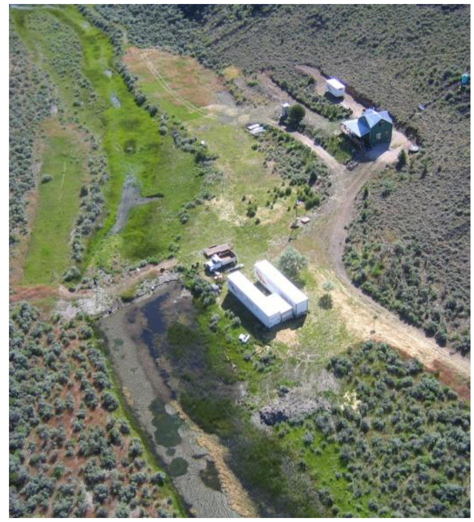
VULNERABILITY ASSESSMENT AND STRATEGIES FOR THE SHELDON NATIONAL WILDLIFE REFUGE AND HART MOUNTAIN NATIONAL ANTELOPE REFUGE COMPLEX

Final Report
December 23, 2011



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Cover photos

Courtesy of Sheldon Hart Mountain NARC. Examples of land uses affecting the Refuges including (clockwise from top left): horse and burro impacts, inholdings development, wildfire, and mining.

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Executive Summary

This report provides the results of the Refuge Vulnerability Assessment (RVA) for the *Sheldon National Wildlife Refuge and Hart Mountain National Antelope Refuge Complex (Refuge Complex).* The purpose of the RVA is to assess the cumulative impacts of stressors on refuge resources over multiple timeframes and develop mitigation and adaptation strategies to address those impacts.

The Refuges are located in northwest Nevada and southeast Oregon in an arid landscape characterized by expanses of sagebrush punctuated by isolated mountain ranges. Both Refuges were established primarily for the conservation of pronghorn, though many sensitive species and habitats are present on the Refuges and surrounding lands.

Both spatial and non-spatial models were used to assess resource response to land use and environmental stressors. Spatial models looked specifically at snapshots in time at 2010 and 2025, while non-spatial assessments produced continuous results from 2000 to 2100. The spatial assessments focused on the subset of stressors that are readily characterized in a spatially explicit manner at the scale of the project area, using one modeling tool. All priority resources were addressed in the spatially explicit assessments. The second set of assessments focused solely on vegetation resources, and on the subset of stressors that are not readily modeled in a spatially explicit manner at the scale of the project area, using other modeling tools. These tools permit an in-depth assessment of how vegetation resources may change in response to biotic and abiotic processes, including grazing and climate change.

The condition of priority resources (species, ecological systems, and infrastructure) on the Refuge Complex was spatially analyzed under the 2010 and 2025 scenarios using the NatureServe Vista software extension for ArcGIS. A variety of spatial data was collected to map stressors in order to define the 2010 and 2025 scenarios; these included data on infrastructure, energy development, non-native grasses, and grazing by livestock[1], horses, and burros. Literature references and expert opinion were used to assign categorical responses (beneficial, neutral, negative) of each priority resource to each type of stressor. The NatureServe Vista program assessed the response of each resource to the combined set of stressors represented in each spatial scenario. These assessments provide a picture of the current and projected cumulative impacts of those stressors on the priority resources for the current (2010) time period and the year 2025.

A subset of the priority resources, vegetation resources, were assessed using the Vegetation Dynamics Development Tool (VDDT). VDDT assesses the change in vegetation resources in response to management activities (or natural disturbances or succession) and which produces results summarized at the watershed level. The change in the vegetation resources' relative proportions on the landscape under potential climate change, with and without the impacts of grazing, was also assessed using a separate climate model. These analyses illustrate the potential changes in vegetation resources across the landscape over time, under varying grazing and juniper management scenarios, with and without the added impacts of climate change.

[1] "Livestock" primarily refers to cattle in this report; sheep and goats are included in this term to the extent that they are present in the assessment area. Grazing by horses and burros are referred to separately.

2010 baseline assessment results

The contrast between grazed lands (grazed by both livestock and feral horses and burros) and ungrazed lands is clear in all of the scenarios assessed spatially. Under the 2010 scenario, all livestock was removed from Hart Mountain Refuge, while feral horse and burro grazing was present at Sheldon Refuge. Because nearly all resources are negatively affected by grazing, Sheldon Refuge had very few hectares of resources that were expected to be retained under this scenario, while the resources of Hart Mountain fared substantially better. However, the resources of both refuges were still impacted by other infrastructure and land uses such as roads, campgrounds, and at Sheldon Refuge, mining areas. While these features negatively impacted resources, their relatively small and discrete extent resulted in more localized impacts; in contrast, grazing was dispersed throughout much of the landscape and therefore impacted vast areas. While a few sagebrush types respond positively to low levels of grazing, sensitive plants and most of the plant community resources respond negatively, resulting in a small number of resources (four out of fifty-four total priority resources) whose extent and health were expected to be maintained at the levels (or goals) established for this assessment.

2025 assessment results

To assess impacts to resources in the year 2025, two scenarios were developed: one where feral horses and burros remain on Sheldon Refuge (the 2025 Road Closures Scenario), reflecting limited changes from current management, and one where they were removed (2025 Revised Refuge Management Scenario), reflecting more extensive changes in refuge management. For both scenarios, projected energy development and infrastructure were added to the suite of stressors expected to be present on the landscape in 2025. With horses and burros present on Sheldon Refuge, the resources' goal achievement remains nearly unchanged from the 2010 baseline scenario, with minor increases or decreases of a few percent: most did not meet their goals. The small decreases imply that energy development outside the Refuge will have minor impact to resources, possibly because most of the area where these energy developments are planned is on land that was already impacted in 2010 by infrastructure, invasive annual grasses, and other stressors. When horses and burros are removed from Sheldon Refuge, the area of resources retained jumps significantly.

VDDT assessment results

The trends illustrated in the 2025 spatial assessments summarized above are projected by the VDDT assessments to continue for vegetation resources, with the control of juniper and removal of grazing on the Refuge lands resulting in increases in native plant cover (priority resources) and decreases in degraded or semi-degraded habitats. Most models showed vegetation resources changing dramatically within watersheds between 2010 and 2050, depending on management, after which the rate of change leveled off. Without juniper control and with grazing present, invasive annual grasslands were projected to increase dramatically, while native shrub-steppe becomes a minor component. Areas susceptible to juniper moved toward woodland types at the expense of shrub-steppe, unless juniper control was incorporated into the model. Shrub-steppe types were degraded through the expansion of non-native grasses unless grazing was removed, in which case native habitats were maintained or even expanded when combined with juniper control.

Climate assessment results

This part of the assessment builds conceptually on the VDDT modeling by incorporating the projected impacts of climate change on vegetation resources. Initial climate modeling results predicted the supporting landscape to become warmer and slightly wetter during the growing season over time. Two major climate models, which are considered to be somewhat conservative (CSIRO and MIROC) and to best represent changes likely to occur in the next 60 years, were used to compare predictions. Drought was modeled to occur randomly, and fire history for the area was incorporated, with more severe fires occurring where non-native annual grasses are present. Climate models were run with and without grazing and juniper control present. Both climate effects and management effects were found to significantly alter the proportion of vegetation resources in relation to degraded habitats in the scenarios. Warming conditions resulted in an increase of grasslands at the expense of shrub-steppe systems, with degraded systems increasing through expansion of non-native grasses. Under no-grazing management, native shrub-steppe systems increased in cover with Wyoming big sagebrush transitioning to Mountain big sagebrush. These models also show a leveling off of vegetation change around 2060, indicating that it may become more difficult to maintain shrub-steppe habitats over time based on climate changes shown by the models. A third, less conservative climate model put together by the Hadley Centre for Climate Prediction and Research is currently being implemented, although the results for the supporting landscape are not available. Initial results applying the Hadley model to the central Oregon Eastern Cascades show similar warming trends but show significantly reduced annual rainfall over time, and increased areas dominated by warmer season, C4 grasses that are currently a minor component in these ecosystems.

All of the assessment results showed the significant impact of livestock grazing on priority resources. Many resources are directly negatively affected by livestock trampling or browsing, and lands that are grazed have higher rates of juniper encroachment and exotic species invasion, resulting in more degraded habitats. All of the climate models show a series of years with major wildfires occurring within the project area sometime before 2060, and the relationship between wildfire frequency, intensity, spread and exotic species has been documented in the scientific literature.

The removal of horse and burro grazing, control of juniper, and management of invasive grasses such as cheatgrass are priority management actions for the Refuge Complex to preserve and maintain its priority sagebrush habitat resources. Models consistently showed that these management actions would result in greater amounts of native shrub-steppe habitat and other priority resources and less area of juniper encroachment and exotic monoculture as compared to grazed lands where juniper and weeds were not controlled. The very dramatic differences in changes in shrub-steppe habitat quality and quantity based on areas and intensity of grazing makes a compelling case for further evaluating the possibility of cooperating with neighboring land owners between and adjacent to the Refuges to implement reduced grazing strategies in those areas, as well as juniper and weed control. We tested this hypothesis with an alternative future scenario and quantified the predicted outcome of this management change, which showed an overall positive effect on the retention of priority resources. The identification of wildlife corridors and ongoing research evaluating how target species such as pronghorn and the greater sage grouse use the area between the refuges has not been completed, and should provide additional guidance in this regard.

Chapter 1. Introduction

Refuge Vulnerability Assessment: Background and Purpose

This report addresses the Sheldon National Wildlife Refuge (hereon referred to as the Sheldon Refuge) and the Hart Mountain National Antelope Refuge (hereon referred to as the Hart Mountain Refuge) and collectively referred to as the Sheldon-Hart Mountain National Wildlife Refuge Complex (Refuge Complex) and the supporting landscape in which the Refuge Complex is found.

This Refuge Vulnerability Assessment (RVA) was conducted by NatureServe in partnership with:

- Sheldon-Hart Mountain National Wildlife Refuge Complex staff
- The Oregon Biodiversity Information Center

The RVA process is described under Content and Scope below; it was conducted for these Refuges for three reasons:

1. To support and inform the development or revision of the Comprehensive Conservation Plans (CCPs) for the Sheldon-Hart Mountain National Wildlife Refuge Complex.

2. To inform collaborative planning among the key stakeholders within the supporting landscape of the Refuge Complex.

3. To support a cooperative project between USFWS and NatureServe to create and test a framework and handbook for refuge vulnerability assessment and alternatives development (RVA). Conducting this RVA assisted in refining and illustrating the RVA methodology as described in the RVA technical guide (NatureServe and USFWS, in review).

RVA Report Organization

The goal of this assessment is to provide information on how priority resources on the Refuge Complex and the supporting landscape may be affected by various management activities, land uses, and in particular, climate change. The results can help inform management decisions and collaborations on and off the refuges. However, the types of models and data that are available to model the effects of the various stressors are significantly different; no single modeling tool has the capability to evaluate the full set of stressors that affect priority resources. Consequently, the report is organized in part around the two sets of modeling efforts – the spatial modeling (using Vista) that assesses the combined impacts of management activities and stressors arising from infrastructure and other land uses, and the non-spatial modeling (using VDDT and climate models) that assesses the impacts of management activities with and without the projected effects of climate change. Although the modeling tools and data sets are different, the assessments evaluated conceptually related scenarios, to allow users of this report to see how the priority resources are affected by various management practices (particularly grazing management) and additional infrastructure, with and without the effects of climate change. This chapter provides a general introduction to the vulnerability assessment in the context of the Refuge Complex; a simplified workflow of the RVA is illustrated in Figure 1. After describing the environmental context of the Refuge Complex and its supporting landscape in Chapter Two, Chapter Three begins with an overview of the spatial and non-spatial assessments and the scenarios that were evaluated in each. The remainder of Chapter Three is divided into the results and interpretation of the spatial assessments, followed by the results and interpretation of the non-spatial assessments. Brief descriptions of methods specific to each component of the various assessments are placed with their associated assessments in Chapter Three to make it easier for different specialists to find all of the relevant information (methods, results, and interpretation) in one section. The reader is referred to appendices in this report, the RVA technical guide (NatureServe and USFWS, in review), or other sources for more detailed information on methods. All of the assessments indicated that managing grazing, juniper and invasive grasses would have substantial positive impacts on priority resources both on and off the Refuge Complex; Chapter Four summarizes the assessment of an alternative future scenario based on those management practices and the management implications of these scenario results. The final chapter provides guidance on updating and maintaining the assessment data so that the spatial scenarios can be readily re-evaluated as new information becomes available.

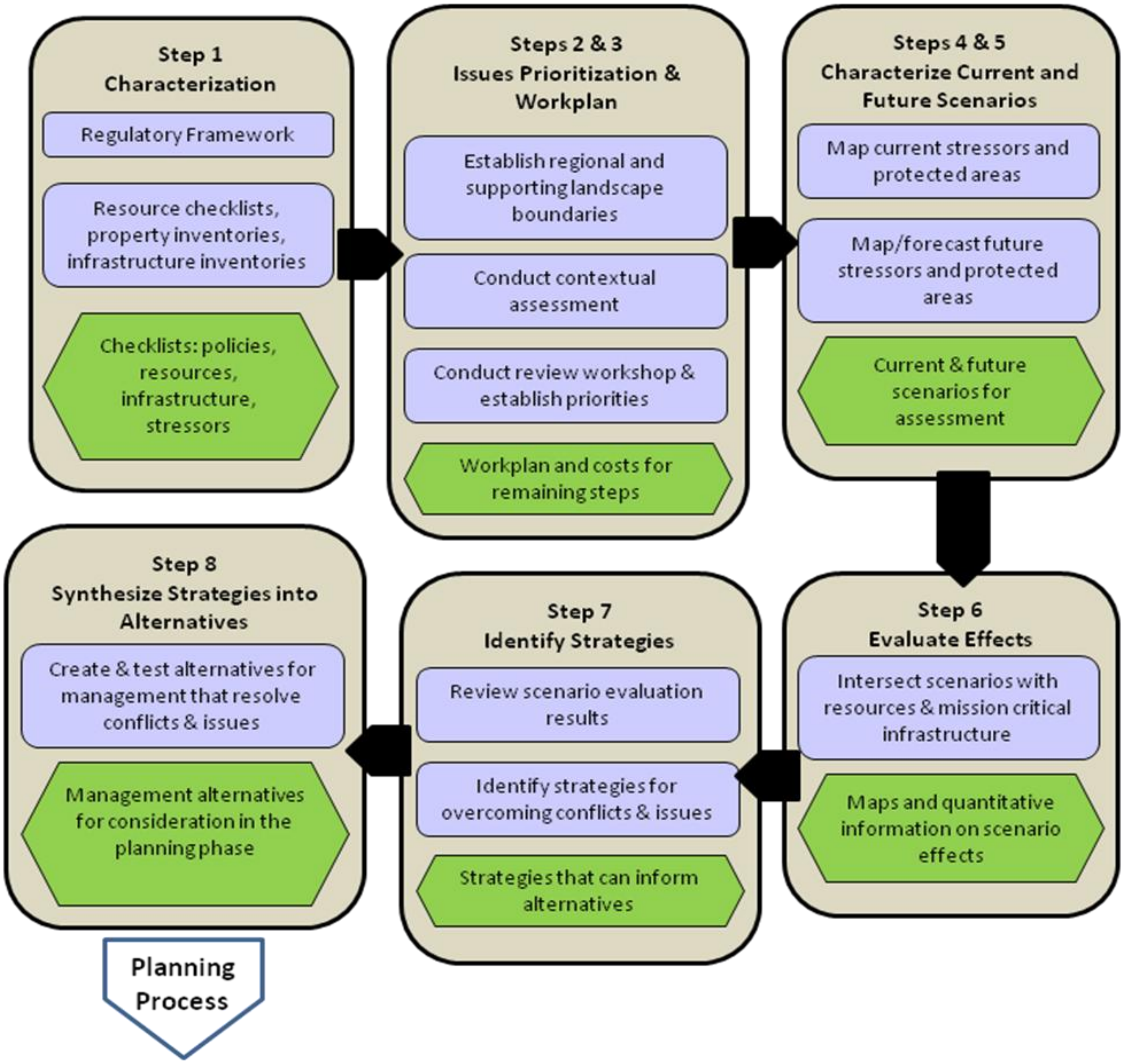
Sheldon and Hart Mountain Refuges are treated together in this report whenever they have consistent and overlapping goals, resources, and stressors. In each section, differences in the Refuges are noted when applicable.

Content and Scope of the RVA

This assessment of refuge vulnerability closely followed the process described in the RVA technical guide (NatureServe and USFWS, in review), but was necessarily constrained by time, funding, and data availability. An RVA generally includes a cumulative effects assessment of stressors (including climate change) on resources over multiple timeframes (scenarios). It then provides a description of strategies and one or more alternative scenarios that could mitigate stressor effects on resources including climate change adaptation. The RVA workflow is illustrated in Figure 1.

Figure 1. Simplified RVA workflow process used in the study.

Rectangles indicate inputs and actions for each step, while hexagons indicate outputs, which also serve as inputs to the subsequent steps.



For this RVA, the assessment team characterized the management and policy framework, the biological and infrastructure resources, and the current and expected stressors affecting the resources on and off refuge within the supporting landscape. Based on the current and projected land management and stressors, the team developed a series of scenarios for the supporting landscape under which stressor impacts on resources were analyzed. Different management and stressor scenarios were defined and assessed in spatial and non-spatial assessments. For the spatial assessments, two time periods were assessed: a 2010 baseline, and 2025. The non-spatial assessments produced results for each year between 2000 and 2100, which are presented in charts showing change over time.

Climate change issues of particular importance include:

- *Effect of changes in temperature, precipitation, and timing of runoff on natural water bodies*. Because streams, springs, and other water bodies provide disproportionately high wildlife value relative to their extent on the landscape, changes to these water resources from altered climate would have significant impacts. Conducting a detailed hydrologic assessment was not within the scope of this study, but a water resources assessment report was conducted for Sheldon Refuge to address this need (Wurster 2009).

- *Additional stress on sagebrush-steppe habitats resulting from changes in temperature and precipitation*. Because this resource is already heavily impacted from ongoing stressors or ongoing effects of past stressors, additional stress from climate change could have serious consequences.

The following specific anticipated climate changes were assessed in this study including synergistic effects among stressors:

- Changes in annual temperature causing increased rates of disturbance or habitat change
- Changes in the amount and timing of precipitation, and seasonal variations in soil moisture
- Modifications of species ranges for some priority species resources, due to habitat modifications, and
- Changes in ecosystem and habitat condition and composition

CCP Issues Treatment in the RVA

Specific issues identified in the draft Sheldon CCP/EIS (and RVA scoping workshops) relevant to the vulnerability assessment are listed here, along with their treatment in this assessment:

- **Wildlife and Habitat Management**: Key issues include 1) invasive species causing deterioration of natural habitats; and 2) degraded habitats from past livestock grazing as well as current impacts from feral horses and burros.
    - **RVA treatment**: Included in all components of this vulnerability assessment.
- **Feral Horses and Burros**: The current feral horse and burro populations (approximately 800 horses and 80 burros present on Sheldon Refuge [USFWS In Press]) are directly affecting the capacity of Sheldon Refuge to support native plants and wildlife and restore the native ecosystem. Horses and burros also pose health and safety risks to motorist on State Route 140, with 5-15 collisions per year.
    - **RVA treatment**: Included Sheldon Refuge and BLM herd areas in all assessments; assumed removal of horses and burros from Sheldon Refuge in 2025 and beyond.
- **Fish Stocking**: There are ponds and reservoirs on Sheldon Refuge that are stocked with native and non-native fish. The current practice of stocking non-native fish in waters within Sheldon Refuge is popular with the public but inconsistent with Service policy. This may not result in elimination of the fishing.
    - **RVA treatment**: Included fishing areas on Refuge lands in spatial assessments.

- **Camping**: The proximity of semi-primitive campgrounds to springs and riparian areas could potentially contaminate water sources, and disturb and displace wildlife from critical habitats. In the developed Virgin Valley Campground there is the potential for overcrowding, user conflicts, and overflow camping expanding into the undeveloped uplands surrounding the campground.
    - **RVA treatment**: Included campgrounds on Refuges lands in spatial assessments.
- **Wilderness Management**: Currently 341,500 acres within Sheldon Refuge are proposed for wilderness designation. The CCP will: 1) examine whether the areas proposed for wilderness designations in 1974 remain suitable today; 2) examine whether other Refuge lands not proposed for wilderness designation meet the minimum criteria for further evaluation as Wilderness Study Areas (WSAs); 3) recommend Proposed Wilderness Areas and WSAs or portions of those areas for designation as wilderness; and 4) identify the minimum management programs and associated tools necessary for maintaining wilderness character of Proposed Wilderness and WSAs and for achieving Refuge purposes.
    - **RVA treatment**: Current management units such as WSAs are included in spatial assessments, but proposed areas are not.
- **Public Access, Roads, and Transportation**: The existing road network has resulted in adverse impacts to wildlife, habitats, cultural and historical resources, Wilderness Study Areas, and to the back-country visitor experience. The CCP will examine confusing road access designations; OHV use on and off roads; roads that are surplus or should be seasonally closed; and opportunities for conversion of closed roads to recreation trails.
    - **RVA treatment**: The current road network is incorporated, and potential road closures on Sheldon Refuge were assessed in the 2025 scenario, in the spatial assessments.

Refuge Regulatory Context

According to the Refuge Complex website (http://www.fws.gov/sheldonhartmtn/index.html), both refuges were established primarily for the conservation of pronghorn. Following are specific purposes for each refuge compiled in their CCPs and originally drawn from the regulatory and policy framework detailed in Appendix A:

Sheldon National Wildlife Refuge Purposes

In Chapter 1 of the Draft Refuge Comprehensive Conservation Plan and Environmental Impact Statement for Sheldon Refuge, the following purposes are compiled:

1. "...as a refuge and breeding ground for wild animals and birds..." Executive Order 5540 dated January 26, 1931.
2. "...set apart for the conservation and development of natural wildlife resources and for the protection and improvement of public grazing lands and natural forage resources ..." Executive Order 7522 dated December 21, 1936.
3. "...to conserve (A) fish or wildlife which are listed as endangered species or threatened species ....or (B) plants..." 16 U.S.C. § 1534 (Endangered Species Act of 1973).

4. "...for use as an inviolate sanctuary, or for any other management purpose, for migratory birds." 16 U.S.C. §715d (Migratory Bird Conservation Act).

Hart Mountain National Antelope Refuge Purposes

From the 1994 CMP (USFWS 1994), the purpose of Hart Mountain Refuge is based on the goals of the National Wildlife Refuge System (NWRS) and authorities establishing Hart Mountain NAR (Executive Order 75231). From these, five goals were developed for the Refuge:

1. Manage for healthy and balanced populations of pronghorn and other species of native wildlife in their natural habitat, to the extent that populations can be influenced on Refuge lands.

2. Manage for the conservation and recovery of threatened and endangered species of plants and animals in their natural ecosystems.

3. Restore and maintain, on Refuge lands, the structure, species composition, and processes of native ecological communities and ecosystems of the northern Great Basin Region.

4. Provide opportunities for wildlife/wildlands-dependent recreation and education oriented to the Great Basin ecosystem while maintaining the rugged, remote and undeveloped character of the Refuge.

5. Provide high quality nesting and brood-rearing habitat for waterfowl and other migratory birds at the Shirk Ranch area, now in BLM ownership.

Planning and Management Guidance

Relevant policies under which the Refuge Complex operates are described in the CCPs. This assessment of refuge vulnerability was conducted primarily under the Biological Integrity, Diversity, and Environmental Health (BIDEH) policy and the National Wildlife Refuge System Administration Act of 1966 (16 U.S.C. 688 ddd-688 eed, as amended by the National Wildlife Refuge System Improvement Act of 1997).

Chapter 2. Refuge Environment

The assessment team began by defining the project area, and characterizing the regulatory and policy framework, the biological resources and physical infrastructure, and the stressors relevant to the resources and infrastructure of the Refuge Complex. The project area and its setting are described in the first section in this chapter. The characterizations and initial assessments of the biological and infrastructure resources are described in the remaining sections of this chapter, and a series of checklists for the regulatory framework, all priority resources, and stressors are found in the appendices (Appendices A-D). The development of these checklists is part of the assessment workflow illustrated previously in Step 1 of Figure 1, with each checklist informing the content of the subsequent one. The checklists were reviewed by Refuge Complex staff, and the assessment team then prioritized the resources and stressors to be evaluated. The finalized checklists of resources and stressors were used to determine the data needs and the full scope of the vulnerability assessment.

Geographic and Ecosystem Setting

The Refuge Complex is located in northwest Nevada (Sheldon Refuge) and southeast Oregon (Hart Mountain Refuge) and covers over 348,000 hectares (860,000 acres) (Figure 2). It lies within Bailey's Columbia Plateau ecoregion (Figure 3) and roughly corresponds to the western half of Omernik's Northern Basin and Range ecoregion (Figure 4), both characterized by expanses of sagebrush punctuated by isolated mountain ranges. The region has variable precipitation, but the landscape of the Refuge Complex is fairly arid and thus springs and riparian features are of great importance for many species. Hart Mountain Refuge "is located on a massive fault block ridge that ascends abruptly nearly three-quarters of a mile above the Warner Valley floor in a series of rugged cliffs, steep slopes, and knife-like ridges" (http://www.fws.gov/Refuges/profiles/index.cfm?id=14622). Sheldon Refuge is located near the southern boundary of the two ecoregions and thus has some similarities to the Great Basin ecoregion immediately to the south. In contrast to the dramatic topography of Hart Mountain, Sheldon Refuge is primarily comprised of sagebrush-dominated tablelands incised with canyons. It has a large number of springs and seeps, playas, and some perennial streams.

In order to assess refuge vulnerability, the assessment team defined two geographic contexts. The first is an ecoregion that served to assess the proportional area of a large list of resources that fall on the Refuge Complex compared to their ecoregion distribution. We utilized ecological units mapped by McNab and Avers (1994) and Omernik (1987) to define this assessment region. This modified ecoregion (Figure 5) was used to inform what resources should be priorities for assessment. The second context is the *supporting landscape* shown in Figure 2. This boundary was intended to incorporate an area that could contribute to the viability of the biological resources present on the Refuge Complex, provide important habitat for species, or influence Refuge Complex resources through stressors such as infrastructure or land management. This area of contribution and influence is also referred to as the "project area;" the terms "project area" and "supporting landscape" are thus used interchangeably in this report. Watershed boundaries were the primary source for defining the project area boundary, with a few minor modifications. The small portion of the project area that fell within California was omitted from this assessment, and the southern boundary was modified to follow the LANDFIRE and NLCD modeling region Zone 9 boundary.

Figure 2. Supporting landscape context of the Sheldon-Hart Mountain National Wildlife Refuge Complex with terrain and landmarks.

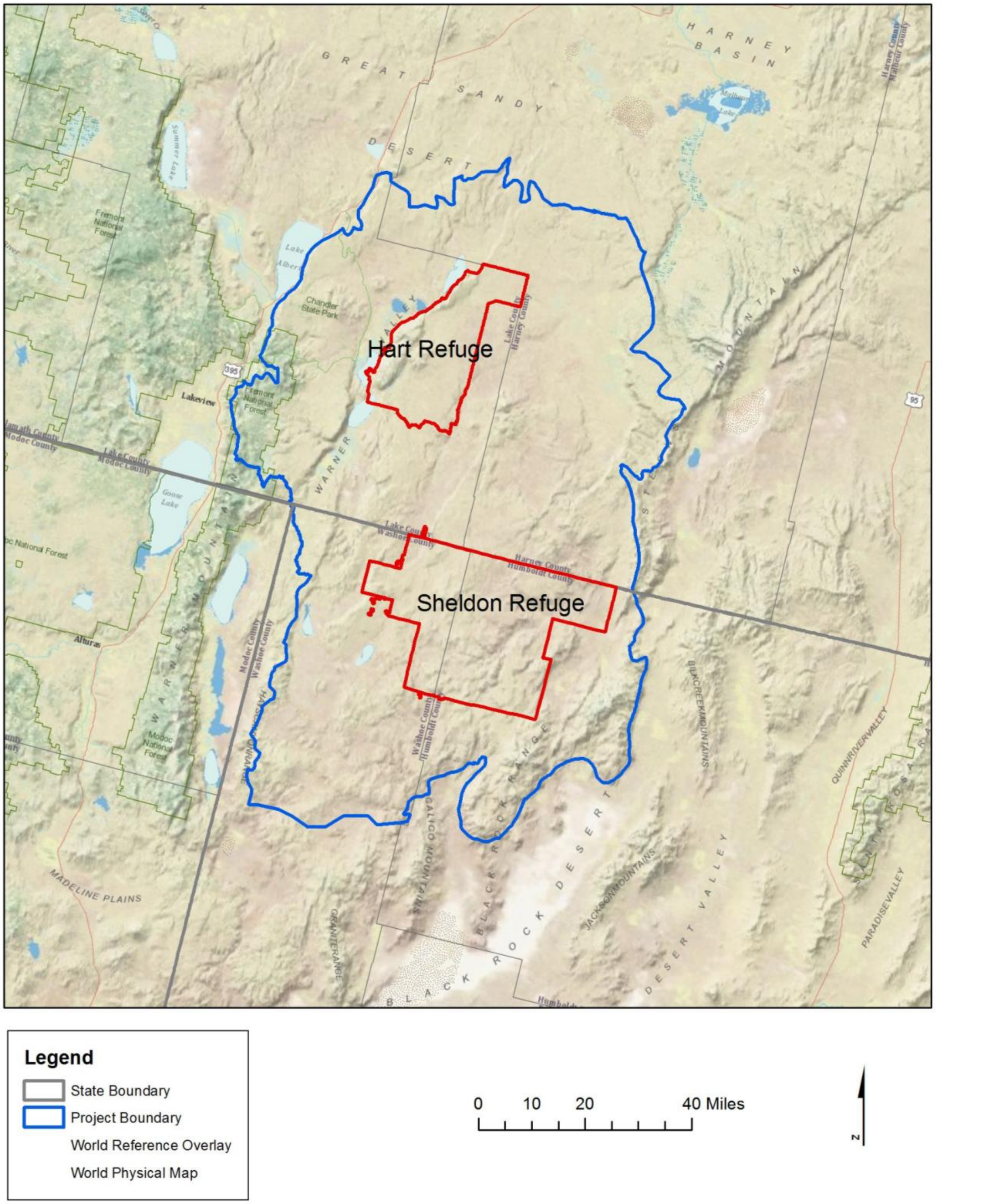


Figure 3. Bailey ecoregions in the Sheldon-Hart Mountain National Wildlife Refuge Complex area.

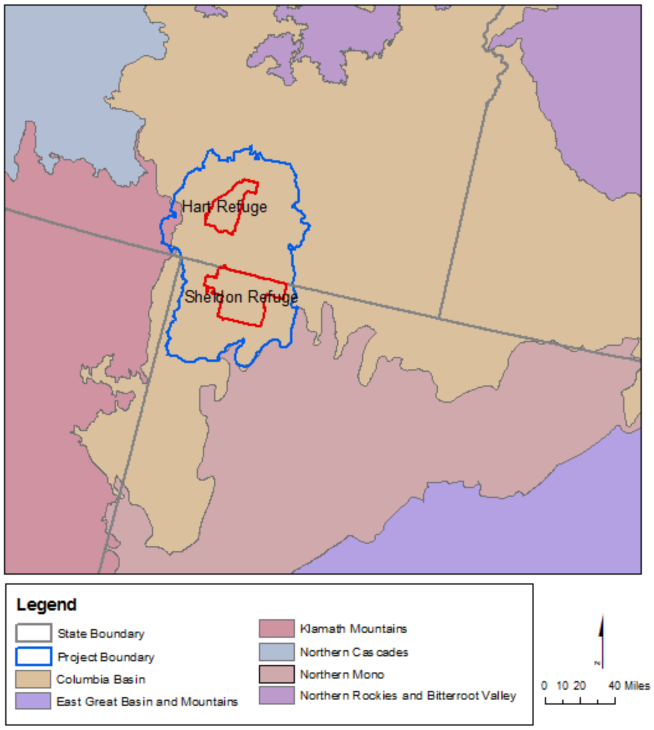


Figure 4. Omernik ecoregions in the Sheldon-Hart Mountain National Wildlife Refuge Complex area.

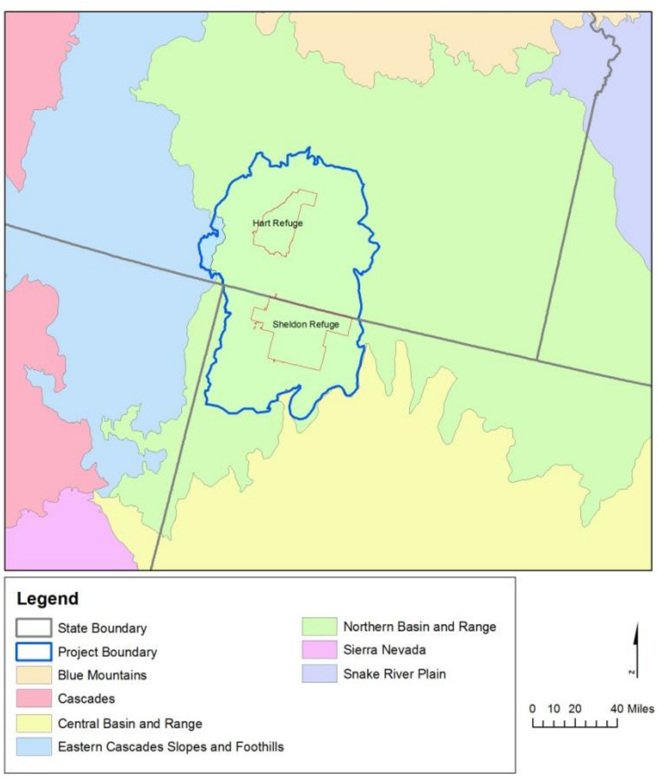
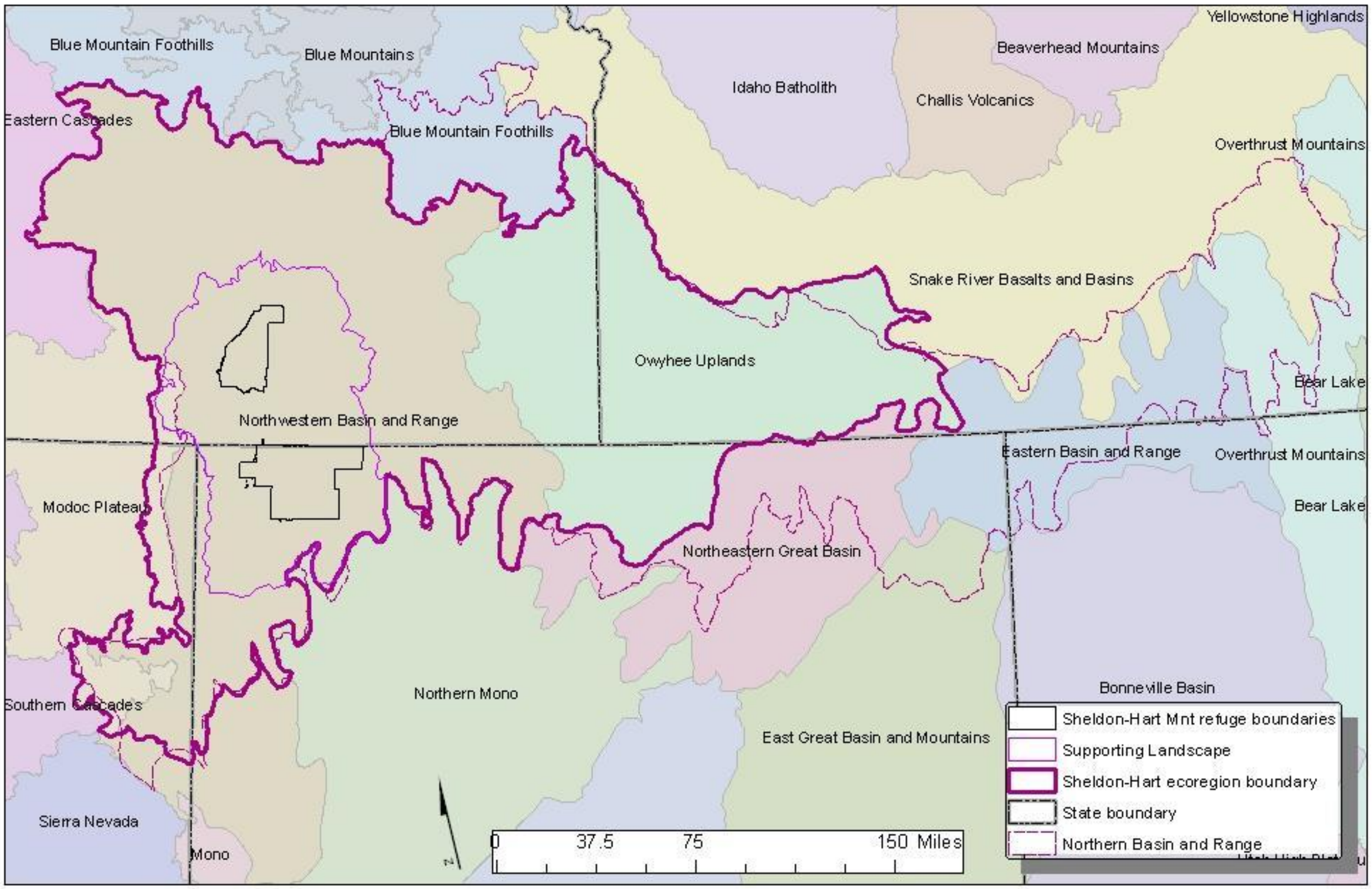


Figure 5. Ecoregion used as broader context for assessing Refuge Complex resources.

The ecoregion boundary used for the Sheldon-Hart RVA is largely drawn from two ecological units, the Northwestern Basin and Range and Owyhee Uplands (McNab & Avers, 1994). These two sections roughly correspond with the western half of the Northern Basin and Range level III ecoregion (Omernik, 1987). The Sheldon-Hart ecoregion boundary was expanded westward into the Modoc Plateau ecological unit to improve hydrological connectivity with the rest of the region.



Climatic Environment

This section characterizes the basic climate variables of temperature and precipitation in recent history and future forecasts; climate change effects on stressors and resources are analyzed later in this report. Historical climate information was obtained from weather stations downscaled with the PRISM software maintained by the Oregon Climate Service at Oregon State University. Future climate forecasts were extracted from the Commonwealth Scientific and Industrial Research Organization (CSIRO, see Dix et al. 2009, Gordon et al. 2002) and the Model for Interdisciplinary Research on Climate (MIROC, see Hasumi and Emori 2004), the same sources as used to model climate change effects. The CSIRO and MIROC models were linked to the MC1 Global Dynamic Vegetation Model developed by Neilson et al. at Oregon State University. The forecasts generally show the area becoming warmer and slightly wetter, with the potential for habitats to move away from shrub-steppe to forested types. However, the results discussed later in the report show that management actions can have as much effect as the climate variables on the vegetation resources present.

Historical Climate

The Northern Basin and Range ecosystem (as the northern extent of the Great Basin ecoregion) is generally higher and cooler than the adjacent Snake River Plain, and has more available moisture and a cooler climate than the Central Basin and Range ecoregion (Thorson et al. 2003). The semi-arid climate in the Northern Basin and Range is also characterized by extreme ranges in daily and seasonal temperatures. The PRISM group has created grids of climate variables based on climate data from 1971 to 2000. The average annual temperature for the project area is shown in Figure 6, and average annual precipitation shown in Figure 7. For this historical period, the average annual low was 1.03^{o} C (33.85^{o} F) and the average annual high 10.29^{o} C (50.52^{o} F). Figure 8 shows the average summer moisture stress of the area (the ratio of temperature to precipitation).

Figure 6. Mean annual temperature from 1971-2000.

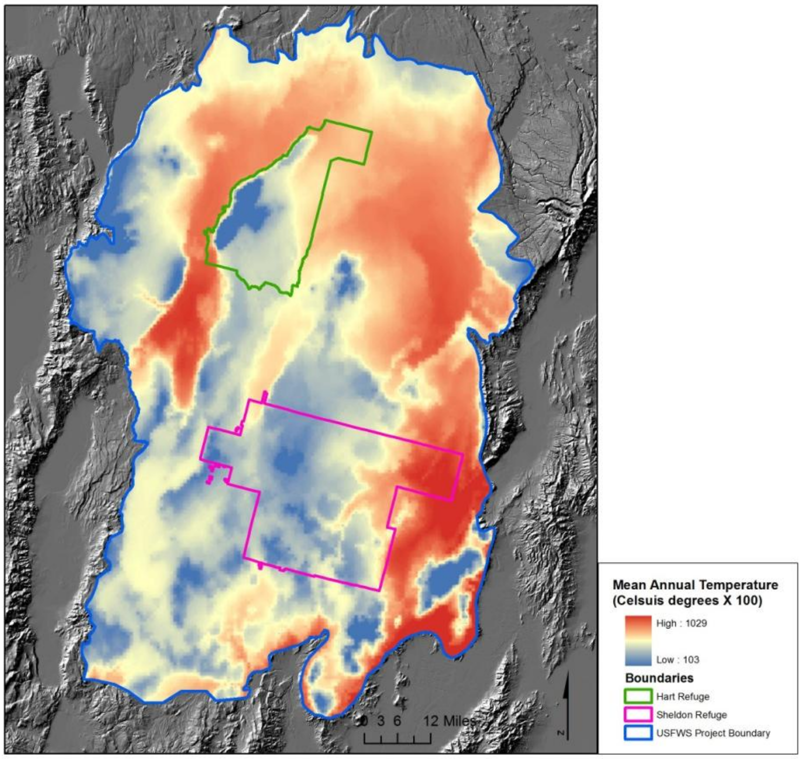


Figure 7. Mean annual precipitation from 1971-2000.

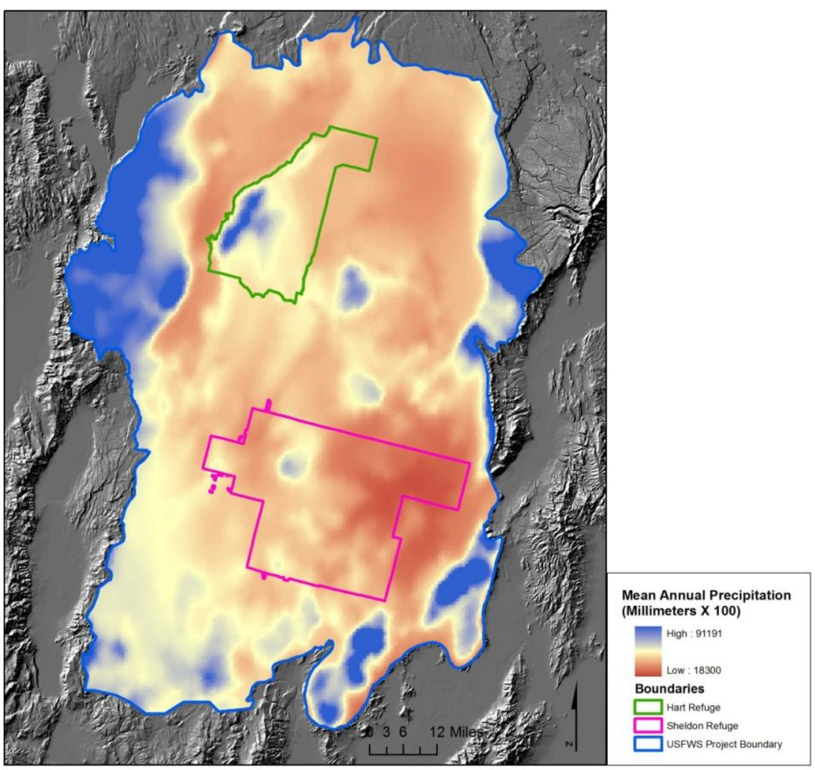
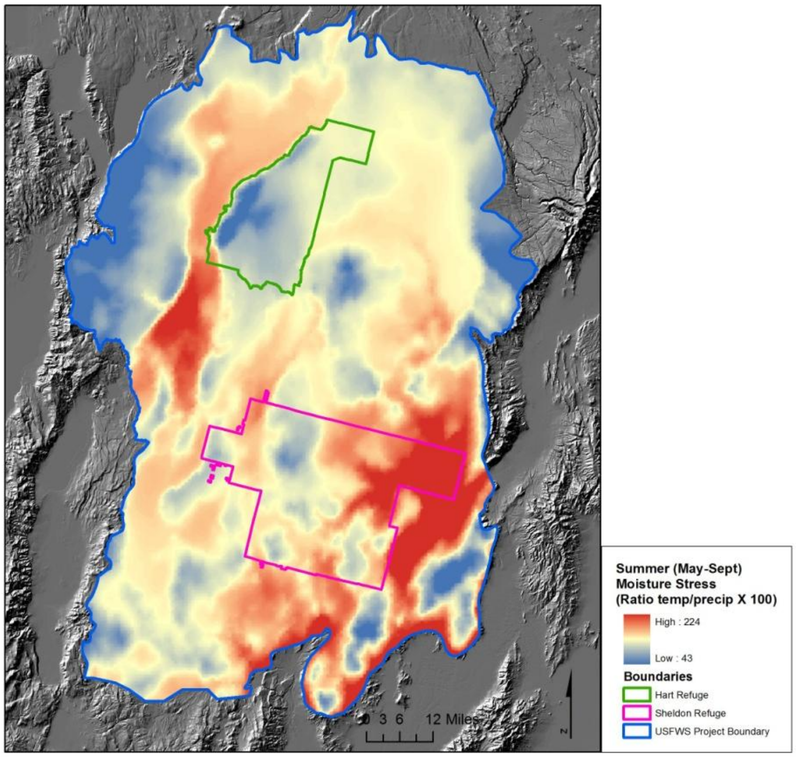


Figure 8. Mean summer (May-Sept) moisture stress from 1971-2000.



Predicted Climate Change

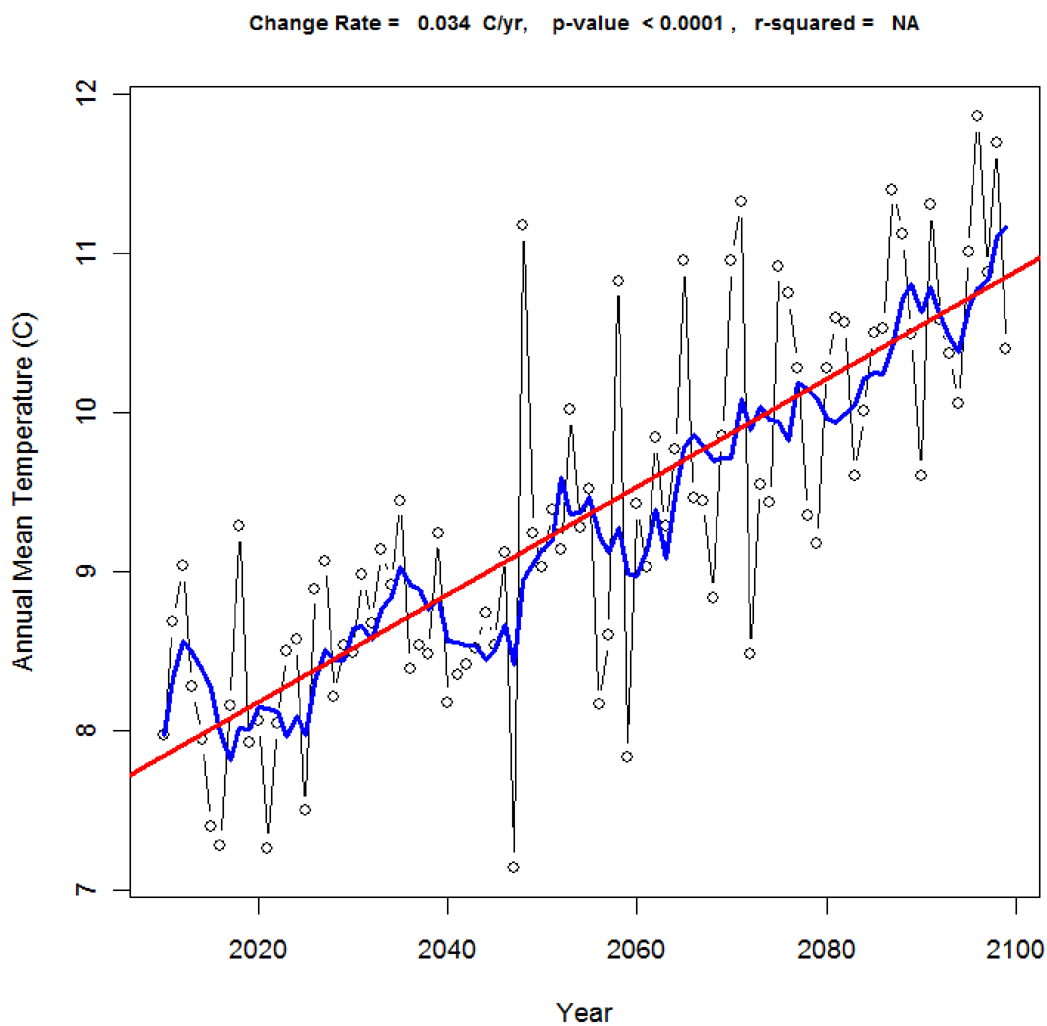
The increased levels of carbon dioxide in Earth's atmosphere and the potential effects of this on climate have been studied by many climate researchers in the past few decades. Documented climate changes in the past 100 years in the Great Basin include region-wide warming, increased precipitation, a decline in snow pack, and earlier arrival of spring (Chambers 2008). Minimum temperatures have increased more than maximum temperatures, and the variability in inter-annual temperatures has declined, leading to a higher probability of warmer than normal years and a lower probability of colder than normal years (Chambers 2008). Annual precipitation across the Great Basin has increased 6%-16% since the 1950s, though snowpack has been declining at most monitoring sites in the Great Basin (Chambers 2008). Spring snowmelt-driven stream flow is now occurring 10 to 15 days earlier than in the mid-1900s, including an increase in variability in spring flow between years (Baldwin et al. 2003; Stewart et al. 2004).

In addition to the impact of decreased snowpack, rising temperatures in the more arid sections of the Great Basin may lead to changes in fire regime. When better growing conditions are present due to these climate change trends (high fall, winter, and spring precipitation) and fuel accumulation from the previous growing season, fires are likely to be more frequent and extensive (Westerling et al. 2006). Additionally, the continued invasion of cheatgrass, expansion of juniper, and increase in tree density are also likely to result in increases in fire frequency and severity (Link et al. 2006). Figure 9 shows the predicted annual temperature for the project area and Figure 10 illustrates predicted precipitation from

2010-2099, as produced by Climate Wizard (TNC et al. 2009). Figure 11 illustrates predicted mean winter temperature where there has been and is expected to be greater changes.

Figure 9. Predicted annual temperature, 2010-2099.

The black line shows the yearly values of mean annual temperature. The blue line is the 5-year rolling average. The red line shows the trend or rate of change over the time period shown.



Map produced by ClimateWizard (c) University of Washington and The Nature Conservancy, 2009. Base climate projections downscaled by Maurer, et al. (2007). We acknowledge the modeling groups, the Program for Climate Model Diagnosis and Intercomparison (PCMDI) and the WCRP's Working Group on Coupled Modelling (WGCM) for their roles in making available the WCRP CMIP3 multi-model dataset. Support of this dataset is provided by the Office of Science, U.S. Department of Energy.

Figure 10. Predicted annual precipitation, 2010-2099.

