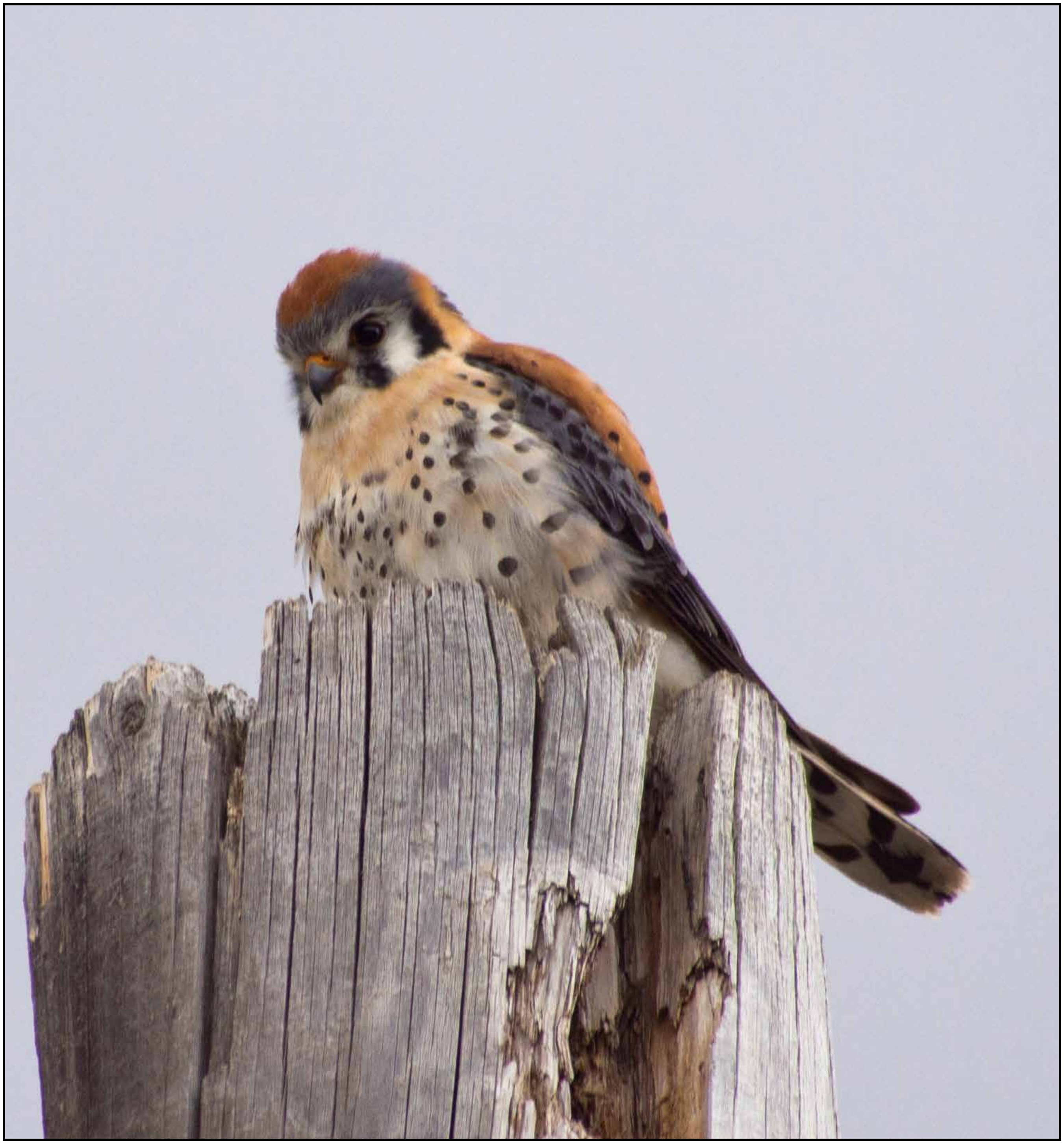
National Park Service
U.S. Department of the Interior

Natural Resource Stewardship and Science

Golden Spike National Historic Site

Natural Resource Condition Assessment

Natural Resource Report NPS/NCPN/NRR—2018/1777



ON THIS PAGE

The American kestrel is a common breeding bird at Golden Spike National Historic Site. Photo Credit: NPS

ON THE COVER

Promontory sunset. Photo Credit: NPS

Golden Spike National Historic Site

Natural Resource Condition Assessment

Natural Resource Report NPS/NCPN/NRR—2018/1777

Author Name(s)

Lisa Baril, Kimberly Struthers, and Mark Brunson

Utah State University
Department of Environment and Society
Logan, Utah

Editing and Design

Kimberly Struthers

October 2018

U.S. Department of the Interior
National Park Service
Natural Resource Stewardship and Science
Fort Collins, Colorado

The National Park Service, Natural Resource Stewardship and Science office in Fort Collins, Colorado, publishes a range of reports that address natural resource topics. These reports are of interest and applicability to a broad audience in the National Park Service and others in natural resource management, including scientists, conservation and environmental constituencies, and the public.

