicated as many as 12 to 16 individual cougars were using bighorn sheep habitat (Service 2020). Rominger (2018) summarized numerous examples of population level declines of bighorn sheep from cougar predation and reviewed several studies that documented single cougars killing one ungulate per week. Therefore, targeting cougars within bighorn sheep range for lethal removal is likely to be an effective way to reduce predation mortality on the Refuge bighorn sheep population and increase adult survival.

Under Alternative C, the Service would take immediate action to protect the bighorn sheep herd from both direct and indirect impacts from cougars by temporarily and strategically conducting administrative lethal removal of cougars. Administrative removal is the lethal removal that would occur only in bighorn sheep habitat to allow the herd size to recover to a sustainable level as defined by bighorn sheep population performance criteria. The intent of cougar removal would be to decrease bighorn sheep adult mortality and increase lamb survival and recruitment. The precarious status of the herd means that any losses are likely an existential threat. All cougars in a designated Bighorn Sheep-Cougar Management Zone (Figure 2.2) encompassing the Refuge bighorn sheep herd range and bounded by clearly recognizable features (i.e., the Refuge boundary, Rock Creek, or existing roads) would be assumed likely to prey on sheep and, therefore, would be targeted for removal. Removals would only occur in the proposed Bighorn Sheep-Cougar Management Zone and would not be intended to eliminate cougars from the Refuge. Over time, given the meta-population structure of cougar population dynamics in the region (see Section 3.3.2), cougars on other portions of the Refuge and surrounding lands would supply immigrants as dominant, adult cougars are removed from the Refuge bighorn sheep range.

Bighorn sheep herd augmentation implemented with appropriate precautions to prevent introducing disease is recognized as a successful method used to hasten recovery of low populations resulting from various causes. Bighorn sheep augmentation would be evaluated and used to supplement the population, increase genetic diversity, and expand the herd into unoccupied suitable habitat only after the primary cause of the bighorn sheep decline has been addressed and only if the benefits justify the action. The number of imported animals would be determined by the availability of source herds, the specific objectives of the augmentation, and cost considerations.

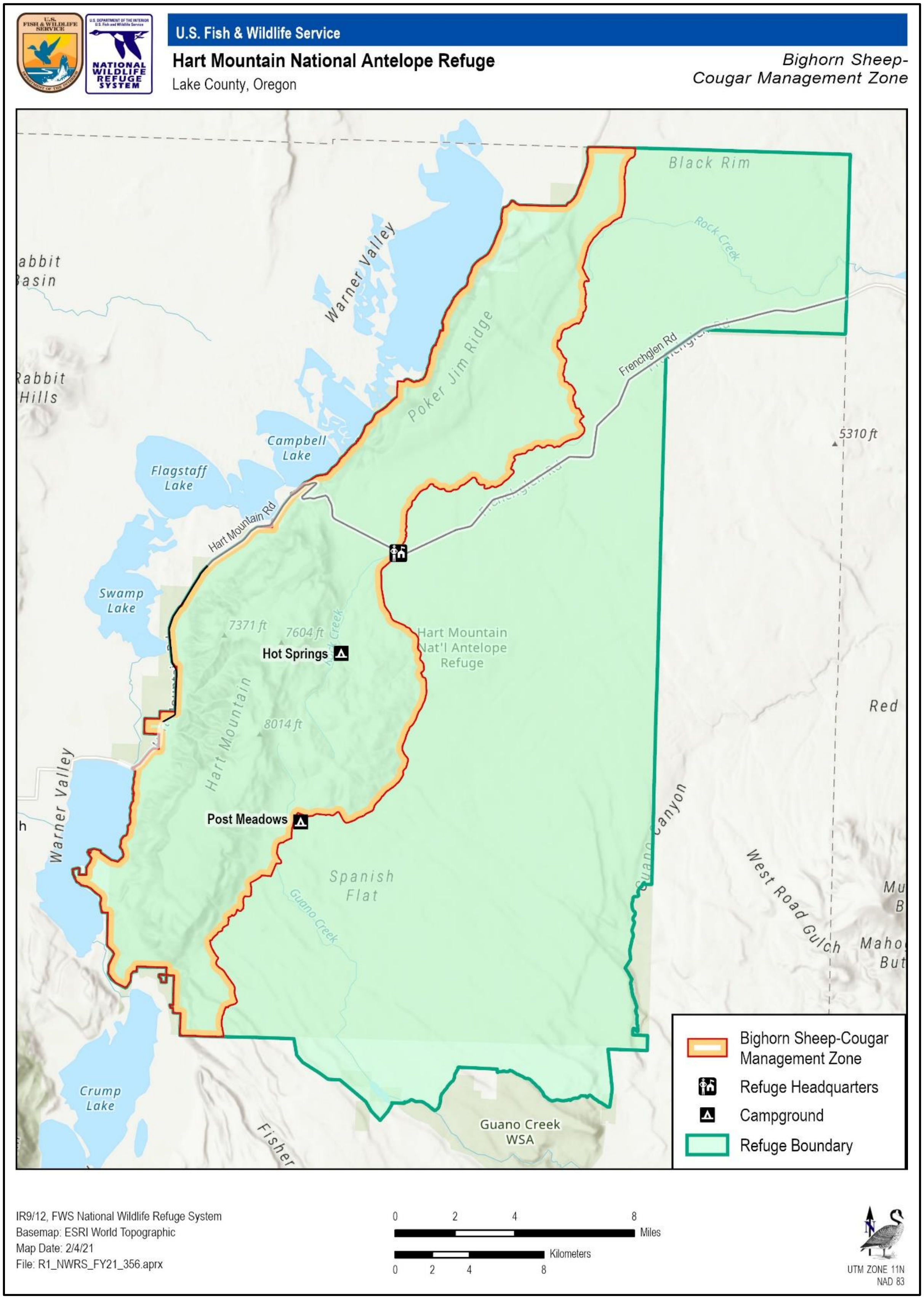

Figure 2.2. The proposed Bighorn Sheep-Cougar Management Zone within Hart Mountain National Antelope Refuge.

Service-authorized agents (trappers/dog handlers) using trained hounds, box traps, snares, and/or calls would conduct removals from August 1 to March 31, concurrent with existing Refuge hunting seasons and when conditions are likely to be more successful. Authorized agents could include Service, ODFW, or USDA APHIS–Wildlife Services personnel, or professional houndsmen, trackers, or trappers under contract or agreement with the Service or ODFW. All authorized agents would be required to follow approved SOPs and best management practices (BMPs) (detailed below). If a cougar has been confirmed to make a bighorn sheep kill outside the August 1 to March 31 period, Refuge staff or authorized agents may exploit the opportunity within 1 to 2 days of sheep death to target and remove cougars in and around the kill site.

The proposed action would include several measures to minimize animal suffering and non-target capture as much as possible. Administrative cougar removal would employ professional, highly skilled cougar trackers that use sign, sighting, calling, and specialized methods to locate, track, and remove targeted cougars in as humane a manner as practicable. A primary method to be used would be specially trained hounds to trail and locate specific individual cougars, which would then be euthanized by gunshot. In some cases, the cougar would be immobilized by lethal injection. Hounds are preferred because this is typically the most effective and selective method of capturing cougars with the lowest potential to affect non-target animals; however, because of inaccessible terrain, solely using dogs would be impractical. Alternative methods that could be used to take cougars include neck snares, foot snares, and box traps combined with euthanasia. Foothold (leghold) traps would only be authorized at site-specific locations if cougars prove to evade hounds and snares within the Bighorn Sheep-Cougar Management Zone.

Traps used in the United States and elsewhere have undergone extensive standards testing and selection as part of an international effort to optimize trap humaneness, selectivity, and effectiveness (Association of Fish and Wildlife Agencies 2006, Batcheller et al. 2000, White et al. 2015, White et al. 2021). Humane traps should be practical and equally effective at capturing target animals and avoiding capturing non-target animals (Andelt et al. 1999). Seasonality and timing of the use of physical capture devices is an important consideration for humaneness.

A humane live-capture (restraint) trap is one that holds an animal with minimal distress or trauma. A humane killing trap is one that renders an animal irreversibly unconscious as quickly as possible. Proper training in the use of traps makes it unlikely that pain or distress would result from the use of traps (Sikes and Animal Care and Use Committee of the American Society of Mammologists 2016). Animals captured in box and cage traps may have fewer physical and behavioral traumas than those captured in snares and foothold traps.

Effectiveness of snares depends greatly on the skill and expertise of the trapper, but snares can be highly selective to minimize unintentional captures. Foothold snares with stops set at the appropriate size for the target species (and to avoid non-target species capture) appear to have an acceptable effect on animal welfare, with little mortality of target species. When neck snares are set correctly as a restraint (not as a kill trap), using a stop on the cable, serious injuries are relatively uncommon, although the risk of mortality may be higher than with foothold snares. Both foot and neck restraint snares can capture non-target species, with risk of mortality. Adding a breakaway snare lock, snare stops, and appropriate pan tension can minimize capture of non-target species and reduce the risk of holding a non-target animal (Iossa et al. 2007).

Pan tension is an adjustment under the pan that will increase the amount of pounds required to trigger the trap or the spring-activated cable device. Pan tension would be adjusted to reduce the potential for lighter, non-target captures such as a bobcat. A stop is an item placed on the cable device to stop the cable device from closing around a smaller circumference to reduce the potential to capture non-target animals.

Any physical live capture method must be carefully evaluated for potential for hypothermia, hyperthermia, and stress caused by disturbance of trapped individuals. If leghold traps are used, checks will occur every 24 hours to minimize any heat or cold stress on trapped individuals. If unfavorable weather conditions occur during trapping efforts or if weather conditions may inhibit the ability to check traps within 24 hours, traps will be made inactive or removed. Trap sites are typically selected to avoid disturbance for the purposes of enhancing animal capture rates and to reduce excessive stress to animals once trapped.

The Service would follow American Veterinary Medical Association (AVMA) recommendations and guidelines for the euthanasia of animals (AVMA 2020). The AVMA states that euthanasia is ending the life of an individual animal in a way that minimizes or eliminates pain, anxiety, or distress prior to loss of consciousness. The AVMA states that for wild and feral animals, many of the recommended methods of euthanasia for captive animals are not feasible. The primary factor influencing methods selected for euthanasia of free-ranging wildlife is lack of control over the animal. Given that close human contact is stressful and difficult to achieve for most free-ranging animals, these animals may have to be euthanized or immobilized from a distance. The AVMA states that gunshot is acceptable with conditions for euthanasia of free-ranging, captured, or confined wildlife, provided that bullet placement is to the head, heart, or neck. When properly used by skilled personnel with well-maintained equipment, gunshot may result in less fear and anxiety and can be rapid, painless, humane, and practical. This would be the predominant method for lethal removal of mountain lions. Euthanizing drugs might also be used following methods recommended by the AVMA.

The BMPs and SOPs listed in this section improve the safety, selectivity, and efficacy of cougar administrative removal activities and reduce or eliminate unwanted environmental effects. Broadly, BMPs have been described as "a method to improve an activity or set of activities by developing recommendations based on sound scientific information, while maintaining practicability" (International Association of Fish and Wildlife Agencies 1997).

- All personnel (trappers/dog handlers) are responsible for conducting official duties in compliance with all federal laws and also applicable state and local laws.
- Vehicle access will be limited to existing roads, and cross-county vehicle travel is prohibited.
- All personnel whose duties involve animal capture will participate in an approved trapper education course.
- Use of all traps, snares, and other animal capture devices by personnel will comply with applicable federal, state, and local laws and regulations related to animal capture.
- All snares will be checked within 48-hour intervals.
- All traps and trapping devices will be set in a manner that minimizes the chances of capturing non-target species.
- If possible, non-target animals that are captured will be released.
- All foothold traps will be checked within 24-hour intervals.
- If an animal that appears to be a licensed pet is captured, reasonable efforts will be made to notify the owner, seek veterinary care if necessary, or deliver the animal to appropriate local authorities.
- Animals targeted for lethal control in direct control projects will be dispatched immediately, removed from capture devices, and properly disposed.
- The use of foothold traps and spring-activated snares must incorporate pan-tension devices as appropriate to prevent or reduce the capture of non-target animals unless such use would preclude capture of the intended target animals.
- Foothold traps with inside jaw spread greater than 5.5 inches, when used in restraining sets, are limited to types with smooth, offset jaws that may or may not be laminated or limited to padded-type jaws. Foothold traps with teeth or spiked jaws are prohibited.
- Foothold traps or snares will not be used under fence lines. Judgment should be used to avoid capture of livestock and other domestic animals.
- The use of break-away locks or stops shall be used due to deer or other large animals that may be exposed to snare sets.
- Capture devices shall be set to minimize visibility of captured animals.
- Conspicuous, bilingual warning signs alerting people to the presence of traps and snares are placed at major access points when they are set in the field. Consult the Refuge manager to confirm major access points.

- Shooting a firearm out of a vehicle is permitted as long as the firearm or device is not loaded (a cartridge in the chamber) until the muzzle is safely out of the window of the vehicle and a clear line of fire is established. The muzzle of the firearm or device may not be retrieved back into the vehicle until the device has no live round in the chamber.
- Whether a firearm is being stored in an office, vehicle, home, camp, or any other location, the maximum level of security available should be employed. Security devices may range from gun safes, vaults, locking gun racks, to cables through the receiver or frame opening locked to an immovable object. All firearm storage will be per this directive.
- All basic rules of firearm safety must be followed.
- All wildlife carcasses, whether in whole or part, will be disposed of consistent with federal, state, county, and local regulations. Animals euthanized with drugs that may pose secondary hazards to scavengers must be disposed of according to federal, state, county, and local regulations, drug label instructions, or, lacking such guidelines, by incineration or at a landfill approved for such disposal.
- Wildlife carcasses may be discarded on the Refuge where they were killed or recovered or deposited on another cooperator's property if approved by the Refuge manager. Carcasses may be composted following federal, state, and local laws. Wildlife carcasses or parts may be disposed of at approved public or private landfills where such facilities are approved for animal disposal. Carcasses shall not be deposited in roadside or commercial business dumpsters unless prior approval to do so has been obtained from the dumpster owner or lessee. Carcasses shall not be disposed of in household trash containers. Wildlife carcasses may be incinerated in approved facilities that comply with federal, state, and local regulations. Open burning should be avoided due to potential fire hazards except when this method is required by regulations and can be conducted safely. All disposals will be made in a manner that demonstrates recognition of public sensitivity to the viewing of wildlife carcasses.
- Personnel will exhibit a high level of respect and professionalism when taking an animal's life, regardless of method. Personnel will be familiar with the methods described in the current AVMA Guidelines for Euthanasia (AVMA 2020), and those methods will be used to euthanize captured or restrained animals, whenever practicable. In free-ranging wildlife, the AVMA recommends methods "be as age-, species-, or taxonomic/class-specific as possible." Personnel will use methods appropriate for the species and conditions.
- When euthanizing a captured or restrained animal, death of the animal must be confirmed; death should be confirmed in free-ranging wildlife when carcass recovery is possible. Confirmation can be achieved by the absence of a blinking response when the cornea is touched and by monitoring heart rate and respiration for a period of time long enough to confirm death.
- Personnel requiring use of immobilization and euthanizing (I&E) drugs must comply with full training and certification. Personnel using I&E drugs must receive approved and official training prior to independent use or possession of I&E drugs.
- Personnel will adhere to safety requirements and use appropriate personal protective equipment.
- Trained dogs shall only be used by authorized personnel.
- Dogs will not be allowed to intentionally kill animals. When the objective is removal, animals will be euthanized as quickly as possible via mortal gunshot.
- Functions performed by trained dogs: target animal detection to determine if further action is warranted; animal retrieval; decoying target wildlife into shooting range; trailing target animals to facilitate live capture or lethal removal.
- Personnel shall not allow trained dogs to have physical contact with or in any way attack, bite, or kill animals that are restrained in a trap or any other device. When trained dogs are used, handlers will be at the site of encounters between animals and dogs as soon as possible to minimize stress and reduce potential injury. If personnel are unable to prevent a trained dog from repeatedly making contact with a restrained animal, personnel must immediately intervene and discontinue use of that dog.

- Personnel shall ensure a dog-in-training is muzzled and controlled on a leash when it is near a restrained animal. If the dog-in-training attacks or attempts to attack a restrained animal, personnel must immediately stop the interaction. Personnel must discontinue use of dogs-in-training that repeatedly attempt to physically contact restrained animals.
- Personnel shall ensure trained dogs used in wildlife damage management activities receive housing, food, water, medical care, and are properly licensed and vaccinated according to state and local laws. Personnel shall ensure dogs are provided a safe transport box. The box shall provide enough shade and ventilation during warm months to keep dogs cool. During cool months, insulation and/or reduced ventilation shall be used to keep dogs comfortable.
- Dog handlers shall control or monitor their trained dogs at all times. A trained dog is considered under control when the dog responds to the command(s) of the dog handler by exhibiting the desired or intended behavior as directed. Dog handlers shall ensure trained dogs to not pose a threat to humans or domestic animals, or cause damage to property. Further, dog handlers shall employ as needed various methods and equipment to monitor and/or control dogs, including but not limited to muzzles, protective vests and collars, electronic training collars, harnesses, leashes, whistles, voice commands, GPS, telemetry collars, identification collar/contract information.
- If the risk of people being present exists, then activities will be conducted during periods when human activity is low, such as at night or early morning, whenever possible.

2.3.3.1 BIGHORN SHEEP POPULATION METRICS AND ACTION THRESHOLD CRITERIA

In the context of experimental scientific investigation, it is often assumed that there is a single factor that limits a population; however, complexity and diversity in habitats, life cycle, and genetic adaptations give bighorn sheep populations the resilience that has allowed them to recover and thrive in many locations. Sustaining a bighorn sheep population over the long term on the Refuge would require conserving some minimum number of sheep on the landscape. That number is likely dynamic and depends on changing habitat and environmental conditions. Therefore, the Service would use other demographic factors that can be measured and used as surrogates for population performance to identify when a sustainable bighorn sheep population has been achieved on the Refuge.

As stated in Section 1.3, the Service will use three vital rates to determine the status and trend of the Refuge bighorn sheep population. Three-year averages are used to compensate for normal annual variation. The field data from which these vital rates would be derived are herd composition counts during semiannual aerial surveys (rates 1 and 3), and mortality records of collared sheep (rate 2). Further explanation and justification of the use of these are presented in Section 3.3.1.10. The vital rate values that together indicate a stable or growing population are as follows:

1. 3-year average annual population growth rate ≥1.0
2. 3-year average annual adult survival ≥80%
3. 3-year average lamb recruitment ratio at or above 30 lambs to 100 adults

Considering local information about bighorn sheep and the available literature regarding minimum viable numbers, selecting a specific desired number of animals on the landscape (population objective) is problematic and not warranted; however, the current estimated Refuge bighorn sheep population is well below the published minimum viable population of 170 suggested by Cassaigne et al. (2010) (Section 1.3). Establishing a population management action threshold in combination with the population performance metrics would establish the minimum necessary to provide opportunity for the population to achieve sustainability over a long period of time. A bighorn sheep management action threshold would ensure management actions are not prematurely ended and the strategies taken to improve population performance measures are sufficiently met and ultimately support a healthy, sustainable bighorn sheep herd on the Refuge. The Service proposes that a management action threshold of 170 observed bighorn sheep in combination with adult survival, lamb recruitment, and population growth be used to initiate or suspend actions to control cougars on the Refuge.

Specifically, lethal control of cougars would be conducted only when all four of the following conditions exist: the 3-year moving average of the bighorn sheep population growth rate is <1.0, the 3-year moving average of annual adult survival is <80%, the 3-year moving average of lamb to adult ratio at recruitment age is <30:100, and the bighorn sheep population is below a 3-year moving average of 170 observed animals. The use of 3-year averages would not necessarily require that a vital rate would need to meet the minimum measures for 3 successive years; rather the average of the most recent 3 years' vital rate values meet the measures (e.g., 2022 lamb:adult ratio = 18:100, 2023 lamb:adult ratio = 22:100, and 2024 lamb:adult ratio = 20:100). The resulting 3-year average lamb:adult ratio = ((18+22+20)/300)*100 or 20 lambs:100 adults. Administrative cougar removal would be suspended after the population performance measures and management action threshold are met for a 3-year moving average, but it could be reinstated if all the measures fall back below the thresholds.

Using all three population performance measures and management action threshold as decision criteria verifies response in the bighorn sheep population and prevents premature and repeated starting or stopping cougar control. Cougar control will not be suspended until all bighorn sheep population performance and management action threshold criteria are met, signifying the population is reaching sustainable levels resilient to normal environmental conditions. Conversely, cougar control will only be initiated if all population performance measures and management action threshold fall below performance criteria, indicating the bighorn sheep population is trending toward unsustainable levels.

Once the bighorn sheep population demonstrates an increasing population trend that is above the management action threshold and is meeting the population performance measures, the Service would evaluate implementing a public cougar hunt in coordination with ODFW and according to Service policy. Although statewide hunter harvest success rate is only 1% to 2%, public hunting could prevent the need for potential future administrative removals by suppressing predation pressure to keep bighorn sheep performance measures above their thresholds. Because there are several steps necessary to open a refuge to public hunting (e.g., compatibility determination and establishing a hunt plan with public notice in the FR), it would take a year or more after the decision to open a hunt before the hunt would begin. If a public cougar hunt was instituted, it would include monitoring and periodic evaluation of its effectiveness at reducing predation pressure on the bighorn sheep herd. Issuance of tags for the hunting of bighorn sheep would not resume on the Refuge until administrative removals of cougars ceased, and total harvest would be conservatively regulated to stay within sustainable limits.

2.3.3.2 ADAPTIVE MANAGEMENT

Consistent with Adaptive Management Implementation Policy (522 DM 1), the Service will use adaptive management for conserving, protecting, and, where appropriate, restoring lands and resources. Within 43 CFR 46.30, adaptive management is defined as a system of management practices based upon clearly identified outcomes; those practices are monitored and evaluated to see whether they are achieving desired results (objectives). The *Adaptive Management: U.S. Department of the Interior Technical Guide* (Williams et al. 2009) also defines adaptive management as a decision process that "promotes flexible decision making that can be adjusted in the face of uncertainties as outcomes from management actions and other events become better understood" and emphasizes learning from management outcomes. Careful monitoring of these outcomes both advances scientific understanding and helps adjust operations as part of an iterative learning process.

Applying adaptive management principles to support natural resource management and conservation of refuge biological diversity is an iterative process that involves establishing desired outcomes with regard to a situation, taking management action to achieve desired outcomes, conducting monitoring to evaluate the effectiveness of those actions, and then determining subsequent management direction considering available scientific information. Along with continuing or modifying management actions, adaptive management can entail modifying resource objectives. Applying evidenced-based management further supports the adaptive management principles that are being applied. Similarly, evidenced-based management is applying information (e.g., monitoring results, research findings, available and relevant scientific literature, and management theories and principles) to inform management decisions in order to achieve a desired outcome (Salafsky et al. 2019).

Principles of adaptive management would be implemented in Alternative C. The adaptive management process would be informed by refuge surveys, including bighorn sheep survival monitoring and bighorn sheep population and composition surveys. The Refuge would develop an IMP (see 701 FW 2) that would include bighorn sheep surveys used to assess bighorn sheep population responses to management actions and progress toward achieving performance objectives.

Under Alternative C, assessment and monitoring would be conducted annually throughout implementation of the population management strategies to inform and guide future actions. The Refuge, in consultation with ODFW, would evaluate the progress and efficacy of management actions relative to bighorn sheep performance measures every 6 years after strategy implementation begins. This evaluation would be used to determine if management actions, including cougar control, are trending toward or meeting population performance objectives. Assessing strategies every 6 years generally coincides with the generational span of bighorn sheep. Specifically, the assessment will examine the population metrics relative to performance measures and the management action threshold, trends shown by those metrics, and other relevant information to examine the effectiveness of the management actions.

If the Refuge determines that thresholds for any of the performance measures and management action threshold are not likely to be met within another 6 years, the cougar management strategies will be evaluated for adjustment. Adjustments to the management actions could include termination of cougar control and new or adjusted cougar management actions. The Refuge and ODFW may also reassess whether the population performance measures and management action threshold remain appropriate given what has been learned during implementation. Appropriate adjustments identified by the management team will be implemented if they are within the scope of management actions defined in Alternative C but may require a new decision or environmental analysis before being implemented.

2.3.3.3 HERD AUGMENTATION

Population augmentation is widely recognized as a wildlife management tool to supplement an ungulate herd at risk of extirpation, replace an extirpated herd, increase herd size, extend herd range, or increase genetic diversity. However, augmentation would have a low chance of success as a stand-alone measure to address the bighorn sheep population decline until the reasons and issues for the population decline are addressed and/or resolved. Translocating bighorn sheep from an outside source into a new area causes stress on the animals and the chance for their survival success will be greatly reduced if predation mortality and habitat issues remain limiting factors within the area and on the existing population. Translocated animals are naïve and unfamiliar with new surroundings and will require time to adapt to new habitat and range. This makes a strong case to preserve and recover the existing herd as the remaining bighorn sheep have adapted to habitat conditions within the Refuge.

Under Alternative C, augmentation could be used to supplement the population once the primary causes of the decline have been addressed, and over the long term if unoccupied habitat in good condition is documented. Best management practices would be used to minimize the possibility of disease introduction or harm to the source or Refuge bighorn sheep population. Augmentation would be coordinated with ODFW and considered using the following conditions:

- Over a 3-year running average, adult survival ≥80%, lambs at recruitment age are ≥30:100 adults, and population growth rate is ≥1.0. Habitat improvement actions have been initiated.
- Spring improvement actions initiated by removing post-settlement juniper near natural spring sources and/or the three artificial watering devices (guzzlers) are operational.
- Identify the source herd and conduct health screenings to confirm disease-free population. Collar and monitor ≥20% of the bighorn sheep reintroduction population.

2.3.4 Alternative D: Comprehensive Integrated Management (Preferred)

The Preferred Alternative (D) is a combination of management actions proposed in Alternatives B and C in which all management actions proposed in alternatives B and C will be implemented. Section 2.5.1 and Section 2.5.2 describe specific goals, objectives, and strategies identified to support bighorn sheep integrated management. An integrated management approach is preferred considering complex interactions between habitat features and demographic factors that ultimately determine sustainability. For example, predation risk is determined not only by the number of predators present, but also by their efficiency at successful hunting, which is directly related to the structure of the habitat insofar as it provides ambush cover for the predator or visibility and escape opportunity for the prey. In the short term, improving survivorship by mitigating mortality sources is needed to reverse the bighorn sheep population decline and minimize the imminent risk of extirpation. Over the long term, management to optimize bighorn sheep habitat on the Refuge would ensure that the herd has the resources necessary to be sustainable and resilient to the environmental stressors to which it would inevitably be subjected. Habitat management would also likely reduce the frequency at which the herd falls below the population performance and management action threshold objective. Additionally, augmentation could be used to supplement the population once the primary causes of the decline have been addressed and over the long term if unoccupied habitat in good condition is documented.

Principles of adaptive management implemented in Alternatives B and C would also be implemented as part of Alternative D. The process would be informed by refuge surveys, including bighorn sheep habitat surveys, survival monitoring, and population and composition surveys. The Refuge would develop an IMP that would include bighorn sheep population and habitat surveys used to assess bighorn population response to management actions and progress toward achieving management objectives. Assessment and monitoring would be conducted annually throughout implementation of the management strategies to inform and guide future actions. The Refuge, in consultation with ODFW, would evaluate the progress and efficacy of management actions relative to bighorn sheep performance measures and management action threshold every 6 years after strategy implementation begins. This evaluation would determine whether habitat and population management actions, including cougar control, were trending toward or meeting performance objectives. If during the 6-year generational review it was determined that habitat objectives or performance thresholds are not likely to be met, the Refuge would identify what has been learned through implementation and develop adjustments to the management actions. Adjustments to the management actions could include new, adjusted, or terminated strategies identified in 2.5.1 and 2.5.2. Adjustments identified by the Refuge and ODFW through this process may require a new environmental analysis or decision before being implemented. This alternative provides a full range of management strategies to adaptively manage the bighorn sheep herd over time that would address the need to take action in a timely manner while providing time to identify and correct habitat issues that may take decades to resolve.

2.4 Elements Considered but Eliminated from Further Analysis

Several alternatives were considered but not analyzed in detail. The alternatives eliminated from detailed consideration are described in the following sections.

2.4.1 Control or Hazing of Golden Eagles

Golden eagles (*Aquila chrysaetos*) are known predators of young bighorn sheep lambs (Deming 1961) and significant predation may occur on the Refuge, but it is not known how many lambs are taken by these eagles in an average year. Golden eagles and their habitat are protected against intentional harm or harassment by the Migratory Bird Treaty Act and the Bald and Golden Eagle Protection Act. Under some circumstances, the Service can issue a permit for golden eagle control actions, but that requires strong justification and is conditional. Moreover, there are no proven effective harassment techniques for this situation making golden eagle population management ineffective and impractical.

2.4.2 Relocation of Cougars

Live capture and relocation of cougars occupying Refuge bighorn sheep range is a potential safety issue for people living, working, or recreating in the relocation area and is prohibited under existing ODFW policies because of a chance of human attack, and/or continuing damage, or human conflict exists (ODFW 2017). In addition, the survivability of capture, transport, and release of a cougar into an unfamiliar area that is likely to be occupied by resident cougars is doubtful and relocation often ends in the severe injury or death of one or both lions in that territory (Arizona Game and Fish Department 2021). Lastly, cougars are able to travel great distances in an attempt to return to their home range, raising serious questions about the practicality and effectiveness of relocating cougars (The Guardian 2021).

2.4.3 Sterilization of Cougars

There is no practical method to administer permanent chemical sterilants within a wild cougar population. Moreover, sterilization would require capture, tranquilization, and surgical neutering of each animal by a veterinarian. Although sterilizing cougars might temporarily reduce their population growth, neutered cougars would continue to prey on bighorn sheep and, therefore, would not result in the reduction in predation pressure that would be necessary for the bighorn sheep population to rebound, especially in the short term. This option would, therefore, not meet the purpose and need of this management plan.

2.4.4 Confirming that a Cougar is Preying on Bighorn Sheep Before it is Removed

Individual cougars can exhibit prey preference even if there are multiple prey species available. Consequently, targeting only those cougars for removal that prefer taking sheep, and leaving any that prefer other prey such as mule deer (*Odocoileus hemionus*), might appear to be the most beneficial to bighorn sheep while minimizing impacts to the cougar population. Certainly, if the opportunity to target a confirmed cougar that preys exclusively on bighorn sheep presents itself, it would be considered. But in practice, targeting only confirmed cougars would require extensive time and budget resources to capture and GPS collar all cougars that might use bighorn sheep habitats on the Refuge, detect and promptly ground-confirm every collared cougar suspected of killing a bighorn sheep, and then track, recapture, and remove the cougars. However, it is likely that cougars found in the Bighorn Sheep-Cougar Management Zone are, or will be, preying on bighorn sheep (Weise 2021). Given the extremely low population and urgency to retain remaining bighorn sheep, additional predation caused by this strategy could further risk extirpation of this population. Moreover, there exists logistical difficulty due to the rugged and often inaccessible terrain and the unlikelihood of collaring and recapturing all the cougars preying on the Refuge bighorn sheep.

Another example of targeting only confirmed bighorn sheep-killing cougars is using collared sheep, rather than collared cougars, to detect and respond to predation events. This methodology is not pertinent and does not relate to the Hart Mountain bighorn sheep population because the vast majority of the bighorn sheep population must be collared, so most bighorn deaths could be detected and investigated to determine cause. The Refuge herd is free-ranging in rugged terrain, and the collaring of even a small portion of the herd is a dangerous and difficult endeavor for both humans and sheep. Moreover, the likelihood of capturing all, or most, of the Hart Mountain bighorn sheep herd is small and could result in many unintended capture deaths.

This strategy was rejected as not addressing the urgency, as being impractical, and as being inefficient at reducing predation and therefore not likely to achieve bighorn sheep population objectives. Lastly, by only removing cougars found in the Bighorn Sheep Cougar Management Zone, impacts to the cougar population are limited to those individuals likely to be preying on bighorn sheep. However, the option to target only cougars confirmed to be preying on bighorn sheep through cougar radio collaring or other means remains open if 1) the bighorn sheep population has increased to the point where it could tolerate the predation mortality inherent to this method (i.e., risk of extirpation is no longer imminent), and 2) sufficient resources and time to implement ongoing comprehensive cougar collaring and tracking has been made available. This is most likely to occur after the initial cougar removal program has been suspended due to the sheep population reaching the recovery criteria, but later declining again below specified thresholds due, at least in part, to predation mortality.

2.4.5 Bighorn Sheep and Domestic Sheep and Goat Separation Fencing

Separation fencing (double fencing) is intended to prevent nose-to-nose contact with domestic livestock and reduce aerosol transmission associated with disease; however, estimates of acceptable effective separation distances varies spatially and temporally (Wild Sheep Working Group 2012) and the effectiveness of separation is limited by the need for diligent fence maintenance and complete bighorn sheep range and boundary fencing. Because of these factors, plus the high cost, and the fact that there are currently no domestic sheep or goat range allotments within the recommended 9.3-mile buffer around the Refuge, there is no consideration to construct double fencing as a disease management strategy in the foreseeable future.

2.4.6 Sport Hunting Only

Sport hunting of cougars was considered as a standalone alternative to reduce the impact of cougar predation on bighorn sheep but was rejected because of its ineffectiveness in reducing the abundance of cougars and reducing mortality on Refuge bighorn sheep. The following analysis is adapted from the 2017 Oregon Cougar Management Plan.

Oregon’s cougar population is estimated to be approximately 6,500 animals. Until 1967, cougars were legally classified as a predator in Oregon and were unprotected. The estimated statewide cougar population was approximately 200 animals in 1960. In the 1990s, cougars were listed as game animals, and in 1994, Measure 18 eliminated the public use of dogs for cougar hunting even though hunting with dogs is generally considered the most effective and selective method.

The hunting season structure for cougars has changed over the last 30 years from a limited duration, controlled hunt format to a year-long, zone quota system. Starting in 2010, the general season begins January 1, and, as long as zone quotas have not been reached, hunters can harvest up to two cougars if they purchased an additional cougar tag. Successful hunters must present the pelt with skull and proof of sex attached at an ODFW office within 10 days of harvest. ODFW collects harvest data during this mandatory check-in process, including a tooth and gum measurement to age individual cougars. Cougars are managed at the zone level in Oregon to account for large home ranges, long dispersal distances, and large differences in landscape features. The state is divided into six cougar management zones that were created by identifying similar habitats, human demographics, land use patterns, prey base, and cougar densities. Zone quotas have been in place since 1995 and quotas currently exist not as an objective, but rather a mortality cap so cougar populations do not fall below Oregon Cougar Management Plan objectives. Since the adoption of the 2006 Cougar Plan, all known mortalities (e.g., hunter-harvest, damage take, human-safety take, administrative removal, and road-killed) count toward zone quotas. If a zone quota is met, that zone is closed to hunting and target area administrative removals for the remainder of the year, but the zone does not close to take related to livestock damage and human safety. Quotas have never been met in Zone F, which includes the Refuge.

Cougar tags can be purchased by anyone with a hunting license. Currently, most cougars are harvested by hunters that randomly encounter a cougar while hunting for other species (but are in possession of a cougar tag). In 2015, of the reporting cougar tag holders that harvested a cougar, 66% did so while pursuing other game. Hunter harvest has remained relatively stable for over a decade and average annual statewide harvest was 261 (range 209–309) from 2004 to 2016. Hunter success rates are low with current harvest techniques and range from 1 to 2%.

The addition of cougar sport hunting would expand hunter opportunities on the Refuge, but the documented low cougar hunter harvest success rates would likely not result in the taking of many cougars, or enough cougars to reduce the current density and reduce bighorn sheep mortality. This option would, therefore, not meet the purpose and need of this management plan. A cougar sport hunting–only alternative was eliminated from further consideration as a method of effecting changes in cougar or bighorn sheep populations. However, once the bighorn sheep population demonstrates an increasing population trend that is above the management action threshold and is meeting the population performance measures, the Service would evaluate implementing a public cougar sport hunt in coordination with ODFW. A public cougar sport hunt would be a separate planning process to formally open the Refuge to sport hunting of cougar.

2.5 Goals, Objectives, and Strategies

Goals and objectives are the unifying elements for successful resource management on refuges. They identify and focus management actions, resolve issues, and link to the refuge purpose(s), Service policy, and Refuge System goals and objectives. Objectives were developed using relevant peer-reviewed literature and in consultation with ODFW biologists, FWS biologists, and Refuge managers and constitute the best available science.

2.5.1 Goal 1. Protect, Maintain, and Enhance Habitats to Meet Life-History Needs of the Bighorn Sheep Herd on the Refuge

Objective 1.1. Enhance, protect, or maintain up to 31,517 acres of habitat characterized

- High quality foraging and wintering grounds in escape terrain (defined in Section 3.3.1.5) and within approximately 985 feet of escape terrain, or within approximately 1,640 feet of escape terrain where patches of escape terrain are separated by 3,280 feet or less (i.e., core habitat defined in Section 3.3.1.5)
- 25 to 50% cover of native herbaceous understory (graminoids, forbs; e.g., bluebunch wheatgrass [*Pseudoroegneria spicata*], Idaho fescue [*Festuca idahoensis*], Sandberg bluegrass [*Poa secunda*], *Lomatium* spp., *Erigeron* spp., *Eriogonum* spp.)
- <10% cover of non-native plant species (e.g., cheatgrass [*Bromus tectorum*]) in the herbaceous understory
- ≤25% canopy cover of the sagebrush or other shrub species in non-riparian areas
- ≤2 feet mean height of shrubs
- ≥80% mean horizontal visibility at approximately 100 feet in habitat areas with high R&R (see Section 3.5.2); ≥62% mean horizontal visibility at approximately 100 feet in habitat areas with low R&R
- Few opportunities for ambush predation and high potential for bighorn sheep to detect ambush predators due to minimal woody cover (e.g., sagebrush) within 165 feet of water sources and important access corridors
- <4 stems/acre of juniper in encroached open areas (i.e., nonwoodland)
- ≤25% canopy cover and/or canopy closure (i.e., canopy density) in juniper and/or mountain mahogany woodlands with good horizontal visibility
- Available water during drought within 2 miles of escape terrain (within 4.3 miles for rams), with passable corridors of quality foraging habitat between escape terrain and these water sources
- Minimal human disturbance within 820 feet of escape terrain

Alternatives	**A**	**B**	**C**	**D**
Objective as written applies to the alternatives indicated (√)		√		√
Strategies Applied to Achieve Objective				
Conduct GIS analysis to map habitat elements based on known habitat requirements of bighorn sheep over all seasons and life stages in order to identify and prioritize areas for in-field assessments		√		√
Conduct in-field assessments and subsequent GIS analyses of habitat conditions to identify deficiencies in one or more attributes as a basis to prioritize and prescribe habitat rehabilitation actions		√		√
Expand use of prescribed burning to improve sheep forage in areas with high resilience to fire and high resistance to invasive species (R&R, see Section 3.5.2) to revert up to approximately 800 acres per year from late shrub–dominated to early and mid-stage succession native forb and grass plant community		√		√
Reduce shrub cover on up to approximately 100 acres per year using selective herbicides and/or site-appropriate mechanical treatment(s) to increase visibility and improve foraging conditions for bighorn sheep in core habitats		√		√
Continue to manage habitat following the CMP	√	√	√	√
Evaluate removal of encroaching post-settlement juniper (<150 years old) from approximately 20,100 acres; due to difficult terrain and logistical concerns, removal efforts would focus on approximately 11,275 acres, at approximately 1,500 acres per year (as is reasonably practicable and as funding is available), of relatively accessible bighorn sheep habitats, using methods appropriate to assessed site conditions		√		√
Manage wildfire opportunistically in high R&R sites as a natural ecological process to remove encroaching juniper and promote native forbs and grasses		√		√
Seed native herbaceous bighorn forage plants after wildfire or prescribed fire, on disturbed soils, and in areas where invasive grasses and forbs have been controlled with IPM techniques	√	√	√	√
Control established invasive herbaceous plants in bighorn sheep forage areas using IPM (including chemical, physical, cultural, and biological means)	√	√	√	√
Prevent establishment of new invasive species within bighorn sheep habitat under an early detection/rapid response strategy	√	√	√	√
Aggressively suppress wildfire to protect sagebrush habitats with low R&R, at high risk of invasion and/or dominance by invasive species (especially IAGs)	√	√	√	√
Maintain juniper woodlands		√		√
Protect old-growth juniper (>150 years old)	√	√	√	√

Protect and maintain mountain mahogany woodlands	√	√	√	√
Restore and maintain three existing guzzlers as soon as is reasonably practicable, evaluating and improving design(s) and/or layout(s) during restoration as necessary; monitor use; evaluate water source distribution and install additional new guzzlers outside of the PJRPWA if needed	√	√	√	√
Assess condition and function of other artificial water sources (e.g., stock ponds, dugouts, impoundments) as soon as is reasonably practicable; restore and maintain function of existing features as needed; reclaim sites of unnecessary or non-repairable features to a native condition		√		√
Evaluate existing natural water sources within 2 miles of escape terrain for potential improvements (e.g., prolong persistence, increase holding capacity, removal of encroaching juniper in the watershed, removal of ambush cover within 165 feet using best management practices), and implement appropriate improvements as necessary and as is reasonably practicable		√		√
Evaluate existing natural water sources within 4.35 miles of escape terrain as soon as is reasonably practicable, including streams/spring brooks and springs/seeps, for duration, condition, and general function within the landscape; rehabilitate attributes as necessary (e.g., reconnect features to the floodplain, re-establish natural features/components), with emphasis on improving duration and condition		√		√
By July 2022, develop an IMP that includes surveys to monitor bighorn sheep habitat management action response		√		√
Update bighorn sheep habitat maps every 6 years (or as needed) to document treatment effectiveness and changes due to stochastic events (such as wildfire)		√		√

Rationale: Bighorn sheep are wide-ranging grazers that require a variety of habitat characteristics related to topography, cover, horizontal visibility, water availability, and forage quality and quantity. Although the ultimate causes of the decline of this particular bighorn sheep population are not yet understood, fundamental principles of wildlife management suggest that changes to many habitat elements over recent decades have played a critical role, and management of these elements would be necessary to allow habitat on the Refuge to support a sustainable bighorn sheep herd over the long term. Habitat management evaluated across the entire herd range would be focused on those areas with accessible terrain where treatments can be conducted and would address life-history needs.

The Refuge would protect all bighorn sheep habitat that is currently in good condition and take advantage of opportunities to improve habitats in fair or poor condition, or where other factors are limiting the potential for the bighorn sheep population to thrive. Completion of in-field assessments and subsequent analyses of extant conditions would facilitate identification and prioritization of beneficial habitat treatments, while maintaining native characteristics. Precise conditions of bighorn sheep habitat throughout the Refuge have not yet been quantified but, based on the results from qualitative vegetation surveys and field reconnaissance, the primary factor influencing habitat conditions within the Refuge is the encroachment of western juniper, largely as a result of changes in climate and long-term suppression of natural fire that has allowed vegetative succession to progress. Juniper and other shrubs encroaching into open foraging areas or movement corridors can impact both quantity and quality of forage, reduce the ability of bighorn sheep to detect and evade predators (especially cougars), reduce access to escape terrain or security cover, and change or severely restrict traditional movement patterns. Treatment of encroaching post-settlement juniper is determined by a host of external, internal, and intrinsic factors that can limit the performance and rate of the treatment.

Water availability is another important feature that can influence quality of bighorn sheep habitat (see Section 3.2.3). Important water sources include natural springs, seeps, creeks, and pools, ponds, lakes, and guzzlers. Water source availability and proximity to other habitat elements during droughts and critical bighorn sheep life stages are to be assessed for potential specific management actions. Water quality assessments would occur if there was an indication of issues. Natural water sources may be enhanced by controlling encroaching juniper in the watershed, increasing water storage capacity and persistence, and reducing concealment cover used by predators in the vicinity. Artificial water sources, such as guzzlers, placed in areas where natural water sources are limited, also need to be evaluated for maintenance and repaired to ensure function. By managing habitats to achieve desired conditions stated in the objective, the necessary ecological integrity would be provided to sustain a healthy bighorn sheep herd.

Bighorn sheep habitat management actions would occur in areas where site-specific assessment and monitoring results indicate the habitat is not achieving management objectives optimal for bighorn sheep. The Refuge will develop an IMP that includes habitat surveys to assess and monitor progress and efficacy of habitat management actions in achieving bighorn sheep habitat objectives. The major parts of an IMP include identifying current and needed surveys, entering surveys and associated metadata into Priority and Review of Inventory and Monitoring Activities on Refuges (PRIMR), and selecting and prioritizing surveys to conduct on the Refuge.

Supporting references for the objective thresholds: Deming 1961; Pallister 1974; Kornet 1978; Van Dyke 1978; Cooperrider et al. 1980; Risenhoover and Bailey 1980; Hansen 1982; Van Dyke et al. 1983; Cottam 1985; Risenhoover and Bailey 1985; Bentz and Woodard 1988; Risenhoover et al. 1988; Smith et al. 1991; Payer 1992; Schirokauer 1996; Sweanor et al. 1996; Greenwood et al. 1999; Smith et al. 1999; Zeigenfuss et al. 2000; Collins and Becker 2001; Bangs 2002; Dicus 2002; DeCesare and Pletscher 2004; Demarchi 2004; Bates et al. 2005; Miller et al. 2005;

DeCesare and Pletscher 2006; Wagner and Peek 2006; Barrett 2007; Miller et al. 2007; Beyer 2008; Whiting et al. 2009a; Whiting et al. 2009b; Greene 2010; Whiting et al. 2012; Miller et al. 2013; Blake 2014; Chambers, Bradley, et al. 2014; Chambers, Miller, et al. 2014; Miller et al. 2014; Wilson 2014; Baker 2015; Miller et al. 2015; Blake and Gese 2016; Chambers et al. 2016; Robinson 2017; Davies, Bates, et al. 2019; Davies, Rios et al. 2019; Miller et al. 2019.

2.5.2 Goal 2: Maintain a Healthy, Sustainable, and Genetically Diverse Population of Bighorn Sheep on the Refuge

Objective 2.1. Maintain a healthy, sustainable herd of bighorn sheep on the Refuge that is characterized by all the following parameters:

Three population performance metrics*:

- Three-year average annual population growth rate ≥1.0
- Three-year average annual adult (up to age 3) survival ≥80%
- Three-year average lamb recruitment ratio at or above 30 lambs to 100 adults

In addition, the Service has identified the following management action threshold:

- Three-year average number >170 observed bighorn sheep within the identified range (Note: 170 observed average number of bighorn sheep is a management action threshold and is not a desired population objective or size)

*These population performance minimums combined with the management action threshold serve as management triggers to initiate or suspend management strategies as indicated below.

Alternatives	A	B	C	D
Objective to maintain a healthy, sustainable bighorn sheep herd on the Refuge that is characterized by all three performance metrics and a management action threshold that applies to the alternatives indicated (√)		√	√	√
Strategies Applied to Achieve Objective				
In coordination with ODFW, conduct semiannual aerial surveys of bighorn sheep in March and July to monitor lamb recruitment and population trends	√	√	√	√
In coordination with ODFW, maintain 25 to 35 adult bighorn sheep with radio/GPS collars in an effort to track individuals and monitor for survival, mortality, and movements	√	√	√	√
Promptly (ideally within 1–2 days of death) locate dead collared bighorn sheep to determine cause of death	√	√	√	√
Conduct administrative lethal removal of cougars occurring within the proposed Bighorn Sheep-Cougar Management Zone on the Refuge using authorized agents when the three population performance metrics and the bighorn sheep management action threshold are not being met			√	√
As the bighorn sheep population approaches the three population performance metrics and the bighorn sheep management action threshold, follow Service regulations to evaluate and establish a phased-in annual public cougar hunt			√	√

Refine techniques and monitor cougar use/visits and numbers using hair/deoxyribonucleic acid (DNA) snare and camera traps and other methods			√	√
Hunting of bighorn sheep would not resume on the Refuge until bighorn sheep population performance metrics and the management action threshold are met		√	√	√
In partnership with ODFW, monitor for bighorn sheep disease, especially *M. ovi*, via health screenings of captured live bighorn sheep and necropsies and analysis of tissue samples from all carcasses that are located on or near the Refuge	√	√	√	√
Promptly remove domestic sheep or goats found on the Refuge as well as any bighorn sheep suspected to have been exposed to domestic sheep in order to prevent infectious disease introductions to the herd	√	√	√	√
Conduct outreach to raise public awareness about bighorn sheep diseases, the potential for infection from domestic sheep and goats, and to request reports of possible exposures and sick sheep		√	√	√
Monitor genetic heterozygosity or allele frequencies by tissue sampling and testing of captured sheep (and opportunistically from discovered carcasses) every 5 years and compare results to previous assessments; augment the bighorn population with sheep from a disease-free source as needed if low genetic diversity concerns are documented			√	√
Once the primary causes of the bighorn sheep decline have been addressed, evaluate and augment the bighorn sheep herd, if needed, with sheep from a disease-free source to supplement the population, extend herd range into unoccupied quality habitat, or replace the herd should it be extirpated			√	√
If there is a need to reinitiate administrative removal of cougars, target only confirmed offending cougars as an alternative strategy if resources are available and the bighorn sheep herd can tolerate resultant predation mortality			√	√
By July 2022, develop an IMP that includes surveys to monitor bighorn sheep performance metrics and bighorn sheep population and management action response		√	√	√

Rationale: The best scientific information available indicates that cougar predation is currently the primary source of mortality to bighorn sheep on the Refuge. Because the low bighorn sheep population cannot withstand current levels of mortality, this herd is in danger of extirpation in the near future if prompt actions are not taken to reduce predation pressure from cougars. Therefore, the Service considers lethal removal of cougars occurring within bighorn sheep habitat on the Refuge to be the most effective and feasible method to mitigate predation mortality in the short term. Once the bighorn sheep population recovers and is meeting the specified management action threshold and performance metrics and the herd is able to withstand natural predation pressure, administrative cougar removal would be terminated. If, in the future, administrative removals must be re-initiated to meet the bighorn sheep population performance measures and management action threshold, targeting confirmed offending cougars could be used as an alternative strategy if resources are available. Once the bighorn sheep population demonstrates an increasing population trend that is above the management action threshold and is meeting the population performance measures, the Service would evaluate implementing a public cougar sport hunt in coordination with ODFW. Targeting specific cougars would require them to be GPS collared. Collaring cougars would require an MRA because GPS collars are considered a Wilderness Act Section 4(c) installation. Should this strategy be used in the future, the Service would complete an MRA prior to initiating any cougar collaring actions.

Consistent with the Service's Biological Integrity, Diversity, and Environmental Health Policy (601 FW 3), public hunting of bighorn sheep would not be authorized or offered as long as administrative removal of cougars is being carried out to achieve the three population performance metrics and the bighorn sheep management action threshold. In addition, Refuge staff would continue to refine techniques and monitor the cougar population.

Bighorn sheep are highly susceptible to contagious diseases carried by domestic sheep and possibly goats and other domestic livestock, and exposure to these animals has the potential to decimate the Refuge population. Therefore, any bighorn sheep believed to have been exposed to domestic animals would be removed from the herd as quickly as possible. Refuge staff would conduct outreach with adjacent landowners to educate them regarding the threats domestic sheep present and to promptly remove escaped animals from the Refuge.

Small populations are potentially susceptible to inbreeding depression because mating between closely related animals is more likely, which results in higher prevalence of recessive genes and reduces individual fitness. Bighorn sheep populations have a history of demographic bottlenecks, isolation, and small size, which have raised substantial concerns that genetic factors may limit their viability. Evidence of inbreeding depression is commonly determined on the basis of heterozygosity-fitness correlations. Because it can be difficult to distinguish genetic versus environmental causes of population decline, inbreeding depression should be suspected when other causes can be reasonably ruled out. Because the field of population genetics is advancing rapidly, it should be routinely assessed for new techniques to evaluate for deleterious effects of inbreeding in bighorn sheep.

The known action to mitigate low heterozygosity is augmentation, by bringing new breeders from a nonrelated source into the herd. Bighorn sheep herd augmentation done with appropriate precautions to prevent introducing disease is recognized as successful method used to hasten recovery of low populations resulting from various causes. Augmentation would be evaluated and conducted when the other primary causes of the bighorn sheep decline have been addressed. The number of imported animals would be determined by the availability of source herds, the specific objectives of the augmentation, and cost considerations.

The Refuge will develop an IMP that will include bighorn sheep surveys to assess management action response and progress toward achieving the performance objectives and inform future management decisions. The major parts of an IMP include identifying current and needed surveys, entering surveys and associated metadata into PRIMR, and selecting and prioritizing surveys to conduct on the Refuge.

Supporting references for the objective thresholds: Geist 1971; Van Dyke et al. 1983; Temple and Wiens 1989; Smith et al. 1991; Cassaigne et al. 2010; DeCesare et al. 2012; Serrouya et al. 2017.

CHAPTER 3. AFFECTED ENVIRONMENT

This chapter describes the general environmental setting of the Refuge and focuses on the affected environment for the proposed alternatives. Descriptions in the CMP that pertain to the affected environment are incorporated where applicable and new information is provided where there is change or where adequate information was not presented in the CMP. A detailed taxonomy of species mentioned in this EIS is presented in Appendix G.

3.1 Geographic and Ecosystem Setting

3.1.1 Great Basin Ecosystem

The Great Basin Ecosystem is defined by sagebrush-steppe, salt desert shrub, and pinyon-juniper woodland habitats and the various fish and wildlife species that live within those habitats. This ecosystem encompasses a portion of the Columbia Basin Plateau in eastern Washington and Oregon and southern Idaho as well as the Great Basin Region extending from the Sierra Nevada Mountains in eastern California, across most of Nevada north of the Mojave Desert, to the Rocky Mountains in Utah, Colorado, and Wyoming. The Great Basin Ecosystem comprises numerous ecoregions, including the Columbia Plateau, Northern Basin and Range, Central Basin and Range, and Wyoming Basin, and supports the majority of sagebrush in North America (Suring, Rowland et al. 2005a; Environmental Protection Agency [EPA] 2020).

3.1.2 The Refuge

Located in a remote area of south-central Oregon, the Hart Mountain NAR encompasses approximately 278,523 acres of sagebrush-steppe habitat within the Great Basin (see Figure 2.1) and is managed by the Service. Originally established on December 20, 1936, for the conservation and protection of the once-imperiled pronghorn (*Antilocapra americana*), the Refuge (along with Sheldon National Wildlife Refuge) now conserves habitat for a number of additional native, rare, and imperiled species of fish, wildlife, and plants that depend upon the sagebrush-steppe ecosystem.

3.1.3 Historic Climate

The Northern Basin and Range ecoregion is generally higher and cooler than the adjacent Snake River Plain and has more available moisture than the Central Basin and Range ecoregion (Thorson et al. 2003). The semiarid (average precipitation 12 inches) climate in the Northern Basin and Range is also characterized by extreme ranges in daily and seasonal temperatures (Crist et al. 2011). The average (1939–2016) high temperatures range from 39 to 81.4 degrees (°) Fahrenheit (F) and average low temperatures range from 18.4 to 44°F. Most precipitation occurs as snowfall with annual total snowfall of 49.3 inches and annual total precipitation of 11.58 inches.