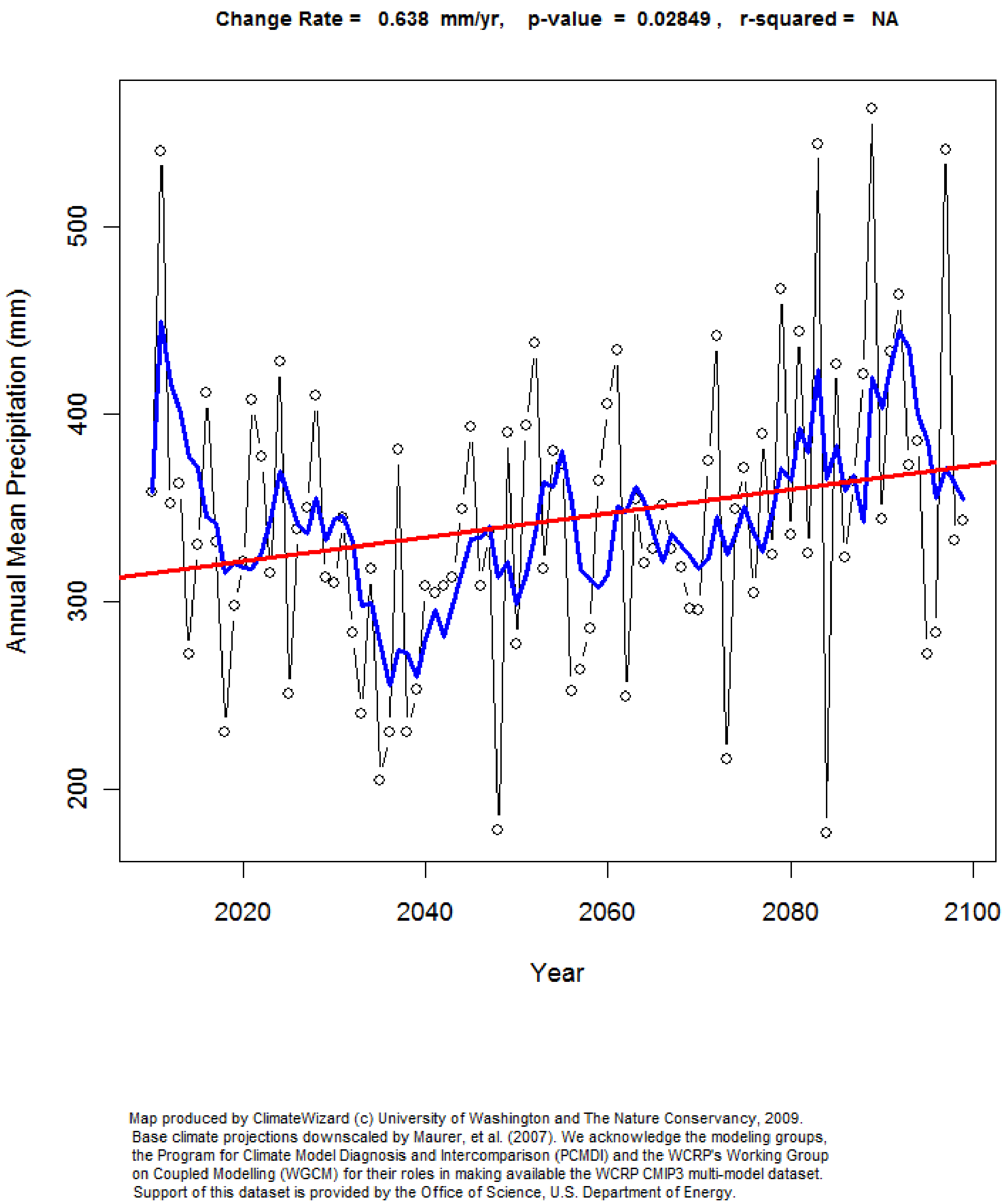
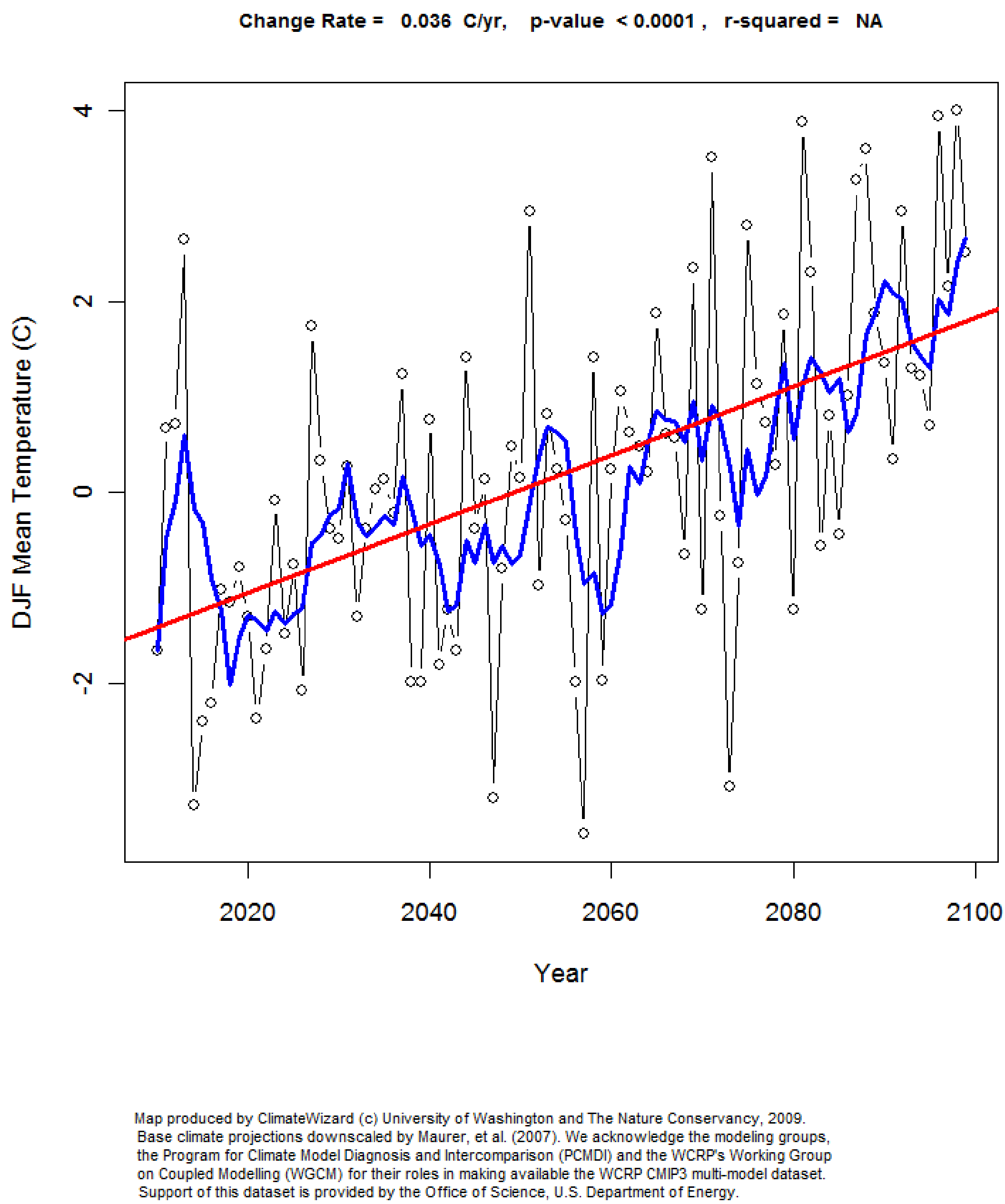


Figure 11. Predicted mean winter temperatures (Dec-Feb), 2010-2099.



Biological Environment

The 1994 Hart Mountain CMP and Sheldon draft CCP list a large number of species associated with the refuges. Mapping and analyzing all species would be prohibitive in terms of cost and time; therefore, a subset of the species resources was identified as priorities (Step 1 in Figure 1) for the RVA. Due to the ready availability of vegetation data layers, we were able to include all ecological systems as priority resources. For this assessment, resources were prioritized based on the following factors:

1. Legal/regulatory requirements derived from the regulatory and policy framework (see Appendix A)
2. Other policies and plans of the Service and partners (see Appendix A)
3. Species and biological community global imperilment status (G-Ranks) as established by NatureServe (indicated in Appendix E)
4. Refuge staff opinion
5. Stakeholder and partner opinion (from a workshop conducted November 2010)
6. Availability of data and expert knowledge sufficient for the analyses

After applying the above criteria, the list was further informed by the results of contextual analyses from the supporting landscape and ecoregional contexts (see the following section, Resources Contextual Assessment). The resulting set of priority resources includes a variety of habitats (or "ecological systems"), and plant and animal species. All resources were also assigned a priority rank from 1 to 3, with a score of 1 given to the highest priority resources for assessment. Priority ranks were assigned based on the importance of the resource to inform or support Refuge goals and policies. The list of priority biological resources and the rationale for their inclusion in the assessment is summarized in Appendix B. Refuge Complex infrastructure features that were identified as "mission critical" (MCI) by Refuge staff are also treated as priority resources and are addressed in the section "Social and Economic Environment" and summarized in Appendix C. It should be noted that not all the resources identified as priority resources in this assessment are current management priorities for the Refuges; this RVA takes a broader scope to inform the Refuges of potential resources of interest and to identify species that could become future management priorities.

Resources Contextual Assessment

Resource contextual assessments (Step 2 in Figure 1) utilized the supporting landscape and ecoregional contexts to analyze the proportion of each priority species and ecological system resource contained in the Refuge Complex relative to the ecoregion. The proportion of priority resources located in different land stewardship categories (e.g., agencies) and conservation status categories (GAP status) was also assessed. In considering the proportion of a biological resource found on the refuge relative to its total amount in the ecoregion, it is helpful to understand what proportion of the ecoregion is occupied by the two refuges and the supporting landscape as a whole (Table 1).

Table 1. Proportion of the ecoregion occupied by the refuges and the supporting landscape.

	Total Area (ha)	**Proportion of ecoregion occupied**
Sheldon Refuge	234,434	2.3 %
Hart Mountain Refuge	114,374	1.1 %
Supporting Landscape	2,291,623	22.4 %
Ecoregion	10,216,449	100.0 %

The purpose of the contextual assessment was to help identify resources that should or should not be considered for assessment. In particular, the contextual assessment identified resources that are not currently management priorities for the Refuge Complex, but are endemic to the refuges, uncommon on the Refuge Complex, or in poor condition outside of the Refuge Complex. For example, rose-flower desert parsley and Three Forks stickseed were not Refuge Complex priorities, but most of their entire known populations lie within the supporting landscape (Table 2). Crosby's buckwheat is limited to a small number of populations in Oregon and Nevada, and several are found in the area between the Refuges (Table 2). These were included in the assessment because the Refuge Complex or the surrounding landscape could serve as an important area for retaining those resources. Similarly, Table 3 illustrates the relative importance of the refuges for ecological system resources.

Table 2. Proportion of species resources located on refuges and in supporting landscape relative to total amount in ecoregion.

This table lists the number (#) of occurrences of each species resource in the ecoregion, the supporting landscape, and on each of the two refuges, as well as the proportion (%) of the resource occurring on each of the refuges, relative to the entire ecoregion.

Resource Group	Resource Name	Ecoregion (#)	Supporting Landscape (#)	Sheldon (#)	Sheldon (%)	Hart Mtn (#)	Hart Mtn (%)
Mammals	Long-eared Myotis†	30	20			2	6.67
Mammals	Long-legged Myotis†	19	14			2	10.53
Mammals	Preble's Shrew*	6		1	16.67		
Mammals	Pygmy Rabbit†	54				3	5.56
Mammals	Spotted Bat*	45	9	1	2.22		
Mammals	Western Small-footed Myotis†	25	11			1	4.00
Mammals	White-tailed Antelope Squirrel*	41	3	1	2.44		
Mammals	White-tailed Jackrabbit†	7	1			1	14.29
Birds	American White Pelican	5					
Birds	Blue-gray Gnatcatcher†	3	1			1	33.33
Birds	Golden Eagle	9					
Birds	Greater Sage-Grouse†	499				26	5.21
Birds	Greater Sandhill Crane†	71				2	2.82
Birds	Snowy Egret	24	18				
Birds	Western Burrowing Owl	42					
Birds	Western Yellow-billed Cuckoo	1					
Fishes	Alvord Chub*	16		5	31.25		
Fishes	Catlow Tui Chub†	6				1	16.67
Fishes	Lahontan Cutthroat Trout	44					

Resource Group	Resource Name	Ecoregion (#)	Supporting Landscape (#)	Sheldon (#)	Sheldon (%)	Hart Mtn (#)	Hart Mtn (%)
Fishes	Sheldon Tui Chub*	6		1	16.67		
Fishes	Warner Sucker	10	1				
Plants	Crosby's Buckwheat	68	21				
Plants	Doublet*	21		3	14.29		
Plants	Long-flowered Snowberry†	14				1	7.14
Plants	Nodding Melicgrass†	23	2			1	4.35
Plants	Playa Phacelia*	18		2	11.11		
Plants	Prostrate Buckwheat†	16				1	6.25
Plants	Rose-flower Desert-parsley*	11		9	81.82		
Plants	Seaside Heliotrope	21					
Plants	Three Forks Stickseed*	16		1	6.25		
Plants	Yellow Scorpionweed*	15	1	1	6.67		

*Proportion of the resource present on Sheldon relative to the ecoregion is greater than the proportion of the ecoregion area that is occupied by Sheldon Refuge land (see also Table 1).
†Proportion of the resource present on Hart Mountain relative to the ecoregion is greater than the proportion of the ecoregion area that is occupied by Hart Mountain Refuge land (see also Table 1).

Table 3. Proportion of ecological system resources located on refuges and in supporting landscape relative to total amount in ecoregion.

Resource Name	Sheldon	Hart Mtn	Supporting Landscape
Aspen Forest and Woodlands	1.09	0.01	31.88
Big Sagebrush Steppe	1.70	0.22	23.36
Cliff, Canyons, and Barren Lands*†	2.31	2.08	21.15
Deciduous Woodlands and Shrublands†	0.57	1.62	18.12
Emergent Marshes and Wet Meadows*	5.35	0.00	62.69
Juniper Savanna	0.00	0.01	0.15
Low Sagebrush Shrublands and Steppes	2.40	1.07	17.38
Montane Mesic Meadows	0.04	0.78	8.66
Montane Sagebrush Steppe*†	3.28	1.98	45.29
Mountain Mahogany Woodlands*	10.50	0.00	47.17
Playa†	0.47	3.37	34.56
Ponderosa Pine Woodlands	0.00	0.00	44.91
Salt Desert Scrubs and Greasewood Flats	2.21	0.39	22.24
Semi-Desert Grasslands and Steppes	1.32	1.19	20.66
Western Juniper Woodlands*†	3.28	1.24	19.25

*Proportion of the resource present on Sheldon relative to the ecoregion is greater than the proportion of the ecoregion area that is occupied by Sheldon Refuge land (see also Table 1).
†Proportion of the resource present on Hart Mountain relative to the ecoregion is greater than the proportion of the ecoregion area that is occupied by Hart Mountain Refuge land (see also Table 1).

Table 4 illustrates the importance of the Refuge Complex for conservation of existing known populations (referred to as "element occurrences" (EOs) by NatureServe and its member organizations in the Natural Heritage Network such as ORBIC) of priority species. Documented populations are assigned a viability or condition rank ranging from A (excellent) to D (poor) or E (extant but viability unknown) by Heritage Network staff when enough information is available (for a detailed explanation of element occurrence ranking, see Hammerson et al. 2008). While these numbers represent known populations and there may be unreported or unsurveyed populations in the supporting landscape, several species have a high percentage of their populations within Refuge boundaries.

Table 4. Element occurrence (EO) distribution proportions in the Refuge Complex vs. supporting landscape.

The number of populations (element occurrences) ranked from A to E and those without a rank are listed for each species followed by the total number of known populations in the supporting landscape (SL). These are then broken down by where they occur: on Sheldon Refuge, on Hart Mountain Refuge, or outside the refuges in the supporting landscape (SL). The definition of "population" varies depending on the species – see www.natureserve.org/explorer/ for detailed information. Pronghorn were tracked by habitat rather than population and so are not shown in this table.

Common Name	Scientific Name	A	B	C	D	E	No Rank	Total EOs	% on Sheldon	% on Hart Mtn	% on SL
American Pika	*Ochotona princeps*			1		4		5	80	20	0
Burrowing Owl	*Athene cunicularia hypugaea*						4	4	0	0	100
Catlow Tui Chub	*Gila bicolor* ssp. 2						4	4	0	25	75
Crosby's Buckwheat	*Eriogonum crosbyae*	4	3	1			5	13	0	0	100
Greater Sandhill Crane	*Grus canadensis tabida*						1	1	0	0	100
Grimy Ivesia	*Ivesia rhypara* var. *rhypara*	3	3	1		4		11	64	0	36
Lahontan Cutthroat Trout	*Oncorhynchus clarkii henshawi*						3	3	33	0	67
Long-Eared Myotis	*Myotis evotis*						100	100	0	4	96
Long-flowered Snowberry	*Symphoricarpos longiflorus*				1		2	3	0	66	34
Long-Legged Myotis	*Myotis volans*						5	5	0	0	100

Common Name	Scientific Name	A	B	C	D	E	No Rank	Total EOs	% on Sheldon	% on Hart Mtn	% on SL
Nodding Melicgrass	*Melica stricta*						6	6	0	17	83
Playa Phacelia	*Phacelia inundata*					2		2	0	0	100
Prostrate Buckwheat	*Eriogonum prociduum*	1		4			3	8	0	13	87
Pygmy Rabbit	*Brachylagus idahoensis*					11		11	0	9	91
Redband Trout - Catlow Valley	*Oncorhynchus mykiss* pop. 3						7	7	0	14	86
Redband Trout - Warner Valley	*Oncorhynchus mykiss* pop. 4					1	6	7	0	29	71
Rose-Flower Desert-Parsley	*Lomatium roseanum*	4					5	9	100	0	0
Sage Grouse*	*Centrocercus urophasianus*	2				105		107	0	24	76
Salt Heliotrope	*Heliotropium curassavicum*						5	5	0	0	100
Sheldon Tui Chub	*Gila bicolor eurysoma*			1		2		3	33	0	67
Three Forks Stickseed	*Hackelia ophiobia*						1	1	100	0	0
Warner Sucker	*Catostomus warnerensis*						10	10	0	30	70
Western Small-Footed Myotis	*Myotis ciliolabrum*						43	43	0	2	98
White-tailed Antelope Squirrel	*Ammospermophilus leucurus*						7	7	14	0	86
White-tailed Jackrabbit	*Lepus townsendii*						1	1	0	0	100
Yellow Scorpion-flower	*Phacelia lutea* var. *calva*					1		1	100	0	0
Grand Total		**14**	**6**	**8**	**1**	**130**	**218**	**377**			

*Sage grouse values in this table are for element occurrences only, which were provided for Hart Mountain Refuge. Data for sage grouse on Sheldon Refuge was provided as breeding range rather than lek sites and so do not appear in this table. Rather, Sage grouse nesting area, breeding range, and core habitat are addressed separately as community types further in the report.

The proportion of each resource throughout the surrounding ecoregion falling in different steward (ownership) categories and in protected status categories using the USGS Gap Analysis Program stewardship categories was also summarized (Table 5). The purpose is to identify any resources represented in the Refuge Complex that are not well represented in areas managed for biodiversity conservation (GAP status 1 and 2) and to identify which stewards contain large percentages of resource area or occurrences. Several species resources are not well represented on lands managed for biodiversity in the ecoregion, such as greater sage grouse, golden eagle, long-eared myotis, and western small-footed myotis. Similarly, many species are located on lands whose stewards may not have resource conservation as a primary goal. Where these species are present on the Refuge Complex (e.g., long-legged myotis, Catlow tui chub), it may be particularly important to try to retain them there. For species not present in significant quantities on the Refuge Complex but present in the supporting landscape (see also Table 2), such as long-eared myotis and Crosby's buckwheat, coordinating on their conservation with other land stewards in the supporting landscape may be indicated.

Table 5. Resource distribution in refuge and different land steward categories and by GAP stewardship (conservation) status.

The total number of occurrences of each resource is listed for the region, followed by the percentage in various ownership and GAP status categories relative to the ecoregion. Pronghorn were tracked by habitat rather than population and so are not included in this summary. Sage grouse values in this table are for element occurrences only, which were provided for Hart Mountain Refuge. Data for sage grouse on Sheldon Refuge was provided as breeding range rather than lek sites and so do not appear in this table. As a result, this summary does not fully reflect the distribution of sage grouse on the refuges relative to the ecoregion. Finally, resources that were initially considered (such as American White Pelican) but not spatially assessed are included in this summary.

Resource Name	Scientific Name	Region	Sheldon	Hart	Other FWS	BLM	State Lands	Tribal Lands	Private	GAP 1	GAP 2	GAP 3	GAP 4
Long-eared Myotis†	*Myotis evotis*	30		6.7		63.3			23.3	13.3	10.0	56.7	20.0
Long-legged Myotis†	*Myotis volans*	19		10.5		57.9			15.8	15.8	21.1	47.4	15.8
Preble's Shrew*	*Sorex preblei*	6	16.7		16.7	50.0			16.7	16.7	33.3	33.3	16.7
Pygmy Rabbit†	*Brachylagus idahoensis*	54		5.6	3.7	64.8			25.9	5.6	9.3	59.3	25.9
Spotted Bat*	*Euderma maculatum*	45	2.2			80.0			17.8	26.7	26.7	33.3	13.3
Western Small-footed Myotis†	*Myotis ciliolabrum*	25		4.0	4.0	60.0			32.0	16.0	12.0	40.0	32.0
White-tailed Antelope Squirrel*	*Ammospermoph ilus leucurus*	41	2.4		0.0	75.6	4.9		19.5		31.7	46.3	22.0

Resource Name	Scientific Name	Region	Sheldon	Hart	Other FWS	BLM	State Lands	Tribal Lands	Private	GAP 1	GAP 2	GAP 3	GAP 4
White-tailed Jackrabbit†	*Lepus townsendii*	7		14.3		71.4			14.3	14.3	28.6	42.9	14.3
American White Pelican	*Pelecanus erythrorhynchos*	5				20.0	40.0		60.0		20.0	20.0	60.0
Blue-gray Gnatcatcher†	*Polioptila caerulea*	3		33.3	33.3	33.3				66.7	33.3		
Golden Eagle	*Aquila chrysaetos*	9				66.7			33.3			66.7	33.3
Greater Sage-Grouse†	*Centrocercus urophasianus*	499		5.2		83.2	0.4	0.6	10.8	7.0	17.2	64.1	11.6
Greater Sandhill Crane†	*Grus canadensis tabida*	71		2.8	1.4	12.7	2.8		73.2	2.8	2.8	21.1	73.2
Snowy Egret	*Egretta thula*	24			8.3		8.3	4.2	83.3		12.5	4.2	83.3
Western Burrowing Owl	*Athene cunicularia hypugaea*	42				66.7		2.4	31.0		2.4	69.0	28.6
Western Yellow-billed Cuckoo	*Coccyzus americanus occidentalis*	1							100.0				100.0
Alvord Chub*	*Gila alvordensis*	16	31.3			25.0			43.8	18.8		37.5	43.8
Catlow Tui Chub†	*Gila bicolor* ssp. 2	6		16.7		16.7			66.7	33.3			66.7
Lahontan Cutthroat Trout	*Oncorhynchus clarkii henshawi*	44				47.7			11.4	6.8	13.6	68.2	11.4
Sheldon Tui Chub*	*Gila bicolor eurysoma*	6	16.7			50.0			33.3	16.7		50.0	33.3
Warner Sucker	*Catostomus warnerensis*	10				30.0			70.0	10.0		20.0	70.0
Crosby's Buckwheat	*Eriogonum crosbyae*	68				95.6			4.4		23.5	72.1	4.4

Resource Name	Scientific Name	Region	Sheldon	Hart	Other FWS	BLM	State Lands	Tribal Lands	Private	GAP 1	GAP 2	GAP 3	GAP 4
Doublet*	*Dimeresia howellii*	21	14.3			52.4			14.3	19.0		76.2	4.8
Long-flowered Snowberry†	*Symphoricarpos longiflorus*	14		7.1		85.7			7.1	14.3	35.7	42.9	7.1
Nodding Melicgrass†	*Melica stricta*	23		4.3		65.2			8.7	17.4	34.8	39.1	8.7
Playa Phacelia*	*Phacelia inundata*	18	11.1			16.7			72.2	11.1		16.7	72.2
Prostrate Buckwheat†	*Eriogonum prociduum*	16		6.3		93.8				6.3	25.0	68.8	
Rose-flower Desert-parsley*	*Lomatium roseanum*	11	81.8						18.2	81.8			18.2
Seaside Heliotrope	*Heliotropium curassavicum*	21				90.5			9.5	33.3		52.4	14.3
Three Forks Stickseed*	*Hackelia ophiobia*	16	6.3			75.0			18.8	62.5	6.3	18.8	12.5
Yellow Scorpionweed *	*Phacelia lutea* var. *calva*	15	6.7			93.3				6.7		93.3	

*Proportion of the resource present on Sheldon relative to the ecoregion is greater than the proportion of the ecoregion area that is occupied by Sheldon Refuge land (see also Table 1).

†Proportion of the resource present on Hart Mountain relative to the ecoregion is greater than the proportion of the ecoregion area that is occupied by Hart Mountain Refuge land (see also Table 1).

Existing Vegetation

Ecological systems are landscape-level vegetation types and are priority refuge resources. The ecological systems present within the project area are shown in Figure 12. This map was created by combining vegetation maps recently completed for the Refuges (rectangular areas) with USGS GAP vegetation data in the supporting landscape. The vegetation types mapped for the Refuge Complex by Tagestad (Tagestad 2010a and 2010b) served to guide the priority habitat resources for this assessment; they are included in the resources checklist in Appendix B. These vegetation resources were cross-walked to NatureServe ecological systems for use in the spatial vulnerability assessment (Vista project).

The Refuge vegetation data served as the primary source of information on the current distribution of ecological systems because they were recently completed and were mapped at a finer scale. The different scales of the vegetation mapping on and off of the refuges has little impact on the analysis, however, and is mainly noticable only when looking at the entire project area; the differences between the two mapping methods become less noticable when looking at smaller extents. When looking at edges of the refuges and the two maps, the differences are primarily related to the minimum mapping units shown.

Ecological systems occur in a range of successional states and conditions. To account for the successional states and ecological condition of the systems in the project area, two additional sets of spatial vegetation data were used in this assessment. The first is a Potential Vegetation Type (PVT) map, often called Potential Natural Vegetation Type (PNVT), which indicates the natural vegetative conditions that can potentially be supported in each part of the landscape absent disturbance (Figure 13). The other vegetation data is the current distribution of cheatgrass, native grasses, and shrubs (Figure 14). These map layers are extracted from a geodatabase containing detailed vegetation information attributed to 30-meter pixels. The vegetation data were modeled using Gradient Nearest Neighbor (GNN) methodology (Ohmann and Gregory 2002) and the network of permanent vegetation plots across the country maintained by the US Forest Service under the Forest Inventory and Analysis National Program. The GNN geodatabase includes map layers of all of the dominant trees, shrubs, grasses and important weeds occurring at the site, which can be used to assess current ecosystem conditions at any given location within the project area. These two datasets were used to indicate the current condition or ecological integrity of the priority ecological system resources identified for the Refuge Complex.

Figure 12. Ecological systems in the Sheldon-Hart Mountain National Wildlife Refuge Complex area.

Two sources were used: vegetation maps recently completed for the refuges, and vegetation maps created for the USGS Gap Analysis Project. The blockiness of the image is a result of the finer scale of the vegetation mapping recently completed for the Refuges; this difference in scale had little impact on the analysis.

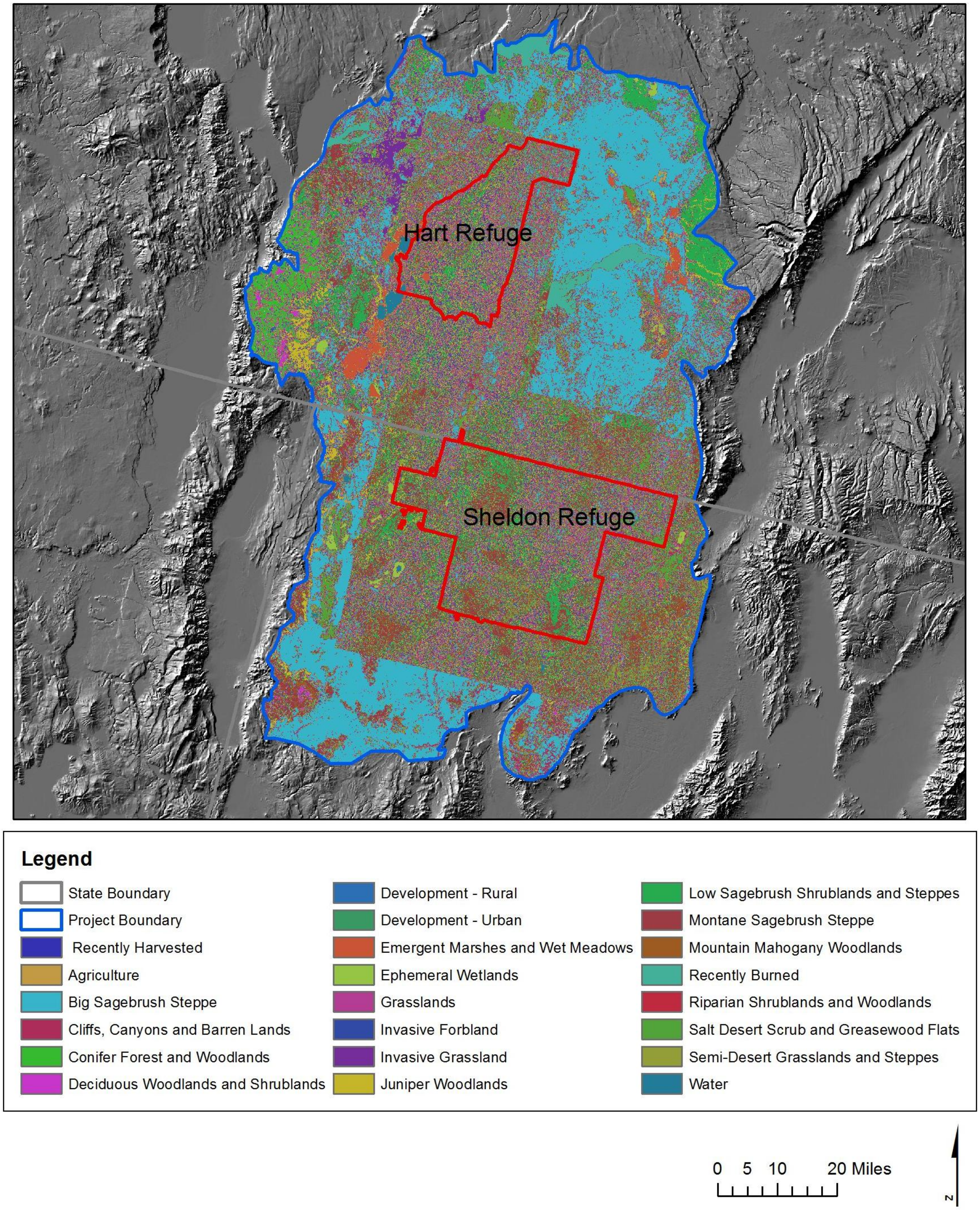


Figure 13. Potential vegetation types (PVTs) for the Sheldon-Hart Mountain National Wildlife Refuge Complex area.

PVTs characterize the stable vegetation type that would be present at a given location under current conditions in the absence of disturbance.

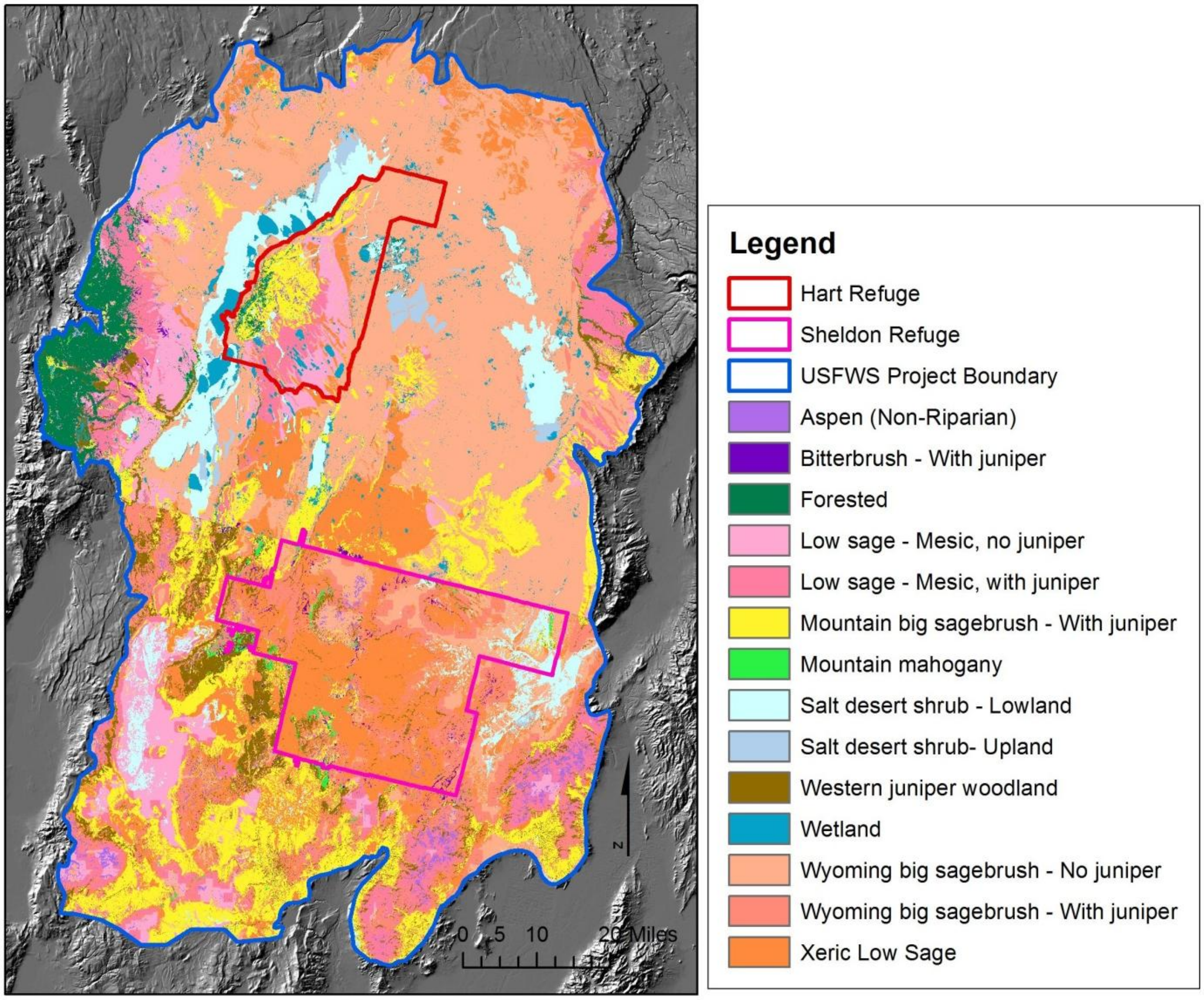
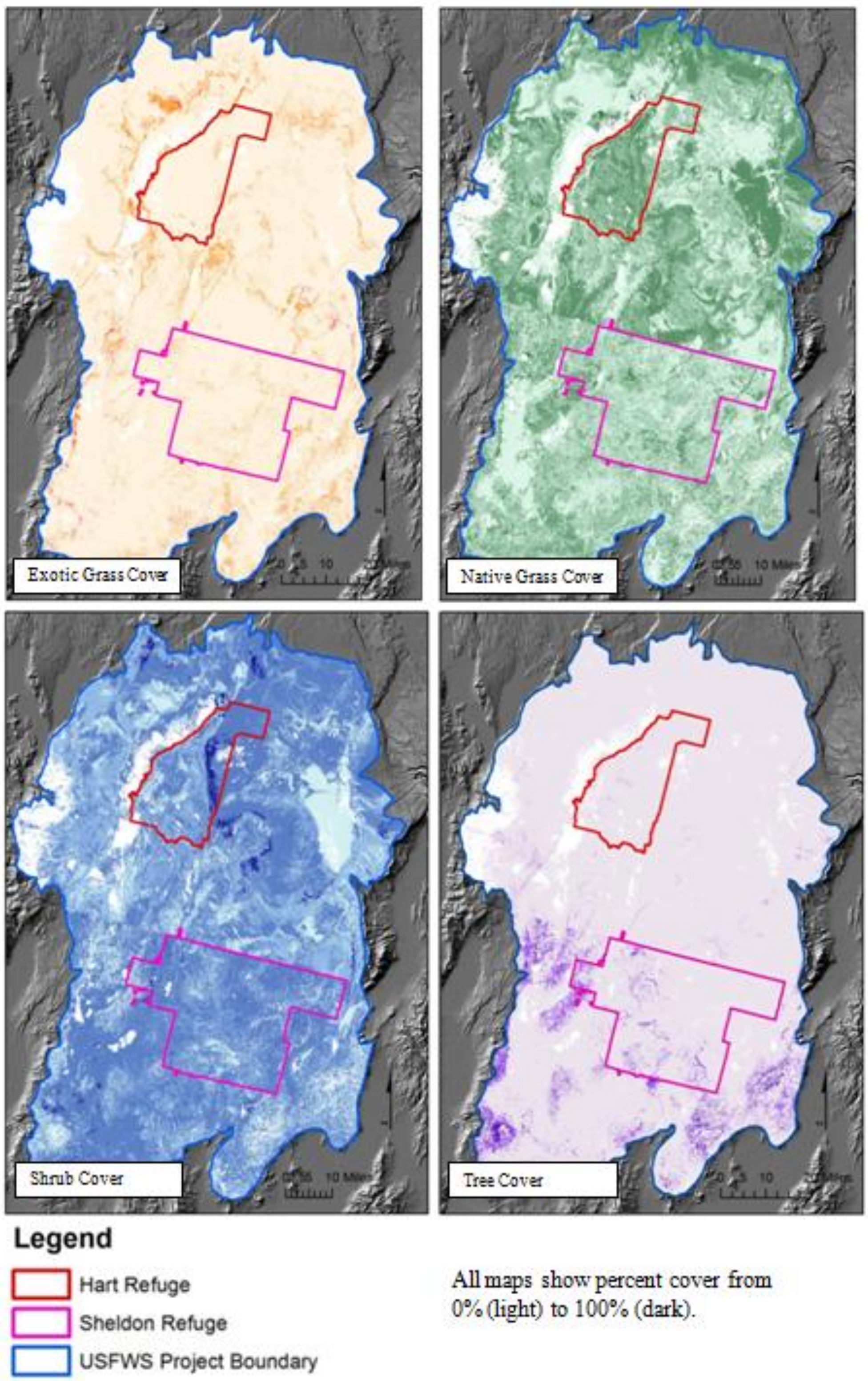


Figure 14. GNN modeling results showing percent cover classes of exotic grasses (top left), native grasses (top right), shrubs (bottom left), and trees (bottom right) for the initial conditions of the 2010 Baseline scenario.

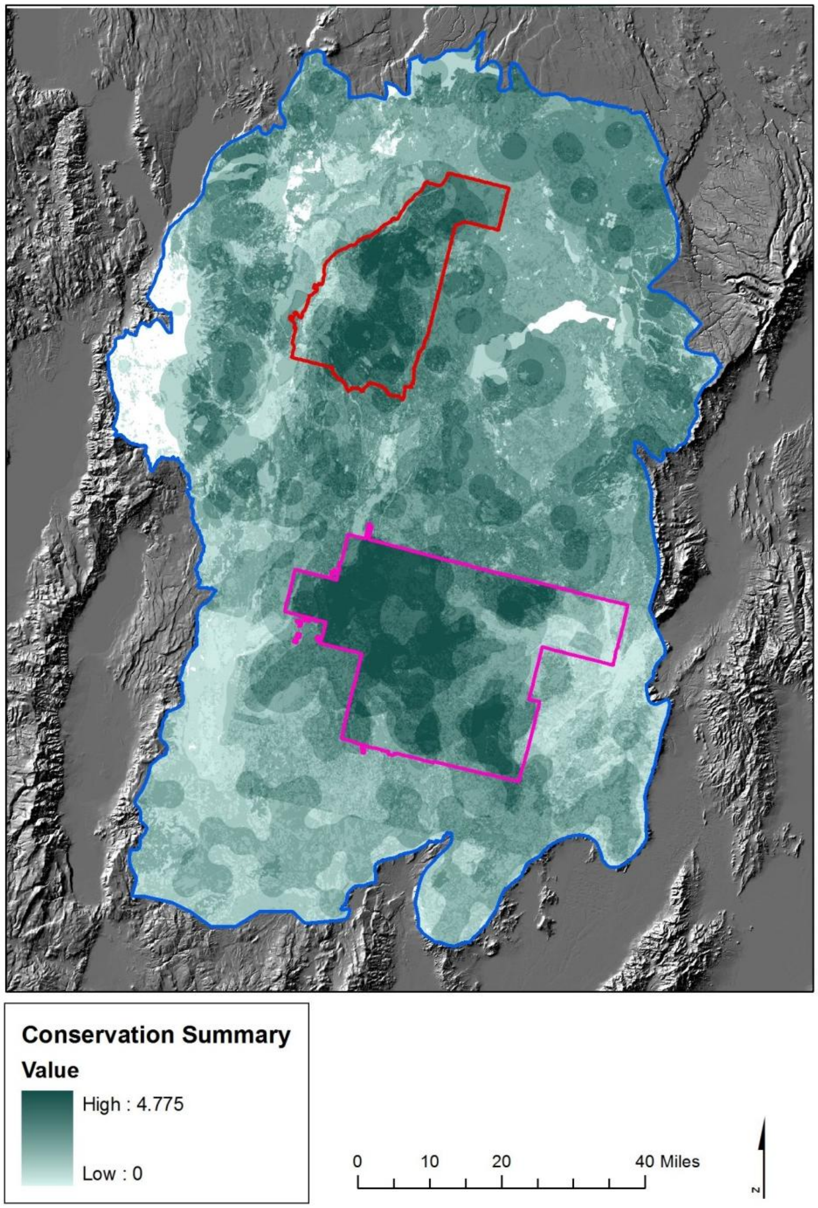


Current Condition of Biological Resources

In preparation for the spatial vulnerability assessment (using the Vista modeling tool), information on the spatial distribution and condition of priority biological resources was compiled and summarized. Known distributions of priority biological resources, including species and habitats, were obtained from the databases of the Oregon Biodiversity Information Center, NatureServe, and Nevada Natural Heritage Program rare species databases, as well as from Sheldon Refuge and Hart Mountain Refuge. Recent records (documented since 1990) known to be extant and having precise locations were incorporated into the Vista project database. The confidence in the distribution and condition of these populations is documented in the Vista database and in Appendix E. Using these data, the current distribution and the combination of condition and confidence were summarized in an Element Conservation Value (ECV) raster layer for each priority resource. Using the resource ECVs, we generated a Conservation Value Summary (CVS) characterizing the current distribution and condition of priority resources throughout the supporting landscape (Figure 15)[2]. Not surprisingly, the Refuge Complex had the highest concentration of high conservation value areas, in part because biological resources are better documented on the refuges, but also because there is a greater concentration of resources present on the Refuge Complex than in the supporting landscape. Sage grouse leks, nesting, and breeding habitats in particular scored highly and contribute to the areas with higher conservation values (shown in darker colors). The lightest areas represent a lack of priority resources.

[2] The CVS is a raster layer that sums the scores for each resource's confidence of distribution, priority weighting, and current condition. A given pixel may have more than one species or habitat resource located in it; the CVS contains the aggregate score for each pixel that is a sum of the resource scores for each individual resource associated with that pixel.

Figure 15. Conservation value summary for all priority biological and infrastructure resources within the Sheldon-Hart Mountain National Wildlife Refuge Complex project area.



Social and Economic Environment

Infrastructure of Management Importance

The vulnerability assessment also addresses the impacts of management and stressors on mission-critical infrastructure (MCI). The refuges' infrastructure is listed in Appendix C. The list also indicates whether the infrastructure feature is a retention target and therefore will be managed for its maintenance as MCI, and whether it is also a stressor on other resources. All MCI were treated as resources and assigned the top priority level as critical resources for the Refuges. Treatment of infrastructure in the RVA can be complex; while MCI is clear, it is more complicated to assess non-mission-critical infrastructure that is either 1) on the Refuge Complex (or future acquisition lands) but the refuge is not responsible for maintaining it or protecting it from natural disturbance, or 2) outside the Refuge Complex but the Refuge Complex has a dependency upon it.

For the entire Refuge Complex, the main infrastructure features of assessment interest are roads, pipelines, boundary fences, and transmission lines. Fine-scale features (signage, kiosks) could not practically be addressed in this study and were not included. One cultural feature, the Last Chance Ranch (a historic homestead), was included by refuge staff as MCI.

Chapter 3. Vulnerability Assessment

Assessment Overview

The intent of this RVA was to assess the cumulative impacts of stressors on priority resources over multiple time frames, with a particular emphasis on climate change. In addition to climate change, critical stressors in this landscape include grazing, non-native annual grasses, roads, energy development and other utilities, and refuge infrastructure (buildings, campgrounds, and day use areas). The results of these assessments can inform the development of mitigation and adaptation strategies to address those impacts. The nature of the data and modeling tools available to evaluate the various stressors at the scale of the assessment area at various points in time necessitated two sets of assessments. One set of assessments focused on the subset of stressors that are readily characterized in a spatially explicit manner at the scale of the project area, using one modeling tool. All priority resources were addressed in the spatially explicit assessments. The second set of assessments focused solely on vegetation resources, and on the subset of stressors that are not readily modeled in a spatially explicit manner at the scale of the project area, using other modeling tools. These tools permit an in-depth assessment of how vegetation resources may change in response to biotic and abiotic processes, including grazing and climate change. A general list of the data sets used in these two sets of assessments is provided in Appendix F.

Description of Assessment Types

Spatial Cumulative Impacts Assessment

Stressors that are readily characterized in a spatially explicit manner – that is, stressors that can easily be mapped – were assessed using NatureServe Vista. Vista permits the assessment of the cumulative impacts of spatially explicit stressors. These stressors include physical features such as roads, utilities, energy infrastructure, and other types of development, as well as other mapped land cover types or features such as agriculture and recently burned land. Land management policies, such as livestock grazing or absence of control of invasive species, can stress biological resources; land ownership boundaries provide an estimate of the spatial extent of grazing or other stressors associated with management activities. The cumulative impacts of these stressors on *all* priority resources were evaluated for the current (2010) land management policies and stressors for the Refuges and supporting landscape, as well as for a pair of future (2025) scenarios characterized by a combination of revised management policies based on a refuge management alternative identified in the draft Sheldon Refuge CCP, and stressors expected to be present at that time. The results for this set of assessments show the amount of identified priority resources that will be retained under the different management and stressor scenarios, as well as their relative condition.

Non-Spatial Vegetation Resources Assessments

Other stressors are not readily mapped and/or the tools for modeling their impacts are not spatially explicit at the scale of the project area. Stressors in this category include the ecological processes (operating outside of their natural range of variation) of climate change and fire. Although grazing was assessed spatially, it has complex interactions with climate and fire (McKenzie et al. 2004, Chambers

2008). Therefore, we wanted to assess these process-related stressors using tools that can account for all of these stressors. A *subset* of priority resources – vegetation community resources – were assessed using these tools. Impacts of grazing and climate change on vegetation resources were modeled using two sets of tools: 1) the Vegetation Dynamics Development Tool (VDDT), and 2) climate models (MIROC, CSIRO models linked to OSU's MC1 dynamic global vegetation model linked to VDDT). VDDT was used to model the impacts of grazing management on vegetation resources **without** taking climate change into account, and the climate models were used to model the impacts of climate change on vegetation with grazing management. In addition to explicitly assessing the impacts of grazing management policies with and without climate change, both tools take into account the effects of fire and disease on vegetation as well. The results of these assessments show the type and degree of changes in vegetation resources with and without climate change.

Assessment Time Frames

Refuge managers identified four points in time for which assessments of vulnerability were needed: the present (2010), 2025, 2060, and 2100. The modeling tools and available data determined what stressors could be assessed under particular time frames. The spatial assessments were limited to set points in time at 2010 and 2025, while the non-spatial assessments produced continuous results from 2000 to 2100, which could be used to characterize refuge vulnerability for the 2025, 2060, and 2100 points in time.

Spatial Cumulative Impacts Assessment

Spatially explicit projected locations of utilities, roads, agricultural land uses, and other infrastructure or development-related stressors are generally not readily available nor meaningfully assessed for time points in the more distant future. In addition, Vista is designed to model stressors at single points in time, rather than continuously over a period of time. Therefore, those stressors were modeled at the current (2010) point in time and in 2025 – time points that are meaningful from a management perspective – but not further into the future.

Non-Spatial Vegetation Resources Assessments

VDDT and the climate models generate a continuous set of results for a period of time; in this particular assessment, the models were run from 2000 to 2100. Using this set of continuous results, grazing and climate change impacts on vegetation resources can be described for any time point of interest within that 100-year time horizon. In this assessment, 2025, 2060 and 2100 were identified as the future time points of interest and the results were summarized accordingly.

Assessment Scenarios

Both sets of assessments were conducted using a conceptually consistent management scenario, the Revised Refuge Management scenario. (The spatially explicit assessments also evaluated two other scenarios.) However, the design of the climate models required that the scenario be generalized to a watershed scale.

Spatial Cumulative Impacts Assessment

For the spatially explicit cumulative effects assessment, three scenarios were defined and assessed: a baseline (2010) scenario that assumes current management policies and stressors, and two future

(2025) scenarios. The 2025 Road Closures Scenario assumes current management on the Refuge and the supporting landscape, other than some refuge roads are closed on Sheldon Refuge; it also includes additional stressors in the form of a proposed energy infrastructure project. The 2025 Revised Refuge Management scenario assumes some management policies consistent with management Alternative 2, as identified in the draft Sheldon Refuge CCP, as well as the proposed energy infrastructure project (Table 6). For the purpose of this RVA, management consistent with Alternative 2 was assumed to include the following:

- Removal of horses and burros from Sheldon Refuge and continuation of horse and burro exclusion on Hart Mountain Refuge
- Some road closures on Sheldon Refuge

Table 6. Scenarios used to model cumulative impacts of spatially explicit stressors.

This table summarizes the scenarios that were assessed using Vista; these scenario assessments cumulatively addressed spatially explicit stressors. All priority refuge resources listed as having spatial assessments in Appendix B (Assessment Type column) were assessed.

Time Point	Scenario Name	Scenario Summary
2010	2010 Baseline	**Management:** Current management policies on Refuges and supporting landscape (no livestock grazing and focus on habitat protection and management on Refuge lands; livestock grazing in supporting landscape) **Other stressors** (not resulting from management policies): Non-native annual grasses, recently burned lands, agricultural uses, off-refuge infrastructure and development
2025	2025 Road Closures	**Management**: Current (2010) management on supporting landscape (same grazing levels), current (2010) management on Refuges other than some roads closed on Sheldon Refuge **Other stressors** (not resulting from management policies): Those stressors present in 2010, plus energy infrastructure projected for 2025, increased non-native annual grass cover
2025	2025 Revised Refuge Management	**Management**: Current (2010) management on supporting landscape (same grazing levels); and some management options identified in the draft Sheldon CCP on Refuge lands: 1) removal of horses/burros and 2) some roads closed on Sheldon Refuge **Other stressors** (not resulting from management policies): Those stressors present in 2010, plus energy infrastructure projected for 2025, increased non-native annual grass cover

Non-Spatial Vegetation Resources Assessments

The management assumptions of the 2025 Revised Refuge Management were used for the non-spatial stressors assessment as well, but without reference to a particular time frame. The VDDT and climate assessments modeled changes in vegetation assuming management practices that are broadly consistent with the 2025 Revised Refuge Management scenario described above (i.e., removal of grazing). Table 7 summarizes the management and stressor scenario as it was assessed using VDDT.

While VDDT model outputs are non-spatial, results can be tied to ownership/management allocations within watersheds, so the outputs could be filtered to show results for Refuge lands within a watershed (or other ownership/management allocations within a watershed).

Table 7. Scenario (management assumptions) used to model changes in vegetation resources *without* climate change.

This scenario was assessed using VDDT. It is comparable to the Revised Refuge Management scenario assessed in Vista, except the VDDT Revised Refuge Management scenario included juniper control. Juniper control was included because it is a priority objective for the Refuges and VDDT has the ability to model the impact of juniper treatment on vegetation resources. Fire suppression was assumed to occur across the entire assessment area for both the VDDT and the climate models.

Scenario Name	Scenario Summary	Relationship to Other Models' Scenarios
Revised Refuge Management	**Management:** Grazing does not occur on the Refuge Complex, but does occur across the rest of the assessment area **Restoration**: Juniper controlled on the Refuge Complex, but is not controlled across the rest of the assessment area	Management generally the same as in the **Revised Refuge Management** scenarios in Vista and climate modeling, where grazing is removed from the Refuge Complex, but still occurs off-Refuge; and with the addition of juniper control on Refuge lands

The climate models are designed to run using watersheds as the analysis units, which precludes fine-scale distinctions in land management policies between Refuge and non-Refuge lands; therefore, management policies were generalized to entire watersheds for the climate assessments. The grazing management and other assumptions are described with each set of climate results.

As noted previously, in contrast to the spatial scenarios which assessed all priority resources, the non-spatial assessments only addressed vegetation resources and their response to combinations of select stressors (grazing, juniper invasion, and climate change).

Table 8. Scenario (management assumptions) used to model changes in vegetation resources as a result of climate change.

These assessments were all conducted using the climate models (linked to MC1 and then to VDDT). These scenarios were assessed for watersheds where juniper is not an issue; therefore, it wasn't necessarily to specify juniper control in setting up the model. Fire suppression was assumed to occur across the entire assessment area for both the VDDT and the climate models.

Spatial Cumulative Impacts Assessment

Overview

For the spatial cumulative impacts assessment, the assessment team characterized the management and policy framework, the biological and infrastructure resources, and the current and expected stressors affecting the resources both on and off refuge lands within the supporting landscape for 2010 baseline conditions and for predicted land use and management in 2025. Based on the current and projected land management and stressors, the team developed three scenarios for the supporting landscape under which stressor impacts on resources were analyzed using the NatureServe Vista software in ArcMap. The scenarios assessed within Vista were the 2010 Baseline, 2025 Road Closures, and 2025 Revised Refuge Management. Details on the methods used for the Vista modeling are found at the end of this Spatial Cumulative Impacts Assessment section.