The Natural Resource Report Series is used to disseminate comprehensive information and analysis about natural resources and related topics concerning lands managed by the National Park Service. The series supports the advancement of science, informed decision-making, and the achievement of the National Park Service mission. The series also provides a forum for presenting more lengthy results that may not be accepted by publications with page limitations.

All manuscripts in the series receive the appropriate level of peer review to ensure that the information is scientifically credible, technically accurate, appropriately written for the intended audience, and designed and published in a professional manner.

This report received informal peer review, which was provided by subject-matter experts who were not directly involved in the collection, analysis, or reporting of the data. The level and extent of peer review was based on the importance of report content or its potentially controversial or precedent-setting nature.

Views, statements, findings, conclusions, recommendations, and data in this report do not necessarily reflect views and policies of the National Park Service, U.S. Department of the Interior. Mention of trade names or commercial products does not constitute endorsement or recommendation for use by the U.S. Government.

This report is available in digital format from the Natural Resource Condition Assessment Program website and the Natural Resource Publications Management website. If you have difficulty accessing information in this publication, particularly if using assistive technology, please email irma@nps.gov.

Please cite this publication as:

Baril, L., K. Struthers, M. Brunson. 2018. Golden Spike National Historic Site: Natural resource condition assessment. Natural Resource Report NPS/NCPN/NRR—2018/1777. National Park Service, Fort Collins, Colorado.

NPS 431/148844, October 2018

Contents

Contents (continued)

Contents (continued)

Figures

Figures (continued)

Page

Tables

Page

Tables (continued)

Appendices

Page

Executive Summary

The Natural Resource Condition Assessment (NRCA) Program, administered by the National Park Service's (NPS) Water Resources Division, provides a multidisciplinary synthesis of existing scientific data and knowledge about current conditions of important national park natural resources through the development of a park-specific report. The NRCA process for Golden Spike National Historic Site (NHS) began with two conference calls with staff from the historic site, NPS Intermountain Region Office, and Utah State University.

Golden Spike was established as a national historic site (NHS) in 1965 to "serve as a national memorial commemorating the completion of the first transcontinental railroad across the United States" through the joining of the Union Pacific Railroad and the Central Pacific Railroad (NPS 2017a). Ten of the NHS's natural resources, grouped into three broad categories, were selected for current condition assessment reporting. The categories included landscapes, air and climate, and biological integrity, (i.e., wildlife and vegetation resources).

The historic site's viewsheds were evaluated and found to be in good condition. The condition of night sky was of moderate concern, and the conditions of the remaining natural resources evaluated were either of significant concern or unknown due to lack of current data.

Acknowledgements

We thank Golden Spike NHS Superintendent, Leslie Crossland, for her assistance in selecting the natural resources for condition evaluation, and the NPS Northern Colorado Plateau Inventory and Monitoring (NCPN) staff for assistance in gathering data; establishing indicators, measures, and reference conditions; and for reviewing drafts of the assessments and chapters. NCPN's inventory and/or monitoring data for the vegetation communities, non-native invasive plants, birds, mammals, and herpetofauna informed conditions for these resources at Golden Spike NHS.

Phyllis Pindea Bovin, NPS Intermountain Region Office NRCA Coordinator, assisted with overall project facilitation and served as subject matter expert review manager. Jeff Albright, NPS NRCA Program Coordinator, provided programmatic guidance.

And finally, to all of the additional reviewers and contributors, who are listed in Appendix A and in each Chapter 4 assessment, respectively, we thank you. Your contributions have increased the value of Golden Spike NHS's NRCA report.

Jupiter steam locomotive. Photo Credit: NPS.

Chapter 1. NRCA Background Information

Natural Resource Condition Assessments (NRCAs) evaluate current conditions for a subset of natural resources and resource indicators in national park units, hereafter “parks.” NRCAs also report on trends in resource condition (when possible), identify critical data gaps, and characterize a general level of confidence for study findings. The resources and indicators emphasized in a given project depend on the park’s resource setting, status of resource stewardship planning and science in identifying high-priority indicators, and availability of data and expertise to assess current conditions for a variety of potential study resources and indicators.

NRCAs represent a relatively new approach to assessing and reporting on park resource conditions. They are meant to complement — not replace — traditional issue- and threat-based resource assessments. As distinguishing characteristics, all NRCAs:

- are multi-disciplinary in scope;[1]
- employ hierarchical indicator frame-works;[2]
- identify or develop reference conditions/values for comparison against current conditions;[3]
- emphasize spatial evaluation of conditions and GIS (map) products;[4]
- summarize key findings by park areas; and[5]
- follow national NRCA guidelines and standards for study design and reporting products.