Hart Mountain NAR has maintained a National Oceanic and Atmospheric Administration (NOAA) weather station that collects temperatures, snow depth and snow accumulation, and precipitation since 1940. NOAA's National Climatic Data Center creates Climate Normals that are produced every 10 years and display a three-decade average of climate variables, such as temperature and precipitation. The most recent Climate Normals for the Refuge are from 1981 to 2010 (Figure 3.1). The monthly Climate Normals show that the Refuge high temperature ranges from 39.8 to 82.8°F, low temperature ranges from 18.1 to 44.0°F, and precipitation ranges from 0.45 to 1.59 inches (NOAA 2020).

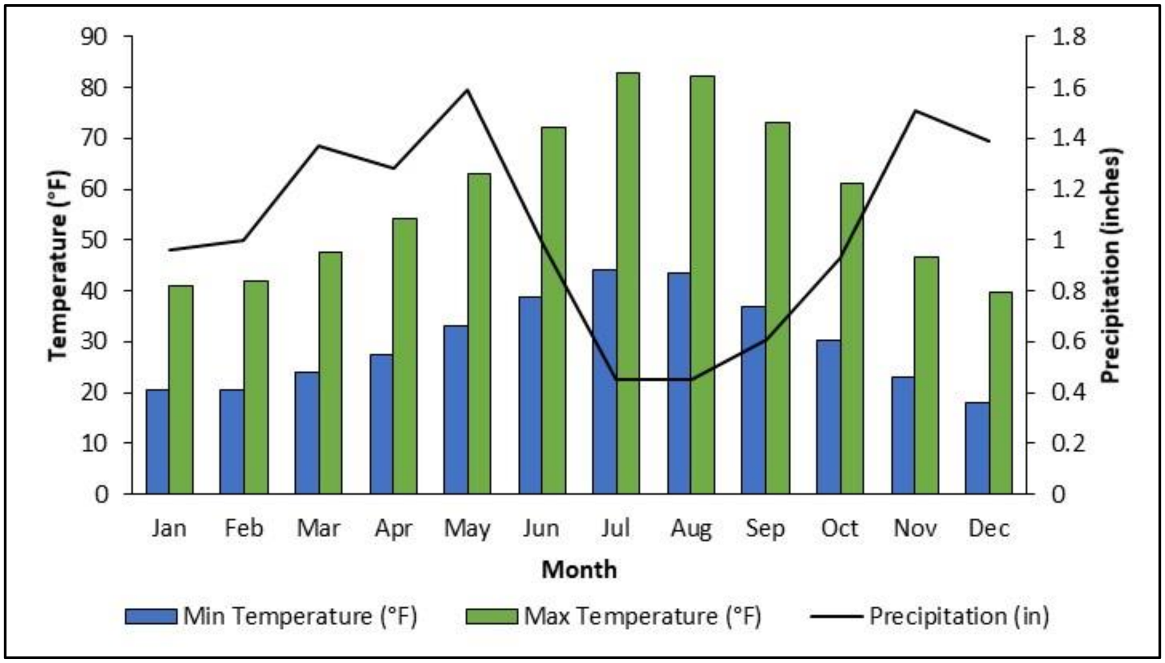

Figure 3.1. Temperature and precipitation normals from 1981–2010, Hart Mountain National Antelope Refuge.

The daily maximum and minimum temperature trends on Hart Mountain have generally remained stable from 1940 to 2020, but the yearly average maximum temperature has increased slightly over the 80-year time frame (Figure 3.2).

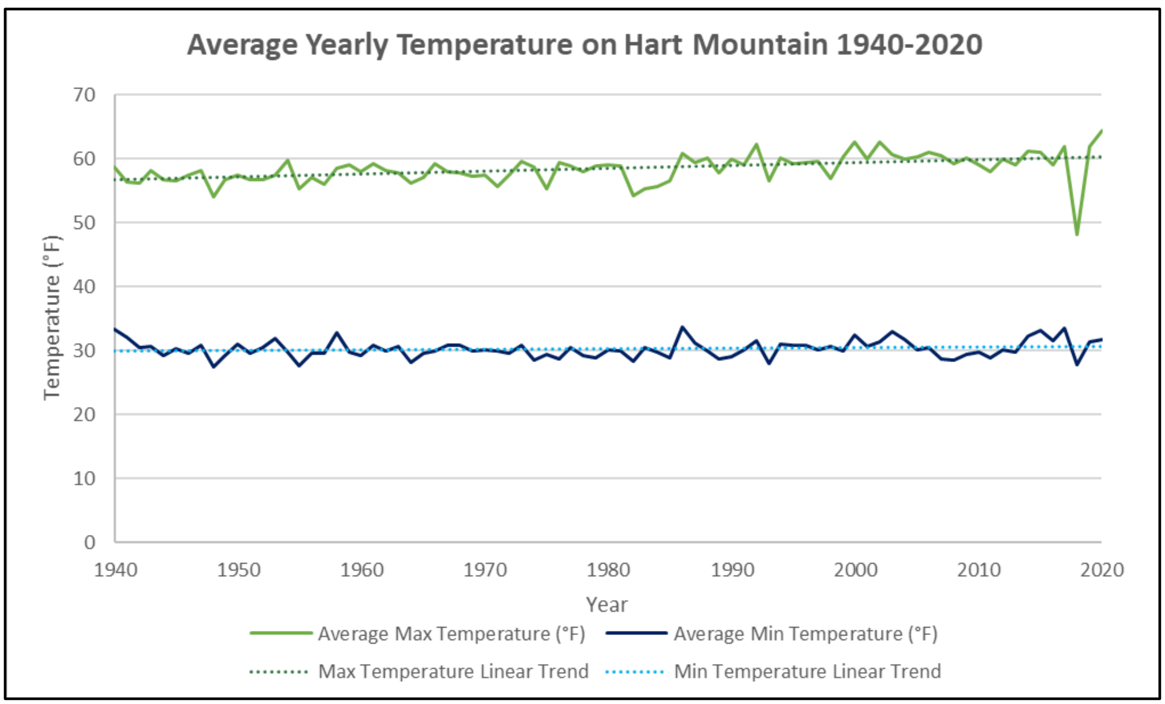

Figure 3.2. Average yearly temperature from 1940–2020 with average minimum and average maximum trendlines, Hart Mountain National Antelope Refuge.

The NOAA climate data from Hart Mountain over the past 80 years indicate a general downward trend in the amount of yearly snowfall and yearly snow depth while yearly precipitation has remained generally the same (Figure 3.3). This indicates that a smaller percentage of the yearly precipitation is falling as snow each year, reducing the overall snowpack on Hart Mountain.

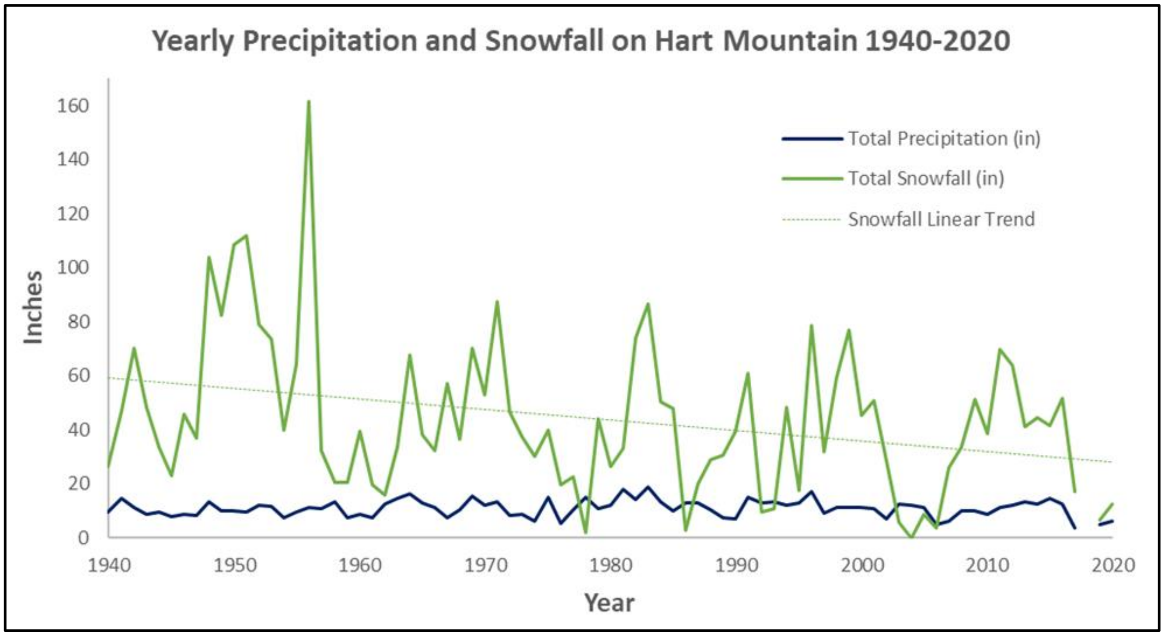

Figure 3.3. Annual precipitation and snowfall from 1940–2020, Hart Mountain National Antelope Refuge.

3.1.4 Recent and Predicted Climate Change

The Intergovernmental Panel on Climate Change (2018) predicted that climate change will impact the resilience of ecosystems around the world. General models consistently project hotter temperatures, a greater proportion of precipitation falling as rain rather than snow, earlier snowmelt, and longer fire seasons in the United States (Littell et al. 2009). Climate models predict that the Intermountain West will experience warming in future scenarios (Intergovernmental Panel on Climate Change 2018). In addition to temperature, climate models also project changes in water availability, most notably in snowpack. Climate models demonstrated that snowpack has been decreasing for the last 50 years (Chambers and Pellant 2008) and it is projected that the percentage of precipitation delivered as snow will be reduced, and snowmelt will start sooner and result in higher peak runoff with the potential increase in temperatures (Loehman 2010). Across the Great Basin, climate models generally agree that annual precipitation will range near average over the next 50 years (Crist et al. 2011; Snyder et al. 2019).

With an increase in temperatures, droughts are likely to become more frequent and last longer, IAGs are likely to expand, and the duration and severity of wildfire seasons are likely to expand (Keyser and Westerling 2019; Snyder et al. 2019). When longer growing conditions are present due to climate change, fuel accumulations from the previous growing season increase and fires are likely to be more frequent, extensive, and extreme (Westerling et al. 2006; Cassell et al. 2019).

Several changes in habitat distribution are predicted by climate models. The proportion of the landscape dominated by Wyoming big sagebrush (*Artemisia tridentata* ssp. *wyomingensis*) will decline and salt desert scrub, mountain big sagebrush (*Artemisia tridentata* ssp. *vaseyana*), and low sagebrush (*Artemisia arbuscula*) will increase (Kleinhesselink and Adler 2018; NatureServe 2020); however, other models predict little change to sagebrush and that pinyon-juniper is likely to decline (Brice et al. 2020). Higher elevation habitats like those found in Refuge bighorn sheep habitat receive increased precipitation over lower-elevation areas, so they are more resilient and have the ability to adapt to landscape cover changes (Soulard and Rigge 2020).

3.2 Physical Environment

3.2.1 Geology

The geology and tectonic activity within the Northern Basin and Range ecoregion is characterized by very large volcanic basalt flows that have gradually been broken into enormous blocks, portions of which have lifted and sunk along long faults to form valleys and towering fault block escarpments, including the Hart Mountain escarpment. As a result, the region is very rugged and covered primarily by slow-growing sagebrush, juniper, and associated bunchgrasses and various other plants.

3.2.2 Soils

Soils in the Refuge are characterized as semiarid, very young, and poorly developed. The soils are largely a result of lake sedimentation, volcanic activity, and water erosion deposition. Chemical and biological soil development processes such as rock weathering, decomposition of plant materials, accumulation of organic matter, and nutrient cycling proceed slowly in this environment; therefore, disruption of soils can lead to long-term changes in plant communities and productivity. Soils on the steep slopes of the escarpment are particularly poorly developed, droughty, erodible, and unproductive. Figure C-3 displays major soil types within bighorn sheep range.

Biological soil crusts (biocrusts) are an integral component of rangeland habitats and soils (see Section 3.4.8). These complex and diverse assemblages reduce soil erosion, enhance nutrient cycling, and contribute to soil organic matter in semiarid and arid plant communities (Evans and Ehleringer 1993; Belnap et al. 2001; Rosentreter and Eldridge 2004; Bahr 2013; see also Kaltenecker, Wicklow-Howard, and Pellant et al. 1999).

3.2.3 Water Resources

This section describes the types and condition of water resources on the Refuge, with discussion of bighorn sheep use. Further details about bighorn sheep use of water sources are in Section 3.3.1.5 (see Water Use subsection), and descriptions of wetland and aquatic habitats are in Section 3.4.5. For this management plan, water resource features were identified, mapped, and categorized using existing Refuge GIS data, feature visibility and extent in multiple years of National Agriculture Imagery Program (NAIP) imagery (see Figures C-9 and C-10). All photographs of water resources (and other key information) are presented in Appendix H.

Calculated acreages of these features are approximate, based on conditions present when GIS data were acquired or available. Water levels change with seasonal, annual, and long-term precipitation patterns and the vegetation responds accordingly, changing the visible perimeters of the features.

3.2.3.1 STREAMS AND SPRING BROOKS

Streams are linear flowing bodies of water that derive from precipitation, snowmelt, and large aquifers draining through point sources such as seeps along much of their length (Figure H-1). Spring brooks are flowing drainages that derive most of their water from point sources such as springs and seeps and often have limited connection to larger water table reservoirs along their lengths (Figure H-2). Streams tend to have higher volumes and larger zones of influence on vegetation than do spring brooks and are more susceptible to function degradation from erosion such as channel down-cutting (Levick et al. 2008; Zeedyk and Clothier 2009; Wheaton et al. 2019).

The lengths (distance) and durations (temporal availability) of surface-available water in stream and spring brook features on the Refuge are determined by precipitation and snowpack in the current and previous few years. Actual hydrological pathways and processes connecting streams to their sources are difficult to determine and are currently unknown for those on the Refuge. The lengths and durations of linear surface water features reported here are inferred from vegetation visible on the NAIP imagery and have not been ground-truthed or directly measured.

There are over 155 miles of streams and spring brooks on the Refuge. Of this, approximately 36 miles are in core bighorn sheep habitats (with approximately 1.9 miles of this within core nursery areas) and 92 miles are in the broader bighorn sheep use areas (i.e., water limits; see Section 3.3.1.5, Water Use subsection, for descriptions of these habitat categories).

Rock and Guano Creeks are the only two truly perennial streams within the Refuge. Both also have multiple perennial spring brook tributary sources, though none of these have perennial surface-flow connection to either Rock or Guano Creeks. Both Rock and Guano Creeks have sufficient water through the summer in at least a portion of their lengths to retain self-sustaining populations of trout, though a majority of the streams' overall length does go dry by the end of summer. A few of the tributary sources also have sufficient water through the summer to sustain small populations of trout, at least in the short term (e.g., Willow Creek), though these features are only seasonally connected to Rock or Guano Creeks and are known to go dry during extended periods (multiple consecutive years) of drought. The spring brook headwaters and perennial reaches of both creeks are outside of bighorn sheep core habitats but are within the broader general ewe and ram use areas.

Many of the prominent canyons along the Hart Mountain escarpment such as Degarmo, Hart, Potter, Juniper, and Cooper, have streams that are typically intermittent with short lengths of intermittent to perennial spring brook headwaters. Many of the springs (both named and unnamed) along the escarpment also have short lengths of spring brooks. The flow of these streams and spring brooks is largely determined by winter snow accumulation and the rate of snowmelt, so actual water availability from these features within the core bighorn sheep habitats is highly variable.

3.2.3.2 SPRINGS AND SEEPS

A spring or seep is a place where ground water flows from rock or soil onto the ground surface, with the difference between the two primarily being amount of flow (i.e., springs have more flow than seeps; Wilson and Moore 1998; Sharp Jr. 2007). For our use, springs also tend to be perennial or have longer periods of surface flow, while seeps tend to have intermittent surface flow. Both have sufficient water to sustain core areas of wetland vegetation visible in NAIP imagery. Springs and seeps are important features for bighorn sheep and other Refuge wildlife because they provide surface-available water in an otherwise dry environment, support wetland vegetation, and often supply the base flow of streams and wetlands long after winter snows have melted.

Springs and seeps are most common on the escarpments of Hart Mountain, although there are several that occur in the tables and on the eastern and southern areas of the Refuge, typically associated with drainage cuts and snowdrift collection points (Figure H-3). There are 313 springs or seeps identified within bighorn sheep habitat on the Refuge, 280 of which have not yet been assessed for condition or duration (Table 3.1), mostly due to inaccessibility and staffing shortages. Of the total number of identified springs and seeps, 189 occur in core bighorn sheep habitats, 183 of which have not yet been assessed.

Table 3.1. Count and Status/Duration of Known Discrete Point-Type Water Features within Bighorn Sheep Habitats on Hart Mountain National Antelope Refuge

Type	**Status/Duration***	**Total Count†**	**Core Bighorn Sheep Habitats‡**		**Core Nursery Areas§**	**On-Refuge Water Limits (Simple Buffers)¶**			**Off-Refuge Water Limits (Simple Buffers)¶,#**		
			Escape Terrain	**Forage Terrain**		**Lambing (within 0.62 mile)#**	**General Ewe (within 1.99 miles)****	**Ram (within 4.35 miles)‡‡**	**Lambing (within 0.62 mile)****	**General Ewe (within 1.99 miles)††**	**Ram (within 4.35 miles)‡‡**
Spring/seep	Perennial	29	2	2	0	2	14	9	–	–	–
	Intermittent	3	0	1	0	1	1	0	–	–	–
	Dry	1	0	1	0	0	0	0	–	–	–
	Not assessed	317	118	65	24	14	54	29	17	18	2
Dugout	Perennial	11	0	0	0	0	3	8	–	–	–
	Intermittent	13	0	1	0	0	3	9	–	–	–
	Dry	17	0	0	0	0	5	12	–	–	–
	Not assessed	33	0	0	0	1	7	7	4	4	10
Impoundment	Perennial	4	0	2	0	1	0	1	–	–	–
	Not assessed	1	0	0	0	0	1	0	0	0	0
Guzzler	Nonfunctional	3	2	0	1	1	0	0	–	–	–
	Not assessed	0	0	0	0	0	0	0	0	0	0
Totals		**432**	**122**	**72**	**25**	**20**	**88**	**75**	**21**	**22**	**12**

* Feature counts and status/duration (i.e., water availability) are based on Refuge GIS data, feature visibility in multiple years of NAIP imagery (i.e., the feature had to be apparent in at least 4 of the 5 available years [2009, 2012, 2014, 2016, 2017] of NAIP imagery), and recent in-field site assessments when available. Flow rate(s), available water volume, zone of vegetative influence, and water quality and chemical composition(s) have not been assessed.

† Total feature counts are the sum of the escape terrain, forage terrain, and the lambing, general ewe, and ram water limit values (both on- and off-Refuge). See Section 3.3.1.5 for definitions of these habitat categories.

‡ Feature counts are only for each specific bighorn sheep habitat use category. Total core bighorn sheep habitat feature counts should be calculated by totaling the escape terrain and forage terrain values.

§ Core nursery areas are bighorn sheep specialty use areas within the larger bighorn sheep habitat area (i.e., areas only selected by ewes with lambs during parturition or early rearing) that overlap both escape and forage terrains and are thus not included in the total counts.

¶ Point-type water features outside of the Refuge, as well as their status and duration, were identified using NAIP imagery and have not been verified through in-field assessments. Irrigation pivots and other irrigated fields in the Warner Valley, west of the Warner Wetlands and Hart Lake, are not in these counts as the extent and timing of irrigation could not be determined and there is no known history of use of these features by bighorn sheep.

There are insufficient Refuge bighorn sheep location histories to identify patterns in movements or water usage by bighorn sheep that could be used to estimate how far bighorn sheep will travel from water sources with any statistical relevance. These buffer widths were derived from literature sources and incidental observations of the Refuge bighorn sheep population. Water limits were modeled as simple buffers using the Multiple Ring Buffer tool in the Proximity toolset within the Analysis toolbox of ArcGIS 10.7.1. Reported feature counts are only those that occur within the given ring buffer, based on being within the Refuge boundary perimeter (i.e., on-Refuge) or outside of the Refuge perimeter (i.e., off-Refuge).

** The lambing water limit includes all potential areas used by ewes with lambs from parturition through dispersal, not just the early season nursery habitats, based on literature values of the maximum distance they travel from water sources. Total lambing (i.e., ewes with lambs) water limit feature counts should be calculated by adding the escape terrain, forage terrain, and the lambing water limit values.

†† The general ewe water limit includes all potential areas used by ewes without lambs or with older-aged (weaned) lambs, based on literature values of the maximum distance they travel from water sources. Total general ewe water limit feature counts should be calculated by adding the escape terrain, forage terrain, and the lambing and general ewe water limit values.

‡‡ The ram water limit is based on incidental observations of bighorn sheep ram water source use on the Refuge as reported by Payer (1992). Total ram water limit feature counts should be calculated by adding the escape terrain, forage terrain, and the lambing, general ewe, and ram water limit values.

The aquifers for most of the Refuge's springs and seeps are believed to be relatively small, localized, and to receive most of their water from snowmelt (U.S. Geological Survey [USGS] 2019). These small aquifers are prone to draining completely during prolonged droughts, which results in springs drying up. This dependence on snowmelt and annual precipitation makes these higher elevation springs susceptible to changes in climate and variable local weather patterns.

Few of the springs and seeps on the Refuge are believed to have been developed. Those that have been developed have typically had spring boxes of various simple designs installed to concentrate and direct flow. With the notable exception of the Refuge's communal water source, none of the few developments known to still exist are believed to be fully functional; i.e., the boxes or associated piping have failed, releasing the spring flow back into the original drainage.

3.2.3.3 ARTIFICIAL WATER IMPROVEMENTS

Dugouts and Impoundments. Water availability and duration has long been an issue within arid and semiarid areas. Early settlers, and later Refuge staff, developed many playas and drainages by excavating large pits (dugouts) in them, intended to concentrate annual runoff at a single point to increase its surface availability and duration (Figure H-4; see also Section 3.2.3.4). These dugouts can hold water longer into the summer and at greater depths than undisturbed playas and drainages and were developed for the benefit of domestic livestock and wildlife, including bighorn sheep. Some playas were also modified by excavating shallow drainage channels into the dugouts and/or using spoils to create impounding berms. Some playas and drainages were further modified with more than one dugout or berm, although this was not typical on the Refuge.

In drainages, these berms were typically created across the main channel or a high-water side channel, effectively creating an earthen dam around a low spot on a gradient to hold water on the landscape (i.e., creating an impoundment; Figure H-6). Some natural pools, such as Warner Pond, were also modified or enlarged using dredging and impoundments to increase their area and/or depth for the benefit of livestock, wildlife, and/or the recreating public.

For this management plan, dugouts were counted and analyzed as separate features from the linear (drainage, stream, or spring brook) or area feature (lake, reservoir, playa, or marsh; see Section 3.2.3.4) in which they were constructed. Although the two are inextricably linked, they often fall into separate categories for status and/or duration.

Most dugouts and impoundments were created prior to availability of GPS, and few were well documented or mapped. It is believed all (or nearly all) of these sites have now been identified by field surveys and NAIP imagery, although many have not been fully described nor assessed for condition and function. There are 56 dugouts and five impoundments within bighorn sheep habitat on the Refuge (see Table 3.1). Of these, one intermittent dugout and two perennial impoundments occur within core bighorn sheep habitats. No dugouts or impoundments occur in core nursery areas.

From their creation until 1994, maintenance of these structures has been sporadic and has often been reactive rather than preventative. Some maintenance occurred on selected dugouts between 1994 and 2000, primarily in the form of clean out and repairs of minor erosion damage. Little maintenance has occurred on any of these structures since 2000 other than repair of flood damage at Hilltop Reservoir.

Guzzlers. Guzzlers are artificial water sources built for wildlife to supplement natural sources. These water developments collect precipitation and divert it into a water storage tank, then water in the tank is fed into a small drinking trough that wildlife can access (Figures H-7, H-8, H-9). Constructing water developments is an important conservation strategy for bighorn sheep where water may limit their population size or distribution (Bleich and Torres 1994; Andrew et al. 1997), and the evidence that water developments are used intensively by bighorn sheep is compelling (Andrew 1994; Bleich et al. 1997). Dolan (2006) summarized published literature and found that desert bighorn sheep benefit from water developments where water is unavailable or limited.

There are three guzzlers on the Refuge, all of which are located on Poker Jim Ridge within bighorn sheep habitat. Two are located in escape terrain (one of which is also within a core nursery area), and the third is within the lambing water limit beyond bighorn sheep core habitats (see Section 3.3.1.5). They were intended to provide water sources for bighorn sheep where natural sources did not existent. Two of the guzzlers were installed in the 1980s, and two more were constructed in August 1990. One of the guzzlers was removed prior to 2008 due to poor function (the specific removal date is not known). Payer (1992) did not observe bighorn sheep using the guzzlers in the short time spent in the guzzler areas. The Refuge has not established guzzler monitoring to document amount or frequency of guzzler use by bighorn sheep; however, incidental observations by ODFW biologists (Muir and Whittaker 2020) confirm guzzler use by bighorn sheep, and Refuge staff found significant wildlife trailing to one of the guzzlers. The Poker Fire of 2019 damaged two of the remaining guzzlers. One was at least partially functional after the fire but failed before late spring 2020. As of summer 2020, all three structures are no longer functional. Two still had water in their storage tanks but this was inaccessible to wildlife.

3.2.3.4 LAKES, RESERVOIRS, PLAYAS, AND MARSHES

For this management plan, water area features on the Refuge were differentiated by type and status, broadly based on their development history, size, water availability, and duration. Five types of water area features were identified to occur within bighorn sheep habitat (Table 3.2):

- Lakes/ponds
- Reservoirs/impoundments
- Playa reservoirs (i.e., playas developed with a dugout or similar feature to concentrate annual runoff)
- Playas (i.e., undeveloped playas)
- Marshes

These feature types were further differentiated based on the status and/or duration of surface water availability (with the assigned status being based on the area feature rather than on any development within the feature, which were counted and differentiated as separate point features under artificial water improvements, above):

- Long-term perennial (year-round water features that retain free water to some degree, including during extended periods of drought)
- Short-term perennial (also year-round water features, but will typically dry out during extended periods of drought)
- Extended season intermittent (water features that usually dry out each year, but which also usually last into summer or late summer)
- Short season intermittent (water features that usually dry out each year by early to mid-summer)
- Ephemeral (water features that are usually only present in response to a stochastic event)
- Dry (water features that only rarely hold water)

Lakes and ponds are basin features that contain surface-available water too deep to allow vegetation to take root across the entirety of its surface (i.e., leaving areas of open, emergent vegetation–free water; Wilson and Moore 1998). Most of the lakes and ponds on and near the Refuge are fringed with emergent marsh vegetation. They support aquatic species such as submerged aquatic vegetation and macroinvertebrates, and water-dependent vertebrates such as marsh birds, wading birds, and waterfowl. A few support fish as well, although most that do were either stocked or supplemented with non-native strains or species by ODFW primarily for public recreation purposes, with the exception of Warner sucker (*Catostomus warnerensis*) in Hart and Crump Lakes, which occur in these bodies as water levels allow. Lakes and ponds are often important sources of reliable water for most desert species, as well as valuable year-round forage for grazing and browsing species. The concentrations of prey also make them prime hunting grounds for predators.

Table 3.2. Type, Typical Water Availability, and Acreages of Area-Type Water Features within Bighorn Sheep Habitat on Hart Mountain National Antelope Refuge

Type	**Status/Duration**	**Total Acres***	**Core Bighorn Sheep Habitats†**		**Core Nursery Areas‡**	**On-Refuge Water Limits (Simple Buffers)§**			**Off-Refuge Water Limits (Simple Buffers)§,¶**		
			Escape Terrain	**Forage Terrain**		**Lambing (within 0.62 mile)¶**	**General Ewe (within 1.99 miles)#**	**Ram (within 4.35 miles)††**	**Lambing (within 0.62 mile)#**	**General Ewe (within 1.99 miles)****	**Ram (within 4.35 miles)††**
Lake/pond	Long-term perennial	2,189	<0.9	<3	0	0	0	0	0	39	2,146
	Short-term perennial	16,863	0	119	0	51	52	0	1,488	8,501	6,652
	Extended season intermittent	3,154	0	8	0	6	31	45	162	727	2,175
	Short season intermittent	541	0	0	0	<0.4	17	15	29	131	349
	Ephemeral	<2.7	<1.3	<0.9	<1.1	0	<0.5	0	0	0	0
	Dry	57	0	0	0	0	<0.1	0	0	0	57
Reservoir/ impoundment	Long-term perennial	<4.7	0	0	0	<4.7	0	0	0	0	0
	Short season intermittent	<1.9	0	0	0	0	0	0	0	<1.9	0
Playa reservoir (developed / modified)	Extended season intermittent	151	0	0	0	11	108	32	0	0	0
	Short season intermittent	254	0	8	0	19	<4.2	189	0	0	34
	Ephemeral	122	0	0	0	0	0	70	0	0	52
Playa (undeveloped)	Short season intermittent	6,907	0	39	0	0	0	0	1,192	4,138	1,538
	Ephemeral	145	0	0	0	0	0	87	0	0	58
	Dry	27	0	0	0	7	12	8	0	0	0
Emergent wetland	Long-term perennial	575	0	0	0	0	7	0	0	417	151
	Short-term perennial	768	0	0	0	18	515	233	0	0	2
	Short season intermittent	11	0	0	0	0	0	11	0	0	0
Totals		**31,773**	**<2.2**	**178**	**<1.1**	**117**	**747**	**690**	**2,871**	**13,953**	**13,214**

Note: Acreages are based on the approximate high water marks (i.e., when full) for each mapped feature. Actual acres of available water vary greatly within and between years and largely depend on recent precipitation. Water volumes, zone of vegetative influence, water quality, and chemical composition of water features have not been assessed.

* Total acreages are the sums of the escape terrain, forage terrain, and the lambing, general ewe, and ram water limit values (both on- and off-Refuge). See Section 3.3.1.5 for definitions of habitat categories.

† Given acreages are only for each specific bighorn sheep habitat use category. Total core bighorn sheep habitat acreages should be calculated by totaling the escape terrain, forage terrain, and nursery area values.

‡ Core nursery areas are bighorn sheep specialty use areas within the larger bighorn sheep habitat area (i.e., areas only selected by ewes with lambs during parturition and/or early rearing) that overlap both escape and forage terrains and are thus not included in the total acreages.

§ Irrigation pivots and other irrigated fields in the Warner Valley, west of the Warner Wetlands, and Hart Lake, were not included in these totals as the extent and timing of irrigation could not be determined and there is no known history of use of these features by bighorn sheep.

¶ We do not yet have sufficient bighorn sheep location histories or resolution to be able to identify or discern patterns in movements or water usage by bighorn sheep, nor to predict (model) these patterns within the larger landscape with any statistical relevance. As such, these distances had to be taken from literature sources and incidental observations of the Refuge bighorn sheep population, necessitating simplicity in mapping these outer limits. Water limits were modeled as simple buffers using the Multiple Ring Buffer tool in the Proximity toolset within the Analysis toolbox of ArcGIS 10.7.1. Reported acreages are only those that occur within the given ring buffer, based on being within the Refuge boundary perimeter (i.e., on-Refuge) or outside of the Refuge perimeter (i.e., off-Refuge).

\# The lambing water limit includes all potential areas used by ewes with lambs from parturition through dispersal, not just the early season nursery habitats, based on literature values of outer limits for water availability/use. Total lambing (i.e., ewes with lambs) water limit acreage should be calculated by adding the escape terrain, forage terrain, and the lambing water limit values.

** The general ewe water limit includes all potential areas used by ewes without lambs or with older-aged (weaned) lambs, based on literature values of outer limits for water availability/use. Total general ewe water limit acreage should be calculated by adding the escape terrain, forage terrain, and the lambing and general ewe water limit values.

†† The ram water limit is based on incidental observations of bighorn sheep ram water source use on the Refuge as reported by Payer (1992). Total ram water limit acreage should be calculated by adding the escape terrain, forage terrain, and the lambing, general ewe, and ram water limit values.

Reservoirs and impoundments are constructed basins, either within drainages through a combination of dredging and build-up of berms, or as expansions of existing basins using similar methods (Wilson and Moore 1998). Their primary purpose was to concentrate and store seasonal runoff. Similar to dugouts and impoundments included as point features (above), most of the larger reservoir and impoundment areas on and near the Refuge were primarily created for grazing domesticated animals or used for irrigation (Figure H-6). Wildlife uses were usually a secondary concern. The primary differences between the point and area feature types are size (area and volume) and duration. Reservoirs and impoundments typically have similar ecological functions in the landscape as lakes and ponds, although with greater seasonality and smaller habitat footprints.

Playas are natural basins or depressions with no or restricted surface outlets where water typically collects in the spring and early summer and dries up by late summer. Water is typically less than 6 inches deep and present during snowmelt runoff and after significant rain events. Depending on their place in the watershed and precipitation, playas commonly may be dry for several years. Playas on the Refuge range in size from <1 acre to over 1,300 acres in size. Most playas on the Refuge have been modified with dugouts, canals, or berms to concentrate and extend the availability of surface water; these are referred to here as playa reservoirs (Figure H-5).

Playa soils often are high in soluble minerals that have precipitated due to evaporation, resulting in distinctive vegetation adapted to ephemeral inundation and unusual soil chemistry. Playa vegetation is often short-lived or ephemeral. Playas often serve as migratory stopover points for birds and can provide nutrients that are otherwise scarce (e.g., selenium [Se]) to many wildlife species.

Emergent wetlands are characterized by having sufficient annual moisture to support wetland species, but do not contain surface water deep or persistent enough to prevent emergent plant growth. Soil surfaces may dry by the end of summer even in years of normal precipitation, but the water table remains sufficiently near the surface to sustain wetland species. Most of the marsh areas on and near the Refuge have a natural outlet, such as a creek or drainage channel. As with lakes, ponds, and playas, marshes provide important resources for many wildlife species.

All emergent wetlands on the Refuge have been artificially modified, including construction of dikes, drainage channels, berms, and dugouts. Many modifications have not been documented or mapped, in part because the structures are difficult to see through the dense vegetation and annual detritus. Little to no maintenance has occurred on these structures in the last 30 years leaving them in various functional conditions.

3.2.3.5 EPHEMERAL POOLS

Ephemeral pools are typically small and very short-lived pools of water (Wilson and Moore 1998). They usually form in shallow impermeable depressions on the landscape, such as in the hard pan areas of the eastern and southern plains of the Refuge, on basalt outcroppings, or in the shallow-soiled, rocky, broken basalt areas along the escarpment and the tops of the primary ridges (i.e., Poker Jim Ridge, North and South Mountains). These pools will typically form in the same sites year after year, but usually only last a few hours to a few days. Ephemeral pools form following snowmelt and significant precipitation events. On the Refuge they can range in size from dozens of yards across to only a few inches across, and most are no more than a few inches deep when full.

Ephemeral pools can be very important short-term water sources for many wildlife species in otherwise dry landscapes, especially following localized summer wet thunderstorm events. Some macro- and micro-invertebrate species are completely reliant on ephemeral pools for the growth and reproductive phases of their life cycles.

The ephemeral pools on the Refuge have not been mapped or quantified because most are too small and too short-lived to detect with available imagery products. No known research has been conducted on these features on the Refuge.

3.2.4 Water Quality

A review of EPA online data (EPA 2021a) indicate that there are no total maximum daily load or National Pollutant Discharge Elimination System violations in the vicinity of the Refuge.

Water quality in Rock Creek is degraded due to excessive in-stream temperatures, due in part to a lack of riparian vegetation to provide streamside shading, and reduced instream flow during late summer and fall. Over 28 miles of Rock Creek are characterized as having less than 25% streamside shading (ODFW 2015). Riparian and physical habitat conditions in the headwaters of Rock Creek are degraded due to proximity of the Hot Springs Campground, and other areas are still considered degraded as a result of past livestock grazing (ODFW 2005a, 2005b). Oregon Department of Environmental Quality (ODEQ) data indicate that several reaches of Rock Creek exceed the 7-day maximum limit of 68°F and, therefore, Rock Creek is considered impaired under Section 303(d) of the Clean Water Act (ODEQ 2020).

3.2.5 Water Rights

Water in Oregon is considered a resource of the State, which grants individuals, corporations, municipalities, and government agencies the right to use the State's water. Because the headwaters of the largest streams are inside the Refuge, there is little opportunity for upstream users to divert water from stream resources. High elevation springs are fed by local aquifers inside the Refuge boundary that are above potential groundwater development areas.

There is one diversion on a private inholding within bighorn sheep habitat that is owned by private landowners. This diversion occurs at the mouth of Hart Canyon and transports water through an open canal and pipeline to a place of use off the Refuge.

3.2.6 Air Quality

Air quality is generally excellent on the Refuge but is often affected by smoke from wildfires in late summer. In 2018, the air quality index for Lakeview had 13 days in the Unhealthy for Sensitive Groups category and 9 days in the Unhealthy category (ODEQ 2019). Twenty-one of those days had a Wildlife Smoke Impact rating (ODEQ 2019). Wildfire smoke from fires on or near the Refuge also occurs in some years and can have a serious impact on air quality.

3.3 Biological Environment – Affected Animals

3.3.1 California Bighorn Sheep

3.3.1.1 TAXONOMIC STATUS

The wild sheep is one of two species in the genus *Ovis* that is native to North America: thinhorn sheep (*Ovis dalli*) and bighorn sheep (*Ovis canadensis*). *Ovis dalli* inhabit Alaska and Canada and *Ovis canadensis* inhabit the western U.S. and Canada. Seven subspecies of bighorn sheep are recognized, two of which occur in Oregon: the California bighorn sheep and the Rocky Mountain bighorn sheep (*O. c. canadensis*). All bighorn sheep on the Refuge belong to the subspecies *O. c. californiana* (California bighorn sheep). Some scientific reports on other subspecies are cited herein when pertinent information on California bighorn sheep is unavailable, or the information otherwise is considered applicable to California bighorn sheep. The term "bighorn sheep" within this document refers to the California bighorn sheep.

3.3.1.2 HISTORY IN OREGON AND THE REFUGE

The seven subspecies of bighorn sheep were once one of the most abundant wild ungulates in the West. Population estimates at the start of the nineteenth century ranged from 1.5 to 2 million (Lawrence et al. 2010; Wild Sheep Working Group 2012). California bighorn sheep were found throughout the steeper terrain of southeastern Oregon, including the non-timbered portions of the Deschutes and John Day River drainages and timbered regions of the Blue and Umatilla mountains, where they were separated from

Rocky Mountain bighorn sheep (Voget 1983). Recent genetic analyses suggested that extirpated bighorn sheep that historically occupied northeastern California, Oregon, and southwestern Idaho more closely resemble desert bighorn sheep (Wehausen and Ramey 2000). Bighorn sheep were an important source of food and clothing for Native Americans, and they were utilized heavily for food and trophies during the homesteading and early settlement periods of Oregon.

Populations declined with the westward expansion of human populations due to overhunting, introduction of domestic sheep and goats, and overgrazing of rangelands. By 1900, many populations were eliminated (Buechner 1960). Disease also contributed to the decline of bighorn sheep populations (Beecham et al. 2007), and many native herds declined to less than 10% of their historical size. According to historical accounts, such declines coincided with the advent of domestic livestock grazing on ranges occupied by bighorn sheep (Grinnell 1928; Shillinger 1937; Council for Agricultural Science and Technology 2008). The last historical record of bighorn sheep in the Hart Mountain area was in 1912, where extirpation of the species corresponded with the introduction of domestic sheep free-range grazing in the area. Unregulated bighorn sheep hunting also contributed to the decline (ODFW 2003; Foster and Whittaker 2010).

The first successful effort to restore bighorn sheep to Oregon began in 1954 when 20 California bighorn sheep from Williams Lake, British Columbia, were successfully released in a 1,000-acre holding pasture on the west face of Hart Mountain (Deming 1961). By 1960, the herd grew to a level that facilitated trap and transplant activities on the Refuge, and in that year, four sheep were transplanted to Steens Mountain in Harney County, Oregon. Between 1960 and 2004, 48 trap and transplant events occurred on the Refuge, representing 642 individual sheep leaving the Refuge population and establishing new herd ranges throughout Oregon and neighboring states.

3.3.1.3 ANNUAL SURVEYS

Bighorn sheep surveys from 1954 through 1988 were conducted in the fall from ground observation points. Since 1989, surveys have been conducted in early summer from helicopters using one to two observers. These surveys, which are conducted in coordination with ODFW staff, are counts of observable ewes, lambs, and rams by age class and represent minimum populations assuming some animals would not be detected during each survey. Based on Foster and Whittaker (2010), the bighorn sheep detection rate on the Refuge averaged 79% of the true population during survey flights with two observers. Therefore, a detection bias correction factor of 0.79 is used to estimate population size from an observed bighorn sheep count (number of sheep observed divided by 0.79 = estimated population). This correction factor is applied to provide an estimated population size as long as survey protocols remain the same, and new data do not indicate that it should be adjusted. The numbers shown in Figure 1.1 are the observed counts made during surveys and are not corrected to provide an estimated population.

For 30 years after reintroduction, the herd steadily increased to 415 sheep observed in 1983 and then fluctuated between 305 and 412 for roughly the next decade. Between 1994 and 2008, the herd declined to between 198 and 357 animals. In 2009, the observed population declined significantly to 144 bighorn sheep and remained relatively stable until 2018 when the observed population dropped to 100. In 2020 the observed bighorn sheep population was only 48 in the entire Hart Mountain range (see Figure 1.1).

3.3.1.4 REFUGE RADIO COLLARING STUDIES

Three separate bighorn sheep collaring studies have occurred on the Refuge that yielded important information about bighorn sheep behavior and survival:

1. Payer (1992) studied habitat use, productivity, and sex and age structure of rams captured between 1990 and 1991. Twenty-one rams were radio collared and monitored for 31 months.
2. Foster and Whittaker (2010) conducted a population performance study between 2004 and 2007, where 49 adult bighorn (12 rams and 37 ewes) were radio collared and monitored to determine cause of adult mortality, measure lamb production and recruitment, monitor herd health, and measure sex and age–specific survival. Two rams died due to capture-related injuries and three collars failed; therefore, survival analysis was based on 44 individuals.

3. After observing low numbers of bighorn sheep during the 2018 survey, ODFW and the Service assessed the current state of the bighorn sheep across the Refuge to evaluate ewe and ram home ranges, seasonal use areas, causes of mortalities of collared bighorn sheep, potential movement corridors, connectivity among herds on and adjacent to the Refuge, and pathogen profiles and exposure to key disease agents. In January 2019, 19 (six males, 13 females) bighorn sheep were captured and outfitted with GPS collars, representing 19% of the 100 bighorn sheep observed during the 2018 summer flight survey. Cause-specific mortality for the marked individuals (see Section 3.3.1.14, Predation) and pathogen profiles (see Section 3.3.1.13, Disease) were reported in the ODFW Progress Report (2020). Movement data continue to be collected and analysis will begin when additional bighorn sheep are collared. Future marking events will add to the sample size and allow the Refuge to analyze and report additional results.

3.3.1.5 THE BIGHORN SHEEP HABITAT MODEL

Bighorn sheep are wide-ranging grazers that require a variety of habitat characteristics related to topography, forage quality and quantity, vegetative structure (cover and horizontal visibility), solar exposure (irradiation and insolation), and water availability, among other variables. Some of these characteristics, such as slope, ruggedness, and patch size, as well as (potential) forage availability, are sufficiently understood and common to bighorn sheep subspecies and populations that they can be predictive on a broad scale and can be analyzed and mapped within a GIS environment using available elevation and vegetation data. Others, such as solar irradiance and insolation, are relatively recently recognized quantitative metrics that, while often shown retroactively to be strongly statistically significant characteristics in describing space use within bighorn sheep habitat, are not yet sufficiently understood to be broadly predictive of potential bighorn sheep habitat or habitat value (i.e., the current understanding of these metrics is based on observation and analysis of a specific population's location histories, but cannot yet be used to predict or value a habitat's potential for bighorn sheep use).

The Refuge is known to provide habitats to meet all life-history requirements for bighorn sheep, though prior to the development of this management plan, these areas had never been explicitly modeled using GIS parameters. To inventory and assess bighorn sheep habitat elements on the Refuge, a GIS-based spatial model was developed using available data of topography, hydrology, and vegetative cover types on the Refuge. The conceptual approach was to develop landscape parameters defining bighorn sheep habitat elements based on descriptive and/or threshold values reported in the scientific literature and from expert opinion, and then apply these to relevant GIS data layers to produce data layers and maps of the habitat elements. Further explanations of criteria used to define habitat elements for this model are in the relevant sections elsewhere in this chapter. The layers were subsequently analyzed to quantify the area of each element. These modeled bighorn sheep habitats will be demarcated for further modeling and/or in-field assessment of quality, quantity, and spatial configuration of additional critical habitat elements (such as irradiation and insolation, R&R scoring, and juniper encroachment impact), to identify and prioritize habitat management actions to be implemented under the management plan.

Escape Terrain. Due to their remarkable adaptations for moving easily over very steep and rugged terrain, bighorn sheep can generally escape from predators and interspecific competition by exploiting such terrain. Steep cliffs and canyons with traversable terraces, rock rims, rock outcroppings, and bluffs are so central to their survival strategy that sheep biologists refer to this as "escape terrain" and it is the focus of bighorn sheep habitat. The extent and distribution of escape terrain regulates the extent to which all other habitat components are used; it was modeled and analyzed separately from all other criteria and valued above all (Geist 1971; Van Dyke et al. 1983; Smith et al. 1991; Beyer 2008). Although the details of the description of threshold values for escape terrain are not uniformly applied within the literature, the most common landscape metrics used in its modeling are slope, ruggedness, and patch size.

At one time ruggedness was viewed as a feature within escape slopes rather than as an independent variable. It is now believed that bighorn sheep likely perceive slope and ruggedness differently when valuing and inhabiting escape terrain and may actually use them differently (Enk 1999; Sappington et al. 2007). Additionally, when both variables are quantified, steep slopes are not necessarily rugged and rugged terrains are not necessarily steep, and the two variables may or may not overlap. Therefore, both factors must be evaluated as independent covariates when modeling bighorn sheep habitats. For our model, we categorized escape terrain into three groups based on these two variables: escape slope, rugged terrain, and rugged escape slope.

Escape slopes are defined as those topographic areas with sufficient slope to act as escape cover regardless of ruggedness. The current recommended threshold values for escape slope are slopes greater than 27° and less than 85°, with an area >1.7 acres (Sweanor et al. 1996; DeCesare and Pletscher 2006; Beyer 2008; see also Holl 1982; Tilton and Willard 1982; Smith et al. 1991; Greene 2010). We adopted these threshold values for our escape slope model.

GIS methods for quantifying ruggedness have evolved as researchers struggled to quantify this intrinsically qualitative variable and to discriminate between steep, even terrain (steep slope and low ruggedness) from uneven and broken steep terrain (steep slope and high ruggedness). Sappington et al. (2007) presented an accepted metric that resolved these issues called a vector ruggedness measure (VRM) using an ArcGIS script for automating the calculation of VRM values from a digital elevation model (Esri 2020a). The VRM value of a given landscape facet can theoretically range from 0 (flat) to 1 (most rugged), though even the most rugged real-world landscapes rarely have VRM values above 0.2 (Sappington et al. 2007). The VRM method requires the user to designate the dimensions of the units of landscape from which the VRM is calculated. We chose a 90 × 90–m floating window. After careful review of the literature, we categorized the VRM values as either rugged (VRM ≥0.003) or not rugged (VRM <0.003) and further categorized the rugged terrain as low (0.003 ≤VRM <0.015), moderate (0.015 ≤VRM <0.02), or high ruggedness (VRM ≥0.02).

Rugged escape slope, what is likely the area of highest value for bighorn sheep, is the intersect of escape slope and rugged terrain (Courtemanch 2014). Our model retains all three identified escape terrain categories, with rugged escape slope considered the highest potential value.

Escape terrain as a topographic feature is not believed to be limiting to bighorn sheep on the Refuge. Escape terrain on the Refuge consists of approximately 12,730 acres, apparently in stable and good condition (Figure C-11); however, conditions of portions of escape terrain, such as high overstory canopy cover and low horizontal visibility, reduce its value for bighorn sheep.

Forage Areas and Diet. Escape terrain provides habitat for resting, lambing, and security, but is also often sparsely vegetated with little or reduced available forage. With so much of their survival inexorably linked to escape terrain, bighorn sheep tend to spend the majority of their time within a relatively short distance from this landscape feature in habitats with greater available forage. Although details of this distance can be very site specific and are influenced by many factors, such as topographic and surface features, forage quality and availability, water location and availability, visibility, and cover, in general most of their time is spent within 985 feet of escape terrain (Tilton and Willard 1982; Smith et al. 1991; Sweanor et al. 1996; Johnson and Swift 2000; Forbes 2001. They will also forage up to 1,640 feet from escape terrain if there is another suitable patch of escape terrain beyond that extended interspace, i.e., where patches of escape terrain are no more than 3,280 feet apart, with no travel barriers between them (Van Dyke et al. 1983; Smith et al. 1991; Schirokauer 1996).

Sufficient GIS data or resolution to accurately map all of available forage areas are not known to be available. For our habitat model, we created a simple buffer using general literature-defined threshold values (985 feet, or 1,640 feet where escape terrain was separated by ≤1,640 feet of suitable habitat) to identify what we call “forage terrain.” Using these values, bighorn sheep forage terrain on the Refuge consists of approximately 18,785 acres (see Figure C-11). Escape terrain and forage terrain combined are viewed as the core bighorn sheep habitat on the Refuge, totaling approximately 31,517 acres.

Bighorn sheep tend to focus their foraging in open areas with low vegetation and high horizontal visibility, such as grasslands, open shrublands, and mixes of these. The availability and quality of forage within these areas is also a selection factor. Perennial bunchgrasses, which make up a large part of bighorn sheep diet (Table 3.3), are an important characteristic of these forage areas, although bighorn sheep are opportunistic foragers and can adapt their diet to available plant communities, whether they are dominated by grasses, forbs, or shrubs (Wilson 1968; Browning and Monson 1980; Wilson et al. 1980;

Van Dyke et al. 1983; Shackleton et al. 1999; Wagner and Peek 2006; others). Their diets will also vary depending on seasonal plant phenology effects on forage quality (Pallister 1974; Cooperrider et al. 1980; Wilson et al. 1980; Wagner and Peek 2006) (see Table 3.3). For example, bighorn sheep will use or preferentially select cheatgrass for a short period in the spring when it is young and green but will avoid it as it matures and senesces. Woody browse in their diets will typically increase in winter months when herbaceous forage is less available. A site's successional stage while recovering from a disturbance such as fire will also affect forage quantity and quality, and its subsequent utility to bighorn sheep.

Table 3.3. Plants Common to Southeastern Oregon's Great Basin and Seasonal Occurrence in Bighorn Sheep Diets

Plant Species by Forage Class		**Level of Use**			
		Winter	**Spring**	**Summer**	**Fall**
Grasses and Grass-Like Species					
Indian ricegrass	*Achnatherum hymenoides*	M	M	L	M
Thurber's needlegrass	*Achnatherum thurberianum*	M	M	L	M
Cheatgrass (non-native invasive)	*Bromus tectorum*	L	M	–	–
Pinegrass*	*Calamagrostis rubescens**	L	L	L	M
Sedge	*Carex* spp.	L	M	M	L
Bottlebrush squirreltail	*Elymus elymoides*	L	L	–	L
Idaho fescue	*Festuca idahoensis*	M	M	L	M
Meadow barley	*Hordeum brachyantherum*	M	–	–	–
Prairie junegrass	*Koeleria macrantha*	L	M	L	L
Great Basin wildrye	*Leymus cinereus*	M	M	M	L
Bluegrass	*Poa* spp.	L	H	M	M
Bluebunch wheatgrass	*Pseudoroegneria spicata*	H	H	M	M
Forbs					
Common yarrow	*Achillea millefolium*	L	L	L	L
Milkvetch/locoweed	*Astragalus* spp.	L	L	L	–
Arrowleaf balsamroot	*Balsamorhiza sagittata*	L	M	L	–
Sagebrush rockcress	*Boechera cobrensis*	–	M	M	–
Western tansymustard	*Descurainia pinnata*	–	L	–	–
Daisy/fleabane	*Erigeron* spp.	–	M	M	–
Cushion buckwheat	*Eriogonum ovalifolium*	–	M	M	–
Other buckwheat species	*Eriogonum* spp.	L	L	L	L
Biscuitroot/desert-parsley	*Lomatium* spp.	M	M	–	–
Lupine	*Lupinus* spp.	L	L	L	L
Penstemon	*Penstemon* spp.	L	–	L	–
Phlox	*Phlox* spp.	–	–	L	L
Daggerpod	*Phoenicaulis* spp.	–	–	M	–
Trees and Shrubs					
Serviceberry	*Amelanchier alnifolia*	L	L	M	L
Low sagebrush	*Artemisia arbuscula*	M	–	M	M
Big sagebrush	*Artemisia tridentata*	M	L	L	–
Fourwing saltbush†	*Atriplex canescens*†	M	L	L	M
Rabbitbrush/goldenbush	*Chrysothamnus* spp. and *Ericameria* spp.	L	L	L	L
Mountain mahogany	*Cercocarpus ledifolius*	H	M	L	M
Shrubby cinquefoil	*Dasiphora fruticosa*	–	–	–	M
Spiny hopsage	*Grayia spinosa*	–	–	–	M
Oceanspray	*Holodiscus discolor*	–	L	L	L
Winterfat	*Krascheninnikovia lanata*	M	M	M	H
Bud sagebrush	*Picrothamnus desertorum*	M	L	–	–
Western chokecherry	*Prunus virginiana* var. *demissa*	L	L	L	L
Antelope bitterbrush	*Purshia tridentata*	H	H	M	–
Currant	*Ribes* spp.	L	–	–	L
Wild rose‡	*Rosa* spp.‡	L	L	M	L
Willow	*Salix* spp.	L	L	M	M

Plant Species by Forage Class		Level of Use			
		Winter	Spring	Summer	Fall
Elderberry (blue or black)	*Sambucus nigra*	–	–	L	L
Mountain snowberry	*Symphoricarpos oreophilus*	L	L	M	L

Source: Adapted from Van Dyke et al. 1983.
Notes: L = light (1 to 5%); M = moderate (6 to 20%); H = heavy (21 to 50+%); – = no data available or <1%.
* Pinegrass is not known to occur on the Refuge, but bluejoint (*Calamagrostis canadensis* var. *canadensis*), a similar species, is.
† Fourwing saltbush is not known on the Refuge, though it is known on Sheldon National Wildlife Refuge. Shadscale saltbush (*Atriplex confertifolia*) and sickle saltbush (*Atriplex gardneri* var. *falcata*), both similar species to fourwing saltbush, are known on the Refuge.
‡ Van Dyke et al. (1983) did not specify a rose species; however, only Woods' rose (*Rosa woodsii* ssp. *ultramontana*) is present on the Refuge and Sheldon National Wildlife Refuge.

There are 18 identified vegetation cover classifications within the core bighorn sheep habitats on the Refuge, although four are only present at trace or near trace levels; there are 20 vegetation cover classes within the broader bighorn sheep habitat area on the Refuge (Table 3.4; see Section 3.4, Figure C-12). There is significant species overlap between these vegetation cover classes, with classes being identified by relative dominance of species and/or by physical characteristics. Specific bighorn sheep use and/or preference of these cover classes on the Refuge cannot yet be evaluated, though recognized and/or preferred bighorn sheep forages are present to common through most of them.