Stressors to Resources and Infrastructure

Stressors addressed in the cumulative effects assessment include land use, infrastructure, management practices, and natural or human-induced disturbances that were spatially explicit. Stressors were included and assessed in this study when they could be mapped, modeled, or discussed as present or forecast on the refuges and when sufficient subject matter expertise was accessible to determine resource/infrastructure response to the stressors. As previously noted, infrastructure can be treated both as a resource if it is considered "mission critical" *and* as a stressor on other resources, as is the case for the Refuge boundary fences and headquarters. The list of stressors is shown in Table 9, and greater detail on the stressor selection process is found in Appendix D. While some water resources were assessed in the RVA, a more extensive (though non-spatial) treatment of water resources and climate change implications on the Sheldon Refuge was conducted by Wurster (2009). Protected areas are intended to have a positive impact on biological resources; it is grouped into the list of stressors below as one of the inputs used to define the scenarios.

Table 9. List of stressors included in the spatial scenarios assessed in Vista.

- Mechanical and Herbicide Treatments
- Seeding/Planting
- Protected Areas
- Species Management
- Federal Land Grazing
- State Land Grazing
- Private Land Grazing
- Irrigated Cropland
- Wind Energy Development
- Solar Energy Development
- Geothermal Energy Development
- Mining
- Day Use Areas including Fishing
- Campgrounds

- Wild Horses and Burros
- Invasive Annual Grasses Low (<12% cover cheatgrass or medusahead)
- Invasive Annual Grasses Mid (12-20% cover cheatgrass or medusahead)
- Invasive Annual Grasses High (>20% cover cheatgrass or medusahead)
- Paved Roads
- Unpaved Roads
- Communications Towers
- Overhead Utility Lines
- Buried Utility Lines
- Inholdings Development
- Housing, Structures
- Water Diversion and Alteration
- Recently Burned
- Water

Characterizing stressors spatially was accomplished in two ways: First, several stressors were mapped using a variety of publicly available data sets (such as roads from 2010 census data, and renewable energy infrastructure from the National Renewable Energy Laboratory). For stressors relating to management practices, a land use type designation was applied based on assumptions about the ownership/designation of the land. Because a cumulative effects assessment model was used, multiple stressors could act on a single pixel. For example, an area of land could be grazed by livestock, have a road running through it, and have an overhead power line. All coincident stressors were therefore applied when assessing the impact to resources present on that parcel of land.

Table 10. Default land use types used for the 2010 and 2025 scenarios analyzed in Vista, based on ownership and designation.

Owner	Designation	Default Land Type
County Government	Not Defined	State Land Grazing
Federal Government	High Rock Canyon ACEC	Protected Areas
Federal Government	BLM Holding	Federal Land Grazing
Federal Government	Instant Study Area	Federal Land Grazing
Federal Government	National Conservation Area	Federal Land Grazing
Federal Government	National Forest	Federal Land Grazing
Federal Government	National Wildlife Refuge	Protected Areas
Federal Government	Other BLM	Federal Land Grazing
Federal Government	Wild and Scenic Area	Federal Land Grazing
Federal Government	Wilderness Area	Federal Land Grazing
Federal Government	Wilderness Study Area	Federal Land Grazing

Owner	Designation	Default Land Type
Federal Government	Not Defined	Federal Land Grazing
Federal Government	Other	Federal Land Grazing
Private	Inholding	Private Land Grazing
Private	Not Defined	Private Land Grazing
Private	Private Land	Private Land Grazing
State Government	Not Defined	State Land Grazing
Tribal Government	Native American Reservation	Private Land Grazing

Spatial Scenario Descriptions

2010 Baseline Scenario

The 2010 Baseline Scenario incorporated current land use and management practices within the project area. Several data sets and information sources were used to characterize the baseline scenario (Figure 16), including Refuge spatial data and management practices, BLM management areas, wetlands data, agricultural areas, roads layers, invasive annual grasses distribution, and others. The major stressors in the baseline scenario are grazing (both by livestock and by wild burros and horses), invasive annual grasses, and infrastructure (roads, power lines, pipelines, campgrounds, etc). More detailed maps showing where specific stressors are occurring on the landscape in these scenarios at the individual refuges can be found in Appendix G.

Figure 16. 2010 Baseline Scenario for the Sheldon-Hart Mountain National Wildlife Refuge Complex and supporting landscape.

Wild horses and burros are found on Sheldon Refuge and areas of the supporting landscape (orange) but are excluded from the Hart Mountain Refuge (blue). The red box indicates the inset area shown in Figure 17.

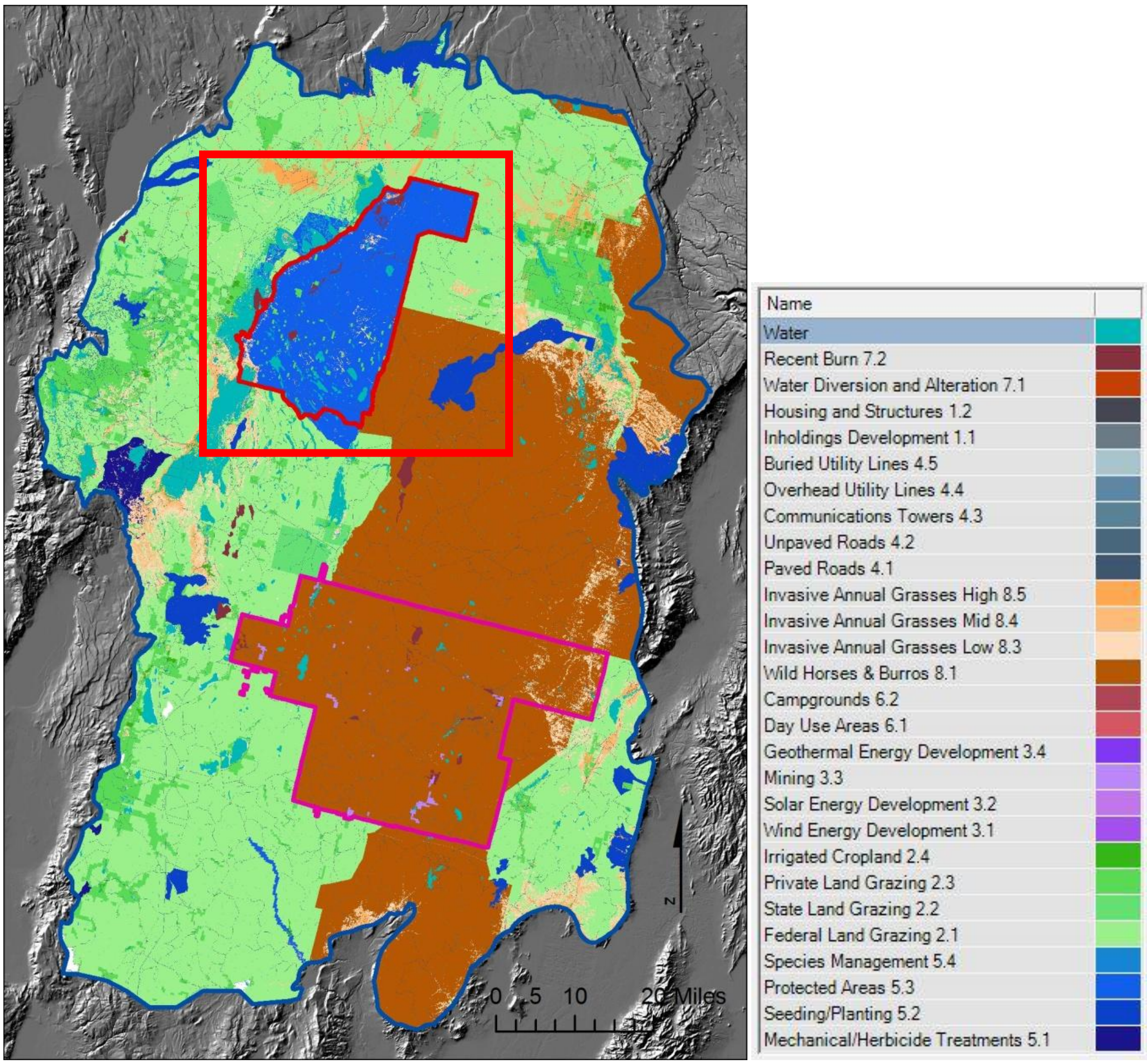
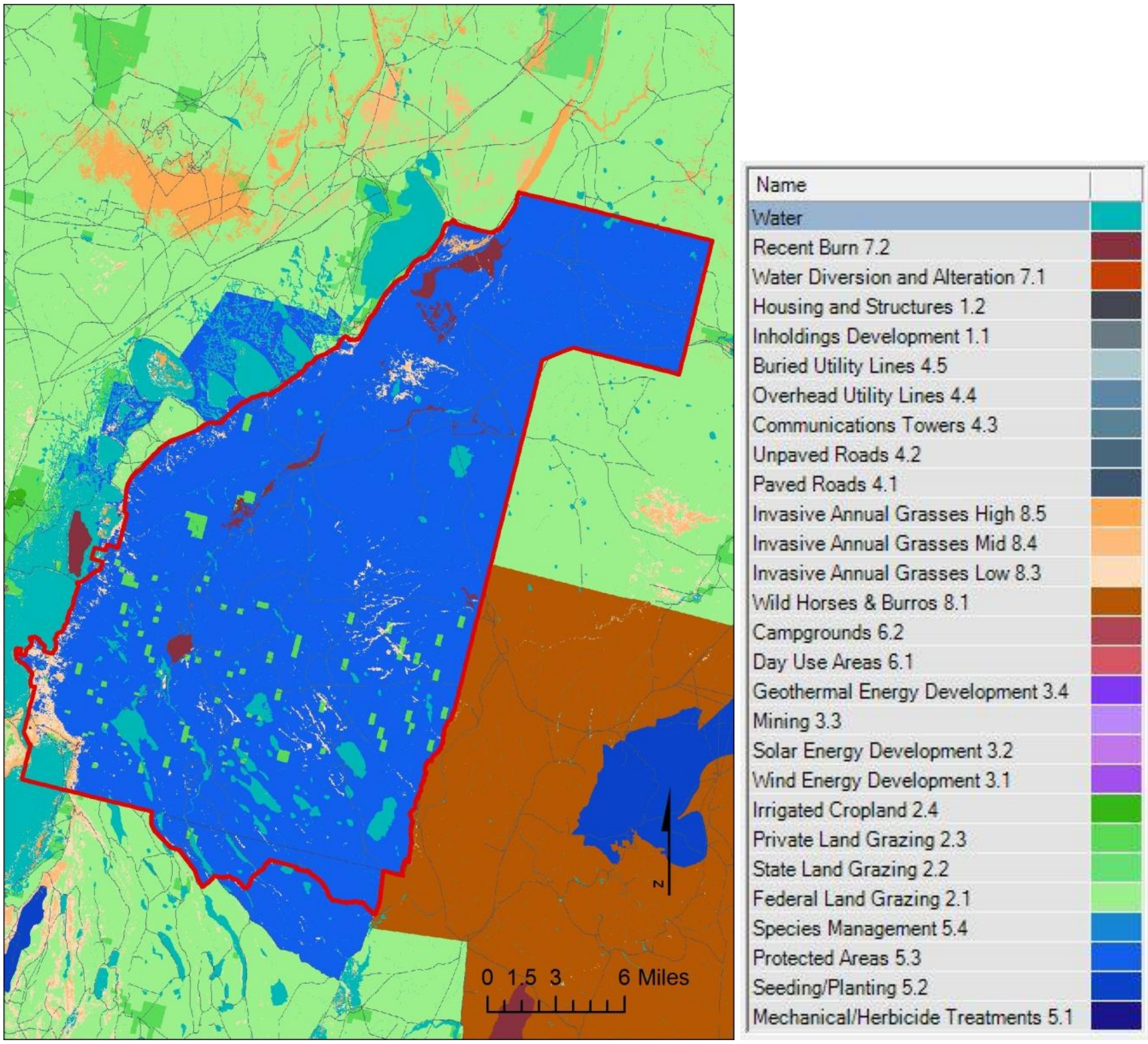


Figure 17. Close-up of land uses at Hart Mountain Refuge under the 2010 Baseline Scenario.

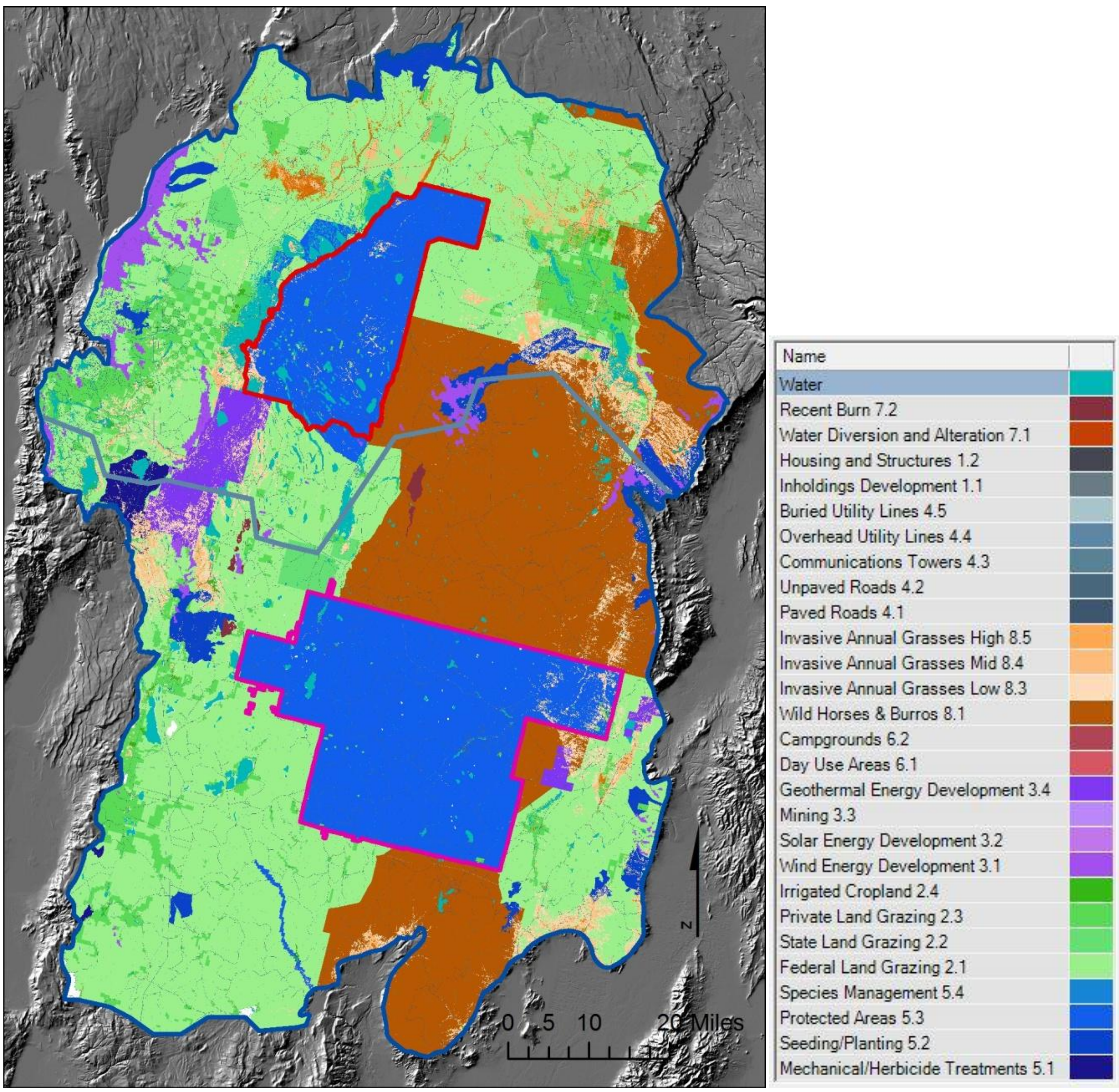


As illustrated in Figure 17, many stressors are concurrent on the landscape. The main stressors present at Hart Mountain Refuge under the baseline scenario are roads (gray lines), invasive annual grasses (cheatgrass and medusahead, shown in the cream/pale orange colors), and recent burns (brown areas). The major stressors in the supporting landscape are grazing (greens) and the presence of wild horses and burros (dark orange/terra cotta). Inholdings within the Refuge were coded as Private Grazing, which is a localized effect and has minimal impact to Refuge resources. The blue area within the Refuge boundary represents protected area management and is assumed to be beneficial for all resources. The dark blue polygon within the horse and burro herd area in the lower right of the figure is a BLM seeding and replanting area, also assumed to be beneficial: although the BLM does use some non-native seed for rehabilitation, current policy is to incorporate a greater percentage of native shrubs and grasses. In many cases, these BLM restoration areas are treated for weeds or fenced to protect establishing vegetation.

2025 Scenarios

The 2025 scenarios build on the baseline scenario with some modifications, additions, and exclusions. For the 2025 Revised Refuge Management scenario, we assumed some management policies consistent with a management alternative identified in the draft Sheldon CCP to modify land use within the Refuge Complex: this consisted of removing some roads from Sheldon Refuge and removing horses and burros from Sheldon Refuge (Figure 18). Thus livestock, horse, and burro grazing was completely excluded from the Refuge Complex in this scenario. The supporting landscape incorporated new energy development including accepted geothermal leases, predicted wind power development, and the building of the West-Wide Energy Corridor (US DOE 2011). The 2025 Road Closures scenario is exactly the same except that horses/burros were assumed to still be present on Sheldon Refuge.

Figure 18. Land use in the 2025 Revised Refuge Management Scenario.

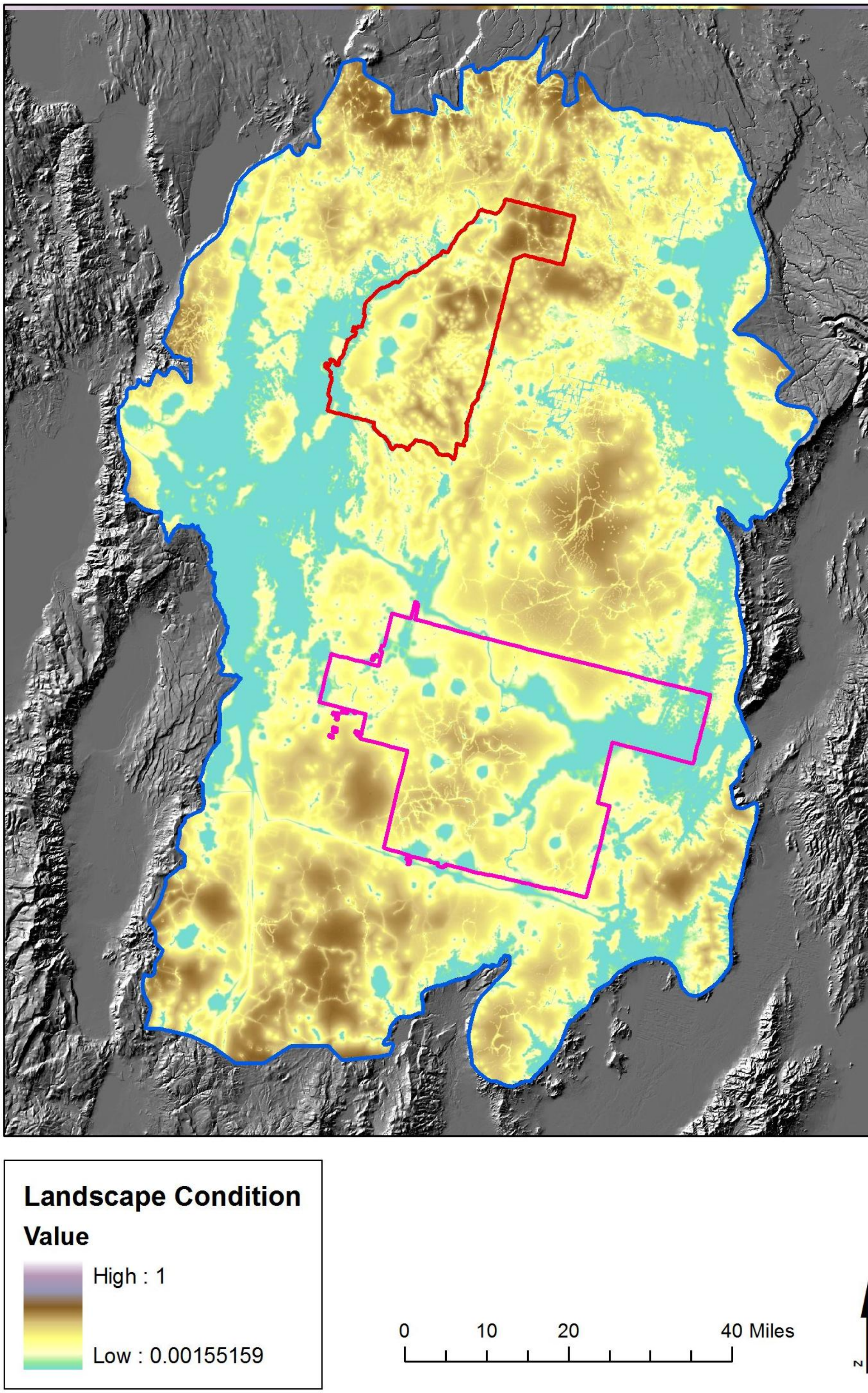


Overall Impacts: Landscape Condition

2010 Baseline Scenario

The cumulative impact of stressors currently present within the project area are shown in the landscape condition model output in Figure 19. Areas of light blue represent lands that are heavily impacted by cumulative stressors. Campgrounds on the refuges have a heavily impacted condition score due to the cumulative effects of the structures, day use activities, and roads associated with campgrounds. The west central part of the project area is impacted by roads, agriculture, power lines, structures, grazing, and non-native grasses. The blue area in the northeast section of Sheldon Refuge is impacted by roads, non-native grasses, power lines, and mining. While much of Sheldon Refuge has been closed to mining through Public Land Order 7761 of April 2011 (a renewal of PLO 6849 initially signed in 1991), there are 65,000 acres open to mining on the Refuge. 20,000 to 30,000 acres have active mining occurring within Virgin Valley in the northeast section of the Refuge. While the acreage is relatively small compared to the rest of the Refuge, the impacts can be significant, as reflected in the decreased landscape integrity values. In addition to direct environmental effects, mining areas lead to compounded stresses due to their associated campgrounds, roads, and day use areas. Because the landscape condition model for the 2025 Road Closures Scenario is nearly indistinguishable from the 2010 Baseline Scenario, that model is not presented here.

Figure 19. Landscape condition model for the 2010 Baseline scenario.

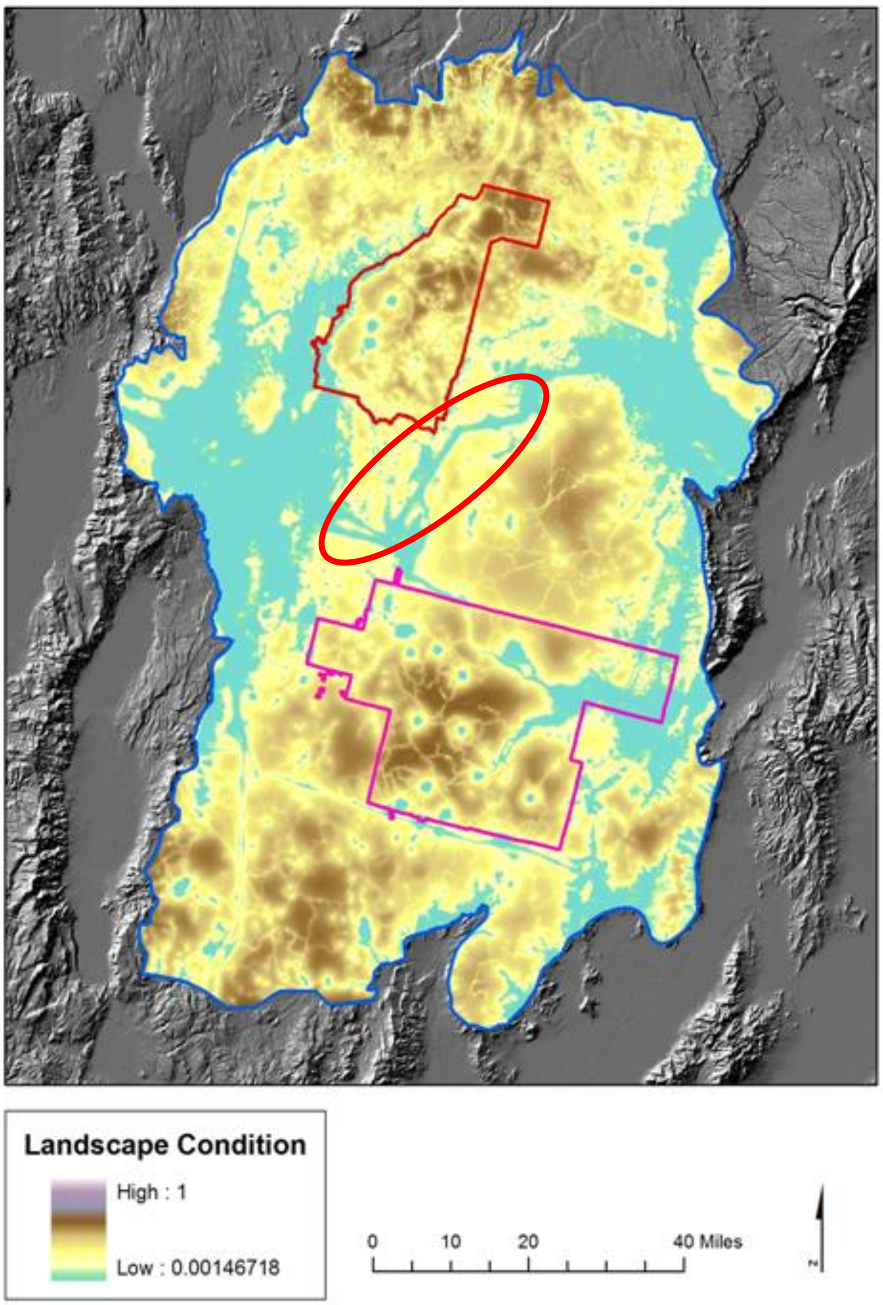


2025 Revised Refuge Management Scenario

Figure 20 shows the landscape condition model output for the 2025 Scenario. Predicted geothermal and wind energy development and the construction of the West-Wide Energy Corridor are major contributors to the areas of decreased landscape condition on this map. The landscape condition of Sheldon Refuge has improved (increased landscape condition value) in this scenario due to the removal of horses and burros.

Figure 20. Landscape condition model for the 2025 Revised Refuge Management Scenario.

The area in the red oval indicates the reduced landscape condition due to the proposed transmission corridor.



Management Implications

The landscape condition models serve to illustrate relative concentrations of stressors on the landscape. These models can be used in planning conservation activities in conjunction with known species locations or priority habitat areas by either: 1) targeting areas with high landscape condition for conservation and prevention of additional stressors to these relatively unimpacted areas; or 2) targeting known areas of lower landscape condition for restoration activities. A third method for applying the results of landscape condition models using the Vista tool is to assign a landscape condition threshold to each priority resource and compare their distributions to the landscape condition. Additionally, as the landscape condition model output is a raster layer, this can be further manipulated in GIS if desired.

Cumulative Impacts on Priority Biological Resources

Following we present results of the assessment of cumulative stressor effects on the retention of priority resources, applying the goals described in Table 14 to the conditions in the 2010 Baseline, the 2025 Road Closures, and the 2025 Revised Refuge Management scenarios. The full results from each scenario are found in Appendix H. Table 11 summarizes key differences between the scenarios and highlights those resources forecast to undergo the greatest degree of impact. Because many retention goals were less than 100%, the percentage of the goal met can exceed 100% (for example, if the goal was to retain 50% of the known distribution of a resource throughout the project area, but in fact 100% of its distribution was retained, the percent of the retention goal met would be 200%). These analyses assessed the retention of resources throughout the project area.

Table 11. Comparison of the percent of the retention goal met across the supporting landscape for resources under each scenario, ordered by resource type and name.

Type	Resource	Known Area (ha)	Known Occs	Retention Goal (%)	Goal Units	% Goal Achieved 2010 Baseline	% Goal Achieved 2025 Road Closures	% Goal Achieved 2025 Revised Refuge Mgt
Mammals	American Pika	56432	5	50	Area	55	55	175
	Long-Eared Myotis	10	12	50	Occ	17	17	17
	Long-Legged Myotis	4	5	50	Occ	0	0	0
	Pronghorn Corridors	4233	2	100	Area	0	0	64
	Pronghorn Nonwinter Range	155913	6	100	Area	12	12	96
	Pronghorn Primary Habitat	1236810	23	100	Area	6	6	17

Type	Resource	Known Area (ha)	Known Occs	Retention Goal (%)	Goal Units	% Goal Achieved 2010 Baseline	% Goal Achieved 2025 Road Closures	% Goal Achieved 2025 Revised Refuge Mgt
	Pronghorn Winter Range	65307	6	100	Area	65	64	90
	Pygmy Rabbit	3255	10	50	Occ	0	0	0
	Western Small-Footed Myotis	8	10	50	Occ	20	20	20
	White-Tailed Antelope Squirrel	4920	7	50	Occ	0	0	0
	White-Tailed Jackrabbit	703	1	50	Occ	0	0	0
Birds	Greater Sandhill Crane	703	1	50	Area	0	0	0
	Sage Grouse	36	121	100	Occ	18	19	19
	Sage Grouse Breeding Habitat	648208	53	100	Area	8	8	25
	Sage Grouse Nesting Habitat	1733430	9	100	Area	5	5	17
	Sage Grouse Range	1309724	1	100	Area	7	7	21
	Western Burrowing Owl	4219	6	0	Occ	0	0	0
Fish	Catlow Tui Chub	47	4	100	Area	35	37	37
	Catlow Valley Redband Trout	9	7	100	Occ	0	14	14
	Lahontan Cutthroat Trout	258	5	100	Area	0	0	0
	Sheldon Tui Chub	24	3	100	Area	0	0	33

Type	Resource	Known Area (ha)	Known Occs	Retention Goal (%)	Goal Units	% Goal Achieved 2010 Baseline	% Goal Achieved 2025 Road Closures	% Goal Achieved 2025 Revised Refuge Mgt
	Warner Sucker	10086	10	100	Area	0	0	0
	Warner Valley Redband Trout	6439	6	100	Area	0	0	0
Communities	Columbia Plateau Low Sagebrush Steppe	528016	4107	60	Area	14	14	47
	Inter-Mountain Basins Big Sagebrush Shrubland	742469	4575	80	Area	63	61	75
	Inter-Mountain Basins Big Sagebrush Steppe	464671	2196	80	Area	49	47	47
	Inter-Mountain Basins Cliff and Canyon	28959	2852	60	Area	30	30	47
	Inter-Mountain Basins Curlleaf Mountain Mahogany	2000	277	80	Area	14	14	14
	Inter-Mountain Basins Greasewood Flat	124595	3194	60	Area	2	2	24
	Inter-Mountain Basins Juniper Savanna	37997	2538	60	Area	130	130	130
	Inter-Mountain Basins Mixed Salt Desert Scrub	77081	2766	60	Area	1	1	15
	Inter-Mountain Basins Montane Sagebrush Steppe	319828	7400	80	Area	63	60	86
	Inter-Mountain Basins Playa	74777	4594	100	Area	5	5	7

Type	Resource	Known Area (ha)	Known Occs	Retention Goal (%)	Goal Units	% Goal Achieved 2010 Baseline	% Goal Achieved 2025 Road Closures	% Goal Achieved 2025 Revised Refuge Mgt
	Inter-Mountain Basins Semi-Desert Grassland	172381	8920	60	Area	6	6	42
	North American Arid West Emergent Marsh	31046	1030	60	Area	2	2	3
	Northern Rocky Mountain Foothill Deciduous Shrubland	27604	2318	40	Area	109	108	144
	Rocky Mountain Aspen Forest and Woodland	14953	672	100	Area	5	5	7
	Rocky Mountain Ponderosa Pine Woodland	35	2	40	Area	215	215	215
	Rocky Mountain Subalpine-Montane Mesic Meadow	20368	1219	100	Area	23	23	28
Plants	Crosby's Buckwheat	69	13	0	Area	0	0	0
	Grimy Ivesia	70	11	100	Area	0	0	74
	Long-Flowered Snowberry	121	4	20	Area	249	249	249
	Nodding Melicgrass	953	6	20	Area	26	26	26
	Playa Phacelia	16	2	0	Area	0	0	0
	Prostrate Buckwheat	111	8	50	Area	7	7	7
	Rose-flower Desert-parsley	72	9	0	Area	0	0	467
	Salt Heliotrope	25	6	20	Area	0	0	0
	Three Forks Stickseed	8	1	50	Area	0	0	165

Type	Resource	Known Area (ha)	Known Occs	Retention Goal (%)	Goal Units	% Goal Achieved 2010 Baseline	% Goal Achieved 2025 Road Closures	% Goal Achieved 2025 Revised Refuge Mgt
	Yellow Scorpionflower	36	1	50	Area	0	0	152
Infrastructure	Hart Boundary Fence	527	2	100	Area	100	100	100
	Hart Headquarters	3	1	100	Occ	100	100	100
	Last Chance Ranch	3	1	100	Occ	100	100	100
	Sheldon Boundary Fence	925	4	100	Area	99	99	99
	Sheldon Headquarters	3	1	100	Occ	100	100	100

2010 Baseline Scenario and 2025 Road Closure Scenarios

Three ecosystem resources met or exceeded their retention goals under the baseline scenario: Inter-Mountain Basins Juniper Savanna, Northern Rocky Mountain Foothill Deciduous Shrubland, and Rocky Mountain Ponderosa Pine Woodland. Only one species had its goals met under the baseline scenario: Long-Flowered Snowberry. However, these four resources are all Priority 3 (lowest priority). Among Priority 1 resources, Inter-Mountain Basins Big Sagebrush Shrubland, Inter-Mountain Basins Montane Sagebrush Steppe, and Pronghorn Winter Range all met over 60% of their goals. The sagebrush types did well based on their tolerance to low levels of commercial (cattle or sheep) grazing, while Pronghorn Winter Range succeeded due to the high concentration within the Hart Mountain Refuge boundary.

Although Pronghorn Winter Range fared well under the 2010 Baseline Scenario, Pronghorn Corridors, Nonwinter Range, and Primary Habitat fell far short of their retention goals with an average of 6% met. In addition, none of the sage grouse goals were met under this scenario, with the highest retention being 18% for lek sites (represented by the Sage Grouse resource). Sage grouse range, breeding, and nesting habitats did poorly (all less than 10% of their goals). These results were due to the large number of negative impacts present outside the refuges, where the majority of these species' habitats are found in the supporting landscape. The negative impact of horse and burro grazing on Sheldon Refuge also contributed to these low retention percentages.

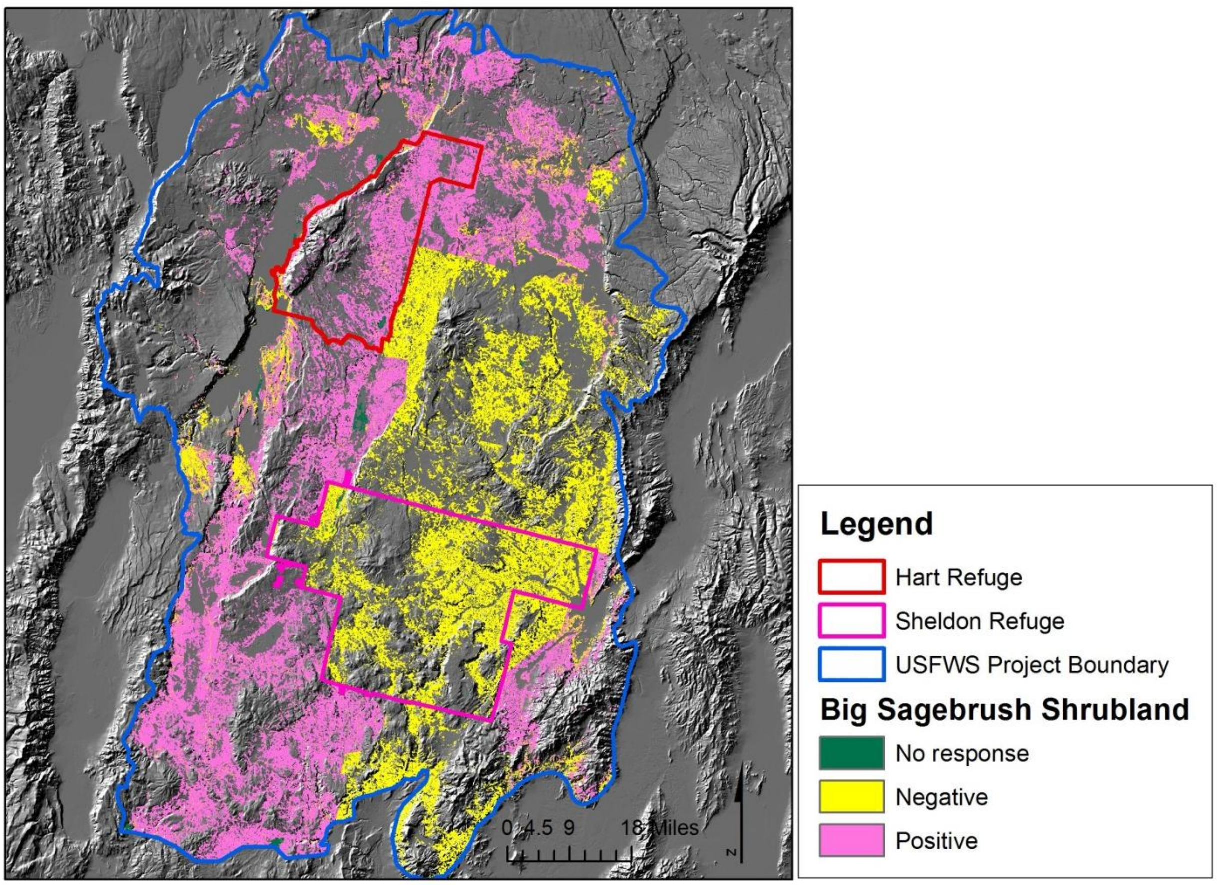
Under the 2025 Road Closures Scenario, resources fared similarly to the 2010 Baseline Scenario with changes of only a few percent in either direction.

To further visualize and explore the results of these assessments, individual resource distributions and responses to stressors can be shown in Vista. The cumulative impact of stressors on the Inter-Mountain

Basins Big Sage-Brush Shrubland under the 2010 Baseline Scenario is shown as an example in Figure 21. The negative effect of wild horses and burros on this resource is shown by the large blocks of yellow pixels (negative impact) on the map (references for the response of resources to different stressors are listed in Appendix I). The level of impact is not assessed; rather categorical negative, neutral, and beneficial responses were modeled. Thus areas with an overall negative impact are shown in yellow and overall beneficial impact shown in pink in Figure 21.

Figure 21. The distribution and response of Inter-Mountain Basins Big Sage-Brush Shrubland under the 2010 Baseline Scenario.

Yellow pixels are areas of negative impact to Big Sagebrush shrubland, primarily due to the presence of horse and burro herds in the eastern half of the project area. Pink pixels are areas of beneficial impact. Hart Mountain Refuge is outlined in red and Sheldon Refuge in magenta.



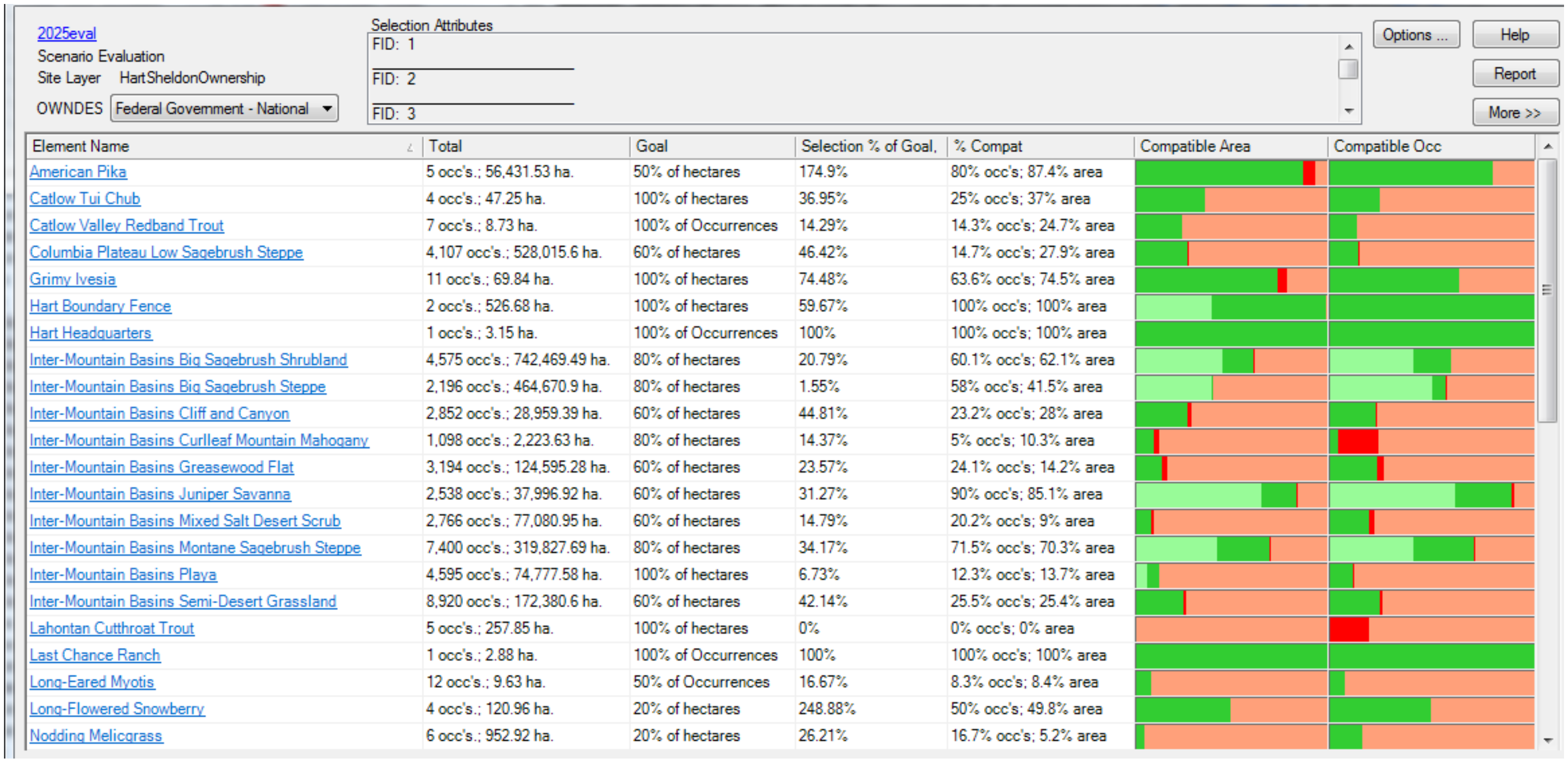
2025 Revised Refuge Management Scenario

In the 2025 Revised Refuge Management Scenario where horses and burros have been removed from Sheldon Refuge, the five resources meeting their goals in the Baseline Scenario again met their retention goals, and four additional species resources met their goals: American Pika, Rose-Flower Desert-Parsley, Three Forks Stickseed, and Yellow Scorpionflower. While the three plant resources are Priority 3, the American Pika is a Priority 2. Pronghorn Nonwinter Range and Pronghorn Winter Range had enormous improvements in their retention goals over the baseline scenario, rising to 96% and 90% met, respectively.

Under the 2025 Revised Refuge Management Scenario the sage grouse resources goals are still unmet, but improved over the baseline. While under the 2010 Baseline Scenario most of the sage grouse goals were less than 10% met, in the 2025 Revised Refuge Management Scenario, the amount met rises to an average of 20.5%. While this is still a low percentage, the percent goal met has doubled compared to the baseline.

To further explore resource retention on refuge lands, Vista's Site Explorer tool can be used to narrow results to these specific areas or a subregion filter can be applied in Vista to analyze effects solely within refuge lands. Figure 22 is an example of the output from Vista's Site Explorer tool showing the results of the 2025 Revised Refuge Management Scenario Evaluation on National Wildlife Refuge lands (Refuge Complex) only. This tool allows the user to see how much a certain parcel or area is contributing to the total goal. For example, the Refuge Complex lands are contributing 21% to the Inter-Mountain Basins Big Sagebrush Shrubland goal out of 78% met across the entire landscape (as shown in Table 11), while the Refuge Complex lands are contributing almost the entirety of the retention goal of Long-Flowered Snowberry (248% out of 249%). This further highlights the importance of the Refuge lands to meeting conservation goals of these priority resources.

Figure 22. Screenshot from 2025 Revised Refuge Management Scenario Site Explorer results, highlighting the contribution of the Refuge Complex to resource retention goals.[3]



Element Name	Total	Goal	Selection % of Goal	% Compat	Compatible Area	Compatible Occ
American Pika	5 occ's.; 56,431.53 ha.	50% of hectares	174.9%	80% occ's; 87.4% area		
Catlow Tui Chub	4 occ's.; 47.25 ha.	100% of hectares	36.95%	25% occ's; 37% area		
Catlow Valley Redband Trout	7 occ's.; 8.73 ha.	100% of Occurrences	14.29%	14.3% occ's; 24.7% area		
Columbia Plateau Low Sagebrush Steppe	4,107 occ's.; 528,015.6 ha.	60% of hectares	46.42%	14.7% occ's; 27.9% area		
Grimy Ivesia	11 occ's.; 69.84 ha.	100% of hectares	74.48%	63.6% occ's; 74.5% area		
Hart Boundary Fence	2 occ's.; 526.68 ha.	100% of hectares	59.67%	100% occ's; 100% area		
Hart Headquarters	1 occ's.; 3.15 ha.	100% of Occurrences	100%	100% occ's; 100% area		
Inter-Mountain Basins Big Sagebrush Shrubland	4,575 occ's.; 742,469.49 ha.	80% of hectares	20.79%	60.1% occ's; 62.1% area		
Inter-Mountain Basins Big Sagebrush Steppe	2,196 occ's.; 464,670.9 ha.	80% of hectares	1.55%	58% occ's; 41.5% area		
Inter-Mountain Basins Cliff and Canyon	2,852 occ's.; 28,959.39 ha.	60% of hectares	44.81%	23.2% occ's; 28% area		
Inter-Mountain Basins Curlleaf Mountain Mahogany	1,098 occ's.; 2,223.63 ha.	80% of hectares	14.37%	5% occ's; 10.3% area		
Inter-Mountain Basins Greasewood Flat	3,194 occ's.; 124,595.28 ha.	60% of hectares	23.57%	24.1% occ's; 14.2% area		
Inter-Mountain Basins Juniper Savanna	2,538 occ's.; 37,996.92 ha.	60% of hectares	31.27%	90% occ's; 85.1% area		
Inter-Mountain Basins Mixed Salt Desert Scrub	2,766 occ's.; 77,080.95 ha.	60% of hectares	14.79%	20.2% occ's; 9% area		
Inter-Mountain Basins Montane Sagebrush Steppe	7,400 occ's.; 319,827.69 ha.	80% of hectares	34.17%	71.5% occ's; 70.3% area		
Inter-Mountain Basins Playa	4,595 occ's.; 74,777.58 ha.	100% of hectares	6.73%	12.3% occ's; 13.7% area		
Inter-Mountain Basins Semi-Desert Grassland	8,920 occ's.; 172,380.6 ha.	60% of hectares	42.14%	25.5% occ's; 25.4% area		
Lahontan Cutthroat Trout	5 occ's.; 257.85 ha.	100% of hectares	0%	0% occ's; 0% area		
Last Chance Ranch	1 occ's.; 2.88 ha.	100% of Occurrences	100%	100% occ's; 100% area		
Long-Eared Myotis	12 occ's.; 9.63 ha.	50% of Occurrences	16.67%	8.3% occ's; 8.4% area		
Long-Flowered Snowberry	4 occ's.; 120.96 ha.	20% of hectares	248.88%	50% occ's; 49.8% area		
Nodding Melicgrass	6 occ's.; 952.92 ha.	20% of hectares	26.21%	16.7% occ's; 5.2% area		

[3] Column definitions: **Element Name** = common name of resource. **Total** = known occurrences and hectares located within Refuge lands. An occurrence is a population unit as defined by NatureServe methodology. **Goal** = the retention goal for the resource based on maintaining a set percentage of occurrences or area. **Selection % of goal** = the percentage of the retention goal that the selected area is contributing (i.e., how important the resources present on the Refuges are in comparison to the supporting landscape). **% Compat** = % of occurrences and area for this resource that is compatible with land use on the Refuges. **Compatible Area** and **Compatible Occ** charts: dark green= compatible on Refuges, light green = compatible in supporting landscape, dark red = not compatible on Refuges, light red = not compatible in supporting landscape.

Management Implications

The minimal change in the degree to which resource goals are met between the 2010 Baseline and 2025 Road Closures Scenarios suggests that under our model assumptions, the additional infrastructure and energy development activities that take place outside the Refuge Complex in the 2025 scenarios have a far lesser impact on priority resources than the presence of horses and burros on Sheldon Refuge.

The greater number of resources reaching their goals under the 2025 Revised Refuge Management Scenario indicates that the removal horses and burros from Sheldon Refuge as set forth in one of the management alternatives in the Sheldon CCP is expected to have a significant positive impact on species and habitats within the supporting landscape. Removing horse and burro grazing from Sheldon Refuge has a large beneficial impact, particularly for plant populations and priority habitats. Improvements to playa and wet meadow habitats due to the removal of horses may also improve early brood habitat for sage grouse.

Resources that consistently met 0% of their goals are entirely located on lands that in these models have land uses that are incompatible with the resource, such as grazing. Another factor contributing to unmet goals may be the lack of spatial (population) data for some of these resources, but the implication is that these resources are outside the reach of Refuge policies and management. The Refuge can support habitats suitable for these species in an effort to encourage use or colonization by these species. For example, migratory bird species such as the Greater Sandhill Crane will benefit from Refuge management of wetland habitat.

Cumulative Impacts on Mission-Critical Infrastructure

This assessment utilized the same approach as for biological resources described above. As illustrated in Table 12, none of the scenarios shows any impacts to any of the Mission-Critical Infrastructure. As all the MCI are located on Refuge lands, and policies are in place to maintain them, there are no threats to these resources from the stressors mapped and assessed in these scenarios.

Table 12. Comparison of the percent of the retention goal met for resources under each scenario, ordered by type and resource name.

Type	Resource	2010 Baseline % Goal Met	2025 Road Closure % Goal Met	2025 Revised Refuge Mgt % Goal Met
Infrastructure	Hart Boundary Fence	100	100	100
	Hart Headquarters	100	100	100
	Last Chance Ranch	100	100	100
	Sheldon Boundary Fence	100	100	100
	Sheldon Headquarters	100	100	100

Management Implications

The results showed no differences between the 2010 Baseline, 2025 Road Closure, and 2025 Revised Refuge Management Scenarios; the stressors assessed in these three scenarios are not expected to impact MCI. However, the primary threat to these MCI resources is increased fire frequency and intensity, and potential fire impacts were assessed using the VDDT modeling tool. VDDT provides generalized results by watershed, and thus our fire predictions based on these results could not be incorporated into the spatially explicit cumulative effects scenarios assessed using Vista. The VDDT results for fire effects into 2100 do show increased fire frequency in the grazed areas around the refuges. The increase in the frequency of major fires occurs in all of the VDDT runs, but the area of the intense fires is greater when the cover of annual grasses is higher, and annual grass cover is higher in all areas grazed by livestock, horses and burros. As a result, fire frequency is generally greater along the edges of the refuges, with a few exceptions. These VDDT results are discussed in detail in the Vegetation Resources Assessment section in this chapter. They are briefly highlighted here because they suggest that the MCI most at risk from the threat of increased fire frequency and intensity would be the Refuge boundary fences. If horses and livestock are to be excluded from the Refuge areas, maintaining the boundary fences is critical. The other MCI do not appear to be vulnerable to future stressors as they are located within the Refuge Complex away from the edges where effects of stressors in the supporting landscape would have an impact.

Cumulative Impacts Assessment Methods

Landscape Condition Modeling

Landscape condition modeling is an approach to quantify the on- and off-site effects of stressors either generically across all resources, for groups of resources, or customized for individual resources. The result is an index, output as a raster, where each pixel has a score on a 0.0-1.0 scale. High values indicate relatively high condition and low values indicate low condition based on the stressor inputs. Note that the landscape condition model only accounts for the presence or proximity of stressors and does not address issues such as fragmentation or species population viability. In this RVA, condition modeling was used to illustrate areas of high concentrations of stressor impacts on the landscape, but was not used to assess resource retention.

The stressors identified for the 2010 and 2025 scenarios were integrated into a general landscape condition model that was then updated for each scenario based on changing stressors and stressor patterns. We used utilities in NatureServe Vista to create these condition models following the standards described by Comer and Hak (2009). Each stressor is given a relative intensity and distance decay score on a 0.0 to 1.0 scale that reflects the relative impact of each stressor to the landscape[4]. Applying these scores in the model provides a normalized condition score of all stressor effects at the site of the stressor and a distance out from it. Stressors that can substantially reduce the natural condition of resources (e.g., mining, paved roads, housing) are given intensity scores closer to zero (poor

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[4] These site intensity and distance decay values are stored in the condition model in the Vista project and are readily revised as needed.

landscape condition remaining), while those that induce less stress or are beneficial to condition (e.g., conservation management, day use areas) are given intensity scores closer to one. Stressors with wide-ranging impacts (e.g., wind energy development, high-intensity mining) are given distance decay scores closer to zero, meaning that their effects decrease at a slower rate with distance from the source, while those with very localized impact are given distance decay scores closer to one (e.g., water diversions). Many stressors only affect the area at the source of the stressor and are therefore given distance decay values of 1 (Table 13).