Although the primary objective of NRCAs is to report on current conditions relative to logical forms of

1. The breadth of natural resources and number/type of indicators evaluated will vary by park.
2. Frameworks help guide a multi-disciplinary selection of indicators and subsequent “roll up” and reporting of data for measures [conditions for indicators] condition summaries by broader topics and park areas
3. NRCAs must consider ecologically-based reference conditions, must also consider applicable legal and regulatory standards, and can consider other management-specified condition objectives or targets; each study indicator can be evaluated against one or more types of logical reference conditions. Reference values can be expressed in qualitative to quantitative terms, as a single value or range of values; they represent desirable resource conditions or, alternatively, condition states that we wish to avoid or that require a follow-on response (e.g., ecological thresholds or management “triggers”).
4. As possible and appropriate, NRCAs describe condition gradients or differences across a park for important natural resources and study indicators through a set of GIS coverages and map products.
5. In addition to reporting on indicator-level conditions, investigators are asked to take a bigger picture (more holistic) view and summarize overall findings and provide suggestions to managers on an area-by-area basis: 1) by park ecosystem/habitat types or watersheds, and 2) for other park areas as requested.

NRCAs Strive to Provide

- Credible condition reporting for a subset of important park natural resources and indicators
- Useful condition summaries by broader resource categories or topics and by park areas

reference conditions and values, NRCAs also report on trends, when appropriate (i.e., when the underlying data and methods support such reporting), as well as influences on resource conditions. These influences may include past activities or conditions that provide a helpful context for understanding current conditions, and/or present-day threats and stressors that are best interpreted at park, watershed, or landscape scales (though NRCAs do not report on condition status for land areas and natural resources beyond park boundaries). Intensive cause-and-effect analyses of threats and stressors, and development of detailed treatment options, are outside the scope of NRCAs.

Due to their modest funding, relatively quick time frame for completion, and reliance on existing data and information, NRCAs are not intended to be exhaustive. Their methodology typically involves an informal synthesis of scientific data and information from multiple and diverse sources. Level of rigor and statistical repeatability will vary by resource or

An NRCA is intended to provide useful science-based information products in support of all levels of park planning. Photo Credit: NPS.

6. An NRCA can be useful during the development of a park's Resource Stewardship Strategy (RSS) and can also be tailored to act as a post-RSS project.
7. While accountability reporting measures are subject to change, the spatial and reference-based condition data provided by NRCAs will be useful for most forms of "resource condition status" reporting as may be required by the NPS, the Department of the Interior, or the Office of Management and Budget.
8. The I&M program consists of 32 networks nationwide that are implementing "vital signs" monitoring in order to assess the condition of park ecosystems and develop a stronger scientific basis for stewardship and management of natural resources across the National Park System. "Vital signs" are a subset of physical, chemical, and biological elements and processes of park ecosystems that are selected to represent the overall health or condition of park resources, known or hypothesized effects of stressors, or elements that have important human values.

Important NRCA Success Factors

- Obtaining good input from park staff and other NPS subject-matter experts at critical points in the project timeline
- Using study frameworks that accommodate meaningful condition reporting at multiple levels (measures / indicators) broader resource topics, and park areas
- Building credibility by clearly documenting the data and methods used, critical data gaps, and level of confidence for indicator-level condition findings

indicator, reflecting differences in existing data and knowledge bases across the varied study components.

The credibility of NRCA results is derived from the data, methods, and reference values used in the project work, which are designed to be appropriate for the stated purpose of the project, as well as adequately documented. For each study indicator for which current condition or trend is reported, we will identify critical data gaps and describe the level of confidence in at least qualitative terms. Involvement of park staff and National Park Service (NPS) subject-matter experts at critical points during the project timeline is also important. These staff will be asked to assist with the selection of study indicators; recommend data sets, methods, and reference conditions and values; and help provide a multi-disciplinary review of draft study findings and products.

NRCAs can yield new insights about current park resource conditions, but in many cases, their greatest value may be the development of useful documentation regarding known or suspected resource conditions within parks. Reporting products can help park managers as they think about near-term workload priorities, frame data and study needs for important park resources, and communicate messages about current park resource conditions to various audiences. A successful NRCA delivers science-based information that is both credible and has practical uses for a variety of park decision making, planning, and partnership activities.

However, it is important to note that NRCAs do not establish management targets for study indicators. That process must occur through park planning and management activities. What a NRCA can do is deliver science-based information that will assist park managers in their ongoing, long-term efforts to describe and quantify a park's desired resource conditions and management targets. In the near term, NRCA findings assist strategic park resource planning[6] and help parks to report on government accountability measures.[7] In addition, although in-depth analysis of the effects of climate change on park natural resources is outside the scope of NRCAs, the condition analyses and data sets developed for NRCAs will be useful for park-level climate-change studies and planning efforts.