Visibility and Vegetative Structure. Bighorn sheep depend on their acute vision to detect and avoid potential danger from predators or other disturbances and to locate and track mates, offspring, and rivals. If terrain or vegetation restricts visibility too much, bighorn sheep may avoid an area. A view parallel to the ground is referred to as horizontal visibility and can be obstructed by vegetation and terrain near eye level. Vertical visibility is the distance that an animal can see or be seen from above, which can also be obstructed by vegetative canopy or steep terrain. Visibility in general has long been believed to be a significant factor in evaluating bighorn sheep habitat (Geist 1971; Berger 1978; Bailey 1980; Risenhoover and Bailey 1980; Hansen 1982; Risenhoover and Bailey 1985; Wakelyn 1987; Smith et al. 1991; Sweanor et al. 1996, others).

Because bighorn sheep are opportunistic foragers, vegetation structure's influence on horizontal visibility may be a more important habitat selection factor than the presence of a particular forage species (Geist 1971; Shackleton et al. 1999). Bighorn sheep tend to avoid areas of dense, tall vegetation, such as canopied riparian zones, dense forests, dense shrub stands, and similar areas that restrict vision, although slope and/or ruggedness is also a factor (Kornet 1978; Van Dyke 1978; Risenhoover and Bailey 1985; Baker 2015).

Specific measures and management thresholds for horizontal visibility in relation to bighorn sheep habitat value are highly inconsistent in the literature; however, an extensive review yields a general consensus that a threshold of ≥60% (55–62%) horizontal visibility at 100 feet (46–131 feet) is suitable bighorn sheep habitat, and >80% visibility is considered prime habitat (Smith et al. 1991; Sweanor et al. 1996; Johnson and Swift 2000; Dicus 2002; Beyer 2008; Karsch et al. 2016). Areas with horizontal visibility >30% and <60% are considered acceptable travel corridors, though their value for forage is negligible (Sweanor et al. 1996; Zeigenfuss et al. 2000). Areas with horizontal visibility ≤30% are generally unacceptable for use by bighorn sheep, and if they are >328 feet wide they may function as barriers to movement (Smith et al. 1991; Sweanor et al. 1996; Demarchi et al. 2000; Johnson and Swift 2000).

Table 3.4. Vegetation Cover Type Groups, Classifications, and Acreages within Bighorn Sheep Habitat on Hart Mountain National Antelope Refuge

National Vegetation Classification Description (Alias)	Total Acres*	Core Bighorn Sheep Habitat[†]		Core Nursery Areas[‡]	On-Refuge Water Limits (Simple Buffers)[§,¶]		
		Escape Terrain	Forage Terrain		Lambing (within 0.62)[#]	General Ewe (within 1.99 miles)**	Ram (within 4.35 miles)[††]
Cliff and Canyon Vegetation							
Inter-Mountain Basins Cliff and Canyon (Canyon Vegetation)	7,674	4,932	1,884	1,807	182	270	406
Barren Lands (Barren – Sparse/Permanently Limited Vegetation)	45	0	2	< 0.15	30	8	5
Shrubland Communities							
Columbia Plateau Low Sagebrush Steppe (Low Sagebrush)	32,609	336	3,496	309	4,393	8,230	16,154
Inter-Mountain Basins Big Sagebrush Shrubland (Wyoming Big Sagebrush)	31,091	953	3,424	388	3,232	7,135	16,347
Inter-Mountain Basins Big Sagebrush Steppe (Basin Big Sagebrush)	2,103	0	< 0.2	0	86	104	1,913
Inter-Mountain Basins Montane Sagebrush Steppe (Mountain Big Sagebrush)	24,942	1,791	4,440	755	2,918	5,848	9,945
Northern Rocky Mountain Lower Montane-Foothill Deciduous Shrubland (Mountain Shrub)	12,310	1,226	1,859	288	1,128	3,821	4,276
Grassland Communities							
Inter-Mountain Basins Semi-Desert Grassland (Perennial Grassland)	6,629	83	1,072	64	1,641	2,340	1,493
Woodland Communities							
Rocky Mountain Ponderosa Pine Woodland (Pine)	87	0	0	0	0	86	< 1.15
Inter-Mountain Basins Juniper Savanna (Juniper)	5,285	1,515	1,022	199	539	1,478	731
Inter-Mountain Basins Mountain Mahogany Woodland and Shrubland (Mountain Mahogany)	4,203	1,526	833	434	177	985	682
Rocky Mountain Aspen Forest and Woodland (Aspen)	722	262	159	56	14	172	115
Wetland and Aquatic							
Rocky Mountain Subalpine-Montane Mesic Meadow (Wet Meadow)	6,037	99	514	10	697	2,782	1,945
North American Arid West Emergent Marsh (Emergent Vegetation)	313	6	11	0	47	139	110
Open Water (Open Water/Marsh)	18	< 0.1	< 0.4	0	5	12	< 0.15
Salt Desert Communities							
Inter-Mountain Basins Greasewood Flat (Greasewood)	834	< 0.3	35	< 0.5	192	401	206
Inter-Mountain Basins Mixed Salt Desert Scrub (Salt Desert)	39	0	< 0.4	0	4	10	25
Inter-Mountain Basins Playa (Playa – Sparse/Ephemeral Vegetation)	371	< 0.2	11	< 0.3	33	147	180
Invasive-dominated							
Invasive Annual Grassland (Invasive Grasses)	757	0	25	< 0.3	69	308	355
Invasive Annual Forbland (Invasive Forbs)	104	0	0	0	5	21	78
Totals	**136,173**	**12,730**	**18,787**	**4,312**	**15,392**	**34,297**	**54,967**

Sources: Adapted from vegetation associations identified and data products provided by Tagestad (2010), using National Vegetation Classification Standards developed and described by FGDC (2008). Aliases are adapted from Tagestad (2010).

* Total acreages are the sum of the escape terrain, forage terrain, and the lambing, general ewe, and ram water limit values.

[†] Given acreages are only for each specific bighorn sheep habitat use category. Total core bighorn sheep habitat acreages should be calculated by totaling the escape terrain and forage terrain values.

[‡] Core nursery areas are bighorn sheep specialty use areas within the larger bighorn sheep habitat area (i.e., areas only selected by ewes with lambs during parturition and/or early rearing) that overlap both escape and forage terrains and are thus not included in the total acreages.

[§] Vegetation cover type data were not available for areas outside of the Refuge boundary perimeter so these could not be analyzed/summarized.

[¶] We do not yet have sufficient bighorn sheep location histories or resolution to be able to identify or discern patterns in movements or water usage by bighorn sheep, nor to predict (model) these patterns within the larger landscape with any statistical relevance. As such, these distances had to be taken from literature sources and incidental observations of the Refuge bighorn sheep population, necessitating simplicity in mapping these outer limits. Water limits were modeled as simple buffers using the Multiple Ring Buffer tool in the Proximity toolset within the Analysis toolbox of ArcGIS 10.7.1. Reported acreages are only those that occur within the given ring buffer.

[#] The lambing water limit includes all potential areas used by ewes with lambs from parturition through dispersal, not just the early season nursery habitats, based on literature values of outer limits for water availability/use. Total lambing (i.e., ewes with lambs) water limit acreage should be calculated by adding the escape terrain, forage terrain, and the lambing water limit values.

** The general ewe water limit includes all potential areas used by ewes without lambs or with older-aged (weaned) lambs, based on literature values of outer limits for water availability/use. Total general ewe water limit acreage should be calculated by adding the escape terrain, forage terrain, and the lambing and general ewe water limit values.

[††] The ram water limit is based on incidental observations of bighorn sheep ram water source use on the Refuge as reported by Payer (1992). Total ram water limit acreage should be calculated by adding the escape terrain, forage terrain, and the lambing, general ewe, and ram water limit values.

Bighorn sheep tend to use forested areas (i.e., restricted vertical visibility) only sparingly, and then only areas with open canopies (Wakelyn 1987; Risenhoover et al. 1988; Enk 1999). Rams are more likely to use forested areas than are ewes, who often actively avoid trees (Payer 1992). Bighorn sheep will use individual trees and small open clusters for thermal or escape cover from overhead threats, though typically only if they have good horizontal visibility (Oldemeyer et al. 1971; Payer 1993; Enk 1999; Demarchi 2004). In their model of bighorn sheep habitat, Smith et al. (1991) used thresholds of canopy cover in spring and summer of <10% cover for rams and <6% cover for ewes in general, whereas in fall and winter they used thresholds of ≤5% canopy cover for both rams and ewes, and ewes with lambs almost never used overstory canopy, opting for the cover of cliff habitats and other escape terrains regardless of threat. It has been well documented that increasing canopy and/or stem density results in less use or outright avoidance by bighorn sheep, likely due to predator avoidance related to decreases in visibility (Geist 1971; Shannon et al. 1975; Kornet 1978; Van Dyke 1978; Risenhoover and Bailey 1980; Wakelyn 1987; Bentz and Woodard 1988; Baker 2015; others). Reductions in canopy and stem density through management actions and/or stochastic events (e.g., wildfire), can lead to bighorn sheep use or increases in use, likely due to increases in visibility (horizontal and vertical) coupled with changes in forage availability, quantity, and quality (Call 1966; Peek et al. 1979; Riggs and Peek 1980; Bentz and Woodard 1988; Smith et al. 1999; Baker 2015; others).

In general, bighorn sheep avoid extensive forage areas with either overstory or shrub canopy cover >25%, larger patches of denser shrubs, and areas of shrubs above 2 feet tall on milder slopes outside of escape terrain, and riparian areas with dense understory (Van Dyke 1978; Smith et al. 1991); however, on steep, rugged slopes they may travel through and rest in taller or denser brush as long as they have ready escape routes.

Solar Exposure and Seasonal Patterns. Bighorn sheep will select and use habitats in part based on their thermal requirements. These needs and habitat selections will vary by gender, activity, season, weather, body condition, and a host of other factors. For example, on winter days warmer southerly exposures with relatively shallow snow depths can reduce cold stress and the energetic cost of uncovering food plants (Shackleton et al. 1999). In summer, southerly exposures can have the opposite effect, and northerly exposures are sought for more available moisture and improved forage availability. Accordingly, the relative availability of heat from solar exposure is a significant site parameter for modeling bighorn sheep habitat use and assessing habitat quality (Geist 1971; Shannon et al. 1975; Tilton and Willard 1982; Payer 1992; Sweanor et al. 1996; Shackleton et al. 1999, Zeigenfuss et al. 2000; Dicus 2002; Keating et al. 2007; Beyer 2008; and others). The actual potential for beneficial solar exposure is dependent on topography, which is fixed on the landscape, and vegetative structure, which may be managed to provide more or less shade, optimize forage quality, or reduce ambush predator cover. Therefore, the objective of GIS modeling of solar exposure is to identify potentially beneficial sites based on topography that can then be evaluated for potential management.

Traditionally, aspect has been used as a surrogate for solar exposure (Oldemeyer 1971; Tilton and Willard 1982; Smith et al. 1991; Johnson and Swift 2000; others). It has been shown that bighorn sheep generally select for south-, southwest-, and southeast-facing slopes during the winter, and north-, east- and west-facing areas for feeding in the summer. Smith et al. (1991) modeled that lambing bighorn sheep were selecting for southerly aspects (90°–270°), and ewes in general were selecting for areas in spring and summer where >75% of the area had southwest aspects (180°–270°). These values and selections were reinforced by Sweanor et al. (1996), with bighorn sheep also selecting for south-facing slopes (135°–235°) with <9.8 inches of snowpack in winter, and northerly aspects (315°–45°) being unsuitable for lambing.

Using aspect alone for modeling solar exposure does not account for either degree of slope or latitude effects on solar energy received (see Keating et al. 2007). A more refined measure of solar exposure combining aspect, slope, and latitude is the solar radiation index (SRI) of a site. SRI values are constrained to a domain of $-1 \leq SRI \leq 1$, with sites with an SRI of -1 receiving minimal amounts of solar radiation and those with an SRI value of 1 receiving large amounts. Keating et al. (2007) found bighorn sheep selecting for winter habitats with median SRI values of 0.61 ranging from approximately 0.19 to 1. Beyer (2008) found core bighorn sheep summer habitats had mean SRI values of 0.65, and core bighorn sheep winter habitats had mean SRI values of 0.71.

An SRI map of an area quantifies solar exposure, but further analysis is needed to account for seasonal differences in bighorn sheep use of sites with different exposures. The Spatial Analyst toolbox of ArcGIS 10.7.1 (Esri 2020b) provides software called the Area Solar Radiation (ASR) tool that calculates site solar exposure within specified dates within the year. Based on literature that breaks the year into bighorn sheep life-history periods (Shannon et al. 1975) and typical dates for these periods relevant to the Refuge herd (Van Dyke 1978), we modeled ASR values within identified bighorn sheep habitats on the Refuge based on the following periods and dates:

- Spring lambing (April 1–June 15)
- Summer lamb-rearing/post-lambing (June 16–August 31)
- Fall pre-rut drift (September 1–October 31)
- Early winter rut/post-rut (November 1–December 31)
- Late winter pre-lambing (January 1–March 31)

Currently these data products are descriptive in nature and potentially useful for developing, evaluating, and prioritizing habitat assessment units identified using other metrics. Predictive use of both SRI and ASR data will likely take several years of tracking location histories to be able to detect statistically significant seasonal patterns in site selection by bighorn sheep.

Water Use. Bighorn sheep are typically able to go for extended periods (up to 5 days or longer) without the need to intake free water, instead relying on metabolic processes (e.g., oxidative metabolism) and preformed moisture in forage sources (Van Dyke et al. 1983; Shackleton et al. 1999; Dicus 2002). Despite these adaptations, bighorn sheep still need sources of fresh water to survive. These sources can include springs and seeps, streams and spring brooks, marshes, ponds and lakes, reservoirs, dugouts, impoundments, and guzzlers (see Section 3.2.3) (Smith et al. 1991; Payer 1992; Dolan 2006). These sources can also include dew, snow/ice, pooled precipitation, and other ephemeral sources (McCann 1956; Kornet 1978; Van Dyke 1978). Alkaline water sources are not believed to be suitable for bighorn sheep, though the degree of alkalinity that would render water unsuitable is not well known (Jones et al. 1957, as cited in Van Dyke et al. 1983; Broyles 1995; Rosenstock et al. 1999; Rosenstock et al. 2005; Simpson et al. 2011; others).

Specifics about bighorn sheep water use and need are not well understood or documented, though are believed to be tied to sex, age, reproductive status, body condition, forage condition, season, and weather (Turner and Weaver 1980; Van Dyke et al. 1983; Shackleton et al. 1999; others). As animals are subjected to greater stressors (such as reproduction, dry conditions, and thermal extremes) they generally require greater amounts of water. Water is most often included in bighorn sheep habitat models as a function of distance and distribution of available fresh water source(s) from escape terrain. Van Dyke et al. (1983) identified that bighorn sheep spend most of their time within 1 mile of free water within their utilized habitats, and that water sources were within 2 miles of escape terrain. This 2-mile general water limit has been supported by Ebert (1993), Dunn (1996), Sweanor et al. (1996), Demarchi et al. (2000), Johnson and Swift (2000), and many others in their models of bighorn sheep habitat. Under certain conditions, ewes may range further for water, but the general ewe water limit (generally, the maximum distance between escape terrain and a water source) for our habitat analyses is 2 miles.

Many of these authors describe this general water limit based on ewe usage, but Andrew (1994) found no difference in water limits between ewes and rams. Payer (1992) observed bighorn sheep rams on the Refuge using water sources 4.35 miles from escape terrain on Poker Jim Ridge, where water is extremely limited, to reaches of Rock Creek between Morgan Drift Road and Flook Knoll in mid-summer, and then shifting to Petroglyph Lake in late summer when the creek dried up. Based on Payer’s observations on the Refuge, we adopted 4.35 miles as the ram water limit for our habitat analyses.

Bighorn sheep ewes with lambs are also known to limit the areas and habitats they are willing to use to include water sources (Van Dyke et al. 1983; Brundige and McCabe 1986; Festa-Bianchet 1988). In their model of bighorn sheep habitat, Smith et al. (1991) identified that habitats beyond 0.62 mile from water were not suitable for lambing. Sweanor et al. (1996), Zeigenfuss et al. (2000), Forbes (2001), and others all reinforced the use of this limit for lambing periods. We adopted 0.62 mile from escape terrain as the lambing water limit for our habitat analyses.

Observations of bighorn sheep on the Refuge reported by Kornet (1978) indicated that bighorn sheep drank from creeks and springs, and from patches of snow and puddles in boulders as conditions allowed, on North and South Mountains. Willow Creek was identified as the primary water source on North Mountain. Water was a limited resource on Poker Jim Ridge, and its availability affected sheep distribution there, whereas water was not limited on Hart Mountain (Payer 1992). In his study, bighorn sheep were not observed drinking within the Poker Jim Ridge area due to very limited water sources; however, seeps were reported as being available "flowing from the cliffs" during months when there was precipitation. In 1985, Cottam reported above-normal winter precipitation on North and South Mountains, providing ample water in spring and summer under those conditions during his study in that area; however, Poker Jim Ridge did not receive as much snow, and bighorn sheep used temporary pools from spring and summer rains on Poker Jim Ridge, where perennial sources do not exist. Payer (1992) suggested ewes left Poker Jim Ridge by summer due to lack of water and likely headed for North Mountain, where he identified the numerous springs and spring brooks (called "creeks" by Payer) below the cliffs as bighorn sheep water sources. Other than Rock Creek and Petroglyph Lake, Payer (1992) did not report bighorn sheep use of any other water sources on Poker Jim Ridge and suggested that water availability exerted a major influence on the seasonal distribution of bighorn rams. Refuge staff observations of Rock Creek within the last 5 years noted that the creek was intermittent and contained little, if any, water by early summer in the reaches described by Cottam in 1985 and Payer in 1992.

Lambing Areas. Bighorn sheep ewes typically group together with other ewes and juvenile males during most of the year. Just prior to parturition (from a few hours to several days prior), individual pregnant ewes will leave their group and typically move to very steep, rugged, secluded areas to give birth to their young (Geist 1971). Pregnant ewes may travel several miles from their group to give birth (Van Dyke et al. 1983). They will typically remain isolated with their newborn for the first 5 to 7 days, after which they will return to rejoin their group with their lamb; this period of isolation likely serves as both an antipredator strategy and to form the mother-young bond, which is critical in "follower" species (where the young follow their mothers rather than hiding) such as bighorn sheep (Geist 1971; Shackleton et al. 1999). These ewe-lamb groups will localize in specific ranges typified by being larger areas of generally steeper, more rugged terrain, even more so than what they use during the rest of the year (Van Dyke et al. 1983). They will remain in these lambing areas for at least 1 to 2 months before expanding into adjoining, less rugged habitats (Shackleton et al. 1999). Lambing areas are often traditional for bighorn sheep, though their use may be modified in response to environmental conditions, such as lingering deep snow or insufficient forage or water (i.e., drought conditions; Van Dyke et al. 1983).

Very little is known about specific parturition sites on the Refuge; however, Kornet (1978) and Cottam (1985) identified lambing areas on the north end of North Mountain and along the Poker Jim Ridge escarpment (Figure H-10 and H-11). Cottam (1985) also identified a lambing area on the southwest end of South Mountain. Additional lambing areas were identified, and refinements of the known areas were made to better define areas and to identify core nursery areas using location data from the annual aerial surveys (see Section 3.3.1.3). Two additional areas were identified on Poker Jim Ridge, and refinements were made to the North and South Mountain areas using these survey data. Areas of the greatest lamb and/or ewe-lamb presence were considered core nursery areas for bighorn sheep on the Refuge (Figure C-4); some ewe-lamb use of closely adjacent habitats around these areas is not fully understood. Additionally, specific patterns of use within and between these lambing areas is not known, though it is believed that ewes and lambs move between the core areas on Poker Jim Ridge and North Mountain rather than these representing truly separate lambing grounds; however, the South Mountain core nursery area is believed to truly be separate from the northern areas (i.e., no cross-over with the other areas is believed to occur). The lambing season on the Hart Mountain NAR typically runs from late April through late May, though it can vary with weather and environmental conditions (Kornet 1978; Cottam 1985; Payer 1992).

3.3.1.6 HERD RANGE

The total area encompassing all bighorn sheep movements on and off the Refuge is the actual herd range, but the portion within the Refuge represents the habitat modeling and management area under Service jurisdiction and is considered in this EIS as the bighorn sheep range. The proposed Bighorn Sheep-Cougar Management Zone (see Figure 2.2) extends from the entire western boundary of the Refuge eastward to include the slopes and top of the escarpment and continues to existing north-south roads that serve as precise administrative landmarks for the eastern boundary of this management zone. The area designated as Refuge bighorn sheep habitat for modeling purposes, consisting of core and water limit habitats (see Figure C-11), is within the proposed Bighorn Sheep-Cougar Management Zone and totals approximately 136,173 acres. Escape terrain and forage terrain within this Refuge habitat is considered core bighorn sheep habitat and totals approximately 31,517 acres (Table 3.5).

Table 3.5. Acres of Bighorn Sheep Habitat Ranges and Management Zones within Hart Mountain National Antelope Refuge

Range or Zone	Descriptive	Acres
Hart Mountain NAR	Lands encompassed within the outer perimeter of the Refuge, including private inholdings (i.e., irrespective of ownership)	280,409
	Lands within the outer perimeter owned (managed) by the Service, not including private inholdings	277,914
Proposed Bighorn Sheep-Cougar Management Zone	Administratively determined and bounded area for managing bighorn sheep and cougar populations	101,669
Bighorn Sheep Habitat Extent	Bighorn sheep habitats identified as escape terrain plus water limits	136,175
Core bighorn sheep habitat	Combined bighorn sheep escape and forage terrains	31,517
Escape terrain	Areas with slopes >27° and <85°, with an area >1.7 acres, and VRM ≥0.003	12,730
Forage terrain	Lands within 985 feet of escape terrain, or within 1,640 feet where escape terrain is separated by ≤500 m of suitable habitat	18,787
Lambing water limit	Lands within 0.62 mile of escape terrain	34,179
General ewe water limit	Lands within 2 miles of escape terrain	68,477
Ram water limit	Lands within 4.35 miles of escape terrain	123,445
Core nursery areas	Areas of the greatest observed lamb and ewe-lamb presence with identified lambing grounds	4,312

During the peak bighorn sheep population in the 1980s, bighorn sheep were observed north and south of the Refuge, and at least one nursery group was using the South Mountain area (see Figure C-4). In recent years most observations and bighorn sheep collar data confirm that Poker Jim Ridge and North Hart Mountain are the center of bighorn sheep activity, indicating a significant retraction of the herd range coinciding with (and possibly corresponding to) the lower population size.

3.3.1.7 IMMIGRATION AND EMIGRATION

Geist (1971) suggested that bighorn sheep likely migrated to new suitable habitat pre-European settlement. Bighorn sheep establish traditional ranges from which adults rarely wander, although yearlings may migrate to encounter new suitable habitat that is not part of an established range if routes exist (Cottam 1985); however, post-European settlement activities of man have likely blocked potential dispersal routes, isolating many bighorn sheep ranges. Kornet, (1978), Cottam (1985), and Payer and Coblentz (1997) did not document bighorn sheep migrating off the Refuge and only observed seasonal elevation movement within the Refuge. Payer and Coblentz (1997) observed no distinct migration, but rather a gradual expansion into contiguous areas within the Refuge in response to forage and water availability. Foster and Whittaker (2010) tracked 44 collared bighorn sheep on the Refuge and did not document collared sheep emigrating from the Refuge, and they never documented unexpected bighorn sheep population growth (immigration) prior to or during the study period. In 2019, several younger GPS-collared rams were documented to migrate from Poker Jim Ridge to Mule Springs Valley, north of the Refuge, but they returned a short time later and spent the remaining time on the Refuge. ODFW has not documented previously unaccounted-for bighorn sheep populations near or around the Refuge during annual aerial surveys, which suggests that bighorn sheep on the Refuge are not emigrating.

3.3.1.8 OTHER BIGHORN SHEEP HERDS NEAR HART MOUNTAIN

According to ODFW, all other bighorn sheep herds in Lake and Harney Counties, Oregon, are stable to slightly increasing in population. Bighorn sheep herds at the Steens Mountain Big Game Unit and the Warner Big Game Unit have experienced increases corresponding to cougar removal programs that were initiated to benefit mule deer (unpublished ODFW data 2021).

According to the Nevada Division of Wildlife, Sheldon National Wildlife Refuge (Sheldon National Wildlife Refuge is defined as Unit 33 and is part of a larger bighorn sheep herd within the area) bighorn sheep population has been on a stable to slightly increasing trend over the past several years. Observed lamb ratios have averaged 39 lambs to 100 ewes between 2015 and 2019. Sample sizes obtained during these late summer aerial surveys have remained consistent with the numbers of animals classified ranging from 62 to 83 animals between 2015 and 2019.

3.3.1.9 REPRODUCTION AND SEXUAL BEHAVIOR

Bighorn sheep are relatively long-lived animals; those that survive their first year commonly live 10 to 12 years. Bighorn sheep are gregarious and live in herds that vary in size, depending on habitat availability, and often break into groups depending on season and gender. During most of the year bighorn sheep segregate into bachelor groups of adult males, and mixed groups of females, juvenile rams, and lambs, but these groups can spatially and temporally overlap.

Bighorns are polygynous with a few older dominant rams doing most of the breeding. Ewes and rams are sexually mature at 18 months, although females usually do not breed until they are 3 years old. Bighorn sheep generally breed during October to November and lamb from April to May. Gestation is approximately 180 days and a single lamb is usually born (twins are very rare). Ewes remain reproductively active throughout their life span but are in their prime from ages 3 to 10. The sex ratio of lambs at birth is believed to be 1 to 1 because there are no data to indicate otherwise (McCarty and Miller 1998).

3.3.1.10 VITAL RATES

As stated in Section 1.3, an estimate of bighorn sheep population size alone is an insufficient basis for management goals or objectives. There are several reasons for this:

1. The minimum viable population on the Refuge is dependent on many environmental variables and not a fixed number.
2. The actual population at any given time is difficult to measure accurately.
3. Understanding the demographic factors that are primarily influencing population size cannot be inferred from size alone. Environmental stressors and management actions directly affect population vital rates (e.g., changes over time of birth rate and annual survival rate), which then determine the population size and population trend.
4. Vital rates are usually changed immediately by their causes, whereas the population response may take considerable time to manifest and detect.

Vital rates provide valuable information, but there is still some uncertainty built into conclusions drawn from them. Using 3-year averages of vital rates compensates to some degree for annual variability. Uncertainty is further reduced when multiple vital rates are monitored simultaneously, each contributing unique information that can be combined for a more holistic view of the population status (Galliard et al. 1998). During aerial surveys, observations of lambs, ewes, and rams recorded by age class are noted. The observation data provide a lamb to ewe ratio, ram to ewe ratio, and population growth rate (Figure 3.4). Vital rates the Service is proposing to monitor and assess consist of the following:

1. *Population annual growth rate*. Each year, the population is sampled through a survey with a systematic and consistent protocol to produce an observed count. The observed sample count is then adjusted with a 0.79 detectability rate to produce an estimated population. The growth rate is expressed as a multiplier quantifying the change in the estimated population from one year to the next. For example, if the population this year is estimated to be 20% greater than last year, the

growth rate is 1.2. By definition, any growth rate >1 indicates a growing population, a rate of <1 indicates a declining population, and a rate of 1.0 is stable. The trend of the population is indicated by averaging the annual growth rate over multiple consecutive years. The accuracy of the calculated growth rate is dependent on how closely the annual population sample represents the actual population size.

2. *Annual adult survival*. This is a number that indicates the probability that an adult bighorn sheep of known age (cohort) will survive to the next year, based on a sample of the cohort consisting of collared individuals that are tracked through their lives. For example, if eight out of 10 1-year-old collared ewes survive to their second year, their annual survival probability is estimated to be 0.8. If there are insufficient collared sheep in a cohort to be representative of that cohort, the adult survival rate can be calculated by grouping all adult sheep within a certain age range to obtain a statistically significant sample. Because bighorn sheep are generally long-lived and have multiple opportunities to breed, a reduction in adult survival has a disproportionately greater effect on population growth than a similar reduction of lamb survival (Galliard et al. 1998).
3. *Lamb to adult ratio at recruitment age*. This demographic metric provides a quantifiable measure of the number of lambs on the landscape relative to the number of adults. This number is estimated based on the observed number of lambs and adults counted during the spring aerial survey, just before the previous year's lambs are recruited as yearlings into the population. Under typical overall adult survival probabilities of 0.8, multiple studies have shown that lamb to adult ratios averaging at or above 30 to 100 are adequate to maintain a population. Recruitment can vary greatly from year to year due to many factors, but a population can only grow (assuming no immigration) if lamb production on average exceeds the overall mortality (the inverse of survivability) over a given time period, such as the average lifespan of herd members.

These three vital rates taken together are sufficient to indicate whether the population is responding to management actions as intended. The addition of an estimate or index of population size (e.g., 170 observed animals averaged for 3 consecutive years) that can serve as a management action threshold would establish the minimum necessary for the population to achieve sustainability over a long period of time, ensure management actions are not prematurely ended, and validate strategies taken to improve population performance measures are sufficiently met.

As stated in 2.3.3.1, using all three population performance measures and management action threshold as decision criteria verifies the condition of the bighorn sheep population and prevents premature and repeatedly starting or stopping cougar control. Cougar control will not be suspended until all bighorn sheep population performance and management action threshold criteria are met, signifying the population is reaching sustainable levels and is resilient to normal environmental conditions. Conversely, cougar control will only be initiated if all population performance measures and management action threshold fall below performance criteria indicating the bighorn sheep population is trending toward unsustainable levels.

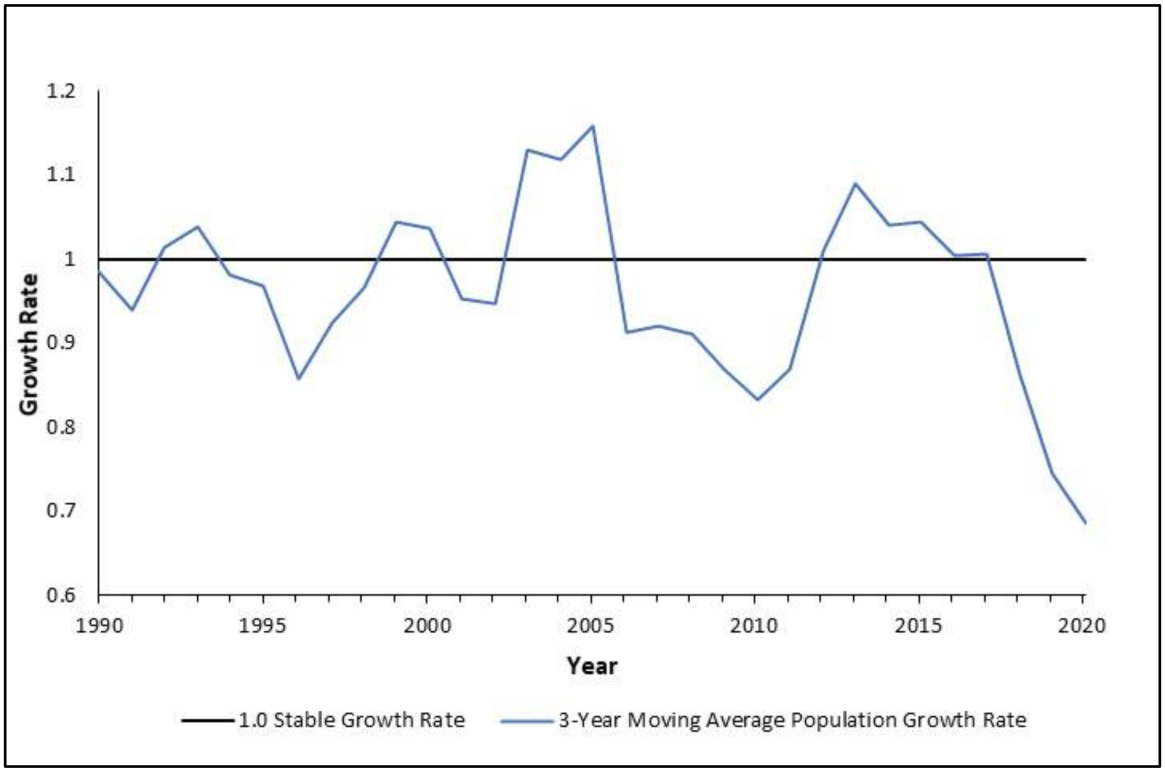

Figure 3.4. Bighorn sheep 3-year moving average population growth rate ($N_t + 1/N_t$) from 1990–2020, Hart Mountain National Antelope Refuge.

3.3.1.11 ADULT SURVIVAL ON THE REFUGE

Kornet (1978), Cottam (1985), Payer (1992), and Payer and Coblentz (1997) documented hunting as the only cause of bighorn sheep mortalities on the Refuge during their bighorn sheep studies. Payer (1992) reported that of 21 collared rams followed for 31 months on the Refuge, only four mortalities occurred, and all were the result of hunter harvest. This suggests that adult rams experienced low natural mortality rates from studies conducted from 1978 to 1992 and that hunting at this time was the most significant mortality factor. Payer states that the population had remained stable from 1982 through 1992 at approximately 300 sheep, largely due to the annual removal of ewes, lambs, and yearlings for transplants to other locations, and ram harvests. These removals helped maintain high productivity and possibly prevented overuse of the range.

Foster and Whittaker (2010) reported that adult survival rates on their radio-collar study of 44 adult bighorn sheep on the Refuge averaged 0.832 and 0.897 over 4 years for adult males and adult females, respectively. Annual survival varied more for males (0.636–1.00) than for females (0.880–0.930). Cougar predation or probable cougar predation accounted for 63.2% of all mortalities, indicating a shift in the primary source of mortality as compared to previous time spans.

Ten of the 19 bighorn sheep collared in January 2019 on the Refuge have died. One individual died within 2 weeks of capture, indicating that capture myopathy likely contributed to death. One collared ram was harvested by a hunter during the last year of the State-authorized hunting season, and one collared animal was not recovered after mortality due to terrain limitations. All other mortality is attributed to cougar predation (70% of all mortalities).

3.3.1.12 BIRTH RATE

The Refuge and ODFW staffs have historically tracked bighorn sheep reproduction on the Refuge using ratios of lambs to 100 ewes observed during early summer surveys as a surrogate for birth rate and early lamb survival (Figure 3.5). More recently, bighorn sheep researchers have preferred using a ratio of lambs to 100 adults rather than focusing on ewes because, even though bighorn sheep are a polygynous species with dominant rams responsible for the majority of inseminations, the overall number and age structure of rams affects the pregnancy and birth rate. The Refuge data (see Figure 3.5) show high annual variability in the number of early summer lambs, which is typical for bighorn sheep (Cain III et al. 2019) because ewe fertility, lamb birth weight, and lamb survival to adulthood are all highly sensitive to any environmental or physiological stress experienced by the ewes. For example, drought that reduces adult forage quality and availability will result in lower lamb production and survival the following spring. In Figure 3.5, note the high annual variability and lack of correlation between the numbers of ewes or lambs and the lambs to 100 ewes ratio while the lambs to 100 ewes ratio has remained relatively stable.

On average, recruitment must be high enough to replace total population mortality over a given time to maintain the population, and higher to result in population growth. Under typical overall adult survival probabilities of 0.8, multiple studies have shown lamb to adult ratios averaging at or above 30 to 100 are adequate to maintain a population; however, lower values of either vital rate could precipitate a population decline if the other rate does not rise to compensate.

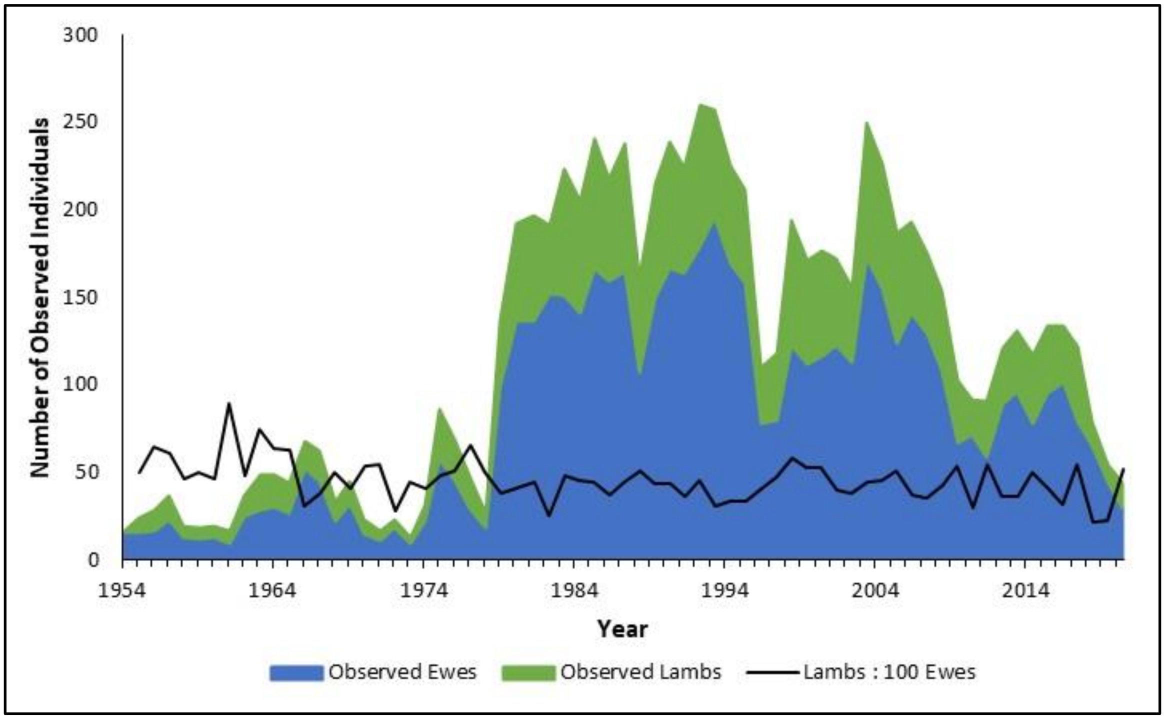

Figure 3.5. Counts of ewes and lambs observed during annual surveys, and the ratio of lambs to 100 ewes since bighorn sheep reintroduction, Hart Mountain National Antelope Refuge.

3.3.1.13 DISEASE

Disease has played an important role in the dynamics of bighorn sheep populations and has been responsible for numerous declines throughout North America (Heinse et al. 2016; Cassirer et al. 2017). Disease was a primary factor in the decline and extirpation of bighorn sheep across much of their historical range through the early- to mid-1900s and continues to affect numbers and distribution. Incidences of pneumonia-related population crashes have been repeatedly associated with the presence of domestic sheep and goats (Alaska Chapter of the Wildlife Society 2015, George et al. 2008, Wehausen et al. 2011). Wild sheep are susceptible to a variety of diseases and parasites that can affect herd viability.

Respiratory infections that result in pneumonia are the most significant health issues experienced by bighorn sheep populations, and many bighorn sheep populations have endured all-age pneumonia die-offs. Pneumonia in bighorn sheep is a microbiologically complex disease, and many diverse bacteria are detected in the lungs of fatally affected animals (Cassirer et al. 2018). *M. ovi* is a primary agent in the etiology of epizootic bighorn sheep pneumonia in populations across the United States, and it acts to induce secondary infection with opportunistic pathogens (Besser et al. 2012). *M. ovi* is a bacterium known to be associated with acute pneumonia that has heavily affected bighorn sheep herds. Bighorn sheep pneumonia complex has caused serious mortality events over many decades and in some areas has significantly limited population size and resilience. Transmission often occurs initially from domestic sheep or goats passing the disease to native wild populations. Domestic species do not show clinical signs of disease but can infect susceptible bighorn sheep herds and result in significant all-age die-offs, including up to 100% lamb mortality. Although pneumonia is often fatal, some individuals survive to become chronic carriers repeatedly transmitting disease to lambs, causing poor lamb survival for years. Clinical signs can include nasal discharge, coughing, respiratory distress, exercise intolerance, and general depression. Currently there is no vaccination or treatment for bighorn sheep pneumonia and no evidence that pneumonia can be transmitted to or cause disease in humans. Managers have been unable to stop pneumonia die-offs once they begin, so prevention by avoiding contact with domestic livestock is paramount.

During the 2018 annual early summer bighorn sheep aerial survey, observers noticed unusually low lamb to ewe ratios, and many lambs were smaller than usual, raising concerns about the health of the herd (Refuge files). A second flight survey was conducted to confirm the previous observations. The Service, in coordination with ODFW, visually evaluated each individual for evidence of respiratory stress, e.g., panting, tongue protruding, and inability to keep up with the rest of the band. Consistent with the first survey, they found small lambs and six ewes that exhibited respiratory stress. ODFW staff then collected and transported one adult ewe exhibiting respiratory stress to a Corvallis, Oregon, lab for further disease testing. The ewe tested negative for *M. ovi* but did have a lungworm infection (ubiquitous in bighorn sheep populations) with focal nodules of that parasite that caused some isolated occurrences of pneumonia within one lung lobe, explaining the observed respiratory stress.

Tissue samples from 21 bighorn sheep were collected during the January 2019 capture and collar project and screened at the State Wildlife Health and Population Laboratory. The subsequent report concluded that there were no dramatic health findings; specifically, no evidence of present or past occurrences of *M. ovi* infection. USGS then conducted a peer review of the findings and concurred "it is clear based on the evidence presented and follow-up conversations we have had with managers at Hart Mountain National Wildlife Refuge and Oregon Department of Fish and Wildlife that the Hart Mountain bighorn sheep herd has been declining for several decades and much more rapidly in the last few years. Based on our evaluation of the data, there does not appear to be a clear association of this decline with respiratory disease or other common diseases observed in this species" (USGS 2020). Health screening letters, reports, and summary are presented in Appendix I.

The risk of disease transmission from domestic sheep and goats to bighorn sheep on the Refuge is considered low because there are no sheep grazing allotments adjacent to the Refuge and few opportunities for contact with wild sheep. In addition, llamas and goats (packing) are not an authorized use on the Refuge. Current ODFW and Refuge protocols for responding to a potential or known contact between bighorn sheep and domestic stock are detailed in Section 2.3.1.

3.3.1.14 PREDATION

The influence of predation on the population dynamics of bighorn sheep can be beneficial from a management perspective through regulation of numbers or natural selection of healthy or sick individuals. Large predators may suppress ungulate population growth, but they may also suppress the abundance of smaller predators that prey on neonatal ungulates (Prugh and Arthur 2015). Cougar predation can impede reintroduction or recovery efforts, reduce numbers below viable population levels under certain conditions, and lead to localized extirpations.

Nearly all predators that are sympatric (occurring in the same area) with bighorn sheep have been documented to prey on them, ranging in size from gray fox (*Urocyon cinereoargenteus*) to grizzly bear (*Ursus arctos horribilis*) (Sawyer and Lindzey 2002). On the Refuge, bobcats (*Lynx rufus*), coyotes (*Canis latrans*), American badgers (*Taxidea taxus*), and golden eagles are possible sympatric bighorn sheep predators (most likely on lambs).

Cougar predation (Wehausen 1996; Ross et al. 1997; Hayes et al. 2000; Kamler et al. 2002) and disease (Singer et al. 2000) have been identified as the most common factors limiting native and reintroduced bighorn sheep populations. Cougar predation has been documented to be a substantial source of mortality to bighorn sheep populations (Logan and Sweanor 2001; Sawyer and Lindzey 2002; Rominger 2018). Rominger (2018) points out that, although many predators kill bighorn sheep, only cougars are currently considered to be the primary proximate cause of mortality for many bighorn sheep populations. One or a few cougars can have a potentially large influence on bighorn sheep population dynamics, even if bighorn sheep are a relatively small proportion of their prey (Longshore 2017). Cougar predation can be periodic, can be viewed as a stochastic influence because it can greatly depress annual adult survivorship, and can act as a population destabilizing factor because it can overpower the influences of other factors on bighorn sheep population dynamics and cause rapid population declines (Longshore 2017).

Following the cessation of more than 70 years of intensive predator control in the United States, cougars have increased numerically and in distribution and have resulted in unsustainable cougar-bighorn sheep ratios (Fecske et al. 2011; Knopff et al. 2014). A density of 1 to 3 cougars per 38 square miles (approximately 24,000 acres; 0.03–0.08 cougar per square mile) when coupled with a standard ungulate kill rate of 1 ungulate per week (Wilckens et al. 2016), may have a profound influence on ungulate population dynamics. On Hart Mountain NAR in 2019 to 2020, cougar hair snares and camera traps indicated that 12 to 16 cougars were using 48 square miles (31,000 acres; 0.25 to 0.33 cougar per square mile) of Refuge bighorn sheep habitat (Refuge data), indicating the density of cougars using the Refuge could have a significant influence on the bighorn sheep population. The Service and ODFW believe cougar density on the Refuge is high enough to have a population-limiting effect by influencing bighorn sheep population dynamics.

Prey populations that may initially decline due to factors such as habitat loss or degradation, overexploitation, or disease, may become vulnerable to predators subsidized by other prey (Johnson et al. 2013. Cougars that largely depend on mule deer but take bighorn sheep opportunistically are examples of this. Cougar predation on bighorn sheep is likely to have the greatest effect in areas where bighorn sheep and mule deer are sympatric and increased cougar predation is typically associated with declines in mule deer populations (Hayes et al. 2000; Schaefer et al. 2000; Rominger et al. 2004; Rominger 2018), which are the primary prey of cougars where they occur (Iriarte et al. 1990). Such cases can lead to either the extirpation of a secondary prey population or trap them in a “predator pit” where low numbers of prey remain but cannot increase under the predation pressure (Messeier 1994; Sinclair et al. 1998). Cougar predation is especially impactful when bighorn sheep density is low (Boyer et al. 2014) and individual cougars become bighorn sheep specialists (Ross et al. 1997; Ernest et al. 2002; Festa-Bianchet et al. 2006). Based on the observed data, the Service and ODFW believe this is the case for the Refuge bighorn sheep herd.

Survival models that incorporate data from radio-collared bighorn sheep can calculate cause-specific mortality rates (Heisey and Fuller 1985; White and Burnham 1999). Cougar-specific mortality rates of bighorn sheep in the United States have been as high as 0.26 (Hayes et al. 2000) and 0.31 (Goldstein and Rominger 2012). Statewide cougar-specific mortality rates for desert bighorn sheep in New Mexico were 0.16 (Goldstein and Rominger 2012) and 88% of the desert bighorn sheep populations went extinct. Equivalent cause-specific mortality rate due to cougar for radio-collared bighorn sheep during the Foster and Whittaker (2010) study on Hart Mountain were 0.11 for males and 0.7 for females (Whittaker, personal communication). These rates are lower than reported by Goldstein and Rominger (2012), but given that habitat conditions have declined for bighorn sheep, alternative prey populations (mule deer) have declined, and cougar populations have remained stable or have increased during the same timeframe, these cougar-specific mortality rates may represent additive mortality on the population.

Cause-specific mortality rates for adult female bighorn sheep from cougar predation in the Peloncillo Mountains, Arizona, was 0.22 during periods without management removal of cougars and declined to 0.05 during periods with an active cougar removal program (Goldstein and Rominger 2012). Following the initiation of cougar control in desert bighorn sheep ranges in New Mexico in 1999, bighorn sheep numbers increased from less than 170 to over 1,100 by 2016 (Ruhl and Rominger 2015). From his synthesis of bighorn sheep predation research, Rominger (2018) concluded that control of cougars, when cougar-ungulate ratios are high, might be required to protect small bighorn sheep populations.

Between January 2019 and January 2021, 10 of 19 bighorn sheep collared in January 2019 on the Refuge have died, and the sources of mortality are summarized in Table 3.6. The "Unknown" cause of mortality is a result of not determining the cause of death due to the animal's location on an inaccessible cliff on Poker Jim Ridge (Figures H-12 and H-13).

Table 3.6. Causes of Death for Collared Adult Bighorn Sheep in 2019 on Hart Mountain National Antelope Refuge

Mortality Cause	Number of Mortality Events	Percent of Mortality Events
Cougar predation	7	70%
Capture myopathy	1	10%
Hunter harvest	1	10%
Unknown	1	10%

Kornet (1978), Cottam (1985), Payer (1992), and Payer and Coblentz (1997) did not observe any cases of predation during bighorn sheep studies on the Refuge. Foster et al. (2008) followed 44 radio-collared bighorn sheep from 2004 to 2007 and found that cougar predation or probable cougar predation accounted for 63.2% of all mortalities. Refuge studies that span from 1978 to 1993 (see Kornet 1978, Cottam 1985, Payer 1992, Payer and Coblentz 1997) indicate that cougar predation on bighorn sheep was nonexistent or too low to detect but was found to be the major single source of known bighorn sheep mortalities in the more recent studies occurring in 2004 to 2008 and 2019 to 2020. Cougar camera traps survey results indicate that densities of cougars inhabiting Refuge sheep habitat are high enough to significantly affect bighorn sheep population dynamics and have likely led to the bighorn sheep decline. Declines in bighorn sheep populations due to cougar predation have been reported for nearly every state where this species occurs, and there is little evidence that bighorn sheep populations recover in the absence of predator control (Rominger 2018).

3.3.1.15 HUNTING

Bighorn sheep hunting tag numbers for the Refuge are set by ODFW based the number of high quality rams estimated to be in the herd (≥30 rams to 100 ewes for 3 consecutive years and >30% of observed rams are Class III or IV) and are not to exceed the number that could be removed without adding uncompensated mortality. ODFW started issuing bighorn sheep tags on Hart Mountain in 1965 and the number of tags issued has ranged from three to a high of 40, which occurred in 1995. Bighorn sheep hunting was suspended for the 2020 season due to the low population.

3.3.1.16 ACCIDENT AND STOCHASTIC EVENTS

One disadvantage of bighorn sheep spending a large portion of their lives in steep terrain is the possibility of injury or death from falls and avalanches or rock falls, and these accidents are not uncommon. Lambs and fighting rams during rut are particularly vulnerable to injury from falls. Fighting rams can also inflict serious injury on each other. Although accidents may occur, the frequency or prevalence of accidents within the Refuge herd is unknown. Stochastic events such as severe storms and fire may result in direct or indirect mortality, and drought can result in malnutrition, starvation, or increased vulnerability to predation and disease. The Refuge does not have evidence to suggest that such events occur with regularity. In September 2019, the Poker Fire burned over 22,000 acres, with much of the event occurring in bighorn sheep habitat on Poker Jim Ridge. There was no indication of direct bighorn sheep mortality from the fire, but the fire did reduce available forage throughout winter until spring when new growth became available. The fire also destroyed significant acreage of sagebrush (both low and big species), as well as a large area of juniper. Sublethal effects of the fire are evolving, such as making fire-impacted shrubs and trees more susceptible to stressors (e.g., drought), leading to continued losses.

3.3.1.17 SELENIUM DEFICIENCY

Soils typical of the North Great Basin are known to be particularly low in Se, an important trace mineral that is taken up by plants and transferred to animals consuming them. Symptoms of mild Se deficiency in domestic sheep include poor reproductive success and reduced immune response that can contribute to susceptibility to pneumonia. Severe Se deficiency can cause nutritional muscular dystrophy or "white muscle disease" as well as sudden death (Rosen et al. 2009). This has raised concern that Se availability may be a limiting factor for bighorn sheep health in at least some situations and led to recommendations that managers should consider provisioning mineral blocks containing Se to improve herd health; however, trace mineral standards have not been well established for bighorn sheep, so determining deficiencies or toxicities of trace minerals are commonly made based on the standards for domestic sheep (Rosen et al. 2009).

When compared to livestock standards, the levels of Se in wildlife and wildlife forage have often been reported as deficient; however, research into the effects of low Se in bighorn sheep has been mixed and inconclusive. In Nevada, Cox (2006) studied whether mineral deficiencies prevented herd growth and found that providing mineral blocks did not significantly affect lamb to ewe ratios. Cox concludes that if the management goal is to prevent major declines rather than to produce population increases, then mineral supplementation may be rational, and that Se is certainly not a "silver bullet" or even "insurance" to guard against epizootics or other health-related risks to a herd.

Bighorn sheep were once widespread and abundant in regions with endemic low levels of Se, and it is reasonable to assume that they have adaptations that make them less vulnerable to endemic mineral deficiencies. Refuge herd health screening in 2019 (see Appendix I) reported that nine of 21 samples were Se deficient by livestock standards, but there is little evidence to suggest Se deficiency is related to the recent population decline. Relatively high recruitment rates in the last decade, and the low incidence of capture myopathy during collaring efforts indicate that Se deficiency does not appear to be affecting the Refuge herd.

3.3.1.18 GENETICS

The distribution of bighorn sheep is naturally fragmented due to their specific habitat requirements, inhibiting sufficient gene flow that can prevent genetic isolation and counteract potential effects of genetic drift (Driscoll et al. 2015) and ultimately lead to inbreeding depression. Johnson et al. (2011) analyzed the relative effects of inbreeding depression on demographic rates of endangered Sierra Nevada bighorn sheep, and found small negative effects of inbreeding depression on fecundity and predicted that negative affects to population growth were possible over the long term; however, the authors also found that adult survival was not affected by inbreeding, and that other survival variables were more likely to have immediate negative effects on populations (Johnson et al. 2011).

The remediation of inbreeding depression may be of lower priority than other possible conservation measures; diminishing the risk of disease, minimizing the effects of predation, and maximizing habitat quality may ultimately be more important than confronting declines in genetic diversity (Cahn et al. 2011; Johnson et al. 2011). Bleich et al. (1996) offered two suggestions for management in the context of developing a long-term strategy for the conservation of bighorn sheep in California: facilitating numerical increases in existing populations by managing habitat for increased carrying capacities, and establishing new populations close to existing populations to aid in the formation of meta-populations. These suggestions would also facilitate the maintenance of genetic diversity and reduce the risk of inbreeding depression in the populations in this study; however, the Refuge bighorn sheep are not known to mix with other herds and are not likely to be part of a meta-population (Muir 2020).

Researchers suggested low genetic variability in the Refuge herd may lead to decreased growth, survival, fertility, and lamb development rate (Whittaker et al. 2004; Olson et al. 2013). To improve genetic variability and potentially the demographic performance of the existing population, the Service collaborated with ODFW in 2012 to release 10 adult ewes on the Refuge captured from a population in the Lower Owyhee River; however, the collars on all those sheep failed within weeks, and it is unknown whether any of these ewes reproduced. The genetic health of the herd will be monitored as part of this management plan.

3.3.2 Cougar Biology and Management (Adapted from Oregon Department of Fish and Wildlife 2017 Cougar Management Plan)

3.3.2.1 RECENT HISTORY AND STATUS IN SOUTHERN OREGON

In Oregon's early history, cougars were characterized as abundant or common throughout most of the forested parts of the state (Bailey 1936). Journals also report that cougars were present in the mountainous portions of southeastern Oregon such as Steens Mountain (Bailey 1936), although they likely occurred at much lower densities. Settlement and burgeoning timber and agricultural industries created conflicts between human interests and cougars. As a result, bounties were placed on cougars as early as 1843 and annual bounties of 200 or more cougars were not uncommon. Bounties and unregulated killing caused cougar numbers to decline markedly from historic levels by the 1930s, and numbers continued to decrease through the late 1960s. Only 27 cougars were submitted in the final bounty year, 1961, and the estimated statewide cougar population in 1960 was approximately 200 animals. There are few reliable data to indicate the status of cougars in the area around the Refuge for the next three decades, but ODFW (2017) modeling indicates cougar densities of approximately 1 per 100 square miles in 1994 tripled by 2006 in Cougar Management Zone F, which includes the Refuge. By 2015, ODFW estimated the cougar population across Oregon at 6,493 individuals (ODFW 2017), a 3,146.5% increase since the 1960s.