While only one set of intensity and distance decay scores was used for this project, separate condition modeling systems can be developed for specific resources or scenarios. For example, a specific sage grouse condition modeling system could be developed to give a greater intensity score to overhead power lines, which may provide perches for raptors and thereby potentially increase sage grouse mortality through increased predation. The values for each stressor were not changed across scenarios for this RVA, but they may similarly be customized as needed. Although stressors were assumed to have the same impact across scenarios in this assessment, their presence and distribution changed across scenarios (e.g., additional energy development and transmission corridors in the future scenarios). Instead of condition models, each resource was individually assigned a categorical response – positive, neutral, or negative – to each stressor, as documented in Appendix I.

Table 13. List of stressors and parameters used for landscape condition modeling in the 2010 and 2025 scenarios.

Lower values indicate greater intensity and more extensive impact for Relative Intensity and Distance Decay, respectively.

Stressor Name	Relative Intensity	Distance Decay
Mechanical and Herbicide Treatments	1	1
Seeding/Planting	1	1
Protected Areas	1	1
Species Management	1	1
Federal Land Grazing	0.5	1
State Land Grazing	0.5	1
Private Land Grazing	0.5	1
Irrigated Cropland	0.3	0.9
Wind Energy Development	0.2	0.1
Solar Energy Development	0.1	0.5
Geothermal Energy Development	0.1	0.5
Mining	0.1	0.1
Day Use Areas including Fishing	0.9	1
Campgrounds	0.5	0.9

Stressor Name	Relative Intensity	Distance Decay
Wild Horses and Burros	0.5	1
Invasive Annual Grasses Low (<12% cover cheatgrass or medusahead)	0.8	1
Invasive Annual Grasses Mid (12-20% cover cheatgrass or medusahead)	0.7	1
Invasive Annual Grasses High (>20% cover cheatgrass or medusahead)	0.5	1
Paved Roads	0.2	0.5
Unpaved Roads	0.5	0.5
Communications Towers	0.8	0.5
Overhead Utility Lines	0.8	0.5
Buried Utility Lines	0.8	1
Inholdings Development	0.5	0.5
Housing, Structures	0.5	0.5
Water Diversion and Alteration	1	1
Recently Burned	0.5	1
Water	1	1

Assessment of Cumulative Effects on Resources

The spatially explicit resource assessment had two objectives and sets of results: 1) quantifying on a per-pixel basis of the cumulative effect of the stressors on the resources and 2) evaluating the results of that quantification against an indicator of resource sustainability (retention goal) for each resource.

Essentially, the assessment intersects resource distributions with stressors (expressed in scenarios) to quantify predicted effects on resources. The results predict remaining viable areas of the resource, and summarize how well the quantitative retention goals are met for each resource. The retention goals are the total area or number of occurrences of the resource that are required to consider the resource viable throughout the supporting landscape. The degree to which this retention goal is met is the primary indicator of resource performance under each scenario; it is not, however, a policy-based indicator and is used only for analytical purposes.

The effect of stressors on each resource is calculated independently based on one of the following:

1. A set of categorical responses specifying the response of each resource to each stressor (the resource responds to each stressor in a negative, neutral, or beneficial way), excluding synergistic and off-site effects, or;

2. A condition model that applies a threshold (a minimum condition threshold is defined for each resource; if the landscape condition is below this threshold due to the cumulative effect of stressors, the resource will be incompatible with the stressors in that location).

For this RVA, the effects of stressors were assessed using categorical responses.

A quantitative retention goal (percent of area or occurrences) was developed for each resource for its total mapped distribution within the supporting landscape because this area is assumed to have direct relevance to the viability of resources on the refuge. These goals were developed using the preliminary goals described in the draft Sheldon Refuge Comprehensive Conservation Plan as a guide, then modified with input from project staff and analysis of distribution of the resources across the supporting landscape (Table 14). Goals were established for assessment purposes to evaluate scenarios and aid development of alternatives; they do not necessarily represent policy objectives for resources. Goals were assigned based on numbers of population occurrences (EOs) for species where occurrence data were available and where it was appropriate; otherwise, goals were based on area of occupancy.

Goals are provided for those species that were included in the spatial (Vista) analyses only. Many of those resources without enough spatial information are peripheral species or those with little impact on the overall conservation value of the project area. It should be noted that the Vista program reports on the compatibility and viability of known, existing distributions of resources and does not model and assess potential increase in resource size or extent under different scenarios. Thus, a value of 100% retention is the highest possible goal in this table. As noted previously in the Biological Environment section, priority ranks were assigned to indicate relative importance of each resource; priority ranks can be used in Vista to give higher weight to top priority species in assessments such as the CVS, or to filter results.

Pronghorn and greater sage grouse, the two species of greatest concern to the Refuges, were treated as multiple resources and had associated goals for their spatial representation. Population occurrence data were not available for pronghorn, as they move long distances and mapping populations would not be feasible. Rather, pronghorn were tracked by the areas and habitats they utilize throughout the year. As pronghorn are migratory, known winter and non-winter habitats (as interpreted from figures in the Hart Mountain Refuge RMP) were included as resources. Additionally, primary habitat as delineated by the most current range map developed by ORBIC and good habitat as determined by NatureServe was also included as a pronghorn resource. Two small areas reported by the Refuge as being used by pronghorn during migrations were included as the Pronghorn Corridor resource, though it is acknowledged that these two locations represent only a small portion of pronghorn movement through the landscape. A study of pronghorn movement by the refuge has been initiated as of this writing and is expected to yield spatial information that can be used in an update of these analyses.

Sage grouse were tracked by four separate resource representations as well, with each resource component assigned a retention goal. The sage grouse resource representations were based on known lek sites and the retention goal for sage grouse was based on occurrences. Breeding range incorporated the area within 2 miles of each lek, sage grouse range incorporated the area within 5 miles of each lek, and nesting range incorporated compatible habitat throughout the supporting landscape; these were each tracked by area.

Table 14. Resource conservation goals for the supporting landscape project area.

Species with goals marked as "NA" are those that did not have adequate spatial data to be included in the Vista analysis but were identified as priority species by the Refuges. Goals are provided either as a percentage of the total area of the resource throughout the supporting landscape, or as a percentage of the total number of occurrences throughout the supporting landscape; "occ" = occurrence.

Type	Common Name	Scientific Name	Priority Level	Goal %	Goal Type	Known Area (ha)	Known Occurrences (when applicable)
Mammals	American Pika	*Ochotona princeps*	2	50	area	56218	5
	Long-eared Myotis	*Myotis evotis*	3	50	occ	7	8
	Long-legged Myotis	*Myotis volans*	3	50	occ	3	4
	Preble's Shrew	*Sorex preblei*	3	NA	area		
	Pronghorn Corridors	Pronghorn Corridors	1	100	area	4219	
	Pronghorn Nonwinter Range (derived from Hart CMP)	Pronghorn Nonwinter Range	1	100	area	64695	
	Pronghorn Primary Habitat (based on compatible habitat and known range)	Pronghorn Primary Habitat	1	100	area	1087775	
	Pronghorn Winter Habitat (derived from Hart CMP)	Pronghorn Winter Habitat	1	100	area	64695	
	Pygmy Rabbit	*Brachylagus idahoensis*	2	50	occ	2537	11
	Spotted Bat	*Euderma maculatum*	3	NA			
	Western Small-footed Myotis	*Myotis ciliolabrum*	3	50	occ	7	6
	White-tailed Antelope	*Ammospermophilus leucurus*	3	50	occ	3487	7

Type	Common Name	Scientific Name	Priority Level	Goal %	Goal Type	Known Area (ha)	Known Occurrences (when applicable)
	Squirrel						
	White-tailed Jackrabbit	*Lepus townsendii*	3	50	occ	703	1
Birds	American White Pelican	*Pelecanus erythrorhynchos*	3	NA	area		
	Blue-gray Gnatcatcher	*Polioptila caerulea*	3	NA	area		
	Greater Sandhill Crane	*Grus canadensis tabida*	3	50	occ	703	1
	Sage Grouse (lek sites)	*Centrocercus urophasianus*	1	100	occ	32	107
	Sage Grouse Breeding Habitat	Sage Grouse Breeding Habitat	1	100	area	602637	
	Sage Grouse Nesting Habitat	Sage Grouse Nesting Habitat	1	100	area	1531864	
	Sage Grouse Range	Sage Grouse Range	1	100	area	1118129	
	Snowy Egret	*Egretta thula*	3	NA	area		
	Western Burrowing Owl	*Athene cunicularia hypugaea*	2	40	occ	2111	4
	Western Yellow-billed Cuckoo	*Coccyzus americanus occidentalis*	3	NA	area		
Fish	Alvord Chub	*Gila alvordensis*	3	NA	area		
	Catlow Tui Chub	*Gila bicolor ssp. 2*	3	100	area	56218	
	Catlow Valley Redband Trout	*Oncorhynchus mykiss pop. 3*	2	100	area	9	
	Lahontan Cutthroat Trout	*Oncorhynchus clarkii henshawi*	2	100	area	21	

Type	Common Name	Scientific Name	Priority Level	Goal %	Goal Type	Known Area (ha)	Known Occurrences (when applicable)
	Sheldon Tui Chub	*Gila bicolor eurysoma*	2	100	area	24	
	Warner Sucker	*Catostomus warnerensis*	2	100	area	6848	
	Warner Valley Redband Trout	*Oncorhynchus mykiss pop. 4*	2	100	area	3934	
Communities	Columbia Plateau Low Sagebrush Steppe	Columbia Plateau Low Sagebrush Steppe	1	60	area	468773	
	Inter-Mountain Basins Big Sagebrush Shrubland	Inter-Mountain Basins Big Sagebrush Shrubland	1	80	area	660331	
	Inter-Mountain Basins Big Sagebrush Steppe	Inter-Mountain Basins Big Sagebrush Steppe	1	80	area	353981	
	Inter-Mountain Basins Cliff and Canyon	Inter-Mountain Basins Cliff and Canyon	3	60	area	28301	
	Inter-Mountain Basins Curl-leaf Mountain-Mahogany Woodland and Shrubland	Inter-Mountain Basins Curl-leaf Mountain Mahogany Woodland and Shrubland	2	80	area	2055	
	Inter-Mountain Basins Greasewood Flat	Inter-Mountain Basins Greasewood Flat	3	60	area	119056	
	Inter-Mountain	Inter-Mountain Basins Juniper	3	60	area	33404	

Type	Common Name	Scientific Name	Priority Level	Goal %	Goal Type	Known Area (ha)	Known Occurrences (when applicable)
	Basins Juniper Savanna	Savanna					
	Inter-Mountain Basins Mixed Salt Desert Scrub	Inter-Mountain Basins Mixed Salt Desert Scrub	3	60	area	75206	
	Inter-Mountain Basins Montane Sagebrush Steppe	Inter-Mountain Basins Montane Sagebrush Steppe	1	80	area	312337	
	Inter-Mountain Basins Playa	Inter-Mountain Basins Playa	3	100	area	63432	
	Inter-Mountain Basins Semi-Desert Grassland	Inter-Mountain Basins Semi-Desert Grassland	1	60	area	166623	
	North American Arid West Emergent Marsh	North American Arid West Emergent Marsh	2	60	area	30087	
	Northern Rocky Mountain Montane-Foothill Deciduous Shrubland	Northern Rocky Mountain Montane-Foothill Deciduous Shrubland	3	40	area	27092	
	Rocky Mountain Aspen Forest and Woodland	Rocky Mountain Aspen Forest and Woodland	1	100	area	14507	
	Rocky Mountain	Rocky Mountain Ponderosa Pine	2	40	area	35	

Type	Common Name	Scientific Name	Priority Level	Goal %	Goal Type	Known Area (ha)	Known Occurrences (when applicable)
	Ponderosa Pine Woodland	Woodland					
	Rocky Mountain Subalpine-Montane Mesic Meadow	Rocky Mountain Subalpine-Montane Mesic Meadow	2	100	area	20521	
Plants	Bebb's Willow	*Salix bebbiana*	3	NA	area		
	Crosby's Buckwheat	*Eriogonum crosbyae*	3	20	area	69	
	Doublet	*Dimeresia howelli*	3	NA	area		
	Grimy Ivesia	*Ivesia rhypara var. rhypara*	2	100	area	70	
	Long-flowered Snowberry	*Symphoricarpos longiflorus*	3	20	area	119	
	Nodding Melicgrass	*Melica stricta*	3	20	area	953	
	Playa Phacelia	*Phacelia inundata*	3	20	area	4	
	Prostrate Buckwheat	*Eriogonum prociduum*	3	50	area	111	
	Rose-flower Desert-parsley	*Lomatium roseanum*	3	20	area	72	
	Seaside Heliotrope	*Heliotropium curassavicum*	3	20	area	18	
	Three Forks Stickseed	*Hackelia ophiobia*	3	50	area	8	
	Yellow Scorpionweed	*Phacelia lutea var. calva*	3	50	area	36	
Infrastructure	Hart Boundary Fence	Hart Boundary Fence	1	100	area	526	
	Hart Headquarters	Hart Headquarters	1	100	occ	3	1
	Last Chance	Last Chance Ranch	1	100	occ	3	1

Type	Common Name	Scientific Name	Priority Level	Goal %	Goal Type	Known Area (ha)	Known Occurrences (when applicable)
	Ranch						
	Sheldon Boundary Fence	Sheldon Boundary Fence	1	100	area	915	
	Sheldon Headquarters	Sheldon Headquarters	1	100	occ	3	1

Non-Spatial Vegetation Resource Assessments

Spatial data for assessing stressors relating to land use (e.g., roads, energy infrastructure, other development, and agriculture) and management (e.g., grazing) within the supporting landscape were considered to be reliable for predictions into 2025. However, to evaluate stressors into the 2060 and 2100 time frame, and to address stressors that are not readily modeled in a detailed, spatially explicit manner, the project team identified other data and modeling tools. VDDT allowed the inclusion of juniper treatments in the models, while climate models allowed the assessment of predicted climate change for the next 100 years. VDDT and the climate models generate a continuous set of results for a period of time; in this particular assessment, the models were run from 2000 to 2100. Using this set of continuous results, grazing and climate change impacts on vegetation resources can be described for any time point of interest within that 100-year time horizon.

Vegetation Resources Assessment

Overview

The effects of land management on vegetation resources into 2060 and 2100 were assessed using the Vegetation Dynamic Development Tool (VDDT). Methods were drawn from the Integrated Landscape Assessment Project (ILAP), a collaborative project between the U.S. Forest Service's Pacific Northwest Research Station, Oregon State University, and the Institute for Natural Resources (ILAP 2011). Models were run for the entire supporting landscape area, both with and without the influence of grazing and juniper treatments, and without the effect of climate change. (Climate change was assessed using a separate suite of models described in the Vegetation Resources Assessment with Climate Change section). Details on the methods used for the VDDT modeling are found at the end of this Vegetation Resources Assessment section.

Revised Refuge Management Scenario

For the Revised Refuge Management assessment, we ran models to assess how vegetation resources are likely to change with all forms of grazing removed from the Refuge Complex and grazing occurring in the surrounding landscape. Additionally, juniper management treatments as described in the Assessment Overview section and the Vegetation Resources Assessment Methods section were applied to the Refuge Complex. Managing juniper had been identified as a Refuge priority and the VDDT models allow these treatments to be incorporated. Table 15 lists the Potential Vegetation Types (the basic vegetation unit used in VDDT modeling; see associated Methods section) that were evaluated. The Revised Refuge Management Scenario as modeled in VDDT is generally conceptually similar to that scenario in both the Vista and the climate models, except for the inclusion of juniper management treatments.

Table 15. Potential vegetation types evaluated with VDDT under the Revised Refuge Management Scenario.

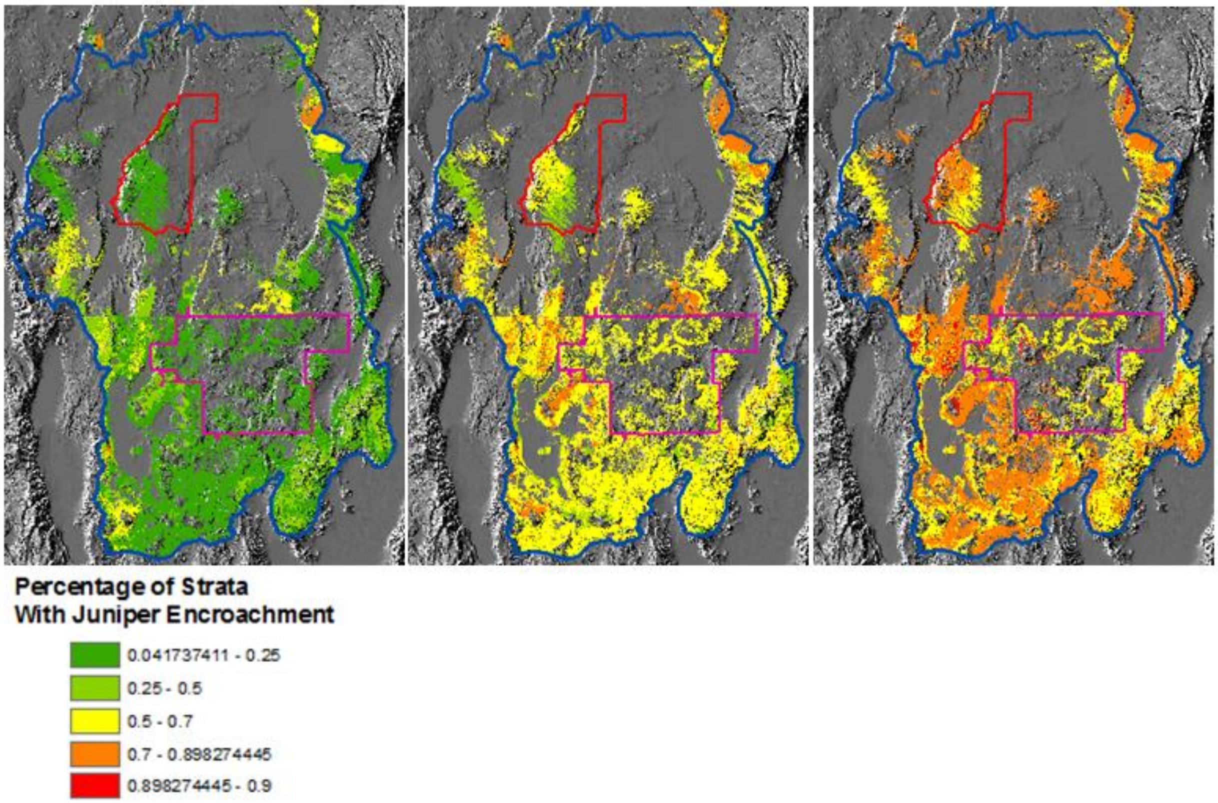
Potential Vegetation Types
Bitterbrush - With juniper
Low sage - Mesic no juniper
Low sage - Mesic with juniper
Low sage - Xeric
Mountain big sagebrush - With juniper
Mountain mahogany
Salt desert shrub - Lowland
Western juniper woodland
Wyoming big sagebrush - No juniper
Wyoming big sagebrush - With juniper

Impacts of Management on Vegetation Resources

The results of VDDT modeling include tables specifying vegetation structure and cover for every pixel and every time step evaluated, providing a wealth of information about the changing landscape. A summary example of these results is shown in Figure 23. These images illustrate how juniper encroachment might proceed from 2010 to 2060 using the Revised Refuge Management grazing assumptions. The VDDT results and the figure show that juniper will expand and significantly reduce both the area of shrub steppe (low sage, mountain big sage, and Wyoming big sage) and the quality of this habitat for shrub-obligate species such as sage grouse. These results apply primarily to western juniper, but Utah juniper also appears to be expanding in similar ways in northeastern Nevada. While there is little doubt that juniper will be controlled on the Refuge Complex, it is much less clear that private or other public landowners with property around the Refuge Complex will be able to make this investment. This will increase the risk to the habitat resources on the Refuge Complex from increased seed sources and fire intensities. The models suggest that the *rate* of juniper expansion appears to be affected by whether an area is grazed or not (juniper expands more rapidly when grazing is present), but the *pattern* of juniper expansion appears to be the same both with and without grazing pressure.

Figure 23. Western Juniper encroachment at (from left to right) 2010, 2025, and 2060 under the Revised Refuge Management Scenario.

Dark green represents areas with limited juniper encroachment (<25% of the vegetative cover is juniper); yellow areas have 50-70% juniper cover; and red areas are approximately 90% juniper cover. Table 15 lists the vegetation types that were modeled as being able to support juniper encroachment. Gray areas are vegetation types that were modeled as being unable to support juniper.



The VDDT outputs show similar patterns of increases in areas dominated by exotic species, either as annual grass monocultures, or more commonly as sagebrush / annual grass shrublands. The amount of area dominated by exotic annual grasses is directly related to grazing patterns in the area.

We further illustrate the results with an example for the Sagehen Creek watershed, which is located between and outside of the Sheldon and Hart Mountain refuges and thus is subject to grazing (Figure 24). Under the Revised Refuge Management Scenario management, the amount of exotic monoculture (red) and shrub steppe/exotic grass (green) habitats steadily increases over the next 40 years to become the dominant vegetation types within the watershed. These increases lead to a corresponding decrease in native shrub-steppe vegetation resources.

Figure 24. Example of graphical VDDT output showing change in abundance of vegetation types in the Sagehen Creek watershed, with off-refuge lands grazed and without juniper controls.

Sagehen Creek is circled in the watershed map at left and a detail of the watershed boundary and management allocation is shown at right with the key to the VDDT ownership-management allocations. The Y-axis of the graph shows percentage of each vegetation type present within the watershed. The X-axis is number of years from baseline (2010). The small area of the watershed in magenta was modeled as ungrazed, but the majority of this watershed is modeled as grazed in these results.

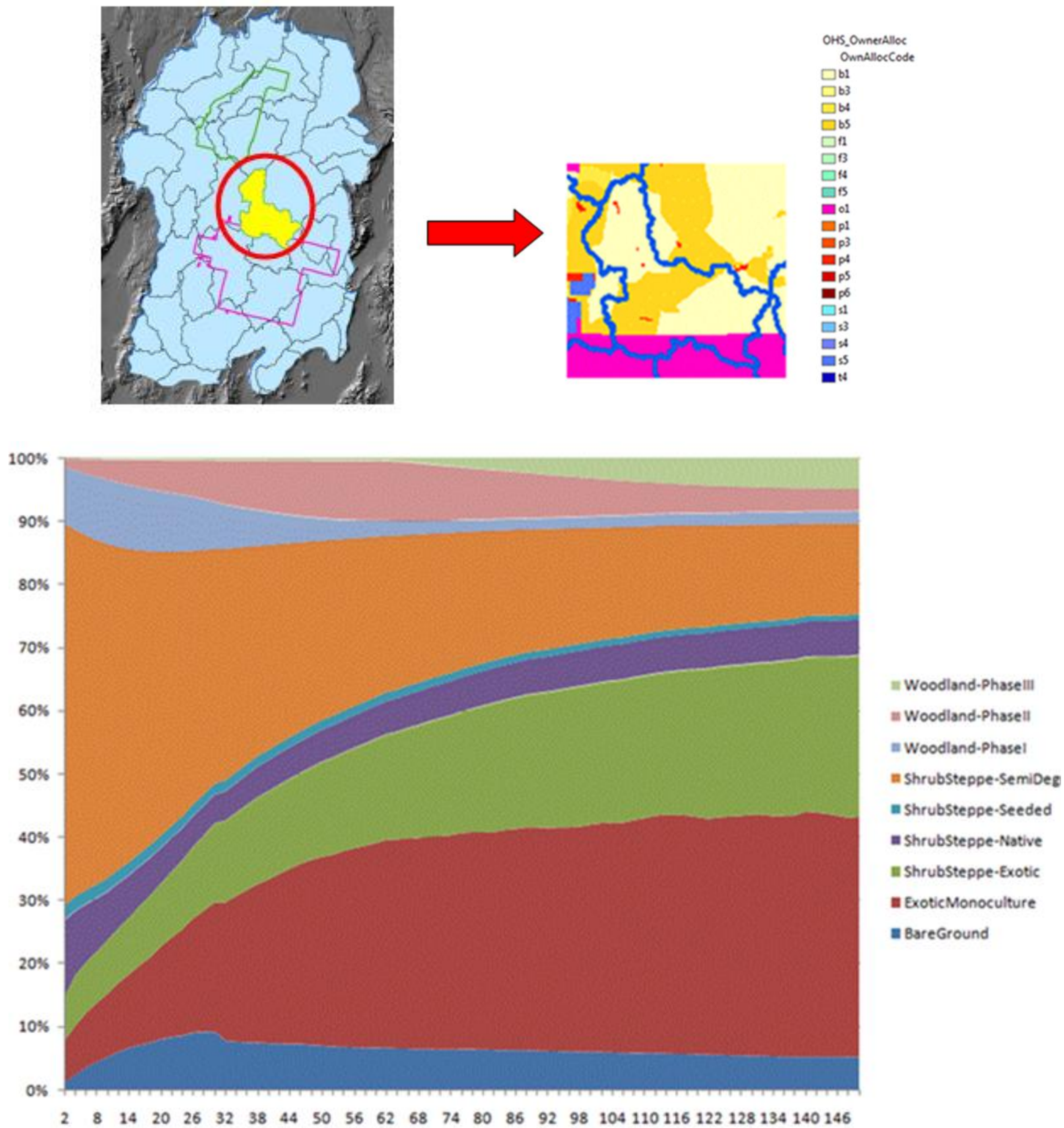


Figure 25 and Figure 26 below further illustrate how management can dramatically alter the pattern of vegetation change over time. Rock Creek and Upper Guano Slough watersheds (shown in pink) were chosen to represent Hart Mountain Refuge under the Revised Refuge Management Scenario as the majority of these watersheds fall within Hart Mountain Refuge's boundary. Both figures show change in Hart Mountain Refuge watersheds, with the first showing all the lands in these watersheds (both ungrazed lands inside the Refuge and the grazed lands outside the refuge), while the second shows only the portions of those watersheds that fall within the refuge boundary (ungrazed lands only). These provide the best evidence of how management outside of the Refuge Complex represents a significant, long-term threat for the vegetation resources of both Hart Mountain Refuge and Sheldon Refuge.

Figure 25. Vegetation changes in Hart Mountain Refuge watersheds, including all lands in and outside of the Refuge within Rock Creek and Upper Guano Slough watersheds (pink area), with grazing removed from the Refuge lands but present off-refuge, and without juniper control treatments.

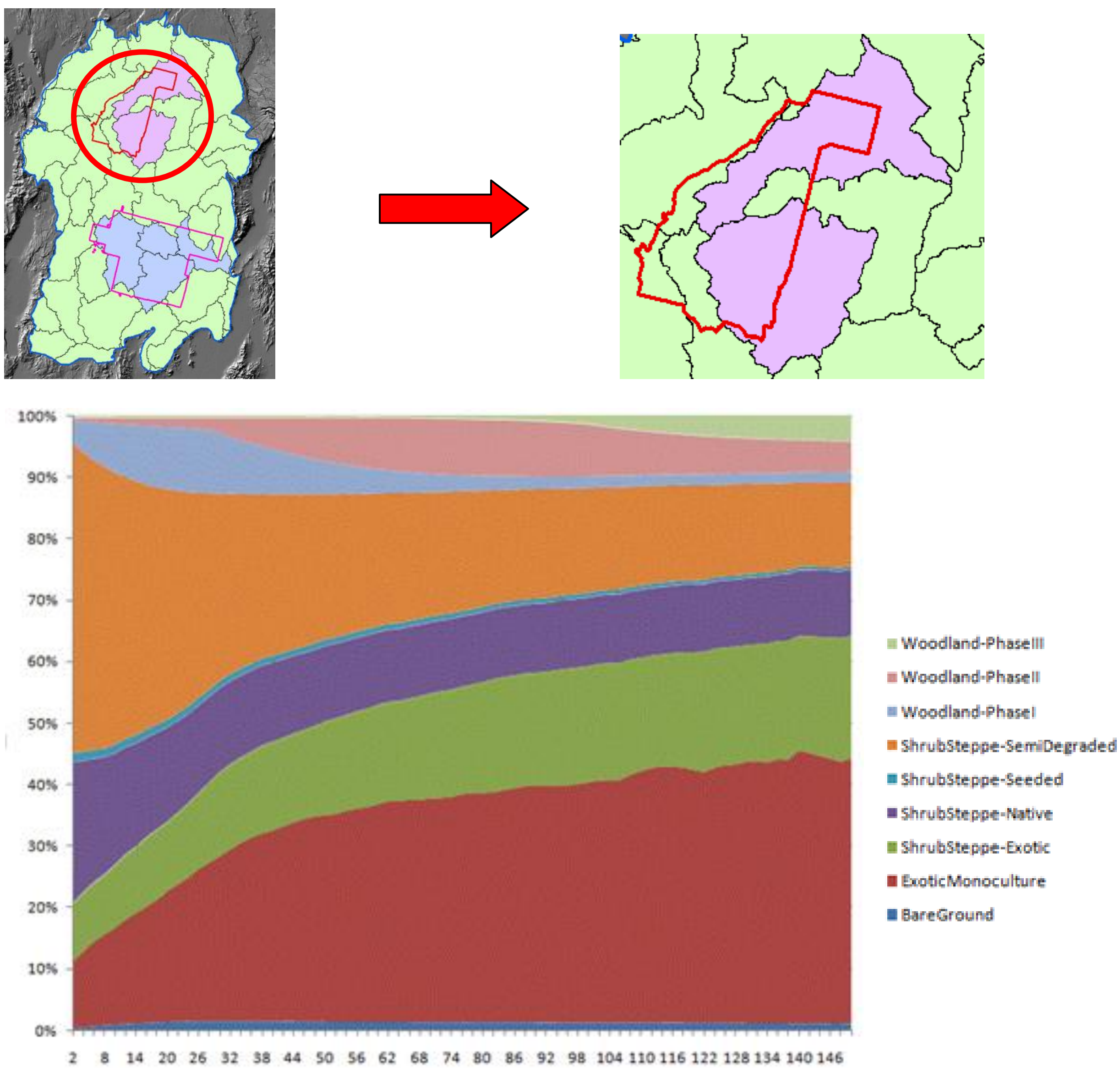
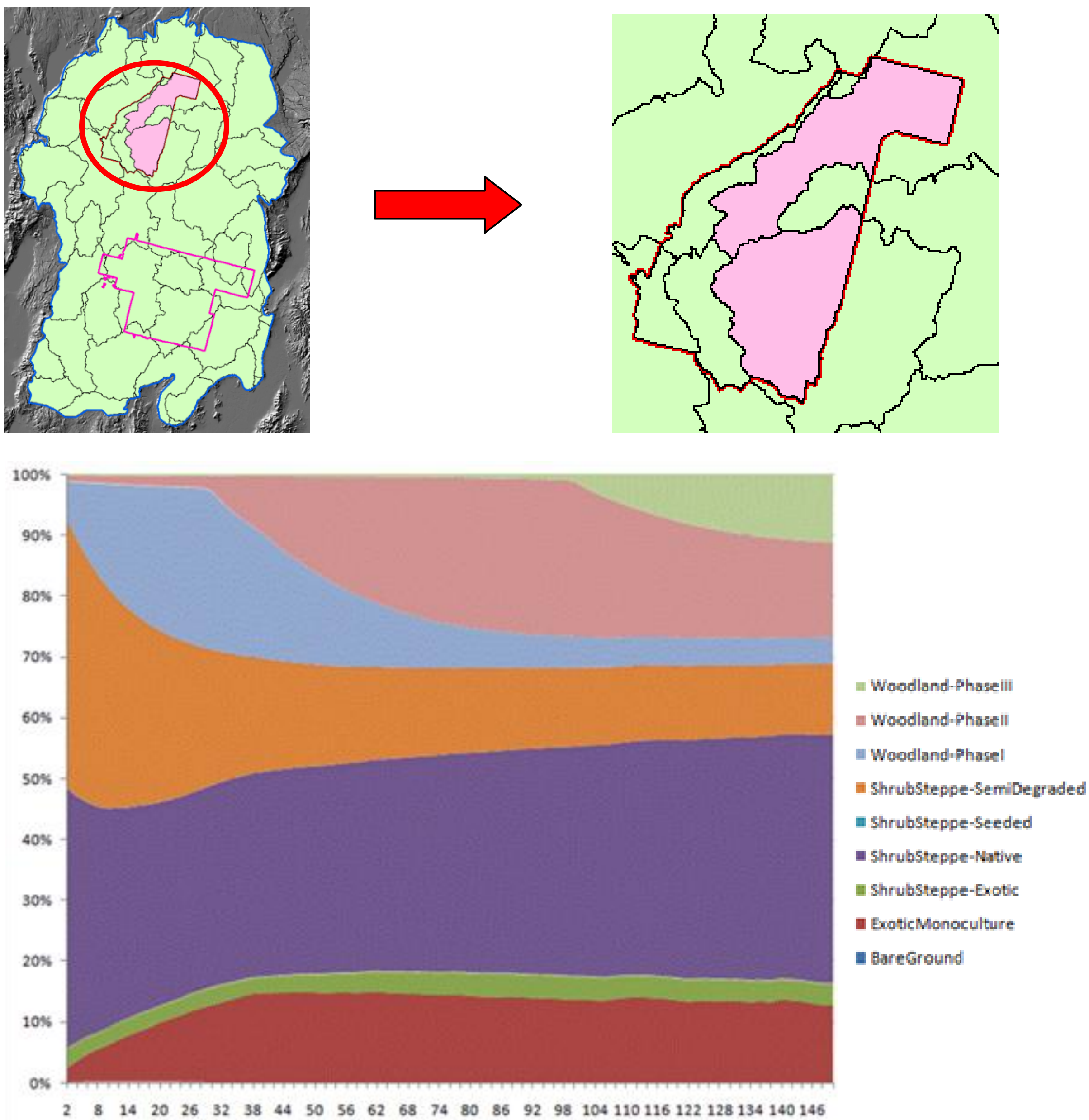


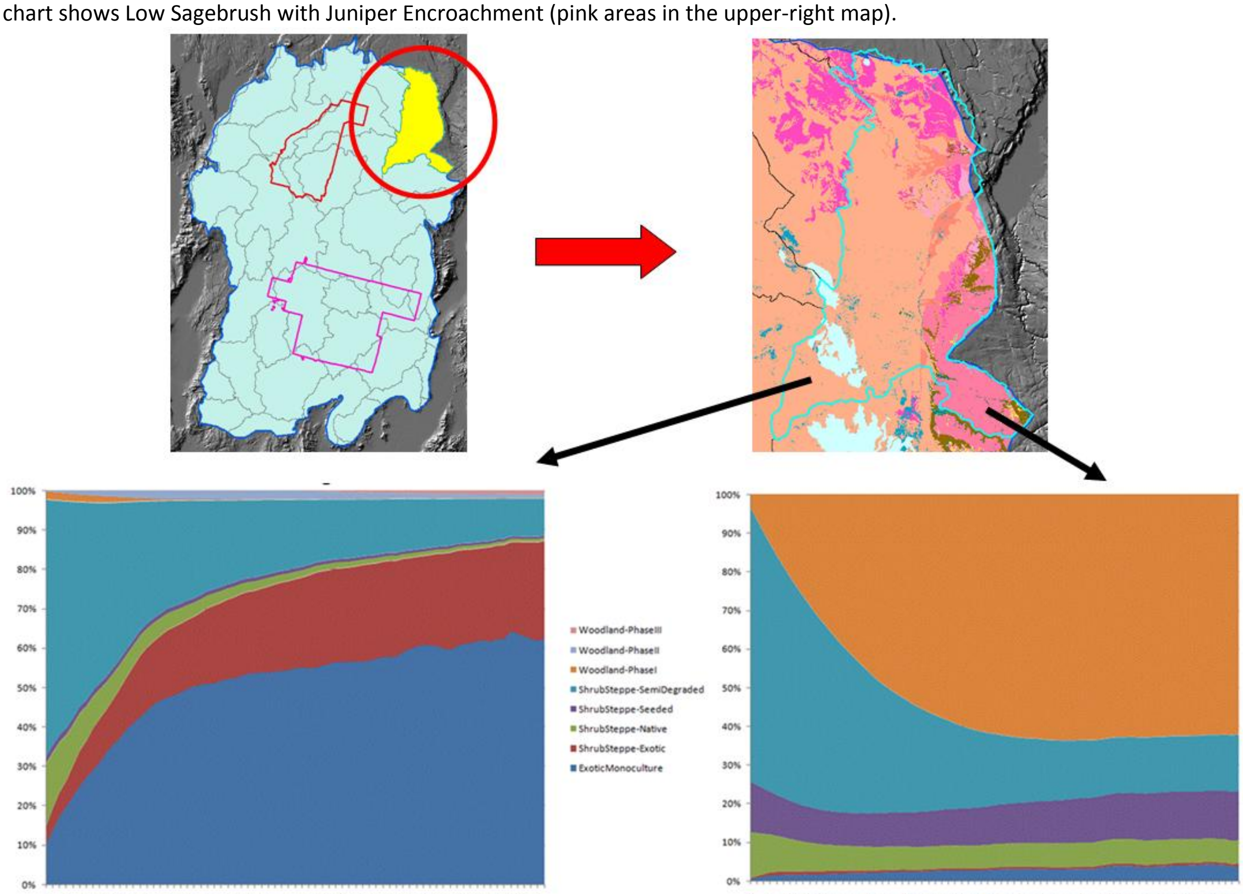
Figure 26. Vegetation changes within Hart Mountain Refuge lands, showing only the area of Rock Creek and Upper Guano Slough watersheds that fall within the Refuge boundary (pink area), with grazing removed but without juniper control treatments.



The models illustrated in these two figures for Hart Mountain Refuge do not include western juniper cutting and control, which is why juniper (Woodland Phases in graph) expansion continues to occur (Figure 26). Assuming fire and cutting continue on the refuge, Figure 26 clearly shows the long-term maintenance and even expansion of native shrub steppe, and a decline of areas dominated by weeds, including the semi-degraded shrub steppe and the cheatgrass-dominated areas (listed as exotic monoculture in the figures). However, Figure 25, which includes both the refuge lands and the areas in the watersheds outside the refuge, shows completely opposite patterns, with almost 60% of the area dominated by exotic annual grasses, either on their own or as sagebrush understories. Since these areas are on the immediate boundaries of the refuge, it suggests that working with adjacent landowners to implement conservation management actions may create a meaningful buffer against weeds, horses, burros, and livestock and thus this is an important management strategy to consider.

The VDDT outputs can also be used to show how changes may impact individual vegetation types within a watershed. Figure 27 shows how different vegetation types within a Potential Vegetation Type in a watershed may change over time. Since this example watershed is near the boundary of Hart Mountain Refuge, it also helps identify potential threats to the refuge that may occur from adjacent lands.

Figure 27. Changes to two potential vegetation types within lands in the Walls Lake Watershed.
The Walls Lake Watershed is highlighted in yellow in the upper-left map, and a close-up of the watershed with the potential vegetation types is on the upper right (PVT types are shown in greater detail in Figure 13). The chart on the bottom left shows vegetation change over time to the Wyoming Big Sagebrush PVT (peach areas in the upper-right map), while the bottom right chart shows Low Sagebrush with Juniper Encroachment (pink areas in the upper-right map).



In Figure 27, the peach areas in the upper right-hand watershed map are those with Wyoming big sagebrush potential vegetation on the edge of the project area. With continued grazing over time, these lands change from being dominated primarily (>60% of the area) by Wyoming sagebrush with a native and exotic mixed understory (semi-degraded shrub steppe, shown in the turquoise area of the chart on the bottom left) to an area with over 70% dominated by exotic annuals (blue and maroon areas of the chart on the left). The low sagebrush areas (pink area in watershed map) show major changes from areas with almost no juniper invasion (5%) (green area of chart on the bottom right) to juniper-invaded low sagebrush steppe (>60%) (orange area of chart on the bottom right).

Vegetation Resources Assessment Methods

VDDT Modeling of Vegetation Changes

The non-spatial assessments utilized the Vegetation Dynamics Development Tool (VDDT) available from ESSA Technologies (ESSA 2010). This tool allows users to define transitions between vegetation types and vegetation condition (state classes) caused by fire, grazing, disease, natural succession, or other factors to model the changes in relative abundance of these vegetation types over time. Relevant vegetation dynamics models created and modified by ORBIC staff for the states of Oregon, Washington, Arizona, and New Mexico for ILAP were applied to the Sheldon-Hart project area. New Gradient Nearest Neighbor (GNN; see Ohmann and Gregory 2002) condition data and Potential Natural Vegetation data were created for the Nevada portion of the project area, combined with existing results for Oregon, and analyses were completed for the entire project area. Details on the methodology for creating the data and the detailed models are available at http://oregonstate.edu/inr/ilap, and a description of the creation of the aggregated geodatabases used for the VDDT models is included in Appendix J.

Since transitions between vegetation states are partly dependent on how the land is managed, VDDT models are run on ownership – management allocations within the watershed(s) being modeled. The USGS Gap Analysis stewardship categories (1-4) were used for ownership – management categories, with 1 being assigned to lands that are completely protected and 4 representing private lands with no management plans (USGS 2011). Additionally two more codes, 5 and 6, were added to represent Modified – Public Land and Modified – Private Land, respectively. The ownership/management allocations used in the VDDT analyses are shown in Figure 28 and an explanation of the codes used is listed in Table 16. All VDDT models were run using the Revised Refuge Management Scenario with grazing occurring off-refuge and excluded on-refuge, with and without juniper control treatments.

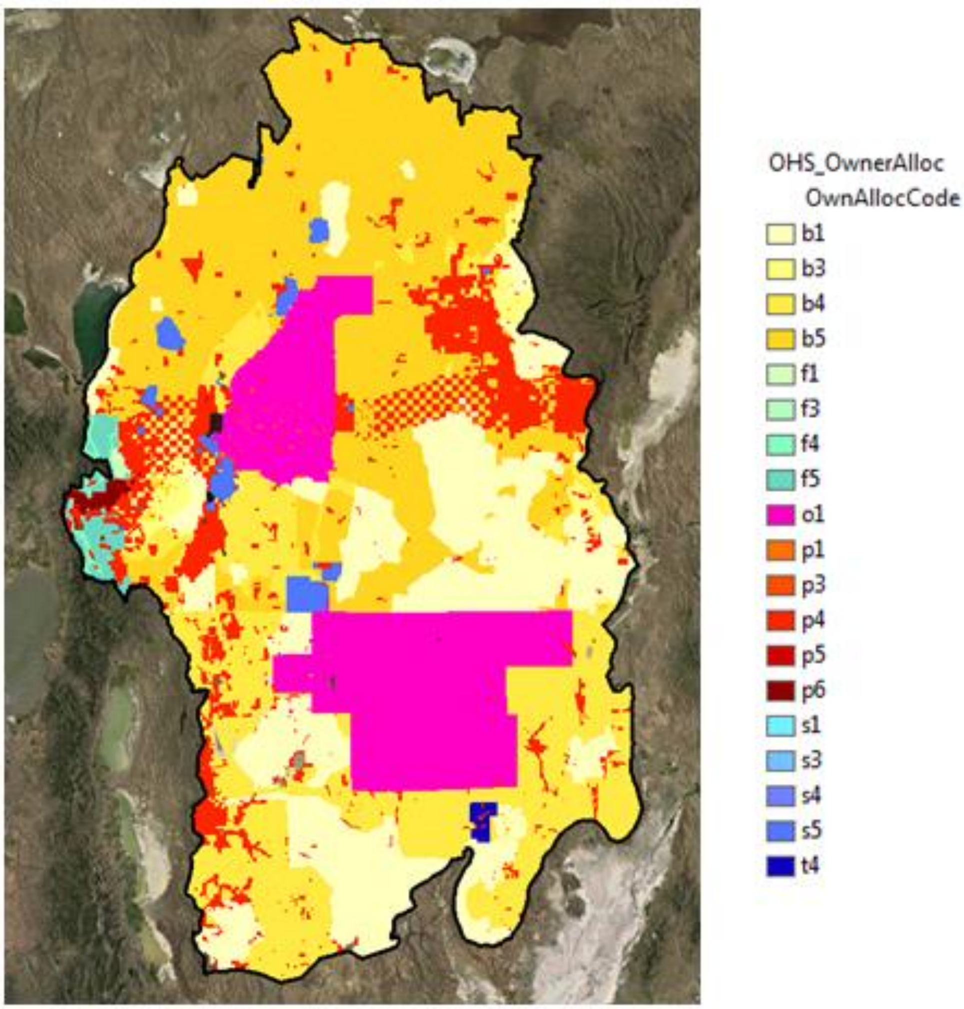
Table 16. Definition of ownership/allocation codes used to determine management type in VDDT modeling.

OwnAllocCo	Owner Name	MgmtName
b1	BLM	Protected & Preservation
b3	BLM	Retention
b4	BLM	Partial Retention
b5	BLM	Modification
f1	USFS	Protected & Preservation
f3	USFS	Retention
f4	USFS	Partial Retention
f5	USFS	Modification
s1	State	Protected & Preservation
s3	State	Retention
s4	State	Partial Retention

OwnAllocCo	Owner Name	MgmtName
s5	State	Modification
p1	Private	Protected & Preservation
p3	Private	Retention
p4	Private	Partial Retention
p5	Private	Modification
p6	Private	Modification - Private
o1	Other Public	Protected & Preservation
t4	Tribal	Partial Retention

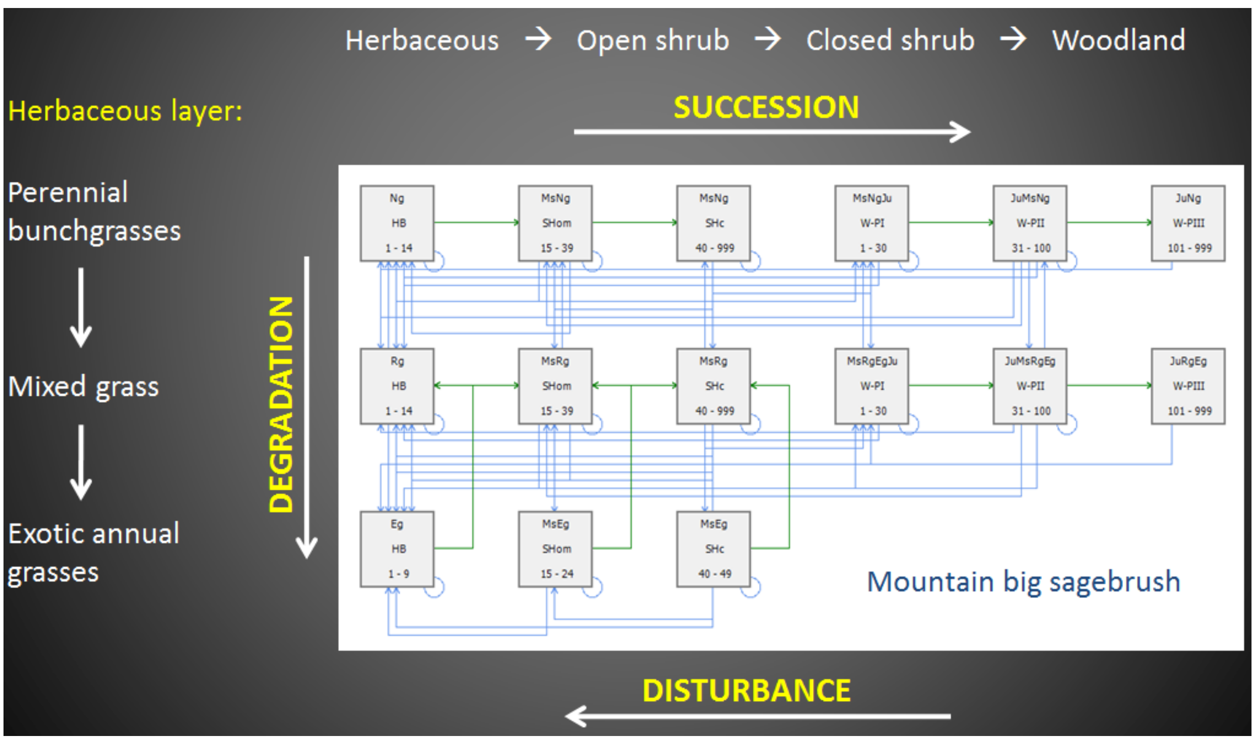
Figure 28. Ownership/management allocation used in the VDDT analyses.

Ownership/management allocations under the Revised Refuge Management Scenario are shown on the left, with the conservation management areas of the Refuge Complex shown in magenta. Abbreviations: b=BLM, f=USFS, o=Refuge, p=Private, s=State, t=Tribal. 1-6=GAP code, with 1=greater conservation management focus.



The Mountain Big Sagebrush VDDT model developed by ILAP serves as an illustration of a VDDT model in Figure 29. The blue lines are the transitions between one vegetation state and another, while the boxes are the different seral states or vegetation condition types modeled. The transitions and their probability of occurrence were developed based on growth rates and fire frequencies that are available from the last 30 years of field data at the Monitoring Trends in Burn Severity (MTBS) project (http://www.mtbs.gov) (USFS and USGS 2011). The potential range of vegetation states that can occur in this habitat are shown. The good condition, non-degraded states are shown in the boxes across the top row of the figure, with perennial bunchgrasses representing native understory. The bottom row shows the states that are dominated by exotic annual or perennial grasses representing a degraded understory. The middle row of boxes show mixed grass states representing an intermediate condition termed "semi-degraded" in this assessment, but which could equally well be referred to as "semi-recovered." Viewing the figure from left to right, the columns of boxes on the left side represent the early seral states which occur immediately following a major disturbance, moving to increasingly closed canopies as succession occurs towards the right. Moving from right to left, disturbance acts to move the vegetation backwards along this succession path.

Figure 29. Mountain big sagebrush VDDT model.



The VDDT models generate a table listing the percentage of land in each ownership/management combination within a watershed that will be in various vegetation states (or state classes or boxes as shown in Figure 29) over time. Although the outputs are not spatially explicit (one cannot determine if a given point will be in a particular vegetative condition), these results can be shown spatially as relative percentages of occurrence in each ownership/management/vegetation state combination in a watershed over time. This permits the illustration of patterns across the landscape, highlighting areas of greater probability for various types of change.

Revised Refuge Management Scenario with Juniper Control Parameters

To make the analysis more straightforward, the VDDT models used one set of management assumptions for all refuge lands and another set for all non-refuge lands. All livestock, horse, and burro grazing was excluded on all refuge lands, including the successful removal of horses and burros from Sheldon Refuge (the magenta o1-coded ownership allocations shown in Figure 28). The VDDT models also addressed the fact that the U.S. Fish and Wildlife Service intends to prevent western juniper expansion on the refuge, by creating an additional restoration treatment scenario and applying it to all refuge lands in the VDDT models along with the removal of livestock, horses and burros. For this variation of the Revised Refuge Management Scenario, the VDDT models were modified to include:

- Prescribed fire
- Juniper cutting
- Combination of prescribed fire and cutting
- Seeding of native species into areas of cheatgrass monocultures

The restoration treatments varied by state class as listed here:

- **Phase I juniper**: burn 3% of phase I juniper annually using prescribed fire.
- **Phase II juniper**: treat 6% of phase II juniper annually divided between 50% prescribed fire and 50% cutting.
- **Phase III juniper**: treat 9% of phase III juniper annually using prescribed fire, cutting, and the combination of prescribed fire and cutting. Note that most juniper will likely either not have enough time to reach phase III or will be treated before it reaches phase III, so these treatments are not very likely to be expressed in the models.
- **Exotic grass**: seed with native species within 1 year of fire, assuming a 75% success rate of conversion back to natives. No seeding happens at all except within 1 year of fire.

Note that all treatment rates are described as the percent of pixels in a particular state class (or group of states) in the VDDT outputs, not as a percent of the entire landscape. Treatment rates originated from Louisa Evers at the BLM Oregon State office. The VDDT model outputs change for each year, so results can be shown yearly from 2000 to 2100.

Vegetation Resources Assessment with Climate Change

Overview

New methods to link VDDT and climate models are being developed at Oregon State University and for the ILAP project. For this RVA, the CSIRO and MIROC models were linked to the MC1 Global Dynamic Vegetation Model developed by Neilson et al. at Oregon State University and tied to the VDDT models in order to predict vegetation change from 2000 to 2100 under the influence of both climate change and grazing. While juniper control could be incorporated into the climate change models, the climate results presented here do not include juniper control; this is because we chose to highlight the Sagehen Creek Watershed where juniper invasion is not a major threat. Details on the methods used for the climate modeling are found at the end of this Vegetation Resources Assessment with Climate Change section, and additional detail on the methods used to create these models is provided in Appendix K.

As described in the Approaches section, the climate change analyses were conducted using broader vegetation types than the ten Potential Vegetation Types (PVTs) summarized in Table 15 previously. For the climate change analyses, these vegetation types were aggregated into four major types: mountain big sagebrush, Wyoming big sagebrush, grasslands and salt-desert scrub. These types were assessed using the CSIRO climate model from Australia and the MIROC climate model from Japan, both of which focused on identifying short-term changes in climate. Eventually, we hope to also obtain results from the Hadley model, which may be more reliable for forecasting long-term changes.