NRCAs also provide a useful complement to rigorous NPS science support programs, such as the NPS Natural Resources Inventory & Monitoring (I&M) Program.[8] For example, NRCAs can provide current condition estimates and help establish reference conditions, or baseline values, for some of a park's vital signs monitoring indicators. They can also draw upon non-NPS data to help evaluate current conditions for those same vital signs. In some cases, I&M data sets are incorporated into NRCA analyses and reporting products.

Over the next several years, the NPS plans to fund a NRCA project for each of the approximately 270 parks served by the NPS I&M Program. For more information on the NRCA program, visit http://www.nature.nps.gov/water/nrca/.

NRCA Reporting Products

- Provide a credible, snapshot-in-time evaluation for a subset of important park natural resources and indicators, to help park managers:
- Direct limited staff and funding resources to park areas and natural resources that represent high need and/or high opportunity situations
  (near-term operational planning and management)
- Improve understanding and quantification for desired conditions for the park's "fundamental" and "other important" natural resources and values
  (longer-term strategic planning)
- Communicate succinct messages regarding current resource conditions to government program managers, to Congress, and to the general public ("resource condition status" reporting).

Carmichael's cut on Union Pacific grade, Golden Spike NHS. Photo Credit: © Mark Brunson.

Chapter 2. Introduction and Resource Setting

2.1. Introduction

2.1.1. Enabling Legislation/Executive Orders

Golden Spike National Historic Site (NHS) was designated on April 2, 1957 then officially established through its enabling legislation on July 30, 1965 (NPS 2017a). Its purpose statement is "to serve as a national memorial commemorating the completion of the first transcontinental railroad across the United States" through the joining of the Union Pacific and the Central Pacific Railroads (NPS 2017a). The historic site's unique resources and values are further described in its five significance statements as follows (text excerpted from NPS (2017a)):

1. *The Transcontinental Railroad Links the Nation*. The transcontinental railroad was among the greatest technological achievements of the 19th century. Golden Spike National Historic Site preserves the location where this achievement, which linked the United States politically, economically, physically, as well as in the national psyche, was completed. Coupled with other western expansion migrations, the transcontinental railroad had profound negative impacts on the lifeways and cultures of the American Indians across the West.

2. *Preserving a Cultural Landscape*. Golden Spike National Historic Site, set in a vast open landscape mostly unchanged from 1869, retains an unparalleled concentration of historic transcontinental railroad engineering features, archeological sites, and associated cultural landscape elements. It is the only park unit set aside in perpetuity that preserves physical evidence of the technology and methods involved in construction, completion, and maintenance of the transcontinental railroad.

3. *Locomotives and Reenactment*. The park's replica locomotives, together with its long history of commemorative activities and reenactment ceremonies, provide visitors a unique opportunity to learn about and experience the transcontinental railroad and have contributed to etching the Last Spike Site into the national consciousness

4. *Technological Feat*. The transcontinental railroad was among the greatest technological feats of the 19th century and represents one of the most ambitious and expensive projects ever undertaken by the federal government. The daunting task of construction across vast expanses of the country, within a relatively short time frame, required the government to forge creative partnerships with private corporations to accomplish this unprecedented construction feat. The legacy of this government corporate partnership, and the fierce competition that it spawned between the rival railroad companies, is clearly reflected in the parallel grades and other features of Golden Spike National Historic Site.

5. *United Effort*. Thousands of American workers and immigrants (Civil War veterans including Buffalo Soldiers, Irish, Chinese, American Indians, Mormons, and others) were employed in the railroad's construction, often toiling under the harshest of conditions in some of the most remote and difficult landscapes of the West.

The national historic site's fundamental and other resources and values statements integrate both the cultural and natural features into their definitions and are listed in the park's Foundation Document (NPS 2017a) and in Chapter 5 of this report.

2.1.2. Geographic Setting

Golden Spike NHS is located in northern Utah (Figure 2.1.2-1), approximately 32 miles west of Brigham City and 90 miles northwest of Salt Lake City in Box Elder County. The historic site preserves a 1,107 ha (2,735.28 ac), area of which 80.5% is in federal ownership and approximately 19.4% is privately held. Elevations range from 1,329 m (4,360 ft) to 1,609 m (5,280 ft), and the site is completely surrounded by private land (NPS 2017).

<u>Population</u>

The current U.S. Census Bureau data show that Utah is the fastest growing state in the nation (U.S. Census Bureau 2016a). However, the absence of reliable sources of water surrounding the area may limit development (NPS 2017a). As of July 1, 2017, the population estimate for Box Elder County was 54,079. The population percent change from April 1, 2010 to July 1, 2017 represents an increase of 8.2% in Box Elder County (U.S. Census Bureau no date).