3.3.2.2 REFUGE SIGHTINGS

Until very recently, there was no systematic effort to estimate cougar numbers on the Refuge, but there are sporadic reliable reports of sightings starting in 1955 and continuing with at least one sighting per decade through the 1990s.

3.3.2.3 REFUGE HAIR SNARE AND CAMERA TRAP DATA

Cougars are difficult to census due to their large home ranges, low densities, and cryptic nature. Beginning in 2019, Refuge staff randomly distributed camera traps and hair snares in a grid pattern superimposed on bighorn sheep habitat with the goal of gathering data to better understand cougars on the Refuge (see Figure C-5). Photos were examined to identify characteristics of individuals and estimate a minimum number that have been detected (Figures H-14 and H-15). Hair snares were designed to collect samples of DNA that may identify individuals, their relatedness to others, and sex.

In 2019 and 2020, 35 and 43 random photo sampling stations, respectively, were set in the field for approximately 30 days and checked twice a week. On average, 10 to 12 stations were deployed at any given time across the Refuge and were operated May through October in 2019 and late April through September in 2020. Overall, there were 32 cougar visits occurring in 16 different sub-grids in 2019 and 19 cougar visits occurring in 13 different sub-grids in 2020. From these cougar visits, Refuge staff were able to collect 20 hair samples and confidently identify 12 individual cougars based on unique markings from photos and four additional cougars without distinctive markings. The hair samples will be submitted for analysis at a later date.

3.3.2.4 CONSERVATION MANAGEMENT

The 2017 Oregon Cougar Management Plan establishes as ODFW policy the maintenance of a statewide population of cougars that is self-sustaining and assures the widespread existence of the species in Oregon. In addition, ODFW will manage for stable cougar populations that do not fall below 3,000 cougars statewide. Other ODFW conservation objectives include proactively managing cougar-human safety/pet conflicts and cougar-livestock conflicts. Oregon is divided into six cougar management zones that were delineated to include similar habitats, human demographics, land use patterns, prey base, and cougar densities. The Refuge falls within Cougar Management Zone F, which includes much of southeastern Oregon. ODFW identified a minimum cougar population of 300 for Zone F. Big game habitat in this zone consists primarily of sagebrush habitats, which generally support mule deer, pronghorn, and bighorn sheep as a prey base at relatively low densities compared to mixed conifer habitats in other zones; however, there are areas within Zone F that support more diverse habitats and higher densities of prey, such as the Refuge (ODFW 2017).

3.3.2.5 COUGAR HUNTING

Until 1967, cougars were legally classified as a predator in Oregon and were, therefore, unprotected. Since then, they have been managed as game animals with regulated hunting and provisions for animal damage control and human safety. Currently, cougar tag quotas are set for each zone, tags can be purchased with a hunting license, and the season is open year round. In 1994 the use of hounds for cougar harvest was banned statewide, leaving tracking and calling as legal methods to hunt. This ended the most effective hunting method for cougars and has resulted in increased local populations. Most cougars are now taken by hunters pursuing other prey and opportunistically encountering cougars. Hunter harvest has remained relatively stable for over a decade and average annual statewide harvest was 261 (range 209–309) from 2004 to 2016. Hunter success rates are low with current harvest techniques and range from 1 to 2%.

Zone quotas have been in place since 1995 and quotas currently (2017) exist not as an objective, but rather a mortality cap so cougar populations do not fall below plan objectives. Since the adoption of the 2006 Cougar Plan, all known mortalities (e.g., hunter harvest, damage take, human-safety take, administrative removal, and road killed) count toward zone quotas. If a zone quota is met, that zone is closed to hunting and target area administrative removals for the remainder of the year. Since 1987, 587 cougars have been killed by hunting in Zone F with an average of 32 hunting mortalities per year from 2000 to 2016. An average of four cougars were killed annually by hunting from 1987 to 2000 in Zone F. Public cougar hunting is not authorized within the Refuge.

3.3.2.6 COUGAR HABITAT CHARACTERISTICS

In much of Oregon, cougar habitat selection coincides with the habitat used by their primary prey, mule deer. Forested areas, canyon or rugged mountainous terrain, and areas with high prey populations are preferred, whereas flat, open areas with no cover (grasslands, desert flats) are avoided. This is consistent with Seidensticker et al. (1973) who described optimum cougar habitat suitability in Idaho as a combination of abundant prey and suitable cover for successful stalking. Habitat changes that negatively affect deer and elk (*Cervus canadensis*) populations likely pose the most significant limitation to cougar populations. By retaining important habitat components it is possible to maintain healthy population of both cougars and their prey.

3.3.2.7 COUGAR REPRODUCTION

Females are polyestrous, meaning that their reproductive cycle is continuous until they become pregnant. Consequently, females can bear young at any time of the year (Logan and Sweanor 2001); however, a majority of births have been documented between the warmer months of May through October (Laundré et al. 2007; Jansen and Jenks 2012). Given the gestation length of approximately 90 days, the corresponding pulse in cougar breeding activity would occur during February through July. Cougar cubs are born in a protected nursery located in spaces among boulders, undercut ledges, and dense lateral and overhead vegetation (Logan and Sweanor 2001). Newborn cubs are highly dependent on adults, and at approximately 4 weeks old the cubs are physically able to explore their immediate surroundings. By approximately 6 weeks old, cubs follow their mother to feed on animals she has killed. The energy demands of a mother and cubs are approximately three times that of an adult male and up to six times that of a lone adult female. A female with young must kill a deer-sized ungulate once every 4 days (Ackerman 1982). In a non-hunted population in New Mexico, the greatest cause of mortality for cougar cubs was infanticide and cannibalism by male cougars (Logan and Sweanor 2001).

Factors affecting cougar productivity (number of cubs born each year) include age at first breeding, birth interval, litter size, sex ratio, and longevity. Seidensticker et al. (1973) believed young females usually breed only after establishing a home range. Females have been documented as breeding for the first time at 17 to 24 months of age (Logan and Sweanor 2001).

After first breeding, females normally breed soon after loss or dispersal of their previous litter (Lindzey 1987) causing birth intervals to vary. Birth intervals range between 12 and 24 months (Hornocker 1970; Lindzey 1987; Lindzey et al. 1994; Robinette et al. 1961). Female cougars may have one to six cubs per litter, but average two to three cubs per litter (Eaton and Velander 1977; Ashman et al. 1983; Logan et al.

1986). Based on the examination of 225 reproductive tracts from pregnant female cougars from 1987 to 2016, mean litter size for Oregon was 2.74 cubs per litter. Sex ratio of cubs at birth is normally equal (Johnson and Couch 1954; Logan et al. 1986; Tanner 1975; Logan and Sweanor 2001). Due to a relatively high reproductive potential, cougars can quickly replace individuals lost from the population.

3.3.2.8 COUGAR DENSITY AND DISPERSAL

Cougar density is influenced by a combination of prey distribution and availability (Pierce et al. 2000) and tolerance for other cougars (Seidensticker et al. 1973). Generally, prey availability is related to quantity and quality of available habitat for the species. Due to cougars' territoriality and dependence on prey availability, cougars typically do not reach density levels observed in many other wildlife species. Varieties of techniques have been used to estimate cougar densities throughout their range. The most rigorous methods rely on intensive radio telemetry and capture-recapture (Logan and Sweanor 2001). Cougar research conducted in Oregon has found some of the highest cougar densities in western North America in the northeastern and southwestern portions of the state. The intensity of these efforts, use of multiple proven techniques, and similarity to recent studies lends high confidence to Oregon cougar density estimates.

Based on population modeling (ODFW 2017), cougar population densities (all age classes) in Zone F (including the Refuge) has slightly increased from 1.3 cougars per 38 square miles in 2006 to 1.4 cougars per 38 square miles in 2015 or approximately 0.04 cougars per square mile. This zone has the lowest cougar density in Oregon. On Hart Mountain NAR in 2019 to 2020, a density of 12 to 16 cougars were using 48 square miles of Refuge bighorn sheep habitat or approximately 0.25 to 0.33 cougars per square mile, which is approximately six to nine times higher than the average cougar density in Zone F (Service, unpublished data).

Dispersal is an important adaptive mechanism for cougars for several reasons: it helps local populations avoid extreme inbreeding, enhances outbreeding, minimizes potential competition for food and mates, increases the likelihood of colonizing unoccupied habitats, and minimizes the risk of extinction in isolated populations (Logan and Sweanor 2001). Cougar offspring become independent of the female between 9 to 21 months of age (Beier 1995; Logan et al. 1986; Sweanor et al. 2000; Logan and Sweanor 2001) with littermates usually independent within 0 to 1.5 months of each other (Logan et al. 1986). Male offspring typically disperse at higher rates than females (Sweanor et al. 2000; Logan and Sweanor 2001) and disperse farther than females with reported mean dispersal distances of 1.36 to 47.6 miles for females and 11.8 to 86.87 miles for males (Beier 1995; Sweanor et al. 2000; Logan and Sweanor 2001).

Dispersal direction appears random and large expanses of unsuitable habitat can be crossed (Logan and Sweanor 2001), but favorable habitats are used to link dispersal movements (Logan and Sweanor 2001), and established habitat corridors may be important for isolated populations (Beier 1995). Understanding the connectivity between populations is an important component in the management of cougars, particularly when the species is managed in a meta-population framework where sink populations are dependent on source populations.

Recent exercises in identifying cougar habitat statewide have suggested high continuity between cougar habitats. Habitat connectivity appears to be a major factor for cougar populations in southeastern Oregon where cougar habitat is scattered and less abundant. In that area, connectivity is facilitated by riparian and montane habitats. Because of these dispersal patterns, most males recruited into a population are immigrants, and immigration may constitute as much as 50% of the recruitment into a population (Logan and Sweanor 2001). The cougars on the Refuge are not, therefore, a distinct population isolated from other cougars of the region.

3.3.2.9 ECOLOGICAL ROLE OF COUGARS

Cougars have a key role shaping dynamics in food webs. Direct and indirect predator-prey interactions involving large carnivores have multiple consequences at the ecosystem level (Ordiz et al. 2013). Large carnivores influence their prey and mesocarnivores numerically and through nonlethal behavioral effects (Ordiz et al. 2013). Predation risk affects the population dynamics and habitat use of prey indirectly by forcing individuals to invest in antipredator behavior, thus sacrificing reproduction or foraging efficiency (Ordiz et al. 2013). Cougars' role in ecosystems also includes the relationships between predator behavior, distribution of carcasses, soil nutrients, and potential influences on biodiversity. Cougars prey on a variety of species, and their population may be supported by the total prey base, rather than a single species. For example, if cougars primarily prey on mule deer, and they are relatively abundant, predation pressure on secondary prey, such as bighorn sheep, may be disproportionate to the abundance of sheep and lead to their decline. Many studies, including reports from Wielgus et al. (2013), document cougars depleting the population of a secondary prey while presumably being in equilibrium with the total prey base (i.e., being supported by the primary prey species). In this case, the Service believes cougar predation on the small bighorn sheep population has the potential to result in the extirpation of bighorn sheep on the Refuge, in conflict with the Refuge objective of managing to preserve native biological communities.

Predator-Prey Relationships. Predator-prey studies assess the effects of age-specific survival on population growth and possible interactions between predation, forage availability (i.e., nutrition), and weather (Forrester and Wittmer 2013). Determining if predation, nutrition, weather or other factors are limiting growth of a population is complex. Monteith et al. (2014) summarized that evidence of mortality is often used to justify predator management to increase ungulate (hoofed mammal, e.g., deer, elk, etc.) populations, which underscores the need to correctly interpret the causes and consequences of mortality. Factors limiting growth of ungulate populations are numerous, interacting, and subject to variability (Bishop et al. 2009). Early debates about ungulate populations were based on competing hypotheses of population effects caused by food limitations and predation (Peek 1980). It is now recognized, as the base of knowledge has grown from further research, that food limitations and predation simultaneously affect ungulate population dynamics (Sinclair and Krebs 2002). Further, the interactions between nutrition and predation are likely mediated by weather, habitat, and other forms of mortality (Vucetich et al. 2005; White and Garrott 2005; Wright et al. 2006; Hopcraft et al. 2010; Brodie et al. 2013; Middleton et al. 2013). That being said, predation can affect a prey population only if predation mortality is at least partially additive to mortality from other causes (Fryxell et al. 2014). Multiple studies have identified three conditions that must be met to determine that predators are affecting an ungulate population: 1) the ungulate population is below carrying capacity, 2) mortality is a primary factor influencing change in prey abundance, and 3) predation is the major cause of mortality (Theberge and Gauthier 1985; Hurley et al. 2011; Forrester and Wittmer 2013). ODFW and the Service believe all three conditions are being met on Hart Mountain NAR.

Cougar Predation Effects on Western United States Bighorn Sheep Populations. Bighorn sheep populations are also very susceptible to predation, especially where their populations have reached precariously low numbers (Mooring et al. 2004). Cougars are the primary predator of bighorns, but coyotes and bobcats will also utilize them as a significant food source. Wehausen (1996) reported several instances where cougar predation on bighorn sheep populations reduced population growth rates, resulting in the cessation of the bighorn sheep restoration program into new habitat. Cougars in California were reported to be a threat to the native Sierra Nevada bighorn sheep population directly through predation and indirectly with their presence by keeping bighorn sheep out of critical winter range. These, in part, were factors that lead to a 1999 emergency listing under the Endangered Species Act (64 FR 19300, followed in 2000 by a final listing [65 FR 20]) because the small bighorn sheep population was in danger of extinction. The State determined that the combination of selective cougar control on bighorn sheep winter ranges may have contributed to increased use of formerly-restricted winter range. Kamler et al. (2002) suggested cougar predation was responsible for the decline in bighorn sheep populations in most areas of Arizona; these declines were most likely linked to overall declines in mule deer populations, which resulted in cougar taking bighorn sheep as alternate prey. Rominger et al. (2004) similarly reported that cougars limited expansion of a transplanted population of bighorn sheep in New Mexico.

Cougar Predation Effects on Oregon Bighorn Sheep Populations. Two bighorn sheep subspecies are native to Oregon: Rocky Mountain and California bighorn sheep. Indiscriminate hunting, loss of habitat through human use and fire suppression, lack of healthy water, unregulated grazing by domestic livestock, and parasites and diseases carried by domestic livestock all contributed to the species' eventual extirpation from Oregon by the mid-1940s. Present populations are the result of reintroductions and occupy only a small percentage of historical ranges. Oregon now supports 12 Rocky Mountain bighorn herds with a population estimate of 637 animals and 32 California bighorn herds with a total population of approximately 3,700 animals. Land use changes and the presence of domestic sheep have rendered much of the original wild sheep ranges unsuitable for occupancy, but there is still considerable suitable habitat into which bighorns have been or can be re-established. Cougar predation has been identified in the bighorn sheep management plan as a factor limiting bighorn sheep populations and in compromising restoration efforts (ODFW 2003).

In Oregon, a telemetry study in 2001 and 2002 of 33 radio-marked California bighorns in the Leslie Gulch herd range found seven of 13 documented mortalities (54%) were killed by cougars, and three other mortalities were suspected cougar kills. Monitoring of radio-collared bighorns in Hells Canyon found the primary causes of mortality to be disease, followed by cougar predation, which accounted for 27% of known mortalities (Cassirer 2004).

Foster and Whittaker (2010) conducted a telemetry study in January 2004 to measure adult mortality of Oregon bighorn sheep on the Hart Mountain NAR that indicated mortality rates of 17% for adult rams and 10% for adult ewes, with 62% of all mortality attributed to cougar predation. The California bighorn sheep population on the Refuge has declined by more than 70% since 2016, with only 48 sheep counted during a 2020 aerial survey (Service 2020b).

3.3.3 Special-Status Wildlife

There are no known populations of federally threatened or endangered wildlife species on the Refuge, but there are species of state and federal conservation concern. These include pygmy rabbits (*Brachylagus idahoensis*), white-tailed jackrabbits (*Lepus townsendii*), several species of bats, greater sage-grouse (*Centrocercus urophasianus*), Brewer's sparrow (*Spizella breweri*), sage sparrow (*Artemisiospiza nevadensis*), ferruginous hawk (*Buteo regalis*), western meadowlark (*Sturnella neglecta*), loggerhead shrike (*Lanius ludovicianus*), Great Basin redband trout (*Oncorhynchus mykiss newberrii*), tui chub (*Gila bicolor*), northern sagebrush lizard (*Sceloporus graciosus*), western toad (*Anaxyrus boreas*), and Oregon spotted frog (*Rana pretiosa*).

3.3.4 Other Mammals

Mule Deer. For more than 50 years there has been an annual survey of the Refuge mule deer herd for the fawn to doe ratio as a measure of reproductive success. Although this survey is not intended to be an accurate count of the Refuge population, it reinforces anecdotal evidence that the mule deer population has trended down in the Refuge and western United States in the last decade. Deer hunter success (Figure 3.6) is a rough indication of long-term trends and confirms the notion that mule deer numbers are well below those of the 1980s.

Mule deer are primarily browsers on woody plants, and diets in the area are generally dominated by bitterbrush and mountain mahogany. Important mule deer fawning habitats include mountain big sagebrush and mountain mahogany cover types. Deer range on the Refuge does substantially overlap with bighorn sheep at the higher elevations, but there is little competition for forage with the possible exception of during deep snow periods when bighorn sheep increase browsing on woody plants.

Mule deer are primary prey species for cougars (Villapique et al. 2011), and it is possible that when there is a scarcity of deer, cougars could increase predation on bighorn sheep to compensate. Because cougars prey on a variety of species, the complexities of inter-species relationships make accurate predictions of cougar response to prey availability difficult.

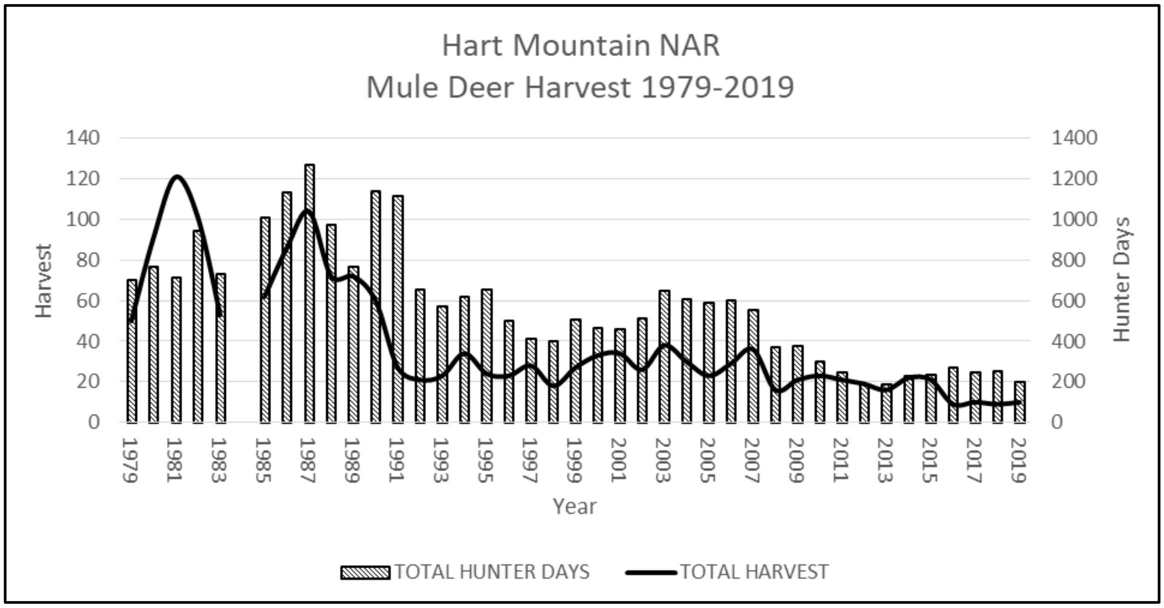

Figure 3.6. The record of mule deer harvest and hunter effort from 1979–2019 on Hart Mountain National Antelope Refuge. Note: this should not be interpreted as a mule deer population index, but it is consistent with regional data indicating a significant reduction of the local deer population since the high in the 1980s.

Elk. North American elk were probably never numerous in the desert and semi-desert regions of the West. Low forage quality and quantity, scarcity of water, and high energetic costs of thermoregulation due to lack of thermal cover make these desert regions poor elk habitat (McCorquodale et al. 1986). Staff have periodically observed small numbers of elk on the Refuge since 1985; the recent population averages <20 individuals annually. Although there is overlap of elk and bighorn sheep range and resource use on the Refuge, the small numbers of elk and their lack of dependence on escape terrain likely renders direct competition between the species negligible.

Pronghorn. Core summer and winter areas for pronghorn overlap primarily at the upper elevations of bighorn sheep habitat, with possible geographic and seasonal differences in the degree of overlap. Throughout their range, pronghorn commonly display migratory behavior between distinct summer and winter ranges (Hoskinson and Tester 1980; Sawyer et al. 2005; White et al. 2007). Collins (2016) confirmed this migratory behavior on the Refuge, which showed strong fidelity to summer ranges and weaker fidelity to winter ranges. Both seasonal ranges encompass some portions of bighorn sheep range, although pronghorn rarely venture onto the steep slopes of escape terrain. Larkins et al. (2018) also found that pronghorn on the Refuge are conditionally migratory and only move as far as needed to secure adequate resources. Pronghorn on the Refuge likely represent a subset of a larger population (summer meta-population) representing areas outside the Refuge covering parts of Oregon and Nevada. Over the last 10 years there is no discernable trend, with the numbers on the Refuge fluctuating between 1,300 to 3,000 individuals during summer flight surveys. The habitat-use patterns of pronghorn relative to bighorn sheep habitat are not known in the Refuge, but there does not appear to be any competition for forage or space use between pronghorn and bighorn sheep.

Mesocarnivores. Medium-sized carnivores that are not at the trophic apex of their ecological communities are often termed mesocarnivores (Roemer et al. 2009). On the Refuge, they include red fox (*Vulpes vulpes*), badgers, bobcats, and coyote. They primarily prey on small mammals and birds and are potential predators of young bighorn sheep; however, they are not generally considered to have significant population-level effects on bighorn sheep. Mesocarnivores recorded on the Refuge that probably do not prey on bighorn sheep lambs include raccoons (*Procyon lotor*), striped skunks (*Mephitis mephitis*), and spotted skunks (*Spilogale putorius*). No formal surveys of mesocarnivores have been conducted on the Refuge and current population numbers are unknown. Ecological relationships between these species, their predators, and their prey are extremely complex and intricate and little understood.

***Rodents*.** There have been no systematic studies or surveys of rodents on the Refuge and the species listed here were either documented on the Refuge or commonly occur in plant communities present on the Refuge. Approximately 30 rodent species are known or believed to occur on the Refuge, ranging in size from small mice to 50-pound beaver.

Sagebrush-obligate or shrubland rodent species that may occur on the Refuge include sagebrush vole (*Lemmiscus curtatus*), Great Basin pocket mouse (*Perognathus parvus*), desert woodrat (*Neotoma lepida*), dark kangaroo mouse (*Microdipodops megacephalus*), and northern grasshopper mouse (*Onychomys leucogaster*). Many of the inhabitants of salt desert scrub, in particular, require burrows for nesting, hunting, predator avoidance, and thermoregulation. Rodents that may occur in cliffs, canyons, talus slopes, and barren lands include bushy-tailed woodrat (*Neotoma cinerea*), desert woodrat, and least chipmunk (*Tamias minimus*). Rodents associated with mountain mahogany and western juniper woodlands include bushy-tailed woodrat, golden-mantled ground squirrel (*Callospermophilus lateralis*), Great Basin pocket mouse, and least chipmunk.

***Pygmy Rabbit*.** Pygmy rabbits are found in much of the Great Basin and some adjacent intermountain areas of western North America. They are the smallest rabbit species in North America and are one of two species of rabbit in North America to dig their own burrows. Pygmy rabbit burrows are found in areas of relatively deep, noncompacted soils, usually with low sand content, and are associated with areas of denser, taller sagebrush. The sagebrush provides cover from predators and food for pygmy rabbits. Their diet largely consists of sagebrush, approaching 99% in winter months. Pygmy rabbits also often establish “toilet sites” and “runs” under and between sagebrush near their burrows, which can be helpful indicators of pygmy rabbit presence and site activity.

The pygmy rabbit was designated as a federal species of special concern following declines in Oregon and Washington, and a lack of solid information about its status elsewhere. In 2003 the Columbia Basin Distinct Population Segment was listed as federally endangered in the state of Washington. In 2010, the Service determined that there has been some loss and degradation of pygmy rabbit habitat range wide, but not to the magnitude that constitutes a significant threat to the species, and that Endangered Species Act protection was not warranted. Pygmy rabbits have been identified as a state species of concern in Oregon and are an Oregon Strategy Species (ODFW 2016).

Pygmy rabbit colonies and colony clusters have been documented on the Refuge scattered through much of the flatland areas east and south of the primary escarpment up to near its eastside base and the intermediate hills. Relatedness within and between colonies and colony clusters (either genetic or dispersal) is unknown, though ongoing research on the Refuge for several years should elucidate this. Pygmy rabbits are typically considered to have limited dispersal capabilities (ODFW 2016), but those in the greater Sheldon-Hart Mountain area have been documented to move up to 7 miles from their source burrows through broad areas of sparse cover and to return to these home sites; others, however, remain within 328 feet of their home burrows throughout their lives (Unpublished data from radiotelemetry work performed on pygmy rabbits on Sheldon National Wildlife Refuge and Beatys Butte Allotment ca. 2000).

No pygmy rabbit colonies are known within the core bighorn sheep habitats. The only known colonies within bighorn sheep habitats occur in the general ewe and ram water limit buffers.

***Other Lagomorphs*.** Black-tailed jackrabbits (*Lepus californicus*), white-tailed jackrabbits, and mountain cottontails (*Sylvilagus nuttallii*) are all fairly widespread through much of the Great Basin, and all occur on the Refuge.

Black-tailed jackrabbits and mountain cottontails are both common on the Refuge. White-tailed jackrabbits are significantly less common. On the Refuge, black-tailed jackrabbits are typically more associated with denser (more closed-canopy) big sagebrush areas, though can be found in low sagebrush and other more open areas as well. They are the most common hare seen in and around the Refuge, especially along roads. On the Refuge, white-tailed jackrabbits have closer association with perennial grasslands and more open (sparser) shrub areas with fair to good native understory components (particularly bunchgrasses) than do black-tailed jackrabbits. Mountain cottontails are normally more associated on the Refuge with slightly higher moisture habitats, including riparian areas and aspen (*Populus tremuloides*) stands, woodlands, mountain shrub communities, and meadows, although they can also be found associated with cliff and canyon areas and in some of the drier communities as long as there is a ready source of moisture, such as a spring, seep, creek, or spring brook. Cottontails are also common at the Refuge headquarters area.

White-tailed jackrabbits are listed as a sensitive species in Oregon and are identified as an Oregon Strategy Species (ODFW 2016). Their primary risk is identified as the loss and degradation of their preferred grassland habitats through shrub encroachment and increases of invasive species. The American pika (*Ochotona princeps*) is known to occur on the Refuge, but its full range and status on the Refuge is unknown. American pika require talus, creviced rocks, and other talus-like habitats in alpine and subalpine areas that provide cool microclimates and have adequate herbaceous forage nearby. Their sensitivity to high temperatures, limited dispersal ability, and low fecundity make them vulnerable to climate change. The American pika is listed as a sensitive species in need of conservation under the Oregon Conservation Strategy (ODFW 2016).

***Chiroptera (Bats)*. **Little research has been conducted on the bats of the Refuge beyond a handful of presence/absence sampling surveys using mist netting and acoustic recordings conducted since the late 1970s. Several bat houses of various designs were installed at the McKee Ranch area after the barn was removed in 2018; all had varying levels of occupation in 2020, though specific species composition and numbers are unknown. A total of 13 species of bats have been documented on the Refuge during sampling surveys (see also O'Shea et al. 2018):

- Pallid bat (*Antrozous pallidus*; Oregon State Sensitive Species)
- Townsend's big-eared bat (*Corynorhinus townsendii*; federal species of concern [FSoC]; Oregon State Sensitive-Critical Species)
- Big brown bat (*Eptesicus fuscus*)
  - Detected subspecies believed to be *bernardinus*
- Silver-haired bat (*Lasionycteris noctivagans*; Oregon State Sensitive Species)
- Hoary bat (*Lasiurus cinereus*; Oregon State Sensitive Species)
- California myotis (*Myotis californicus*; Oregon State Sensitive Species)
  - Detected subspecies believed to be *californicus*
- Western small-footed myotis (*Myotis ciliolabrum*; FSoC)
  - Dark-nosed small-footed myotis (*Myotis melanorhinus*) are also reported in older records though are now treated as the same species as western small-footed myotis (see species profiles, below)
- Long-eared myotis (*Myotis evotis*; FSoC)
- Little brown myotis (*Myotis lucifugus*)
  - Detected subspecies believed to be *carissima*
- Fringed myotis (*Myotis thysanodes*; FSoC; Oregon State Sensitive Species)
- Long-legged myotis (*Myotis volans*; FSoC; Oregon State Sensitive Species)
  - Detected subspecies believed to be *interior*
- Yuma myotis (*Myotis yumanensis*; FSoC)
  - Detected subspecies believed to be *sociabilis*
- Canyon bat (aka western pipistrelle; *Parastrellus hesperus*)

An additional four species have been documented on Sheldon National Wildlife Refuge in similar habitats as those present on the Hart Mountain NAR and with full (apparent) habitat connectivity between the two areas. Although these four species have not yet been detected on Hart Mountain NAR, they could realistically occur:

- Spotted bat (*Euderma maculatum*; FSoC; Oregon State Sensitive Species)
- Western red bat (*Lasiurus blossevillii*)
- Big free-tailed bat (*Nyctinomops macrotis*; FSoC)
- Mexican free-tailed bat (*Tadarida brasiliensis*)

Although bats are often tied to specific habitats or features for foraging, roosting, and wintering, some species have considerable flexibility in these associations (see the review by Weller et al. 2009). Tables 3.7 through 3.9 summarize the foraging, roosting, and wintering habits and habitats of the bat species documented on and near the Hart Mountain NAR and provide some information about degree and flexibility of these associations. The information in these tables is adapted from Harvey et al. (2011), O'Shea et al. (2018), Animal Diversity Web (2021), and Bat Conservation International (2021).

Table 3.7. Forage Habitats of Bat Species of Hart Mountain National Antelope Refuge

Bat Species (*Scientific Name*)	***Bat Forage Habitats***												
	Open Water	**Riparian Corridors**	**Meadows**	**Forest Edge/Open Forest**	**Above Forest Canopy**	**Shrublands**	**Grasslands**	**Developed Areas (around buildings, lights, etc.)**	**Cropland**	**Open Ground**	**Roadways**	**Cliffs/Canyons**	**General Aerial (to over 10,000 feet above ground level)**
Species Detected on Hart Mountain NAR													
Big brown bat (*Eptesicus fuscus*)	P	C	C	C	O	C	C	P	C	O	–	–	–
California myotis (*Myotis californicus*)	C	P	O	P	O	–	–	–	–	O	–	–	–
Canyon bat (aka western pipistrelle) (*Parastrellus hesperus*)	GA*	GA*	O	P	O	C	C	–	O	–	–	C	–
Fringed myotis (*Myotis thysanodes*)	O	O	–	O	P	C	–	–	–	–	–	–	–
Hoary bat (*Lasiurus cinereus*)	P	–	O	–	–	C	C	U	O	O	–	–	–
Little brown myotis (*Myotis lucifugus*)	P	O	O	C	–	–	–	O	O	–	–	–	–
Long-eared myotis (*Myotis evotis*)	P	O	–	O	C	–	–	–	–	–	–	–	–
Long-legged myotis (*Myotis volans*)	C	C	O	P	P	C	O	–	O	–	–	–	–
Pallid bat (*Antrozous pallidus*)	–	–	–	–	–	C	O	–	–	P	O	–	–
Silver-haired bat (*Lasionycteris noctivagans*)	P	O	O	O	C	–	–	O	–	–	O	–	–
Townsend's big-eared bat (*Corynorhinus townsendii*)	–	–	–	P	–	P	O	–	–	–	–	–	–
Western small-footed myotis (*Myotis ciliolabrum*)	P	P	C	–	–	–	C	–	–	–	–	–	–
Yuma myotis (*Myotis yumanensis*)	P	O	–	–	–	–	–	–	–	–	–	–	–
Species Detected Near Hart Mountain NAR That May Occur on Refuge													
Big free-tailed bat (*Nyctinomops macrotis*)	–	?	?	?	?	?	?	?	?	?	–	–	–
Mexican free-tailed bat (*Tadarida brasiliensis*)	?	?	?	–	?	?	?	–	?	–	–	–	P
Spotted bat (*Euderma maculatum*)	?	–	C	C	?	C	C	–	?	O	–	–	–
Western red bat (*Lasiurus blossevillii*)	–	–	–	P	–	–	–	P	–	–	–	–	–

Notes: C = commonly used; O = occasionally used; P = primary or preferred; U = uncommon, but known to occur; ? = unknown, but thought to occur.
* GA = generally avoided. Canyon bats do not generally forage over water though they are otherwise very strongly associated with water. This avoidance is possibly due to their weakness as flyers. Although highly maneuverable, a slight breeze can bring them to a standstill.

Table 3.8. Day Roost Strategies and Sites of Bat Species of Hart Mountain National Antelope Refuge

Bat Species (*Scientific Name*)	Day Roost Strategy					Day Roost Sites											
	Solitary	**Small Groups (<25–30)**	**Large Groups (>25–30)**	**Sexual Segregation**	**Mixed Species (though often still segregated by species)**	**Cliff, Rock Crevices**	**Scree Fields, Rock Piles**	**Caves, Abandoned Mines**	**Old-Growth Trees (cavities, furrows, loose bark)**	**Stumps, Fallen Logs**	**Forest Canopy**	**Riparian Corridors (in overstory canopy)**	**Occupied Buildings, Other Artificial Structures**	**Unoccupied Buildings, Other Artificial Structures**	**Bat Houses (well-designed/well-placed)**	**Debris Piles/Wood Piles**	**Burrows (of other species)**
Species Detected on Hart Mountain NAR																	
Big brown bat (*Eptesicus fuscus*)	–	O	P		O	C	–	O	C	–	–	–	C	C	C	O	–
California myotis (*Myotis californicus*)	–	P	–	P (Y)	–	C	–	C	P	–	–	–	O	O	O	–	–
Canyon bat (aka western pipistrelle) (*Parastrellus hesperus*)	–	–	–	–	–	P	O	C	–	–	–	–	O	O	O	?	?
Fringed myotis (*Myotis thysanodes*)	–	O	P	P	–	C	–	P	O	–	–	–	–	O	–	–	–
Hoary bat (*Lasiurus cinereus*)	P	O	–	P (Y)	O	–	–	O	–	–	P	P	–	–	–	–	–
Little brown myotis (*Myotis lucifugus*)	M: ?	F: O	F: P	P	O	O	–	–	P	–	–	–	C	C	C	O	–
Long-eared myotis (*Myotis evotis*)	C	P	–	–	GA	P	U	O	P	O	–	–	–	O	U	O	–
Long-legged myotis (*Myotis volans*)	–	C	P	–	–	O	–	U	P	–	–	–	U	O	U	–	–
Pallid bat (*Antrozous pallidus*)	U	C	C	P (Y)	–	P	–	C	O	–	–	–	U	O	O	–	–
Silver-haired bat (*Lasionycteris noctivagans*)	P	–	–	P	–	–	–	–	P	–	–	–	U	U	O	–	–
Townsend's big-eared bat (*Corynorhinus townsendii*)	M: P F: O	M: O F: C	M: GA F: C	P	–	P	–	P	–	–	–	–	GA	C	O	–	–
Western small-footed myotis (*Myotis ciliolabrum*)	C	P	–	–	–	P	O	C	GA	O	GA	–	U	C	O	U	–
Yuma myotis (*Myotis yumanensis*)	M: P	O	P	P (Y)	C	C	–	P	C	O	–	–	C	P	C	–	–
Species Detected Near Hart Mountain NAR That May Occur on Refuge																	
Big free-tailed bat (*Nyctinomops macrotis*)	C	C		P	–	P	–	–	O	–	–	–	O	O	–	–	–
Mexican free-tailed bat (*Tadarida brasiliensis*)	–	O	P	–	–	–	–	P	O	–	–	–	C	C	C	–	–
Spotted bat (*Euderma maculatum*)	?	–	–	?	–	P	–	–	–	–	–	–	–	–	–	–	–
Western red bat (*Lasiurus blossevillii*)	P	–	–	–	–	–	–	U	–	–	P	P	–	–	–	–	–

Notes: C = commonly used; F= females; GA = generally avoided; M = males; O = occasionally used; P = primary or preferred; U = use is uncommon, but known to occur; Y = during rearing of young; ? = use is unknown, but thought to occur.

Table 3.9. Over-Wintering Strategies and Sites of Bat Species of Hart Mountain National Antelope Refuge

Bat Species (*Scientific Name*)	**Over-Wintering Strategy**						**Over-Wintering Sites**						
	Unknown	**Otherwise Not Well Documented/Understood**	**Migratory (Long Distance) [>100–200 miles]**	**Migratory (Short Distance) [<100–200 miles]**	**Periodic Torpor[2]**	**Hibernation[2]**	**Unknown**	**Cliff, Rock Crevices, Scree Fields**	**Caves, Abandoned Mines**	**Old-Growth Trees (Cavities, Loose Bark)**	**Occupied Buildings, Other Artificial Structures**	**Unoccupied Buildings, Other Artificial Structures**	**Bat Houses (Well-designed/Well-placed)**
Species Detected on Hart Mountain NAR													
Big brown bat (*Eptesicus fuscus*)	–	–	–	P	O	P	–	O	C	O	C	O	U
California myotis (*Myotis californicus*)	–	–	–	–	O	P	–	–	P	–	–	–	–
Canyon bat (aka western pipistrelle) (*Parastrellus hesperus*)	–	–	–	–	P-S	P-N	–	P	P	–	–	–	–
Fringed myotis (*Myotis thysanodes*)	–	P	?	?	–	–	P	–	–	–	–	–	–
Hoary bat (*Lasiurus cinereus*)	–	–	P	–	–	–	–	–	–	–	–	–	–
Little brown myotis (*Myotis lucifugus*)	–	–	–	C	C	C	–	O	P	–	–	–	–
Long-eared myotis (*Myotis evotis*)	–	P	–	?	?	–	P	–	–	–	–	–	–
Long-legged myotis (*Myotis volans*)	–	P	–	–	?	?	–	U	P	–	–	–	–
Pallid bat (*Antrozous pallidus*)	–	P	–	P	P	–	–	P	C	–	U	U	–
Silver-haired bat (*Lasionycteris noctivagans*)	–	P	–	P	–	P	–	C	O	P	–	U	–
Townsend's big-eared bat (*Corynorhinus townsendii*)	–	–	–	–	–	P	–	–	P	–	GA	–	–
Western small-footed myotis (*Myotis ciliolabrum*)	–	–	–	–	–	P	–	–	P	–	–	–	–
Yuma myotis (*Myotis yumanensis*)	–	P	?-S	?-S	?-N	?-N	–	?-N	–	?-N	–	–	–
Species Detected Near Hart Mountain NAR That May Occur on Refuge													
Big free-tailed bat (*Nyctinomops macrotis*)	UNK	–	–	–	–	–	P	–	–	–	–	–	–
Mexican free-tailed bat (*Tadarida brasiliensis*)	–	–	P	–	–	–	–	–	P	–	C	C	C
Spotted bat (*Euderma maculatum*)	UNK	–	–	–	–	–	P	–	–	–	–	–	–
Western red bat (*Lasiurus blossevillii*)	UNK	–	–	–	–	–	P	–	–	–	–	–	–

Notes: C = commonly used; GA = generally avoided; NP = northern populations (respective of the whole of the species' range); O = occasionally used; P = primary or preferred; SP = southern populations (respective of the whole of the species' range); U = use is uncommon, but known to occur; UNK = overwintering strategy is entirely unknown; ? = use is unknown but thought to occur.

3.3.5 Birds

Eagles. Golden eagles and bald eagles (*Haliaeetus leucocephalus*) are protected under the Migratory Bird Treaty Act (16 USC 703–712), as well as the Bald and Golden Eagle Protection Act (16 USC 668–668c).

Golden eagles are found on the Refuge. The Oregon Eagle Foundation conducted golden eagle surveys on the Refuge from 2011 to 2020. There are 28 known golden eagle nesting sites on the Refuge, and a majority of them occur within or close to bighorn sheep habitat (Service 2019a). Golden eagles are known to prey on a variety of small to medium mammals and birds, including bighorn sheep lambs; however, the extent of their impact on the bighorn sheep population is unknown.

Bald eagles are also found on the Refuge. There is one known bald eagle nesting site on the Refuge that is located in DeGarmo Canyon. This nest is considered to be active with recent activity in 2020. Bald eagle surveys and monitoring are not conducted on the Refuge, so the full range of bald eagles on the Refuge is unknown. Bald eagles are primarily fish and carrion eaters but will take a variety of species as prey. They are generally not considered significant predators of bighorn sheep lambs.

Greater Sage-Grouse. The Refuge provides core habitat for greater sage-grouse, a species that has been extirpated in some states and has undergone dramatic population declines in its core range. In 2010, the Service listed sage-grouse as a candidate species under the Endangered Species Act. This means the Service found that listing the range-wide sage-grouse population as a threatened or endangered species may be warranted, but it was precluded by higher priority listing actions. In 2015, the Service conducted a further status review and found that listing was not warranted. There is currently no open hunting season for sage-grouse in the Refuge.

The sage-grouse population on the Refuge has fluctuated considerably during the past 70 years. Sage-grouse populations exhibit density dependent fluctuations over time (Garton et al. 2011). The observed male attendance at trend lek complexes counted during both 2020 and 2019 was 139 in 2020, a 28.7% increase from observed male attendance of 108 recorded at those same leks in 2019. This represents the first increase following 3 consecutive years of population decline (2016–2019) on the Refuge. Despite the slight increase observed in 2020, the population remains at the second lowest level observed from 2003 to 2020. Observed male attendance was 64.5% below the 2003 baseline level (n2003 = 391, n2020 = 139) at trend lek complexes counted during both 2003 and 2020. Currently, the Refuge supports approximately 30 leks/lek complexes and the spring population is estimated at approximately 500 birds. Standardized count procedures, in place in Oregon since 1996, have improved the reliability of sage-grouse population estimates; however, multiple potential sources of uncertainty remain, and true population size remains unknown (Walsh et al. 2004; ODFW 2011).

There is considerable spatial overlap of sage-grouse use areas within bighorn sheep habitat according to telemetry data from marked sage-grouse. The areas of overlap of typically occur on top of open flats and rarely on the steep slopes.

Other Birds. A number of sagebrush-dependent birds, including Brewer’s sparrow, sage sparrow, and sage thrasher (*Oreoscoptes montanus*), have received special conservation status in one or more western states (Knick and Rotenberry 2002; Wildlife Action Plan Team 2013). Brewer’s sparrow, sage sparrow, ferruginous hawk, western meadowlark, and loggerhead shrike occur in bighorn sheep habitat and have been identified as Oregon Strategy Species (ODFW 2016).

3.3.6 Fish

Trout. One native trout species, the Great Basin redband trout (Catlow Valley Species Management Unit [SMU] population segment; hereafter referred to as Catlow redband), and several introduced species and/or stocks occur or have been known to occur in waters of the Refuge (Table 3.10). Catlow redband are found in Rock Creek and intermittently in its tributaries (including Willow, Bond, Barnhardy, and Cold Creeks; collectively referred to as Rock Creek Drainage Basin). Cutthroat trout (*Oncorhynchus clarkii*), rainbow trout (*Oncorhynchus mykiss*), and hybrids of the two (known as “cuttbows”

[*Oncorhynchus clarkii* × *mykiss*]), are found in Guano Creek and intermittently in its tributaries (including Stockade, Goat, Box, and Warner Creeks; collectively referred to as Guano Creek Drainage Basin). Rainbow trout are found in Warner Pond.

Table 3.10. Trout Species Status and Water Bodies (and Tributaries) Where They Occur or Have Occurred on Hart Mountain National Antelope Refuge

Trout Species	**Status**	**Rock Creek Drainage Basin**	**Guano Creek Drainage Basin**	**Warner Pond**
Catlow redband (*Oncorhynchus mykiss newberrii*)	FSoC, SS	NS	Possible NS	–
Great Basin redband trout (*Oncorhynchus mykiss newberrii*)	FSoC, SS	–	Possible NS	–
Rainbow trout (*Oncorhynchus mykiss*)	–	Stocked	Stocked	Stocked
Cutthroat trout (*Oncorhynchus clarkii*)	–	–	Stocked	–
Lahontan cutthroat trout (*Oncorhynchus clarkii henshawi*)	N/A	–	Stocked	–
Alvord cutthroat trout (*Oncorhynchus clarkii alvordensis*)	–	–	Stocked (EX)	–
Cuttbow (*Oncorhynchus clarkii* × *mykiss*)	–	–	HY	–

Notes: EX = believed extinct; HY = naturally occurring hybrid of introduced (stocked) species; N/A = not applicable (other populations have status, but not those on the Refuge); NS = native species (species native to the stream); SS = Oregon State Sensitive Species; Stocked = historically introduced and stocked multiple years.

Hatchery rainbow trout of unknown genetic origins were stocked in Rock Creek periodically between 1960 and 1973 and 1979, when stocking efforts of the creeks ceased (there is inconsistency in the reported dates of when the efforts were ended; ODFW 2005a, 2005b). No cutthroat trout of any subspecies are believed to have been stocked in Rock Creek. Despite the introduction of rainbow trout, the redband trout within Rock Creek are still considered genetically as true redband trout, though with some introgression of coastal-origin rainbow trout (DeHaan et al. 2015). Interestingly, DeHaan et al. (2015) also found that the Rock Creek population grouped closer to the populations in the Fort Rock SMU, whereas the other populations within the Catlow Valley SMU (Threemile and Home Creeks) grouped closer to the Malheur Lakes SMU, indicating possible recent gene flow among some of these populations (such as through transplants by unknown parties); however, the Rock Creek redband also had higher genetic diversity than the average across all of DeHaan et al.’s (2015) observed populations, confirming its status as a native population. The redband trout in Rock Creek are still considered part of the Catlow Valley SMU, with relatively high abundance of fish and genetic diversity, suggesting it is a potential “stronghold” population for redband trout with unique conservation value for the species (DeHaan et al. 2015).

As reported by Behnke (1992), rainbow trout were stocked in Guano Creek by the State of Oregon in 1957, 1962, 1963, 1964, and 1969. The rainbow trout are described as being of coastal genetic origin, though it is not clear what the specific source (or sources) may have been (ODFW 2005a). Lahontan cutthroat trout (*Oncorhynchus clarkii henshawi*) from Willow Creek of the Whitehorse (or Coyote Lake) Basin were stocked in Guano Creek by the state in 1957. Additional Lahontan cutthroat trout (believed to have been of Heenan Lake, California, in origin) were stocked in Guano Creek in 1969, 1973, 1976, and 1978, and possibly also in 1967 (there is some inconsistency in the reported dates) (Behnke 1992; ODFW 2005a, 2005b). Alvord cutthroat trout (*Oncorhynchus clarkii alvordensis*), a likely extinct subspecies, are believed to have been transplanted into Guano Creek from Trout Creek (Oregon) by unknown parties prior to 1928 (Behnke 1992). Fish with distinctively Alvord patterning are still occasionally found in the Guano Creek, though efforts at spawning these fish in controlled hatchery settings have only produced progeny with non-Alvord characteristics (D. Banks, ODFW District Fish Biologist, personal communications), suggesting the Alvord patterning occurs by genetic chance rather than as a distinct subpopulation within the creek (Hurn 2013). Guano Creek is thought by some to have been troutless prior to this first stocking with Alvord cutthroat trout, though this is not definite because Guano Creek, like Rock Creek, had a connection to pluvial Lake Catlow before it dried >10,000 years ago, allowing for the potential of a geographically distinct redband trout population segment (Behnke 1992; ODFW 2005b). Redband trout have not been detected in Guano Creek during several recent sampling surveys, though ODFW still officially recognizes the potential for redband trout to occur in Guano Creek (ODFW 2005b; Lohr et al. 2012).

The State of Oregon has periodically stocked Warner Pond with hatchery rainbow trout of unknown genetic origins. Warner Pond has been modified since settlement to increase its depth and surface area and is naturally surface-isolated from the waters of the rest of the Refuge and the Warner Valley. No fish (of any species) are believed to have naturally occurred in this pond prior to these stocking efforts.

Lahontan cutthroat trout are technically considered Threatened under the Endangered Species Act, though the introduced and heavily hybridized Guano Creek population is not part of this designation or included in the recovery plan (Service 1995). Catlow redband are a FSoC and are considered an at-risk sensitive species in the state of Oregon. Redband trout (including Catlow redband) are managed under a 2014 range-wide conservation agreement among several states and other partners (including the Service), as well as a subsequent conservation strategy, that together are primarily intended to ensure the integrity, survival, and recovery of redband populations and their habitats (Interior Redband Conservation Team 2016). Both Guano and Rock Creeks are considered part of the Guano hydrologic unit code (HUC)-8 sub-basin population for redband trout; Warner Pond is considered part of the Warner Lakes HUC-8 sub-basin population (Interior Redband Conservation Team 2016).

Under the CMP, trout as a group are considered a "featured species" that may receive management emphasis to their benefit. Conversely, management actions will not be undertaken that could lead to long-term or permanent detrimental impacts to a "featured species" population. Changes in land management strategies on the Refuge since 1994 have improved conditions for trout in both the Rock Creek and Guano Creek systems, though there are ongoing issues of low water availability (quantity and duration), high in-stream water temperatures during portions of the year, poor physical condition of some reaches, and some legacy limitations in upland and riparian vegetation communities (ODFW 2005a, ODFW 2005b; Earnst et al. 2012; Lohr et al. 2012; Batchelor et al. 2014; Beschta et al. 2014; DeHaan et al. 2015; Meeuwig and Clements 2015; others). Stocking of the Refuge's creeks ended many years ago. Rainbow trout have been stocked in Warner Pond since the creek stocking programs ended, though has not occurred for several years.

Tui Chub. Tui chub are relatively small fish in the minnow group. Tui chub, believed to be either the Sheldon tui chub subspecies, or an as-yet undescribed genetically and geographically distinct endemic subspecies within the Catlow tui chub subspecies group, had historically occurred in Guano Creek, though likely in naturally limited numbers (Hubbs and Miller 1948; Williams and Bond 1981; Lee et al. 1997; ODFW 2005b). Numerous sampling surveys conducted on Guano Creek in the last 30 years, including at least one specifically looking for tui chub (ODFW 2005b; Lohr et al. 2012), have failed to detect these fish, raising the possibility of their extirpation; however, because tui chub are fairly cryptic, capable of surviving brackish pools as creeks dry out, and will often hide in shallow cavities in undercut banks, they may still exist in Guano Creek (Lohr et al. 2012).

Tui chub in Rock Creek were found in very low numbers in 1994 (Lee et al. 1997); fair numbers were detected in 2015, with 80% of them occurring in the creek reaches immediately upstream of Flook Meadow (Meeuwig and Clements 2015); however, these reaches routinely dry up by the end of summer in periods of drought. The fish are thought to die as the water disappears, leaving only the small percentage of fish in the middle and/or upper reaches to sustain and repopulate the creek in wetter years.

Tui chub of the Rock and Guano Creek drainages are considered species of concern, although due to a lack of information concerning their genetics, species relatedness, and general abundance, they are considered a "Data Gap" species by ODFW under their Oregon Conservation Strategy (ODFW 2016).

Warner Sucker. The federally threatened Warner sucker is presently known to occur in parts of Crump and Hart Lakes, the spillway canal north of Hart Lake, and other areas in the Warner Basin, as water levels allow. No potential sucker habitat is known to occur within the identified bighorn sheep habitats on the Refuge (i.e., Service-managed areas) or will be affected by actions proposed under this bighorn sheep management plan. Accordingly, Warner sucker will not be analyzed further in this document.

3.3.7 Reptiles and Amphibians

Reptiles. There have been no known systematic studies or surveys to document reptiles on the Refuge; species discussed here are those that have been documented or are expected to occur on the Refuge based on appropriate habitat within their known ranges. Little is known about the actual populations and ranges of these species, or their relationships with specific cover types on the Refuge.

The sagebrush-obligate reptile species that may occur on the Refuge is the northern sagebrush lizard, which is an Oregon Strategy Species considered in need of conservation (ODFW 2016). Other species found in shrub uplands include desert horned lizard (*Phrynosoma platyrhinos*), and pygmy short-horned lizard (*Phrynosoma douglasii*). Several species of reptiles require talus slopes and rocky outcroppings, including side-blotched lizard (*Uta stansburiana*) and western fence lizard (*Sceloporus occidentalis*). Species associated with mountain mahogany and western juniper woodlands include pygmy short-horned lizard and western fence lizard.

The striped whipsnake (*Masticophis taeniatus*) and western yellow-bellied racer (*Coluber constrictor mormon*) are found in sagebrush-steppe, mountain mahogany, and western juniper woodlands and occur on the Refuge; racers are also often found associated with meadows and riparian areas.

Amphibians. Five amphibian species are known or suspected to occur on the Refuge: Great Basin spadefoot (*Spea intermontana*), Pacific chorus frog (*Pseudacris regilla*; also known as the Pacific tree frog), western toad, Oregon spotted frog, and the long-toed salamander (*Ambystoma macrodactylum*). No systematic surveys of amphibians or the status of breeding sites and other critical habitat elements have occurred on the Refuge; only general statements about them can be made at this time.

All of these depend on water bodies persistent enough to allow their egg and larval forms to complete their development (weeks to months) at least in some years, and adults generally do not range far from potential breeding sites. As species adapted to an arid and seasonally cold climate, amphibians on the Refuge have life histories that include periods of estivation (surviving dry periods) and hibernation (surviving cold periods) where they seek out survivable microclimates and become inactive. The required availability of these specific habitat elements make amphibians generally vulnerable to climate change or landscape disturbances that affect the hydrology of water features, physical and vegetative thermal cover, and connectivity between adult and breeding habitats. The natural concentration of local populations at aquatic breeding sites has facilitated the spread of novel pathogens worldwide in recent years that have decimated some amphibian populations, but it is unknown if this has occurred on the Refuge.

3.4 Biological Environment – Affected Plant Communities

The plant communities (cover types) of the Refuge mostly fall within the Great Basin and Columbia Plateau ecoregion types, each of which includes a variety of distinct habitats and vegetation types. Each cover type is defined by the relative abundance of associated plant species. The health and function of these cover types are the foundation upon which management of the Refuge is based and, therefore, are very important for developing and implementing future management decisions.