Impacts of Management on Vegetation Resources with Climate Change

Figure 30 and Figure 31 represent the outputs of these models summarized for all the watersheds in the supporting landscape, leaving out the coniferous forests in the upper parts of the watershed. They illustrate the impacts of projected climate change on the proportion of the four vegetation types present across the supporting landscape. (Because most of the supporting landscape is currently grazed and has little juniper control and these models were run for the entire landscape based on current conditions, they assume that grazing occurs throughout and juniper is not controlled). The sharp jumps show annual variation in vegetation proportions, usually as a result of a year with many large-scale fires. However, the long-term trends in the vegetation resources are the most important to understand, not the year to year variations.

Figure 30. Changes in area of major vegetation types for the entire supporting landscape as predicted by the CSIRO climate model and MC1.

Grazing is assumed to occur throughout the landscape (which includes the Refuge Complex).

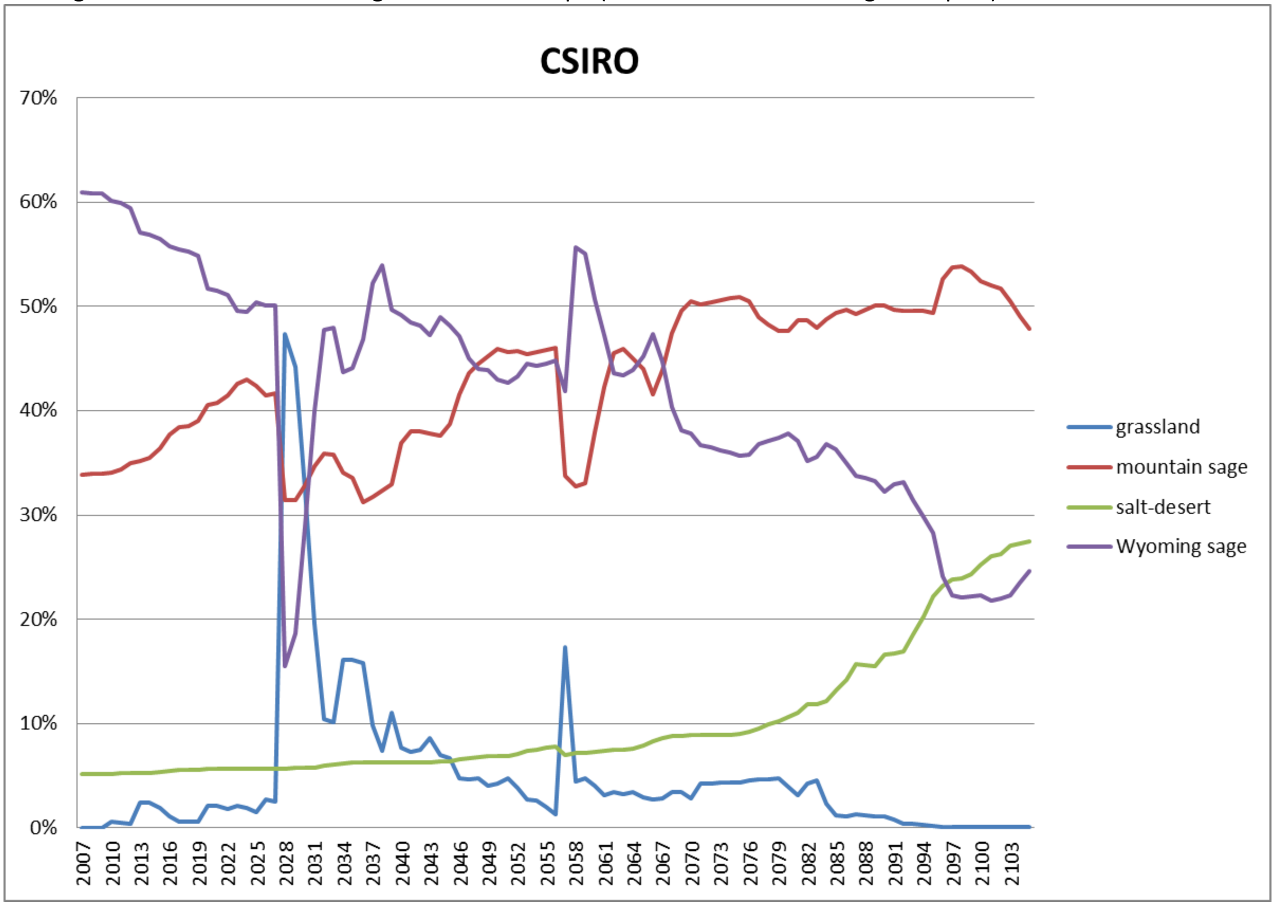
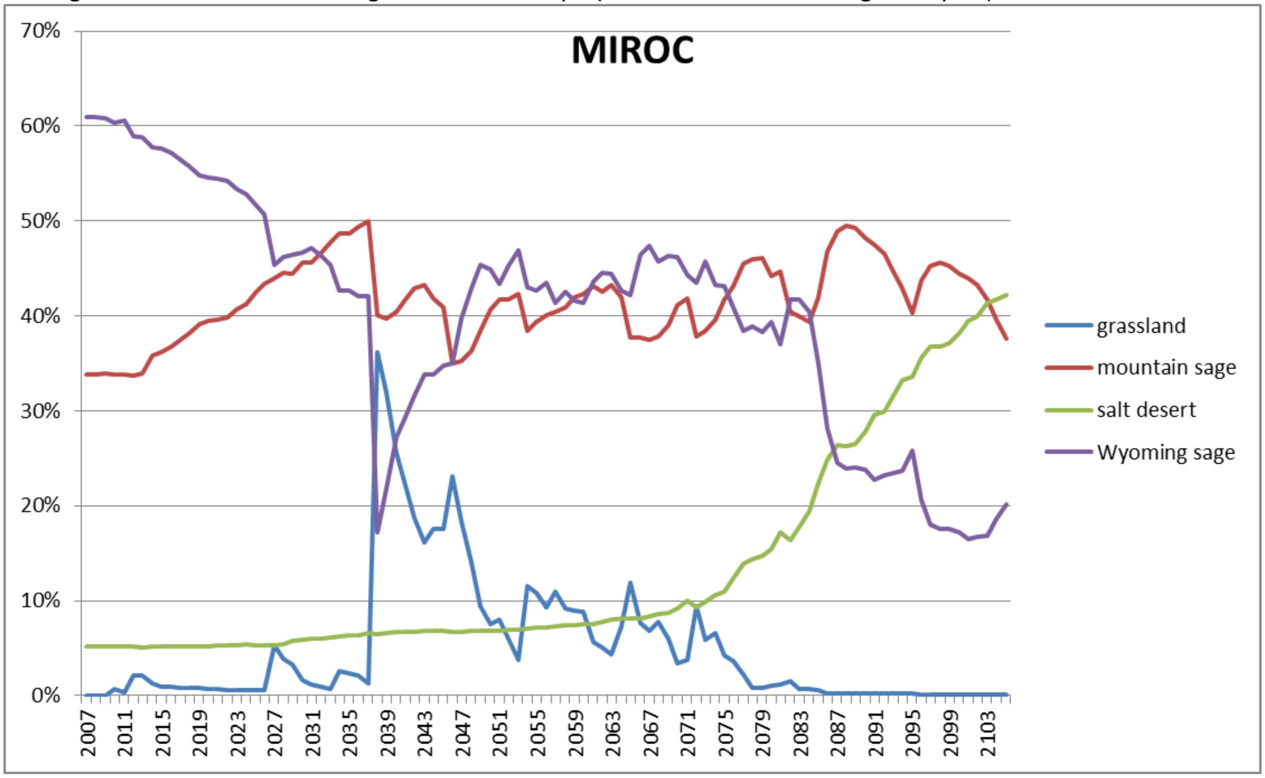


Figure 31. Changes in area of major vegetation types for the entire supporting landscape as predicted by the MIROC climate model and MC1.

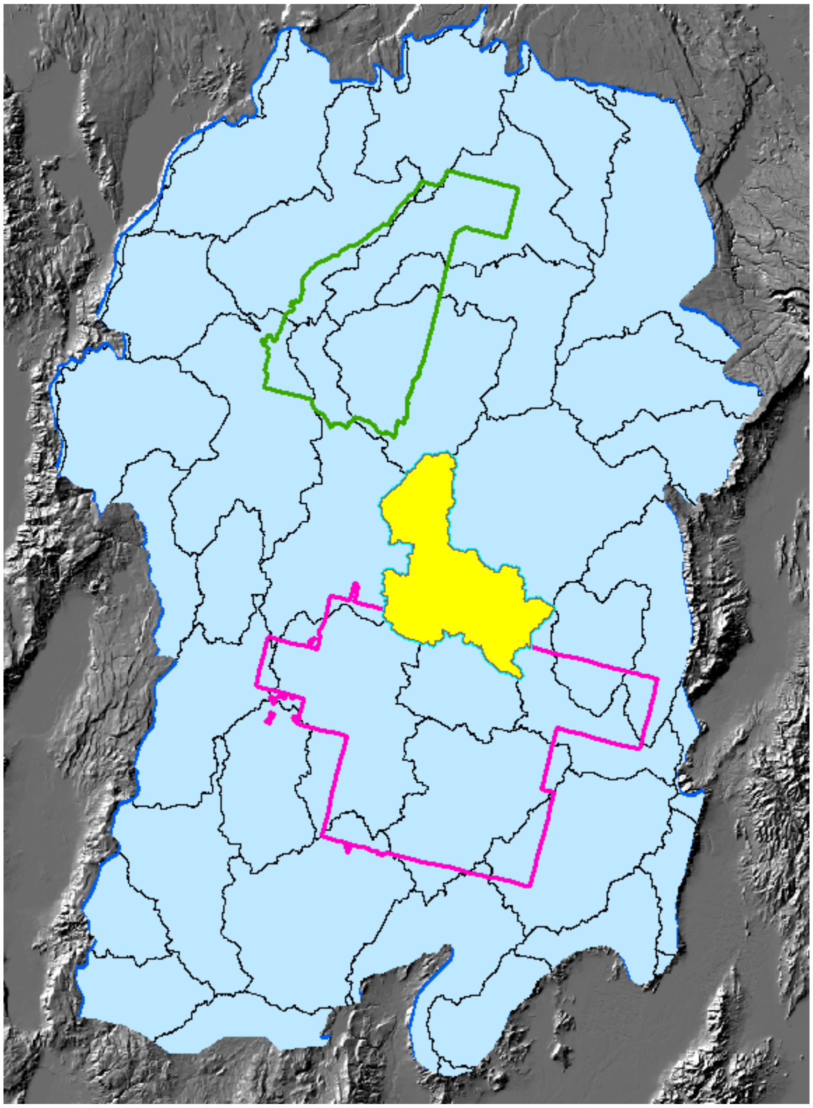
Grazing is assumed to occur throughout the landscape (which includes the Refuge Complex).



Both of these climate models show significant declines in the proportion of the landscape dominated by Wyoming sagebrush over time, with a large increase in salt desert scrub habitat and a smaller increase in mountain big sagebrush. The proportion of grasslands varies, mostly increasing after fires and then decreasing again. The CSIRO models shows the Wyoming sagebrush declining from 60% of the landscape over time, to 22% of the area, while salt desert scrub increases from 5% to 25%. The MIROC changes are similar but larger, with Wyoming sagebrush decreasing to 17% and salt desert scrub increasing to 38% of the landscape. Both models also show mountain big sagebrush (which includes the mesic low sagebrush habitat in this analysis) increasing, from 34% to 52% in the CSIRO model and to 44% in the MIROC model.

However, since the lands on the refuges are managed very differently than the non-refuge lands, and since land management is able to significantly change the condition of vegetation resources, we also looked at how the model results would vary with all grazing removed. To illustrate these management effects, we focused on identifying specific changes in vegetation in the Sagehen Creek watershed (Figure 32), one of the large watersheds between the refuges, under two different management regimes: grazing vs. non-grazing.

Figure 32. The Sagehen Creek watershed, highlighted in yellow, used as an example to illustrate vegetation change under the CSIRO and MIROC climate models.



The following set of figures illustrates the predicted impacts of the combination of climate change and management on vegetation in the Sagehen Creek watershed. The first two figures (Figure 33 and Figure 34) show how the areas or relative proportions of the four main non-forested habitat types in the watershed change over time under the two management scenarios (grazed and ungrazed) and under each of the climate models (CSIRO and MIROC).

The subsequent four figures show how the condition of the components of a single vegetation type, Wyoming big sagebrush, changes in the watershed based on the two climate models and management scenarios. This is important because both the conditions of the habitats and the area they occupy respond differently to the different climates and management regimes. Wyoming big sagebrush was selected because it is a resource of management concern, but similar data was produced for all of the vegetation types in the watershed.

Figure 33. Amount of the four primary vegetation types in the Sagehen Creek under CSIRO climate predictions with grazing present.

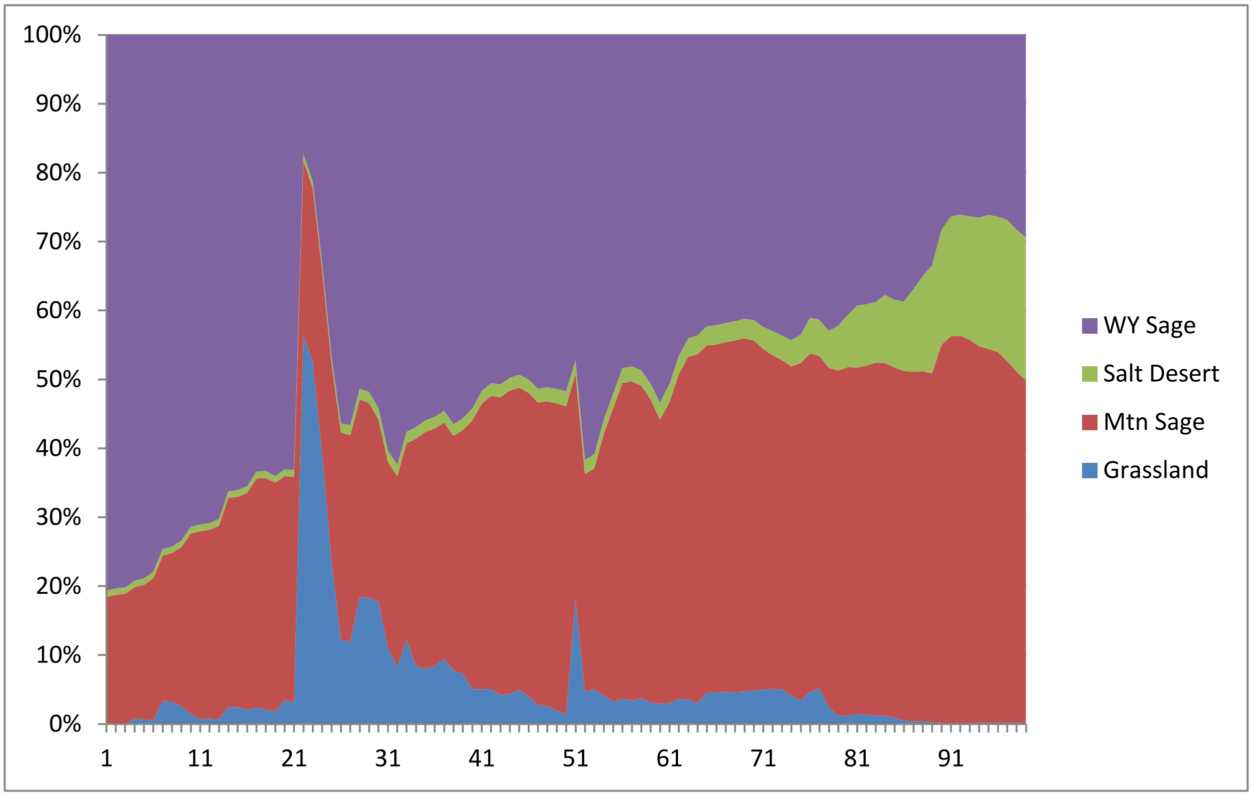


Figure 34. Amount of the four primary vegetation types in the Sagehen Creek under CSIRO climate predictions and no grazing present (left), under MIROC predictions with grazing present (center) and under MIROC with no grazing present (right).

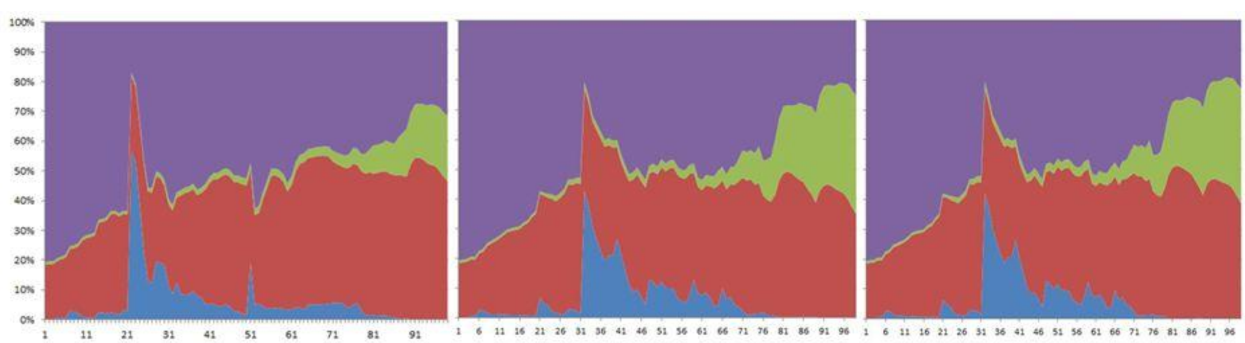


Figure 33 and Figure 34 above show very significant declines in areas of Wyoming big sagebrush habitats over time, with corresponding increases in areas of salt desert scrub, and a small but significant increase in area of mountain big sagebrush. Salt desert is a very minor part of this landscape currently, but the climate models show these areas increasing to over 20% of the landscape. They also show that the amount of each habitat does not change substantially based on the different management treatments. The MIROC model shows significantly more warming, with greater declines of Wyoming sagebrush and greater increases in salt desert scrub than the CSIRO model, but the overall trends are the same.

The four figures below show the differences in the condition of the components of the Wyoming sagebrush habitat under the same CSIRO and MIROC climate models, and the two management scenarios (grazed and ungrazed). As is the case in the amount of the different habitats, there are differences between the two climate models, but the trends are basically the same. However, unlike the figures above showing the change in *proportions* of the four non-forest types, when examining the change in *condition* of the Wyoming sagebrush components in this watershed, we see markedly different results between the grazed and ungrazed management regimes.

Figure 35. Changes in condition of the Wyoming Sagebrush habitats in the Sagehen Creek Watershed under the CSIRO-predicted climate regime, with grazing present.

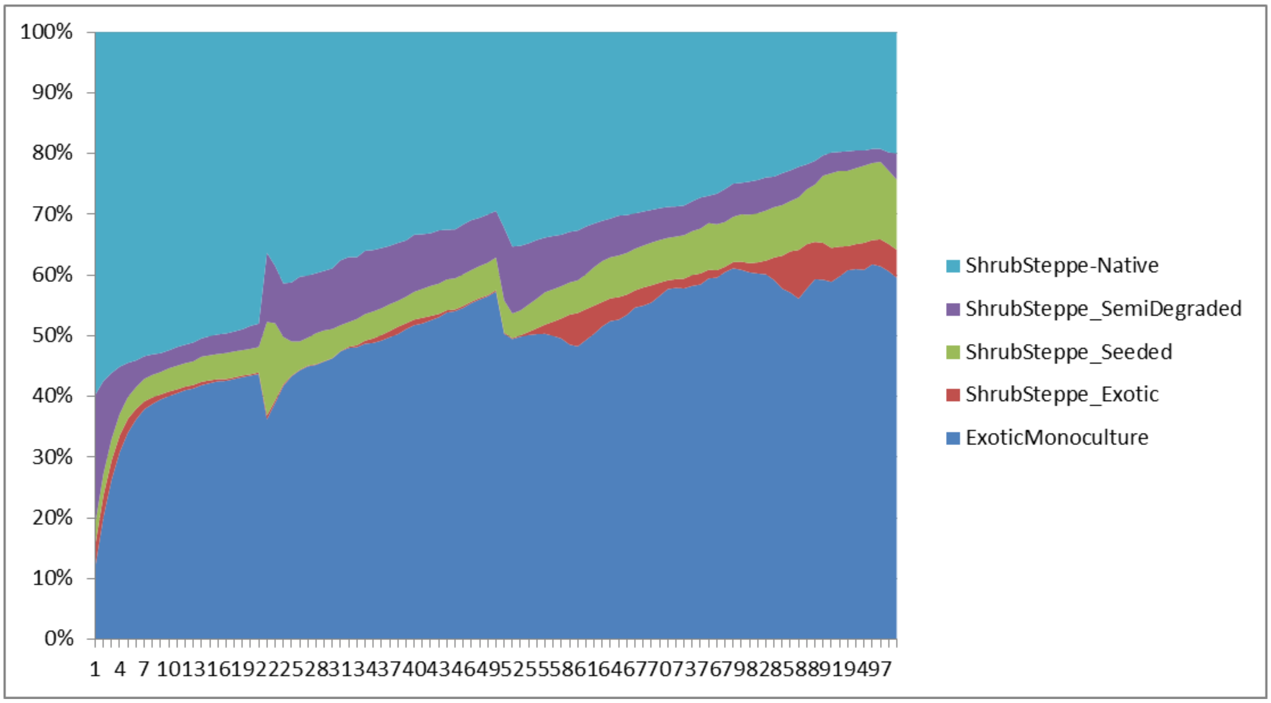


Figure 36. Changes in condition of the Wyoming Sagebrush habitats in the Sagehen Creek Watershed under the MIROC-predicted climate regime, with grazing present.

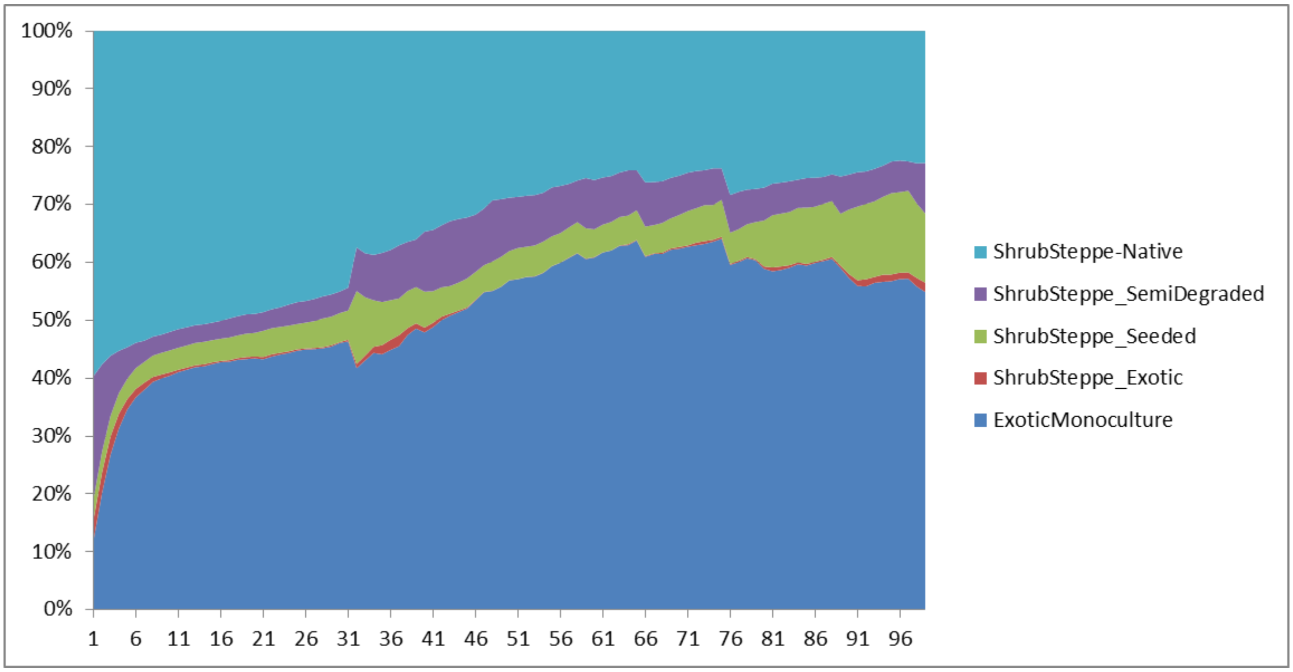


Figure 37. Changes in condition of the Wyoming sagebrush habitats in the Sagehen Creek Watershed under the MIROC-predicted climate regime, without grazing.

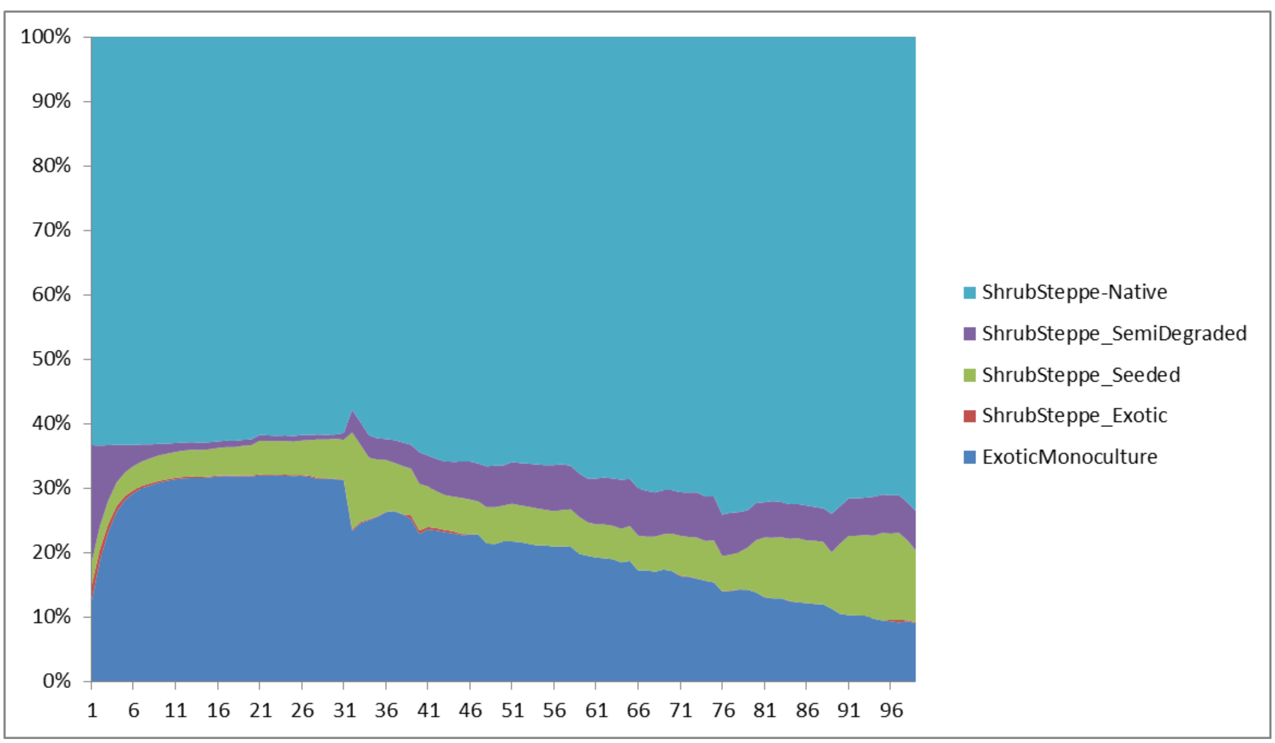
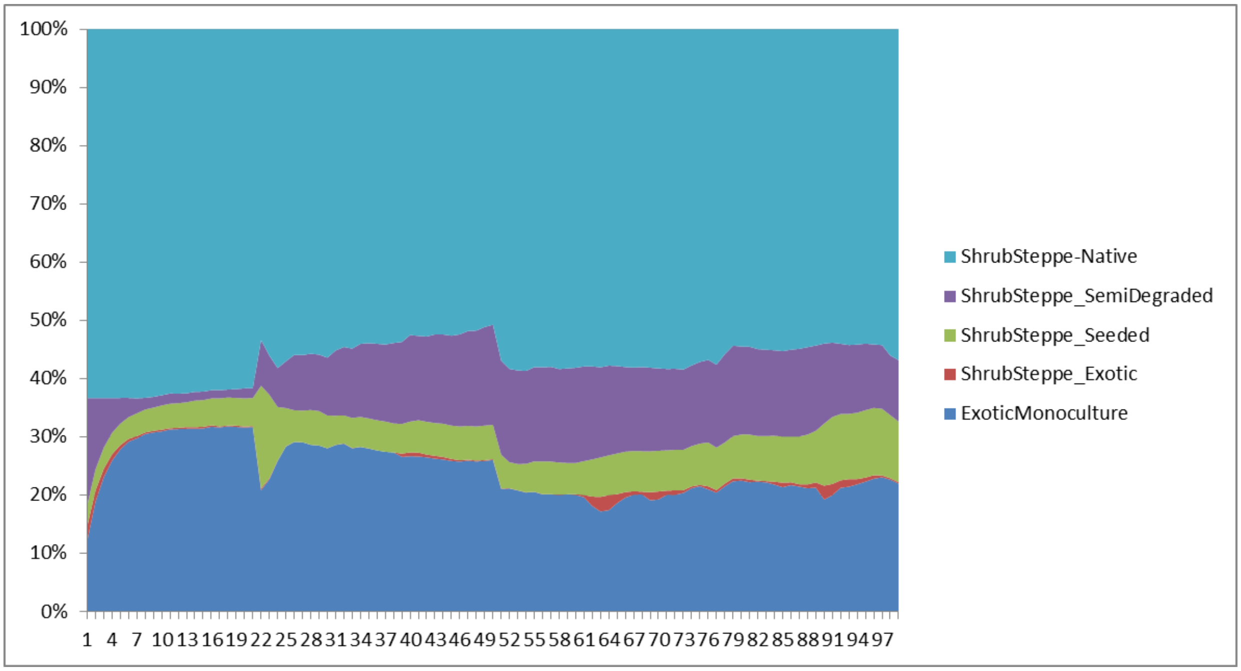


Figure 38. Changes in condition of the Wyoming sagebrush habitats in the Sagehen Creek Watershed under the CSIRO-predicted climate regime, without grazing.



While management appears to make limited difference in the proportion of habitats, the models suggest it does make a difference in their condition. Without grazing and with projected climate change, over 60% of Wyoming sagebrush habitats are in good condition and are over 70% dominated by native species. By contrast, with grazing remaining on the landscape, barely 30% of the Wyoming sagebrush habitats are dominated by native understory species, while most of the limited remaining habitat is dominated by invasive species.

It is important to keep in mind these are early results of a very complex model, using relatively coarse climate data. Because these are preliminary results, only the major trends are likely to be reflective of changes that are likely to occur. Work currently underway includes improving the capacity of the models to incorporate more detailed current conditions into the climate change analyses and linking wildlife habitat attributes for target species to the climate change model outputs in order to predict wildlife population increases or decreases over time. The first initial model for the greater sage grouse has been created, which defines 1) the suitable condition classes (or boxes) for the VDDT models, 2) the areas in which the species occurs, and 3) the habitat attributes, such as shrub density, presence and cover of understory species (both native and introduced), and the presence and amount of western juniper.

Vegetation Resources Assessment with Climate Change Methods

We applied climate change models to assess potential effects of changing climate on the major vegetation in the project area into the next century. The models were developed by The Commonwealth Scientific and Industrial Research Organization (CSIRO) and the Model for Interdisciplinary Research on Climate (MIROC). The CSIRO model was compiled by the Australian Weather Service (Gordon et al. 2010) and represents a middle-of-the-road climate model. The MIROC model is from Japan (Nozawa 2007) and is generally considered to be a fairly conservative model, best used for predicting short-term climate changes. These are the only climate models that have been linked and calibrated to reflect vegetation changes by OSU in their MC1 Global Dynamic Vegetation Model (Neilsen 1995, Bachelet et al. 2001). The Institute for Natural Resources team is currently working on adding a third climate model, created by the Hadley Centre for Climate Prediction and Research at Oxford, England, but these results will not be available until March of 2012.

All three of the models show significant warming occurring in the area. However, the CSIRO and MIROC models show initially an increase in spring and summer precipitation, leading to generally more mesic vegetation types. While the Hadley model has not been run for the Sheldon-Hart landscape, in the adjacent east Cascades of Oregon, it showed significant reductions of moisture. If these reductions in moisture were modeled for the Sheldon-Hart area, it would alter the results of this vulnerability assessment. This highlights the uncertainty that can be associated with this kind of modeling. While scientifically rigorous models can provide the best available data to inform management decisions, it is important to monitor the actual observed variables against the projected variables. If management policies in the Sheldon-Hart area are revised in light of these model results, actual climate trends should be monitored relative to the projected trends that informed the management changes, so that management practices may be re-evaluated and updated if reality does not match projections.

For this analysis, the OSU MC1 model has been linked to the major vegetation types used in the VDDT models. As a result, the models can predict changes in areas of different vegetation types and major classes within the 10-digit HUC analysis units. In addition, the climate models are run for only the predominant types in the project area, including Mountain big sagebrush, Sagebrush, Salt Desert Scrub, and the major forest types. Some important types in the analysis area, including low sagebrush, have been merged into one of these two sagebrush types, reducing the level of detail described in the results.

The model outputs are preliminary. The climate models use coarse, 8-km climate grids. (The ILAP Climate Change Team has developed 800-meter downscaled grids for an analysis in central Oregon and southern Arizona, but these are not yet available for other areas. When the 800-meter data become available, they will be more appropriate for assessing and reporting on individual management allocation areas.) Because the current data are coarse, the climate model outputs show only summary data for all lands within a watershed; the model assumes that all of the lands within a given watershed are managed in the same way. Consequently, for the climate portion of this assessment, the models were run with grazing and no-grazing scenarios applied across watersheds or groups of watersheds.

Chapter 4. Alternatives, Goals, Objectives, and Strategies

This RVA project was primarily focused on assessing the impacts of stressors on refuge resources at various points in time under various scenarios. Because the Refuge Complex already has one completed CCP and an updated CCP in progress, we also assessed the stated CCP objectives and strategies (to the extent possible at the time of the assessment) for potential revisions in light of these assessment findings. The following strategy recommendations do not represent CCP alternatives but are intended to inform the development of alternatives or management actions consistent with adopted alternatives depending on the status of the CCP. Since many possible alternative strategies are feasible, our objective in this chapter is to illustrate the process for alternative development and assessment.

Strategy Development Process and Options

Connectivity Scenario

To illustrate the process of developing and assessing management alternatives based on RVA results, an alternative management scenario was identified and assessed. The assessment results showed that removal of grazing and control of juniper and invasive species had substantial positive impacts on priority resources. Therefore, an alternative scenario that excludes grazing and includes juniper and invasives control in additional areas was designed and evaluated to determine what impacts it might have on refuge resources. This scenario is referred to as the “refuge connectivity scenario” or “connectivity scenario.” This scenario assumed that management both on the Refuges and on some public lands between or adjacent to the Refuges followed a combination of the Revised Refuge Management scenario used in Vista and the corresponding scenarios used in VDDT and the climate model. In other words, grazing was removed both from the Refuges and the public lands directly between them, and active management to control invasives and juniper expansion was implemented in these areas in the VDDT models. This scenario was assessed using all three modeling tools (Vista, VDDT and the climate model). The cumulative impacts of spatially explicit stressors were characterized, and the changes in vegetation with and without climate change were identified.

Scenario Name	Scenario Summary
Vista Connectivity Scenario	**Management**: Revised Refuge Management on Refuge lands (removal of horses/burros and some Sheldon Refuge roads closed), and removal of grazing in the Connectivity Area, a hypothetical area between the Refuges and some adjacent public lands **Other stressors** (not resulting from management policies): Those stressors present in 2010, plus energy infrastructure projected for 2025, increased non-native annual grass cover
VDDT Connectivity Scenario	**Management**: Grazing does not occur and juniper is controlled on the Refuge Complex, and this management is also applied to the Connectivity Area, a hypothetical area between the Refuges and some adjacent public lands
Climate Connectivity Scenario	**Management**: Grazing does not occur on the Refuge Complex watersheds, and this management is also applied to the Connectivity Area watersheds, a hypothetical area between the Refuges and some adjacent public lands

This scenario was developed from the 2025 Revised Refuge Management Scenario described earlier because it is most similar to the types of management changes proposed in the Draft Sheldon CCP alternative scenario. Using this scenario as a starting point, we identified areas that could potentially improve connectivity between the two refuges and between the refuges and nearby habitat areas, if proposed refuge resource management policy (mainly, excluding or restricting grazing and managing for conservation of wildlife and habitats) was extended to adjacent federal and state lands. Private lands were excluded from management changes in the connectivity scenario (a few small inholding areas were inadvertently included), although other programs such as NRCS and private conservation organization programs could be applied to those areas to address potential spread of stressors such as invasive species and juniper encroachment. We did not propose removal of the West-Wide Energy Corridor in this scenario, although it is relatively simple to add or remove features from any scenario and reassess the outcomes using the Vista software. Alternative compatible management was targeted for lands that 1) have a relatively high density of conservation resources present based on the Conservation Value Summary (Figure 15), and 2) are publically owned. . This scenario is not meant to be viewed as a formal policy alternative but was developed simply as a way to assess effects on priority resources suing this set of management assumptions. In other words, it is an exploratory, “what-if” scenario. The large block of blue in Figure 39 represents the extent of the theoretical no-grazing, conservation management area assessed by this scenario.

The distribution of stressors in the Vista Connectivity Scenario is shown in Figure 39. When compared to the landscape condition model for the 2025 Revised Refuge Management Scenario (Figure 20), the landscape condition under the Vista 2025 Connectivity Scenario (Figure 40) significantly improves in the connectivity areas (e.g., the brown areas to the north and south-west of Sheldon Refuge). Development in the central west and eastern sections of the project (blue areas) continues to significantly degrade the landscape condition of those areas. The results of landscape condition modeling for the Vista Connectivity Scenario are shown in Figure 40.

Figure 39. Vista Connectivity Scenario.

Blue shaded areas reflect management that has a positive or neutral effect on priority resources, not policy or ownership status.

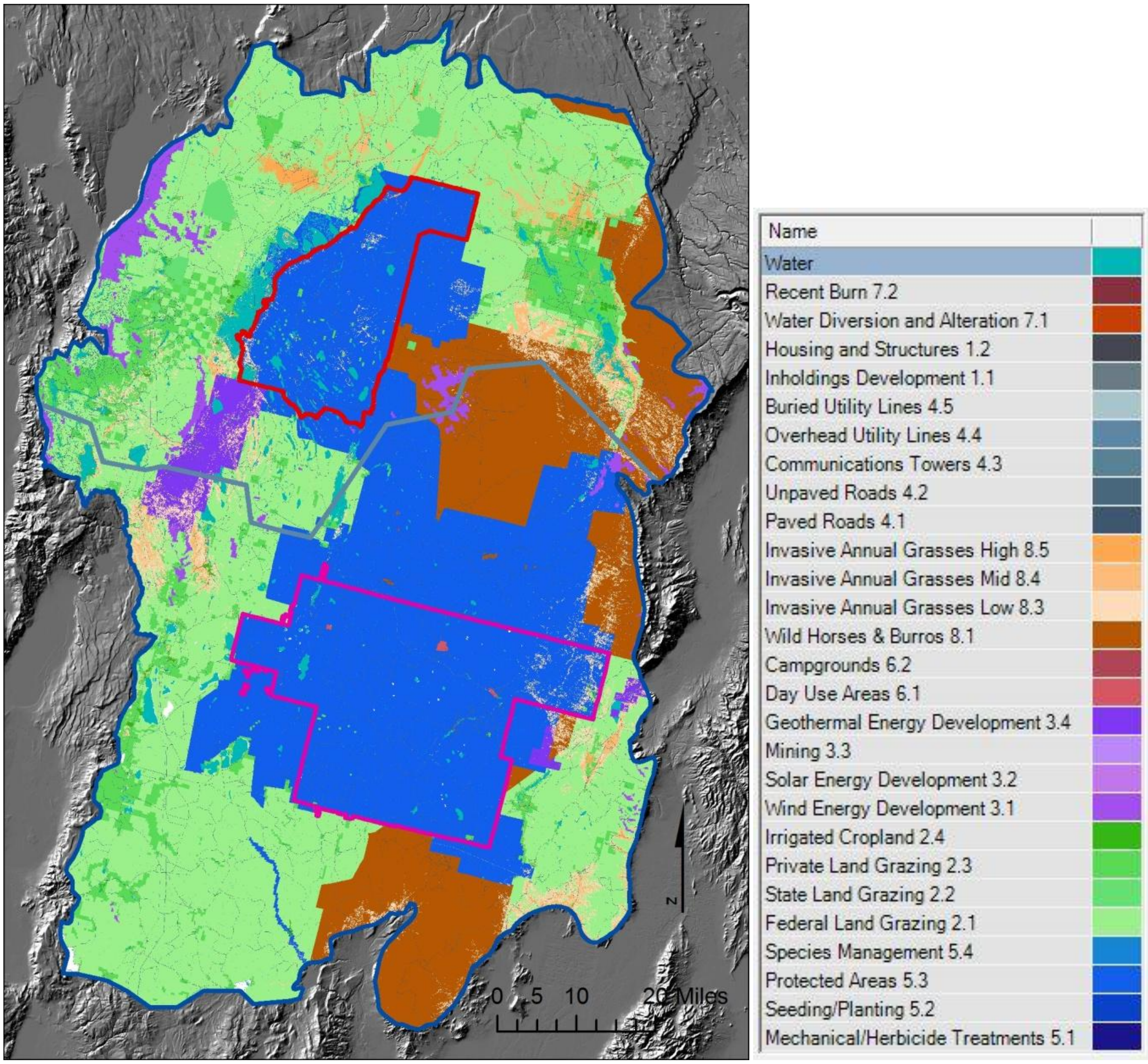
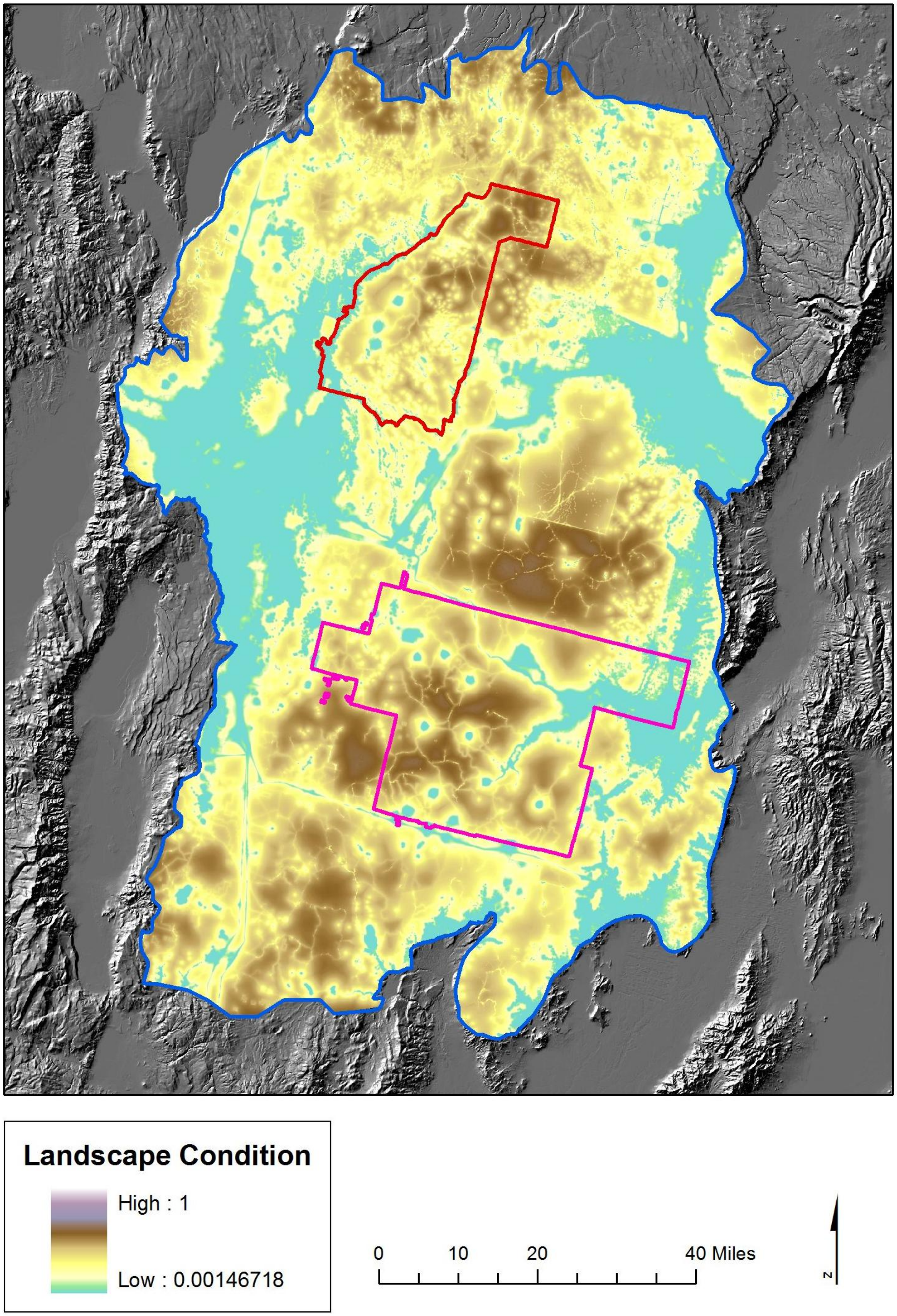
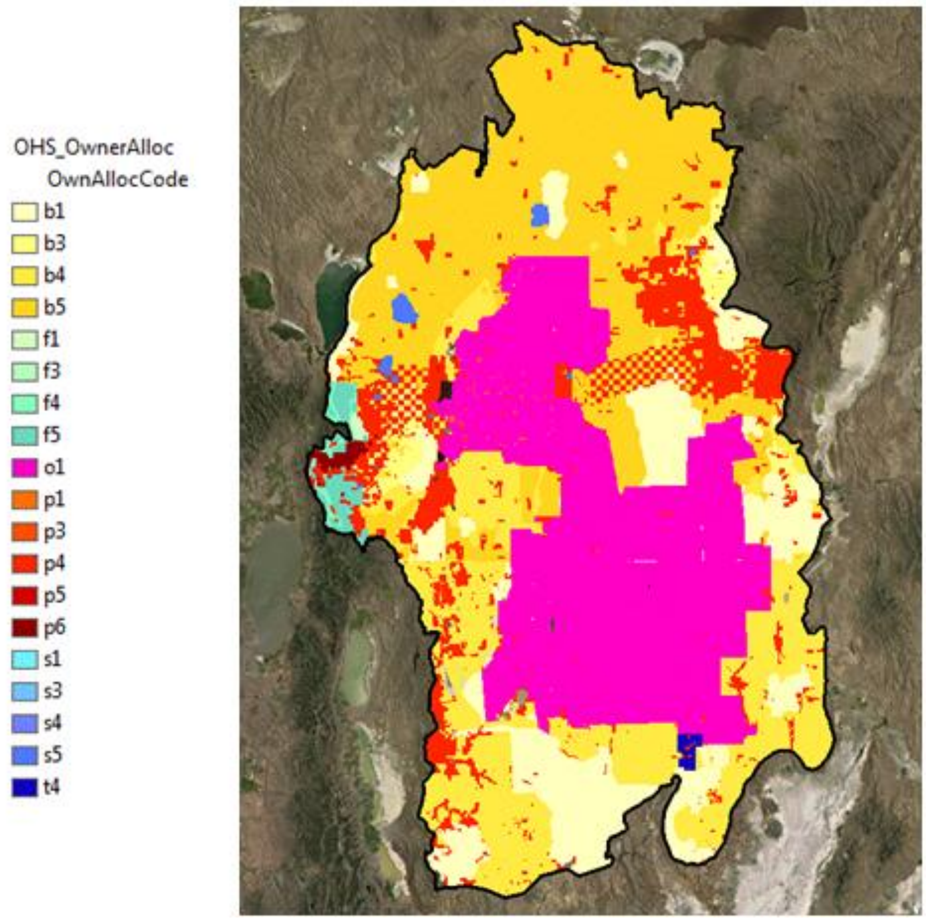


Figure 40. Landscape condition model for the Vista Connectivity Scenario.



This exploratory connectivity scenario was similarly assessed using VDDT, using the same connectivity area, to determine the impacts of the revised management on vegetation resources. The ownership/management allocations used in the VDDT analyses were modified to reflect the reduced grazing impacts in the VDDT Connectivity Scenario, shown in Figure 41.

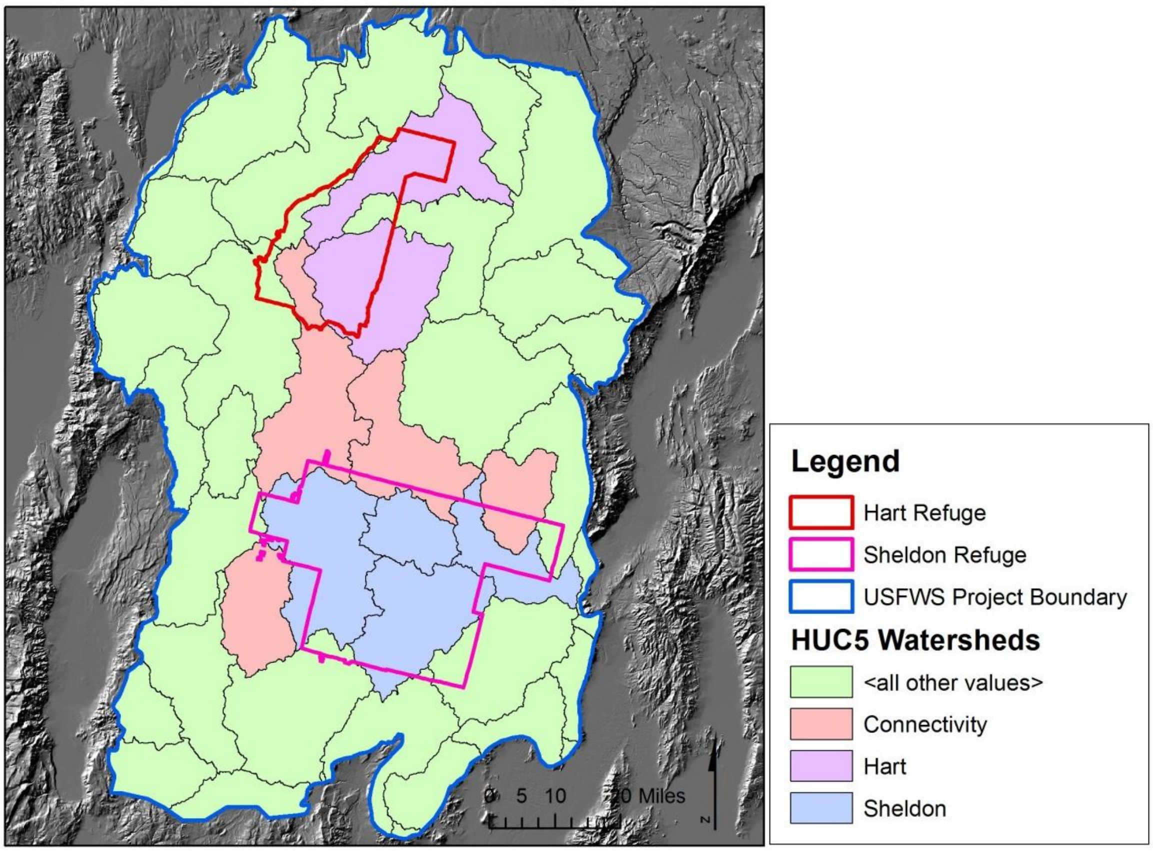
Figure 41. Ownership/management allocation used in the VDDT Connectivity Scenario.
Ownership/management allocations under the VDDT Connectivity Scenario are shown below, with the conservation management areas of the Refuge Complex and with connecting public lands under theoretical no-grazing management shown in magenta. Abbreviations: b=BLM, f=USFS, o=Refuge, p=Private, s=State, t=Tribal. 1-6=GAP code, with 1=greater conservation management focus.



The climate model was also modified to identify a third set of watersheds for the Climate Connectivity Scenario, shown in Figure 42. The watersheds shown in pink in the figure were modeled as ungrazed in the Climate Connectivity Scenario.

Figure 42. Watersheds used to represent Refuge lands and the connectivity area in the Climate Connectivity Scenario.

The watersheds representing the current Hart Mountain Refuge are in purple, Sheldon Refuge in blue, the connectivity area in pink, and the remainder of the supporting landscape in green.



Connectivity Scenario Results

The cumulative effects of the Vista Connectivity Scenario were evaluated for priority resources using Vista. Complete results are included at the end of Appendix H. Table 17 compares the results of the Baseline, 2025 Revised Refuge Management, and Vista Connectivity Scenarios. The average goal achievement at the bottom of the table indicates the large gains made first by removing horses on the Sheldon Refuge (expressed in the 2025 Revised Refuge Management Scenario) and then an additional average goal achievement of 19% in the Vista Connectivity Scenario.

Table 17. Cumulative effects assessment results comparing the percent of retention goal met for resources under the 2010 Baseline, 2025 Revised Refuge Management, and Vista Connectivity Scenarios.