<u>Climate</u>

There is a U.S. Climate Reference Network (USCRN) weather station at Golden Spike NHS, administered by the National Oceanic and Atmospheric Administration (NOAA) (Witwicki 2013). The climate monitoring program is an initiative that "provides long-term observations of temperature and precipitation that can be coupled to past long-term observations for the detection of climatic change. High-quality, automated stations record air temperature and precipitation, as well as measures of ground-surface temperature, solar radiation, wind speed, and sensor performance about every two seconds" (Witwicki 2013). According to NCPN (2018), "annual precipitation [at the historic site] averages 203–305 millimeters (8–12 in), mostly as snow and experiences a late-summer dip in average

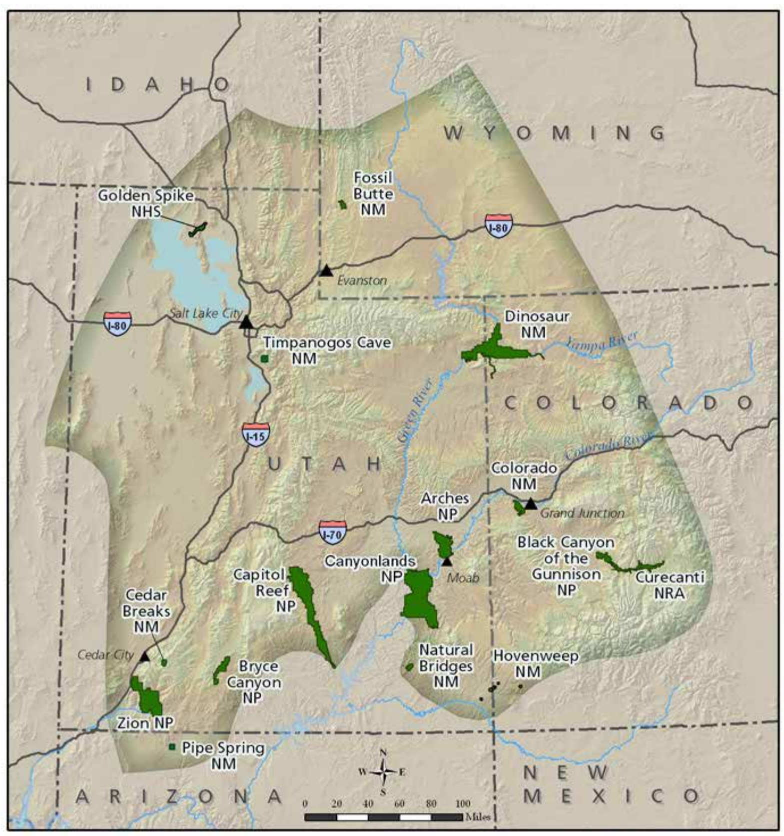


Figure 2.1.2-1. Golden Spike NHS is located in northwest Utah and is one of 16 park units within the NPS Northern Colorado Plateau Inventory and Monitoring Network. Figure Credit: NPS NCPN.