Tagestad (2010) developed baseline vegetation classification maps for the Refuge using 2009 Landsat 5 imagery and ERDAS Imagine software, following 2008 Federal Geographic Data Committee national vegetation classification standards (see also Comer et al. 2003; Lowry et al. 2005; Prior-Magee et al. 2005; USNVC 2019; NatureServe 2020). Ground-truthing of the classifications as part of that work showed that although the mapping and classification wasn't perfect, it was serviceable and is currently the best available for the Refuge. We used these vegetation datasets for describing and quantifying bighorn sheep habitats (see Table 3.4; see also Figure C-12).

An important fact to remember when identifying and interpreting these vegetative cover types is that most of them exist within a gradient of conditions, and the distinct boundaries and area measurements generated by the GIS work are artificial and imprecise. For example, most of the wetland-related cover types are defined by arbitrary delineations along a gradient from driest to wettest (i.e., playa > wet meadow > emergent vegetation > open water). In reality there is considerable functional and ecological overlap between these types, and the degree of overlap fluctuates with season, weather patterns, and changes in climate. Additionally, several of these cover types can also represent transitional stages, such as perennial grasslands potentially being an early seral stage of sagebrush cover types following a disturbance, such as fire. The cover types and their boundaries of the Refuge are in a constant state of flux.

3.4.1 Cliff and Canyon Cover Types and Barren Lands

3.4.1.1 CLIFFS AND CANYONS

Inter-Mountain Basins Cliff and Canyon cover types (NatureServe Unique ID: CES304.779) are generally rugged, unvegetated to sparsely vegetated (typically with <10% plant cover overall) with widely scattered trees and shrubs (e.g., juniper, sagebrush). They include steep cliff faces, bluffs, high walls, narrow canyons, rocky ledges, crevices, and rock outcrops of various igneous, sedimentary, and metamorphic bedrock types. They also include areas of unstable scree, desert pavement, scarps, talus slopes, slides, cinder cones and dunes, and gravel pits. Soil depths are highly variable though most are relatively shallow. Snow depths can also vary widely, depending on solar exposure and event-specific weather patterns.

Cliff and canyon cover types are important to many wildlife species and provide structure for nesting, roosting, denning, shelter from weather, protection from predators, and areas for foraging. Their value is also related to the larger landscape context they are in, as they provide more valuable cover where there is adjacent higher quality forage (Ward and Anderson 1988). This cover type dominates bighorn sheep core habitat, especially critical escape terrain, although its value there lies in the combination of forage species available within and near this cover type and the rugged and steep terrain. The cliff and canyon cover type is also the most prevalent and possibly the most important cover type in the bighorn sheep core lambing areas.

3.4.1.2 BARREN LANDS

Barren Lands are areas that have relatively low vegetation cover (typically <15–0%). These include areas of exposed bedrock, desert pavement, scarps, talus, slides, and volcanic cinder. These also include areas of human alteration and/or management, such as borrow pits, gravel yards, parking areas, and other accumulations of unvegetated earthen material.

Barren lands are often interspersed within cliff and canyon types and are unreliably distinguished during imagery analyses, and, therefore, are combined in our bighorn sheep habitat model.

3.4.2 Shrubland Communities

Shrubland communities are those upland cover types that are dominated by dryland shrubs intolerant of alkaline or saline soils. In the Refuge, these are sagebrush-dominated vegetative communities. The sagebrush genus (*Artemisia*) is diverse, ranging from annual/biennial forbs to long-lived woody shrubs. Our sagebrush-dominated vegetative communities are in this latter group. The shrubland communities are by far the most extensive vegetative cover type on the Refuge.

Woody species of sagebrush are generally divided into low and tall groups (see summary by Knick et al. 2003). Low sagebrush and black sagebrush (*Artemisia nova*) are the primary species in the low sagebrush groups, although black sagebrush is not known to occur at a detectable level (GIS remote analysis) within bighorn sheep habitats on the Refuge. Several species and subspecies of sagebrush fall within the tall sagebrush group on the Refuge, with Wyoming big sagebrush, basin big sagebrush (*Artemisia tridentata* ssp. *tridentata*), and mountain big sagebrush being the most widely distributed and most common on the Refuge. Each of these have their own environmental requirements and associations, and as such form their own community types. Mountain big sagebrush is further divided based on the soil and environmental conditions of the area, which give rise to different habitat conditions and capabilities, usually indicated by the presence of other codominant or common shrub species.

The three big sagebrush taxa and their respective communities generally shift in relative abundance along a gradient of decreasing soil temperature and increasing soil moisture (West and Young 2000; Miller et al. 2011). Basin big sagebrush commonly is restricted to deep alluvial soils along stream courses, although it is a shrub-steppe dominant in some settings (Miller et al. 2011). Mountain big sagebrush communities are generally found in forest clearings, on foothills and toe slopes between 3,940 feet and 9,840 feet of elevation, and on deep, well-drained soils in more cool and mesic environments (Davies and Bates 2010a). Wyoming big sagebrush plant communities occupy xeric foothills and valleys with moderate to shallow soils.

Perennial vegetation cover, density, and production were generally greater and more diverse in mountain sagebrush compared to Wyoming big sagebrush plant communities (Davies and Bates 2010a, 2010b). In addition, native perennial forb biomass production was approximately 4.5-fold greater in mountain big sagebrush compared to Wyoming big sagebrush plant communities because they tend to occur on locations with a more mesic moisture regime (Davies and Bates 2010a, 2010b).

Hybridization commonly occurs between sagebrush taxa in areas of overlap (McArthur and Sanderson 1999; McArthur 2000). This can significantly complicate identification of species and community types in the field. Many of these hybrids are recognized as their own taxa; for example, Bonneville sagebrush (*Artemisia tridentata* ssp. *X bonnevillensis*) is a stable hybrid of mountain big sagebrush and Wyoming big sagebrush (Garrison et al. 2013); xeric big sagebrush (*Artemisia tridentata* ssp. *xericensis*) is likely a hybrid of mountain big sagebrush and basin big sagebrush (Rosentreter and Kelsey 1991), although this taxonomic recognition is controversial. Innes (2017) stated "hybridization is likely the source of new genetic combinations that helped big sagebrush adapt to past climate changes, and such hybridization may help big sagebrush adapt to climate changes in the future." Hybridization may be a resilience mechanism (see also Section 3.5.2).

Although none of these hybrids have been mapped on the Refuge, they are thought to commonly occur near many or most of the identified boundaries between vegetation cover types. These hybrids may exacerbate the imprecision of the ecological significance of the mapped boundaries and subsequent area calculations based on remote imagery.

Shrubland communities are critically important for all sagebrush-obligate species, such as greater sage-grouse, sage thrasher, sage sparrow, Brewer's sparrow, and northern sagebrush lizard. They are also important habitats for most other desert-dwelling species, including jackrabbits, mule deer, numerous ground squirrel species, short-eared owl (*Asio flammeus*), American badger, coyote, cougar, and bobcat. For bighorn sheep, they primarily serve as important foraging and cover habitats during all seasons.

3.4.2.1 LOW SAGEBRUSH STEPPE

Columbia Plateau Low Sagebrush Steppe (NatureServe Unique ID: CES304.080) is dominated by low sagebrush, which generally occurs on shallow, fine-textured, poorly drained clays that are frequently very stony (Miller et al. 2011). Rabbitbrush (both *Ericameria* spp. and *Chrysothamnus* spp.), sub-shrubs such as cushion buckwheat (*Eriogonum ovalifolium*), and small, scattered islands of big sagebrush and antelope bitterbrush (*Purshia tridentata*) also occur within the low sagebrush community type. Winterfat (*Krascheninnikovia lanata*) at one time was also common but was significantly reduced or lost due to over-selection by livestock. Other associated species include Sandberg's bluegrass, bottlebrush squirreltail (*Elymus elymoides*), Idaho fescue, bluebunch wheatgrass, Thurber's needlegrass (*Achnatherum thurberianum*), and prairie junegrass (*Koeleria macrantha*). A variety of forbs are usually present, including phlox (*Phlox* spp.), biscuitroots/desert-parsleys (*Lomatium* spp.), milkvetch/locoweeds (*Astragalus* spp.), hawksbeards (*Crepis* spp.), clover (*Trifolium* spp.), buckwheats (*Eriogonum* spp.), and lupines (*Lupinus* spp.).

Low sagebrush steppe communities experience infrequent to very infrequent fire due to variable but generally sparse fuels; average return intervals are estimated to be 79 to 1,250-plus years (Missoula Fire Sciences Laboratory [MFSL] 2012a). Shrub die-offs have occurred, but causes are generally not understood.

3.4.2.2 WYOMING BIG SAGEBRUSH SHRUBLAND

Inter-Mountain Basins Big Sagebrush Shrubland (NatureServe Unique ID: CES304.777) is dominated by Wyoming big sagebrush. Soils are typically deep, well-drained and non-saline. Other shrubs may include spiny hopsage (*Grayia spinosa*), basin big sagebrush, silver sagebrush (*Artemisia cana*), and rabbitbrush, depending on the site conditions. Low sagebrush steppe patches commonly occur within this habitat on rocky or windblown sites. Sandberg's bluegrass is the primary understory herbaceous species in intact stands; cheatgrass and other invasive bromes can dominate in disturbed stands. Other native species include bluebunch wheatgrass, Idaho fescue, squirreltail, Great Basin wildrye (*Leymus cinereus*), and needle-and-thread (*Hesperostipa comata*). Forbs are relatively sparse except following disturbance and include lupine, hawksbeard, milkvetch, and balsamroots (*Balsamorhiza* spp.) in healthy systems.

Wyoming big sagebrush shrublands historically experienced relatively infrequent fire due to highly variable fire fuels; average fire-return intervals were estimated to be 25 to 100 years (Rose and Miller 1998; Innes 2019a). Shrub die-offs have occurred, but the causes are largely unknown, although numerous theories have been posited (e.g., drought, insect, disease) with no conclusive evidence. Typical canopy cover in this habitat ranges from 8 to 23%; at 12 to 15% cover understory production can begin to decline (Winward 1991). If a site with a high canopy cover (approximately 20%) is seriously disturbed, recovery to a shrub-dominated canopy can take 40 years or more in drier sites (Winward 1991). In the Great Basin, past overgrazing has allowed IAGs, mostly cheatgrass, to establish within many of these shrublands. In some areas, cheatgrass has contributed to larger and more frequent fires than occurred historically and is resulting in habitat conversion. In addition, grazing has also contributed to an increased density of large shrubs and a reduction in perennial grasses. On the Refuge, domestic livestock grazing was removed in 1994, and the community is recovering from its effects.

Encroachment by cheatgrass in disturbed areas is a concern, especially following fire. Although some sites are known to be degraded (such as those near the Hart Lake road, below the escarpment), most of the Wyoming big sagebrush habitats on the Refuge appear to be in overall fair condition.

3.4.2.3 BASIN BIG SAGEBRUSH STEPPE

Inter-Mountain Basins Big Sagebrush Steppe (NatureServe Unique ID: CES304.778) communities are dominated by basin big sagebrush. Soils are typically deep, well-drained, friable, and non-saline and often have very well-developed biocrusts in undisturbed areas. These sites typically have more precipitation and available ground moisture than Wyoming big sagebrush areas, but basin big sagebrush does not tolerate saturated soils; Miller et al. 2011). Other shrubs may include rabbitbrush, Wyoming big sagebrush, mountain big sagebrush, silver sagebrush, and antelope bitterbrush. Native perennial bunchgrasses and forbs dominate the understory and include bluebunch wheatgrass, Thurber's needlegrass, Great Basin wildrye, and Sandberg's bluegrass. The forb component can be diverse, with more than 200 species identified over the range of this habitat type in the Great Basin. Annual forbs may dominate following disturbance.

Basin big sagebrush steppe has a variable mean fire-return interval estimated to be <50 to 150 years (Innes 2019a). Periodic drought and insect outbreaks are also disturbance factors. Shrub canopy closure may rarely reach a maximum of 30 to 40%. Recently, IAGs have encroached on patches of varying sizes, although the condition of this community on the Refuge is still considered to be fair overall. On the Refuge, a lack of fire has resulted in a greater proportion of the late-seral closed canopy class than is thought to have occurred historically, a condition that may remain stable for considerable time (Innes 2019a). Livestock grazing has further increased the proportion of rabbitbrush and decreased native bunchgrass vigor and abundance in all seral stages. Although livestock grazing was removed from the Refuge in 1994, some impacts are still apparent, including missing or degraded biocrusts, localized soil compaction, and reduced native plant species and increased invasive species presence.

3.4.2.4 MONTANE SAGEBRUSH STEPPE

Inter-Mountain Basins Montane Sagebrush Steppe (NatureServe Unique ID: CES304.785) communities are dominated by mountain big sagebrush, and generally occur on relatively moist, rolling upland sites, stony (deep-soiled) flats, ridges, nearly flat ridgetops, and mountain slopes. Soils are typically relatively deep and fine-textured, with some source of subsurface moisture or otherwise near mesic conditions, with higher precipitation and areas of snow accumulation (Prior-Magee et al. 2005; Miller et al. 2011). Climates tend to be cooler than the other big sagebrush cover types (Miller et al. 2011). Depending on site characteristics and history, other shrubs may include bitterbrush, rabbitbrush, silver sagebrush, Woods' rose, wax currant (*Ribes cereum*), and mountain snowberry (*Symphoricarpos oreophilus*), although mountain big sagebrush will always be or become the dominant species. Wyoming big sagebrush may be present to codominant in the drier margins of the cover type. Low sagebrush steppe patches commonly occur within this habitat on rocky or windblown sites. At most sites shrub cover can be unusually high for a steppe system (over 25% cover, and in many cases over 50% cover), with the relatively higher moisture availability promoting equally high grass and forb covers (Innes and Zouhar 2018). Grasses include Thurber's needlegrass, Idaho fescue, bluebunch wheatgrass, Great Basin wildrye, and Sandberg's bluegrass. As with the basin big sagebrush steppe habitat type, the forb component can be extremely diverse. Daisies (*Erigeron* spp.), buckwheats, biscuitroots/desert-parsleys, phlox, balsamroots, milkvetches/locoweeds, wild onion (*Allium ascalonicum*), and penstemons (*Penstemon* spp.) are all important forbs.

Mountain sagebrush habitats incur stand-replacing fire every 15 to 25 years on average (Miller and Rose 1995; Rose and Miller 1998; Miller and Rose 1999; Innes and Zouhar 2018). The disturbance pattern largely creates a variety of age classes across the larger landscape ranging from 100 to 5,000 acres in size. Under pre-European settlement conditions, mosaic burns generally killed the aboveground portion of at least 75% of plants due to the relatively continuous herbaceous layer. These stands also incur periodic mortality due to insects, disease, winter kill, rodent irruptions, and drought. These disturbances in combination may have significantly reduced the cover of dense stands every 50 to 100 years.

3.4.2.5 MOUNTAIN SHRUB

Northern Rocky Mountain Montane-Foothill Deciduous Shrubland (NatureServe Unique ID: CES306.994) communities are similar to the Montane Sagebrush Steppe cover type, although deciduous shrub species are typically much more prevalent, often codominant with or dominant over mountain big sagebrush. Mountain shrub communities are in areas with better soil development, generally deeper soils, slightly higher available moisture, and higher precipitation and snow accumulation than true montane sagebrush steppe communities. Mountain shrub communities also have good drainage (i.e., water does not pool). In addition to mountain big sagebrush, the common shrub species include antelope bitterbrush, wax currant, and mountain snowberry. Other shrub species may include Woods' rose, rabbitbrush, other currants (*Ribes* spp.), and Oregon grape (*Mahonia aquifolium*). Herbaceous components are very similar to the Montane Sagebrush Steppe cover type, although Great Basin wildrye is usually more common.

Bitterbrush is considered a valuable forage shrub on many ranges occupied by wintering ungulates, including bighorn sheep and mule deer. Initially, fire suppression coupled with intensive spring perennial grazing by livestock appeared to favor bitterbrush establishment, growth, survival, and increased density (Salwasser 1979; Bunting et al. 1985); however, livestock overgrazing, senescence, extreme natural fire, and encroachment by big sagebrush has severely reduced bitterbrush abundance across much of its range (Murray 1983; see Ganskopp et al. 2004). Currently, diminished bitterbrush recruitment and reduced vigor are attributed mainly to the absence of disturbance, including fire (Adams 1975; Salwasser 1979; Bedunah et al. 2004). Plant age and vigor in particular can contribute to sprouting responses; shrubs less than 5 or greater than 60 years old do not sprout well (Martin and Driver 1983). Fire exclusion in many mountain shrub stands has resulted in western juniper and big sagebrush encroachment. Protection of old stands from fire resulting in excessive fuel accumulation, plant competition, and reduced sprouting capability, has increased the prevalence of extreme fire behavior, leading to damage or eradication of mountain shrub cover from fire across the Great Basin (Martin and Driver 1983). Other sources of disturbance include periodic defoliation by insects (e.g., tent caterpillar, grasshopper, tussock moth) and disease (e.g., root rot, fungus) (Dyer et al. 2007).

3.4.3 Grassland Communities (Perennial Grasslands)

Inter-Mountain Basins Semi-Desert Grassland (Nature Serve Unique ID: CES304.787) includes semi-desert steppes and grasslands characterized by sparsely to moderately vegetated mosaics of shrubs and perennial grasses. They occur in xeric lowland and upland areas, including swales, playas, plateau tops, alluvial fans, and plains. On the Refuge, substrates are relatively well-drained loamy-textured soils, derived from sedimentary, igneous, or metamorphic rocks. The herbaceous layer is dominated by drought-resistant perennial bunchgrasses, including bluebunch wheatgrass, Idaho fescue, Thurber’s needlegrass, Sandberg’s bluegrass, bottlebrush squirreltail, Great Basin wildrye, and prairie junegrass. Shrubs include sagebrush (both low and big, depending on underlying soil conditions and depths), bitterbrush, and rabbitbrush. Winterfat was also common historically, but most was lost on the Refuge due to its being highly preferred by domestic livestock; recovery has not yet occurred.

One confounding issue in identifying and mapping this habitat type is that it is also found in relatively recent burn scars on the Refuge, representing an early seral stage of several of the shrubland community types. Some of these areas have likely been transformed into permanent or very long-lasting perennial grasslands. Others may shift back to shrubland fairly quickly. Without historical and detailed ecological analyses, differentiating stable perennial grassland from one of these early seral stages is problematic.

A further compounding issue is that the composition and structure of semiarid or desert grasslands of western North America have changed dramatically over the past 150 years. Native brushy or woody species in these communities have increased in density and cover due to changes in local conditions (Van Auken 2000). Causes for shrub or woody plant encroachment in semiarid grasslands have been much debated and include climate change, chronic high levels of grazing, changes in fire frequency and intensity, changes in grass competitive ability, spread of seed by livestock, small mammal population changes, elevated levels of carbon dioxide (CO_2), and combinations of these factors (see Van Auken 2000).

Perennial grasslands are high-value grazing areas for ungulates, including bighorn sheep, pronghorn, and mule deer. White-tailed jackrabbits are closely associated with grasslands and other associated open shrub habitats. Perennial grasslands are also important breeding, foraging, and cover habitats for many declining bird species.

3.4.4 Woodland Communities

3.4.4.1 PONDEROSA PINE WOODLAND

Rocky Mountain Ponderosa Pine Woodland is dominated by ponderosa pine (*Pinus ponderosa*). It is generally viewed as a relict (or remnant) community type on the Refuge, remaining from when the climate was cooler and wetter in the Greater Sheldon-Hart area, now surviving only in protected sites with lower average temperatures and greater moisture. Pine stands on the Refuge include the approximately 80-acre Blue Sky stand at the confluence of Guano and Stockade Creeks, in the valley bottom below Warner Peak, and as small (generally <1 acre each) scattered patches in the headwater areas of some of the larger canyons on the escarpment (e.g., Degarmo, Potter, Hart).

The Refuge’s pine stands are important habitats for many migratory bird species, numerous owls and other raptor species, and a wide variety of invertebrate communities. They are important foraging, roosting, and over-wintering habitats for several bat species (see Tables 3.7–3.9). They are also commonly used by mule deer, coyotes, bobcats, cougars, and numerous rodent and mustelid species.

Bighorn sheep have never been observed using the Blue Sky stand. Some of the small escarpment stands may be used occasionally by bighorn sheep rams as thermal cover. This cover type will not be significantly affected by the proposed bighorn sheep management plan.

3.4.4.2 WESTERN JUNIPER SAVANNA

Inter-Mountain Basins Juniper Savanna (no NatureServe Unique ID) is a mix of both western juniper woodlands and savannas of widely varied ages. The closest NatureServe cover type is likely Columbia Plateau Western Juniper Woodland and Savanna (NatureServe Unique ID: CES304.082), though this has not been independently verified. There are multiple component association types within this group type likely represented on the Refuge (Figures H-20 and H-21).

The vegetation in western juniper woodlands and savannas is characterized by mature stands and old growth (>150 years in age) of western juniper, with an understory of open shrub-steppe (big sagebrush, bitterbrush, rabbitbrush, and low sagebrush) and deep-rooted perennial bunchgrasses representing the dominant species (Miller et al. 2005; Miller et al. 2019; NatureServe 2020). Younger juniper stands (<150 years in age) are now common within and around the mature stands of juniper. Big sagebrush is the most common understory shrub species, with the subspecies being driven by the climatic, hydrologic, and soil conditions present at a given site. The most common perennial bunchgrasses associated with juniper habitats are Idaho fescue, bluebunch wheatgrass, Thurber’s needlegrass, prairie junegrass, bottlebrush squirreltail, and Sandberg’s bluegrass.

Juniper woodland’s value to wildlife tends to vary with the age of the trees as well as the density of the stand. Old-growth juniper tends to have the highest value, providing cover, nesting, roosting, and hibernating habitat for a wide variety of species, including migratory birds, raptors, numerous species of bats, lizards, and invertebrates. Old trees are also often used as cover habitat by cougar, coyotes, bobcats, mule deer, and a host of small mammals. Old-growth western juniper trees provide biodiversity and genetic pools, and long-term climatic records (Waichler et al. 2001). Post-settlement (i.e., <150 years old) juniper are also often used, but to a lesser degree than old growth. Bighorn sheep ewes tend to avoid juniper, especially during lambing seasons, though they will occasionally use individual or small clumps of trees for thermal cover outside of the lambing period. Payer (1992) reported that 21 collared rams followed for 31 months on the Refuge used habitats with western juniper, but ewes seldom did.

Mature stands of western juniper exhibit considerable diversity in structure and composition, varying from open-shrub tree savannas to nearly closed-canopy woodlands; however, tree canopy cover in the majority of stands is less than 20% (Table 3.11). A key indicator of mature western juniper woodland is the presence of old-growth trees, standing and fallen dead snags, and recruitment of younger trees (Miller et al. 2007; Miller et al. 2014). The oldest trees and juniper woodland areas tend to occur in rockier areas with lower fire frequency, while the younger stands tend to occur in areas that had historically been shrub-steppe habitats with historically greater fire return frequency (Miller et al. 2005; Miller et al. 2019). Occasionally old-growth trees are found growing in deeper, well-drained soils associated with mountain big sagebrush–grassland communities but are usually absent from aspen communities (Miller and Rose 1995; Miller et al. 2019). Juniper recruitment declines with woodland maturity because of a decrease in favorable germination conditions as shrubs die out and intra-specific competition increases (Miller et al. 2005). On some more arid sites, juniper woodland development has led to desertification and reduction in site productivity and understory structure (Miller et al. 2000).

Table 3.11. Approximated Changes in Overstory Canopy Cover Acreages within Bighorn Sheep Habitats on Hart Mountain National Antelope Refuge, 1964–2012

Canopy Cover Data Source*	**Total Acres†**	**Core Bighorn Sheep Habitat‡**		**Core Nursery Areas§**	**On-Refuge Water Limits (Simple Buffers)¶,#**		
		Escape Terrain	**Forage Terrain**		**Lambing (within 0.62 mile)****	**General Ewe (within 1.99 miles)††**	**Ram (within 4.35 miles)‡‡**
USGS topographic quadrangle canopy (based on 1964 imagery)	6,359	1,552	862	207	731	1,866	1,348
Sage Grouse Initiative (SGI) canopy (based on 2012 imagery)	79,757	11,184	13,287	3,215	8,508	23,055	23,723
<1% canopy cover (and >0% canopy cover)§§	*56,927*	*3,722*	*9,596*	*1,635*	*6,866*	*16,690*	*20,053*
1–4% canopy cover	*8,985*	*2,289*	*1,546*	*624*	*575*	*2,406*	*2,169*
4–10% canopy cover	*7,796*	*2,714*	*1,262*	*583*	*490*	*2,196*	*1,134*
10–20% canopy cover	*5,243*	*2,156*	*776*	*329*	*508*	*1,486*	*317*
20–50% canopy cover	*806*	*303*	*107*	*44*	*69*	*277*	*50*
USGS and SGI canopy cover overlap (woodland and in-fill areas)	5,156	1,494	798	191	681	1,384	798
1–4% canopy cover	*940*	*109*	*101*	*34*	*81*	*303*	*346*
4–10% canopy cover	*1,771*	*438*	*296*	*68*	*176*	*500*	*361*
10–20% canopy cover	*1,971*	*753*	*325*	*66*	*358*	*458*	*77*
20–50% canopy cover	*473*	*194*	*76*	*23*	*66*	*123*	*14*
SGI canopy cover only (juniper encroachment areas)	74,601	9,690	12,489	3,024	7,827	21,671	22,924
<1% canopy cover (and >0% canopy cover)§§	*56,927*	*3,722*	*9,596*	*1,635*	*6,866*	*16,690*	*20,053*
1–4% canopy cover	*8,045*	*2,180*	*1,445*	*590*	*494*	*2,103*	*1,823*
4–10% canopy cover	*6,025*	*2,276*	*966*	*515*	*314*	*1,696*	*773*
10–20% canopy cover	*3,271*	*1,403*	*451*	*263*	*150*	*1,028*	*239*
20–50% canopy cover	*333*	*109*	*31*	*21*	*3*	*154*	*36*
USGS canopy only (areas of non-juniper and/or lost canopy)	1,203	58	64	16	50	481	550
Totals¶¶	**80,960**	**11,242**	**13,351**	**3,231**	**8,558**	**23,536**	**24,272**

* USGS canopy cover data were hand-digitized from 1967 data series topographic maps (7.5-minute quadrangle, or 1:24,000-scale, all originally created using 1964 imagery). Because the USGS maps did not differentiate canopy cover by species, juniper canopy acres are inflated by areas of mountain mahogany, other conifers, and riparian species (such as aspen [*Populus Tremuloides*]). The SGI canopy cover data were produced for the SGI by Falkowski et al. (2017) and downloaded from the SGI resource map webpage (SGI 2017). These data have not been field tested to determine statistical accuracy but are the best available.

† Total acreages are the sum of the escape terrain, forage terrain, and the lambing, general ewe, and ram water limit values.

‡ Given acreages are only for each specific bighorn sheep habitat use category. Total core bighorn sheep habitat acreages should be calculated by totaling the escape terrain and forage terrain values.

§ Core nursery areas are bighorn sheep specialty use areas within the larger bighorn sheep habitat area (i.e., areas only selected by ewes with lambs during parturition and/or early rearing) that overlap both escape and forage terrains and are thus not included in the total acreages.

¶ Overstory canopy cover outside of the Refuge boundary was not evaluated because vegetation cover type data are not available for water limit areas outside of the Refuge boundary and no treatments are proposed for these areas under this management plan.

We do not yet have sufficient bighorn sheep location histories or resolution to be able to identify or discern patterns in movements or water usage by bighorn sheep, nor to predict (model) these patterns within the larger landscape with any statistical relevance. As such, these distances had to be taken from literature sources and incidental observations of the Refuge bighorn sheep population, necessitating simplicity in mapping these outer limits. Water limits were modeled as simple buffers using the Multiple Ring Buffer tool in the Proximity toolset within the Analysis toolbox of ArcGIS 10.7.1. Reported acreages are only those that occur within the given ring buffer.

** The lambing water limit includes all potential areas used by ewes with lambs from parturition through dispersal, not just the early season nursery habitats, based on literature values of outer limits for water availability/use. Total lambing (i.e., ewes with lambs) water limit acreage should be calculated by adding the escape terrain, forage terrain, and the lambing water limit values.

†† The general ewe water limit includes all potential areas used by ewes without lambs or with older-aged (weaned) lambs, based on literature values of outer limits for water availability/use. Total general ewe water limit acreage should be calculated by adding the escape terrain, forage terrain, and the lambing and general ewe water limit values.

[‡‡] The ram water limit is based on incidental observations of bighorn sheep ram water source use on the Refuge as reported by Payer (1992). Total ram water limit acreage should be calculated by adding the escape terrain, forage terrain, and the lambing, general ewe, and ram water limit values.
[§§] The SGI canopy cover source data do not make a distinction between areas with very low canopy cover and areas with no juniper occurrence, primarily due to the inherent limitations in being able to make this distinction using only remote-sensing data. As such, the <1% canopy cover (and >0% canopy cover) category acreage is estimated based on NAIP imagery and institutional knowledge of juniper occurrence on Hart Mountain NAR. These estimates are likely an overestimation of the acreage of areas actually within this category (i.e., areas actually without juniper are likely included in the totals for this classification).
[¶¶] Total acreages determined by summing USGS and SGI canopy cover overlap (woodland and in-fill areas), SGI canopy cover only (juniper encroachment areas), and USGS canopy only (areas of non-juniper canopy and/or lost canopy).

Numerous inventories and studies have demonstrated a rapid expansion of western juniper into adjacent sagebrush habitats since the late 1800s (Miller et al. 2019). Over 90% of the existing western juniper woodlands have developed in the last 120 years; only 3 to 5% of existing woodlands are considered old growth (Johnson 2005; Miller et al. 2008) (Figures H-18 and H-19). This expansion is primarily the result of changes in climate and in the natural fire regime, and the removal of fine fire fuels through grazing by livestock (Eddleman et al. 1994; Miller et al. 2019). Younger trees have filled in between larger old trees creating much higher tree densities than historically occurred (Miller et al. 2008). Western juniper is a strong competitor and can drastically alter or eliminate the understory component by encroachment. Conversion of sagebrush communities to juniper woodlands has severely reduced the extent and quality of the sagebrush-steppe ecosystem (Suring, Wisdom et al. 2005b). Juniper expansion into deep, well-drained soils, where they historically were not abundant, results in increased soil erosion, reduced stream flows due to juniper transpiration, reduced forage production, and the replacement of mesic and semiarid plant communities with woodlands (Miller et al. 2005). The replacement of aspen, riparian, and mountain big sagebrush communities by western juniper may have detrimental effects on wildlife populations dependent upon these habitats. Juniper encroachment is detrimental to sagebrush-obligate wildlife species because of the loss of sagebrush, fragmentation of sagebrush habitats, acceleration of soil erosion, potential decreases in herbaceous forage, and increased predation (see summary by Davies et al. 2011).

On the Refuge, juniper stand acreage has more than doubled since 1964 based on quantitative comparison of 1964 and 2012 imagery (Falkowski et al. 2017) (see Table 3.11). Photos from the late 1930s (Refuge files; also Gruell 1995) and qualitative reports of conditions on the Refuge in the 1860s through the settlement period (e.g., Shaver et al. 1905) also indicate significant juniper increase in extent and density since those dates (Figures H-16 and H-17).

In summary, sub-dominance of western juniper can be beneficial for many wildlife species, but increasing dominance at both the community and landscape levels has resulted in a general decline in landscape and plant community diversity and a subsequent decline of wildlife abundance and diversity (Miller et al. 2005). Identifying specific impacts of this expansion on Refuge resources and development of management action triggers are in progress. Impacts are evaluated using metrics identified by Miller et al. (2005, 2007, 2014, 2015), Chambers, Bradley et al. (2014); Chambers, Miller et al. (2014); Chambers, Pyke (2014); and Chambers et al. (2016), among others, and results are used to develop responsive management prescriptions. Metrics include qualitative descriptions of the juniper phase of development; native and invasive community components; signs of erosion; fuel characteristics; and quantitative measures of juniper stem density, bunchgrass frequency, horizontal visibility, shrub cover, and R&R scoring (see Section 3.5.2).

The Service has been working to control encroaching juniper from several areas of sagebrush-steppe on the Refuge since the early 1990s, focusing on areas of post-settlement juniper in generally deeper soils with dominant sage-steppe understories. Removals were done to improve the resiliency of the shrub habitats by removing fuel load to reduce residency and intensity of fire should a wildfire burn through the area, and to restore and protect the health and integrity of desirable sagebrush-steppe vegetation in areas known to be important sage-grouse habitat. Before 2011 these efforts were generally small in acreage, using a limited pool of Service personnel. Beginning in 2011 the Service began contracting with commercial forestry crews to conduct hand removal using chainsaws and loppers, which allowed larger areas to be cleared.

Between 2001 and 2020, encroaching juniper has been removed from approximately 2,346 acres within core bighorn sheep habitats, and approximately 20,058 acres within Refuge bighorn sheep habitats (Table 3.12 and Figure C-7). Encroaching juniper is estimated to remain within approximately 14,491 acres of bighorn sheep habitats, with sparse to extremely sparse encroaching juniper (i.e., areas of <1% cover) estimated to occur in an additional approximately 41,381 acres, though ground assessments are needed to confirm these estimates. The habitat management alternative of the bighorn sheep management plan proposes to remove post-settlement juniper from up to approximately 11,275 acres of accessible bighorn habitats, averaging about 1,500 acres per year, to benefit bighorn sheep. Encroaching post-settlement juniper would also likely be removed from sparse and very sparse areas as it is encountered during the proposed removal efforts in order to maintain these cover types. Depending on seed banks and neighboring sources, as well as other perturbating stochastic events such as wildfire, juniper will likely have to be controlled on a 20 to 40–year cycle to maintain the sagebrush steppe as new junipers sprout and threaten to degrade the shrub habitats.

Table 3.12. Acres of Juniper Removal within Bighorn Sheep Habitats on Hart Mountain National Antelope Refuge Since 2001

Bighorn Sheep Habitat Type	Acres of Removed Encroaching Juniper*	Acres of Encroaching Juniper to Potentially Be Removed†
Refuge bighorn sheep habitat	20,058	14,491 (*11,275*)†
Core bighorn sheep habitat	2,346	8,542 (*5,326*)†
Escape terrain	433	5,781
Forage terrain	1,913	2,761
Lambing water limit‡	2,438	882
General ewe water limit§	9,399	3,067
Ram water limit¶	5,875	1,999
Core nursery areas#	0	1,369

* Acreage totals represent absolute totals rather than aggregate totals in that they only count areas receiving treatment and do not reflect secondary or follow-up treatments within the same given area.
† An estimated 3,216 acres of areas of encroaching juniper within core bighorn sheep habitat are believed to be inaccessible for removal and are thus not included in the proposed removal acreage (acres used in totaling proposed removal acreage included in parentheses).
‡ The lambing water limit includes all potential areas used by ewes with lambs from parturition through dispersal, not just the early season nursery habitats, based on literature values of outer limits for water availability/use. Total lambing (i.e., ewes with lambs) water limit acreage should be calculated by adding the escape terrain, forage terrain, and the lambing water limit values.
§ The general ewe water limit includes all potential areas used by ewes without lambs or with older-aged (weaned) lambs, based on literature values of outer limits for water availability/use. Total general ewe water limit acreage should be calculated by adding the escape terrain, forage terrain, and the lambing and general ewe water limit values.
¶ The ram water limit is based on incidental observations of bighorn sheep ram water source use on the Refuge as reported by Payer (1992). Total ram water limit acreage should be calculated by adding the escape terrain, forage terrain, and the lambing, general ewe, and ram water limit values.
# Core nursery areas are bighorn sheep specialty use areas within the larger bighorn sheep habitat area (i.e., areas only selected by ewes with lambs during parturition and/or early rearing) that overlap both escape and forage terrain and are thus not included in the total acreages.

3.4.4.3 MOUNTAIN MAHOGANY WOODLAND AND SHRUBLAND

Inter-Mountain Basins Curl-Leaf Mountain-Mahogany Woodland and Shrubland (NatureServe Unique ID: CES304.772) is dominated by curl-leaf mountain mahogany (*Cercocarpus ledifolius*). These stands occupy exposed rocky outcroppings, escarpments, and ridges associated with late-enduring snowbanks, exposed bedrock, and higher elevations or ridges. Mountain mahogany is a slow-growing, drought-tolerant species that generally does not resprout after burning and needs the protection from fire that rocky sites and sparse vegetative growth provide. Soils are variable in texture but typically have low fertility. Sites are usually hot and dry. Mountain big sagebrush, Wyoming big sagebrush, antelope bitterbrush, low sagebrush, and scattered juniper may also occur depending on site conditions and surrounding habitats. Snowberry, wax currant, and Woods’ rose can also occur despite the typical site conditions. Common associates include Thurber’s needlegrass, prairie junegrass, Sandberg’s bluegrass, Idaho fescue, and lupines. Undergrowth is often very sparse. This system includes both woodlands and shrublands, distinguished primarily by the size of the mahogany plants and degree of shrub and grass presence. Most stands occur as shrublands on ridge tops and steep rimrock slopes, or as small trees in steppe areas.

Mountain mahogany serves as important thermal cover for mule deer, pronghorn, and bighorn sheep (primarily rams). It also provides important winter forage (see Table 3.3). Leckenby et al. (1982) concluded that dense stands of trees or shrubs over 5 feet tall provided optimal thermal cover; however, these taller stands provide minimal food resources. Other species occurring in these habitats include cougar, bobcat, North American porcupine (*Erethizon dorsatum*), bushy-tailed woodrat, golden-mantled ground squirrel, Great Basin pocket mouse, hoary bat, and least chipmunk. These stands provide habitat for reptiles, including pygmy short-horned lizard and western yellow-bellied racer.

Like some of the other woodland cover types, mountain mahogany stands have exhibited dramatic increases in density and distribution in the last century or more attributed to fire exclusion and livestock grazing, which diminished competing grasses and shrubs (Gruell 1995, 1999). On the Refuge, approximately 88% of the stands sampled are estimated to have been established after 1900 (Gruell

1995). Stands that are dominated by older trees may have crowns too tall for wildlife to browse and not be conducive to recruitment of new plants. Factors that may limit natural seedling establishment include the presence of mountain mahogany litter that inhibits seed germination, competition for water and soil resources, and browsing of seedlings (see summary by Ibáñez et al. 1999). If natural fire were to enter these stands in their current overgrown conditions, it is likely that most or all mountain mahogany would be killed by the intense heat and these areas would be lost as valuable wildlife cover, forage, and nesting habitat.

3.4.4.4 ASPEN FOREST AND WOODLAND

Rocky Mountain Aspen Forest and Woodland (NatureServe Unique ID: CES306.813) includes woodlands along riparian habitats, in lithic areas, or within snow pockets dominated by quaking aspen and/or willow (*Salix* spp.). Distribution of this cover type is primarily limited by inadequate soil moisture to meet its high evapotranspiration demand. Quaking aspen is further limited by solar exposure and topographic shading, being generally restricted to higher elevations and protected areas with only partial exposure to sun during the day, such as narrow drainages or northerly exposures of table rimrock. The understory structure may be complex, with multiple shrub and herbaceous layers; or simple, with only an herbaceous layer. The herbaceous layer may be dense or sparse, and dominated or codominated by forbs and graminoids. Common shrubs found in these woodlands include currants, snowberry, Woods' rose, chokecherry (*Prunus virginiana*), oceanspray (*Holodiscus discolor*), serviceberry (*Amelanchier* spp.), and red-osier dogwood (*Cornus sericea*). Herbaceous layers are highly variable and diverse, and can include sedges, rushes, grasses, and forbs adapted for shade and moist or saturated soils.

Decades of livestock overuse and exclusion of fire have resulted in extensive loss of riparian woodlands (particularly aspen stands) and ecologically degraded conditions for much of what remains in the Intermountain West, including the Refuge (Schier 1975; Dobkin 1994; Fleischner 1994; Heltzel and Earnst 2006). For example, Wall et al. (2001) reported that three-fourths of aspen communities below elevations of 7,000 feet in the Great Basin have either been replaced or are being encroached by western juniper. Fire has been reported to be an important factor in facilitating the long-term presence and health of aspen across the landscape; disease, insects, and native browsing also influence the age structure (see Wall et al. 2001). Historically, total stand replacement in aspen woodlands was estimated to occur every 100 years, on average, with smaller disturbances every 16 years (Wall et al. 2001).

After removal of grazing from the Refuge in 1994, the aspen and willow woodlands have largely started to recover. Many of the aspen stands have been assessed for condition within the last 10 years (see Collins 2018). These woodlands are largely considered to be in fair to good condition, most with fair to good reproduction, primarily through sucker growth; however, selected stands are known to be in moderate to severe decline, largely due to changes in moisture availability and encroachment by dryland shrubs (primarily sagebrush) and juniper (Collins 2018). Willow stands have not been specifically assessed but are believed to be increasing and improving since removal of grazing pressure (Ballard 2010; Poessel et al. 2020).

The aspen woodland community type provides important habitat for many species occurring on the Refuge. Known or suspected breeding birds using aspen stands include ash-throated flycatcher (*Myiarchus cinerascens*), dusky flycatcher (*Empidonax oberholseri*), blue-gray gnatcatcher (*Polioptila caerulea*), broad-tailed hummingbird (*Selasphorus platycercus*), calliope hummingbird (*Selasphorus calliope*), rufous hummingbird (*Selasphorus rufus*), Cassin's finch (*Haemorhous cassinii*), lazuli bunting (*Passerina amoena*), Lewis' woodpecker (*Melanerpes lewis*), northern flicker (*Colaptes auratus*), northern oriole (*Icterus galbula*), Swainson's thrush (*Catharus ustulatus*), warbling vireo (*Vireo gilvus*), MacGillivray's warbler (*Geothlypis tolmiei*), orange-crowned warbler (*Vermivora celata*), yellow warbler (*Setophaga petechia*), and tree swallow (*Tachycineta bicolor*). Many non-breeding birds also use aspen woodlands.

Several species of mammal also occur in this habitat type, including cougar, bobcat, coyote, North American porcupine, long-tailed weasel (*Mustela frenata*), ermine (*Mustela erminea*), mountain cottontail, yellow pine chipmunk (*Tamias amoenus*), fringed myotis, little brown myotis, western small-footed myotis, Preble's shrew (*Sorex preblei*), and vagrant shrew (*Sorex vagrans*). In addition, mule deer utilize these woodlands for resting, foraging, and cover, including during fawning. Bighorn sheep use of aspen stands is not entirely known, though rams have been observed using them in the summer, likely as cover habitat.

3.4.5 Wetland and Aquatic Communities

Wetland and aquatic habitats in western rangelands have exceedingly high values for human society, fish, and wildlife, disproportionate to the approximate 0.1% of the land area they cover (Ohmart 1996). These areas serve to trap and stabilize eroded sediments, detoxify compounds, act as phosphorus sinks for soil enrichment, and serve as denitrification areas to provide high water quality (Ohmart 1996). Wetland areas are also the most ecologically productive and diverse of all terrestrial habitats. This results from a relative abundance of water in a variety of physical environments arising from moisture gradients supporting diverse vegetation components, and a general mosaic of seral stages created by dynamic stream morphology (Clary and Medin 1999). Wetland habitats are particularly important in the arid Refuge environment by providing water and relatively cool, often shaded conditions critical to many species of native flora and fauna (Ohmart 1996; Clary and Medin 1999). Because many desert aquatic species are dependent on ephemeral, saline, or geothermal wetland habitats, prolonged human disturbance of them has resulted in the loss of biodiversity in the Great Basin (Herbst 1996).

On the Refuge, the most reliable water sources are natural springs and associated spring brooks, the majority of which are located between 5,700 and 6,700 feet in elevation. See Section 3.2.3 for a more detailed description of water sources and hydrology within bighorn sheep habitats on the Refuge. Wetlands on the Refuge include wet meadows, emergent marshes, and open water marshes.

Most meadow and many wetland and riparian communities were heavily grazed when cattle were allowed on the Refuge. Since removal of cattle from the Refuge in 1994, wetland, riparian, and snowpocket aspen, native forb cover, and mesic shrub cover have all significantly increased, whereas sagebrush encroachment in riparian areas has decreased (Earnst et al. 2012). Indicators of riparian health, including bank stability, stream morphology, ecological stability, and plant community integrity all improved following the removal of livestock (Ballard 2010; Poessel et al. 2020). Most notably, changes in riparian woody community types, such as increased willow densities and decreased non-riparian shrub densities (e.g., sagebrush, rabbitbrush) have been documented (Ballard 2010; Earnst et al. 2012). These vegetative changes indicate a shallower depth to groundwater and improved riparian condition (Dobkin et al. 1998; Wright and Chambers 2002).

Wetland and aquatic habitats on the Refuge provide important habitat for a wide variety of resident and migratory birds. Although most shorebirds using Refuge wetlands are spring and fall migrants, species including American avocet (*Recurvirostra americana*), American bittern (*Botaurus lentiginosus*), killdeer (*Charadrius vociferus*), Virginia rail (*Rallus limicola*), sora (*Porzana carolina*), black-necked stilt (*Himantopus mexicanus*), long-billed curlew (*Numenius americanus*), spotted sandpiper (*Actitis macularius*), willet (*Tringa semipalmata*), Wilson's phalarope (*Phalaropus tricolor*), and common snipe (*Gallinago gallinago*) are known to nest on the Refuge around permanent water sources. Other common waterbird species that occur seasonally in Refuge aquatic habitats are sandhill crane (*Grus canadensis*), black-crowned night heron (*Nycticorax nycticorax*), double-crested cormorant (*Phalacrocorax auritus*), Forster's tern (*Sterna forsteri*), black tern (*Chlidonias niger*), snowy plover (*Charadrius nivosus*), greater and lesser yellowlegs (*Tringa melanoleuca* and *Tringa flavipes*), sandpipers (least [*Calidris minutilla*], solitary [*Tringa solitaria*], and western [*Calidris mauri*]), and grebes (Clark's [*Aechmophorus clarkii*], eared [*Podiceps nigricollis*], horned [*Podiceps auritus*], pied-billed [*Podilymbus podiceps*], and western [*Aechmophorus occidentalis*]). These habitats also provide foraging areas for a range of seasonally resident and migrating raptors, including American kestrel (*Falco sparverius*), bald and golden eagles, ferruginous hawk, northern harrier (*Circus hudsonius*), rough-legged hawk (*Buteo lagopus*), Swainson's hawk (*Buteo swainsoni*), short-eared owl, and western screech owl (*Megascops kennicottii*). Passerines also occupy these habitats and include bobolink (*Dolichonyx oryzivorus*), Brewer's blackbird (*Euphagus cyanocephalus*), red-winged blackbird (*Agelaius phoeniceus*), calliope hummingbird, rufous hummingbird, savannah sparrow (*Passerculus sandwichensis*), fox sparrow (*Passerella iliaca*), vesper sparrow (*Pooecetes gramineus*), and western bluebird (*Sialia mexicana*). Several species of waterfowl also nest on the Refuge, including Canada goose (*Branta canadensis*), canvasback (*Aythya valisineria*), gadwall (*Mareca strepera*), mallard (*Anas platyrhynchos*), northern pintail (*Anas acuta*), northern shoveler (*Spatula clypeata*), redhead (*Aythya americana*), ruddy duck (*Oxyura jamaicensis*), blue-winged teal (*Anas discors*), green-winged teal (*Anas carolinensis*), and cinnamon teal (*Anas cyanoptera*).

Wetland habitats provide essential habitat for a variety of small mammals, including Preble's shrew, Merriam's shrew (*Sorex merriami*), vagrant shrew, water shrew (*Sorex palustris*), montane vole (*Microtus montanus*), Belding's ground squirrel (*Urocitellus beldingi*), and white-tailed antelope ground squirrel (*Ammospermophilus leucurus*). In addition, these habitats provide important foraging areas for bighorn sheep, mule deer, porcupine, striped skunk, hoary bat, spotted bat, and little brown myotis. Additionally, occurrences of river otter (*Lontra canadensis*) and muskrat (*Ondatra zibethicus*) in aquatic habitats have been reported though are believed rare.

3.4.5.1 WET MEADOWS

Rocky Mountain Subalpine-Montane Mesic Meadows (NatureServe Unique ID: CES306.829) occur in areas with finely textured soils that are seasonally moist or saturated in the spring to early summer and are dominated by wetland-dependent plant species such as sedges, rushes, and spikerushes, as well as numerous grass species. Saturated surface soils in wet meadows will often dry out later in the growing season, although water tables usually remain near the surface year round. On the Refuge, wet meadows occur on gentle to moderate slopes typically associated with perennial streams and springs, such as Rock and Guano Creeks and their tributaries. The largest meadows are primarily found within the flood plains adjacent to the larger streams within the Refuge. Small wet meadow communities (<3 acres in size) occur below high elevation springs and seeps and associated spring brooks, or below annually persistent snowbanks.

Large meadows on the Refuge that were historically heavily grazed suffered from loss of vegetation diversity and cover, soil compaction, and systemic changes to their hydrology, which increased stream sedimentation and water temperatures in their associated creeks. In the absence of grazing, willow density and distribution has increased stream shading and has stabilized soils along several portions of Rock and Guano Creeks, though not to pre-disturbance conditions (Ballard 2010; Poessel et al. 2020). Smaller meadows that were grazed also suffered some degree of damage and are believed to have largely recovered their function, but sufficiently detailed historical data to confirm this are unavailable.

There have been approximately 17 species of sedge, four species of rush, and two spikerushes identified in the wet meadow communities on the Refuge. Although usually not dominant within the community, forbs are a large and critical component providing diversity to support complex ecological relationships. Forb diversity is also one of the primary metrics used to identify and value a wet meadow's overall health. Although hundreds of species of forbs have been identified within the wet meadows, several of the more important taxa include daisies and other asters (Asteraceae), bluebells (*Hyacinthoides* spp.), penstemons, lupines, goldenrod (*Solidago* spp.), yarrow (*Achillea millefolium*), wild iris (*Iris* spp.), and camas (*Camassia* spp.). Horsetail (*Equisetum hyemale*) is also sometimes common in smaller, protected meadows in the escarpment canyons and other protected basaltic valleys, usually in close association with willow or aspen stands (see Section 3.4.4.4).

Wet meadows are extremely important habitats for many species of wildlife on the Refuge for forage value, cover, available water, and many other functions. Pronghorn and mule deer make extensive use of the meadows, primarily for forage and cover. Bighorn sheep are known to use some of them preferentially as forage areas during much of the year. Many raptor species, migratory songbirds, marsh birds, sandhill cranes, and many other bird species are reliant on wet meadows, as are many of the Refuge's mammal species, from mice to coyotes. Greater sage-grouse also show a strong preference for wet meadows from fledging through late summer, primarily attracted to the quality forb forage and insect availability. Bats use wet meadows as primary foraging areas, also attracted to the large insect community on the meadows. Hymenoptera (bees, wasps, ants), Lepidoptera (moths and butterflies), and numerous other pollinator species also rely on wet meadows.

3.4.5.2 EMERGENT AND OPEN WATER MARSH

North American Arid West Emergent Marsh (NatureServe Unique ID: CES300.729) and open water marsh (no NatureServe Unique ID) share many characteristics with wet meadows, although generally retain more water longer. Emergent marshes are usually perennial shallow water areas that permit vegetative growth throughout most of their surface. Open water marshes are perennial water areas with enough depth to limit the amount of emergent vegetative growth, generally having less than 25% cover of vegetation or bare soil. Water levels may fluctuate significantly through the year depending on water source, feature depth, and weather, though are usually perennial except during extended periods of extreme drought. Marsh soils are typically mineral-based but high in organic matter content, though usually without forming peat.

Common emergent vegetation includes cattails, bulrush (both *Schoenoplectus* and *Scirpus* spp.), and some species of rush. Open water marsh also often has submerged or floating vegetation, such as pondweed (*Potamogeton*), knotweed (*Polygonum*), water crowfoot (*Ranunculus aquatilis*), and duckweed (*Lemna*). Emergent marshes are important breeding, cover, and foraging habitats for numerous species of marsh birds and migratory songbirds. Open water marshes are important feeding and resting areas for waterfowl and other water birds. They are also extensively used by several bat species for water and for foraging due to the high prevalence of insect species. Both habitat types are important water and forage areas for other mammal species, such as mule deer, coyotes, bobcats, cougars, and others. Bighorn sheep are known to use these features as water sources.

3.4.6 Salt Desert Communities

3.4.6.1 GREASEWOOD FLATS AND SALT DESERT SCRUB

Inter-Mountain Basins Greasewood Flat (NatureServe Unique ID: CES304.780) and Inter-Mountain Basins Mixed Salt Desert Scrub (NatureServe Unique ID: CES304.784) cover types are primarily defined by their substrate and by the dominant and codominant shrub species. They generally occur as a mosaic of communities interspersed on alkaline or moderately saline soils with a shallow water table that floods intermittently but remains dry for most growing seasons. The water table remains high enough to support vegetation that can tolerate salt accumulations. Variability of seasonal precipitation will affect spring plant growth. These cover types typically occur near drainages on stream terraces and flats or may form rings around more sparsely vegetated playas.

The greasewood flat type is comprised of open to moderately dense shrublands dominated or codominated by black greasewood (*Sarcobatus vermiculatus*). The salt desert scrub community type often includes few greasewoods, being typically dominated by other salt-tolerant shrub species, such as spiny hopsage (*Grayia spinosa*), shadscale saltbush (*Atriplex confertifolia*), horsebrush (*Tetradymia*), or winterfat. Wyoming big sagebrush, basin big sagebrush, rabbitbrush (both *Chrysothamnus* and *Ericameria* spp.), and silver sagebrush may also be codominant or common in both habitat types depending on site conditions and history. If present, the herbaceous layer for both types is usually dominated by grasses. Common herbaceous species include Sandberg's bluegrass, Indian ricegrass (*Achnatherum hymenoides*), needle-and-thread, saltgrass (*Distichlis spicata*), bottlebrush squirreltail, and Great Basin wildrye.

Moisture supporting these intermittently flooded habitats is usually derived off-site, and they are dependent upon natural watershed function for persistence (Reid et al. 1999). The length and severity of drought in the Great Basin has increased since the beginning of the twentieth century, likely increasing stress on this community type. Disturbance events are generally unpredictable and include drought (mean frequency 1 per 70 years), flooding (mean frequency 1 per 100 years), and fire (ranging from 1 per 150–1,000 years), and stand-replacing fire is rare. Historic overgrazing by livestock on the Refuge contributed to an increase of shrubs on these sites, resulting in significant areas of Great Basin wildrye stands being converted to greasewood-dominated types. Upland salt desert shrub and greasewood communities are also easily invaded and may be quickly replaced by cheatgrass and other invasive plant species (e.g., *Halogeton* spp.). The invasion of cheatgrass has altered fire behavior and frequency in these community types.

3.4.6.2 PLAYA

Inter-Mountain Basins Playas (NatureServe Unique ID: CES304.786) are found within the playa feature type (see Section 3.2.3.4). It is defined by being mostly barren to sparsely vegetated (generally <10% cover) within an undrained playa basin. Salt crusts are common throughout, with small saltgrass beds in depressions and sparse shrubs around the margins. These systems are intermittently or ephemerally flooded. Playas are formed and maintained through a combination of dissolution of subsurface basin material and wind deflation (Osterkamp and Wood 1987; Gustavson et al. 1995; Reeves and Reeves 1996). These processes concentrate salts and clay minerals in playa soils, making them more alkaline, and reduce water infiltration. The water is further prevented from percolating through the soil by an impermeable soil sub-horizon and is held to evaporate. As a result, playa habitats may become flooded after even a small amount of precipitation. Soil salinity varies greatly with soil moisture and greatly affects species composition.