Type	Resource	Retention Goal %	2010 Baseline % Goal Met	2025 Revised % Goal Met	Vista Connectivity % Goal Met
Mammals	American Pika	50	55	175	180
	Long-Eared Myotis	50	17	17	33
	Long-Legged Myotis	50	0	0	0
	Pronghorn Corridors	100	0	64	64
	Pronghorn Nonwinter Range	100	12	96	96
	Pronghorn Primary Habitat	100	6	17	33
	Pronghorn Winter Range	100	65	90	91
	Pygmy Rabbit	50	0	0	0
	Western Small-Footed Myotis	50	20	20	40
	White-Tailed Antelope Squirrel	50	0	0	0
	White-Tailed Jackrabbit	50	0	0	0
Birds	Greater Sandhill Crane	50	0	0	0
	Sage Grouse	100	18	19	32
	Sage Grouse Breeding Habitat	100	8	25	39
	Sage Grouse Nesting Habitat	100	5	17	31
	Sage Grouse Range	100	7	21	40
	Western Burrowing Owl	40	0	0	0
Fish	Catlow Tui Chub	100	35	37	37
	Catlow Valley Redband Trout	100	0	14	14
	Lahontan Cutthroat Trout	100	0	0	0
	Sheldon Tui Chub	100	0	33	98
	Warner Sucker	100	32	29	41
	Warner Valley Redband Trout	100	39	38	56
Communities	Columbia Plateau Low Sagebrush Steppe	60	14	47	79
	Inter-Mountain Basins Big Sagebrush Shrubland	80	65	78	87
	Inter-Mountain Basins Big Sagebrush Steppe	80	55	52	62
	Inter-Mountain Basins Cliff and Canyon	60	30	47	60

Type	Resource	Retention Goal %	2010 Baseline % Goal Met	2025 Revised % Goal Met	Vista Connectivity % Goal Met
	Inter-Mountain Basins Curlleaf Mountain Mahogany	80	14	14	17
	Inter-Mountain Basins Greasewood Flat	60	2	24	35
	Inter-Mountain Basins Juniper Savanna	60	151	142	144
	Inter-Mountain Basins Mixed Salt Desert Scrub	60	1	15	55
	Inter-Mountain Basins Montane Sagebrush Steppe	80	66	88	103
	Inter-Mountain Basins Playa	100	11	14	26
	Inter-Mountain Basins Semi-Desert Grassland	60	6	42	73
	North American Arid West Emergent Marsh	60	3	4	13
	Northern Rocky Mountain Foothill Deciduous Shrubland	40	109	144	167
	Rocky Mountain Aspen Forest and Woodland	100	5	7	7
	Rocky Mountain Ponderosa Pine Woodland	40	215	215	215
	Rocky Mountain Subalpine-Montane Mesic Meadow	100	26	32	39
Plants	Crosby's Buckwheat	20	0	0	68
	Grimy Ivesia	100	0	74	78
	Long-Flowered Snowberry	20	249	249	249
	Nodding Melicgrass	20	26	26	26
	Playa Phacelia	20	166	166	166
	Prostrate Buckwheat	50	7	7	19
	Rose-flower Desert-parsley	20	0	498	498
	Salt Heliotrope	20	73	73	157
	Three Forks Stickseed	50	0	165	165
	Yellow Scorpionflower	50	0	152	152
Avg	**All resources**		**33%**	**63%**	**75%**

The Vista Connectivity Scenario results are the same as the 2025 Revised Refuge Management Scenario except for the following significant improvements:

1. Two additional resources met their goals: Salt Heliotrope and Inter-Mountain Basins Montane Sagebrush Steppe (although the Salt Heliotrope is a Priority 3 resource, Montane Sagebrush Steppe is a top priority, making this a notable achievement for this scenario);

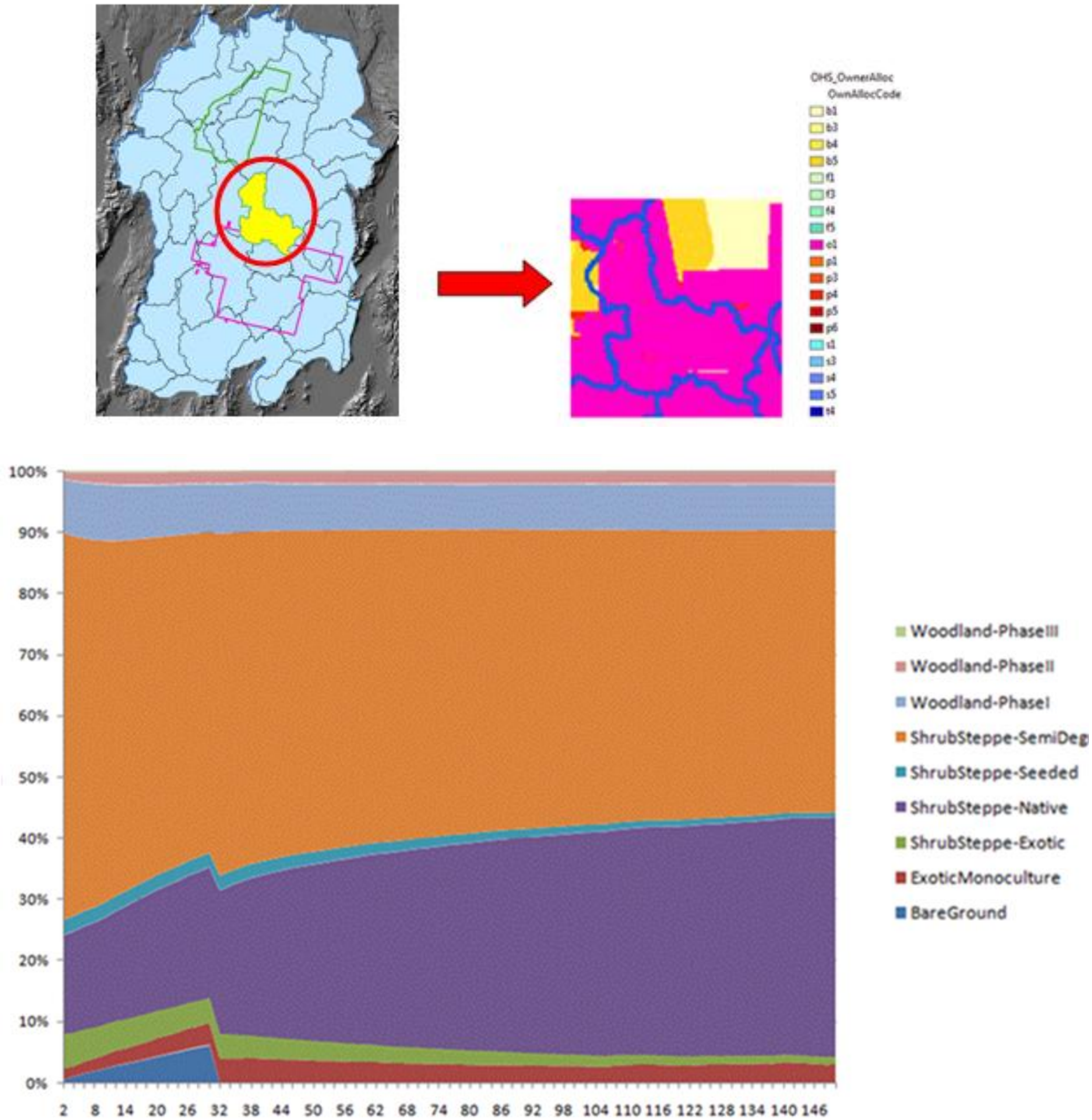
2. Sheldon Tui Chub and Pronghorn Nonwinter Range essentially met their goals with 98% and 96% respectively; and

3. Many other resources saw an approximately 20% increase in their retention goals met under this scenario over the 2025 Revised Refuge Management Scenario.

The VDDT Connectivity Scenario was assessed to explore the effect of decreased grazing between the refuges on vegetation change into 2100. As with the VDDT assessment of the Revised Refuge Management Scenario, Sagehen Creek was evaluated in the VDDT assessment of the Connectivity Scenario. The results from the Connectivity Scenario for Sagehen Creek are shown in Figure 43, which can be directly compared to the Revised Refuge Management scenario results shown in Figure 24. With grazing removed and restoration treatments applied to Sagehen Creek in the Connectivity Scenario, the amount of native shrub-steppe increases significantly. In addition, both exotic monoculture and sagebrush/cheatgrass decline to insignificant levels. The sharp drop in the chart around year 30 is due to a major drought, which is programmed to randomly occur in the VDDT models.

Figure 43. Change in abundance of vegetation types in the Sagehen Creek watershed under the VDDT Connectivity scenario.

Sagehen Creek is circled in the watershed map at top left, and a detail of the watershed boundary and management allocation shown at the right with the key to the VDDT ownership-management allocations (full descriptions in Table 16). The Y-axis of the graph shows percentage of each vegetation type present within the watershed. The X-axis is number of years from 2000, the year at which the model begins.



Areas in the VDDT Connectivity Scenario show significant improvements rather than the significant declines when grazing was present and few conservation management actions were taken (Figure 27). With the VDDT Connectivity Scenario, most of the Sagehen Creek watershed becomes managed for conservation (removal of grazing with restoration treatments), so the amount of native shrub-steppe increases significantly over present conditions. In addition, both exotic monoculture and sagebrush/cheatgrass decline to very minor levels. The changes are much less dramatic on watersheds contained within the Refuge Complex, since the starting conditions have much less cover of annual grasses, there is no grazing present, and juniper is controlled. Where exotic annual grasses are dense, they increase the probability and frequency of fires, which promotes their continued expansion.

The best way to compare the impacts of the Revised Refuge Management and VDDT Connectivity Scenarios is to look at the acreages of the important habitats over time in the area between the refuges, which is the only area which has very significant management changes between these two scenarios. Table 18 and Table 19 below show the acreage of the modeled potential vegetation types, and their conditions, in the years 2010, 2025, 2060 and 2100, for the Revised Refuge Management Scenario (Table 18) and the VDDT Connectivity Scenario (Table 19) for the Connectivity watersheds (the pink watersheds shown in Figure 42).

Table 18. Acres of Different Vegetation Types and their Conditions from the VDDT output for the four Connectivity watersheds shown in Figure 42 under the Revised Refuge Management Scenario, without climate change.

Vegetation Type / Condition	**Acres in 2010**	**Acres in 2025**	**Acres in 2060**	**Acres in 2100**
Bitterbrush - With juniper	**1563**	**1516**	**1420**	**1342**
ShrubSteppe-Exotic	37	96	162	217
ShrubSteppe-Native	261	264	603	665
ShrubSteppe-Semi-Degraded	1265	1156	655	460
Low sage - Mesic no juniper	**18519**	**18558**	**18564**	**18566**
ShrubSteppe-Exotic	1624	777	594	588
ShrubSteppe-Native	5728	5287	9738	9917
ShrubSteppe-Semi-Degraded	11167	12494	8232	8061
Low sage - Mesic with juniper	**13638**	**11526**	**11265**	**11288**
ShrubSteppe-Exotic	612	211	70	53
ShrubSteppe-Native	6446	5761	9157	9918
ShrubSteppe-Semi-Degraded	6580	5554	2038	1317
Low sage - Xeric	**146657**	**133374**	**113916**	**105663**
ShrubSteppe-Exotic	10956	15497	22284	31880
ShrubSteppe-Semi-Degraded	135701	117877	91632	73783
Mountain big sagebrush - With juniper	**45143**	**25859**	**18345**	**19570**
ShrubSteppe-Exotic	4906	1119	328	337
ShrubSteppe-Native	8884	10841	10364	10788
ShrubSteppe-Semi-Degraded	31353	13899	7653	8445
Mountain mahogany	**4035**	**3883**	**3427**	**2885**
ShrubSteppe-Exotic	103	226	317	310
ShrubSteppe-Native	3932	3657	3110	2575
Salt desert shrub - Lowland	**7271**	**7314**	**7365**	**7408**
ShrubSteppe-Exotic	2461	1921	1076	553

Vegetation Type / Condition	Acres in 2010	Acres in 2025	Acres in 2060	Acres in 2100
ShrubSteppe-Native	1413	2045	3207	4009
ShrubSteppe-Semi-Degraded	3397	3348	3082	2846
Western juniper woodland	**2770**	**376**	**1617**	**1463**
ShrubSteppe-Native	2770	376	1617	1463
Wyoming big sagebrush - No juniper	**128569**	**119850**	**107080**	**102610**
ShrubSteppe-Exotic	15423	18824	29985	36408
ShrubSteppe-Native	21480	15430	17573	20756
ShrubSteppe-Semi-Degraded	91666	85596	59522	45446
Wyoming big sagebrush - With juniper	**10645**	**8271**	**10985**	**11645**
ShrubSteppe-Exotic	984	560	1191	1898
ShrubSteppe-Native	1445	1896	4909	6994
ShrubSteppe-Semi-Degraded	8216	5815	4885	2753

Note that the areas of almost all of the priority shrub steppe habitats are declining under the scenario shown above. In particular, ~26,000 acres of Wyoming sagebrush habitat is lost, ~41,000 acres of xeric low sagebrush habitat is lost, and ~25,500 acres of mountain big sagebrush are lost, mostly replaced by annual grasslands.

Table 19. Acres of Different Vegetation Types and their Conditions from the VDDT output for the four Connectivity watersheds under the VDDT Connectivity Scenario, without climate change.

Vegetation Type / Condition	Acres in 2010	Acres in 2025	Acres in 2060	Acres in 2100
Bitterbrush - With juniper	**2193**	**2234**	**2245**	**2392**
ShrubSteppe-Exotic	0	0	0	0
ShrubSteppe-Native	434	497	2244	2389
ShrubSteppe-Semi-Degraded	1759	1737	1	3
Low sage - Mesic no juniper	**17605**	**17669**	**17690**	**17682**
ShrubSteppe-Exotic	852	399	250	266
ShrubSteppe-Native	6694	6602	13558	13870
ShrubSteppe-Semi-Degraded	10059	10668	3882	3546
Low sage - Mesic with juniper	**13681**	**11671**	**11732**	**11848**
ShrubSteppe-Exotic	502	170	55	38
ShrubSteppe-Native	6628	5997	9865	10753
ShrubSteppe-Semi-Degraded	6551	5504	1812	1057
Low sage - Xeric	**152744**	**146249**	**145377**	**142663**
ShrubSteppe-Exotic	9188	10195	9875	11137
ShrubSteppe-Semi-Degraded	143556	136054	135502	131526
Mountain big sagebrush - With juniper	**55110**	**47729**	**49226**	**49328**
ShrubSteppe-Exotic	1117	224	96	91
ShrubSteppe-Native	15583	31923	44582	46318
ShrubSteppe-Semi-Degraded	38410	15582	4548	2919
Mountain mahogany	**4281**	**4280**	**4284**	**4288**

Vegetation Type / Condition	Acres in 2010	Acres in 2025	Acres in 2060	Acres in 2100
ShrubSteppe-Exotic	8	8	1	2
ShrubSteppe-Native	4273	4272	4283	4286
Salt desert shrub - Lowland	**7444**	**7495**	**7542**	**7591**
ShrubSteppe-Exotic	2516	1958	1073	549
ShrubSteppe-Native	1461	2131	3320	4152
ShrubSteppe-Semi-Degraded	3467	3406	3149	2890
Western juniper woodland	**3226**	**497**	**1908**	**1706**
ShrubSteppe-Native	3226	497	1908	1706
Wyoming big sagebrush - No juniper	**135825**	**132724**	**132272**	**134175**
ShrubSteppe-Exotic	8620	8932	10019	10583
ShrubSteppe-Native	41218	45843	73328	94013
ShrubSteppe-Semi-Degraded	85987	77949	48925	29579
Wyoming big sagebrush - With juniper	**12082**	**11556**	**15589**	**15816**
ShrubSteppe-Exotic	641	388	712	913
ShrubSteppe-Native	2235	3261	8117	11293
ShrubSteppe-Semi-Degraded	9206	7907	6760	3610

These results illustrate how under the reduced grazing and restoration treatments of the VDDT Connectivity Scenario, the native shrub steppe vegetation communities in these watersheds expand, with 10,000 acres of additional habitat for xeric low sagebrush, 5,700 more acres of mountain big sagebrush, and the remaining important native habitats remaining largely unchanged. The differences are dramatic, although all the changes result from the combination of restoration and grazing removal identified in the refuge management plans and could be relatively readily adopted on adjacent public lands.

Table 20 illustrates the results of the Climate Connectivity Scenario for the Wyoming sagebrush type in Sagehen Creek watershed. The table compares the change in condition of Wyoming sagebrush under the CSIRO model where grazing is removed and juniper controlled versus when grazing is present and juniper not controlled. While both grazed and ungrazed areas show a significant decline in the amount of Wyoming sagebrush in the watershed, removing grazing results in better condition of the remaining Wyoming sagebrush, with 57% remaining in native condition when grazing is removed; only 20% remains in native condition with grazing present. This analysis shows that incorporating climate change into these analyses appears to significantly change the results compared to the VDDT scenarios, but that changes in management appear to be just as significant a driver of vegetation change.

Table 20. Change in the Wyoming sagebrush type in the Sagehen Creek watersheds under the Climate Connectivity Scenario, incorporating the VDDT output and the CSIRO Climate models.

Results are presented with grazing removed and with grazing present in this watershed.

Vegetation Type/Condition	2010	2025	2060	2099	% Change 2010-2099	Proportion of 2099 Total
WY Sage - ungrazed	**96597.7**	**61303.1**	**53834.6**	**19677.6**	**-391%**	
ExoticMonoculture	29910	17390	10800	4329	-591%	22%
ShrubSteppe_Exotic	286.6	19.77	59.3	49.42	-480%	0%
ShrubSteppe_Seeded	4022.6	4022.3	2896.1	2046.1	-97%	10%
ShrubSteppe_SemiDegraded	1690.6	4921.884	8796.3	2075.84	19%	11%
ShrubSteppe-Native	60687.88	34949.19	31282.9	11177.2	-443%	57%
WY Sage - grazed	**97895.3**	**60689.3**	**54396.7**	**20124.1**	**-386%**	
ExoticMonoculture	39210	26290	26250	11980	-227%	60%
ShrubSteppe_Exotic	751.184	69.19	2995	929.1	19%	5%
ShrubSteppe_Seeded	3745.9	3419.7	2915.7	2322.9	-61%	12%
ShrubSteppe_SemiDegraded	2896.3	5900.65	4467	869.8	-233%	4%
ShrubSteppe-Native	51291.9	25009.77	17769	4022.3	-1175%	20%

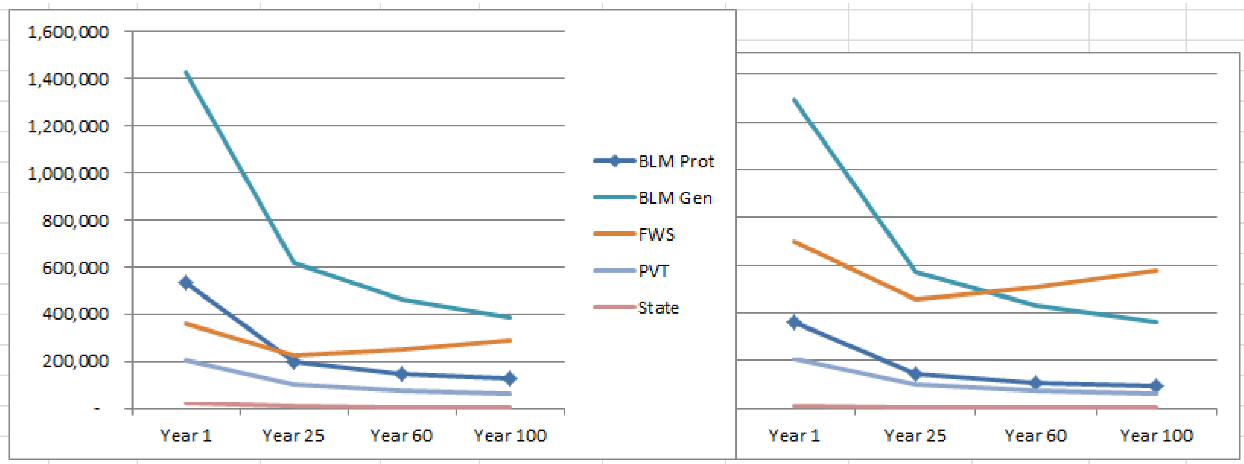
Implications of Connectivity Management

Sage Grouse Habitat Changes

As part of the ILAP project, habitat affinities were identified for priority species, including the western sage grouse. The draft model for the western sage grouse has been created, which defines the suitable condition classes (or boxes) for the VDDT models, the areas in which the species occurs, and the habitat attributes, such as shrub density, presence and cover of understory species (both native and introduced), and the presence and amount of western juniper. Because of the sage grouse's sensitivity to increased juniper cover, and the potential for many more areas to be invaded without juniper controls, the results show how the area of sage grouse habitat dramatically decreases in the supporting landscape (Figure 44).

Figure 44. Acres of Sage Grouse habitat on non-refuge lands in the supporting landscape in two scenarios.

The figure on the left shows results under the 2025 Revised Refuge Management Scenario, while the right shows results from the Connectivity Scenario.



Both the Revised Refuge Management Scenario and Connectivity scenarios show significant declines of sage grouse habitat in all management types in the supporting landscape except for the USFWS Refuge Lands, which initially decline, but then recover. The initial declines are based on an expected lag time to achieve control of expanding juniper after management is initiated. The declines are substantial in both scenarios, with over two million acres of sage grouse habitat lost over the next 100 years. However, the trends in the 2025 Connectivity Scenario on the refuge lands are much better, indicating the potential for a stable sage grouse population over time under this management pattern. This difference is likely magnified since the analysis does not take into account the species' migration patterns; they move by walking when migrating with young, making them more vulnerable in the 2025 Revised Refuge Management Scenario. Changes in areas occupied are even more pronounced when analyzed with climate change.

Wild Horse and Burro Management

The scenario evaluations highlight the value of removing livestock and horse grazing from the landscape to conserve priority resources. In the baseline scenario, the differences between Hart Mountain Refuge, where there is no grazing present, and Sheldon Refuge, where there is currently grazing by wild horses and burros, are shown by using the Site Explorer tool to compare the contribution of each refuge to the retention goals of priority resources (Figure 45 and Figure 46). As nearly all priority resources have a negative response to horse and burro grazing, many resources present on Sheldon Refuge are negatively affected by current management. Removing the influence of grazing by horses and burros has a significantly beneficial impact on these resources and their overall retention goals for the project area (see Connectivity scenario for further discussion).

Figure 45. Contribution of Hart Mountain Refuge to resource retention goals under the baseline scenario.

Element Name	Goal	Selection % of Goal
American Pika	50% of hectares	55.18%
Catlow Tui Chub	100% of hectares	35.24%
Catlow Valley Redband Trout	100% of Occurrences	0%
Columbia Plateau Low Sagebrush Steppe	60% of hectares	13.84%
Hart Boundary Fence	100% of hectares	61.06%
Hart Headquarters	100% of Occurrences	100%
Inter-Mountain Basins Big Sagebrush Shrubland	80% of hectares	7.39%
Inter-Mountain Basins Big Sagebrush Steppe	80% of hectares	1.54%
Inter-Mountain Basins Cliff and Canyon	60% of hectares	28.15%
Inter-Mountain Basins Curlleaf Mountain Mahogany	80% of hectares	14.33%
Inter-Mountain Basins Greasewood Flat	60% of hectares	1.66%
Inter-Mountain Basins Juniper Savanna	60% of hectares	16.41%
Inter-Mountain Basins Mixed Salt Desert Scrub	60% of hectares	0.76%
Inter-Mountain Basins Montane Sagebrush Steppe	80% of hectares	8.03%
Inter-Mountain Basins Playa	100% of hectares	4.47%
Inter-Mountain Basins Semi-Desert Grassland	60% of hectares	6.13%
Long-Eared Myotis	50% of Occurrences	16.67%
Long-Flowered Snowberry	20% of hectares	248.88%
Nodding Melicgrass	20% of hectares	26.21%
North American Arid West Emergent Marsh	60% of hectares	1.65%
Northern Rocky Mountain Foothill Deciduous Shrubland	40% of hectares	108.97%
Pronghorn Nonwinter Range	100% of hectares	12.2%
Pronghorn Primary Habitat	100% of hectares	6.35%
Pronghorn Winter Range	100% of hectares	64.88%
Prostrate Buckwheat	50% of hectares	7.15%
Pygmy Rabbit	50% of Occurrences	0%
Rocky Mountain Aspen Forest and Woodland	100% of hectares	5.42%
Rocky Mountain Ponderosa Pine Woodland	40% of hectares	214.65%
Rocky Mountain Subalpine-Montane Mesic Meadow	100% of hectares	23.18%
Sage Grouse	100% of Occurrences	18.18%
Sage Grouse Breeding Habitat	100% of hectares	7.51%
Sage Grouse Nesting Habitat	100% of hectares	5.22%
Sage Grouse Range	100% of hectares	6.88%
Warner Sucker	100% of hectares	0.21%
Warner Valley Redband Trout	100% of hectares	0.32%
Western Small-Footed Myotis	50% of Occurrences	20%

Figure 46. Contribution of Sheldon Refuge to resource retention goals under the baseline scenario.

Element Name	Goal	Selection % of Goal,
American Pika	50% of hectares	0%
Columbia Plateau Low Sagebrush Steppe	60% of hectares	0%
Grimy Ivesia	100% of hectares	0%
Inter-Mountain Basins Big Sagebrush Shrubland	80% of hectares	0.01%
Inter-Mountain Basins Big Sagebrush Steppe	80% of hectares	0%
Inter-Mountain Basins Cliff and Canyon	60% of hectares	0.01%
Inter-Mountain Basins Greasewood Flat	60% of hectares	0.03%
Inter-Mountain Basins Juniper Savanna	60% of hectares	14.34%
Inter-Mountain Basins Mixed Salt Desert Scrub	60% of hectares	0.02%
Inter-Mountain Basins Montane Sagebrush Steppe	80% of hectares	0%
Inter-Mountain Basins Playa	100% of hectares	0%
Inter-Mountain Basins Semi-Desert Grassland	60% of hectares	0%
Lahontan Cutthroat Trout	100% of hectares	0%
Last Chance Ranch	100% of Occurrences	100%
North American Arid West Emergent Marsh	60% of hectares	0%
Northern Rocky Mountain Foothill Deciduous Shrubland	40% of hectares	0%
Pronghorn Corridors	100% of hectares	0%
Pronghorn Nonwinter Range	100% of hectares	0%
Pronghorn Primary Habitat	100% of hectares	0%
Pronghorn Winter Range	100% of hectares	0%
Rocky Mountain Aspen Forest and Woodland	100% of hectares	0%
Rocky Mountain Subalpine-Montane Mesic Meadow	100% of hectares	0%
Rose-flower Desert-parsley	20% of hectares	0%
Sage Grouse Breeding Habitat	100% of hectares	0%
Sage Grouse Nesting Habitat	100% of hectares	0%
Sage Grouse Range	100% of hectares	0%
Sheldon Boundary Fence	100% of hectares	52.18%
Sheldon Headquarters	100% of Occurrences	100%
Sheldon Tui Chub	100% of hectares	0%
Three Forks Stickseed	50% of hectares	0%
Yellow Scorpionflower	50% of hectares	0%

Juniper Encroachment

The current juniper management strategy for Sheldon Refuge was detailed in a 2001 environmental assessment (Bennet 2001). Juniper control through hand and mechanical removal is used on the Refuge Complex to prevent conversion of native shrub-steppe communities to juniper woodlands. As maintenance of native shrub-steppe habitats is a priority for the Refuge Complex, juniper control is a top management priority.

The VDDT analysis shows juniper encroachment to be an imminent and rising threat across many areas of the supporting landscape (Figure 23). The juniper management strategy currently adopted by the

Refuges should continue into the future to maintain native shrub-steppe habitats, and perhaps be expanded as proposed in Alternative 2 of the draft Sheldon Comprehensive Conservation Plan (USFWS in press). Alternative 2 would emphasize juniper management as the top habitat management goal and focus in the western portion of Sheldon Refuge, the area where juniper is currently located. Hart Mountain Refuge should adopt a similar plan; the maps in Figure 23 could inform where juniper removal efforts should be concentrated, such as in the central-western section of Hart Mountain Refuge.

Management of Public Uses on Refuge Lands

Once grazing is removed from the Refuge Complex, infrastructure becomes the greatest stressor in our analyses. Roads, campgrounds, and power lines have a negative impact on many of the identified priority species. Closing roads will lessen impacts to species and decrease the likelihood of non-native plant dispersal along roadsides. Campgrounds could be consolidated into areas that are already impacted by other stressors, such as in the Virgin Valley area of Sheldon Refuge. The current impact of campgrounds can be seen in the Landscape Condition Model for the baseline scenario (current management) in Figure 19.

Managing for Species Vulnerable to Climate Change

The Nevada Natural Heritage Program recently evaluated several species in Nevada for their potential vulnerability to climate change using NatureServe's Climate Change Vulnerability Index (CCVI, Young et al. 2011). The CCVI is a non-spatial, expert opinion-based assessment, although it can and typically does utilize an overlay of element occurrences with spatial climate change data to inform the experts of the expected degree of climate change exposure species are forecast to encounter. Many factors are taken into account in the index including the presence of barriers to movement, thermal or hydrological requirements, response to disturbance, and interaction with other species. Highlights of the results for those species identified as priority resources for this project are shown in Table 21. The entirety of Nevada's CCVI results can be found in Appendix L. It should be kept in mind that this assessment reflects the effect of climate change on these species in the state of Nevada. Local effects within the Refuge Complex may be more pronounced.

Table 21. Results of the Climate Change Vulnerability Index tool for relevant species, as completed by the Nevada Natural Heritage Program for the state of Nevada.

Resource Name	Relative Range in Nevada	Confidence	Index
American Pika	Southern edge of range	Moderate	Highly Vulnerable
American White Pelican	Southern edge of range	Very High	Moderately Vulnerable
Golden Eagle	Center of range	Very High	Presumed Stable
Greater Sage-grouse	Southern edge of range	Low	Highly Vulnerable
Greater Sandhill Crane	Southern edge of range	Very High	Presumed Stable
Lahontan Cutthroat Trout	Southern edge of range	Very High	Moderately Vulnerable

Resource Name	Relative Range in Nevada	Confidence	Index
Long-eared Myotis	Center of range	Very High	Increase Likely
Preble's Shrew	Southern edge of range	Very High	Presumed Stable
Pygmy Rabbit	Southern edge of range	Moderate	Extremely Vulnerable
Snowy Egret	Northern edge of range	Very High	Presumed Stable
Spotted Bat	Center of range	Very High	Presumed Stable
Western Burrowing Owl	Northern edge of range	Very High	Presumed Stable
Western Small-footed Myotis	Entire range	Very High	Presumed Stable
Western Yellow-billed Cuckoo	Northern edge of range	Low	Moderately Vulnerable

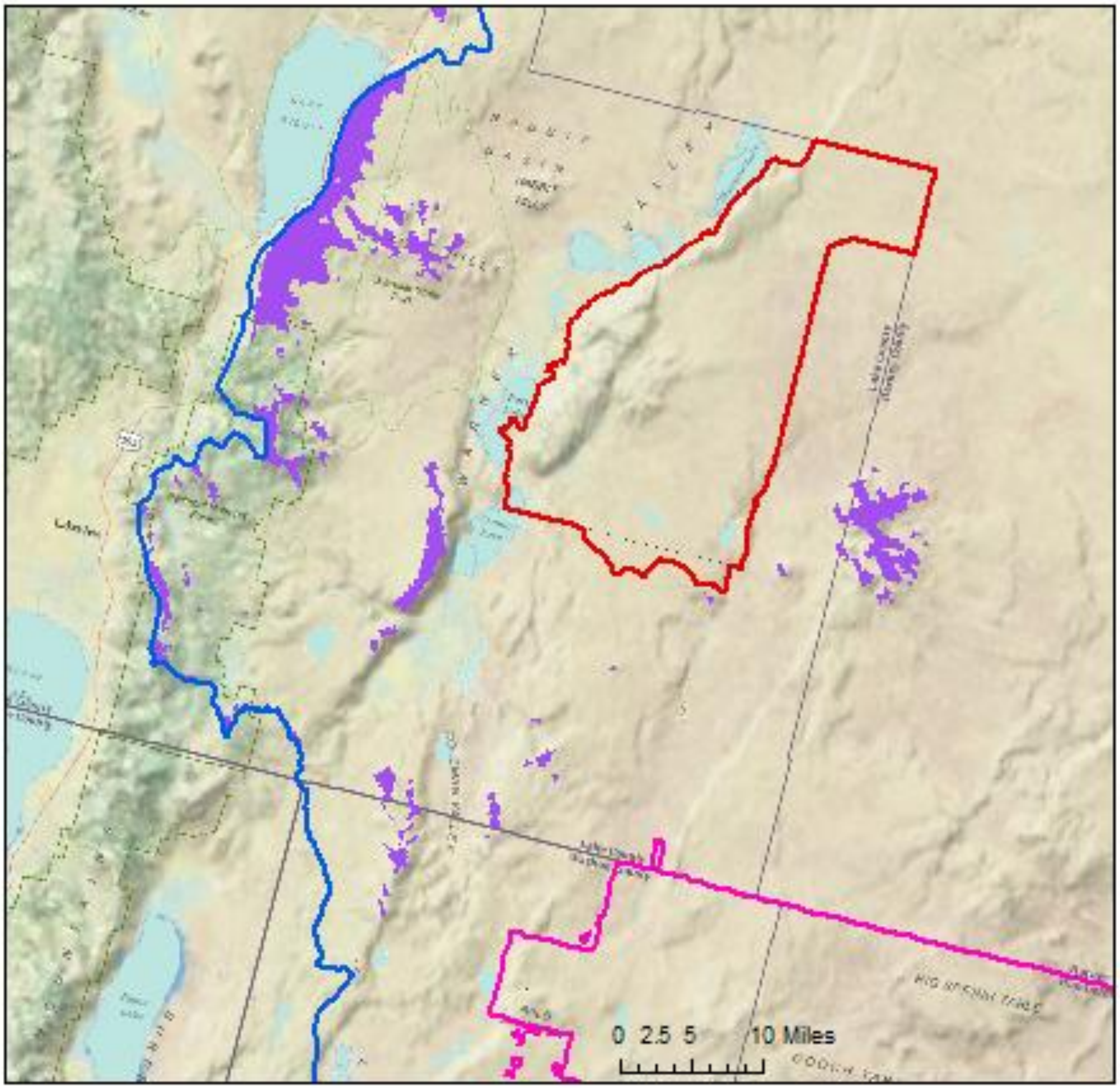
Several species assessed in Nevada's CCVI are presumed to be stable, but three species stand out as extremely or highly vulnerable: pygmy rabbit, sage grouse, and American pika. While habitat exists for the sage grouse and pika on Refuge Complex lands, the pygmy rabbit's habitat is mostly off-refuge. By removing grazing in the areas between the refuges, known pygmy rabbit populations and potential habitat would experience fewer stressors, potentially increasing their resilience to climate changes. Sage grouse habitat is currently a management priority on the Refuge Complex through reduction of juniper and invasive species management. Managing for American pika will be more difficult, as its higher elevation habitat will be more quickly affected by rising temperatures, and dramatic declines have been reported for pikas in the Great Basin in direct response to increasing temperatures (Beever et al. 2004). However, there has been encouraging evidence of low-elevation (~ 1900-2100 m) pika populations in northwestern Nevada (Beever et al. 2008). Pikas studied by Beever et al. in Hays Canyon, Nevada were found to use cheatgrass as a food source, stashing cheatgrass in their hay piles. While this is good news for pikas, it is bad news for managers as this could aid in the spread of cheatgrass, which can germinate after being cut or even digested by herbivores.

Renewable Energy Development

The assessment of cumulative impacts under the 2025 Road Closures Scenarios identified renewable energy development as a significant contributor to future stress in the supporting landscape. While renewable energy development is incompatible with NWR policy and therefore would not occur within Refuge Complex lands, there is likelihood for its development in the supporting landscape. Several proposals and permits have been filed on nearby lands to develop wind, geothermal, and solar energy infrastructure. Some of these developments can have far-reaching impacts, making these developments an issue for Refuge managers. For example, our analysis predicts that wind production areas will not be located adjacent to the Refuges, but these developments will have an impact in the supporting landscape (Figure 47). In addition to the impact of wind turbines themselves, access and maintenance roads would also be developed to service wind farms. Roads can become vectors for the dispersal of non-native plants and can fragment habitats, further impacting species in the area.

Figure 47. Potential areas of future wind energy development (purple).

These areas are based on NREL data (www.nrel.gov) showing areas coded as “good” to “superb” for wind potential and located within 10 km of existing or proposed energy corridors.



Recent concern over the impact of wind turbines on wildlife, including golden eagles, has led to draft recommendations by the USFWS to improve the siting of turbines by incorporating buffers around known eagle nests and other conservation areas of concern (USFWS 2011). The golden eagle (*Aquila chrysaetos*) was not initially identified as a priority resource for this project, but recent conservation concern warrants its inclusion. There is a state-wide survey in progress in Oregon which, when combined with historical observation data, will provide an updated baseline for this species’ status in the state. While golden eagles are known to occur in the area, no historical nesting data was available for the project area, and habitat maps are currently under review; therefore, our evaluation of this species is non-spatial.

When evaluating how and where to encourage golden eagle conservation management, it is important to consider the fact that eagles are predators of another priority species – sage grouse. The presence of raptor perches negatively impacts sage grouse populations as these perches allow raptors such as golden eagles to more successfully hunt prey. With the invasion of juniper predicted to continue into the future, golden eagle populations may increase to the detriment of sage grouse populations.

There are favorable wind energy sites within the supporting landscape; given the current trend towards building renewable energy infrastructure, there will likely be large-scale developments of wind energy in the area, increasing the stress to golden eagles and other susceptible species such as bats. While the Refuges may have little direct control on the siting or size of future wind developments, many of these potential wind development areas are located on federal lands and collaboration with neighboring agencies may allow for productive input. It also appears, however, that most of these potential development areas have relatively low conservation value in our analysis so their effects may be primarily on migrating or highly vagile species moving through those areas.

Recent studies show greater sage grouse hens move between Hart Mountain for nesting and Beatty Butte, and bighorn sheep move north and south along the east rim of Warner Valley (Paul Steblein, personal communication). Both routes pass through or near areas of high wind development potential. The movements of these species should continue to be documented and this information shared between developers, planners, and land managers to best site future developments to balance the needs of these species with the needs for economic and energy development.

The USFWS has the opportunity to present preferred alternatives for energy developments on nearby lands through public involvement during the Environmental Impact Assessment (EIA) process. The USFWS has been active in the past in submitting scientific opinion to mitigate impacts to wildlife and habitats, and should remain vigilant in participating in the EIA process. Additionally Refuge staff have the potential to leverage their relationships with land managers in adjacent agencies to coordinate their efforts where agencies have mutual interest in mitigating energy developments or advising on the siting of projects. The tools and products developed for this project, such as the Conservation Value Summary maps, can aid in identifying areas of high conservation value in the surrounding areas.

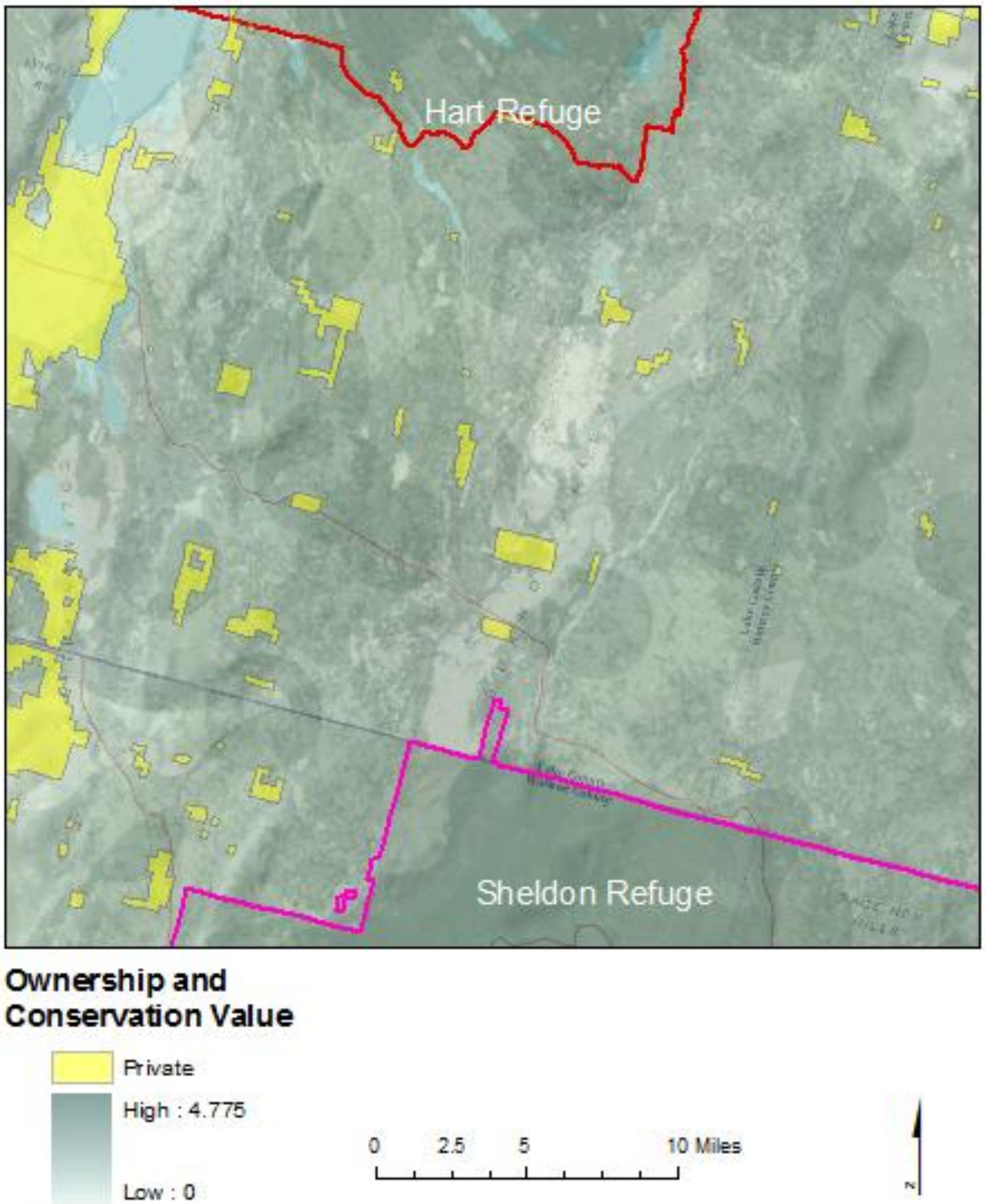
One infrastructure development of note as an impact to the Refuge Complex is the West-Wide Energy Corridor (shown in gray in Figure 18). This approved planned energy corridor runs between the two Refuges and could present a barrier to species migrations and connectivity between the Refuges. The extent and nature of the associated development of this corridor will determine the scope of these impacts. A fully buried transmission line would have a smaller long-term effect than an above-ground line, though the maintenance roads and other activities associated with maintaining the corridor will be present in either situation. The Refuges are currently studying animal migrations between the Refuges and the results of this study will shed more light on the potential impacts of this corridor. In addition, the Western Governors Association is also analyzing wildlife corridors in the larger Northern Basin and Range Ecoregion in southeastern Oregon and southern Idaho, looking at critical wildlife movement and impacts from energy development. Further, BLM is initiating an update of its Rapid Ecoregional

Assessment which typically includes such stressors. More information should come from these studies and analyses.

Private Lands and Conservation

Several private holdings adjacent to or between the two refuges were calculated to have high conservation value using the Vista CVS function. Conservation groups may have the opportunity to purchase nearby private lands to contribute to the Refuge's conservation goals through easements, preserves, or land swaps. In particular, the higher elevation lands between the Coleman Valley and the Guano Valley contain a strip of high conservation value due to the presence of sage grouse (Figure 48). This area was excluded from our Connectivity Scenario due to the presence of these private parcels. If arrangements could be made with these properties from willing sellers or through easements, a greater area of connectivity could be made to capture more of the high conservation value present here. While there are other private lands with some conservation value adjacent to the Refuge Complex, this corridor presents the highest value and the greatest potential impact of including private lands in compatible management/land use.

Figure 48. Private holdings located in high conservation value areas between Hart Mountain and Sheldon Refuges.

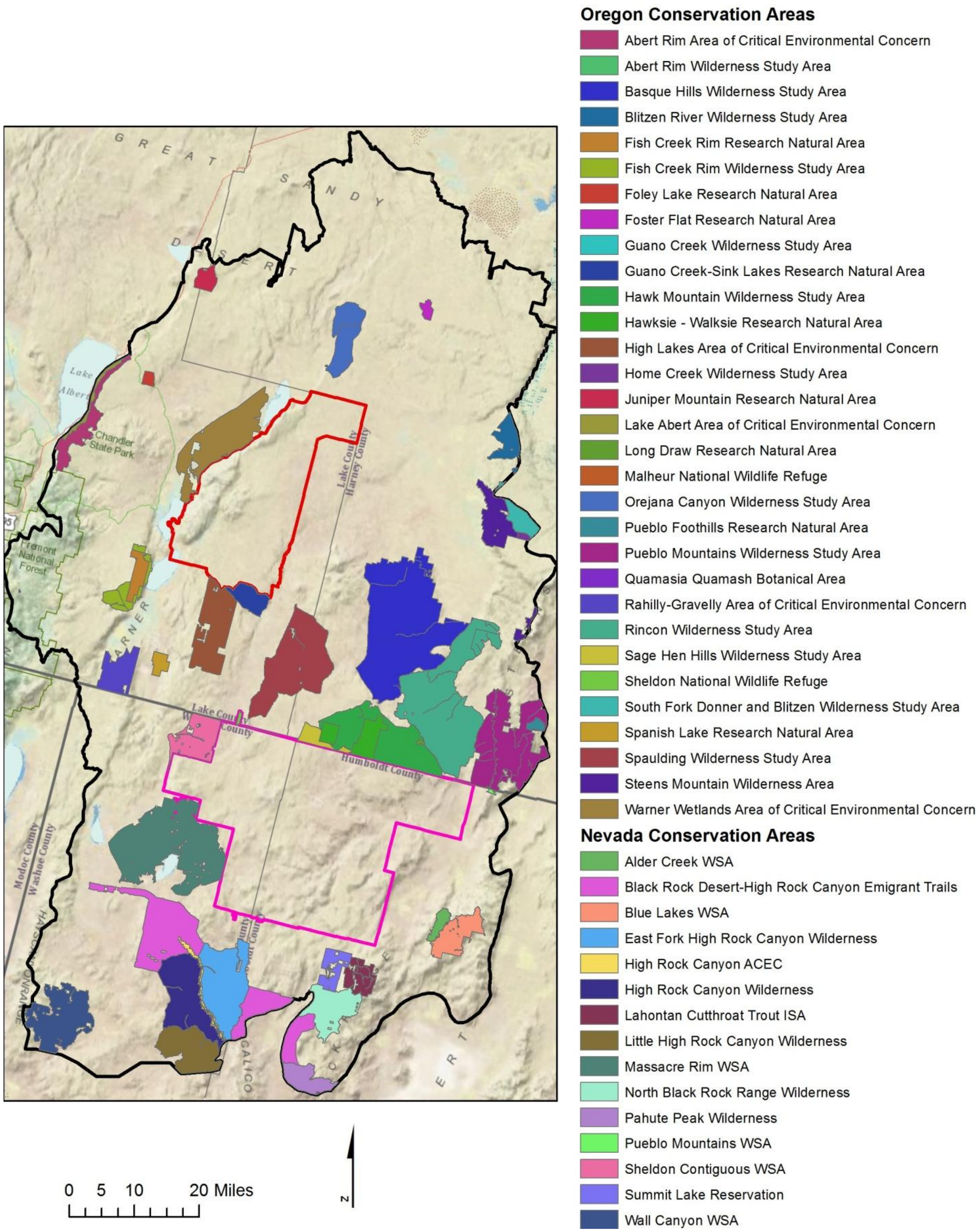


Public Lands Opportunities

The results of the 2025 Connectivity Scenario assessment using Vista (see Table 11, Appendix H, and scenario evaluation results discussion) showed that there are adjacent public lands with high conservation value that could potentially have a significantly beneficial impact on priority resources within the supporting landscape. Some of these areas already have some level of conservation protection or intent, indicating that cooperation among USFWS and other agencies to revise management to be consistent with the goals of the USFWS may be possible through inter-agency agreements.

Figure 49 shows the abundance of these lands in the project area. Designations shown include wilderness areas, wilderness study areas, research natural areas, and areas of critical concern. While these designations do have some conservation implications, the protections within each can differ significantly, and all may allow grazing.

Figure 49. Public lands with some level of existing conservation management or intent.



The VDDT and the climate change analysis show that major threats to the Refuge Complex are likely to be most significant immediately along the refuge boundaries. All of the climate models show a series of years with major wildfires occurring within this area sometime before 2060, and the links between wildfire frequency, intensity, spread and exotic species has been documented for many years (Whisenant 1990; Chambers et al. 2005). The very dramatic differences in changes in shrub steppe habitat quality and quantity based on areas and intensity of grazing makes a compelling case for excluding or continuing to exclude livestock and horses from both the Hart Mountain and Sheldon Refuges, and for further evaluating the possibility of creating a virtual connection between the two refuges by managing priority resources in the areas between the refuges primarily for conservation. The increase in the frequency of major fires occurs in all of the VDDT runs, but the area of the intense fires is greater when the cover of annual grasses is higher; and annual grass cover is higher in all areas grazed by livestock, horses and burros. As a result, fire frequency is greater along the edges of the refuges, although the western boundary of Hart Mountain NWR is somewhat protected by cliffs and the Warner Basin wetlands, and the southern and boundary of Sheldon NWR by more limited fuels. The work identifying wildlife corridors and the ongoing research evaluating how target species, such as the pronghorn and the greater sage grouse, use the area between the refuges has not been completed and should provide additional guidance in this regard.

Chapter 5. Maintaining and Updating the Assessment Databases

The vulnerability assessment database is composed of various parts:

1. The NatureServe Vista ESRI ArcMap and Microsoft Access project databases (note these function jointly through the Vista software). This includes species distribution shapefiles, as well as other inputs and outputs:
    a. Landscape Condition Model outputs
    b. Project boundary shapefiles
    c. Shapefiles used for stressor inputs
2. Vegetation data
3. Climate data (raster layers of average annual temperature and precipitation from 1971 to 2000)
4. VDDT models and climate model outputs
5. Documentation, user guides, and references

Following is a summary of recommendations for maintaining and updating these databases and data sets and key data gaps encountered in the assessment.

Database Maintenance and Updates

NatureServe Vista database

The Vista project database is readily used and updated by users proficient in ESRI's GIS software. When new data are incorporated, the scenarios evaluated in this RVA can be re-assessed. Generally, we recommend that the NatureServe Vista tool and database be updated as new or improved information is developed or acquired, such as:

- New resource distribution maps
- Better information on resource conservation requirements and responses to stressors
- Maps reflecting current scenario components (actual land use, management, other stressors, conservation acquisitions or policy changes)
- Refined/revised future scenario development proposals and plans
- Improved climate change results

This new and improved information can be used in Vista to:

1. Update the Vista database including resource distributions. We recommend updating current distributions and then updating distributions at regular intervals in the future (e.g., in 5-year increments or as appropriate to the pace of change). Saving the resource name with the year, e.g., pronghorn 2015, and storing each timeframe's representation of that resource can document changes in distribution due to changes in management and climate.
2. Update and maintain the baseline scenario. Similar to updating the resource distributions and other database components, we suggest saving snapshot scenarios in 5-year increments to document and track change that can be calibrated to observed ecological changes. The resulting

scenario and scenario evaluation record can prove highly valuable for backcasting and calibrating future evaluations.

3. Revise resource parameters such as how resources respond to stressors based on field observation and new published work.
4. Target inventory and monitoring to assess accuracy of climate change predictions, e.g., juniper and cheat grass expansion and effects on climate sensitive resources.

Other Data

Data used for the non-spatial vegetation resources assessments may receive updates as well. VDDT is freely available from ESSA Technologies, and as vegetation data are updated or new data sets become available, the vegetation resources may be re-assessed.

The combination of tools used for the climate assessments is a recent innovative development. The complexity of the integration of modeling tools and data used in this assessment necessitate that any updates to the climate assessment be conducted by specialists with expertise in climate models.

Data Gaps

A number of data gaps were encountered in the assessment process. In some cases, projects are underway that would address these gaps. As these data become available, it will be appropriate to re-visit the assessment using the new data. Lack of data also indicate where monitoring is appropriate or recommended to assess on-going changes in priority resources.

- Pronghorn occurrence and migration data were not available; in the current assessment, we utilized coarse habitat data as a surrogate. The recently initiated pronghorn GPS project should provide valuable empirical data that, combined with subsequent modeling (species distribution and connectivity modeling), can replace the data used in this RVA and provide greater precision to the assessment and planning for pronghorn.

- Other ongoing research to identify large-scale movement of the target wildlife species, particularly the greater sage grouse, golden eagle and pronghorn, should remain the highest priority for research. Monitoring their distribution both within the refuges, and their use of the area between the two refuges, would also be a high priority.