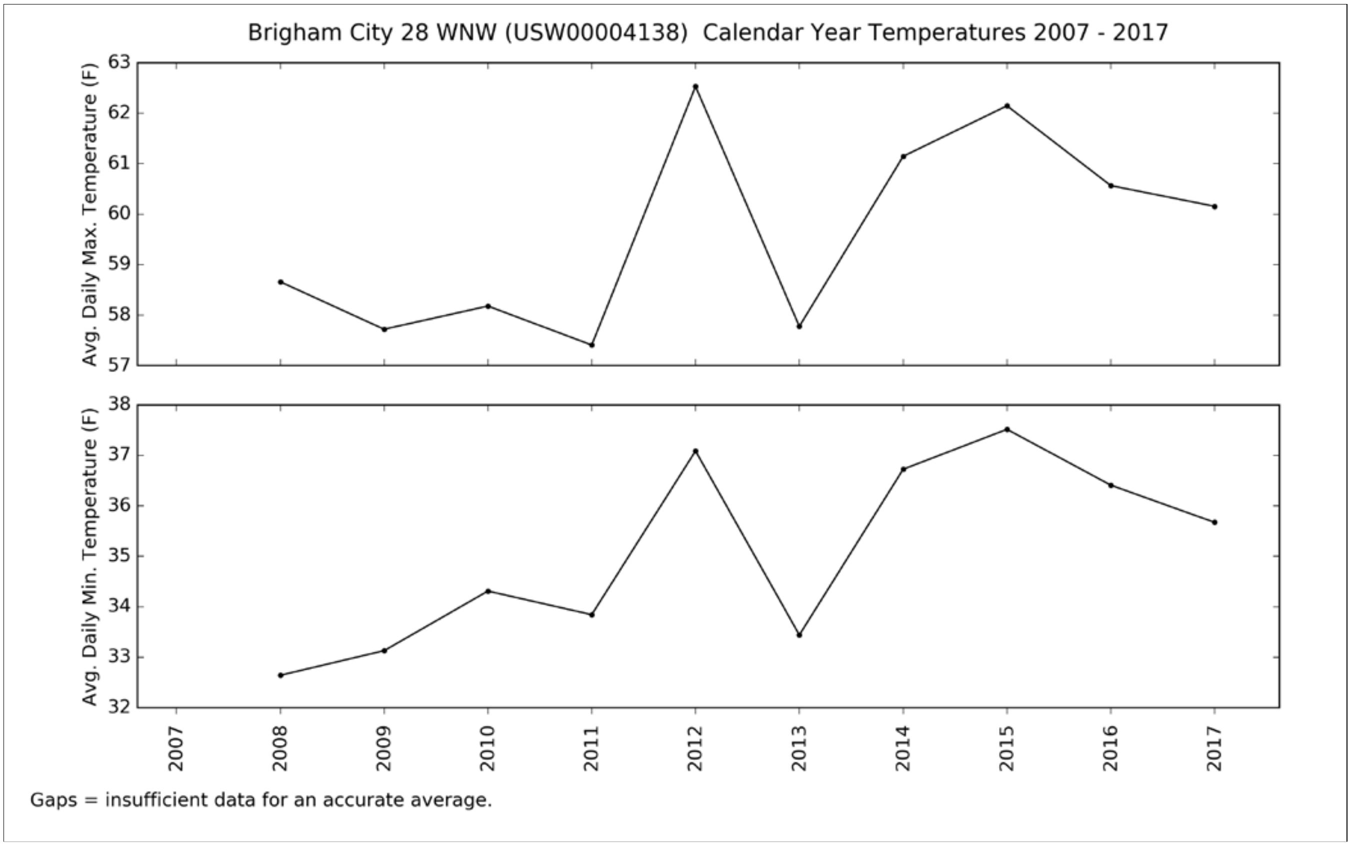


Figure 2.1.2-2. Average daily temperatures (2007-2017). Figure Credit: Climate Analyzer 2018.