Because playa hydrology is determined by localized weather conditions, playas may be flooded seasonally or annually for several consecutive years or may be dry for a number of years and flooded only rarely. Water depth ranges from only a thin film to several inches of water. During flooded conditions, typically during spring, playas teem with aquatic invertebrates. These invertebrates provide important forage for migrating birds. As playas begin to dry later in the season, the moist soils support grasses, sedges, and forbs, which provide forage for pronghorn, deer, sage-grouse, and likely bighorn sheep. Little information is available related to playa formation and ecology, but for the Southern High Plains region of Texas and New Mexico, Haukos and Smith (2003) stated that because scattered individual playas collectively form the basis for diversity of the region, impairment of an individual playa contributes disproportionately to the decline of biodiversity across a much larger area. Although differences exist, there is sufficient ecological similarity that this standard likely holds for playas in other regions, including the northern Great Basin (and, consequently, Hart Mountain NAR). Therefore, a successful conservation strategy depends upon protection of as many playas as possible in the landscape rather than prioritizing only a select few.

Short-lived or briefly-showing salt-tolerant perennial forbs and annuals exist across much of the playa surface when conditions allow (see Albert 2017, 2018; Larson 2018). In wetter playas the most common plants are spikerush, bulrush (both *Schoenoplectus* and *Scirpus* spp.), and occasionally cattail (*Typha* spp.). As the playas dry, these are often replaced by other forbs, including calicoflower (*Downingia*), suncup/primrose (*Camissonia*), western marsh cudweed (*Gnaphalium palustre*), knotweed, and desert combleaf (*Polyctenium fremontii*). The margins and high points of the playa habitats often have salt-tolerant shrub species, most commonly silver sagebrush, rabbitbrush (both *Chrysothamnus* and *Ericameria* spp.), spiny hopsage, and black greasewood; as well as graminoids, including saltgrass, Sandberg’s bluegrass, and squirreltail.

Most of the playa water features on the Refuge have been modified to increase water availability, primarily through construction of dugouts and related structures (see Section 3.2.3.3). This has significantly altered the hydrology of the features, which has also altered the playa vegetation. Shrub encroachment increases in invasive annual species, and reductions in native playa forbs commonly occurs.

3.4.7 Invasive Species

Native plant communities within the sagebrush steppe are extraordinarily susceptible to invasion by non-native species (e.g., Jardine and Anderson 1919, as cited in Young et al. 1972). Invasive non-native species are those that establish, persist, and propagate in their new environment and are likely to cause economic or environmental harm (EO 13112 [1999]; Beck et al. 2006). From a natural resource management perspective, a non-native plant species is harmful when it interferes with an area’s management goals and purposes. On the Refuge, invasive plant species displace native plants, alter the composition and structure of plant communities, affect food webs, and modify ecosystem processes such as fire regimes or hydrological cycles (Mack 1986; Olson 1999; Reisner et al. 2013).

The spread of invasive plant species across the Great Basin was facilitated by the rapid expansion and increase in grazing and associated land-use practices that resulted from European exploration and settlement in the American West (Knapp 1996; Chambers et al. 2007; Morris and Rowe 2014). Invasive plants are most likely to become established where native vegetation has been disturbed; e.g., intensively grazed sites, cabin sites, campgrounds, hiking trails, off-road tracks, roads, and fire suppression lines (Masters and Sheley 2001). Most invasive plants also need some agent to transport them to new areas (Trombulak and Frissell 2000). Several of these agents are common on the Refuge and within bighorn sheep habitats, including vehicles on roads, people, pets, wildlife, and maintenance and firefighting equipment. Habitat disturbances due to climate change will likely increase opportunities for invasive species to spread (Inkley et al. 2004).

Belsky and Gelbard (2000) identified the following disturbance factors that contribute to plant community vulnerability to invasion: selective grazing of native plants over weed species; trampling vegetation and compacting soils; impacts to biocrusts and mycorrhizal fungi (see Section 3.4.8); impacts to soil nitrogen levels; and changes in fire regimes. Knapp (1996) found that cattle, sheep, and feral horses facilitated IAG spread in the Great Basin, and cheatgrass in particular. The introduction of IAG, along with selected invasive annual forbs (IAF) such as tall tumblemustard (*Sisymbrium altissimum*) and Russian thistle (*Salsola* spp.), to the arid portions of the sagebrush ecosystem has fundamentally and perhaps irreversibly altered the natural fire regimes by increasing the frequency and severity of fires (Yenson 1981; West 1979 as cited in Knick et al. 2005; Innes 2019b). IAG and selected IAF species alter successional patterns in post-fire plant communities by interfering with native seedling establishment, competing with established perennials for resources, altering soil chemistry, and shortening the interval between fires (Stewart and Hull 1949; Knapp 1996; Zouhar 2003; Fryer 2017).

IAG dominance and associated fires reduce populations, diversity, and recovery of biocrusts, which affect nutrient cycling, water infiltration, and potential soil erosion (Howard 1994; Archer 2001; Zouhar 2003; Fryer 2017). IAG has also been associated with soil organic matter loss and changes in its composition and distribution (Norton et al. 2004). Cheatgrass was well established throughout much of its current distribution in the Intermountain West by 1930; however, cheatgrass has rapidly increased its dominance in native plant communities during the past 30 years. Although cheatgrass can colonize regions in the absence of fire, the combination of fire, livestock grazing, habitat management practices, other disturbances, and climate conditions have accelerated cheatgrass dominance in some sagebrush systems (see summary by Knick et al. 2005).

The expansion of IAG is of particular concern to the Refuge; however, compared with much of the rest of the Great Basin, current IAG infestation on the Refuge is considered relatively low and primarily confined to travel corridors and other disturbed sites (e.g., campgrounds, historic homesteads, burned areas). Approximately 68 non-native plants have been documented or observed on the Refuge; of these, approximately 44 are considered invasive (Refuge files). Approximately 29 additional non-native plant species have been documented in surrounding counties and may potentially be introduced to or otherwise invade the Refuge.

IAG, and in particular invasive bromes (cheatgrass, Japanese brome [*Bromus japonicus*], field brome [*Bromus arvensis*]), are considered common and widespread on the Refuge but have not generally attained dominance in native communities. They are generally only directly treated in response to a disturbance (such as fire) or to maintain bare ground, such as along roadways or in work yards. The current management objective is to prevent further expansion or dominance of invasive bromes. Medusahead (*Taeniatherum caput-medusae*) and ventenata (*Ventenata* spp.) are a priority for treatment and eradication; both have been detected on the Refuge in discrete sites. Less than 0.6% of bighorn sheep habitats are considered dominated by IAG, all of which are invasive bromes (see Table 3.4; see also Figure C-12). These are almost exclusively in old burned areas and along roadways and high-use areas such as parking areas and campgrounds.

IAF are also considered common and widespread on the Refuge but are rarely dominant, except on small disturbances such as tailings at old badger holes and along managed roadsides. The most common are Russian thistle, tumblemustard, tansymustard (*Descurainia sophia*), sweetclover (*Melilotus officinalis*), and clasping pepperweed (*Lepidium perfoliatum*). Less than 0.08% of bighorn sheep habitats are considered dominated by IAF (see Table 3.4; see also Figure C-12). As with IAG, these areas of IAF dominance are almost exclusively in old burned areas and along roadways.

Other known invasive plant species that are often priorities for inventory and/or treatment include scotch thistle (*Onopordum acanthium*), musk thistle (*Carduus nutans*), Russian knapweed (*Rhaponticum repens*), perennial pepperweed (*Lepidium latifolium*), kochia (*Kochia scoparia*), fivehorn smotherweed (*Bassia hyssopifolia*), Mediterranean sage (*Salvia aethiopis*), and reed canarygrass (*Phalaris arundinacea*).

In addition to inventory and treatment, the Service employs principles of prevention to minimize introduction and spread of invasive plant species. To this end, guidelines and practices have been adopted for Refuge operations and actions, following the Service's *Pacific Region's Policy on Minimizing the Introduction of Invasive Species by Service Activities* (Service 2016; see Appendix E).

The Service prioritizes invasive plant species for inventory and early detection, rapid response, and targeted treatment based on location and abundance on the Refuge, potential threat level, ecological impacts, and legal mandates for control or eradication (see Service and Utah State University 2018). All management projects are evaluated for risk of invasives infestation or expansion due to that project.

3.4.8 Biological Soil Crusts

Biocrusts are an integral component of rangeland habitats and soils. Where intact, these complex and diverse assemblages of bryophytes (mosses and liverworts), fungi and microfungi, bacteria, cyanobacteria, algae, and lichens dominate the uppermost part of the soil surface (Rosentreter and Eldridge 2004). Dominance of the various components varies with location and ecoregion, with mosses and lichens usually dominating in mature biocrusts in the Great Basin (Belnap et al. 2001). Endemic species and assemblages are believed common, though are rarely described due partly to the difficulty of species identification and technical expertise that can be required (Belnap et al. 2001, Becerra-Absalón et al. 2019). Biocrusts occur across the Refuge in various forms and assemblages in most vegetative community types.

Biocrusts are different than physical crusts (sometimes referred to as hardpan), though they will often appear physically similar during dry periods. Physical crusts are a potentially detrimental, impermeable, nonbiotic structural feature that can form on the surface of arid soils, usually as a result of rainfall and drying cycles (Belnap et al. 2001). In general, as biocrusts decrease due to intensive or repeated disturbance, physical crusts become more common (Belnap et al. 2001). Physical crusts are also common and widespread on the Refuge, though their size, depth, and strength vary greatly with soil type, slope, moisture regime and hydrology, and disturbance history.

Biocrusts provide living cover and stability in environments where soil conditions and high evapotranspiration rates do not support dense vascular plant cover. All components of biocrusts tolerate extreme desiccation and rewetting cycles without negative effects, unlike most vascular plants (Belnap et al. 2001). Biocrusts actively respond to soil moisture and can resume metabolic activity within minutes of wetting, though full and prolonged moisture is usually required for full biological function (Belnap et al. 2001). Biocrusts reduce soil erosion, enhance nutrient cycling (nitrogen in particular), and contribute to soil organic matter in semiarid and arid plant communities (Evans and Ehleringer 1993; Belnap et al. 2001; Rosentreter and Eldridge 2004; Bahr 2013; see also Kaltenecker, Wicklow-Howard, and Rosentreter et al. 1999). When intact, biocrusts are critical components in maintaining a habitat's R&R to damage from stochastic events (such as wildfire) and invasion and/or dominance by IAG.

Biocrusts are highly susceptible to damage from trampling and other crushing forces, intense and/or repeated fire, changes in plant communities and competition from infilling of interspaces, soil degradation, and changes in hydrology. There is considerable evidence that plant communities of the Great Basin did not evolve in the presence of large numbers of grazing animals: naturally sparse vegetation in intact systems, the common reliance on the nitrogen provided by biocrusts, the lack of physiologic defenses against grazing in the dominant bunchgrasses, and the lack of native dung beetles

(Stebbins 1981; Mack and Thompson 1982; Evans and Ehleringer 1993; Evans and Belnap 1999; Belnap et al. 2001). Accordingly, biocrusts of the region are poorly adapted to recover after physical disturbance or to establish or recover in the presence of short-lived vascular plants (such as IAG) that fill the spaces between larger plants (Kaltenecker and Wicklow-Howard 1994; Kaltenecker 1997; Kaltenecker, Wicklow-Howard, and Pellant et al. 1999, as reported by Belnap et al. 2001).

Although most of the communities of the Great Basin evolved with some level of fire, the large-scale, high-intensity, long residency, and short-interval fires now impacting the ecoregion were not the norm. Due to their slow recovery, biocrusts can be severally degraded, compositionally altered, or outright lost due to these changes in the fire regimes (Belnap et al. 2001; Aanderud et al. 2019). Biocrusts exhibit successional stages of recovery, although the specific trajectory depends on the type, duration, frequency, and intensity of disturbance (Johansen et al. 1993; Johansen et al. 1984; Belnap et al. 2001; Bahr 2013). For severe disturbances, biocrusts can take decades or longer to recover integrity, and may lose endemic components and not match either the pre-disturbance or any remnant undisturbed assemblages (Anderson et al. 1982; Aanderud et al. 2019; Becerra-Absalón et al. 2019; Johansen et al. 1984; Johansen and St. Clair 1986; Kaltenecker, Wicklow-Howard, and Rosentreter 1999; Bahr 2013; others).

3.4.9 Special-Status Plants

There are two special-status plants known to occur on the Refuge, Cusick's buckwheat (*Eriogonum cusickii*) and prostrate buckwheat (*Eriogonum prociduum*), outside of bighorn sheep habitat in sites with distinctive soil and environmental conditions not known to comprise bighorn sheep habitat. Both species are state candidate species in Oregon. Two other species, Crosby's buckwheat (*Eriogonum crosbyae*) and grimy mousetail (*Ivesia rhypara*, also known as grimy ivesia), are known from Sheldon National Wildlife Refuge and areas in Oregon close to Hart Mountain NAR but have not been documented within the Refuge boundaries. These species are not expected to be affected by the proposed bighorn sheep management plan and will not be discussed further.

3.5 Ecological Role of Fire and Fire Management

Wildlife coevolved with shrub-steppe plant communities and adapted to the natural processes of those communities, including fire. Some wildlife species specialize in early seral communities, such as grasslands, which follow soon after fire. Others favor climax seral stages of shrub and/or tree communities. Still others act as generalists or opportunists, adapting to a "middle ground" ecological role regardless of the seral condition of the habitat, or with sufficient mobility or willingness to move between seral conditions and ecological communities in order to meet their survival and reproductive needs. These habitat communities reflect a complex interaction of environmental variables, including soil, topography, hydrology, climate, and disturbance history (Connelly et al. 2004; Suring, Rowland et al. 2005a). Fire has always been an important influence on wildlife populations and biodiversity in these habitats (Clark and Starkey 1990; Knick et al. 2005; Block et al. 2016; Spitz et al. 2018; Sittler et al. 2019; many others).

Fire is not only natural within shrub-steppe habitats; it is also necessary to maintain plant and wildlife diversity across the landscape. If fire is excluded from the shrub-steppe, habitat conditions trend toward larger and larger continuous expanses of late-seral and climax shrub- and/or tree-dominated vegetative communities, which are unable to support the level of native biodiversity in wildlife populations inherent in more dynamically diverse mosaic landscapes (Davies et al. 2014; Stine et al. 2014; Block et al. 2016; Davies and Bates 2020). Additionally, when disturbance comes it often no longer creates a mosaic of these seral stages, but rather can lead to landscape-level change beyond the ability of many wildlife species to adapt (Martin and Sapsis 1992; Gruell 1999). Conversely, if fire occurs too often it can leave shrub-steppe habitats open to invasion by fire- and disturbance-tolerant species such as cheatgrass (Knapp 1996; Davies et al. 2012). This in turn can lead to larger and larger expanses of early-seral and/or annual grassland vegetative communities, which in turn can lead to loss of dynamic diversity in the landscape, and consequently loss of biodiversity (D'Antonio and Vitousek 1992; Chambers, Bradley, et al. 2014).

3.5.1 Fire Regimes

The biodiversity of an ecosystem can often be strongly influenced by the pyrodiversity in the landscape (Kauffman and Sapsis 1989; Martin and Sapsis 1992; Kelly et al. 2017). The pyrodiversity is quantified and described as the spatial and temporal heterogeneity of the fire regime (or regimes) of the vegetative communities of a landscape. A fire regime is identified by the frequency (interval), seasonality, magnitude (severity, residency, and intensity), predictability, dimensions (size and shape), spatial patterns (patchiness), and rotation (cycle) of fire within a vegetative community, and its recovery time after a fire disturbance (Martin and Sapsis 1992; Morgan et al. 2001; Baker 2006). The interaction of the pyrodiversity and biodiversity within cover types of the Refuge and their specific fire regimes have not been fully described; however, the fire regimes for the majority of the fire-adapted vegetative cover classes have been described for the broader region (Table 3.13).

Table 3.13. Fire Regime Descriptions for Vegetation Cover Type Classifications within Bighorn Sheep Habitat on Hart Mountain National Antelope Refuge

National Vegetation Classification Description (Alias)	Fire Interval (years)	Fire Severity (% of fires)			Info Sources
		Replacement	Mixed	Low	
Cliff and Canyon Vegetation					
Inter-Mountain Basins Cliff and Canyon (Canyon Vegetation)	Site-specific	–	–	–	–
Barren Lands (Barren – Sparse/Permanently Limited Vegetation)	N/A	–	–	–	Innes 2014
Shrubland Communities					
Columbia Plateau Low Sagebrush Steppe (Low Sagebrush)	79–1,250	33–100%	0–67%	0%	Steinberg 2002, MFSL 2012a, MFSL 2012b
Inter-Mountain Basins Big Sagebrush Shrubland (Wyoming Big Sagebrush)	10–70	45%	55%	0%	Sapsis 1990, Tirmenstein 1999, Innes 2019a
Inter-Mountain Basins Big Sagebrush Steppe (Basin Big Sagebrush)	12–43	51%	46%	3%	Sapsis 1990, Tirmenstein 1999, Innes 2019a
Inter-Mountain Basins Montane Sagebrush Steppe (Mountain Big Sagebrush)	15–80	100%	0%	0%	Sapsis 1990, Tirmenstein 1999, Innes 2017, Innes and Zouhar 2018, others
Northern Rocky Mountain Lower Montane-Foothill Deciduous Shrubland (Mountain Shrub)	44–500	56–99%	20–44%	0%	MFSL 2012c
Grassland Communities					
Inter-Mountain Basins Semi-Desert Grassland (Perennial Grassland)	25–81*	33–82%	18–67%	0%	MFSL 2012d, MFSL 2012e, MFSL 2012f
Woodland Communities					
Rocky Mountain Ponderosa Pine Woodland (Pine)	8–68	4–15%	0–43%	43–96%	Fitzgerald 2005, MFSL 2012g, Fryer 2016
Inter-Mountain Basins Juniper Savanna (Juniper)	97–185	22–32%	36–65%	5–38%	Murphy and Fryer 2019
Inter-Mountain Basins Mountain Mahogany Woodland and Shrubland (Mountain Mahogany)	14–112	24–100%	0–52%	0–34%	MFSL 2012h
Rocky Mountain Aspen Forest and Woodland (Aspen)	25–33	29–46%	54–71%	0%	MFSL 2012i, MFSL 2012j, MFSL 2012k
Wetland and Aquatic					
Rocky Mountain Subalpine-Montane Mesic Meadow (Wet Meadow)	10–589*	44–100%	0–56%	0–49%	MFSL 2012e, MFSL 2012f
North American Arid West Emergent Marsh (Emergent Vegetation)	Site-specific	–	–	–	–
Open Water (Open Water/Marsh)	N/A	–	–	–	Common sense (water doesn't burn)
Salt Desert Communities					
Inter-Mountain Basins Greasewood Flat (Greasewood)	208–1,000	100%	0%	0%	MFSL 2012l
Inter-Mountain Basins Mixed Salt Desert Scrub (Salt Desert)	20–2,000	54–100%	0–46%	0%	MFSL 2012m
Inter-Mountain Basins Playa (Playa – Sparse/Ephemeral Vegetation)	N/A	–	–	–	Innes 2014
Invasive-dominated					
Invasive Annual Grassland (Invasive Grasses)	<10–30*	80–100%	0–20%	0%	Zouhar 2003, Zouhar et al. 2008, Pilliod et al. 2017
Invasive Annual Forbland (Invasive Forbs)	<10–30*	80–100%	0–20%	0%	Zouhar et al. 2008, Pilliod et al. 2017

Sources: Adapted from vegetation associations identified and data products provided by Tagestad (2010), using National Vegetation Classification Standards developed and described by FGDC (2008). Aliases are adapted from Tagestad (2010).
Note: N/A = not applicable.
* Fire intervals in these vegetation classes are highly dependent on the species, species composition(s), inter-annual weather patterns, and the degree of litter build-up (retention).

3.5.1.1 FREQUENCY, ROTATION, AND SEASON

The fire frequency, or fire interval, is a broad term used to describe the expected recurrence of fire in a given area (the vegetative cover type in this case) over time, or the average number of years between two successive fire events within a given area. These fires do not necessarily have to overlap spatially, they just occur within the same given descriptive area. A similar concept applied on a landscape scale is called the fire rotation, or cycle, which is the amount of time required to burn an area roughly equivalent to the overall given area. This may be a single fire, or multiple burns spread out both spatially and temporally. In the case of multiples, these burns may or may not overlap within this area, but they will roughly total the overall acreage of the area in question. In the intact cover types on the Refuge (i.e., those whose function is similar to pre-settlement function), the fire rotation is generally much longer than the fire frequency.

As plant communities have changed, such as with the expansion of IAGs, these two metrics are likely shortening and getting closer together (i.e., decreasing frequency between fires, and increasing acreages per fire leading to a shorter fire rotation). The Refuge has thus far experienced less change in these metrics than similar areas (see Balch et al. 2013) in the region. This may or may not be a reflection of less change in the fire regimes of the Refuge's habitats, fewer potential ignition events, or simple stochasticity.

With the decrease in fire return intervals in some big sagebrush plant communities, increased levels of sagebrush cover and density can reduce or eliminate the herbaceous component (West 1983, in Davies et al. 2009). West (2000; in Davies et al. 2009) estimated that approximately 25% of the big sagebrush steppe ecosystem was comprised of decadent, even-aged stands. Long-term maintenance in a big sagebrush state has also been demonstrated to reduce resistance to exotic plant invasions (Davies et al. 2008), although sagebrush has been shown to facilitate establishment and persistence of perennial grasses under some conditions (Davies et al. 2007). There is a desire to increase the diversity of big sagebrush structural characteristics and understory productivity across landscapes to provide a mosaic of various habitats (see summary by Davies et al. 2009); however, an interesting conservation conundrum exists for the sagebrush ecosystem, because the fire regime alterations underlying the undesirable shifts in vegetation can be either a decrease or an increase in fire frequency (Davies et al. 2011). At higher elevations, exemplified by mountain big sagebrush plant communities, the lack of periodic fire has allowed conifer encroachment. Conversely, at lower elevations (commonly Wyoming big sagebrush communities, and at times basin big sagebrush communities), frequent fires have promoted exotic annual grass dominance (Davies et al. 2011).

Seasonality describes the propensity for fires to occur during certain times of the year, largely dependent on environmental conditions (Martin and Sapsis 1992). Lightning is essentially the only cause of natural fire on the Refuge. Most lightning strikes occur with rainfall during the time of the year that is too cool and wet for wildfires to start and spread, or strike in areas with limited interspace vegetation, such as in old-growth juniper woodlands or in sparse vegetation along the cliffs and canyons of the escarpment. Larger lightning-caused fires within the Refuge are generally intense, fast-moving fires driven primarily by localized winds. Although relatively infrequent, the majority of lightning fires occur in the area from June through September, with some fires occasionally starting as early as mid-May or as late as mid-October.

Human-caused fires fall into three general categories: arson, accidental, or prescribed fire. Human-caused fire can theoretically occur at any time of year, though larger fires usually occur during the same time periods as larger lightning-caused fires due to the same environmental conditions. Prescribed fire activities on the Refuge are typically conducted September through April, but prescribed fires have been ignited on the Refuge during every month of the year when prescriptions for ignition have been met.

3.5.1.2 MAGNITUDE (INTENSITY, RESIDENCY, AND SEVERITY)

The magnitude of a fire is a function of its intensity, residency, and severity, where intensity is the amount of energy or heat released by a fire per unit of time, residency is the amount of time required for the flaming front of a fire to pass a given point or the total length of time that the flaming front occupies a given point (duration of heating), and severity is the degree to which a site has been altered or disrupted by a fire (Martin and Sapsis 1992; Morgan et al. 2001; Keeley 2009).

Fire intensity is closely related to how much fuel is available to burn and the environmental conditions at the time of burning (e.g., fuel moisture content). Fire intensity is often indicated by flame length, which is the average distance between the flame tip and the midpoint of the flame depth at the base (ground level) of the fire front, and rate of spread. In the big sagebrush steppe and shrubland vegetation types in the bighorn sheep habitats on the Refuge, flame lengths are usually closely tied to live fuel moisture (LFM), or the ratio of the amount of water to the amount of dry plant material in living plants. When LFM ratios are greater than 120%, flame lengths (and intensity) can be moderate to fairly low unless driven by strong winds. When LFM ratios are less than 100%, then average flame lengths can commonly be greater than 20 feet with a rapid rate of spread, indicating high to extreme intensity (Service 2015, as amended).

Residency is correlated with the type and quantity of fuels, as well as environmental and weather variables, and can impact the degree of impact or damage to a habitat. Generally speaking, the longer a fire burns on a given point, the greater the potential impact to that point. Fires in the sagebrush steppe and shrubland vegetation types tend to burn fairly rapidly, though can smolder for several days on the larger main stems of woody shrubs. Fires in the grassland types tend to burn rapidly, with little residency. Fires in woodland types or in slash piles (such as those created during some juniper removal methods) can burn for days to months, though tend to be localized to the woody material.

Fire severity is a product of fire intensity and residence time. In the cover types on the Refuge, severity is categorized by the relative amount of kill or top-kill to the canopy layer (mid-story or top shrub canopy in shrub habitats or overstory canopy in treed habitats): "replacement" severity fires cause >75% kill or top-kill; "mixed" severity fires cause 26 to 75%; and "low" severity fires (also called surface fires) cause <26% (TNC et al. 2006; Barrett et al. 2010). Despite the often intense nature of fires within the Refuge, natural fuel conditions are discontinuous and light, generally resulting in the potential for rapid fires with low to moderate severity. Shrubs and other woody plants are often killed (leaving skeletons) or completely consumed by flames of varying intensity, but basal stems of perennial bunchgrasses, and underground plant rhizomes, suckers, and runners are left intact to regrow and sprout the following season. Seed banks are often damaged, though are seldom fully consumed except under areas of high severity. When fuel conditions are drier than normal, fire intensity and duration can result in all plants being killed or consumed (Service 2015, as amended).

3.5.1.3 DIMENSIONS AND PATCHINESS

The pattern and extent of burned areas is an inherent characteristic of fire and in most cases greatly influences the habitat value for wildlife, though specific predictive patterns are not known or well understood or are site dependent (Baker 2006). Even small prescribed fires can decrease the value of sagebrush habitats for sagebrush obligates, such as Brewer's sparrows and sage thrashers (Knick et al. 2003, Erickson 2011); however, targeted prescribed fires can benefit species by providing a habitat component that is otherwise lacking, such as horizontal visibility in bighorn sheep habitat. Fire regimes in intact systems often provide a mosaic of seral stages, increased structural diversity, and patch configurations that are beneficial for a wide assemblage of species when viewed at a large scale. The recent shifts in fire regimes toward larger burns occurring more frequently can maintain historical patchiness in shrublands without invasive grasses, but the contiguous fine fuel created when the grasses are dominant can result in decreased patchiness (Keane et al. 2008; Baker 2013; Bukowski and Baker 2013; Innes 2019b).

3.5.1.4 RECOVERY TIME

The amount of time that it takes the dominant vegetation of a community type to return following a fire is called the recovery time or period. In intact shrub-steppe ecosystems, this is usually less than the fire rotation time. In fact, the recovery period may actually be a fraction of fire rotation time, potentially resulting in multiple recovery cycles on sites within the rotation period for a given area (Baker 2006); however, as communities and fire regimes diverge from historical condition and function, such as when IAGs dominate, recovery may take much longer, or follow a trajectory leading to a state change in the community.

3.5.2 Resistance and Resilience

Resistance of communities is the degree to which they have the capacity to ***retain*** their fundamental structure, processes, and functions when exposed to invasive species, disturbances such as fire, or stresses such as drought (D'Antonio and Thomsen 2004; Folke et al. 2004; Chambers, Bradley, et al. 2014). IAGs (especially cheatgrass and other invasive bromes), and to a lesser extent IAFs (in particular Russian thistle, mustards, and annual pepperweeds), can significantly affect the resistance of the communities of the Refuge. IAG and IAF can cause systemic change to the fire regime of most of the Refuge cover types and can significantly limit or eliminate the habitat value of invaded areas for focal wildlife species.

Resilience of communities is the degree to which they have the capacity to ***maintain*** or ***regain*** their fundamental structure, processes, and functions following disturbance (such as fire or ground disturbance), stresses, or management action (Holling 1973; Allen et al. 2005; Chambers, Bradley, et al. 2014). A detailed explanation of the factors that influence R&R in sagebrush ecosystems can be found in Chambers, Bradley et al. (2014), Chambers, Miller et al. (2014), Chambers et al. (2019), and in Miller et al. (2014, 2015).

For portions of the Refuge with moderate to low resilience to disturbance and resistance to invasive plants (i.e., Wyoming big sagebrush stands), fire severity is expected to be higher and natural sagebrush and perennial herbaceous recovery is less likely. For the other primary bighorn sheep habitats (i.e., mountain big sagebrush, mountain shrub), both resilience to disturbance and resistance to invasive annual plants is higher. In these areas, fire severity would be expected to be lower with a higher probability of natural sagebrush and perennial herbaceous recovery.

Wyoming big sagebrush communities are considered the least resilient and most susceptible of the big sagebrush complex to invasive plants. The majority of grasslands dominated by cheatgrass in the Intermountain West were likely former Wyoming big sagebrush steppe (Davies et al. 2008). The decline of Wyoming big sagebrush-bunchgrass communities has generated debate regarding the value and risks associated with using prescribed fire to mimic historical fire regimes (Davies et al. 2008); however, research being conducted on the Refuge has shown evidence of the resilience of at least some of these communities. Ellsworth et al. (2016) has shown that 17 years after prescribed fire efforts in Wyoming big sagebrush communities in the Flook Lake and Flook Knoll area, there is no statistical difference in IAG cover between burned and unburned plots. Native herbaceous cover was higher in burned plots versus unburned controls. Additionally, sagebrush was widespread in the burned areas, though cover had not yet returned to pre-burn levels, likely indicating a naturally long recovery time and rotation. The continued dominance of native herbaceous and woody species and the lack of dominance by invasive annuals are strong indicators of a resilient habitat.

Low sagebrush communities are also considered to be not resilient or resistant, largely due to their typical ecological conditions and naturally sparse growth and relatively slow regrowth of native species, making them vulnerable to invasion by IAG and subsequently susceptible to increased fire potential and degradation (Miller et al. 2014).

Hybridization between species and subspecies of sagebrush is common along the transitional boundaries between types. It has been theorized that this hybridization may function as a mechanism of resilience, potentially providing for genetic diversity following disturbance and longer-term changes and stressors (such as climate change). This may in turn provide for greater fitness for the shrub species in adapting to these disturbances and stressors. This theory has not been well studied or tested, but the Refuge uses locally derived seed and plantings, if available, for rehabilitation and restoration projects, assuming that it has merit.

3.5.3 Fire Management on the Refuge

Past land management practices, including grazing and wildfire suppression, and the proliferation of IAGs such as cheatgrass have altered the patterns and types of vegetation and fuel across the landscape of the Refuge. Historically, fire was important in influencing succession, composition, and structure of habitats. The pre-European settlement landscape supported a diversity of perennial grasses and forbs due to a frequent occurrence of fires ignited by lightning and Native Americans. During the past 150 years in the absence of fire, the historical abundance of native bunch grasses and forbs has given way to woody vegetation, primarily sagebrush, mountain mahogany, and western juniper. This conversion has been attributed to overgrazing by domestic livestock and the aggressive suppression of natural fire.

In the 1980s Refuge managers noticed that plant communities lacked diversity and vigor and were dominated by stands of sagebrush. In the 1990s, managers started applying prescribed fire to Hart Mountain NAR to return an important ecological role within the landscape. The objectives were to reduce late succession shrub components and promote growth of grasses, forbs, and new shrubs that were preferred by antelope and mule deer. In the CMP, the Refuge established a target of 22,000 to 40,000 acres to be treated with prescribed fire to focus management on restoring habitats and ecosystem processes.

The introduction of cheatgrass to the sagebrush ecosystem has altered the natural fire regime by increasing the frequency and severity of fires. Cheatgrass alters the successional patterns of post-fire plant communities by interfering with native seedling establishment, competing with native plants for resources, and shortening the interval between fires. Because cheatgrass has rapidly increased its dominance in native plant communities outside the Refuge in the last 30 years and can alter landscapes, the Refuge has significantly reduced the use of prescribed fire. Although the Refuge is not heavily infested with cheatgrass, burning large swaths of sagebrush habitats could be counterproductive due to potential cheatgrass invasion and degradation of habitat for bighorn sheep and other sagebrush-obligate species; however, addressing potential structural issues in core bighorn sheep habitats (e.g., large areas of dense shrubs with limited horizontal visibility), as well as long-term maintenance of vegetation succession and diversity in all bighorn sheep habitats, may require using fire at specific and appropriate temporal and spatial scales.

The Refuge follows an approved fire management plan for actions related to fire (Service 2015, as amended). This plan is reviewed and amended annually as necessary by fire management and administrative personnel on the Refuge and in the region. There has been a long-standing practice of suppression of wildfires in and around the Refuge during high and extreme fire periods common in the summer months. The rationale for this practice is to avoid the risks associated with spread of IAGs and IAFs into burned areas, the often high intensity of wildfires in the area, potential damage to sensitive habitats, and the safety of the public and property. Prescribed fires are usually conducted after summer cure and prior to spring green-up when perennial grasses are dormant, and as a result are less intense than natural fires occurring during drought. In addition, the paramount importance of safety dictates that prescribed burns are conducted only when strict environmental conditions are met that do not mimic the effects of natural fires that occur during the hot, dry, and windy summer conditions.

The Refuge does not have complete records of its fire history. Prior to the widespread availability of Landsat and similar satellite-based data products beginning in the mid-1980s, mapping of habitat-altering events and actions was primarily limited to hand-drawings on paper maps, the accuracy of which are highly variable and dependent on terrain and the person doing the drawing. Descriptions of larger fire events were usually recorded in the annual narratives, though their perimeters were not well mapped or described, if at all. Few, if any, small events (such as lightning strikes on individual juniper trees or "self-outing" fires in the sagebrush during wet thunderstorms) were ever recorded even if they were detected. Most of the fire information prior the establishment of the Refuge in 1936 is limited to fire scar tissue and relative tree age of ponderosa pines, juniper, and mountain mahogany (see Gruell 1995, 1999). The known fire history of the Refuge within bighorn sheep habitats is reported in Table 3.14 (see also Figure C-8). Acres burned since 2009 (the date of the Landsat imagery that was used by Tagestad [2010] to classify the vegetation of the Refuge), within bighorn sheep habitats and by cover type, are reported in Table 3.15. Although many of these acres have been shifted to an earlier successional stage, it is not yet known if any have been permanently shifted to a different cover type.

Table 3.14. Summary of Known Fire History and Acres Burned within Bighorn Sheep Habitat on Hart Mountain National Antelope Refuge

Fire Type by Time Period*	Refuge Totals	Refuge Fire Count	Bighorn Sheep Habitat Totals†	Bighorn Sheep Fire Count	Core Bighorn Sheep Habitat‡		Core Nursery Areas§	On-Refuge Water Limits (Simple Buffers)¶,#		
					Escape Terrain	Forage Terrain		Lambing (within 0.62 mile)**	General Ewe (within 1.99 miles)††	Ram (within 4.35 miles)‡‡
Prior to 1964	**6,251**	**7**	**6,251**	**7**	**1,065**	**2,868**	**891**	**1,121**	**282**	**915**
Wildfire	*5,849*	*6*	*5,849*	*6*	*1,065*	*2,868*	*891*	*1,121*	*282*	*513*
Prescribed fire	*402*	*1*	*402*	*1*	*0*	*0*	*0*	*0*	*0*	*402*
Escaped prescribed fire	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*
Pile burn	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*
1964–1984	**7,737**	**4**	**5,895**	**2**	**0**	**0**	**0**	**51**	**1,084**	**4,760**
Wildfire	*7,110*	*1*	*5,372*	*1*	*0*	*0*	*0*	*0*	*611*	*4,760*
Prescribed fire	*555*	*2*	*523*	*1*	*0*	*0*	*0*	*51*	*472*	*0*
Escaped prescribed fire	*72*	*1*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*
Pile burn	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*
1985–1993	**13,852**	**16**	**3,865**	**16**	**12**	**200**	**20**	**541**	**260**	**2,851**
Wildfire	*54*	*7*	*54*	*7*	*2*	*5*	*0*	*12*	*25*	*10*
Prescribed fire	*3,057*	*8*	*2,825*	*8*	*10*	*195*	*20*	*529*	*235*	*1,855*
Escaped prescribed fire	*10,741*	*1*	*986*	*1*	*0*	*0*	*0*	*0*	*0*	*986*
Pile burn	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*
1994–2008	**20,822 (*18,599*)**	**77**	**16,611 (*15,613*)**	**68**	**863 (*835*)**	**3,032 (*2,967*)**	**546 (*534*)**	**2,542 (*2,514*)**	**3,752 (*3,498*)**	**6,421 (*5,797*)**
Wildfire	*3,083*	*7*	*2,896*	*5*	*97*	*1,092*	*0*	*988*	*367*	*351*
Prescribed fire	*15,819 (13,795)*	*62*	*11,797 (10,976)*	*55*	*745 (721)*	*1,622 (1,600)*	*546 (534)*	*855*	*2,890 (2,659)*	*5,684 (5,142)*
Escaped prescribed fire	*1,186*	*4*	*1,186*	*4*	*12*	*172*	*0*	*384*	*232*	*386*
Pile burn	*733 (730)*	*4*	*733 (730)*	*4*	*10*	*146*	*0*	*315 (312)*	*263*	*0*
2009–2012	**6,357 (*6,059*)**	**20**	**7,318 (*7,011*)**	**18**	**601**	**1,859 (*1,812*)**	**553**	**1,487 (*1,417*)**	**2,177 (*2,069*)**	**1,194 (*1,114*)**
Wildfire	*2,664*	*2*	*2,664*	*2*	*465*	*1,171*	*549*	*575*	*453*	*0*
Prescribed fire	*1,226 (1,085)*	*9*	*2,187 (2,037)*	*7*	*0*	*0*	*0*	*19*	*1,285 (1,198)*	*883 (820)*
Escaped prescribed fire	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*
Pile burn	*2,467 (2,342)*	*9*	*2,467 (2,342)*	*9*	*136 (134)*	*688 (641)*	*5*	*893 (823)*	*439 (434)*	*310*

Fire Type by Time Period*	Refuge Totals	Refuge Fire Count	Bighorn Sheep Habitat Totals†	Bighorn Sheep Fire Count	Core Bighorn Sheep Habitat‡		Core Nursery Areas§	On-Refuge Water Limits (Simple Buffers)¶,#		
					Escape Terrain	Forage Terrain		Lambing (within 0.62 mile)**	General Ewe (within 1.99 miles)††	Ram (within 4.35 miles)‡‡
2013–2020	**26,769 (*25,201*)**	**21**	**26,207 (*24,640*)**	**20**	**448**	**2,109**	**121**	**3,825**	**12,272 (*11,020*)**	**7,552 (*7,239*)**
Wildfire	*20,573*	*4*	*20,011*	*3*	*290*	*1,425*	*121*	*2,769*	*8,598*	*6,930*
Prescribed fire	*209*	*2*	*209*	*2*	*0*	*0*	*0*	*32*	*177*	*0*
Escaped prescribed fire	*57*	*2*	*57*	*2*	*0*	*0*	*0*	*56*	*1*	*0*
Pile burn	*5,930 (5,685)*	*13*	*5,930 (5,685)*	*13*	*159*	*684*	*0*	*968*	*3,496 (3,251)*	*623*
Totals	**81,788 (*69,139*)**	**145**	**66,148 (*54,004*)**	**131**	**2,991 (*2,502*)**	**10,069 (*7,823*)**	**2,131 (*1,649*)**	**9,567 (*7,392*)**	**19,828 (*15,389*)**	**23,694 (*20,898*)**

Note: Acreages are presented as both aggregate totals (simple summations of acres burned by individual fires, irrespective of overlap or reburned areas) and absolute totals (GIS-derived generalizations accounting for overlap or reburned areas). Where these two numbers do not match (i.e., where overlaps occur), the aggregate acreage is given first and the absolute acreage is given in parentheses. Where these numbers match only the aggregate total is given.

* Time periods are broken out based on key dates in available imagery, cover data, and/or management thresholds: 1964 imagery was used to develop 1967 topography and canopy cover maps; Landsat imagery was used annually starting in 1985 to identify burned areas by year; the CMP was finalized and implemented in 1994; Landsat imagery from 2008 was used to classify vegetation on the Refuge; and NAIP imagery from 2012 was used by Falkowski et al. (2017) to delineate juniper canopy cover in Oregon. Known fires are summarized based on their broad burn type and intent: wildfires are those starting naturally (such as lightning) or caused accidentally (such as by an unattended campfire; no incidents of arson are known on the Refuge); prescribed fires are broadcast fires intentionally started for management purposes; escaped prescribed fires are those areas outside of the intended burn area of a prescribed fire effort; and pile burns are the larger encompassing project area for discrete burn sites (i.e., acres reported under this classification do not represent the actual burn area, but rather the larger project perimeter, the majority of which remained unburned during the burning of the piles, though they may have been impacted by actions taken during these activities or by conditions and processes inherent after the disturbance caused by these actions).

† Total acreages are the sum of the escape terrain, forage terrain, and the lambing, general ewe, and ram water limit values.

‡ Given acreages are only for each specific bighorn sheep habitat use category. Total core bighorn sheep habitat acreages should be calculated by totaling the escape terrain and forage terrain values.

§ Core nursery areas are bighorn sheep specialty use areas within the larger bighorn sheep habitat area (i.e., areas only selected by ewes with lambs during parturition and/or early rearing) that overlap both escape and forage terrains and are thus not included in the total acreages.

¶ Vegetation cover type data were not available for areas outside of the Refuge boundary perimeter so these could not be analyzed/summarized.

\# We do not yet have sufficient bighorn sheep location histories or resolution to be able to identify or discern patterns in movements or water usage by bighorn sheep, nor to predict (model) these patterns within the larger landscape with any statistical relevance. As such, these distances had to be taken from literature sources and incidental observations of the Refuge bighorn sheep population, necessitating simplicity in mapping these outer limits. Water limits were modeled as simple buffers using the Multiple Ring Buffer tool in the Proximity toolset within the Analysis toolbox of ArcGIS 10.7.1. Reported acreages are only those that occur within the given ring buffer.

** The lambing water limit includes all potential areas used by ewes with lambs from parturition through dispersal, not just the early season nursery habitats, based on literature values of outer limits for water availability/use. Total lambing (i.e., ewes with lambs) water limit acreage should be calculated by adding the escape terrain, forage terrain, and the lambing water limit values.

†† The general ewe water limit includes all potential areas used by ewes without lambs or with older-aged (weaned) lambs, based on literature values of outer limits for water availability/use. Total general ewe water limit acreage should be calculated by adding the escape terrain, forage terrain, and the lambing and general ewe water limit values.

‡‡ The ram water limit is based on incidental observations of bighorn sheep ram water source use on the Refuge as reported by Payer (1992). Total ram water limit acreage should be calculated by adding the escape terrain, forage terrain, and the lambing, general ewe, and ram water limit values.

Table 3.15. Total Acres Burned within Bighorn Sheep Habitat Since Acquisition of 2009 Landsat Imagery Used to Classify Vegetation of Hart Mountain National Antelope Refuge

National Vegetation Classification Description (Alias)	**Total Acres***	**Core Bighorn Sheep Habitat**[†]		**Core Nursery Areas**[†]	**On-Refuge Water Limits (Simple Buffers)**[§,¶]		
		Escape Terrain	**Forage Terrain**		**Lambing (within 0.62 mile)**[#]	**General Ewe (within 1.99 miles)****	**Ram (within 4.35 miles)**[††]
Cliff and Canyon Vegetation							
Inter-Mountain Basins Cliff and Canyon (Canyon Vegetation)	672	408	198	180	22	21	22
Barren Lands (Barren – Sparse/Permanently Limited Vegetation)	0	0	0	0	0	0	0
Shrubland Communities							
Columbia Plateau Low Sagebrush Steppe (Low Sagebrush)	7,032	40	853	66	1,689	3,032	1,419
Inter-Mountain Basins Big Sagebrush Shrubland (Wyoming Big Sagebrush)	9,478	156	1,233	143	1,384	3,456	3,249
Inter-Mountain Basins Big Sagebrush Steppe (Basin Big Sagebrush)	942	0	0	0	58	79	805
Inter-Mountain Basins Montane Sagebrush Steppe (Mountain Big Sagebrush)	5,734	167	915	154	942	2,449	1,262
Northern Rocky Mountain Lower Montane-Foothill Deciduous Shrubland (Mountain Shrub)	1,504	84	277	11	106	749	287
Grassland Communities							
Inter-Mountain Basins Semi-Desert Grassland (Perennial Grassland)	1,683	4	181	17	594	733	170
Woodland Communities							
Rocky Mountain Ponderosa Pine Woodland (Pine)	41	0	0	0	0	41	0
Inter-Mountain Basins Juniper Savanna (Juniper)	781	75	71	47	38	0	79
Inter-Mountain Basins Mountain Mahogany Woodland and Shrubland (Mountain Mahogany)	280	33	32	10	16	125	74
Rocky Mountain Aspen Forest and Woodland (Aspen)	42	7	4	< 1.4	< 0.3	25	5
Wetland and Aquatic							
Rocky Mountain Subalpine-Montane Mesic Meadow (Wet Meadow)	819	3	7	0	74	462	272
North American Arid West Emergent Marsh (Emergent Vegetation)	73	0	< 0.15	0	11	55	7
Open Water (Open Water/Marsh)	0	0	0	0	0	0	0
Salt Desert Communities							
Inter-Mountain Basins Greasewood Flat (Greasewood)	140	< 0.1	9	< 0.5	46	0	49
Inter-Mountain Basins Mixed Salt Desert Scrub (Salt Desert)	5	0	< 0.15	0	0	0	4
Inter-Mountain Basins Playa (Playa – Sparse/Ephemeral Vegetation)	51	0	< 0.15	0	4	< 1.7	45
Invasive-dominated							
Invasive Annual Grassland (Invasive Grasses)	319	0	24	0	47	178	71
Invasive Annual Forbland (Invasive Forbs)	5	0	0	0	< 0.1	5	< 0.2
Totals	**29,602**	**980**	**3,803**	**632**	**5,031**	**11,967**	**7,821**

Sources: Adapted from vegetation associations identified and data products provided by Tagestad (2010), using National Vegetation Classification Standards developed and described by FGDC (2008). Aliases are adapted from Tagestad (2010).

* Total acreages are the sum of the escape terrain, forage terrain, and the lambing, general ewe, and ram water limit values.

[†] Given acreages are only for each specific bighorn sheep habitat use category. Total core bighorn sheep habitat acreages should be calculated by totaling the escape terrain and forage terrain values.

[‡] Core nursery areas are bighorn sheep specialty use areas within the larger bighorn sheep habitat area (i.e., areas only selected by ewes with lambs during parturition and/or early rearing) that overlap both escape and forage terrains and are thus not included in the total acreages.

[§] Vegetation cover type data were not available for areas outside of the Refuge boundary perimeter so these could not be analyzed/summarized.

[¶] We do not yet have sufficient bighorn sheep location histories or resolution to be able to identify or discern patterns in movements or water usage by bighorn sheep, nor to predict (model) these patterns within the larger landscape with any statistical relevance. As such, these distances had to be taken from literature sources and incidental observations of the Refuge bighorn sheep population, necessitating simplicity in mapping these outer limits. Water limits were modeled as simple buffers using the Multiple Ring Buffer tool in the Proximity toolset within the Analysis toolbox of ArcGIS 10.7.1. Reported acreages are only those that occur within the given ring buffer.

[#] The lambing water limit includes all potential areas used by ewes with lambs from parturition through dispersal, not just the early season nursery habitats, based on literature values of outer limits for water availability/use. Total lambing (i.e., ewes with lambs) water limit acreage should be calculated by adding the escape terrain, forage terrain, and the lambing water limit values.

** The general ewe water limit includes all potential areas used by ewes without lambs or with older-aged (weaned) lambs, based on literature values of outer limits for water availability/use. Total general ewe water limit acreage should be calculated by adding the escape terrain, forage terrain, and the lambing and general ewe water limit values.

[††] The ram water limit is based on incidental observations of bighorn sheep ram water source use on the Refuge as reported by Payer (1992). Total ram water limit acreage should be calculated by adding the escape terrain, forage terrain, and the lambing, general ewe, and ram water limit values.

3.6 Social, Cultural, and Economic Environment

3.6.1 Surrounding Land Use

More than 77% of lands in Lake County are federally owned public lands, where 55% are managed by the BLM and 5% includes Hart Mountain NAR. The Refuge is nearly surrounded by public lands that are managed by the BLM for multiple uses, primarily livestock grazing and recreation. Lakeview District BLM's land management practices include wildlife habitat management, fire suppression, invasive plant treatment, wildfire rehabilitation and restoration, listed species management and recovery, wetland management, spring and creek restoration, and juniper treatments. Successful BLM sagebrush restoration projects focusing on greater sage-grouse habitat included juniper treatments in the South Warner area and Clover Flat area of the District. A variety of primitive and semi-primitive facilities provide a wide range of recreation opportunities, including hunting, fishing, camping, rock collecting, horseback riding, hang gliding, bicycle riding, photography, off-highway vehicle use, wildlife viewing, and during some years, boating. Those most affected in this planning effort are interested in wildlife-dependent recreation, wildlife population and habitat management, and the functions of the ecosystem as a whole. In general, stakeholders may be characterized as local residents, ranchers, ecological interest groups, humane organizations, animal rights representatives, hunters and sportsmen, and non-consumptive wildlife-related recreational users.

3.6.2 Refuge Built Environment

Roads include three maintained gravel roads, and numerous primitive and unmaintained dirt roads. Trails throughout the Refuge backcountry and wilderness areas are primarily abandoned vehicle routes historically used for access to livestock developments and private inholdings. The Refuge headquarters, two primitive campgrounds, one semi-primitive campground, one developed campground, a horse corral, a fishing dock, a small visitor contact station, and a number of informational signs and kiosks are maintained to support hunting and other recreation activities and are all outside of bighorn sheep habitat.

3.6.3 Socioeconomic Environment

The affected socioeconomic environment includes the diverse values, lifestyles, and livelihoods of the American public, especially those that reside in Lake County, Oregon. Lake County is one of the least densely populated areas of the United States. In 2017, Lake County had a population of 7,807 (U.S. Department of Commerce Census Bureau 2019). According to the Service's Socioeconomic (Service 2019b) profile for the Refuge (Census Tract 9601), in 2018, Lakeview had a population of 2,753 people with 51% male and 57% over the age of 50. High school graduates made up 88% of the population, and 14% had a bachelor's degree or higher. English was the only language spoken in 95% of homes, and 95% of the population was white. The main industries in Lake County were agriculture and forestry, public administration, and health care, and 44% of household incomes ranged between $10,000 to $35,000. A detailed socioeconomic profile is presented in Appendix J.

3.6.4 Cultural Resources

Cultural resources are the physical remains, sites, objects, records, oral testimony, and traditions that connect people to our nation's past. They include archaeological and historical artifacts, traditional ecological knowledge, sites, landscapes, sacred locations, and traditional cultural properties. Cultural resources are integral components of the landscape. They tell us how people have used the land and its wildlife. At the Refuge, cultural resources remind us that human beings had already been part of the web of life for thousands of years before the arrival of European Americans in the mid-1800s.

Archaeological evidence indicates that humans have lived in south-central Oregon for at least 13,000 years. The Native American cultural history at the Refuge is based on interpretation of the archaeological record on and near the Refuge. Several excavations and archaeological research projects have been completed at sites near the Refuge, but relatively little information has been collected within the bighorn sheep range on the Refuge.

Hart Mountain is within the traditional area of the Northern Paiute, and in particular the Burns Paiute Tribe, Fort Bidwell Indian Community, and Fort McDermitt Paiute and Shoshone Tribes. The Refuge coordinates and consults with Native American tribes who are affected or who have an interest in the management of the Refuge regarding various management actions and in particular those that have the potential to impact historically or traditionally important locations or resources. The Refuge also operates under the Service policies relating to the National Historic Preservation Act (36 CFR 800.5) and the Archaeological Resources Protection Act and coordinates with the Oregon State Historic Preservation Office when conducting any activity that may potentially disturb historical or archaeological sites (Procedures for inadvertent archaeological discoveries are discussed in Appendix K).

3.6.5 Public Uses

The Refuge estimates an average of 10,000 to 15,000 visitors per year. In 2019 it was estimated that there were 10,000 visitors, with hunters accounting for 25% of those (Service 2019b). Entries in visitor registers show the majority of visitors to the Refuge are primarily residents living in central and northwestern Oregon, California, and Washington. Many local residents also visit the Refuge but are only a small proportion of overall visitation due to the fact that the local area is sparsely populated. It is estimated that approximately 30 to 50% of all Refuge visitors camp overnight within the Refuge.

The Refuge is located in Lake County, Oregon, and it is assumed that visitors spend most of their money within this county. In 2017, total expenditures were $897,400, with nonresidents accounting for $723,700 (Service 2019b; see Table 3.16). Hunting activities accounted for 41% of total expenditures.

Table 3.16. 2017 Visitor Recreation Expenditures in Lake County, Oregon

Activity	Residents	Nonresidents	Total
Nonconsumptive	$127,000	$398,700	$525,700
Hunting	$44,500	$323,700	$368,200
Fishing	$2,200	$1,300	$3,500
Total expenditures	**$173,700**	**$723,700**	**$897,400**

Source: Adapted from the 2017 Service Banking on Nature Report.

The species hunted on the Refuge include mule deer, pronghorn, bighorn sheep, chukar, quail, and waterfowl. In 2020, 70 pronghorn tags (archery, youth, and rifle seasons) and 53 mule deer tags (archery and muzzleloader seasons) were issued.

Bighorn sheep are managed as a once-in-a-lifetime hunting opportunity in Oregon. The first hunting season for bighorn sheep on the Refuge occurred in 1965 and consisted of two hunts with three tags each. The most tags issued in a season was 42 in 1995, and rapidly declined to approximately five in 2002 (Figure 3.7). Tag numbers were increased largely to compensate for the disproportionate number of ewes removed during transplant operations and were decreased due to lower overall population numbers on the Refuge in later years (ODFW 2003). Harvest levels since 1998 have rarely exceeded 15% of the total observed ram population and averaged less than 4% of the total population since the first hunt season.

Because of the decline in number of observed individuals from 149 to 68 between 2018 and 2019 summer flight surveys, low recruitment, and few Class IV rams, the decision was made to close the bighorn sheep hunting season for 2020; it will remain closed until the population recovers.