- Species including pygmy rabbits and white-tailed jackrabbits appear to be declining elsewhere in the region, and may warrant some basic monitoring to determine if the Refuge Complex provides important habitat for them and if they are declining in this area as well.

- From a habitat perspective, the refuge vulnerability assessment shows that grazing and grazing removal creates major change. The available data provides information on change in the dominant vegetation types, including the major sagebrush steppe communities. Initial reports on removal of horses at Hart Mountain NWR show that removing them will likely to increase the condition and diversity of riparian areas at Sheldon NWR and in any other areas which may become part of the refuges. Documenting the rate of these changes is important, especially if they can be tied to improvements in aquatic conditions. Also, monitoring change in the area of some of the more locally occurring vegetation types, including quaking aspen, mountain mahogany and mountain shrublands (areas dominated by snowberry, chokecherry, serviceberry and bitterbrush) which provide important wildlife habitat should be considered.

- Because the analysis linking of the climate change models to the management scenarios is both so important and so provisional, this information needs to be updated within a year or two. The two climate centers covering the Hart-Sheldon landscape are funded to continue to update the outputs of the climate change models, and to continue to downscale the results. When the climate model outputs are downscaled to 800 meters, the local watershed results will be more reliable. In addition, it will shortly be easier to compare the predicted outcomes of all the different climate models, making it easier to identify the changes which all the models predict.

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Appendix A. Regulatory and Policy Framework

This table identifies the relevant laws, policies, and plans the refuge is using to guide its planning and management.

Regulation, Policy, or Plan	Policy/Plan Intent	Resource (E-explicit/I-inferred)	Management Influence
1994 Hart Mountain CCP	Establish management plan for the refuge	Refuge resources	Little for this study as it is being revised
Migratory Bird Conservation Act		Migratory birds (E)	
Charles Sheldon Wild Life Refuge, Nevada (Executive Order [EO] 5540, Jan 26, 1931)		Wild animals and birds (E)	
Enlarging Charles Sheldon Wildlife Refuge, Nevada (EO 7364, May 6, 1936)		Migratory birds (E)	
Charles Sheldon Pronghorn Range, Nevada (EO 7522, Dec 21, 1936)		Pronghorn and other “secondary” species necessary for a balanced wildlife population (E)	
National Wildlife Refuge System Administration Act		Fish, wildlife, and plant resources (E)	
Mineral Withdrawal of a Portion of the Sheldon National Wildlife Refuge; Nevada (PLO 7761, Apr 26, 2011)	Removed mining as an allowable use until April 21, 2031		This stressor no longer allowed except in the special designated mining district
Endangered Species Act	Recover endangered species populations	At-risk species (E)	Aligns with Refuge management priorities for wildlife and wildlife habitats
Transfer of Certain Real Property for Wildlife Conservation Purposes Act	Conserve species habitat	Wildlife (E)	Collaboration with land trusts, neighboring agencies

Regulation, Policy, or Plan	Policy/Plan Intent	Resource (E-explicit/I-inferred)	Management Influence
Refuge Recreation Act	Allows recreational use of refuges, when such uses do not interfere with the area's primary purposes	Refuge resources (I)	
National Wildlife Refuge System Improvement Act	Ensures that the Refuge System is managed as a national system of related lands, waters, and interests for the protection and conservation of Nation's wildlife resources	Refuge resources (E)	
National Environmental Policy Act	Prevent or eliminate environmental damage	Habitats (I)	Aligns with Refuge management priorities for wildlife and wildlife habitats; provides EIS framework
North American Waterfowl Management Plan 1994, Intermountain West Joint Venture		Waterfowl (E) but lacks population goals for Sheldon	
Partners in Flight (PIF), Sheldon Refuge Plan			
Pacific Flyway Plans	Protection of habitat for migratory birds	Canada Geese, Greater White-fronted Geese, Snow Geese, Ross' Geese, Swans: Pacific Trumpeter, Rocky Mountain Trumpeter, Western Tundra, Eastern Tundra; Sandhill Cranes, Mourning Dove (E)	Provides resting habitat only, little habitat so little influence on the assessment.

Regulation, Policy, or Plan	Policy/Plan Intent	Resource (E-explicit/I-inferred)	Management Influence
Intermountain West Regional Shorebird Conservation Plan	Protection of shorebird populations	long-billed curlew, mountain plover and upland sandpiper, snowy plover, black-necked stilt, American avocet, long-billed curlew, long-billed dowitcher, and Wilson's phalarope (E)	Aligns with Refuge management priorities for wildlife and wildlife habitats
Draft Intermountain West Region Waterbird Conservation Plan	Protection of additional waterbirds not covered by other plans	41 species but not area-specific	Aligns with Refuge management priorities for wildlife and wildlife habitats
Species Recovery Plans			Aligns with Refuge management priorities for wildlife and wildlife habitats
Nevada Wildlife Action Plan		Species of Greatest Conservation Need identified in the plan	
Nevada Partners in Flight			
Nevada Management Plans for various species		Mule Deer, Big Game Status, Elk Species Management, Bat Conservation, Pronghorn Ecology, Management and Conservation, and Greater sage-grouse Conservation (E)	
National Historic Preservation Act			
Landscape Conservation Cooperative			
Important Bird Area (entire complex sagebrush obligates)			

Appendix B. Resources Checklist

This checklist identifies the candidate and final resources that were initially identified from the draft BIDEH policy and the Conservation Targets lists for the draft Sheldon NWR CCP and finalized during two scoping workshops with the refuge staff.

Assessment status is a dynamic field that was updated throughout the course of the study. Any resource listed was initially a candidate for assessment; those selected to be assessed were then listed as "assessment." In this way, the checklist maintains a record of the resources considered for assessment.

Resource	**Identified By**	**Assessment type** (spatial or non-spatial)	**Adequate expertise and/or data**	**Rationale for inclusion**	**Assessment status** (candidate, assessment)
Ecological Communities / Vegetation Resources					
Aspen Forest and Woodlands	Refuges	spatial	Y	Refuge priority	assessment
Big Sagebrush Shrublands	Refuges	spatial	Y	Refuge priority	assessment
Big Sagebrush Steppe	Refuges	spatial	Y	Refuge priority	assessment
Cliffs, Canyons, and Barren Lands	Refuges, ORBIC	spatial	Y	Refuge priority	assessment
Deciduous Shrublands	Refuges	spatial	Y	Refuge priority	assessment
Emergent Marshes and Wet Meadows	PIF	spatial	Y	Refuge priority	assessment
Ephemeral Wetlands	Refuges	not assessed (addressed as part of playas, emergent marshes)	na	Refuge priority	candidate
Greasewood Flats	Refuges	spatial	Y	Refuge priority	assessment
Juniper Savanna	Refuges	spatial	Y	Refuge priority	assessment
Low Sagebrush Shrublands and Steppes	Refuges	spatial	Y	Refuge priority	assessment
Montane Mesic Meadows	Refuges	spatial	Y	Refuge priority	assessment
Montane Sagebrush Steppe	Refuges	spatial	Y	Refuge priority	assessment

Resource	Identified By	Assessment type (spatial or non-spatial)	Adequate expertise and/or data	Rationale for inclusion	Assessment status (candidate, assessment)
Mountain Mahogany Woodlands	Refuges	spatial	Y	Refuge priority	assessment
Playa	Refuges	spatial	Y	Refuge priority	assessment
Ponderosa Pine Woodlands	Refuges	spatial	Y	Refuge priority	assessment
Salt Desert Scrubs	Refuges	spatial	Y	Refuge priority	assessment
Semi-desert Grasslands and Steppes	Refuges	spatial	Y	Refuge priority	assessment
Springs and Spring Brooks	Refuges	spatial	N	Refuge priority	assessment
Streams and Reservoirs	Refuges	spatial	Y	Refuge priority	assessment
Thermal Springs	Refuges	not assessed	N	Refuge priority	candidate
Western Juniper Woodlands	Refuges	spatial	Y	Refuge priority	assessment
Birds					
American Avocet	NatureServe	not assessed	na		candidate
American White Pelican	Refuges	non-spatial	N	Federal SOC	assessment
Blue-Gray Gnatcatcher	Refuges	non-spatial	N	Refuge priority	assessment
Cooper's Hawk	NatureServe	not assessed	na		candidate
Ferruginous Hawk	NatureServe	not assessed	na		candidate
Golden Eagle	ORBIC	non-spatial	Y	numbers declining	assessment
Gray Flycatcher	NatureServe	not assessed	na		candidate
Greater Sage-grouse	Refuges	spatial	Y	Federal ESA Candidate	assessment
Juniper Titmouse	NatureServe	not assessed	na		candidate
Lazuli Bunting	NatureServe	not assessed	na		candidate
Loggerhead Shrike	NatureServe	not assessed	na		candidate
Long-billed Curlew	NatureServe	not assessed	na		candidate
Northern Goshawk	NatureServe	not assessed	na		candidate
Orange-crowned Warbler	NatureServe	not assessed	na		candidate
Prairie Falcon	NatureServe	not assessed	na		candidate
Red-naped Sapsucker	NatureServe	not assessed	na		candidate
Sage Sparrow	NatureServe	not assessed	na		candidate

Resource	**Identified By**	**Assessment type** (spatial or non-spatial)	**Adequate expertise and/or data**	**Rationale for inclusion**	**Assessment status** (candidate, assessment)
Sage Thrasher	NatureServe	not assessed	na		candidate
Sandhill Crane	Refuges	spatial	Y	ODFW State Vulnerable (breeding population)	assessment
Snowy Egret	Refuges	non-spatial	N	Refuge priority	assessment
Western Burrowing Owl	Refuges	spatial	Y	Federal SOC	assessment
Western Snowy Plover	NatureServe	not assessed	na		candidate
Western Yellow-Billed Cuckoo	Refuges	non-spatial	N	Federal ESA Candidate	assessment
Yellow-breasted Chat	NatureServe	not assessed	na		candidate
Mammals					
American Pika	Refuges	spatial	Y	numbers declining	assessment
California Bighorn Sheep	NatureServe	not assessed	na		candidate
Long-Eared Myotis	NatureServe	spatial	Y	Federal SOC	assessment
Long-Legged Myotis	NatureServe	spatial	Y	Federal SOC	assessment
Mule Deer	Refuges	not assessed			candidate
Preble’s Shrew	NatureServe	non-spatial	N	Federal SOC	assessment
Pronghorn	Refuges	spatial	Y	Refuge priority	assessment
Pygmy Rabbit	Refuges	spatial	Y	Federal SOC	assessment
Spotted Bat	NatureServe	non-spatial	N	Federal SOC	assessment
Western Small-Footed Myotis	NatureServe	spatial	Y	Federal SOC	assessment
White-Tailed Antelope Squirrel	NatureServe	spatial	Y	State heritage priority	assessment
White-Tailed Jackrabbit	ORBIC	spatial	Y	Federal SOC	assessment
Fish					
Alvord Chub	NatureServe	spatial	Y	Federal SOC	assessment
Catlow Tui Chub	NatureServe	spatial	Y	Federal SOC	assessment
Lahontan Cutthroat Trout	NatureServe	spatial	Y	Federally Threatened	assessment
Sheldon Tui chub	NatureServe	spatial	Y	Federal SOC	assessment
Warner Sucker	NatureServe	spatial	Y	Federally Threatened	assessment

Resource	Identified By	**Assessment type** (spatial or non-spatial)	Adequate expertise and/or data	Rationale for inclusion	**Assessment status** (candidate, assessment)
Reptiles					
Long-nosed Leopard Lizard	NatureServe	not assessed	na		candidate
Plants					
Bebb's Willow	NatureServe	not assessed	na	State heritage priority	candidate
Biscuitroot	NatureServe	not assessed	na		candidate
Crosby's Buckwheat	ORBIC	spatial	Y	Federal SOC	assessment
Doublet	NatureServe	spatial	Y	State heritage priority	assessment
Long-Flowered Snowberry	NatureServe	spatial	Y	State heritage priority	assessment
Nodding Melicgrass	NatureServe	spatial	Y	State heritage priority	assessment
Playa Phacelia	NatureServe	spatial	Y	Federal SOC	assessment
Prostrate Buckwheat	NatureServe	spatial	Y	Federal SOC	assessment
Rose-Flower Desert-Parsley	NatureServe	spatial	Y	State heritage priority	assessment
Seaside Heliotrope	NatureServe	spatial	Y	State heritage priority	assessment
Three Forks Stickseed	NatureServe	spatial	Y	Federal SOC	assessment
Yellow Scorpionweed	NatureServe	spatial	Y	State heritage priority	assessment
Cultural resources					
Geothermal Hot Springs (Sheldon)	NatureServe	not assessed	na		candidate
Homesteads	NatureServe	not assessed	na		candidate
Paleontological resources	NatureServe	not assessed	na		candidate
Historic structures and sites	NatureServe	not assessed	na		candidate
Fishing areas	NatureServe	spatial	Y	Refuge priority	assessment
Hunting areas	NatureServe	non-spatial	na		candidate
Proposed wilderness	NatureServe	not assessed	na		candidate
RNA	NatureServe	spatial	Y	Refuge priority	assessment
Scenic Byway (proposed)	NatureServe	not assessed	na		candidate

Appendix C. Infrastructure Checklist

This checklist identifies those infrastructure features/types within the Refuge Complex that were considered for inclusion in the assessment as priority resources to be retained and/or as stressors on other resources. If the infrastructure resource is not listed as a retention target, it is either planned for or could be considered for future removal. Generally, most infrastructure resources are considered to be stressors on the biological resources. However, if an infrastructure feature is already planned for removal or is confidently believed to not stress any other resources, it was not treated as a stressor. If not enough data were available, the feature was not included in the assessment.

Feature Name/Type	Retention Target	Stressor on Resources	Comment or feature name(s)	Data?
Paved and improved gravel roads	Y	Y		Y
Improved road native material roads	Y	Y		Y
2-tracks	Some	Y	Some on refuge will be closed.	Y
Visitor contact station	Y	Y	(Sheldon)	Y
Visitor center	N	N	Off refuge	
Campgrounds	Y	Y	Some may be closed/relocated	Y
Communications tower	Y	Y	Small facility	Y
Fire lookout tower	Y	Y		N
Refuge headquarters	Y	Y	Hart and Sheldon headquarters included as both stressors and resources	Y
Administrative buildings	Y	Y		Y
Maintenance buildings and barns	Y	Y		Y
Refuge residences	Y	Y		Y
Surplus buildings	N	Y	Planned for removal	N
Kiosks	Y	Y		N

Feature Name/Type	Retention Target	Stressor on Resources	Comment or feature name(s)	Data?
Non-motorized travel routes (Desert Trail and currently closed 2-tracks used as trails)	N	Y	Hiking routes designated by recreation groups, not established or maintained by the refuge. Decision to move to stressors.	N
Trail (Degarmo Cyn Trail)	Y	Y	Built by volunteers	N
Overlook Trail	Y	Y		N
Water control structures	Some	Y	NWR will ID specific ones. Have data for Sheldon.	Y
Gates	N	Y		N
Interior Fences	N	Y	Currently being removed	N
Exterior Fences and cattle guards	Y	Y	Hart and Sheldon boundary fences included as both stressors and resources	Y
Signs	N	N		N
Constructed ponds/reservoirs (controlled)	Some	Y		Y - Sheldon
Constructed ponds/reservoirs (uncontrolled)	Some	Y	some data from bat foraging locations off-refuge	Y - Sheldon
Utility lines (overhead)	Y	Y	have data for major lines off-refuge	Y
Utility lines (buried)	Y	Y	Ruby Pipeline off-refuge. Hart has buried lines, but no data for these.	Y
Gravel pits	Y	Y		N
Air strips	Y	Y		N
Inholdings structures	Y	Y		N
DOT rest area	Y	Y		N
Fishing docks	Y	Y	Have spatial data for fishing areas, not docks specifically	Y

Appendix D. Stressors Checklist

This checklist identifies those stressors currently known or assumed to be occurring within the supporting landscape and those reasonably anticipated in the future for the Refuge Complex. The checklist was used to obtain spatial data layers or develop models for those stressors to include them in scenarios to be assessed for impacts on resources. The “Future” column indicates whether the stressor was expected (under current plans) to continue into the future or is not currently in the assessment region but anticipated to be in the future. Current stressors were assumed to continue into the future unless mitigated. The “Included” column indicates whether the stressor was included in the assessment. Data available includes both spatial and non-spatial datasets. Question marks in the “Future” column indicate uncertainty of future Refuge management; these will become clearer when the final management decisions are chosen from the Refuge planning documents. Stressors included in the landscape condition model were given weights relative to their impact on the landscape, shown previously in Table 13.

Stressor name/type	Effects	Current	Future	Included	Data Available
Feral horses and burros (Sheldon)	Herbivory, soil disturbance/erosion, water source disturbance and development	Y	?	Y	Y
Feral horses and burros (surrounding lands, not on Hart)	Impact to surrounding wildlife habitats	Y	Y	Y	Y
Altered fire regime	Altered plant composition, promotion of invasive species, soil erosion, altered nutrient cycling	Y	Y	Y	Y
Juniper expansion and infill	Habitat replacement, avian predator distribution Connectivity	Y	Y	Y	Y
Mining (Sheldon and off refuge)	Plant and soil disturbance/removal	Y	Y	Y	Y, Sheldon
Off-road vehicle use not on tracks	Plant and soil disturbance, erosion, wildlife disturbance, hydrologic disturbance, promotion of exotic/invasive species	Y	Y	Y	N
Roads/auto traffic (see infrastructure list)	Wildlife fatalities, air pollution, noise pollution, increased wildlife avoidance/fragmentation	Y	Y	Y	N
Wildlife poaching	Wildlife removal	Y	?	N	N
Campgrounds	Localized trampling, wildlife disturbance, trash	Y	Y	Y	Y
Resource Collecting	Fossil hunting, etc	Y	Y	N	Y
Day Use Areas, Fishing	Disturbance to wildlife, vehicle traffic	Y	Y	Y	Y

Stressor name/type	Effects	Current	Future	Included	Data Available
Communications towers	Bird and bat impact, disturbance to sage grouse	Y	Y	Y	Y
Agriculture contaminants (including active spraying)	Sedimentation Toxins: kill invertebrates and food sources, direct toxicity to resources as assumed output of intensive agricultural areas	Y	Y	Y	N
Agricultural (cropped) development (off-refuge, SSURGO model).	Habitat clearing, fragmentation, increased contaminants	Y	Y	Y	Y
Chained cleared pasture development (private, contact NRCS if they have a projection, utilize SSURGO?)	Habitat clearing, wildlife disturbance	Y	Y	N	N
Other private undefined land use	Habitat conversion, structures, agriculture, grazing possible	Y	Y	Y	Y
Water diversion and alteration (wildlife/cattle tanks, drinkers, water appropriation in Virgin Valley)	Stream flow regime, groundwater reductions, spring draw down, habitat alteration, increase in mesopredators	Y	Y	Y	Y (Sheldon)
Conflicting habitat management (on refuge and by state agencies—parks, heritage, DGIF, TNC (owned and easements)	Promotion of some habitats/species over others	Y	Y	Y (part)	Y
Livestock and horse grazing (off refuge, BLM, USFS, private and state land)	Habitat degradation, weed vectors, riparian impacts, wildlife disturbance	Y	Y	Y	Y
Invasive native species (Artemisia; excludes juniper)	Plant composition changes, fire regime changes, loss of forage	Y	Y	N	N
Invasive exotic plants (cheatgrass and medusahead)	Plant composition changes, fire regime changes, loss of forage	Y	Y	Y	Y

Stressor name/type	Effects	Current	Future	Included	Data Available
Invasive exotic animals (guppies, bullfrogs)	Loss of diversity, hybridization, endangered species loss	Y	Y	N	N
Introduced wildlife diseases (e.g., WNV assoc with feral horses—non spatial assessment example)	Population stress or extirpation	Y	Y	N	N
Hunting (sage grouse and pronghorn)	Site disturbance from trampling, general localized wildlife disturbance, introduction of exotic species	Y	?	N	N
Inholdings development (possibly treat same as generic private development/clearing)	Habitat clearing, fragmentation, introduction of invasive plants and free ranging introduced mesopredators (e.g., house cats)	Y	Y	Y	Y
Overhead utility lines (current and proposed—see western energy corridor website for a route between refuges)	Bird collision, vegetation clearing, soil disturbance	Y	Y	Y	Y
Buried utility lines (maintained corridor—ex and proposed)	Vegetation clearing, soil disturbance	Y	Y	Y	PART
Non-point source water pollution	Nitrification and toxins in water bodies	Y	Y	N	N
Oil/chemical spills along roadways	Toxic runoff into water bodies	Y	Y	N	N
Former toxics sites	Toxins in soil and toxic runoff into water bodies	Y	?	N	N
Elevated predation	Population impacts on imperiled wildlife. Consider as response to development	Y	Y	Indirect	N
Human pedestrian and dogs activity (trespass and permitted)	Chasing wildlife, disturbing the wildlife behavior, displacing wildlife	Y	Y	Indirect	N
Light pollution	Disturbance to nocturnal animals	Y	Y	N	N
Air pollution deposition e.g., mercury	Inhibition of breeding success	Y	Y	N	N

Stressor name/type	Effects	Current	Future	Included	Data Available
Energy development (wind)	Habitat alteration, direct mortality—collision	Y	Y	Y	Y
Energy development (solar)	Habitat alteration, disturbance, traffic/roads	N	Y	Y	N
Energy development (geothermal)	Habitat alteration, disturbance, traffic/roads	Y	Y	Y	Y
Wildlife disease	Increased mortality or decreased fitness	Y	?	N	N
Predator control (outside refuge)	Decreased predation stress, decreased predator populations	Y	?	N	N
Extreme weather events (frequency/intensity)	Increased stress to habitats	Y	Y	N	N
Increased air temperature (annual average and seasonal extreme?)	Heat stress on vegetation and wildlife, decreased soil moisture, drought intensity	Y	Y	Y	Y
Air temperature change (seasonal)	Phenology change, drought stress	Y	Y	Y	Y
Decreased air temperature	Drought frequency/intensity	N	?	N	N
Increased precipitation	Raised groundwater levels, alteration of soil moisture, nest flooding	Y	?	Y	Y
Decreased precipitation (annual average)	Drought frequency/intensity, fire frequency	N	?	Y	Y
Change in precipitation timing	Reduced snowpack	?	Y	N	N
Altered phenology	Uncoupling of wildlife-vegetation-prey relationships, impacts on feeding and reproduction	Y	Y	N	N
Cheatgrass invasion	Change and reduction in distribution of sage and desert scrub ecosystems	Y	Y	Y	Y

Appendix E. Resource Data Sources

This table documents the data sources for resource spatial distributions and responses, and documents the associated confidence of those data sources on a scale from 0 (no confidence) to 1 (complete confidence). Global Ranks are those assigned by NatureServe, viewable online on the NatureServe Explorer site (http://natureserve.org/explorer). Priorities were determined by project staff. Resources are ordered by type then by common name. Federal status is determined by USFWS (http://www.fws.gov/endangered/).

Type	Common name	Scientific name	Federal Status	Priority	Global Rank	Data Source of Distribution Layer	Data Confidence Value	Confidence Judgment
Mammals	American Pika	*Ochotona princeps*		2	G5	ORBIC PODS dataset, Refuge data	1.00	Natural Heritage data well QC'd, Refuge data trusted source
	Long-eared Myotis	*Myotis evotis*	SOC	3	G5	ORBIC database, NV Natural Heritage database, NatureServe layers	0.80	records have greater locational uncertainty
	Long-legged Myotis	*Myotis volans*	SOC	3	G5	ORBIC database, NV Natural Heritage database, NatureServe layers	0.80	records have greater locational uncertainty
	Preble's Shrew	*Sorex preblei*	SOC	3	G4	not enough spatial information available	NA	
	Pronghorn Corridors	Pronghorn Corridors		1	G5	NatureServe layers, Refuge	1.00	Natural Heritage data well QCd, Refuge data trusted source
	Pronghorn Nonwinter Range	Pronghorn Nonwinter Range		1	G5	NatureServe layers, Refuge	1.00	Natural Heritage data well QCd, Refuge data trusted source
	Pronghorn Primary Habitat	Pronghorn Primary Habitat		1	G5	NatureServe layers, GAP maps, Refuge veg maps	0.75	account for average veg map accuracy

Type	Common name	Scientific name	Federal Status	Priority	Global Rank	Data Source of Distribution Layer	Data Confidence Value	Confidence Judgment
	Pronghorn Winter Habitat	Pronghorn Winter Habitat		1	G5	NatureServe layers, Refuge	1.00	Natural Heritage data well QCd, Refuge data trusted source
	Pygmy Rabbit	*Brachylagus idahoensis*	SOC	2	G4	ORBIC database, NV Natural Heritage database, NatureServe layers	1.00	Natural Heritage data well QCd, Refuge data trusted source
	Spotted Bat	*Euderma maculatum*	SOC	3	G4	not enough spatial information available	NA	
	Western Small-footed Myotis	*Myotis ciliolabrum*	SOC	3	G5	ORBIC database, NV Natural Heritage database, NatureServe layers	0.80	records have greater locational uncertainty
	White-tailed Antelope Squirrel	*Ammospermophilus leucurus*		3	G5	ORBIC database, NV Natural Heritage database, NatureServe layers	0.80	records have greater locational uncertainty
	White-tailed Jackrabbit	*Lepus townsendii*		3	G5	ORBIC database, NV Natural Heritage database, NatureServe layers	0.80	records have greater locational uncertainty
Birds	American White Pelican	*Pelecanus erythrorhynchos*	SOC	3	G4	not enough spatial information available	NA	
	Blue-gray Gnatcatcher	*Polioptila caerulea*		3	G5	not enough spatial information available	NA	
	Greater Sage Grouse	*Centrocercus urophasianus*	C	1	G3G4	ORBIC database, NV Natural Heritage database, NatureServe layers	1.00	Natural Heritage data well QCd, Refuge data trusted source
	Greater Sandhill Crane	*Grus canadensis tabida*		3	G5T4	ORBIC database, NV Natural Heritage database, NatureServe layers	0.80	records have greater locational uncertainty
	Sage Grouse	Sage Grouse	C	1	G3G4	NatureServe layers, GAP	0.75	account for average

Type	Common name	Scientific name	Federal Status	Priority	Global Rank	Data Source of Distribution Layer	Data Confidence Value	Confidence Judgment
	Breeding Habitat	Breeding Habitat				maps, Refuge veg maps		veg map accuracy
	Sage Grouse Nesting Habitat	Sage Grouse Nesting Habitat	C	1	G3G4	ORBIC database, NV Natural Heritage database, NatureServe layers	1.00	Natural Heritage data well QCd, Refuge data trusted source
	Sage Grouse Range	Sage Grouse Range	C	1	G3G4	ORBIC database, NV Natural Heritage database, NatureServe layers	1.00	Natural Heritage data well QCd, Refuge data trusted source
	Snowy Egret	*Egretta thula*		3	G5	not enough spatial information available	NA	
	Western Burrowing Owl	*Athene cunicularia hypugaea*	SOC	2	G4	ORBIC database, NV Natural Heritage database, NatureServe layers	1.00	Natural Heritage data well QCd, Refuge data trusted source
	Western Yellow-billed Cuckoo	*Coccyzus americanus occidentalis*	C	3	G5	not enough spatial information available	NA	
Fish	Alvord Chub	*Gila alvordensis*	SOC	3	G2	not enough spatial information available	NA	
	Catlow Tui Chub	*Gila bicolor ssp. 2*	SOC	3	G4T1	ORBIC database, NV Natural Heritage database, NatureServe layers	1.00	Natural Heritage data well QCd
	Lahontan Cutthroat Trout	*Oncorhynchus clarkii henshawi*	LT	2	G4T3	ORBIC database, NV Natural Heritage database, NatureServe layers	1.00	Natural Heritage data well QCd, Refuge data trusted source
	Redband Trout - Catlow Valley	*Oncorhynchus mykiss pop. 3*	SOC	2	G5T1Q	ORBIC database, NV Natural Heritage database, NatureServe layers	1.00	Natural Heritage data well QCd, Refuge data trusted

Type	Common name	Scientific name	Federal Status	Priority	Global Rank	Data Source of Distribution Layer	Data Confidence Value	Confidence Judgment
								source
	Redband Trout - Warner Valley	*Oncorhynchus mykiss pop. 4*	SOC	2	G5T2Q	ORBIC database, NV Natural Heritage database, NatureServe layers	1.00	Natural Heritage data well QCd, Refuge data trusted source
	Sheldon Tui Chub	*Gila bicolor eurysoma*	SOC	2	G4T1	ORBIC database, NV Natural Heritage database, NatureServe layers	1.00	Natural Heritage data well QCd, Refuge data trusted source
	Warner Sucker	*Catostomus warnerensis*	LT	2	G1	ORBIC database, NV Natural Heritage database, NatureServe layers	1.00	Natural Heritage data well QCd, Refuge data trusted source
Communities	Columbia Plateau Low Sagebrush Steppe	Columbia Plateau Low Sagebrush Steppe		1		GAP maps, Refuge veg maps	0.75	account for average veg map accuracy
	Inter-Mountain Basins Big Sagebrush Shrubland	Inter-Mountain Basins Big Sagebrush Shrubland		1		GAP maps, Refuge veg maps	0.75	account for average veg map accuracy
	Inter-Mountain Basins Big Sagebrush Steppe	Inter-Mountain Basins Big Sagebrush Steppe		1		GAP maps, Refuge veg maps	0.75	account for average veg map accuracy
	Inter-Mountain Basins Cliff and Canyon	Inter-Mountain Basins Cliff and Canyon		3		GAP maps, Refuge veg maps	0.75	account for average veg map accuracy

Type	Common name	Scientific name	Federal Status	Priority	Global Rank	Data Source of Distribution Layer	Data Confidence Value	Confidence Judgment
	Inter-Mountain Basins Curl-leaf Mountain-Mahogany Woodland and Shrubland	Inter-Mountain Basins Curl-leaf Mountain Mahogany Woodland and Shrubland		2		GAP maps, Refuge veg maps	0.75	account for average veg map accuracy
	Inter-Mountain Basins Greasewood Flat	Inter-Mountain Basins Greasewood Flat		3		GAP maps, Refuge veg maps	0.75	account for average veg map accuracy
	Inter-Mountain Basins Juniper Savanna	Inter-Mountain Basins Juniper Savanna		3		GAP maps, Refuge veg maps	0.75	account for average veg map accuracy
	Inter-Mountain Basins Mixed Salt Desert Scrub	Inter-Mountain Basins Mixed Salt Desert Scrub		3		GAP maps, Refuge veg maps	0.75	account for average veg map accuracy
	Inter-Mountain Basins Montane Sagebrush Steppe	Inter-Mountain Basins Montane Sagebrush Steppe		1		GAP maps, Refuge veg maps	0.75	account for average veg map accuracy
	Inter-Mountain Basins Playa	Inter-Mountain Basins Playa		3		GAP maps, Refuge veg maps	0.75	account for average veg map accuracy
	Inter-Mountain Basins Semi-Desert Grassland	Inter-Mountain Basins Semi-Desert Grassland		1		GAP maps, Refuge veg maps	0.75	account for average veg map accuracy
	North American Arid West Emergent Marsh	North American Arid West Emergent Marsh		2		GAP maps, Refuge veg maps	0.75	account for average veg map accuracy

Type	Common name	Scientific name	Federal Status	Priority	Global Rank	Data Source of Distribution Layer	Data Confidence Value	Confidence Judgment
	Northern Rocky Mountain Montane-Foothill Deciduous Shrubland	Northern Rocky Mountain Montane-Foothill Deciduous Shrubland		3		GAP maps, Refuge veg maps	0.75	account for average veg map accuracy
	Rocky Mountain Aspen Forest and Woodland	Rocky Mountain Aspen Forest and Woodland		1		GAP maps, Refuge veg maps	0.75	account for average veg map accuracy
	Rocky Mountain Ponderosa Pine Woodland	Rocky Mountain Ponderosa Pine Woodland		2		GAP maps, Refuge veg maps	0.75	account for average veg map accuracy
	Rocky Mountain Subalpine-Montane Mesic Meadow	Rocky Mountain Subalpine-Montane Mesic Meadow		2		GAP maps, Refuge veg maps	0.75	account for average veg map accuracy
Plants	Bebb's Willow	*Salix bebbiana*		3	G5	not enough spatial information available	NA	
	Crosby's Buckwheat	*Eriogonum crosbyae*	SOC	3	G3	ORBIC database, NV Natural Heritage database, NatureServe layers	1.00	Natural Heritage data well QCd
	Doublet	*Dimeresia howellii*		3	G4?	not enough spatial information available	NA	
	Grimy Ivesia	*Ivesia rhypara var. rhypara*	SOC	2	G2T2	ORBIC database, NV Natural Heritage database, NatureServe layers	1.00	Natural Heritage data well QCd, Refuge data trusted source
	Long-flowered Snowberry	*Symphoricarpos longiflorus*		3	G5	ORBIC database, NV Natural Heritage database, NatureServe layers	1.00	Natural Heritage data well QCd

Type	Common name	Scientific name	Federal Status	Priority	Global Rank	Data Source of Distribution Layer	Data Confidence Value	Confidence Judgment
	Nodding Melicgrass	*Melica stricta*		3	G4	ORBIC database, NV Natural Heritage database, NatureServe layers	1.00	Natural Heritage data well QCd
	Playa Phacelia	*Phacelia inundata*	SOC	3	G2	ORBIC database, NV Natural Heritage database, NatureServe layers	1.00	Natural Heritage data well QCd
	Prostrate Buckwheat	*Eriogonum prociduum*	SOC	3	G3	ORBIC database, NV Natural Heritage database, NatureServe layers	1.00	Natural Heritage data well QCd
	Rose-flower Desert-parsley	*Lomatium roseanum*		3	G2G3	ORBIC database, NV Natural Heritage database, NatureServe layers	1.00	Natural Heritage data well QCd
	Seaside Heliotrope	*Heliotropium curassavicum*		3	G5	ORBIC database, NV Natural Heritage database, NatureServe layers	1.00	Natural Heritage data well QCd
	Three Forks Stickseed	*Hackelia ophiobia*	SOC	3	G3	ORBIC database, NV Natural Heritage database, NatureServe layers	1.00	Natural Heritage data well QCd
	Yellow Scorpionweed	*Phacelia lutea var. calva**		3	G4T3	ORBIC database, NV Natural Heritage database, NatureServe layers	1.00	Natural Heritage data well QCd
Infrastructure	Hart Headquarters	Hart Headquarters		1		Refuge layer	1.00	Refuge data trusted source
	Hart Boundary Fence	Hart Boundary Fence		1		Refuge layer	1.00	Refuge data trusted source
	Sheldon Boundary Fence	Sheldon Boundary Fence		1		Refuge layer	1.00	Refuge data trusted source
	Sheldon Headquarters	Sheldon Headquarters		1		Refuge layer	1.00	Refuge data trusted source
	Last Chance Ranch	Last Chance Ranch		1		Refuge layer	1.00	Refuge data trusted source

Appendix F. Data Checklist

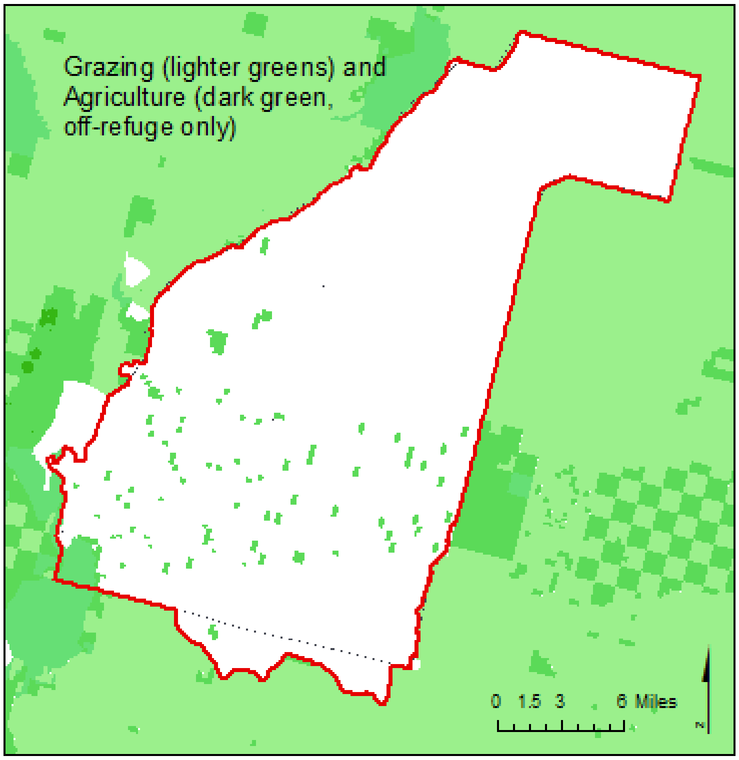
This checklist summarizes the data sets used in the refuge vulnerability assessment as well as data gaps.

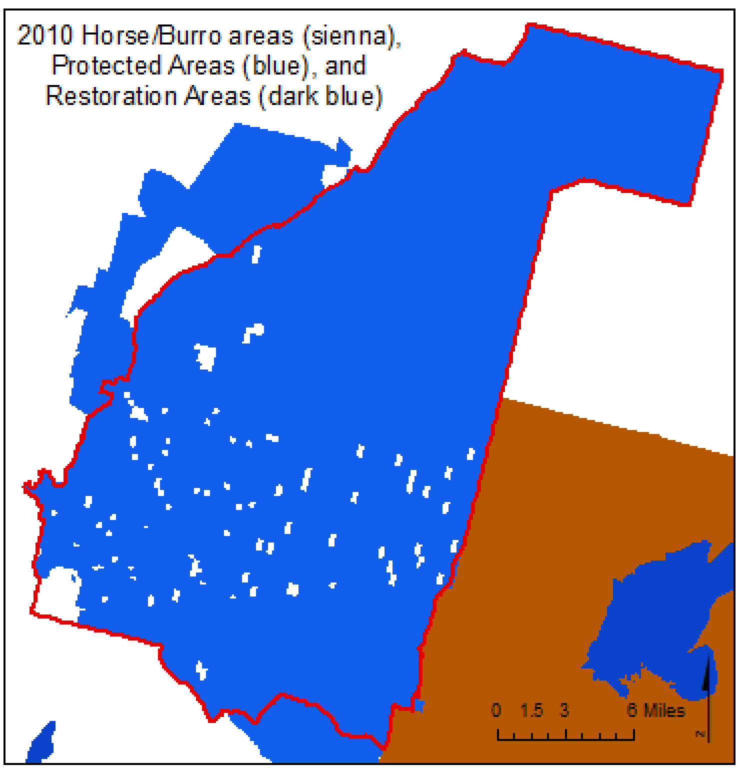
Data Theme	Data Source	Secured	Quality/Improvement needs
Boundaries			
Regional	USGS	Y	
Ecoregions	USFS (Bailey), EPA (Omernik)	Y	
Watershed	USGS	Y	
Supporting landscape	ESRI	Y	
Acquisition/Ownership	NatureServe, ORBIC, PAD-US	Y	
Refuge ownership	NatureServe, Refuges	Y	
Resource Distribution Maps			
Ecosystems/habitat types (coarse filter)	Refuge vegetation maps, GAP maps for OR and NV	Y	
Biological communities (fine filter)	Refuge vegetation maps, GAP maps for OR and NV	Y	types from different sources cross-walked to NatureServe community names
Species	ORBIC, Nevada Natural Heritage, NatureServe, USFWS	Y	Removed historical and locationally uncertain records. Some species not enough spatial data to include.
Sage grouse leks		N	OR leks and buffered NV leks
Antelope corridor data		N	Data are incomplete
Resource Viability Requirements			

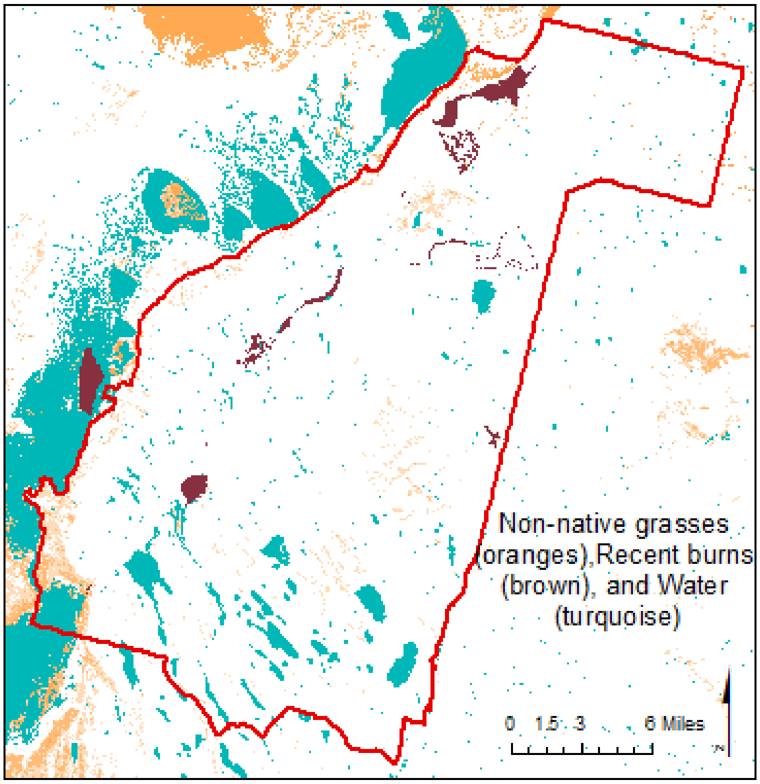
Data Theme	Data Source	Secured	Quality/Improvement needs
Minimum occurrence size	NatureServe Explorer, ORBIC, reference search	Y	Only used for species where enough data was present and existing EOs supported minimum value
Condition threshold		N	Thresholds not used in project, though condition models were created and are included.
Supporting landscape retention goal	Refuges, ORBIC	Y	
Responses to stressors/management	NatureServe Explorer, ORBIC, reference search	Y	expert opinion used to fill in gaps where literature source not found
Infrastructure Type/Location Maps			
Roads and rail	Refuges, 2010 Census data	Y	
Buildings	Refuges, GAP land cover map	Y	probably lacking some private building information
Power/transmission	USFS SageMap data, Refuges	Y	may not have all smaller lines, especially in supporting landscape
Water control structures	Refuges	Y	do not have off-refuge data
Infrastructure Viability Requirements			
Infrastructure type minimum occurrence size	Refuges	Y	Where applicable
Infrastructure type minimum condition threshold	Refuges	Y	
Infrastructure type retention goal (e.g., if there is redundancy of an infrastructure type and less than 100% is required to be retained)	Refuges	Y	

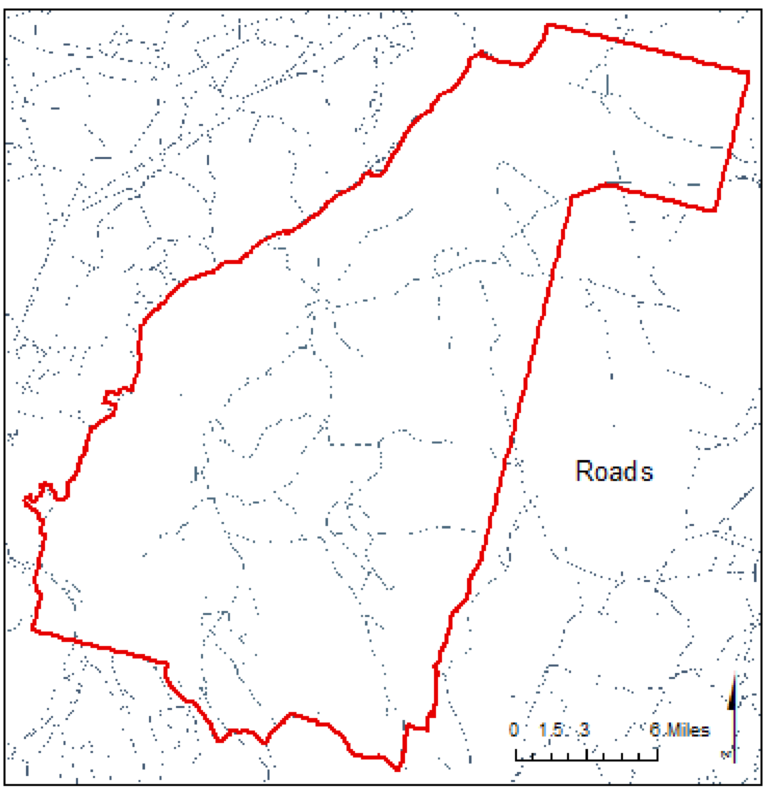
Data Theme	Data Source	Secured	Quality/Improvement needs
Scenario Input Maps			
Current protected areas (e.g., GAP status I and II)	GAP stewardship layer, BLM Lakeview Management Plan, BLM ownership layer, Refuge data, PAD-US	Y	
Current public land and private conservation land stewards	GAP stewardship layer, BLM Lakeview Management Plan, BLM ownership layer, Refuge data	Y	may be missing some smaller private organization conservation groups
Proposed conservation areas (e.g., SWAP, TNC, Audubon, DU, etc.)		N	
Current land use	several sources – Refuges, BLM, GAP ownership, census data, etc.	Y	
Future zoned or modeled land use		N	
Current infrastructure	Refuges	Y	
Planned or proposed infrastructure	Refuges	Y	
Current management practices	Refuges	Y	
Planned/proposed management	Refuges	Y	Sheldon CCP
Current invasive species	Nevada Annual Grasses raster (Nevada Natural Heritage), VDDT inputs (ORBIC/ILAP)	Y	
Modeled invasives spread	VDDT modeling outputs (ORBIC/ILAP)	Y	
Modeled wildfire risk areas	ORBIC/ILAP	Y	non-spatial VDDT outputs
Other modeled future climate changes (temp, soil moisture, salinity, pH, etc.)	ORBIC/ILAP	Y	non-spatial climate change modeling outputs

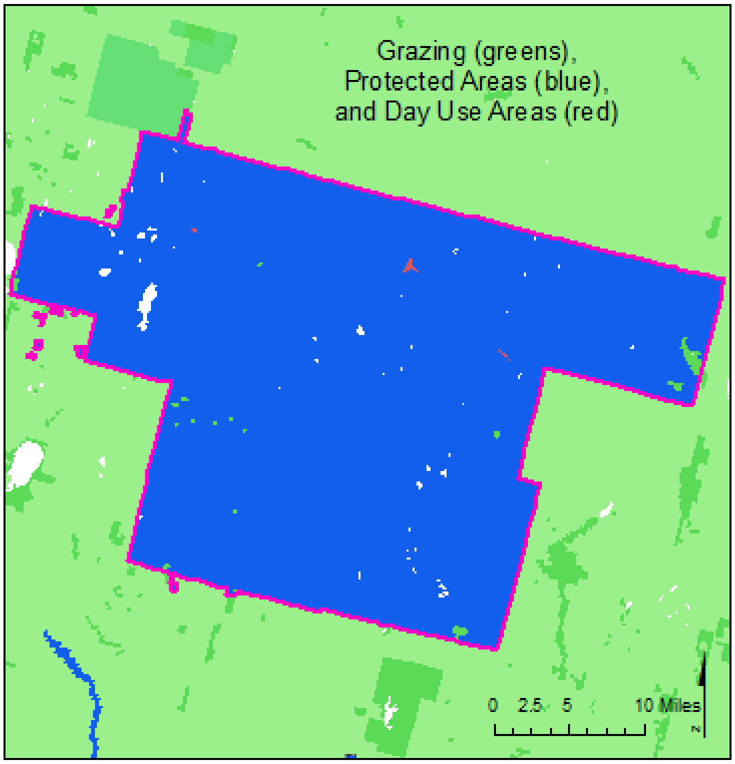
Appendix G. Detailed land use maps for Sheldon and Hart Mountain Refuges under the 2010 Scenario.