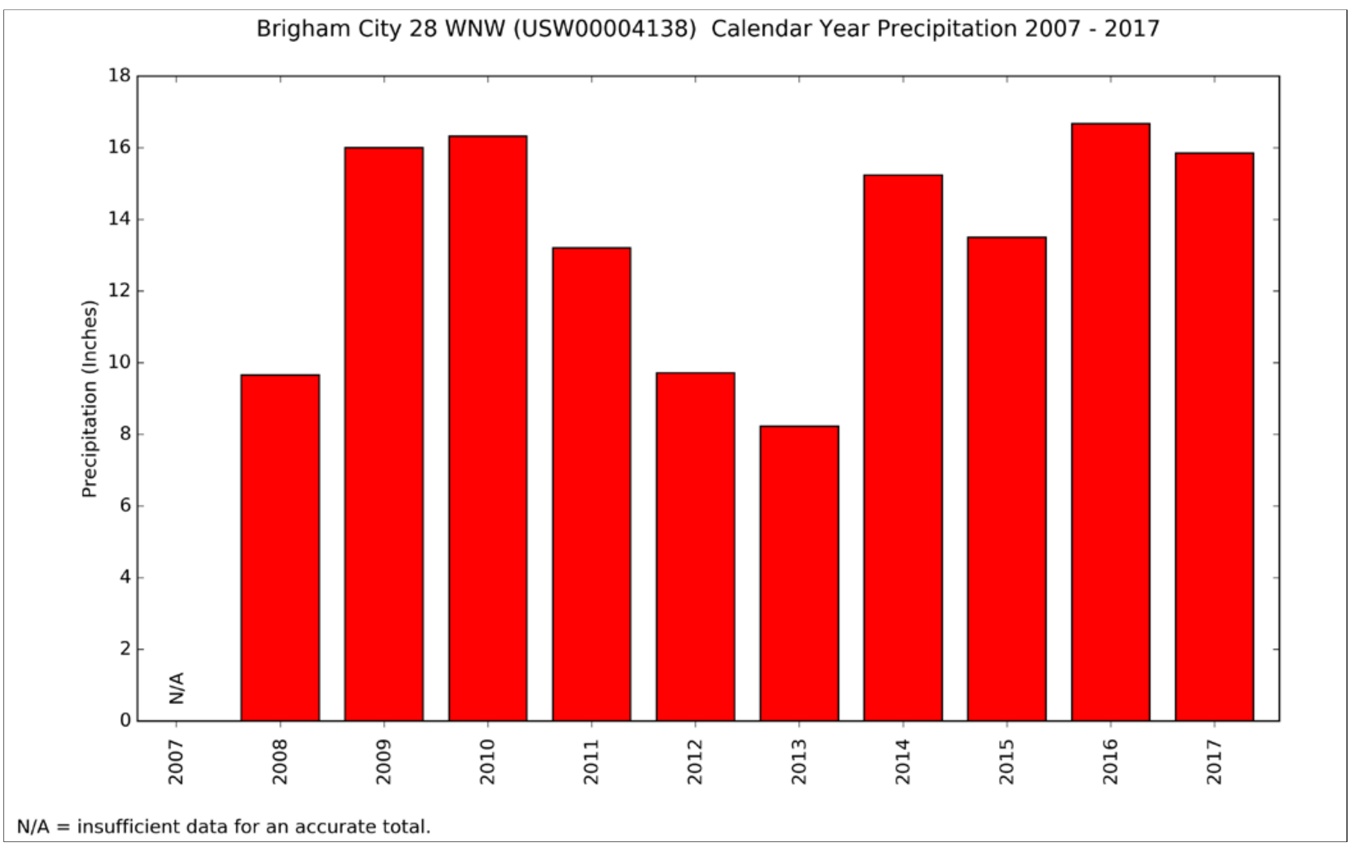


Figure 2.1.2-3. Calendar year precipitation totals (2007-2017). Figure Credit: Climate Analyzer 2018.

monthly precipitation. Temperatures range from highs of 20°F (-6.7°C) in winter to an occasional 104°F (40°C) in summer."

2.1.3. Visitation Statistics

Visitation data for Golden Spike NHS are available from 1967-2017 (NPS Public Use Statistics Office 2018). The total number of visitors each year has been recently increasing, however, the highest number of visitors was 169,600 in 1969 (Figure 2.1.3-1). The months with the highest average number of visitors are May and July (NPS Public Use Statistics Office 2018).

2.2. Natural Resources

2.2.1. Ecological Units, Watersheds, and NPScape Landscape-scale

Ecological Units

Golden Spike NHS is located in the Basin and Range Province (Hunt 1974) within the NPS Northern Colorado Plateau Inventory and Monitoring Network (NCPN). The topography is characterized by abrupt changes in elevation, alternating between narrow faulted mountain chains and flat arid valleys or basins. Basin big sagebrush (*Artemisia tridentata* var. *tridentata*) and rubber rabbitbrush (*Ericameria nauseosa*) are the most common shrub communities. Where fire has removed these shrubs, herbaceous plant communities are found. Riparian vegetation is limited to a very short reach of Blue Creek that crosses the extreme eastern end of the park (NCPN 2018).

Watershed Units

Golden Spike NHS is located within four watersheds, with the majority of its area situated in the Promontory-Blue Creek watershed. (U.S. Geological Survey [USGS 2014], Figure 2.2.1-1).

NPScape Landscape-scale

Most of Golden Spike NHS's natural resources (e.g., viewshed, night sky, soundscape, wildlife, etc.) are affected by landscape-scale processes. A landscape perspective can provide a broader perspective and more comprehensive information to better understand resource conditions throughout the park. Studies have