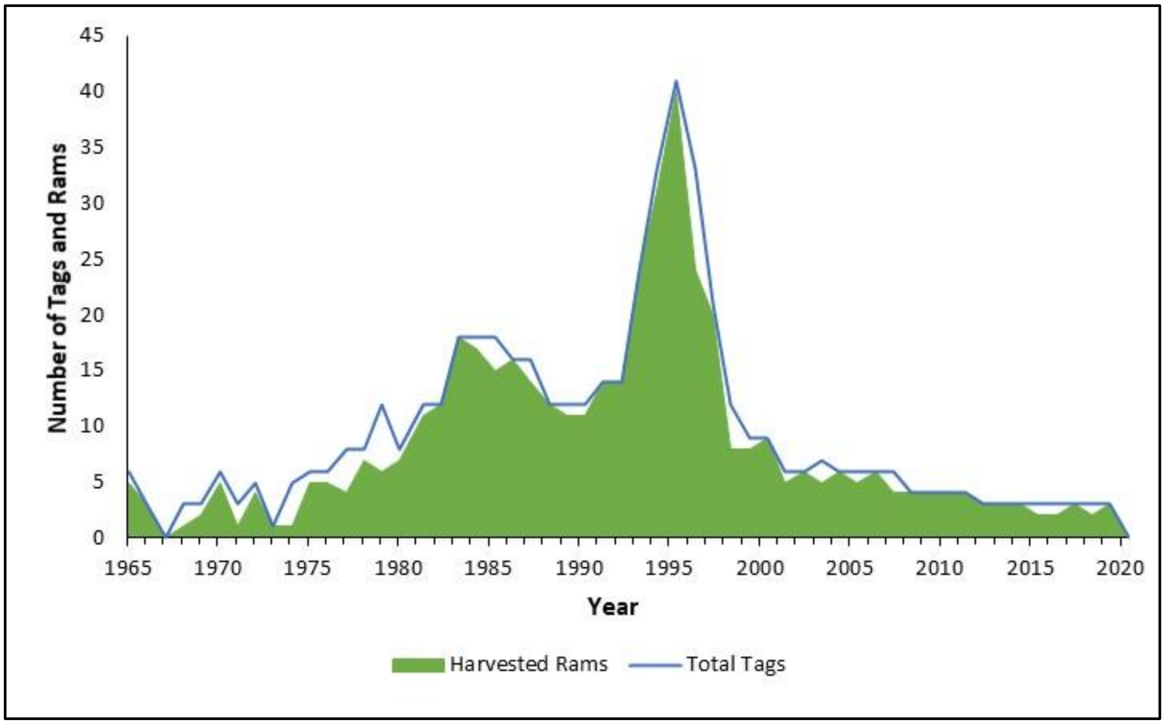

Figure 3.7. Number of bighorn sheep tags authorized and harvested by year on Hart Mountain National Antelope Refuge.

3.6.6 Aesthetic Resources

Aesthetic resources are the natural and cultural features of the landscape that can be directly experienced by people and that contribute to the public's enjoyment of the environment. These include visual, aural, and other ambient features that affect the quality of the visitor's experience. The Hart Mountain escarpment and adjacent open land represents a pristine natural landscape interrupted only by the access road and is an aesthetic asset. Many Refuge visitors seek the aesthetic pleasure of viewing plants and wildlife in their natural environment. Bighorn sheep are frequently a prize species for wildlife watchers, and the likelihood of seeing them is directly proportional to the number of sheep on the Refuge.

3.6.7 Environmental Justice

EO 12898, Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations, requires all Federal agencies to incorporate environmental justice into their missions by identifying and addressing disproportionately high or adverse human health or environmental effects of their programs and policies on minorities and low-income populations and communities. Environmental justice promotes the fair treatment of people of all races, income and culture with respect to the development, implementation and enforcement of environmental laws, regulations and policies. Fair treatment implies that no person or group of people should endure a disproportionate share of the negative environmental impacts resulting either directly or indirectly from the activities conducted to execute this country's domestic and foreign policies or programs. All activities are evaluated for their impact on the human environment and compliance with EO 12898 to ensure environmental justice. Refuge System personnel use wildlife damage management methods as selectively and environmentally conscientiously as possible. It is not anticipated that the proposed actions would result in any adverse or disproportionate environmental impacts to minority or low-income persons or populations.

3.7 Special Designation Areas

3.7.1 Proposed Wilderness

In 1972 the president proposed that Congress designate 16,462 acres of Poker Jim Ridge as a Wilderness Area under the 1964 Wilderness Act. This proposal has never been acted upon, but it is Service policy that all proposed wilderness areas, including the PJRPWA, be managed consistently with policy and guidance for designated wilderness until further action is taken by Congress. Generally, activities that conflict with wilderness values, such as permanent artificial structures and roads, use of mechanized tools and equipment, and commercial uses, are prohibited in wilderness areas unless there is an approved Minimum Requirements Analysis (MRA) decision authorizing a specific action.

Keeping it Wild 2 is an interagency strategy to monitor trends in wilderness character across the National Wilderness Preservation System (Landres et al. 2015). Keeping it Wild 2 defines wilderness character as "a holistic concept based on the interaction of 1) biophysical environments primarily free from modern human manipulation and impact, 2) personal experiences in natural environments relatively free from the encumbrances and signs of modern society, and 3) symbolic meanings of humility, restraint, and interdependence that inspire human connection with nature. Taken together, these tangible and intangible values define wilderness character and distinguish wilderness from all other lands."

The monitoring strategy proposed in Keeping it Wild 2 links the conceptual definition of wilderness character to a practical meaning of wilderness character by using a framework of "qualities." These qualities are derived from the statutory definition of wilderness in Section 2(c) of the Wilderness Act. These qualities are "untrammeled," "natural," "undeveloped," "solitude or primitive and unconfined recreation," and a wilderness may also contain "ecological, geological, or other features of scientific, educational, scenic, or historical value" based on the features that are inside that wilderness.

Landres et al. (2015) defined these qualities and provided examples of how they are preserved and how they can be degraded, as follows:

- **Untrammeled.** Wilderness is essentially unhindered and free from the actions of modern human control or manipulation. This quality is influenced by any activity or action that controls or manipulates the components or processes of ecological systems inside the wilderness. Management actions that are not taken support or preserve the untrammeled quality, whereas actions that are taken degrade this quality, even when these actions are taken to protect resources, such as spraying herbicides to eradicate or control nonindigenous species or reducing fuels accumulated from decades of fire suppression.
- **Natural.** Wilderness ecological systems are substantially free from the effects of modern civilization. This quality is degraded by many things, such as loss of indigenous species, occurrence of nonindigenous species, alteration of ecological processes such as water flow and fire regimes, effects of climate change, loss of dark skies, and occurrence of artificial sounds. It is preserved or improved, for example, by controlling or removing nonindigenous species or restoring ecological processes.
- **Undeveloped.** Wilderness retains its primeval character and influence and is essentially without permanent improvement or modern human occupation. This quality is influenced by what are commonly called the "Section 4c prohibited uses," that is, the presence of modern structures, installations, habitations, and use of motor vehicles, motorized equipment, or mechanical transport. The removal of structures and not conducting these prohibited uses preserve or improve this quality. In contrast, the presence of structures and prohibited uses degrades this quality, whether by the agency for administrative purposes, by others authorized by the agency, or when there are unauthorized uses.
- **Solitude or a primitive and unconfined type of recreation.** Wilderness provides outstanding opportunities for solitude or primitive and unconfined recreation. This quality is primarily about the opportunity for people to experience wilderness and is influenced by settings that affect this

opportunity. It is preserved or improved by management actions that reduce visitor encounters and signs of modern civilization inside the wilderness. In contrast, this quality is degraded by agency-provided recreation facilities, management restrictions on visitor behavior, and actions that increase visitor encounters.

The majority of lands within the Proposed Wilderness appear essentially natural and undisturbed to the casual observer. Exceptions to the natural appearance consist of several hundred acres where juniper trees were cut and later burned, and three locations where water developments (guzzlers) have been constructed for wildlife benefit.

Other activities potentially affecting wilderness character that have occurred in the proposed wilderness include radio collars on select wildlife; use of motorized equipment for fire suppression, as needed; removal of native juniper; control of invasive non-native plants; and native seeding. These activities are deemed necessary to prevent habitat degradation or to restore natural conditions and ecological function in order to meet Refuge purposes and obligations under the Refuge Improvement Act. MRAs have been approved for activities otherwise restricted in wilderness areas. Resource inventory, monitoring, and research activities are temporary and do not typically result in any long-term alteration of wilderness character.

Opportunities for solitude and primitive and unconfined types of recreation on the PJRPWA are considered outstanding, except during management and monitoring activities mentioned above, and during periodic low-level military aircraft training exercises. Visitors are free to explore and travel throughout the Proposed Wilderness on foot or by horseback with few regulations or restrictions and very little contact with Refuge staff.

Many plant and wildlife species are found throughout the unit, but perhaps the most sought after by the public for wildlife observation, photography, and hunting is bighorn sheep. This species relies on the rugged cliffs along the escarpment of Poker Jim Ridge for safety and protection from predators, and seldom ventures far from the security of these areas. These bighorn sheep represented the longest established population within the State of Oregon and are emblematic of wilderness in the American West.

3.7.2 Research Natural Areas

Within the PJRPWA, 640 acres of old-growth juniper woodland was identified as nationally significant for ecological preservation and study and was designated as a research natural area (RNA) in 1972. The stands of pre-settlement juniper within the RNA were considered to have considerable scenic, ecological, and scientific value since at least the initial wilderness review in 1968. Although bighorn sheep may occasionally use this area for thermal cover or other purposes, no active management under this plan will occur within the RNA.

CHAPTER 4. ENVIRONMENTAL CONSEQUENCES

4.1 Analytic Methodology

This section of the EIS describes the scientific and analytic basis for the comparison of alternatives (40 CFR 1502.16) by analyzing the environmental consequences (positive and negative effects) of each of the four alternatives in relation to topics identified in Chapter 3, Affected Environment. The three action alternatives are compared to the No Action Alternative (A) to determine if and to what extent effects would be greater, lesser, or the same. Thus, the No Action Alternative is the baseline for the comparative analysis. Details of the alternatives are presented in Chapter 2, Alternatives, Goals, Objectives, and Strategies.

Potential effects of management actions may be straightforward and made with confidence in some cases, but indirect effects on complex biological systems are often dependent on many factors that are highly variable and poorly understood, resulting in uncertain predictions of effects. For this reason, the sections on biological or ecological effects on a resource topic describe hypothetical potential effects based on current scientific understanding of causal relationships within the system that may or not in fact be born out when one or more of the actions are implemented. This is the primary reason why evidence-based conservation principles (see Section 2.2.6, Adaptive Management) that require results monitoring to inform the evaluation of the management actions are such integral components of the proposed management plan.

Wherever possible, the magnitude of the action that might have the described effect is given, usually as an estimate of the maximum annual areal extent over which an action may be applied or the portion of an estimated population likely to be affected. For example, prescribed burns may occur on, and affect up to 800 acres in a single year; however, in most cases those quantities cannot be determined until more detailed analyses are completed after the bighorn sheep management plan has been approved. In lieu of exact quantities for the magnitude of an action, the maximum size or degree of a potential effect of that action is estimated based on practical considerations of what can be accomplished each year of implementation, relative to the known or estimated total amount of that affected resource (e.g., cover type or population) at the scale of the proposed Bighorn Sheep-Cougar Management Zone, the Refuge, and the region. The direct and indirect effects are then described in terms of direction (positive, neutral, or negative), degree of severity (negligible, minor, intermediate, or major), and time frame (short term or long term) at the appropriate scales.

The direction (positive or negative) and magnitude of the effects are categorized according to the following scale:

Positive			Neutral	Negative		
Major	Intermediate	Minor	Negligible	Minor	Intermediate	Major

The definitions (adapted from the Service's *NEPA for National Wildlife Refuges: A Handbook* [2014]) of the rank terms are as follows:

- *Positive:* The quantity or quality of the resource is increased or improved.
- *Neutral:* The quantity or quality of the resource is not detectably altered either positively or negatively.
- *Negative:* The quantity or quality of the resource is decreased or diminished.
- *Negligible:* The environmental effects are so minor that they would neither destabilize nor noticeably alter any important attribute of the resource considered.
- *Minor:* Effects would be detectable, but temporary, localized, small, and of little consequence to a population, wildlife or plant community, recreation opportunity, visitor experience, or cultural resource. Mitigation measures, if needed to offset adverse effects, would be easily implemented and are likely to be successful.

- *Intermediate:* Effects would be readily detectable and localized with consequences to a population, wildlife or plant community, recreation opportunity, visitor experience, or cultural resource. Mitigation measures would be needed to offset adverse effects and would be extensive, moderately complicated to implement, and probably successful.
- *Major:* Effects would be obvious and would result in substantial consequences to a local area or regional population, wildlife or plant community, recreation opportunity, visitor experience, or cultural resource. Extensive mitigation measures may be needed to offset adverse effects and would be large scale, possibly very complicated to implement, and may not guarantee success. In some instances, major effects would include the irretrievable loss of the resource.

Other terms that may be used to describe the potential effects of implementing the alternatives are as defined in the Service's NEPA handbook (2014) as follows:

- *Direct effect*: Management action involves altering the resource at the time and place of the action.
- *Indirect effect:* The resource affected directly mediates an effect on another resource, or the effect happens later or distant from the action.
- *Short term:* 1 year; or generally affects the present quality of life for the public.
- *Long term:* More than 1 year; or has the potential to affect the quality of life for future generations.
- *Cumulative effects:* Impacts on the environment resulting from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions regardless of which agency (federal or non-federal) or person undertakes the actions.

4.1.1 Short-Term Uses of Man's Environment and the Maintenance/Enhancement of Long-term Productivity

NEPA (1502.10 (2)(C)(iv)) and Council on Environmental Quality (CEQ) regulations (40 CFR 1502.16) require a discussion of the relationship between short-term uses and long-term productivity of the environment from implementation of the proposed action or one of the alternatives. In this context, "short term" refers to the total duration of project implementation, and "long term" refers to an indefinite period beyond the project implementation phase.

The Service's Preferred Alternative (D) proposes actions to restore and protect the biological diversity, integrity, and environmental health of bighorn sheep habitat by seeking to restore plant communities to native conditions and addressing a disrupted predator/prey relationship that currently threatens the bighorn sheep herd with extirpation from the Refuge.

Short-term impacts and long-term benefits anticipated from implementing the action alternatives (B, C, and D) are described for each environmental resource in this chapter. These typically involve short-term impacts as habitat management actions and cougar control take place at the Refuge. The minor short-term impacts associated with the Preferred Alternative (D) would result in long-term benefits of restored biological diversity, integrity, and environmental health of the Refuge and healthy populations of wildlife interacting into the future.

4.2 Effects on the Physical Environment

4.2.1 Climate

No actions under any alternatives would have an effect on local or regional climate, but habitat management actions implemented under Alternatives B and D would mitigate and increase resilience to some effects of climate change. Specifically, in proportion to the degree that climate change influences vegetation succession processes that would result in woody plant encroachment, grassland and sagebrush rehabilitation actions would slow or reverse those processes more under Alternatives B and D than Alternative A (No Action Alternative). Similarly, actions under Alternatives B and D to improve water availability would mitigate the effects of more frequent and prolonged droughts associated with climate change on habitat quality for a variety of species. On the scale of the proposed Bighorn Sheep-Cougar Management Zone, these positive effects would be minor in the short term and intermediate in the long term as the total area treated increases. At the Refuge and regional scales, climate change resiliency effects would be negligible.

4.2.2 Soils

Most impacts to soils from any of the action alternatives (B–D) would be related to trampling, heat from fires, and stream channel repairs, and would differ from the No Action Alternative (A) by being more extensive and concentrated in bighorn sheep range. Trampling effects (soil compaction and vegetation damage) would be primarily from foot traffic during cougar removal operations associated with Alternative C and habitat management activities in Alternatives B and D, and mitigated by avoiding working on highly erodible soils, biocrusts, and steep slopes. Heat effects on soils would be minimized by timing prescribed burns when moisture and wind conditions limit their maximum temperatures. Burning of slash piles would occur during winter when frozen ground and snow would minimize soil damage. Negative effects on soil from trampling and fire would be negligible to minor due to the small areas affected and the short-term to moderate-term recovery time.

Positive effects on soils under Alternatives B and D include reduction of streambank erosion associated with improving herbaceous cover in riparian and spring recharge areas, and post-fire native seeding operations that control erosion. These effects would be minor in the short term to intermediate in the long term as the treated footprint grows in size.

4.2.3 Air Quality

Local air quality would be temporarily affected by smoke from wildfires and prescribed fires. Reactions to wildfires would not differ from Alternative A, and prescribed burns under Alternatives B and D would differ by being more frequent, more extensive, and concentrated within bighorn sheep range. Prescribed burns would be conducted in compliance with a strict fire plan policy following an approved prescribed burn plan and would only occur during favorable wind conditions to minimize off-site impacts. Smoke from prescribed burns associated with Alternatives B and D would have temporary, localized, and negligible effects on air quality.

Woody and invasive plant removal conducted under Alternatives B and D would potentially change fire regimes on treated areas by lowered availability and density of fuel resulting in reduced fire intensity and residence time producing less smoke. Such effects would be minor in the short term, and intermediate in the long term as more areas are treated.

4.2.4 Water Sources

The categories of natural and artificial water sources that would potentially be more affected by the actions associated with Alternatives B and D than with Alternative A are listed in Table 4.1, along with their potential impacts. The specific water features to be affected would be determined by habitat analyses that identify which features provide important habitat value and have the potential to be improved to benefit bighorn sheep under Alternatives B and D. In all cases, there would be minor, short-term negative impacts associated with groundwork (e.g., soil and vegetation disturbance), and long-term minor to intermediate positive impacts associated with hydrologic function restoration, predator cover reduction, erosion control, and water retention. See Section 4.4.4 for a discussion of potential effects on wetlands. Playas and lakes would not be significantly affected by actions under the proposed alternatives.

Table 4.1. Water Features, Potential Actions, and Short- and Long-Term Effects of Implementing Alternatives B and D.

Water Feature	Potential Action	Short-Term Effects	Long-Term Effects
Springs and seeps	Remove juniper from recharge area to reduce transpiration and predator cover	Disturb vegetation	Extend spring hydroperiod and lower predation risk for bighorn sheep
Stream channels	Repair streambeds and hydrologic function Restore riparian vegetation	Disturb soil and vegetation	Extend water availability Increase shade to lower water temperature
Stock ponds, dugouts, and impoundments	Excavate reservoirs and repair dams Reduce predator cover	Disturb soil and vegetation Disturb vegetation	Extend water availability Lower predation risk for bighorn sheep
Guzzlers	Repair or replace structures Reduce predator cover	Disturb soil and vegetation Disturb vegetation	Extend water availability Lower predation risk for bighorn sheep

4.2.5 Water Quality

The primary water quality issue on the Refuge is high water temperatures that degrade trout habitat due to lack of adequate streamside shading. Negative effects on stream shading under the alternatives affecting woody vegetation would be mitigated by avoiding removal of any plants that are directly shading springs and streams. Streambed repair, including planting willow and other desirable native plants in riparian zones, would have some minor, local, and long-term positive effects on shading.

Negative effects on water quality from herbicide application would be minimized by following best management practices specified in the relevant PUP and labeling requirements of each herbicide. Only herbicides labeled for aquatic use would be applied where the potential for water contamination is present.

4.3 Effects on the Biological Environment – Animals

4.3.1 Effects on California Bighorn Sheep

By definition, actions are beneficial when they have a direct or indirect positive influence on the critical vital rates of the bighorn sheep population (Table 4.2), as defined in Chapter 3. In accordance with the goals and objectives of this bighorn sheep management plan proposed in Chapter 2, all actions under Alternatives B through D are intended and expected to have minor, intermediate, or major long-term positive effects on the bighorn sheep herd on the Refuge compared with Alternative A, which would likely have short- and long-term negative effects. The Preferred Alternative (D) would have the greatest positive effects compared to Alternatives A through C because it represents a comprehensive approach integrating multiple strategies with the greatest chance of sustaining a healthy bighorn herd as described in Objective 2.1.

Some activities during aerial and ground operations under Alternatives B and D may have short-term negligible to minor negative effects by disturbing and temporarily displacing sheep. Some activities related to aerial surveys, especially capture operations under Alternatives B and D, would cause short-term stress to targeted individuals, and could potentially result in injury or death. These risks would be minimized by strict adherence to safety and animal care and welfare protocols developed and implemented by ODFW (Foster 2004; Sikes 2016; see Wild Sheep Capture Guidelines in Appendix L). Table 4.3 summarizes the direct and indirect positive and negative effects of implementing specific strategies associated with the alternatives, and the potential effects of not implementing the strategies under alternatives where they are not proposed.

There is a small possibility that bighorn sheep may be captured or injured by snares or foothold traps set for cougars. This possibility is minimized by trapping personnel adherence to the BMPs and SOPs listed in Section 2.3.3 and the employment of only highly trained and experienced trappers who know how to avoid capturing non-target animals. In particular, trap placement and the use of stops will minimize the likelihood that a sheep would accidentally enter a trap.

The benefits of preventative management actions such as disease and genetic monitoring under all alternatives would only manifest if a health issue is detected and successfully mitigated. Benefits of planned actions under Alternatives B and D, such as improving water availability and removing predator cover, would depend on bighorn habitat assessments that 1) identify that such elements are in need of improvement, 2) locate sites where management is feasible, and 3) result in successful implementation of the management action at those sites.

Management actions resulting in less conditional benefits are juniper removal and other vegetation management that generally improves all bighorn sheep habitat in direct proportion to the area treated, thus accruing more benefits in the long term as treated areas accumulate; and cougar control under Alternatives C and D, which would reduce both the threat and incidence of predation mortality on all ages of bighorn sheep while cougars are actively removed and until they are replaced after removal ends. These actions would directly and indirectly affect herd vital rates (see Table 4.2) by improving the quality, quantity, and spatial configuration of forage patches, and increasing reproduction and survivability of lambs and adults. As the vital rates meet and exceed the demographic criteria specified in Chapter 2, the herd population is projected to increase and eventually achieve a size that is resilient in the face of predation pressure and other stressors.

All three bighorn sheep population vital rates are positively affected by each action alternative, the differences being the approaches and timing of those effects. Habitat improvements made under Alternatives B and D would take time to increase the resources available to bighorn sheep resulting in increasing lamb production and survival, increasing adult survival, and ultimately raising the population growth rate. Alternative C would reduce predation mortality for all age groups, thus raising the vital rates, but would not directly affect habitat resources that could ultimately limit population growth. Alternative D combines these different approaches and maximizes their collective beneficial effects.

The time it will take for the bighorn sheep herd to respond to implementation of any of the action alternatives is dependent on many factors, including the rate that habitat improvement actions can be implemented (i.e., treated habitat elements or acres/year); the amount and timing of rainfall and other environmental factors that affect the vegetation response to treatments; stochastic events like disease outbreaks, wildfires, extreme storms, or drought that affect the health and survival of sheep; the success of removing cougars that prey on bighorn sheep; and the intrinsic capacity of the sheep population to increase its size under changing conditions.

The past management actions that would continue under Alternative A have clearly not prevented the bighorn sheep herd from declining and, as described in previous chapters, there is no reason to expect adoption of this alternative will meet the goals of restoring and conserving the Refuge herd. Habitat management actions that were primarily intended to benefit greater sage-grouse have likely had some incidental benefits to bighorn sheep but have so far proved insufficient to improve vital rates. At the recent rate of decline, the herd could become extirpated in less than 10 years under Alternative A.

Based on estimates of how much area within Refuge bighorn sheep habitat would be subject to and available for improvement under Alternatives B and D (see Table 3.12) and the number of acres that, based on experience, could reasonably be treated in a year if funding and personnel were available, it would take between 10 and 20 years to treat the Refuge’s total bighorn sheep habitat. Although bighorn sheep will benefit from any substantive increase in improved habitat, it is unknown to what degree that habitat resources are limiting to the critical vital rates, and a measurable population-level response could take 5 to 10 years to occur, accounting for time to treat significantly large areas and the time needed for the vegetation to respond to treatments such as juniper removal or prescribed fire. That vegetative response could include existing plants released from shade or new plants germinating from the seed bank or broadcast seed, which would take from one to several growing seasons to become fully available to sheep as forage. Overstory plants removed to improve horizontal visibility would have immediate effects.

Although the demographic response by bighorn sheep to habitat improvements will be incremental and likely take several years to begin manifesting after improvements are implemented, the effects of cougar removal that results in increased survival of would-be sheep prey could have immediate positive effects, depending on the proportion of the cougar population that could be removed and on which sheep survive.

The greatest effect would result from increased survival of breeding ewes, followed by survival of lambs, juveniles, and adult rams. It is unlikely that cougar removal will totally eliminate cougar-caused mortality, but reduction of annual cougar-caused mortality from 62% of total mortality (as found by Foster and Whittaker [2010]) by even half could push population growth over 1.0 very quickly.

Table 4.2 Effects of Implementing the Four Alternatives on Bighorn Sheep Population Performance Metrics

Vital Rate	Alternative			
	No Action (Alternative A)	**Habitat Only (Alternative B)**	**Population Only (Alternative C)**	**Comprehensive (Alternative D - Preferred)**
Population growth rate	Not managed	Increased LT	Increased ST	Increased ST and LT
Adult survival	Not managed	Increased LT	Increased ST	Increased ST and LT
Lamb to adult ratio	Not managed	Increased LT	Increased ST	Increased ST and LT

Note: LT = long term; ST = short term.

4.3.2 Effects on Cougars

Under Alternatives A and B, cougars would not be removed or otherwise managed on the Refuge, but the Refuge subpopulation would be indirectly affected by ODFW management policies pertaining to the regional population within Cougar Management Zone F, which includes the Refuge. Cougars on the Refuge would likely continue preying on bighorn sheep and other prey species at rates similar to those in recent years, unless or until the prey base changes. As apex generalist predators, cougars respond in the short term to the decline of one prey species by switching to another prey species or expanding their home ranges, or both, which would likely increase intraspecific competition and reduce cougar density on the landscape. If the prey scarcity persisted, cougars may experience a lower recruitment rate resulting from lower cub survival and fewer and smaller litters.

Under Alternatives C and D, individual cougars would be directly affected by the process of lethal removal, depending on the method of capture used. If they were tracked and chased by hounds, they would undergo stress from fear during the chase and subsequent cornering in a tree or rock refuge. If they were captured in a box trap, they would also be stressed at least during the initial hours of capture as they attempted to escape. If they were captured by a foothold trap (snare or leghold), they would experience stress from fear, pain from the trap, and possible injury from attempts to escape. In all these cases, they would likely experience additional stress as the human approached them before being dispatched by a carefully aimed lethal gunshot, which would result in an immediate death. If a cougar is captured in a neck snare designed to kill it by asphyxiation, its attempt to free itself will result in a rapid death, with a period of stress before loss of consciousness. A cougar killed by a skilled hunter with a rifle, without first being chased or trapped, would likely experience very short-term stress or pain, assuming the gunshot was accurately placed to cause a quick death.

There is no practical field method of lethal removal that would accomplish the goal of significantly reducing cougar predation on bighorn sheep without some degree of stress and pain experienced by the targeted cougar, but mitigation and minimization of stress and pain is possible and an integral part of this proposed plan. This is accomplished by strict adherence to all the SOPs and BMPs listed in Section 2.3.3 and employing only highly trained and experienced personnel committed to ethical and humane practices. The removal program also prioritizes methods that minimize cougar pain and suffering, relying primarily on hounds, box traps, and snares, and only using foothold traps if these other methods are shown to be ineffective.

Table 4.3. Potential Effects of Proposed Alternatives on Bighorn Sheep Herd

Action	**Alternative**				**Comments/Indirect Effects**
	No Action (A)	**Habitat Only (B)**	**Population Only (C)**	**Comprehensive (D - Preferred)**	
Aerial survey	0	0	0	0	Survey data would influence management decisions.
Capture	ST, -	ST, -	ST, -	ST, -	Capture effects are ST to targeted sheep.
Track collared sheep	0	ST,0 LT, ++	ST,0 LT, ++	ST,0 LT, +++	Tracking is noninvasive but would yield LT data on bighorn sheep performance and inform B, C, and D actions.
Prescribed burn	ST, 0 LT, +	ST, - LT, ++	NA, 0	ST, - LT, ++	ST effects last until burned vegetation recovers. Positive effects are cumulative as more acreage is treated under B and D.
Invasive plant management	0	ST, 0 LT, +	NA, 0	ST, 0 LT, +	Effects are cumulative as more acreage is treated, leading to a LT positive effect.
Water availability	0	ST, 0 LT, ++	NA, 0	ST, 0 LT, ++	No ST effect while need is evaluated; LT effect depends on actual need and management ability to respond to need. Under A and C, conditions may deteriorate.
Predator cover reduction	NA LT, --	ST, + LT, ++	NA LT, --	ST, + LT, ++	Effects are cumulative as more acreage is treated; benefit depends on management ability to respond to need. Under A and C, predator cover will increase.
Juniper removal	NA LT, ---	ST, + LT, ++	NA LT, --	ST, + LT, +++	Effects are cumulative as more acreage is treated.
Cougar removal	NA LT, ---	NA LT, --	ST, ++ LT, +++	ST, ++ LT, +++	Benefit depends on management ability to reduce cougar-caused mortality. Cougar ambush cover reduction under B somewhat mitigates cougar predation.
Disease monitoring	ST, 0 LT, +	ST, 0 LT, +	ST, 0 LT, +	ST, 0 LT, +	Benefits accrue if disease outbreak occurs and can be mitigated by management response.
Genetic monitoring	ST, 0 LT, +	ST, 0 LT, +	ST, 0 LT, +	ST, 0 LT, +	Benefits accrue if disease outbreak occurs and can be mitigated by management response.
Herd enhancement	NA LT, ---	NA LT, ---	ST, 0 LT, +++	ST, 0 LT, +++	Benefits accrue if herd enhancement becomes necessary.

Note: LT = long term; NA = action is not proposed under the respective alternative; ST = short term; 0 = negligible; -, --, --- = minor, intermediate, major negative; +, ++, +++ = minor, intermediate, major positive.

4.3.2.1 COUGAR REMOVAL POPULATION-LEVEL EFFECTS

Any population-level response within the proposed Bighorn Sheep-Cougar Management Zone would happen in the context of the regional cougar population and the conditions affecting it at the landscape scale. For example, home range expansion by an adult male cougar would only be a successful response to prey scarcity in the proposed Bighorn Sheep-Cougar Management Zone if sufficient prey were available in that larger home range, and adjacent resident cougars could be successfully displaced. The complex interplay among cougars, their multispecies prey base, intraspecific competition, meta-population dynamics, potential human conflict, and other unpredictable mortality sources renders any prediction of the Refuge cougars' status in the short to long term as highly speculative. Therefore, analysis of the direct effects of cougar removals under Alternatives C and D are focused here on the predictable likely effects of a lower density of cougars in the proposed Bighorn Sheep-Cougar Management Zone than would be the case under Alternatives A and B.

Currently, the annual cougar tag quota for Zone F is 140, which represents the maximum number of mortalities from all sources allowed by ODFW before hunting (and any administrative population management ongoing in the zone) would be terminated for the year. In recent years, the highest known mortality was 45 cougars (in 2018 when an administrative cougar target area elsewhere in Zone F was in effect), which is well below the 140 quota that ODFW considers sustainable for the zone population. Although any cougars removed under this bighorn sheep management plan would be counted toward the annual mortality quota for the zone, consistently low zone harvest levels over a 10-year period indicate that reaching or exceeding the annual zone quota is highly unlikely.

Based on cougar hair snare and camera trap data collected from the Refuge cougar study area in 2019 (May–October) and 2020 (May–September), the minimum number of cougars using the Refuge is estimated to be between 12 and 16 (Service 2020a). For the purpose of this analysis, and because an active removal program may result in increased immigration as dispersing cougars replace those removed, 16 cougars removed a year under Alternatives C and D would be considered the theoretical annual limit; however, it is unlikely that 16 individuals would actually ever be removed due to practical and logistical limitations. Postulating the active administrative removal of as many as 16 cougars per year from the proposed Bighorn Sheep-Cougar Management Zone, added to other sources of cougar mortality occurring at normal rates throughout Zone F, total cougar mortality will most likely remain less than what ODFW cougar population modeling indicates is sustainable under current and foreseeable projections.

Under these circumstances, Alternatives C and D would result in a short-term moderate to major effect (as intended) and a long-term (post removal program) negligible direct effect on the cougars using the proposed Bighorn Sheep-Cougar Management Zone. In addition, there would be a short- and long-term negligible effect on the regional cougar population. To the extent that a healthy, sustainable bighorn herd provides additional prey for cougars in the future, Alternatives B through D would have a long-term positive indirect effect on the cougar population once the administrative removal program was suspended, and cougars were allowed to return. Alternative D would have the greatest potential of restoring a balanced predator-prey interaction between cougars and the bighorn sheep herd on the Refuge.

It is anticipated that most of the cougars regularly using the proposed Bighorn Sheep-Cougar Management Zone would be removed within the first two removal seasons, and the number of subsequent removals would depend on the immigration rate. Wildlife meta-populations often display source-sink dynamics where growing subpopulations (sources) supply individuals that disperse and replace losses in low-producing subpopulations (sinks). It is unknown whether the cougar subpopulation in the proposed Bighorn Sheep-Cougar Management Zone currently plays either of these roles, but a successful active removal program would likely create a sink that would receive dispersers at an above-normal rate. This process would result in regular replacement of removed cougars and necessitate ongoing vigilance to detect and remove arriving cougars until the program was suspended. It would also likely result in fairly rapid (i.e. several years) restoration of the cougar numbers to equilibrium with the prey base and intraspecific social constraints in the Zone after the program was suspended.

4.3.2.2 ECOLOGICAL EFFECTS OF COUGAR REMOVAL

Suppression of cougar predation pressure on prey other than sheep due to fewer cougars in the proposed Bighorn Sheep-Cougar Management Zone associated with Alternatives C and D may result in increased survival rates and subsequent population increases for species such as mule deer and jackrabbits. This response could be muted to the degree that mesocarnivores (that may or may not be typical cougar prey) benefit by being released from predation pressure and competition for prey by fewer cougars. If there are more bobcats and coyotes, then there may be more predation by these species on bighorn sheep lambs and other prey species. These effects are likely to be negligible to minor in the short term during the cougar removal (but see mule deer below), and negligible in the long term when administrative cougar removal is suspended.

The bighorn sheep habitat improvement actions under Alternatives B and D that are designed to reduce predator cover and increase sheep visibility, if successful, would reduce cougar predation, and possibly result in shifts in prey choice, hunting strategies, and cougar home range size. This would be compensated by higher prey densities as the bighorn sheep (and possibly mule deer) numbers increase. Overall, this effect would be minor to intermediate negative for cougars in the short term and negligible to minor negative in the long term.

4.3.3 Effects on Mule Deer

As discussed in Section 3.3.4, mule deer are considered the primary prey species for cougars, and it may seem reasonable to expect that a decline in the numbers of cougars in the proposed Bighorn Sheep-Cougar Management Zone resulting from implementation of Alternatives C and D would benefit mule deer to some degree. But mule deer numbers are not considered critically low as they are for bighorn sheep, and deer have less restrictive habitat requirements and range over much larger areas of the Refuge than sheep. The best judgement of wildlife managers is that numbers of mule deer have been declining in the region for many years, but it is unknown how much cougar predation has contributed to this, or if it is a limiting factor to the mule deer population on the Refuge. Given these facts, it can be speculated that cougar removal would likely reduce predation mortality to mule deer in the short term but because cougar removal is expected to terminate when bighorn sheep populations recover, it is unlikely to result in a significant change in the Refuge mule deer population in the long term.

Vegetation manipulation under Alternatives B and D to improve bighorn sheep habitat would likely benefit mule deer by increasing the quantity and quality of available forage, reducing predator cover, and perhaps improving water availability. But because their habitat is not centered on escape terrain, deer are intrinsically less restricted in their options to adapt to changes in resource availability than sheep and may have been less affected by recent landscape processes that have hurt sheep. Because mule deer are only partial competitors for resources with bighorns, they would not benefit as much as bighorn sheep from the habitat improvements proposed under this management plan. The effects of vegetative manipulations under Alternatives B and D are expected to be short- and long-term positive, minor to intermediate on mule deer.

To the degree that mule deer and bighorns are resource competitors, a significant increase in sheep numbers resulting from a successful recovery would increase that competition proportionately; however, that competition would be mitigated by the effects of improved habitat mentioned above, and possibly by the sheep relieving cougar predation pressure on deer by providing alternate prey. Assessment of this latter effect is complicated by the possibility that the cougar population would be regulated by the total ungulate prey availability, i.e., more sheep would support more cougars and not affect predation pressure on deer. Short- and long-term effects of more sheep on mule deer are, therefore, likely to be negligible to minor positive.

There is a small possibility that mule deer may be captured or injured by snares or foothold traps set for cougars. This possibility is minimized by trapping personnel adherence to the BMPs and SOPs listed in Section 2.3.3 and the employment of only highly trained and experienced trappers who know how to avoid capturing non-target animals. In particular, trap placement, the use of stops on snares, pan tension setting, and the use of lures and bait will minimize the likelihood that a deer would accidentally enter a trap and be injured. Any non-target animal accidentally captured would be assessed for the extent of its injuries, if any, and either released on-site if it could be done safely, or humanely euthanized.

4.3.4 Effects on Other Ungulates

Similar to deer, elk and pronghorn are not associated with the bighorn sheep escape terrain on the Refuge, and spatial overlap with sheep range is minimal. Resource competition with sheep is also minimal, and cougar predation on elk and pronghorn is not considered a major source of mortality. Bighorn sheep habitat improvement under Alternatives B and D would have minor benefits to the portions of those Refuge populations of elk and pronghorn that use sheep range, but population-level effects are likely to be negligible. Fewer cougars resulting from administrative removals under Alternatives C and D may reduce predation mortality on elk and pronghorn but is unlikely to substantially affect the Refuge numbers or distributions of these species.

There is a very small possibility that elk or pronghorn may be captured or injured by snares or foothold traps set for cougars. This possibility is minimized by trapping personnel adherence to the BMPs and SOPs listed in Section 2.3.3 and the employment of only highly trained and experienced trappers who know how to avoid capturing non-target animals. In particular, trap placement, the use of stops on snares, pan tension setting, and the use of lures and bait will minimize the likelihood that a deer would accidentally enter a trap and be injured. Any non-target animal accidentally captured would be assessed for the extent of its injuries, if any, and either released on-site if it could be done safely, or humanely euthanized.

4.3.5 Effects on Mesocarnivores

The mesocarnivores present on the Refuge include coyotes, badgers, red fox, bobcat, raccoon, spotted skunk, and striped skunk. The interrelationships between these species, their prey, and their habitats are extremely complex and intricate, and any projections of their responses to changes that would result from implementing specific aspects of the bighorn sheep management plan are highly speculative and can only be verified by meticulous field studies. All of these species are potential prey of cougars, and may benefit from fewer cougars resulting from administrative removals under Alternatives C and D. If there are more bobcats and coyotes, for example, because of release from competition from cougars, there may be more predation by these species on bighorn sheep lambs and other prey species; however, most of these species also benefit by scavenging cougar-killed carcasses, and fewer available carcasses could have negative effects. With the possible exception of bobcats, these species' ranges on the Refuge are not centered on bighorn sheep escape terrain, and so modifications of bighorn habitat would only affect some portion of each of their populations.

There is a small possibility that some of these species may be captured or injured by snares or foothold traps set for cougars. This possibility is minimized by trapping personnel adherence to the BMPs and SOPs listed in Section 2.3.3 and the employment of only highly trained and experienced trappers who know how to avoid capturing non-target animals. In particular, trap placement, the use of stops on snares, pan tension setting, and the use of lures and bait will minimize the likelihood that a deer would accidentally enter a trap and be injured. Any non-target animal accidentally captured would be assessed for the extent of its injuries, if any, and either released on-site if it could be done safely, or humanely euthanized.

None of these species are particularly dependent on young juniper stands, so reduction of that cover type would have minimal effects, although some may be temporarily disrupted by clearing operations. All of these species typically prey (to varying degrees) on rodents and would possibly benefit as several rodent species may become more abundant as a result of more and healthier grass, forb, and riparian communities created to benefit bighorns under Alternative B and D. Overall, due to their adaptable nature and the restricted area that would be directly affected by actions under the bighorn sheep management plan relative to the ranges of these mesocarnivore populations (which extend well beyond Refuge boundaries), short- and long-term effects of implementation of any of the action alternatives on each species should be negligible.

4.3.6 Effects on Species of Conservation Concern

4.3.6.1 EAGLES

State and federal guidelines to mitigate any disturbance to eagles and their nests would be followed under any of the alternatives proposed. Nest surveys to locate nests in planned work areas would be conducted, and work would be scheduled outside of nesting season, or buffers would be established and respected. No negative effects on eagles are expected from field work under this management plan.

Under the No Action Alternative, persistent low numbers or extirpation of bighorn sheep would deprive golden eagles of lambs as prey relative to lambs available from a recovered herd under the action alternatives. It is unknown whether this would have a negative effect on eagle reproduction or survival, or on alternate prey species. Successful recovery of the herd would provide more lambs as prey but would have unknown effects on eagles or their other prey.

There is a small possibility that an eagle may be captured or injured by snares or foothold traps set for cougars. This possibility is minimized by trapping personnel adherence to the BMPs and SOPs listed in Section 2.3.3 and the employment of only highly trained and experienced trappers who know how to avoid capturing non-target animals. In particular, trap placement, pan tension, stops on snares, and the use of lures and very limited use of sight bait will minimize the likelihood that an eagle would accidentally enter a trap. If an eagle is captured uninjured, it would be released on-site; otherwise, if the injury is debilitating and can be treated, it would be transported to a trained veterinary or rehabilitator for recovery and release.

Golden eagles are scavengers on large animal carcasses, and cougar removal may result in fewer carcasses available to them at critical times, although this could be somewhat offset by more lambs in the long term. Woody plant removal and bighorn forage improvement under Alternatives B and D may increase prey abundance and hunting success for eagles. Overall, the net direct and indirect effects of any of the action alternatives on eagles should be negligible in the short term to minor positive in the long term. The short- and long-term effects of these actions are summarized in Table 4.4.

4.3.6.2 GREATER SAGE-GROUSE

Sage-grouse breeding behavior and habitat use has been well studied on the Refuge and continued monitoring and avoidance would prevent the bighorn sheep habitat improvement groundwork from disturbing any sage-grouse lek and nest sites. Juniper removal operations under Alternatives B and D should benefit sage-grouse in the long term by removing raptor perch trees and expanding and restoring sagebrush preferred by the grouse. This effect would become more significant as more acreage is treated; however, because sage-grouse habitat extends well beyond the bighorn sheep range on the Refuge, the proportion of grouse habitat that might eventually be affected is relatively minor. The net effects of bighorn sheep habitat improvement work are expected to be negligible in the short term and minor positive in the long term.

Cougar removal is expected to have no direct effect on sage-grouse, but if the mesocarnivores that are also grouse predators (e.g., coyote, badger, fox, skunks) benefit significantly from fewer cougars, there may be an indirect negative effect on sage-grouse. That potential effect, if it occurs, would attenuate when the cougar removal program is suspended. The short- and long-term effects of these actions are summarized in Table 4.4.

4.3.6.3 OTHER BIRDS OF CONCERN

The same landscape changes that have had negative habitat implications for bighorn sheep have contributed to the decline and conservation concern–designation of the other sagebrush-dependent and grassland-dependent bird species listed in Section 3.3.5. It follows, then, that the bighorn sheep habitat restorations prescribed under Alternatives B and D would also benefit these birds. Specifically, restoration of sagebrush and grassland habitat is expected to have a positive effect on these species in the short term, which should increase as more acreage is treated in the long term. There may be a concurrent negative effect on generalist or juniper-dependent birds that currently use the areas to be targeted for treatment, but those species' habitats have been expanding due to the historical changes in the region, and the land area to be treated under the bighorn sheep management plan is very small in comparison to the habitat available to them regionally. Overall direct and indirect effects of the habitat improvement activities on all landbirds are expected to be negligible in the short and long term, except for sagebrush- and grassland-dependent species, which will experience minor positive effects in the long term.

Direct injury and nest destruction caused by land management operations would be mitigated by avoiding disturbance during the nesting season. Cougar removal should have no direct effect on landbirds, but if the mesocarnivores that are also bird predators are significantly benefitted by fewer cougars, there may be an indirect negative effect on birds. That potential effect, if it occurs, would attenuate when the cougar removal program is suspended. The short- and long-term effects of these actions are summarized in Table 4.4.

4.3.6.4 PYGMY RABBIT

There are currently no known pygmy rabbit colonies within core bighorn sheep range on the Refuge, but there are some within the adult bighorn sheep water limits. Groundwork for bighorn sheep habitat improvement would avoid pygmy rabbit colony areas to prevent direct negative effects. Juniper removal to benefit sheep would also benefit pygmy rabbits, which prefer sagebrush cover types. Similar to sage-grouse, pygmy rabbit habitat on the Refuge extends well beyond sheep range, so although the benefits of juniper clearing would accumulate as more acreage is treated, the proportional effect on the rabbits would remain fairly minor in the long term.

Cougar removal is expected to have no significant direct effect on pygmy rabbits, but if the mesocarnivores that are also rabbit predators (e.g., coyote, badger, fox) are significantly benefitted by fewer cougars, there may be an indirect negative effect on the rabbits. That potential effect, if it occurs, would attenuate when the cougar removal program is suspended. The short- and long-term effects of these actions are summarized in Table 4.4.

4.3.6.5 WHITE-TAILED JACKRABBIT

White-tailed jackrabbits are much less common on the Refuge than black-tailed jackrabbits and are associated with open grasslands outside bighorn sheep range. Habitat management for bighorn sheep is unlikely to occur in existing white-tailed jackrabbit habitat unless it is targeted for invasive plant control, because it is likely already prime foraging for sheep if it is within their range. Generally, bighorn sheep habitat improvement would also benefit white-tailed jackrabbits because it would result in more grassland and less-dense shrubland cover types. Short-term negative effects may occur from prescribed burns until the vegetation recovers. Jackrabbits may benefit from cougar removal reducing predation mortality, but this could be diminished if other predators such as coyotes, bobcats, and golden eagles increase in response. The net short- and long-term impacts of implementation of any or all of the action alternatives is likely to be negligible to white-tailed jackrabbits, mostly due to the probable limited range overlap with bighorn sheep. The short- and long-term effects of these actions are summarized in Table 4.4.

4.3.6.6 PIKA

The specialized habitat requirements of pika (cool talus slopes with adequate herbaceous forage nearby) make it likely that they occur within bighorn sheep range on the Refuge, but unlikely that their habitat would be targeted for active management under Alternatives B and D due to access issues and the general lack of woody plants. If juniper removal occurs adjacent to talus slopes with pika, it should result in improved forage opportunities for pika. Cougar removal would have no direct effect on pika, but it is conceivable that golden eagle predation pressure could be increased or decreased depending on how eagles respond to fewer cougars and more sheep. The net short- and long-term impacts of implementation of any or all of the action alternatives are likely to be negligible to pika. The short- and long-term effects of these actions are summarized in Table 4.4.

4.3.6.7 BATS

Many species of bats that have been documented as present on the Refuge are species of concern (see list in Section 3.3.4), but little is known about any species' abundance, distribution, and habitat relationships relevant to evaluating the potential effects of the bighorn sheep action alternatives. It seems safe to expect that cougar removals under Alternatives C and D would not have any significant direct or indirect effects on any bat species, but minor local effects of some bighorn sheep habitat improvement activities (under Alternatives B and D) are conceivable. For example, bats that roost or forage in juniper stands may be displaced by juniper removal, although removal of old-growth juniper that provides prime habitat is not intended. It is not clear whether bats would be able to readily find alternative roosting and foraging sites if they were displaced from treated stands. It is also possible that changes to vegetative cover types would alter the abundance or spatial and temporal distribution of key insect species that, in turn, would change bat foraging patterns or foraging efficiency. Improvement of the hydrological functioning of springs, streams, and ponds may increase their production of insects and benefit bats. Bats that roost or hibernate in rock crevices, caves, and old-growth tree cavities should not be directly affected by any of the action alternatives because little or no management would occur in these areas. Overall, as with other widespread species, the proportion of the regional populations of most bat species that occupy bighorn sheep range on the Refuge is probably small, thus limiting the potential for significant impact of sheep management at the population scale. The short- and long-term effects of these actions are summarized in Table 4.4.

4.3.6.8 NORTHERN SAGEBRUSH LIZARD

The potential effects of the action alternatives on sagebrush lizards are similar to those described for pygmy rabbits, as they are both sagebrush-obligate species; however, less is known about the numbers and distribution of the lizards on the Refuge, which would make it more difficult to avoid disturbing them during groundwork. Consequently, actions such as juniper clearing and prescribed fire may injure or kill individuals unable to escape the disturbance. This possibility is mitigated by the likelihood that prime lizard habitat (i.e., sagebrush dominated) would be less likely to be subject to active management, cheatgrass control would benefit lizards, and that most lizard habitat is outside sheep range. In the long term, sagebrush cover-type restoration and cheatgrass control is expected to have a minor positive effect on the lizard population. The short- and long-term effects of these actions are summarized in Table 4.4.

4.3.6.9 TROUT AND OTHER FISH

No direct effects on fish are expected by any of the action alternatives. Potentially significant indirect effects are related to water duration and temperature improvements resulting from watershed management activities such as removing juniper from spring recharge areas, streambank stabilization, and riparian vegetation restoration. The short- and long-term effects of these actions are summarized in Table 4.4. The net effects of these activities would be to increase the hydroperiod of intermittent streams, reduce sedimentation, and increase shade to ameliorate high stream temperatures, all of which should benefit native fish that are currently stressed by degraded streams. Overall effects on native fish from bighorn sheep habitat improvement actions under Alternatives B and D are expected to be short-term negligible and long-term intermediate positive within those watersheds where such actions are implemented.

Table 4.4. Potential Effects of Proposed Alternatives on Species of Conservation Concern

Species of Concern	**Alternative**				**Notes and Mitigation of Negative Effects**
	No Action (Alternative A)*	**Habitat Only (Alternative B)**	**Population Only (Alternative C)**	**Comprehensive (Alternative D - Preferred)**	
Eagles	Lo: ST 0; LT - Re: ST 0; LT 0	Lo: ST 0; LT + Re: ST 0; LT 0	Lo: ST 0; LT 0 Re: ST 0; LT 0	Lo: ST 0; LT + Re: ST 0; LT 0	No disturbance to active nests; availability of bighorn lambs may affect golden eagle breeding.
Greater sage-grouse (*Centrocercus urophasianus*)	Lo: ST 0; LT + Re: ST 0; LT +	Lo: ST 0; LT + Re: ST 0; LT 0	NA: 0	Lo: ST 0; LT + Re: ST 0; LT 0	Expansion and improvement of sagebrush would be beneficial, but the proposed Bighorn Sheep-Cougar Management Zone (BSCMZ) is only a small portion of Refuge and regional habitat.
Sagebrush and grassland birds	Lo: ST 0; LT + Re: ST 0; LT +	Lo: ST 0; LT + Re: ST 0; LT 0	NA: 0	Lo: ST 0; LT + Re: ST 0; LT 0	Expansion and improvement of sagebrush and grassland would be beneficial, but BSCMZ is only a small portion of Refuge and regional habitat.
Pygmy rabbit (*Brachylagus idahoensis*)	Lo: ST 0; LT + Re: ST 0; LT +	Lo: ST 0; LT + Re: ST 0; LT 0	NA: 0	Lo: ST 0; LT + Re: ST 0; LT 0	Occupied habitat would be avoided; juniper removal and sagebrush expansion would be beneficial, but BSCMZ is only a small portion of Refuge and regional habitat.
White-tailed jackrabbit (*Lepus townsendii*)	Lo: ST 0; LT + Re: ST 0; LT +	Lo: ST 0; LT + Re: ST 0; LT 0	NA: 0	Lo: ST 0; LT + Re: ST 0; LT 0	Limited overlap with bighorn sheep range; grassland improvements would be beneficial.
Pika (*Ochotona princeps*)	NA: 0	NA: 0	NA: 0	NA: 0	Juniper removal adjacent to talus slopes may improve forage.
Bats	NA: 0	NA: 0	NA: 0	NA: 0	BSCMZ is a small portion of Refuge and regional habitat; rock crevice roost sites will not be affected.
Northern sagebrush lizard (*Sceloporus graciosus*)	Lo: ST 0; LT + Re: ST 0; LT +	Lo: ST 0; LT + Re: ST 0; LT 0	NA: 0	Lo: ST 0; LT + Re: ST 0; LT 0	Sagebrush habitat will be expanded and improved; prescribed burns may injure or kill individuals, but BSCMZ is only a small portion of Refuge and regional habitat.
Trout and other fish	NA: 0	Lo: ST 0; LT + Re: ST 0; LT 0	NA: 0	Lo: ST 0; LT + Re: ST 0; LT 0	No direct effects; lower water temperatures and extended hydroperiods would be beneficial.

Note: Lo = local (proposed Bighorn Sheep-Cougar Management Zone) LT = long term; NA = no action is proposed that would directly affect resource; Re = regional; ST = short term; 0 = negligible; -, --, --- = minor, intermediate, major negative; +, ++, +++ = minor, intermediate, major positive.
* It is assumed that past habitat improvement work to benefit sage-grouse and pronghorn would continue under Alternative A and that this could affect some of these other species. See Chapter 2 for descriptions of the alternatives and Tables 4.1 and 4.3 for summaries of effects on water resources and bighorn sheep.

4.3.7 Effects on Other Mammals

4.3.7.1 BLACK-TAILED JACKRABBITS AND MOUNTAIN COTTONTAIL RABBITS

Improved forage quantity and quality from expansion of sagebrush cover types resulting from juniper removal and invasive grass and forb control would probably benefit black-tailed jackrabbits. Jackrabbits may also experience less direct predation from cougar reduction within the proposed Bighorn Sheep-Cougar Management Zone, although they may experience more from certain mesocarnivores if the mesocarnivores respond positively to fewer cougars. Any effects of implementing the management plan action alternatives would be reduced because black-tailed jackrabbit range on the Refuge and beyond far exceeds the area that may be directly affected by the management plan action alternatives. The net short- and long-term, direct and indirect impacts of implementation of any or all of the action alternatives are likely to be negligible to black-tailed jackrabbits.

Mountain cottontail rabbits' preference for woodlands and dense shrublands near water sources may be negatively affected by woody plant removal intended to benefit bighorn sheep. This effect would be mitigated by the maintenance of aspen woodlands, mountain mahogany stands, and riparian willow thickets prescribed under Alternatives B and D. Cougar removal may indirectly increase predation pressure on cottontails depending on how certain mesocarnivores respond. Any effects of implementing the action alternatives of the management plan would be reduced because cottontail range on the Refuge and beyond far exceeds the area that may be directly affected by the management plan action alternatives. The net short- and long-term, direct and indirect impacts of implementation of any or all of the action alternatives are likely to be negligible to mountain cottontails.

4.3.7.2 RODENTS

Rodent species most likely to be affected by bighorn sheep habitat improvement actions under Alternatives B and D are those most associated with young juniper stands, which would be negatively affected, and those associated with grassland or open sagebrush cover types, which would be positively affected in proportion to the areas of each of these cover types treated under the management plan. There may be a net increase in small rodent biomass associated with a more diverse and denser herbaceous layer resulting from juniper removal and invasive control, but that would need to be verified by field studies. Removal or reduction of woody overstory may increase rodent risk from raptor predation. Individual animals may be displaced, injured, or killed by juniper clearing operations and prescribed burns, but most species can retreat to burrows to avoid direct disturbance. But, as with other widespread species, the proportion of the regional populations of most rodent species that occupy bighorn sheep range on the Refuge is relatively small, thus limiting the potential for significant impact of sheep management at the population scale.