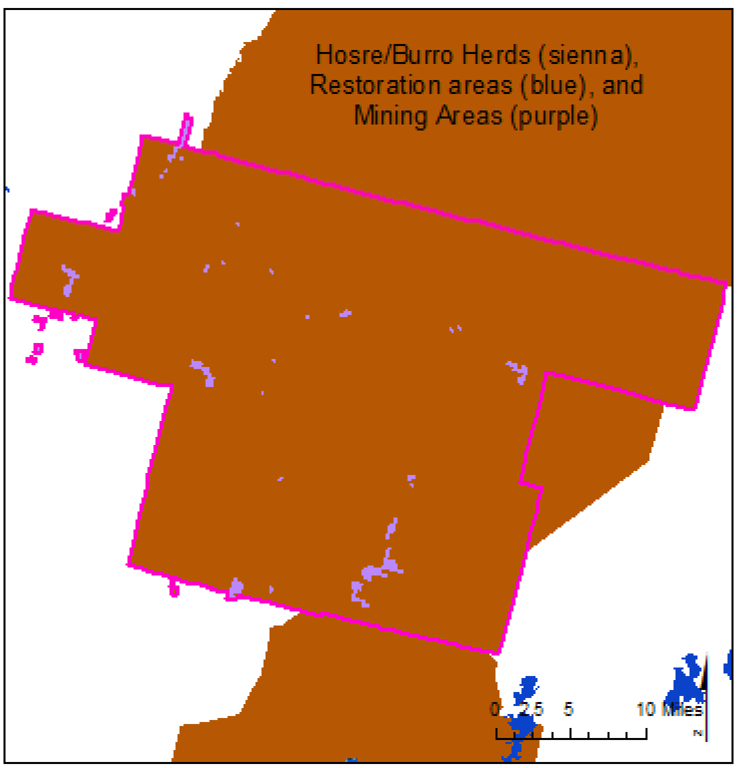


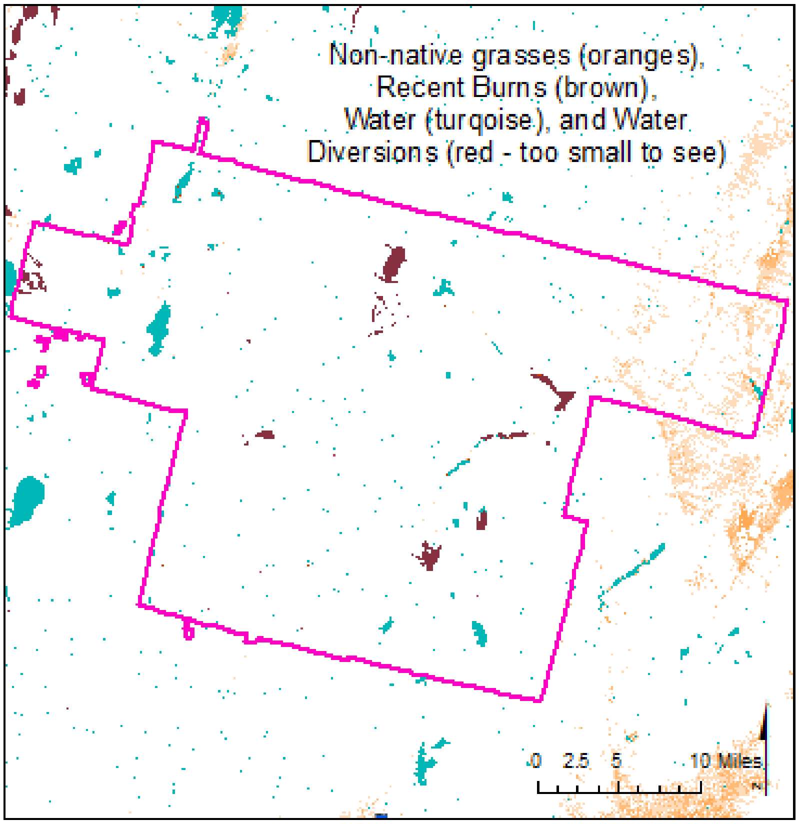


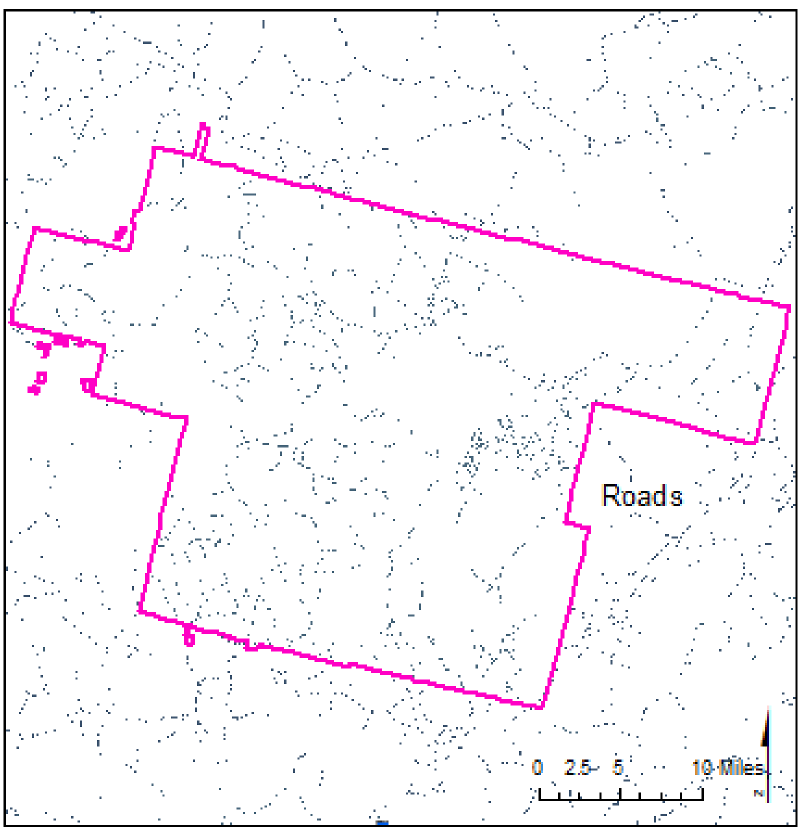

Non-native grasses
(oranges),Recent burns
(brown), and Water
(turquoise)
0 1.5 3 6 Miles


Roads
0 1.5 3 6 Miles


Grazing (greens),
Protected Areas (blue),
and Day Use Areas (red)
0 2.5 5 10 Miles


Hosre/Burro Herds (sienna),
Restoration areas (blue), and
Mining Areas (purple)
0 2.5 5 10 Miles


Non-native grasses (oranges),
Recent Burns (brown),
Water (turqoise), and Water
Diversions (red - too small to see)
0 2.5 5 10 Miles


Roads
0 2.5 5 10 Miles

Appendix H. Scenario Evaluation Results

Baseline Scenario Results

Type	Resource Name	Current Hectares	Current Occs	Retention Goal (%)	Compatible Hectares	Compatible Occs	% of Goal Met
Mammals	American Pika	56432	5	50	15570	1	55%
	Long-Eared Myotis	10	12	50	1	1	17%
	Long-Legged Myotis	4	5	50	0	0	0%
	Pronghorn Corridors	4233	2	100	0	0	0%
	Pronghorn Nonwinter Range	155913	6	100	19016	3	12%
	Pronghorn Primary Habitat	1306733	8,396	100	78480	2	6%
	Pronghorn Winter Range	65307	6	100	42370	2	65%
	Pygmy Rabbit	3255	13	50	0	0	0%
	Western Small-Footed Myotis	8	10	50	1	1	20%
	White-Tailed Antelope Squirrel	4920	7	50	0	0	0%
	White-Tailed Jackrabbit	703	1	50	0	0	0%
Birds	Greater Sandhill Crane	703	1	50	0	0	0%
	Sage Grouse	36	121	100	7	22	18%
	Sage Grouse Breeding Habitat	648228	55	100	49768	4	8%
	Sage Grouse Nesting Habitat	1752859	3,239	100	92740	2	5%
	Sage Grouse Range	1309724	1	100	90076	1	7%
	Western Burrowing Owl	4219	6	40	0	0	0%
Fish	Catlow Tui Chub	47	4	100	17	1	35%
	Catlow Valley Redband Trout	9	7	100	0	0	0%

Type	Resource Name	Current Hectares	Current Occs	Retention Goal (%)	Compatible Hectares	Compatible Occs	% of Goal Met
	Lahontan Cutthroat Trout	258	5	100	0	0	0%
	Sheldon Tui Chub	24	3	100	0	0	0%
	Warner Sucker	10086	10	100	21	1	32%
	Warner Valley Redband Trout	6439	6	100	21	1	39%
Communities	Columbia Plateau Low Sagebrush Steppe	528016	4,107	60	44238	221	14%
	Inter-Mountain Basins Big Sagebrush Shrubland	742469	4,575	80	371565	2,135	65%
	Inter-Mountain Basins Big Sagebrush Steppe	464671	2,196	80	181046	1,167	55%
	Inter-Mountain Basins Cliff and Canyon	28959	2,852	60	5224	198	30%
	Inter-Mountain Basins Curlleaf Mountain Mahogany	2224	1,098	80	229	55	14%
	Inter-Mountain Basins Greasewood Flat	124595	3,194	60	1292	103	2%
	Inter-Mountain Basins Juniper Savanna	37997	2,538	60	30210	2,294	151%
	Inter-Mountain Basins Mixed Salt Desert Scrub	77081	2,766	60	466	65	1%
	Inter-Mountain Basins Montane Sagebrush Steppe	319828	7,400	80	162093	4,258	66%
	Inter-Mountain Basins Playa	74778	4,595	100	3367	217	11%
	Inter-Mountain Basins Semi-Desert Grassland	172381	8,920	60	6619	451	6%
	North American Arid West Emergent Marsh	31046	1,030	60	310	83	3%
	Northern Rocky Mountain Foothill Deciduous Shrubland	27604	2,318	40	12032	337	109%
	Rocky Mountain Aspen Forest and Woodland	14953	672	100	810	54	5%
	Rocky Mountain Ponderosa Pine Woodland	35	2	40	30	2	215%
	Rocky Mountain Subalpine-Montane Mesic Meadow	21498	6,045	100	4723	235	26%

Type	Resource Name	Current Hectares	Current Occs	Retention Goal (%)	Compatible Hectares	Compatible Occs	% of Goal Met
Plants	Crosby's Buckwheat	69	13	20	0	0	0%
	Grimy Ivesia	70	11	100	0	0	0%
	Long-Flowered Snowberry	121	4	20	60	2	249%
	Nodding Melicgrass	953	6	20	50	1	26%
	Playa Phacelia	16	2	20	0	0	166%
	Prostrate Buckwheat	111	8	50	4	1	7%
	Rose-flower Desert-parsley	72	9	20	0	0	0%
	Salt Heliotrope	25	6	20	0	0	73%
	Three Forks Stickseed	8	1	50	0	0	0%
	Yellow Scorpionflower	36	1	50	0	0	0%
Infrastructure	Hart Boundary Fence	527	2	100	526	2	100%
	Hart Headquarters	3	1	100	3	1	100%
	Last Chance Ranch	3	1	100	3	1	100%
	Sheldon Boundary Fence	925	4	100	914	4	100%
	Sheldon Headquarters	3	1	100	3	1	100%

2025 Revised Refuge Management Scenario Results

Type	Resource Name	Current Hectares	Current Occs	Goal %	Compatible Hectares	Compatible Occs	% of Goal Met
Mammals	American Pika	56432	5	50	49348	4	175%
	Long-Eared Myotis	10	12	50	1	1	17%
	Long-Legged Myotis	4	5	50	0	0	0%
	Pronghorn Corridors	4233	2	100	2702	1	64%
	Pronghorn Nonwinter Range	155913	6	100	149015	6	96%
	Pronghorn Primary Habitat	1306733	8,396	100	215078	3	17%
	Pronghorn Winter Range	65307	6	100	58894	6	90%
	Pygmy Rabbit	3255	13	50	0	0	0%
	Western Small-Footed Myotis	8	10	50	1	1	20%
	White-Tailed Antelope Squirrel	4920	7	50	0	0	0%
	White-Tailed Jackrabbit	703	1	50	0	0	0%
Birds	Greater Sandhill Crane	703	1	50	0	0	0%
	Sage Grouse	36	121	100	7	23	19%
	Sage Grouse Breeding Habitat	648228	55	100	160617	6	25%
	Sage Grouse Nesting Habitat	1752859	3,239	100	287977	2	17%
	Sage Grouse Range	1309724	1	100	280711	1	21%
	Western Burrowing Owl	4219	6	40	0	0	0%
Fish	Catlow Tui Chub	47	4	100	17	1	37%
	Catlow Valley Redband Trout	9	7	100	2	1	14%
	Lahontan Cutthroat Trout	258	5	100	0	0	0%
	Sheldon Tui Chub	24	3	100	8	1	33%

Type	Resource Name	Current Hectares	Current Occs	Goal %	Compatible Hectares	Compatible Occs	% of Goal Met
	Warner Sucker	10086	10	100	21	1	29%
	Warner Valley Redband Trout	6439	6	100	21	1	38%
Communities	Columbia Plateau Low Sagebrush Steppe	528016	4,107	60	147438	603	47%
	Inter-Mountain Basins Big Sagebrush Shrubland	742469	4,575	80	445148	2,589	78%
	Inter-Mountain Basins Big Sagebrush Steppe	464671	2,196	80	174563	1,113	52%
	Inter-Mountain Basins Cliff and Canyon	28959	2,852	60	8118	663	47%
	Inter-Mountain Basins Curlleaf Mountain Mahogany	2224	1,098	80	230	55	14%
	Inter-Mountain Basins Greasewood Flat	124595	3,194	60	17644	770	24%
	Inter-Mountain Basins Juniper Savanna	37997	2,538	60	29575	2,254	142%
	Inter-Mountain Basins Mixed Salt Desert Scrub	77081	2,766	60	6950	560	15%
	Inter-Mountain Basins Montane Sagebrush Steppe	319828	7,400	80	220207	5,170	88%
	Inter-Mountain Basins Playa	74778	4,595	100	5054	527	14%
	Inter-Mountain Basins Semi-Desert Grassland	172381	8,920	60	43855	2,273	42%
	North American Arid West Emergent Marsh	31046	1,030	60	621	148	4%
	Northern Rocky Mountain Foothill Deciduous Shrubland	27604	2,318	40	15909	868	144%
	Rocky Mountain Aspen Forest and Woodland	14953	672	100	1018	84	7%
	Rocky Mountain Ponderosa Pine Woodland	35	2	40	30	2	215%
	Rocky Mountain Subalpine-Montane Mesic Meadow	21498	6,045	100	5760	453	32%
Plants	Crosby's Buckwheat	69	13	20	0	0	0%
	Grimy Ivesia	70	11	100	52	7	74%
	Long-Flowered Snowberry	121	4	20	60	2	249%
	Nodding Melicgrass	953	6	20	50	1	26%

Type	Resource Name	Current Hectares	Current Occs	Goal %	Compatible Hectares	Compatible Occs	% of Goal Met
	Playa Phacelia	16	2	20	0	0	166%
	Prostrate Buckwheat	111	8	50	4	1	7%
	Rose-flower Desert-parsley	72	9	20	72	9	498%
	Salt Heliotrope	25	6	20	0	0	73%
	Three Forks Stickseed	8	1	50	7	1	165%
	Yellow Scorpionflower	36	1	50	27	1	152%
Infrastructure	Hart Boundary Fence	527	2	100	526	2	100%
	Hart Headquarters	3	1	100	3	1	100%
	Last Chance Ranch	3	1	100	3	1	100%
	Sheldon Boundary Fence	925	4	100	914	4	100%
	Sheldon Headquarters	3	1	100	3	1	100%

Vista Connectivity Scenario Results

Type	Resource	Current Hectares	Current Occs	Retention Goal (%)	Compatible Hectares	Compatible Occs	% of Goal Met
Mammals	American Pika	56432	5	50	50829	4	180%
	Long-Eared Myotis	10	12	50	2	2	33%
	Long-Legged Myotis	4	5	50	0	0	0%
	Pronghorn Corridors	4233	2	100	2702	1	64%
	Pronghorn Nonwinter Range	155913	6	100	149869	6	96%
	Pronghorn Primary Habitat	1306733	8,396	100	407943	4	33%

Type	Resource	Current Hectares	Current Occs	Retention Goal (%)	Compatible Hectares	Compatible Occs	% of Goal Met
	Pronghorn Winter Range	65307	6	100	59503	6	91%
	Pygmy Rabbit	3255	13	50	0	0	0%
	Western Small-Footed Myotis	8	10	50	2	2	40%
	White-Tailed Antelope Squirrel	4920	7	50	0	0	0%
	White-Tailed Jackrabbit	703	1	50	0	0	0%
Birds	Greater Sandhill Crane	703	1	50	0	0	0%
	Sage Grouse	36	121	100	13	39	32%
	Sage Grouse Breeding Habitat	648228	55	100	255920	16	39%
	Sage Grouse Nesting Habitat	1752859	3,239	100	535489	2	31%
	Sage Grouse Range	1309724	1	100	518765	1	40%
	Western Burrowing Owl	4219	6	40	0	0	0%
Fish	Catlow Tui Chub	47	4	100	17	1	37%
	Catlow Valley Redband Trout	9	7	100	2	1	14%
	Lahontan Cutthroat Trout	258	5	100	1	1	0%
	Sheldon Tui Chub	24	3	100	24	3	98%
	Warner Sucker	10086	10	100	1230	3	41%
	Warner Valley Redband Trout	6439	6	100	1214	2	56%
Communities	Columbia Plateau Low Sagebrush Steppe	528016	4,107	60	249729	1,125	79%
	Inter-Mountain Basins Big Sagebrush Shrubland	742469	4,575	80	500831	3,115	87%
	Inter-Mountain Basins Big Sagebrush Steppe	464671	2,196	80	213354	1,364	62%
	Inter-Mountain Basins Cliff and Canyon	28959	2,852	60	10382	978	60%
	Inter-Mountain Basins Curlleaf Mountain Mahogany	2224	1,098	80	277	73	17%

Type	Resource	Current Hectares	Current Occs	Retention Goal (%)	Compatible Hectares	Compatible Occs	% of Goal Met
	Inter-Mountain Basins Greasewood Flat	124595	3,194	60	26100	1,235	35%
	Inter-Mountain Basins Juniper Savanna	37997	2,538	60	30133	2,276	144%
	Inter-Mountain Basins Mixed Salt Desert Scrub	77081	2,766	60	25618	1,270	55%
	Inter-Mountain Basins Montane Sagebrush Steppe	319828	7,400	80	258301	5,955	103%
	Inter-Mountain Basins Playa	74778	4,595	100	14453	1,257	26%
	Inter-Mountain Basins Semi-Desert Grassland	172381	8,920	60	75923	4,110	73%
	North American Arid West Emergent Marsh	31046	1,030	60	2384	251	13%
	Northern Rocky Mountain Foothill Deciduous Shrubland	27604	2,318	40	18430	1,220	167%
	Rocky Mountain Aspen Forest and Woodland	14953	672	100	1034	90	7%
	Rocky Mountain Ponderosa Pine Woodland	35	2	40	30	2	215%
	Rocky Mountain Subalpine-Montane Mesic Meadow	21498	6,045	100	7120	565	39%
Plants	Crosby's Buckwheat	69	13	20	9	1	68%
	Grimy Ivesia	70	11	100	54	8	78%
	Long-Flowered Snowberry	121	4	20	60	2	249%
	Nodding Melicgrass	953	6	20	50	1	26%
	Playa Phacelia	16	2	20	0	0	166%
	Prostrate Buckwheat	111	8	50	10	2	19%
	Rose-flower Desert-parsley	72	9	20	72	9	498%
	Salt Heliotrope	25	6	20	4	2	157%
	Three Forks Stickseed	8	1	50	7	1	165%
	Yellow Scorpionflower	36	1	50	27	1	152%

Type	Resource	Current Hectares	Current Occs	Retention Goal (%)	Compatible Hectares	Compatible Occs	% of Goal Met
Infrastructure	Hart Boundary Fence	527	2	100	526	2	100%
	Hart Headquarters	3	1	100	3	1	100%
	Last Chance Ranch	3	1	100	3	1	100%
	Sheldon Boundary Fence	925	4	100	914	4	100%
	Sheldon Headquarters	3	1	100	3	1	100%

Appendix I. Resource Requirements and Responses

The first table in this appendix contains the conservation requirements (minimum required occurrence size, condition threshold, and supporting landscape retention goal) for each resource. Minimum areas for viability were used for those resources for which references were available and had extant populations consistent with that area. Importance weightings (on a scale of 0 to 1) were assigned based on the resource's Priority Rank as follows: Priority 1 = 1.0; Priority 2 = 0.8; Priority 3 = 0.6. The second table lists the categorical response of each resource to each current and expected stressor in the supporting landscape.

Resource Conservation Requirements

Type	Common name	Viability Unit of Assessment	Minimum Area for Viability (ha)	Importance Weighting	Retention Goal (%)
Mammals	American Pika	area		0.8	50
	Long-eared Myotis	occurrence		0.6	50
	Long-legged Myotis	occurrence		0.6	50
	Pronghorn Corridors	area		1.0	100
	Pronghorn Nonwinter Range	area		1.0	100
	Pronghorn Primary Habitat	area	800	1.0	100
	Pronghorn Winter Habitat	area		1.0	100
	Pygmy Rabbit	occurrence	10	0.8	50
	Western Small-footed Myotis	occurrence		0.6	50
	White-tailed Antelope Squirrel	occurrence	30	0.6	50
	White-tailed Jackrabbit	occurrence	60	0.6	50
Birds	Greater Sandhill Crane	occurrence		0.6	50
	Sage Grouse	occurrence	200	1.0	100
	Sage Grouse Breeding Habitat	area	200	1.0	100
	Sage Grouse Nesting Habitat	area	200	1.0	100
	Sage Grouse Range	area		1.0	100
	Western Burrowing Owl	occurrence		0.8	40
Fish	Catlow Tui Chub	area		0.6	100
	Lahontan Cutthroat Trout	area		0.8	100
	Redband Trout - Catlow Valley	area		0.8	100
	Redband Trout - Warner Valley	area		0.8	100

Type	Common name	Viability Unit of Assessment	Minimum Area for Viability (ha)	Importance Weighting	Retention Goal (%)
	Sheldon Tui Chub	area		0.8	100
	Warner Sucker	area		0.8	100
Communities	Columbia Plateau Low Sagebrush Steppe	area	1	1.0	60
	Inter-Mountain Basins Big Sagebrush Shrubland	area	1	1.0	80
	Inter-Mountain Basins Big Sagebrush Steppe	area	1	1.0	80
	Inter-Mountain Basins Cliff and Canyon	area	1	0.6	60
	Inter-Mountain Basins Curl-leaf Mountain-Mahogany Woodland and Shrubland	area	1	0.8	80
	Inter-Mountain Basins Greasewood Flat	area	1	0.6	60
	Inter-Mountain Basins Juniper Savanna	area	1	0.6	60
	Inter-Mountain Basins Mixed Salt Desert Scrub	area	1	0.6	60
	Inter-Mountain Basins Montane Sagebrush Steppe	area	1	1.0	80
	Inter-Mountain Basins Playa	area	1	0.6	100
	Inter-Mountain Basins Semi-Desert Grassland	area	1	1.0	60
	North American Arid West Emergent Marsh	area	1	0.8	60
	Northern Rocky Mountain Montane-Foothill Deciduous Shrubland	area	1	0.6	40
	Rocky Mountain Aspen Forest and Woodland	area	1	1.0	100
	Rocky Mountain Ponderosa Pine Woodland	area	1	0.8	40
	Rocky Mountain Subalpine-Montane Mesic Meadow	area	1	0.8	100
Plants	Crosby's Buckwheat	area		0.6	20
	Grimy Ivesia	area		0.8	100
	Long-flowered Snowberry	area		0.6	20
	Nodding Melicgrass	area		0.6	20
	Playa Phacelia	area		0.6	20
	Prostrate Buckwheat	area		0.6	50
	Rose-flower Desert-parsley	area		0.6	20
	Seaside Heliotrope	area		0.6	20
	Three Forks Stickseed	area		0.6	50
	Yellow Scorpionweed	area		0.6	50

Type	Common name	Viability Unit of Assessment	Minimum Area for Viability (ha)	Importance Weighting	Retention Goal (%)
Infrastructure	Hart Boundary Fence	area		1.0	100
	Hart Headquarters	occurrence		1.0	100
	Last Chance Ranch	occurrence		1.0	100
	Sheldon Boundary Fence	area		1.0	100
	Sheldon Headquarters	occurrence		1.0	100

Resource Responses

The responses of resources to stressors are recorded in the table below. Categorical responses were assigned: negative (–), neutral (=), and positive (+). The source for these assigned responses is the project team (Refuges, NatureServe, ORBIC) unless marked with the following annotations: * NatureServe Explorer; ‘ ORBIC Habitat Suitability Matrix for the Northern Basin and Range Ecosystem; ^ Sheldon Comprehensive Conservation Plan (draft).

Resource	Agriculture	Invasive Forbland	Invasive Grassland	Juniper Woodlands	Recently Burned	Water (aquatic species)	Roads	Transmission Lines	Development – Urban	Development – Rural	Mech. & Herbicide Treatments	Seeding & Planting	Grazing (commercial)	Wind Energy Potential	Solar Energy Potential	Mining	Recreation Activities	Wild Horses & Burros	Buried Utility Lines	Communications Towers
American Pika	–'	–'	–'	+'	–	–'	–*	–	–'	–'	+	+	–^	–	–	–	–	–^	–	–
Long–eared Myotis	–'	–'	–'	+'	–	–'	–	–	='	+'	+	+	–	–	–	–	–	–	–	–
Long–legged Myotis	–'	–'	–'	+'	–	–'	–	–	='	+'	+	+	–	–	–	–	–	–	–	–
Pronghorn Corridors	='	='	='	–'	+*	–'	–'	–	–'	–'	+	+	–*	–	–	–	–	–	–	–
Pronghorn Nonwinter Range	='	='	='	–'	+*	–'	–'	–	–'	–'	+	+	–*	–	–	–	–	–	–	–

Resource	Agriculture	Invasive Forbland	Invasive Grassland	Juniper Woodlands	Recently Burned	Vater aquatic species)	Roads	Transmission Lines	Development – Urban	Development – Rural	Mech. & Herbicide Treatments	Seeding & Planting	Grazing (commercial)	Wind Energy Potential	Solar Energy Potential	Mining	Recreation Activities	Wild Horses & Burros	Buried Utility Lines	Communications Towers
Pronghorn Primary Habitat	='	='	='	–'	+*	–'	–'	–	–'	–'	+	+	–*	–	–	–	–	–	–	–
Pronghorn Winter Habitat	='	='	='	–'	+*	–'	–'	–	–'	–'	+	+	–*	–	–	–	–	–	–	–
Pygmy Rabbit	–'	–'	–'	–'	–*	–'	–	–	–'	–'	+	+	–*	–	–	–	–	–	–	–
Western Small–footed Myotis	–'	='	+'	+'	–	–'	–	–	–'	+'	+	+	–	–	–	–	–	–	–	–
White–tailed Antelope Squirrel	–'	–'	–'	–'	–	–'	=*	–	–'	–'	+	+	–	–	–	–	–	–	–	–
White–tailed Jackrabbit	+'	+'	+'	='	+	–'	–	–	–'	+'	+	+	–	–	–	–	–	–	–	–
Greater Sandhill Crane	+'	+'	+'	–'	–	+'	–	–	–'	–'	+	+	–	–	–	–	–	–	–	–
Sage Grouse	='	='	–*	–*	–*	–'	–	–	–	–	+	+	–*	–*	–*	–*	–*	–*	–*	–*
Sage Grouse Breeding Habitat	–	=	=	–	–	–*	–*	–	–	–	+	+	–*	–	–	–*	–*	–*	–	–
Sage Grouse Nesting Habitat	–	=	=	–	–	–*	–*	–	–	–	+	+	–*	–	–	–*	–*	–*	–	–
Sage Grouse Range	–	=	=	–	–	–	–	–	–	–	+	+	–*	–	–	–	–	–	–	–
Western Burrowing Owl	='	='	+'	–'	+*	–'	–	–	–'	='	+	+	–	–	–	–	=*	–	–	–

Resource	Agriculture	Invasive Forbland	Invasive Grassland	Juniper Woodlands	Recently Burned	Vater aquatic species)	Roads	Transmission Lines	Development – Urban	Development – Rural	Mech. & Herbicide Treatments	Seeding & Planting	Grazing (commercial)	Wind Energy Potential	Solar Energy Potential	Mining	Recreation Activities	Wild Horses & Burros	Buried Utility Lines	Communications Towers
Catlow Tui Chub	–*	–*	–*	–*	–*	+*	–*	–*	–*	–*	+	+	–^					–^		
Lahontan Cutthroat Trout	–*	–*	–*	–*	–*	+*	–*	–*	–*	–*	+	+	–^	–	–	–	–	–^	–	–
Redband Trout – Catlow Valley	–*	–*	–*	–*	–*	+*	–*	–*	–*	–*	+	+	–^	–	–	–	–	–^	–	–
Redband Trout – Warner Valley	–*	–*	–*	–*	–*	+*	–*	–*	–*	–*	+	+	–^	–	–	–	–	–^	–	–
Sheldon Tui Chub	–*	–*	–*	–*	–*	+*	–*	–*	–*	–*	+	+	–^	–	–	–	–	–^	–	–
Warner Sucker	–*	–*	–*	–*	–*	+*	–*	–*	–*	–*	+	+	–^	–	–	–	–	–^	–	–
Columbia Plateau Low Sagebrush Steppe	–	–^	–^	–^	–^	–	–^	–	–^	–^	+	+	–^	–	–	–^	–^	–^	–	–
Inter–Mountain Basins Big Sagebrush Shrubland	–	–^	–^	–^	+^	–	–^	–	–^	–^	+	+	+^	–	–	–^	–^	–^	–	–
Inter–Mountain Basins Big Sagebrush Steppe	–	–^	–^	–^	–^	–	–^	–	–^	–^	+	+	+^	–	–	–^	–^	–^	–	–
Inter–Mountain Basins Cliff and Canyon	–	–	–	–	+^	–	–	–	–	–	+	+	–	–	–	–	–	–	–	–

Resource	Agriculture	Invasive Forbland	Invasive Grassland	Juniper Woodlands	Recently Burned	Vater aquatic species)	Roads	Transmission Lines	Development – Urban	Development – Rural	Mech. & Herbicide Treatments	Seeding & Planting	Grazing (commercial)	Wind Energy Potential	Solar Energy Potential	Mining	Recreation Activities	Wild Horses & Burros	Buried Utility Lines	Communications Towers
Inter–Mountain Basins Curl–leaf Mountain–Mahogany Woodland and Shrubland	–	–	–	–^	–^	–	–	–	–	–	+	+	–^	–	–	–	–	–^	–	–
Inter–Mountain Basins Greasewood Flat	–	–	–^	–^	–^	–	–	–	–	–	+	+	–	–	–	–	–	–^	–	–
Inter–Mountain Basins Juniper Savanna	–	–		–^	–^	–	–	–	–	–	+	+	–	–	–	–	–	+^	–	–
Inter–Mountain Basins Mixed Salt Desert Scrub	–	–	–^	–^	–^	–	–	–	–	–	+	+	–	–	–	–	–	–^	–	–
Inter–Mountain Basins Montane Sagebrush Steppe	–	–	–	–^	+^	–	–^	–	–^	–^	+	+	–^	–	–	–^	–^	–^	–	–
Inter–Mountain Basins Playa	–	–	–	–	–	+^	–	–	–	–	+	+	–^	–	–	–	–^	–^	–	–
Inter–Mountain Basins Semi–Desert Grassland	–	–^	–^	–^	+	–	–^	–^ "	–^	–^	+	+	–^	–	–	–^	–^	–^	–^	–

Resource	Agriculture	Invasive Forbland	Invasive Grassland	Juniper Woodlands	Recently Burned	Water (aquatic species)	Roads	Transmission Lines	Development – Urban	Development – Rural	Mech. & Herbicide Treatments	Seeding & Planting	Grazing (commercial)	Wind Energy Potential	Solar Energy Potential	Mining	Recreation Activities	Wild Horses & Burros	Buried Utility Lines	Communications Towers
North American Arid West Emergent Marsh	–	–^	–^	–^	–	–	–^	–	–^	–^	+	+	–^	–	–	–	–	–^	–	–
Northern Rocky Mountain Montane–Foothill Deciduous Shrubland	–	–	–	–^	–	–	–	–	–	–	+	+	–^	–	–	–	–	–^	–	–
Rocky Mountain Aspen Forest and Woodland	–	–	–	–^	+^	=	–	–	–	–	+	+	–^	–	–	–	–	–^	–	–
Rocky Mountain Ponderosa Pine Woodland	–	–	–	–	–	–	–	–	–	–	+	+	–	–	–	–	–	–	–	–
Rocky Mountain Subalpine–Montane Mesic Meadow	–	–^	–^	–^	–	–	–^	–	–^	–^	+	+	–^	–	–	–	–	–^	–	–
Crosby's Buckwheat	–	–	–	–	–	–	–*	–	–	–	+	+	–*	–	–	–*	–*	–*	–	–
Grimy Ivesia	–*	–*	–*	–	–	–	–*	–	–*	–*	+	+	–*	–	–	–*	–*	–*	–	–
Long–flowered Snowberry	–	–	–	–	–	–	–	–	–	–	+	+	–	–	–	–	–	–	–	–

Resource	Agriculture	Invasive Forbland	Invasive Grassland	Juniper Woodlands	Recently Burned	Vater aquatic species)	Roads	Transmission Lines	Development – Urban	Development – Rural	Mech. & Herbicide Treatments	Seeding & Planting	Grazing (commercial)	Wind Energy Potential	Solar Energy Potential	Mining	Recreation Activities	Wild Horses & Burros	Buried Utility Lines	Communications Towers
Nodding Melicgrass	–	–	–	–	–	–	–	–	–	–	+	+	–	–	–	–	–	–	–	–
Playa Phacelia	–	–	–	–	–	–	–*	–	–	–	+	+	–*	–	–	–	–*	–*	–	–
Prostrate Buckwheat	–	–	–	–	–	–	–*	–	–	–	+	+	–*	–	–	–*	–*	–*	–	–
Rose–flower Desert–parsley	–	–	–	–	–	–	–	–	–	–	+	+	–	–	–	–	–	–	–	–
Seaside Heliotrope	–	–	–	–	–	–	–	–	–	–	+	+	–	–	–	–	–	–	–	–
Three Forks Stickseed	–	–	–	–	–	–	–	–	–	–	+	+	–	–	–	–	–	–	–	–
Yellow Scorpionweed	–	–	–	–	–	–	–*	–	–	–	+	+	–	–	–	–*	–*	–	–	–
Hart Boundary Fence	=	=	=	=	=	=	=	=	=	+	=	=	=	=	=	=	=	=	=	=
Hart Headquarters	=	=	=	=	=	=	=	=	=	+	=	=	=	=	=	=	=	=	=	=
Last Chance Ranch	=	=	=	=	=	=	=	=	=	+	=	=	=	=	=	=	=	=	=	=
Sheldon Boundary Fence	=	=	=	=	=	=	=	=	=	+	=	=	=	=	=	=	=	=	=	=
Sheldon Headquarters	=	=	=	=	=	=	=	=	=	+	=	=	=	=	=	=	=	=	=	=

Appendix J. Metadata for VDDT Modeling Source Geodatabase

Hart-Sheldon Project
VDDT Modeling Roll-Up Geodatabase

Roll-Up Geodatabase: OHS_20110521.GDB

Datasets:

Oregon Hart-Sheldon (OHS) is treated as a unique project. In other words, although datasets used for OHS may wholly or partially originate from the Region 6 (Oregon, Washington) portion of the Integrated Landscape Assessment Project (ILAP), they are treated independently for the OHS project area.

The entire Hart-Sheldon project area (Oregon/Nevada) is represented.

The analysis/modeling for Hart-Sheldon is as a non-forest (arid land) landscape.

General parameters: The coordinate system for vector/raster datasets in the GDB is the ILAP Region 6 coordinate system. Rasters are 30-meter. Rasters are aligned to R6 GNN.

Files used to generate the final datasets in the roll-up geodatabase (OHS_20110521.GDB) are contained in OHS_DEVELOPMENT.GDB)

ModelingZone (Project Area vector)
For the Hart-Sheldon project area, used the ONDA Project Boundary.

ONDA_PROJECT_BOUNDARY.SHP copied to ONDA_PROJECT_BOUNDARY_ORIGPRJ (updated GIS_Acres), which was reprojected to ONDA_PROJECT_BOUNDARY (updated GIS_Acres, metadata carried over from original, added rollup attributes), which was then copied as MODELINGZONE.

OHS_ONDA_Mask (Project Area raster)
Raster of Hart-Sheldon project area was generated from the vector dataset. This raster serves as the project area mask (clip) as well as the project extent raster and snap raster (snapped to GNN).

MODELINGZONE rasterized with the PolygonToRaster tool (extent: MODELINGZONE, SnapRaster = GNN_MOSAIC.IMG, cell size = 30m, cell assignment = cell center) to create OHS_ONDA_MASK.

HUCS and HUC_LUT (raster and look-up table)
5th-field (aka HUC10) HUC watershed boundaries. HUC_ID is a three-digit sequential ID for each HUC starting at 101.

R6_HUC5_UNCLIPPED Clipped (extent: MODELINGZONE, clip features: MODELINGZONE) to create HUC5_CLIPPED (multipart feature class). Edited HUC5_CLIPPED: added HUC_ID field; ensured that all HUC_10 values are unique in the multipart feature class; calculated HUC_ID as 3-digit unique ID for each

HUC_10 starting at 101. HUC5_CLIPPED converted into single-part (MultipartToSinglepart: extent = MODELINGZONE) feature class called HUC5_CLIPPED_SP.

HUC5_CLIPPED_SP converted into raster (PolygonToRaster: Value = HUC_ID, extent and SnapRaster = OHS_ONDA_MASK, cell size = 30m, cell assignment = cell center) called HUCS.

HUC_LUT created as follows: Exported the attribute table from HUC5_CLIPPED as HUC_LUT1 (contains both HUC_10 and HUC_ID and no duplicates). Joined HUC_LUT1 to R6_HUC5_LUT via the HUC_10 attribute and exported as HUC_LUT.

OwnerAlloc and OwnerAlloc2 and Owner_LUT (2 rasters and look-up table)

Owner-allocation data combining land ownership and land management information.

The OWNER_LUT look-up table was copied from the ILAP WNE forest roll-up geodatabase. The table is the same template used in all the roll-up geodatabases.

Two Owner-Allocation vector datasets were provided: HS_OWNERALLOC , HS_OWNERALLOC2. Each dataset contained only the Owner_ID field. Added the field Value_LUP to the two vectors; joined each dataset to OWNER_LUT via the Owner_ID attribute, and calculated Value_LUP = Value (a unique number associated with each unique Owner_ID).

Converted both OwnerAllocation vectors into rasters: HS_OWNERALLOC to OWNERALLOC; HS_OWNERALLOC2 to OWNERALLOC2. Used the PolygonToRaster tool (Value field = Value_LUP, cell size = 30m, cell assignment = cell center, extent/snap = OHS_ONDA_MASK).

GNN and GNN_LUT (raster and look-up table)

For Nearest Neighbor vegetation models, used the ILAP Region 6 arid lands NN in combination with the NN developed for the Nevada portion of Hart-Sheldon.

The NN raster R6_NN_ARID_M covered Oregon and SHELDON_GNN covered Nevada.

The two rasters were mosaicked together with the OR pixels taking precedence over NV pixels wherever there is overlap (exception: if, for a particular location, OR has NoData and NV has a pixel in the overlap region, then the NV pixel shows up). Also, 500,000 was added to the Values in the NV data to deal with differences in the two NN systems.

NV Data:
SHELDON_GNN renamed SHELDON_GNN_ORIGPRJ (dataset needed reprojection and cell sizes needed to be 30 meters). SHELDON_GNN_ORIGPRJ reprojected to GNN_OHS (cell size = 30m, resampling technique = nearest); rebuilt attribute table. GNN_OHS copied to GNN_OHS2 to get rid of Value 0 (background) and to snap to 'standard' GNN (snap = OHS_ONDA_MASK) and to make 32-bit unsigned integer like the ILAP GNN (was signed integer even though no negative Values); rebuilt attribute table.

Created look-up table SHELDON_GNN_LUT from the spreadsheet SHELDON_GNN_LUT1.XLSX provided by Treg Christopher (minus Value = 0 (Value_old) = 500000 (Value_new)). Copied SHELDON_GNN_LUT as SHELDON_GNN_LUT2 and edited: deleted an extraneous field, converted the format of a couple fields.

Edited GNN_OHS2: Added Value_New field; calculated Value_New = Value + 500,000. Ran Lookup tool on GNN_OHS2 on the Value_New field to create GNN_OHS3.

GNN_OHS3 was stamped with the base Sheldon-Hart non-forest mask (OHS_MASK3) to eliminate any pixels not modeled arid lands. Created GNN_OHS4 using the Times tool (input raster1 = GNN_OHS3, input raster2 = OHS_MASK3); rebuilt attribute table.

R6 Data:
Created lookup-table R6_NN_ARID_M_LUT from the R6_NN_ARID_M raster. Copied (exported) the table as R6_NN_ARID_M_LUT2.

Copied R6_NN_ARID_M as R6_NN_ARID_M2 and deleted all fields but Value.

R6 and NV Data:
Created a single LUT for Hart-Sheldon GNN: using the Append tool, appended SHELDON_GNN_LUT2 to R6_NN_ARID_M_LUT2 (No_Test option, fields verified in Field Map). Renamed R6_NN_ARID_M_LUT2 as GNN_LUT_ALL. Copied GNN_LUT_ALL as GNN_LUT.

Mosaicked the Region 6 and Nevada NN rasters using the MosaicToNewRaster too (inputs: R6_NN_ARID_M2 and GNN_OHS4, output = GNN_ALL, ILAP R6 coordinate system, pixel type = 32_Bit_Unsigned, cellsize = 30m, # bands = 1, mosaic method = first, mosaic colormap mode = reject, snap = OHS_ONDA_MASK) to create the GNN_ALL raster for Hart-Sheldon; built statistics with the default options; built raster attribute table. Clipped GNN_ALL to the Hart-Sheldon project area using the ExtractByMask tool (mask/extent/snap = OHS_ONDA_MASK) to create the “GNN” layer; built attribute table.

Edited GNN_LUT: deleted records not found in the raster GNN. Combined the GNN raster with the GNN_LUT table via the Value field using the JoinField tool to add fields into the raster.

PVT and PVT_LUT (raster and look-up table)

The Potential Vegetation Type (PVT) raster and look-up table were completed by mosaicking existing PVT data for the ILAP Oregon Southeast and Oregon East Cascades modeling regions with the PVT provided for the Hart-Sheldon project.

The Mask field in the PVT raster (and PVT_LUT) is set to 1 for arid lands and set to 0 for forests and not-modeled areas.

R6 Data:
Copied PVT and PVT_LUT from OSE non-forest and from OEC non-forest roll-up geodatabases: PVT_OSE_NF, PVT_OEC_NF, PVT_LUT_OSE_NF, PVT_LUT_OEC_NF. Edited both PVT rasters to create a Value_New field which will serve as a lookup field of revised Values. Created PVT_OSE_NF2 and PVT_OEC_NF2 by running the Lookup tool on the Value_New field.

NV Data:

SHELDON_PVT provided for Nevada portion of Hart-Sheldon project. SHELDON_PVT renamed SHELDON_PVT_ORIGPRJ (needed reprojection and cell size = 30m). SHELDON_PVT_ORIGPRJ reprojected (resampling technique = nearest, cell size = 30m) as PVT_OHS1; rebuilt attribute table. PVT_OHS1 copied to PVT_OHS2 to get rid of Value 0 (background) and to align to other rasters (snap = OHS_ONDA_MASK); rebuilt attribute table. Edited PVT_OHS2 to create a Value_New field which will serve as a lookup field of revised Values. Created PVT_OHS3 by running the Lookup tool on the Value_New field.

The SHELDON_PVT_ORIGPRJ attribute table was copied as the SHELDON_PVT_LUT.

R6 and NV Data:
Treg Christopher provided the spreadsheet OHS_PVT_LUT_WITHEXTRAS.XLSX for a more-than-just-OHS PVT look-up table. Converted this into the table OHS_PVT_LUT_EXTRA.

Mosaicked the OSE, OEC, and OHS PVT rasters together to create PVT1 using the MosaicToNewRaster tool (inputs: PVT_OSE_NF2 and PVT_OEC_NF2 and PVT_OHS3; output = PVT1; coordinate system = ILAP R6; pixel type = 32 Bit Unsigned; cell size = 30m; # of bands = 1; mosaic method = first; mosaic colormap mode = reject; snap = OHS_ONDA_MASK); built statistics using the default options; built attribute table. Clipped PVT1 to the Hart-Sheldon area to create PVT using ExtractByMask (mask/extent/snap = OHS_ONDA_MASK); built attribute table.

Copied OHS_PVT_LUT_EXTRA as PVT_LUT, and deleted records not in the PVT raster. Combined PVT and PVT_LUT via the Value/PVTID fields using the JoinField tool to add fields to the raster.

RegionMask

The REGIONMASK raster represents modeled non-forest pixels in the Hart-Sheldon project area. Forests and areas not modeled (e.g., water, urban, agriculture) are NoData pixels.

REGIONMASK was created from the existing ILAP Region 6 NN non-forest mask (NN_NONFOREST_MASK_18MAR11B) and a (less complicated) mask for the Nevada portion of the project developed from SWreGAP land cover and NLCD 2001 tree canopy data.

R6 Data:
Created NN_NONFOREST_MASK_18MAR11B from NN_NONFOREST_MASK_18MAR11 by using the LUP field in the latter raster; the former contains only 2 Values (0 = not modeled; 1 = modeled area) (the original version had the modeling regions split out instead of just being modeled-area pixels). Copied “B” to NN_NONFOREST_MASK_18MAR11C to make the raster 8 bit unsigned integer; rebuilt attribute table.

NV Data:
Clipped the SWreGAP land cover raster (SWREGAP_R6CS) with the GAP_CLIP polygon to create SWREGAP_CLIP. Copied SWREGAP_CLIP to SWREGAP_CLIP2 to eliminate Value = 0 (background) and to align the pixels to the standard snap raster (OHS_ONDA_MASK); rebuilt attribute table.

Edited SWREGAP_CLIP2: added the Mask_ForNF field and populated with the values from Treg’s spreadsheet SHELDON_GAP_FORMASKING.XLSX. This will be used to separate some GAP veg types between forest or nonforest; codes: 0 = not modeled; 1 = arid lands; 2 = forests; 3 = forest or arid land depending upon percent canopy cover. Generated SWREGAP_CLIP3 by running the Lookup tool on the Mask_ForNF field.

Downloaded a percent canopy cover dataset (NLCD 2001 Percent Canopy Version 1.0): NLCD_CANOPY_MOSAIC.IMG. The Values are percent cover (e.g., 1 = 1%). Clipped the canopy raster with CAN_CLIP to create NLCD_CAN_CLIP1_PRJ1, which was then reprojected (resampling technique = nearest, cellsize = 30m, snap = OHS_ONDA_MASK) to NLCD_CAN_CLIP1_PRJ2, which was clipped to the project area to create NLCD_CAN_CLIP2_PRJ2.

Edited NLCD_CAN_CLIP2_PRJ2: added the fields PerCov and PerCovDesc and calculated the fields as follows (based upon the Values which are percent cover):

0	0 to < 10% tree canopy cover
10	=> 10% tree canopy cover.

Created NLCD_CAN_CLASS by running the Lookup tool on the PerCov field.

Combined the SWREGAP_CLIP3 and NLCD_CAN_CLASS rasters to create NV_GAP_CANCL. Edited the attribute table as follows:

VALUE	SWREGAP_CLIP3	NLCD_CAN_CLASS	VegClass	VegClassDesc	NF_Mask
2	0	0	0	Not Modeled	0
3	0	10	0	Not Modeled	0
1	1	0	1	Arid Land	1
5	1	10	1	Arid Land	1
7	2	0	2	Forest	0
8	2	10	2	Forest	0
4	3	0	1	Arid Land	1
6	3	10	2	Forest	0

Created NV_NONFOREST_MASK by running the Lookup tool on the NF_Mask attribute in NV_GAP_CANCL. Copied NV_NONFOREST_MASK to NV_NONFOREST_MASK2 to eliminate the not-arid-land pixels (Value 0); rebuilt attribute table. This base NV non-forest mask can be joined to the Region 6 non-forest mask.

R6 and NV Data:
Mosaicked the R6 and NV nonforest masks - NN_NONFOREST_MASK_18MAR11C and NV_NONFOREST_MASK2 – to create OHS_MASK1 using the MosaicToNewRaster tool (inputs: NN_NONFOREST_MASK_18MAR11C and NV_NONFOREST_MASK2; output = OHS_MASK1; R6 coordinate system; 8 bit unsigned; cellsize 30m; mosaic first; colormap reject; snap = OHS_ONDA_MASK); built statistics using the default options; built attribute table. The R6 mask is a solid fill; the NV mask is nonforest only: this – combined with the R6 mask taking mosaic preference over NV – enables the (eventual) completion of an OHS non-forest mask which essentially appends NV to R6 and there will be only non-forest pixels (this addresses the issue of overlapping pixels between the R6 and NV non-forest masks). Created OHS_MASK2 by clipping OHS_MASK1 with the ExtractByMask tool (clip/extent/snap = OHS_ONDA_MASK). Copied (CopyRaster) OHS_MASK2 to OHS_MASK3 to convert Value 0 to NoData and to convert to 8 bit unsigned integer; rebuilt attribute table.

OHS_MASK3 is the base non-forest mask for the Hart-Sheldon Hart project area. However, for the roll-up geodatabase, the mask cannot contain non-forest modeled-area pixels where the input rasters (GNN, HUCS, PVT, OWNERALLOC, OWNERALLOC2) contain NoData pixels. OHS_MASK3 was combined (Combine tool) with a version of each of the input rasters (GNN, HUCS, PVT, OWNERALLOC) where each input was reclassified to have only Value = 1; when OHS_MASK3 is combined with the simplified input rasters, only pixels that exist in all of the rasters will remain in the output. OHS_MASK4 is the output of this process and is the final non-forest mask for use in VDDT modeling. OHS_MASK4 was copied as REGIONMASK.

Appendix K. Methodology for Climate Change Modeling

Our objective was to link output from the Dynamic Global Vegetation Model MC1 to a suite of VDDT models.

First we calibrated 30-arcsec MC1 output using historical climate data plus maps and information about existing vegetation.

We then developed a crosswalk between the broad MC1 vegetation types (VTs) and VDDT potential vegetation types (PVTs). The crosswalk is as follows:

PVT Code	PVT Name	MC1 Name
gpp	bluebunch wheatgrass – Sandberg bluegrass	temperate grassland
ssd	salt desert shrub	coniferous xeromorphic woodland (xeromorphic shrubland)
swn	wyoming big sage – no juniper	temperate mesic shrubland
smb	mountain big sage – with juniper	temperate needleleaf woodland

We created a local calibration for MC1 for each landscape, and used this calibration to run MC1 using future climate data from two A2 GCMs.

We aggregated the VDDT PVTs into a single "mega-model" that incorporated representative current and future major PVTs for each landscape.

Transition multiplier files were then developed using output from MC1 that:

(1) changed fire probabilities annually; and

(2) directed annual shifts through time from one VDDT PVT type to another.

Output from these VDDT models showed far less landscape change than comparable MC1 output, partially due to inherent inertia in vegetation as modeled by VDDT. While there is considerable uncertainty in our projections, the models allow managers and others to explore some potential outcomes of climate change on landscape-level vegetation dynamics using the VDDT platform.

Appendix L. Climate Change Vulnerability Assessment Results

These two tables contain the complete results of the climate change vulnerability assessments developed by the Nevada Natural Heritage Program. The first table contains the Part 1 results, the second table contains the Part 2 results. See Young et al. 2011 (http://www.natureserve.org/prodServices/climatechange/pdfs/Guidelines_NatureServeClimateChangeVulnerabilityIndex_r2.0_Apr10.pdf) for detailed discussion of the CCVI. The results below were produced on June 10, 2011.

CCVI List Part 1	Common Name	Lahontan Cutthroat Trout	Golden Eagle	Western Burrowing Owl	Greater Sage-grouse	Western Yellow-billed Cuckoo	Snowy Egret	Greater Sandhill Crane
	Area Assessed	Nevada	Nevada	Nevada	Nevada	Nevada	Nevada	Nevada
	Relative Range	Southern edge of range	Center of range	Northern edge of range	Southern edge of range	Northern edge of range	Northern edge of range	Southern edge of range
	GRank	G4T3	G5	G4	G4	G5T3Q	G5	G5T4
	SRank	S3	S4	S3B	S3S4	S1B	S4	S2BS3M
Temperature Scope (Prediced °F increase)	**>5.5**	30	35	40	40		40	40
	5.1-5.5	60	40	40	30	85	35	30
	4.5-5.0	10	25	20	30	15	25	30
	3.9-4.4							
	<3.9							
Hamon AET:PET Moisture Metric Scope (% Annual Change in Moisture)	**< -0.119**							
	-0.119 - -0.097	40	10	10	10		10	10
	-0.096 - -0.074	50	40	40	40		50	50
	-0.073 - -0.06	5	15	15	25		20	20
	-0.05 - -0.028	5	25	25	25	20	20	20
	>-0.028		10	10		80		
Natural Barriers	**B2a**	SI	N	N	N	N	N	N
Anthropogenic Barriers	**B2b**	SI	N	N	N	N	N	N
Climate Change Mitigation	**B3**	N	Inc	Inc	Inc	Inc	Inc	Inc
Dispersal/Movement	**C1**	Dec	Dec	Dec	SD	Dec	Dec	Dec

CCVI List Part 1	Common Name	Lahontan Cutthroat Trout	Golden Eagle	Western Burrowing Owl	Greater Sage-grouse	Western Yellow-billed Cuckoo	Snowy Egret	Greater Sandhill Crane
historical thermal niche	**C2ai**	SD	SD	N-SD	SD	SI-N	SD	N
physiological thermal niche	**C2aii**	Inc	N	N	SI	SI-N	N	N
historical hydrological niche	**C2bi**	N	SI-N	SI	SI	GI-Inc	SI	SI
physiological hydrological niche	**C2bii**	Inc	N	N	N	SI-N	Inc	Inc
Disturbance	**C2c**	SI	N	N	Inc	N	N	N
Ice/snow	**C2d**	N	N	N	N	N	N	N
Physical habitat	**C3**	SD	SI	N	SD	SD	SD	SD
Other spp for hab	**C4a**	N	N	SI	GI-Inc	SI-N	N	N
Diet	**C4b**	N	N	N	SI	SI	N	N
Other spp disp	**C4d**	N	N	N	N	N	N	N
Other spp interaction	**C4e**	N	N	N	N	N	N	N
	Index	MV	PS	PS	HV	MV	PS	PS
	Confidence	VH	VH	VH	Low	Low	VH	VH

CCVI List Part 2	Common Name	American White Pelican	Pygmy Rabbit	Spotted Bat	Western Small-footed Myotis	Long-eared Myotis	American Pika	Preble's Shrew
	Area Assessed	Nevada	Nevada	Nevada	Nevada	Nevada	Nevada	Nevada
	Relative Range	Southern edge of range	Southern edge of range	Center of range	Entire range	Center of range	Southern edge of range	Southern edge of range
	GRank	G4	G4	G4	G5	G5	G5	G4
	SRank	S2B	S3	S2	S3	S4	S2	S1

CCVI List Part 2	Common Name	American White Pelican	Pygmy Rabbit	Spotted Bat	Western Small-footed Myotis	Long-eared Myotis	American Pika	Preble's Shrew
Temperature Scope	**A >5.5F**		45	35	35	35	25	30
	A 5.1F	20	30	40	40	40	25	40
	A 4.5F	80	25	25	25	25	50	30
	A 3.9F						0	
	A <3.9F						0	
Hamon AET:PET Moisture Metric Scope	**< -0.119**						0	
	-0.119		10	10	10	10	45	5
	-0.096		50	40	40	40	45	90
	-0.073	20	20	15	15	15	10	5
	-0.05	80	20	25	25	25	0	
	>-0.028			10	10	10	0	
Natural Barriers	**B2a**	N	N	N	N	N	GI	SI
Anthropogenic Barriers	**B2b**	N	N	N	N	N	N	N
Climate Change Mitigation	**B3**	Inc	SI	SI	SI	N	N	N
Dispersal/Movement	**C1**	Dec	SD	Dec	Dec	Dec	SD	N
historical thermal niche	**C2ai**	N	SD	SD	SD	N-SD	N-SD	SD
physiological thermal niche	**C2aii**	N	N	N	N	N	GI	N
historical hydrological niche	**C2bi**	Inc	SI	SI	N	SD	SD	SI
physiological hydrological niche	**C2bii**	SI	N	N	N	N	N	N
Disturbance	**C2c**	N	Inc	N	N	N	N	N
Ice/snow	**C2d**	N	N	N	N	N	SI	N
Physical habitat	**C3**	SI	SI-N	SI	SI	SD	Inc-SI	SD
Other spp for hab	**C4a**	N	GI-Inc	N	N	N	N	N

CCVI List Part 2	Common Name	American White Pelican	Pygmy Rabbit	Spotted Bat	Western Small-footed Myotis	Long-eared Myotis	American Pika	Preble's Shrew
Diet	**C4b**	SI	Inc	N	N	N	N	N
Other spp disp	**C4d**	N	N	N	N	N	N	N
Other spp interaction	**C4e**	N	N	N	N	N	N	N
	Index	MV	EV	PS	PS	IL	HV	PS
	Confidence	VH	Mod	VH	VH	VH	Mod	VH

Factor Scores:
GI Greatly Increase Vulnerability
Inc Increase Vulnerability
SI Somewhat Increase Vulnerability
N Neutral
SD Somewhat Decrease Vulnerability
Dec Decrease Vulnerability

Confidence (in species information):
VH Very High confidence
High High confidence
Mod Moderate confidence
Low Low confidence

Index Scores:
EV - Extremely Vulnerable: Abundance and/or range extent within geographical area assessed extremely likely to substantially decrease or disappear by 2050.
HV - Highly Vulnerable: Abundance and/or range extent within geographical area assessed likely to decrease significantly by 2050.
MV - Moderately Vulnerable: Abundance and/or range extent within geographical area assessed likely to decrease by 2050.
PS - Not Vulnerable/Presumed Stable: Available evidence does not suggest that abundance and/or range extent within the geographical area assessed will change (increase/decrease) substantially by 2050. Actual range boundaries may change.
IL - Not Vulnerable/Increase Likely: Available evidence suggests that abundance and/or range extent within geographical area assessed is likely to increase by 2050.