Rodent species specializing in cliffs, canyons, and talus slopes, such as bushy-tailed woodrat and least chipmunk, whose range on the Refuge is largely within bighorn sheep range, are expected to be negligibly affected because little vegetation manipulation would occur on very steep slopes due to poor accessibility.

Any indirect effects of cougar removal on rodents would likely be mediated by the responses of rodent predators, including mesocarnivores and raptors. If mesocarnivore species are released from predation mortality and competition with fewer cougars, increased predation pressure on small rodents could result. Overall net direct and indirect effects of implementation of any of the action alternatives on any rodent species is expected to be negligible in the short and long term.

4.3.8 Effects on Other Reptiles and Amphibians

The lack of specific information about the distribution, abundance, and habitat relationships of the various reptile and amphibian species (see Section 3.3.7) on the Refuge makes it difficult to evaluate the duration and magnitude of the likely effects that implementing the action alternatives may have on them; however, the following general statements seem plausible:

- The magnitude of any population-level effects (positive or negative) is constrained by the proportion of any species' population that occurs within the active management area of the proposed Bighorn Sheep-Cougar Management Zone affected by implementation of the action alternatives.
- Cougar removal should have negligible direct and indirect effects on any species of reptile or amphibian.
- Species strongly associated with sagebrush and grassland cover types should benefit in the long term as healthier versions of these types increase on the landscape.
- Individuals present in active work areas may be displaced, injured, or killed.
- Species associated with talus slopes and rock outcroppings should not be significantly affected because little or no management would occur in these areas.
- Species that use young juniper stands may suffer from a reduction of juniper habitat in the proposed Bighorn Sheep-Cougar Management Zone, but those using other tree species would not be significantly affected.
- Amphibians may benefit if aquatic breeding sites are successfully managed for extended duration.

All of these effects are likely to be negligible in the short and long term on reptile or amphibian species present in the proposed Bighorn Sheep-Cougar Management Zone, with the possible exception of a local population of an amphibian benefitting significantly in the long term from the restoration of a failing breeding site.

4.4 Effects on the Biological Environment – Plant Communities

The goal of the bighorn sheep habitat improvement Alternatives (B and D) is to increase the number of sheep that can be supported by the habitat in the vicinity of the escape terrain of the Refuge. This is accomplished largely by directly managing plant communities, and this section describes how they may be affected by that management. The underlying premise is that ecological processes in recent decades have degraded the habitat quantity and quality for bighorn sheep to the extent that it can no longer support a sustainable herd. In this context, the proposed actions are restorative and are designed to approximate historical conditions that supported native communities of plants and animals, including bighorn sheep and many other species. Proposed vegetation management within this management plan is intended and expected to have significant positive effects for bighorn sheep.

Because cliff and canyon cover types, barren lands, and natural lakes and ponds would not be directly or significantly affected by the proposed management actions, they are not discussed further here.

4.4.1 Effects on Shrubland Communities

Decisions about prioritizing where shrubland management actions would occur would be based on criteria outlined in Chapter 2, Section 2.5.1, rather than by type of shrub community. That is, upland shrubland with brush canopy closure >25%, >4 encroaching juniper stems per acre, >10% herbaceous cover of non-native invasives, or mean shrub height over 2 feet may be targeted for treatment to bring these metrics back to desired sheep habitat characteristics. Initial focus would be to treat areas in accessible core habitat to be identified using the GIS habitat model and field reconnaissance.

Low sagebrush communities are less likely to need shrub topping or thinning but may need treatment for herbaceous invasives. Shrublands on deeper soils and/or moister sites are more likely to have overly dense shrub canopy and juniper encroachment. The degree of disturbance to the shrubland by the treatment would depend on how far off from the criteria it is, the methodology of the treatment, and the total area treated at a time.

Efforts to remove encroaching juniper would primarily focus on approximately 11,275 acres of accessible areas in core bighorn sheep habitats, the vast majority of which are shrubland communities. Approximately 1,500 acres may be treated per year by work crews on foot using chainsaws and hand tools. Old-growth juniper (over 150 years old) would not be directly managed or affected. Removal of encroaching juniper would result in retention or reestablishment of a more diverse plant community with increased quantity and quality of forage plants available to bighorn sheep and many other species. It would also remove ambush predator cover and increase horizontal visibility for sheep in many areas.

Slash resulting from woody plant thinning would be piled for winter burning to minimize soil and root damage and potential fire creep and would be conducted according to an approved prescribed burn plan. Burn pile sites (e.g., ash piles) would be reseeded with locally adapted native seed. Work would be done by crews on foot with hand tools and chainsaws (as needed) and may involve off-road utility vehicles with high-float (low-impact) tires as necessary and appropriate. If approved herbicide is used, such as to paint woody stems (i.e., cut stump), spot spray, or other similar targeted treatments, backpack or hand-held spray equipment would be used. Potential fuel and herbicide spillage would be mitigated by best management practices used by trained workers. Crew members would be trained in plant identification, how to minimize damage to soils and non-target plants, and to protect any animals, active nests, or burrows encountered.

Shrub reduction by physical means or herbicide application is expected to occur on up to approximately 100 acres per year, using ground or aerial methods depending on access and site conditions, primarily to address issues of horizontal visibility. Prescribed burning to address issues of horizontal visibility, invasives, or to convert late seral shrub cover to grass and forb–dominated cover may occur on up to approximately 800 acres per year and would be conducted according to an approved prescribed burn plan.

The loss of shrubland due to conversion to grassland would be compensated somewhat by removal of encroaching juniper less than 150 years old that would increase healthy shrubland. The direct and indirect effects of shrubland management within the Bighorn Sheep Habitat Extent would be minor to intermediate positive in the short term and intermediate to major positive in the long term. On the Refuge and regional scales, direct and indirect management effects would be negligible in the short term and minor positive in the long term.

4.4.2 Effects on Perennial Grassland Communities

Healthy grasslands near escape terrain are prime bighorn sheep foraging habitats. Decisions prioritizing where existing grassland communities would be treated under Alternatives B and D to benefit bighorn sheep would be made based on criteria described in Chapter 2, Section 2.5.1; specifically, these criteria are areas with >10% cover of non-native invasive grasses and forbs, >4 stems of juniper per acre, evidence of recent shrub invasion, and/or located on accessible sites within core bighorn sheep habitat.

The degree of disturbance to the grassland by the treatment would depend on the degree of departure from the criteria, the methodology of the treatment, and the total area treated at a time. Manual shrub removal is expected to occur on up to approximately 100 acres per year, some of which would occur on existing grassland cover types. Invasive grasses and forbs would be treated as necessary and appropriate with hand tools, approved herbicides, and prescribed burns and reseeded with locally adapted native seed as necessary. Larger infestations would be treated using ground or aerial methods, depending on access and site conditions. Prescribed burning to convert late seral shrub cover to grassland may occur on up to 800 acres per year, and it would only be conducted according to an approved Refuge prescribed burn plan.

Slash resulting from woody plant thinning would be piled for winter burning to minimize soil and root damage. Work would be done by crews on foot with hand tools and chainsaws. If approved herbicide is used to broadcast spray, then backpack spray tanks would be used. Potential fuel and herbicide spillage would be mitigated by best management practices used by trained workers. Crew members would be trained in plant identification, how to minimize damage to soils and non-target plants, and to protect any animals, active nests, or burrows encountered. Depending on seed banks and neighboring sources, and disturbances such as wildfire, these areas would likely need re-treatment to remove encroaching junipers on a 20 to 40–year cycle to maintain the sagebrush steppe.

There would be a net increase in grassland area and improvement in grassland condition in the Bighorn Sheep Habitat Extent as a result of bighorn sheep habitat improvement actions. The direct and indirect effects of grassland management within these areas would be minor to intermediate positive in the short term and intermediate to major positive in the long term. On the Refuge and regional scales, direct and indirect management effects would be negligible in the short term and minor positive in the long term.

4.4.3 Effects on Woodland Communities

Direct management of woodland communities would be fairly restricted under implementation of Alternatives B and D. As with the shrubland communities above, encroaching juniper would be removed from those aspen and ponderosa pine communities within larger shrubland-dominated landscapes as part of treatments for those shrubland communities. These treatments are included in the acreage estimates given under those for the shrubland communities. Disturbances and potential impacts to the aspen and ponderosa pine communities would be similar as to those identified for the shrubland communities. Direct and indirect management effects on aspen and ponderosa pine communities would be negligible to minor negative in the short term, owing primarily to the disturbance of the removal, but intermediate to major positive in the long term through removal of competition and improvements or restoration of hydrological function(s).

As with juniper encroachment in the shrublands, western juniper woodlands on the Refuge have been undergoing a process of infilling. This has left much of their understories degraded by the increase in canopy cover, canopy closure, and stem density of juniper, with corresponding reductions in shrub, grass, and forb species and other related losses of biodiversity. Restoration of this post-settlement juniper woodland infilling and degradation are extremely difficult, costly, and with a low likelihood for success using currently available techniques such as hand cutting and piling. As such, direct management of these communities would be very limited under Alternatives B and D because it would likely have little benefit for bighorn sheep; however, those juniper woodland communities still within the earlier stages of infilling, with good (or potentially good) horizontal visibility, relatively intact and diverse native understories, and limited presence of invasive species may be targeted for thinning efforts to remove newer growth (post-settlement) infill trees as part of the efforts identified under Section 2.4.1. Old-growth juniper would not be directly managed or affected. Although specific acreages of old-growth juniper woodland stands are not yet known, it is not expected to be common within the Bighorn Sheep Habitat Extent. Regardless, these efforts would not reduce total acreage of juniper woodland but would increase the productivity and biodiversity within any treated areas.

Mountain mahogany woodlands and shrublands would be preserved and protected, but some portions in accessible parts of the Bighorn Sheep Habitat Extent with closed canopies may also be targeted for thinning, using methods similar to juniper thinning operations, in order to promote understory vegetation and mahogany regeneration. As with aspen and ponderosa pine, encroaching juniper may be removed from mountain mahogany stands as part of the efforts under Section 2.4.1. These efforts would not result in a reduction of mountain mahogany woodland but would increase productivity and biodiversity within treated areas.

4.4.4 Effects on Wetland Resources

Wetland cover types, including wet meadows, emergent marshes, and open waters, are not expected to be directly affected by implementation of the action alternatives, with the exceptions of possible invasive plant control operations within them and minor temporary effects during dugout and impoundment maintenance and improvement projects. Wet meadows and marshes in the Bighorn Sheep Habitat Extent may be targeted for treatment with approved herbicides if more than 10% of the area is covered by invasive plants.

Riparian wetlands may be temporarily disturbed by streambank stabilization and horizontal visibility improvement projects, but site reclamation would mitigate those effects. Wetlands fed by springs and seeps may experience a community shift toward more obligate wetland plants if hydrological function is improved by management actions.

Wetland vegetation is highly valued as forage by bighorn sheep because of its nutrient and moisture content, and wetlands may be subject to disproportionate seasonal grazing pressure, especially in drought conditions, due to their relative scarcity on the landscape as the bighorn sheep herd increases over time. This grazing may affect the species composition and vegetative structure of the wetland plant communities in unknown ways, depending on the vegetative species present and their relative composition and the actual degree of grazing.

4.4.5 Effects on Salt Desert Communities

These salt desert cover types (greasewood flats, salt desert scrub, and playas) may be targeted for removal of encroaching juniper, shrub-thinning, or invasive plant control operations under Alternatives B and D using methods mentioned above for shrubland cover types; salt desert cover types would be affected similarly to shrubland cover types. Because they occupy a small fraction of the area occupied by shrubland within the Bighorn Sheep Habitat Extent, they would likely be low on the priority list of areas to be targeted for treatment. Management actions would be intended to restore these types to historical conditions and not affect their areal extent.

The direct and indirect effects of salt desert community management from Alternatives B and D within the Bighorn Sheep Habitat Extent would be negligible to minor positive in the short term and minor to intermediate positive in the long term. On the Refuge and regional scales, direct and indirect management effects would be negligible in the short term and minor in the long term.

4.4.6 Effects on Biological Soil Crusts

Little can be done to hasten the natural slow process of biocrust recovery after disturbance beyond protecting the disturbed biocrust from further disturbance. Therefore, management of biocrust to preserve its important functions in desert communities consists of minimizing physical disturbance, most notably trampling from foot traffic and fire, during field operations under Alternatives B and D, and to a much lesser degree under Alternative C, where no large work crews would be in the field. This includes locating repeatedly travelled paths in dense vegetation or previously disturbed corridors (such as game trails) and avoiding biocrusts, minimizing off-road vehicular use, timing extensive field operations to occur when the ground is frozen or snow-covered and to avoid muddy or extremely dry conditions, and timing and locating prescribed burns to avoid development of very hot and long residency fires. These mitigating practices should be followed whenever practicable.

Invasive annual grasses can compete directly with biocrusts, so successful control under Alternatives B and D may be beneficial to biocrusts in the long term. Due to the concentration of most extensive field operations in dense vegetation, and relatively small areas of biocrust disturbance likely under the habitat improvement actions of Alternatives B and D, the overall direct and indirect effects of their implementation on biocrusts is expected to be negligible to minor negative in localized areas within the Bighorn Sheep Habitat Extent in the short and long term, and negligible at the Refuge and regional scales.

4.5 Effects on the Social, Cultural, and Economic Environment

4.5.1 Surrounding Land Use

There is a small chance that under Alternatives C and D landowners adjacent to the proposed Bighorn Sheep-Cougar Management Zone would be less likely to have conflicts or livestock depredation by cougars during the time cougars are removed from the Refuge. To the degree that bighorn sheep water resources are improved under Alternatives B and D, seasonal water flow off the Refuge may persist longer. Otherwise, there should not be significant effects from the action alternatives on surrounding land use.

4.5.2 Refuge Built Environment

Infrastructure facilities may experience greater use than under the No Action Alternative due to personnel other than staff (contractors, cooperators, volunteers) working on management activities such as fire control, juniper and invasive removal, and site rehabilitation under Alternatives B and D; and cougar removal, wildlife capture and marking, research and monitoring activities under Alternatives C and D. Campgrounds and other visitor facilities may also experience greater use as the bighorn sheep herd increases and visitors respond to the improved wildlife viewing and hunting opportunities. As a result, facilities maintenance costs may increase more than they would under the No Action Alternative to an undetermined but likely minor amount over the long term. See Table 4.5 for a summary of the potential effects of implementing actions proposed, or not implementing them when not proposed, under each alternative (A–D) at local and regional scales.

4.5.3 Socioeconomic Conditions

Under the No Action Alternative the likelihood of the bighorn sheep herd remaining at low numbers and possibly disappearing would have a negative impact on the local economy due to the loss of expenditures related to bighorn hunting and viewing opportunities. Specifically, the number of nonresidents visiting the area and spending on food, lodging, supplies, local guides, and fuel would be reduced.

Implementing the action alternatives would have positive effects on the local economy above those of the No Action Alternative. Additional habitat improvement work under Alternatives B and D would employ contractor and volunteer crews working on the Refuge and spending locally. Cougar removal under Alternatives C and D would involve cooperators or contractors working regularly on the Refuge over 8 months each year. Additional wildlife research and monitoring activities may also involve personnel other than Refuge and ODFW staff.

4.5.4 Cultural Resources

All actions that have the potential to affect cultural resources would be reviewed under the National Historic Preservation Act Section 106 and mitigated, if necessary, before implementation and, therefore, no negative impacts would occur. Increased presence of personnel working in bighorn sheep habitat would increase the chances that previously unknown cultural resources would be discovered (see Appendix K).

4.5.5 Public Use

There is a potential for loss of visitors due to the lack of bighorn sheep hunting and viewing opportunities in the short term and in the long term if action alternatives are not implemented, or if they fail to recover the bighorn sheep herd. If the efforts to recover the herd under Alternative B, C, or D are successful, eventually sheep hunting would be reestablished, and visitation associated with hunting and wildlife viewing would increase an unknown amount over the long term. In any case, there would be a corresponding change in the use of campgrounds and other visitor facilities.

4.5.6 Aesthetic Resources

The aesthetic experience of Refuge visitors would be potentially affected if they find themselves in the visual or auditory range of crews conducting ground activities associated with the habitat improvement strategies under Alternatives B and D or cougar removal actions under Alternatives C and D. If the visitors' primary objective includes quiet, solitude, and unimpeded nature appreciation, the effect of such an encounter would be negative but temporary. There would also be incidents of temporary effects created by helicopters involved with surveys or animal capture, hunting hounds actively tracking cougars, and chainsaws associated with woody plant removal that may interfere with visitors' aesthetic experience to a greater extent than under the No Action Alternative.

Viewshed impacts would result from prescribed burning and reduction of juniper; these may be considered negative by some visitors, but they would be minor and short term.

Table 4.5. Potential Effects of Proposed Alternatives on Physical and Human Environments and Animal and Plant Communities

Resource*	**No Action (A)**	**Habitat Only (B)**	**Population Only (C)**	**Comprehensive (D - Preferred)**	**Notes and Mitigation of Negative Effects**
Physical Environment					
Climate change	Lo: ST 0; LT + Re: ST 0; LT 0	Lo: ST +; LT ++ Re: ST 0; LT 0	NA: 0	Lo: ST +; LT ++ Re: ST 0; LT 0	Climate change not affected, but effects mitigated
Soils	NA: 0	Lo: ST 0; LT + Re: ST 0; LT 0	NA: 0	Lo: ST 0; LT + Re: ST 0; LT 0	Trampling effects mitigated by riparian erosion control in the LT
Air quality	Lo: ST -; LT 0 Re: ST 0; LT 0	Lo: ST -; LT + Re: ST 0; LT 0	NA: 0	Lo: ST -; LT + Re: ST 0; LT 0	Fuel reduction under Alternative B results in less smoke in LT
Human Environment					
Land use	NA: 0	NA: 0	NA: 0	NA: 0	
Built environment	NA: 0	Lo: ST -; LT 0 Re: ST 0; LT 0	NA: 0	Lo: ST -; LT 0 Re: ST 0; LT 0	More use of facilities by work crews
Socioeconomic	NA: 0	Lo: ST +; LT + Re: ST 0; LT 0	Lo: ST +; LT + Re: ST 0; LT 0	Lo: ST ++; LT + Re: ST 0; LT 0	Work crews and cougar removal agents would spend money locally; LT increase in visitation
Cultural resources	NA: 0	NA: 0	NA: 0	NA: 0	Possible disturbance of artifacts mitigated by monitoring and crew training
Public use	Lo: ST -; LT - Re: ST 0; LT 0	Lo: ST 0; LT + Re: ST 0; LT 0	Lo: ST 0; LT + Re: ST 0; LT 0	Lo: ST 0; LT + Re: ST 0; LT 0	Loss of bighorns may result in less visitation; recovery may mean more visitation
Aesthetic resources	Lo: ST 0; LT - Re: ST 0; LT 0	Lo: ST -; LT - Re: ST 0; LT 0	Lo: ST -; LT - Re: ST 0; LT 0	Lo: ST -; LT - Re: ST 0; LT 0	Effects of collared sheep, crew encounters, and juniper clearing offset by benefits to sheep
Water quality	NA: 0	Lo: ST 0; LT + Re: ST 0; LT 0	NA: 0	Lo: ST 0; LT + Re: ST 0; LT 0	Cumulative riparian vegetation improvement could lower stream water temperatures
Proposed wilderness	NA: 0	Lo: ST -; LT + Re: ST 0; LT 0	Lo: ST -; LT 0 Re: ST 0; LT 0	Lo: ST -; LT + Re: ST 0; LT 0	ST loss of wilderness values necessary for habitat and native wildlife benefits
Animals					
Cougars	NA: -	Lo: ST -; LT + Re: ST 0; LT 0	Lo: ST -; LT 0 Re: ST 0; LT 0	Lo: ST -; LT + Re: ST 0; LT 0	Local population disruption necessary to restore healthy predator-prey interactions
Mule deer	Lo: ST 0; LT + Re: ST 0; LT 0	Lo: ST +; LT + Re: ST+; LT 0	Lo: ST +; LT + Re: ST+; LT 0	Lo: ST ++; LT + Re: ST+; LT 0	Mule deer benefit from cougar removals and habitat improvement actions (including under Alternative A)
Other ungulates	Lo: ST 0; LT + Re: ST 0; LT 0	Lo: ST 0; LT + Re: ST 0; LT 0	Lo: ST +; LT 0 Re: ST 0; LT 0	Lo: ST 0; LT + Re: ST 0; LT 0	Habitat improvements (including under Alternative A) will benefit other ungulates locally
Mesocarnivores	NA: 0	NA: 0	Lo: ST +; LT 0 Re: ST 0; LT 0	Lo: ST +; LT 0 Re: ST 0; LT 0	Species interactions extremely complex and unpredictable; possible ST benefit from fewer cougars
Rabbits and hares (Except white-tailed jackrabbits)	NA: 0	NA: 0	NA: 0	NA: 0	ST negative effects mitigated by LT habitat improvements that benefit these species
Rodents	NA: 0	NA: 0	NA: 0	NA: 0	ST negative effects mitigated by LT habitat improvements that benefit these species
Reptiles and amphibians (except northern sagebrush lizards)	NA: 0	NA: 0	NA: 0	NA: 0	Evaluation of effects limited by lack of Refuge-specific information

Resource*	No Action (A)	Habitat Only (B)	Population Only (C)	Comprehensive (D - Preferred)	Notes and Mitigation of Negative Effects
Plant Communities					
Shrublands	Lo: ST +; LT ++	Lo: ST ++; LT +++	NA: 0	Lo: ST ++; LT +++	Smaller effect under Alternative A; shrub to grassland conversion more than compensated for by woodland to shrub conversion
	Re: ST 0; LT 0	Re: ST 0; LT +		Re: ST 0; LT +	
Grasslands	Lo: ST +; LT ++	Lo: ST ++; LT +++	NA: 0	Lo: ST ++; LT +++	Smaller effect under Alternative A; cumulative increase in grassland area and quality
	Re: ST 0; LT 0	Re: ST 0; LT +		Re: ST 0; LT +	
Woodlands	Lo: ST -; LT +	Lo: ST -; LT ++	NA: 0	Lo: ST -; LT ++	Minor ST disturbance; LT improvement of diversity and productivity
	Re: ST 0; LT 0	Re: ST 0; LT +		Re: ST 0; LT +	
Wetlands	NA: 0	Lo: ST 0; LT +	NA: 0	Lo: ST 0; LT +	May benefit from local restored hydrology
		Re: ST 0: LT 0		Re: ST 0: LT 0	
Salt desert community	NA: 0	Lo: ST 0; LT +	NA: 0	Lo: ST 0; LT +	May benefit from shrub thinning and invasive removal, but mostly avoided
		Re: ST 0: LT 0		Re: ST 0: LT 0	
Biocrust	NA: 0	Lo: ST -; LT 0	Lo: ST -; LT 0	Lo: ST -; LT 0	Areas of biocrust to be avoided during vulnerable periods when possible
		Re: ST 0: LT 0	Re: ST 0: LT 0	Re: ST 0: LT 0	

Note: Lo = local (proposed Bighorn Sheep-Cougar Management Zone); LT = long term; NA = no action is proposed that would directly affect resource; Re = regional; ST = short term; 0 = negligible; -, --, --- = minor, intermediate, major negative; +, ++, +++ = minor, intermediate, major positive.
* See Chapter 2 for descriptions of the alternatives, and Tables 4.1, 4.3, and 4.4 for summaries of effects on water resources, bighorn sheep, and animal species of conservation concern.

Some visitors may consider viewing bighorn sheep with radio collars aesthetically objectionable and diminishing of their wildlife viewing experience. Alternatives C and D involve collaring up to 35 individuals for the purpose of tracking their habitat use, behavior patterns, and survivability, and the value of this information is critical for evaluating the herd status and success of the management plan. The effect on visitors would be mitigated by public outreach materials that explain the value of having collared sheep.

4.5.7 Environmental Justice

EO 12898 – Federal Actions to Address Environmental Justice in Minority and Low-Income Populations, requires federal agencies to address and identify, as appropriate, disproportionately high and adverse human or environmental effects of its programs, policies, and activities on minority populations, low-income populations, and Indian Tribes in the United States. No activities associated with action alternatives are expected to have any effects on environmental justice issues.

4.6 Special Designation Areas

4.6.1 Effects on Proposed Wilderness

Any actions implemented on the PJRPWA would have the same ecological effects as described above; however, proposed actions must also be evaluated for their potential effects on wilderness characteristics, as defined by the Wilderness Act.

The Service secures "an enduring resource of wilderness" by maintaining and, where appropriate, restoring, a wilderness area's biological integrity, diversity, environmental health, and wilderness character. But Service policy also requires restraint in managing wilderness areas (610 FW 1.14). In wilderness (and areas proposed for wilderness designation), the Service typically does not interfere with wilderness system processes or the wilderness ecosystem's response to natural events unless a response is necessary to accomplish refuge purposes, including Wilderness Act purposes, or in cases where these processes become unnatural. Examples of unnatural process include excessive fuel loads from past fire suppression activities, disrupted predator/prey relationships, elimination of native grazers, and the spread of invasive species. In such cases, the Improvement Act requires the Service to take action to restore and maintain biological integrity.

The following describes how the proposed actions would potentially affect the four qualities of wilderness character (untrammeled, natural, undeveloped, and solitude or primitive and unconfined recreation), and how those effects can be mitigated.

4.6.1.1 UNTRAMMELED

Untrammeled is defined as wilderness ecological systems that are unhindered and free from intentional actions of modern human control or manipulation. Trammeling would result from work crews entering the proposed the wilderness area to conduct any vegetation manipulation, including juniper thinning, non-native invasive removal, and prescribed burns, and guzzler maintenance and installation under Alternatives B and D. These operations would occur consistent with the wilderness restrictions, with the exception of the use of chainsaws for cutting woody plants. Chainsaw juniper removal use has undergone an MRA process (see Appendix F) that determined it is a necessary tool for accomplishing Refuge management goals for habitat restoration that benefits bighorn sheep and other native species. Trammeling would also result from cougar removal activities under Alternatives C and D where the removal of cougars is an intentional action that manipulates natural processes in the PJRPWA. Hunting with hounds and trapping using snares to remove cougars within the PJRPWA would also be conducted in a way that is consistent with wilderness restrictions. Cougar removal has undergone an MRA process (see Appendix F) that determined it is a necessary action to accomplish Refuge goals to recover bighorn sheep, a native species. The effects of trammeling that result from foot traffic and cougar removal would be minimized by avoiding repetitive travel that establishes persistent trails or damages fragile soils and vegetation by using hounds as priority cougar control and restricting snares to the escarpment, where topography precludes the use of dogs and hunters. Natural processes will be temporarily altered for the benefit of maintaining diversity on the Refuge to include native species and healthy predator-prey relationships. Treatments such as thinning, herbicide application, and prescribed burns would leave more persistent evidence of their occurrence but are considered necessary to accomplish management goals and would be beneficial to the wilderness characteristics in the long term.

4.6.1.2 NATURAL

This quality of the PJRPWA has been degraded by anthropocentric-driven processes described in Chapter 3, such as altered fire regimes and domestic livestock grazing, that have resulted in loss of biological integrity, diversity, environmental health, and wilderness character. The actions proposed in all action alternatives directly address this degradation and are justified as necessary under the Service policy authorized by the Improvement Act. Maintaining a healthy and viable bighorn sheep population is critically important to maintaining the natural quality of wilderness character and the biological integrity, diversity, and environmental health of the Refuge and the PJRPWA.

The specific actions under Alternatives B and D to be approved by MRAs include use of chainsaws for woody plant removals and installation and maintenance of wildlife guzzlers within the proposed wilderness (see Appendix F). All other management actions associated with Alternatives B, C, and D and listed in Section 3.7.1 are not expected to violate wilderness restrictions but would temporarily affect the wilderness qualities of solitude and freedom from artificial noise while work crews are engaged in field work. Sightings of collared bighorn sheep common to all four alternatives and encounters with active hound hunts or trapping situations of cougars under Alternatives C and D would detract from natural wildlife viewing experiences. Cougar removal has undergone an MRA process (see Appendix F) that determined it is a necessary action to accomplish Refuge goals to recover bighorn sheep, a native species. These temporary effects are expected to be short term, minor, and negative due to the low visitation rate of the PJRPWA and the small areas, infrequency, and short duration of the disturbances; however, visual evidence of some of the actions could persist for several to many years, including tree stumps, fire scars, and guzzlers, leading to long-term minor negative effects on natural qualities.

4.6.1.3 UNDEVELOPED

The undeveloped nature of the PJRPWA would not be changed by any action alternatives, with the exception of the potential repairs of existing wildlife guzzlers or the installation of new ones if they were considered necessary water sources for bighorn sheep under Alternatives B and D and approved via the MRA process. It is also possible that one or more of the existing nonfunctioning guzzlers within the PJRPWA could be removed if they were deemed unnecessary. Cougar removal has undergone an MRA process (see Appendix F) that determined it is a necessary action to accomplish Refuge goals to recover bighorn sheep, a native species. Foothold and neck snares are considered temporary installations, which are Wilderness Act Section 4 (C)–prohibited tools. Foothold and neck snares remaining in the wilderness as the management plan is in effect diminishes the undeveloped quality of the PJRPWA. The potential effects of these operations include the presence of built structures, trammeling (as described above), unnatural sounds from helicopter and tool use, and long-term site alterations. These effects on the undeveloped quality of PJRPWA would be long-term, minor, and negative due to persistent presence of guzzlers, mitigated by the positive effect on bighorn sheep and other native species benefitting from the water source.

4.6.1.4 SOLITUDE OR A PRIMITIVE AND UNCONFINED TYPE OF RECREATION

The opportunities for solitude and unconfined recreation would be diminished to the degree that visitors seeking these qualities would encounter additional field operations under the three action alternatives. Alternative D would have the greatest total effect because it involves work crews in the field for habitat improvement operations and cougar removal agents over extended times, thus resulting in the greatest chance of encounters. In descending order of chance encounters from Alternative D are Alternatives B and C, respectively. Overall, this effect is considered minor to intermediate and negative, depending on how many visitors might be affected due to the low visitation rate of the PJRPWA, the ruggedness of the terrain, and the infrequency and short duration of the disturbances.

4.6.2 Research Natural Area

There are 640 acres of old-growth juniper woodland in the PJRPWA that are designated as an RNA. This area would be excluded from any groundwork proposed in the alternatives and would not be directly affected.

4.7 Long-Term and Cumulative Effects

4.7.1 Reasonably Foreseeable Future Actions

One option described in this management plan is the initiation of a public cougar hunt on the Refuge to supplement or extend some level of cougar management beyond the administrative removal program. If this occurred, it would potentially indefinitely extend motivation for some unknown additional number of hunters to visit the Refuge, with associated effects on the Refuge management and infrastructure. Based on the experiences elsewhere in the state, the number of additional hunters is expected to be small, and their effect proportionally negligible or minor. A full analysis of this option would be conducted as part of a proposed hunt plan and associated environmental review if the Service proposes a public cougar hunt on the Refuge.

Because the bighorn sheep habitat improvement actions proposed are intended to counter ecological forces on the landscape that cannot be completely mitigated, such as ecological succession, fire regimes, and climate change, the Refuge expects to have to re-treat targeted areas on a multiyear rotational basis to be determined by regular monitoring of changing conditions. This means that effects of management actions are expected to continue well beyond recovery of the bighorn sheep herd.

4.7.2 Cumulative Effects of Proposed Actions

As mentioned in Section 3.3.2, cougars on the proposed Bighorn Sheep-Cougar Management Zone and the rest of the Refuge are affected by the ODFW Cougar Management Plan (ODFW 2017) as it applies to Cougar Management Zone F. Within Zone F, an annual quota of known cougar mortalities from all sources is determined by ODFW population modeling exercises, where mortalities resulting from Alternatives C and D will be counted toward that total. Although the current quota is 140 individuals, the maximum number of mortalities in Zone F has never been higher than 45. Nevertheless, cougars taken from the proposed Bighorn Sheep-Cougar Management Zone may influence ODFW biologists' determination of where and when to designate active cougar target areas where an extra effort is made to remove cougars in response to localized unusual depredation or safety situations. It is unknown whether cougar removals from the proposed Bighorn Sheep-Cougar Management Zone would affect the likelihood of future cougar depredations or safety problems occurring in parts of Zone F outside the Refuge.

The efforts to mitigate for juniper encroachment and the spread of invasive plants within the Bighorn Sheep Habitat Extent outlined in this management plan join with ongoing similar efforts elsewhere on the Refuge where encroaching juniper has been removed for the benefit of sage-grouse. Additionally, similar juniper control efforts have been ongoing within BLM and other public and private lands in the region. Upon approval of this management plan, the majority of Refuge efforts would be focused on bighorn sheep range in addition to enhancement projects within sage-grouse habitat, but they would also benefit other species of concern to some degree. The cumulative effects of these efforts would expand habitat for multiple native species that have suffered from juniper encroachment and degradation of the integrity of sagebrush habitats proportionate to the total areas treated.

Although there is no documented evidence of bighorn sheep from the Refuge intermixing with other regional bighorn populations, it is conceivable that a larger Refuge herd could have immigrants that would facilitate interbreeding and establish metapopulation dynamics. If this happens, it could counter the negative effects of inbreeding and improve the overall health of the herds involved.

4.7.3 Effects on Climate Change

In issuing their guidance on climate change and NEPA reviews, CEQ (2016) recommended that agencies use projected greenhouse gas (GHG) emissions (to include, where applicable, carbon sequestration implications associated with the proposed agency action) as a proxy for assessing potential climate change effects when preparing a NEPA analysis for a proposed agency action. CEQ noted that in the land and resource management context, how a proposed action affects a net carbon sink or source depends on multiple factors, such as the climatic region, the distribution of carbon across carbon pools in the project area, and the ongoing activities and trends. CEQ notes that it is possible that the net effect of ecosystem restoration actions, such as those proposed under Alternatives B and D, although resulting in short-term biogenic emissions, may lead to long-term reductions of atmospheric GHG concentrations through increases in carbon stocks or reduced risks of future emissions.

Burning piles of juniper slash and prescribed burns in sagebrush habitat emit CO_2, methane (CH_4), and small amounts of nitrous oxide, which are all GHGs. Fluorinated gasses, which include hydrofluorocarbons, perfluorocarbons, sulfur hexafluoride, and nitrogen trifluoride are synthetic, powerful GHGs that are emitted from a variety of industrial processes and are not discussed here.

The *Smoke Management Guide for Prescribed Fire* (National Wildfire Coordinating Group 2001) provides emission factors for a variety of pollutants, including CO_2 and CH_4. For a broadcast burn of juniper slash, an average fire will release about 3,231 pounds of CO_2 and 12.0 pounds CH_4 for every ton of slash burned. For broadcast-burned sagebrush, the emission factors are 3,126 pounds of CO_2 and 12.0 pounds CH_4 for every ton of sagebrush burned. For juniper that is first piled and then burned, the reported emission factors for CO_2 and CH_4 are about 3,207 and 16.6 pounds emitted for each ton consumed, respectively. The CO_2 emissions from burning weigh more than the initial fuel weight because the carbon atoms produced from complete combustion bind with two heavier oxygen atoms in the air creating the heavier CO_2 molecule.

Estimating GHG emissions from vegetation treatments requires making a number of assumptions. Treatment methods will largely depend on how dense the target trees are, steepness of slopes, and distance from winter-accessible roads. The majority of acres will likely be treated by either lopping and scattering the slash or hand-severing the vegetation and leaving it in place. These treatments would be used in areas of steep topography due to safety concerns. However, it is estimated that there would be between 2,000 and 2,500 acres of cut/pile/cover within the estimated 11,275 treatable (accessible) acres. These piles would be burned during the winter months. Based on previous treatments, it is estimated that there are between 30,000 and 37,500 piles within these 2,000 to 2,500 acres (at 15 piles per acre). The size of the slash piles is between 6 feet in diameter and 5 feet in height and 8 feet in diameter and 8 feet in height. On an annual basis, it is estimated that there are 3,000 to 3,750 piles within each 1,500-acre annual treatment block and that it would take 10 years to treat all acres.

Using these figures, GHG annual emissions were estimated using the Piled Fuels Biomass and Emissions Calculator for conifers (Wright 2015) developed by the U.S. Forest Service, Pacific Northwest Research Station (Table 4.6).

Table 4.6. Estimated Greenhouse Gas Annual Emissions

Gross cubic foot volume	PM	PM_{10}	$PM_{2.5}$	CO	CO_2	CH_4	NMHC
485,000 to 607,000	8.1–0.1	5.7–7.2	5.0–6.3	28.1–35.2	1,232.6– 1,540.7	2.1–2.6	1.6–2.1

Notes: Values are tons of emissions per year. NMHC = non-methane hydrocarbons.

According to the EPA's GHG equivalences calculator (EPA 2021), 1,400 tons of CO_2 and 2 tons of CH_4 are equivalent to the emissions of 286 passenger vehicles driven for 1 year.

Woody and invasive plant removal conducted under Alternatives B and D would potentially change fire regimes on treated areas over the long term by reducing fuel loads, resulting in reduced fire intensity and residence time, producing fewer GHG emissions in the future. Removal of woody material reduces the density of woody species, such as mature juniper plants, lessening the probability of intense crown fires. Invasive annual grass management will also reduce fine fuels that can contribute to larger, more intense fires by carrying fire into larger areas with greater fuel loads (Zouhar 2003; Murphy and Fryer 2019). Less intense fires due to fuels management also typically retain a larger percentage of carbon sequestration within the ecosystem because a larger proportion of woody vegetation remains alive postfire compared to more intense fires in which a larger proportion of woody vegetation commonly dies (North and Hurteau 2011).

Restoring areas dominated by cheatgrass to bunchgrass- and sagebrush-dominated systems has the potential to sequester substantial amounts of carbon. A study of soil carbon under sagebrush- and cheatgrass-dominated systems found substantial differences in carbon storage (Austreng et al. 2011). Soil carbon stores were greatest under sagebrush (59,776 pounds per acre) and lowest under cheatgrass (31,226 pounds per acre), a difference of 28,550 pounds per acre. Belowground biomass was greatest under sagebrush (27,658 pounds) and lowest beneath cheatgrass (12,490 pounds), a difference of 15,168 pounds per acre, which accounted for approximately 20% of the total increase in belowground carbon beneath sagebrush. The results indicate that restoring cheatgrass to bunchgrass would result in carbon storage benefits of 13,383 pounds per acre and a bunchgrass to native sagebrush benefit of 15,167 pounds of carbon storage per acre. Given that hundreds of acres would be restored, the amount of potential carbon sequestration resulting from habitat restoration actions could be substantial.

Sagebrush ecosystems store upward of 90% of ecosystem carbon belowground in root systems and soil; in comparison, juniper-dominated woodlands store about half of ecosystem carbon in aboveground woody biomass (Rau et al. 2012). During a fire event, a large amount of aboveground biomass is burned, releasing the carbon stored in that biomass while belowground carbon typically remains intact. Therefore, the larger proportion of carbon stored belowground in sagebrush ecosystems remains sequestered while over half the carbon stored aboveground in juniper woodlands is emitted into the atmosphere during a fire event. This is particularly true during intense wildfires in which a majority of aboveground vegetation is burned and often killed, creating a carbon emission source (Rau et al. 2012). Overall, restored sagebrush ecosystems consistently store more carbon belowground than juniper woodlands, resulting in a longer-term consistent carbon sequestration.

4.8 Summary of Environmental Consequences

4.8.1 Irreversible or Irretrievable Commitment of Resources

NEPA (1502.10 (2)(C)(v)) and CEQ regulations (42 USC 4332(C)(v)) require an EIS to include a discussion of any irreversible and irretrievable commitments of resources that would be involved in the proposed action and alternatives to the proposed action. An irreversible commitment of resources occurs when a nonrenewable resource such as minerals or petroleum-based fuels are consumed. Because these nonrenewable resources are consumed, their use cannot be reversed.

An irretrievable commitment of resources occurs when the use or consumption of the resource would be neither renewable nor recoverable for use by future generations. Irretrievable commitment applies to nonrenewable resources, such as minerals or cultural resources, and to those resources that are renewable only over long time spans.

Under Alternative D, the Service’s Preferred Alternative, the irreversible and irretrievable commitments of resources would be minor.

No environmental effects resulting from implementation of any of the action alternatives are irreversible in the long term; however, resources, including additional operating funds, personnel time commitments, supplies, and equipment that would not otherwise be needed for Refuge operations, would be irretrievable (Table 4.7). Minor amounts of nonrenewable petroleum-based fuels and other supplies would be used to transport personnel and materials to and from field sites, for plant community restoration fieldwork, repair of on-site guzzlers, and for the administrative removal of cougars.

Table 4.7. Annual Resources Anticipated to Implement each Action Alternative

Resource	**Habitat Only (B)**	**Population Only (C)**	**Comprehensive (D - Preferred)**
Personnel hours	Refuge biologist Refuge manager Habitat improvement work crew Fire crew	Refuge biologist Refuge manager Cougar removal agents	Refuge biologist Refuge manager Habitat improvement work crew Fire crew Cougar removal agents
Supplies	Herbicide Fuel (crew transport, chainsaws)	N/A	Herbicide Fuel (crew and agents transport, chainsaws)
Equipment	Hand tools Chainsaws Personal protective equipment	N/A	Hand tools Chainsaws Personal protective equipment
Costs	Personnel: $75,000 Supplies: $20,000 Contract cutting crew: $500,000 Total: $595,000	Personnel: $50,000 Cougar Removal agents: $75,000 Total: $125,000	Personnel: $125,000 Cougar removal agents: $100,000 Supplies: $25,000 Contract cutting crew: $500,000 Total: $750,000

CHAPTER 5. CONSULTATION AND COORDINATION

5.1 Summary of Public Scoping

The Service completed the initial scoping phase of the EIS, which is the first formal step in engaging and soliciting public, agency, and tribal participation in the EIS process (a list of the individuals who prepared the EIS is presented in Appendix M). The purposes of scoping are to notify the affected public of the opportunity to participate in the preparation of the EIS and encourage them to comment on preliminary vision and goals and to help identify potential issues, management actions and concerns, significant problems or impacts, and opportunities or alternatives to resolve them. The Service published an NOI to prepare a bighorn sheep management plan and EIS in the FR on May 8, 2020 (85 FR 27430-27431). The NOI initiated the public scoping period, which extended to June 8, 2020.

Additional outreach efforts included a news release that was sent to local Oregon media contacts in Portland, Salem, Eugene, Bend, Klamath Falls, Lakeview, and Medford. It was also posted on the Refuge's website. The news release and associated follow up resulted in a May 8, 2020, article being published in the *Herald and News*. It is likely that additional articles were also produced.

Because of the COVID-19 pandemic, two planned public meetings could not be held; however, virtual meetings were held with those organizations that made a request and information that would have been presented at the public meetings was posted on the Refuge website. In addition, letters and emails were sent, and in some cases personal telephone calls were made, to notify and invite comments from 24 nongovernmental organizations that have been interested in the Refuge, bighorn sheep, and predators in the past; all surrounding landowners; state and local elected officials, including Lake County Commissioners; 20 other national organizations; and three federally recognized tribes.

After the public scoping period, the planning team reviewed and evaluated all potential issues, management concerns, and the opportunities to resolve them that the planning team, other Service personnel, partners, and the public have identified in order to determine significant issues. The Service defines an issue as: "Any unsettled matter that requires a management decision, e.g., an initiative, opportunity, resource management problem, threat to the resources of the unit, conflict in uses, public concern, or the presence of an undesirable resource condition" (602 FW 1.6K). Significant issues typically are those that are within our jurisdiction, suggest different actions or alternatives, and will influence our decision (602 FW 3.4(C)(3)(b)). Issues raised by the public were related to the following (some positions advocated are noted in parentheses):

- *Bighorn sheep*: the need for lambing terrain assessments; the potential for translocations to Hart Mountain; low genetic variability; whether to augment the population; need to monitor the sheep population to determine whether habitat restoration is effective.
- *Hunting*: appropriate level of hunting on the Refuge (ban all hunting; open a cougar hunting season for the public); methods of administrative removal (using hounds, traps [both leghold and live]) and incidental take of [other species].
- *Population management*: appropriate number of bighorn sheep (minimum should be 200; maximum should be 350); disease transmission (disease transmission is not an issue).
- *Predator control:* appropriate trigger for cougar removal (if the bighorn sheep population falls below 200, then cougars should be removed); whether cougars are a cause of bighorn sheep decline; number one cause of bighorn sheep deaths was from cougars; need intensive cougar studies prior to any predator control; if cougars are to blame for the decrease in bighorn sheep, shouldn't there be more dead bighorn sheep than are being found.
- *Habitat*: relative prioritization of medusahead rye eradication and control; post-settlement juniper removal; use of prescribed fire (should be restricted to burning juniper slash piles); role of water (water is not an issue; maintain existing guzzlers); juniper encroachment (a widespread issue in most of southeastern Oregon, not specific to Hart Mountain); overgrazing by extremely high local

densities of sheep in the 1990s; need to identify habitat characteristics that are contributing to the reduced ability of the Refuge to support sheep and whether those characteristics can be altered to favor sheep survival.

- In addition to the issues identified above, other public comments included: allow goat packing; collect information on Sheldon National Wildlife Refuge such as predators, habitat, and bighorn sheep; pronghorn population rebounded without predator control, but with habitat work and public education.

5.2 Federal, State, and Local Agency Consultation and Coordination

As a cooperating agency, coordination has been ongoing with the ODFW. In May 2020, a meeting was held with ODFW to discuss development of the draft bighorn sheep management plan. During the meeting and follow-up calls, bighorn sheep management issues were identified and preliminary action alternatives were developed, and a bighorn sheep management planning team was identified. In November 2020, USDA APHIS–Wildlife Services agreed to be a cooperating agency and was part of the bighorn sheep management planning team. The planning team consisted of representatives of the Refuge, ODFW, USDA APHIS–Wildlife Services, and a contractor. The bighorn sheep planning team regularly met throughout the development of the draft management plan.

In May 2020, letters were sent to state and local elected officials, including Lake County Board of Commissioners.

In June 2020, a phone consultation was completed with the EPA, Region 10, to discuss development of the draft bighorn sheep management plan, issues of concern, and publication coordination requirements.

In February 2021, a Lake County Commissioner was briefed on the draft bighorn sheep management plan and EIS progress.

In April 2021, letters were sent to state and local elected officials, including the Lake County Board of Commissioners.

In May 2021, a phone consultation was completed with the EPA, Region 10, to discuss development of the draft bighorn sheep management plan and issues of concern.

In June 2021, a Lake County Commissioner was briefed on the draft bighorn sheep management plan and EIS.

5.3 Consultation with Native American Governments

In May 2020, letters were sent to representatives of Fort Bidwell Indian Community, Burns Paiute Tribe, and Fort McDermitt Paiute and Shoshone Tribes associated with the Refuge. No responses were received.

In April 2021, telephone calls were made and emails were sent to representatives (chairs) of Fort Bidwell Indian Community, Burns Paiute Tribe, Fort McDermitt Paiute and Shoshone Tribes, Summit Lake Paiute Tribe, Cedarville Rancheria of Northern Paiute Indians, Pit River Tribe, Winnemucca Indian Colony of Nevada, and Klamath Tribes.

5.4 Consultation with Nongovernmental Organizations

In May 2020, letters and emails were sent, and in some cases personal telephone calls were made, to notify and invite comments from 24 nongovernmental organizations. Six written responses were received.

In May 2020, a virtual meeting was held with the Oregon Natural Desert Association to discuss development of the draft bighorn sheep management plan. A written response was received.

In April 2021, letters and emails were sent to notify and invite comments from 24 nongovernmental organizations.

In May 2021, a virtual meeting was held with the Friends of Hart Mountain to discuss development of the draft bighorn sheep management plan.

In September 2021, a virtual meeting was held with the Oregon Natural Desert Association to discuss development of the bighorn sheep management plan.

5.5 List of Agencies, Organizations, and Persons Sent Copies of the Environmental Impact Statement

Elected Officials

- Governor
- Representative
- Senator
- Senator
- Representative (District 60)
- Senator (District 30)
- Lake County Board of Commissioners
- Harney County Court

Tribes

- Fort Bidwell Indian Community
- Burns Paiute Tribe
- Cedarville Rancheria of Northern Paiute Indians
- Winnemucca Indian Colony of Nevada
- Fort McDermitt Paiute and Shoshone Tribes
- Summit Lake Paiute Tribe
- Pit River Tribe
- Klamath Tribes

Organizations

- Oregon Natural Desert Association
- Oregon Hunters Association
- Oregon Hunters Association (Lake County Chapter)
- Oregon Hunters Association (Klamath County Chapter)
- Friends of Hart Mountain
- Wild Sheep Foundation
- Mule Deer Foundation
- The Wilderness Society
- The Order of the Antelope
- Oregon Chapter of the Foundation for North American Wild Sheep
- Defenders of Wildlife
- Predator Defense
- Oregon Backcountry Hunters and Anglers
- Association of Fish and Wildlife Agencies
- National Wildlife Federation, Oregon Office
- National Wildlife Refuge Association
- Oregon Chapter Sierra Club
- The Conservation Fund
- The Nature Conservancy
- The Wildlife Society, Oregon Chapter
- Western Association of Fish and Wildlife Agencies - Wild Sheep Working Group
- Western Watersheds
- Wildlands Defense
- Wilderness Watch

Neighboring Landowners

- Roaring Springs Ranch
- Beaty Butte Grazing Association
- O’Keeffe Ranch
- LX Ranch Inc.
- LX Ranch Inc.
- Laird Land Company, LLC
- Rock Creek Ranch
- Hart Mountain Store

- Adel Store
- Kiely Brothers Ranch
- John Flynn Ranch
- Jack Flynn Cattle Co.
- The JJF Ranch Limited Partnership
- Con Fitzgerald Ranch, Inc.
- Department of State Lands, Eastern Region Manager
- Fitzgerald Partners, Inc.
- Rosanne Fitzgerald
- Fitzgerald Partners, Inc.
- Taylor Westside Ranch, Inc.
- The Taylor Ranch, Inc.

Agencies

- BLM Burns District Office
- BLM Lakeview District Office
- Fremont-Winema National Forest
- ODFW, Salem
- ODFW, Lakeview
- USGS National Wildlife Health Center
- USGS Northern Rocky Mountain Science Center

Local Newspapers and Places to Distribute Information

- Lake County Chamber of Commerce
- Lake County Library
- Harney County Library
- Lake County Examiner
- Herald and News

5.6 Substantive Changes Made to the Final EIS in Response to Comments Received

In response to comments received, several changes were made to the final EIS.

Section 1.3.1 Bighorn Sheep Population Performance Measures

- Referenced Kofa National Wildlife Refuge Final Environmental Assessment to reduce cougar predation on desert bighorn sheep and clarify relative period of bighorn sheep population decline and recovery.

Section 1.5.2 U.S. Department of Agriculture Animal and Plant Health Inspection Service–Wildlife Services

- Amended Animal Damage Control Act of March 2, 1931, with updated nomenclature.

Section 2.2.6 Adaptive Management

- Relocated Adaptive Management section from Section 2.2 Elements Common to All Alternatives to Section 2.3.3 Alternative C: Population Management Only.

Section 2.3.1 Alternative A: No Action (Current Management)

- Added reference to disease from domestic sheep and goats.
- Added reference to prohibition of pack goats and llamas.

Section 2.3.2 Alternative B: Bighorn Sheep Habitat Improvement

- Clarified factors affecting juniper treatment within bighorn sheep habitat.
- Added specific monitoring and assessment discussion.

Section 2.3.3 Alternative C: Population Management Only

- Clarified how bighorn sheep augmentation would be part of the alternative.

- Added clarification and details on how cougar administrative removal would occur.
- Amended the best management practices and standard operating procedures to restrict the use of leghold traps only after hounds and snares are proven to be ineffective.
- Amended the best management practices and standard operating procedures to reduce the potential for nontarget wildlife effects.
- Clarified when administrative removal would be initiated and suspended using the performance triggers and management action threshold.
- Clarified the option to propose and evaluate a public cougar hunt.
- Added a discussion on adaptive management.

Section 2.3.3.1 Bighorn Sheep Population Metrics and Action Threshold Criteria

- Clarified how population performance averages are calculated.
- Clarified when a public cougar hunt would be evaluated.

Section 2.3.3.2 Herd Augmentation

- Clarified the use of bighorn sheep augmentation in Alternative C.
- Amended to include the conditions under which augmentation would be implemented.

Section 2.3.4 Alternative D: Comprehensive Integrated Management (Preferred)

- Clarified the use of bighorn sheep augmentation in Alternative D.
- Added discussion on adaptive management detailing monitoring and assessments.

Section 2.4.2 Relocation of Cougars

- Clarified why cougar relocation was an element considered but eliminated from analysis.

Section 2.4.4 Confirming That a Cougar is Preying on Bighorn Sheep Before it is Removed

- Clarified why targeted cougar removal was an element considered but eliminated from analysis.

Section 2.4.6 Sport Hunting Only

- Clarified when a public cougar hunt would be evaluated.

Section 2.5.1 Goal 1. Protect, Maintain, and Enhance Habitats to Meet Life-History Needs of the Bighorn Sheep Herd on the Refuge

- Amended to include implementation qualifiers.
- Added a management strategy to develop and Inventory and Monitoring Plan.

Section 2.5.2 Goal 2: Maintain a Healthy, Sustainable, and Genetically Diverse Population of Bighorn Sheep on the Refuge

- Added targeted cougar removal as a conditional and optional strategy if there is a need to reinitiate administrative removals.
- Added a management strategy to develop an inventory and monitoring plan.

Section 3.3.1.8 Other Bighorn Sheep Herds Near Hart Mountain

- Clarified the status of bighorn sheep herds on Steens Mountain.

Section 3.3.1.10 Vital Rates

- Added a discussion on population performance criteria and management action threshold as cougar control action triggers.

Section 3.3.1.13 Disease

- Amended to include reference to pneumonia-related population crashes.
- Amended to include the prohibition of llamas and pack goats on the Refuge.

Section 3.3.1.14 Predation

- Added an additional reference regarding cougar predation on bighorn sheep.

Section 3.3.2.9 Ecological Role of Cougars

- Clarified ecological role of cougars with respect to bighorn sheep.

Table 4.3 Potential Effects of the Proposed Alternatives on Bighorn Sheep Herd

- Adjusted effects of the actions on bighorn sheep.

Section 4.3.1 Effects on California Bighorn Sheep

- Discussed effects of using traps and snares for cougar administrative removal on bighorn sheep.

Section 4.3.2 Effects on Cougars

- Discussed effects of using traps and snares for administrative removal of cougars.

Section 4.3.3 Effects on Mule Deer

- Discussed effects of using traps and snares for cougar administrative removal on mule deer.

Section 4.3.4 Effects on Other Ungulates

- Discussed effects of using traps and snares for cougar administrative removal on other ungulates.

Section 4.3.5 Effects on Mesocarnivores

- Discussed effects of using traps and snares for cougar administrative removal on mesocarnivores.

Section 4.3.6.1 Eagles

- Discussed effects of using traps and snares for cougar administrative removal on eagles.

Section 4.6.1.1 Untrammeled

- Clarified definition and how the proposed actions affect the wilderness character.

Section 4.6.1.2 Natural

- Clarified how the proposed actions affect the wilderness character.

Section 4.6.1.3 Undeveloped

- Clarified how the proposed actions affect the wilderness character.

Section 4.7.3 Effects on Climate Change

- Clarified the effects of the alternatives on climate change using updated information and calculated projected greenhouse gas emissions related to slash pile burning.

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