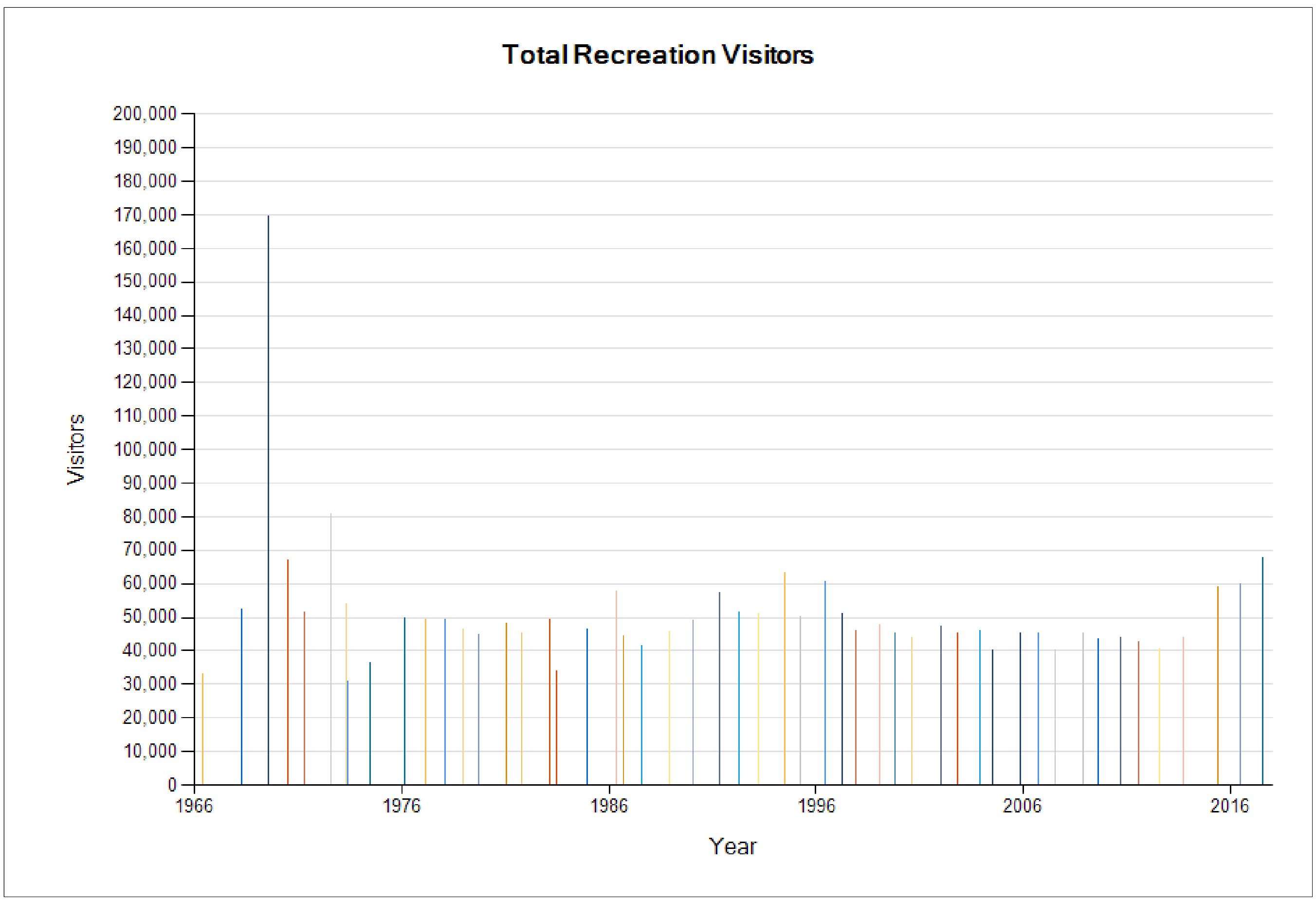


Figure 2.1.3-1. Total number of annual visitors to Golden Spike NHS from 1967-2017. Figure Credit: NPS Public Use Statistics Office 2018.

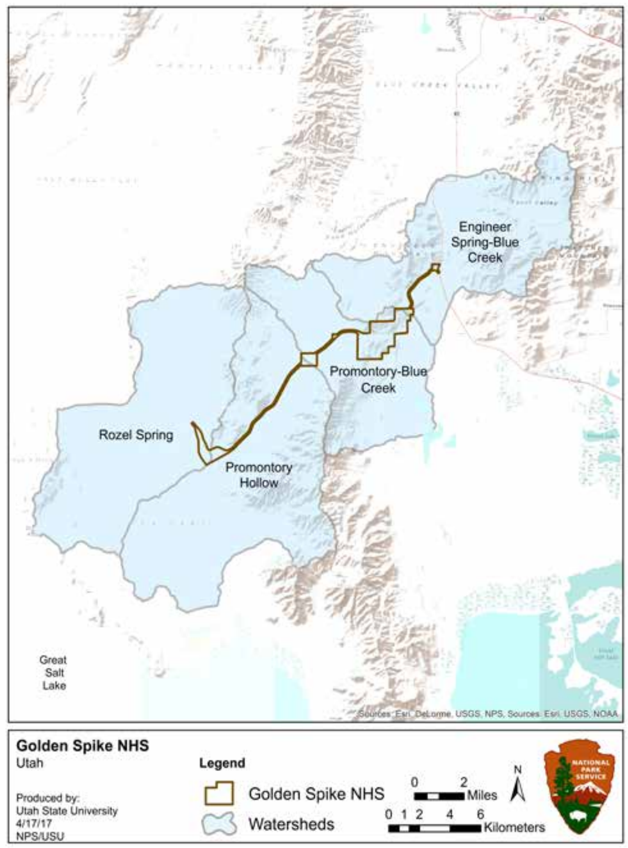


Figure 2.2.1-1. Golden Spike NHS is located in four watersheds.

shown that natural resources rely upon the larger, surrounding area to support their life cycles (Coggins 1987 as cited in Monahan et al. 2012), however, most parks are not large enough to encompass self-contained ecosystems for the resources found within their boundaries. When feasible, landscape-scale indicators and measures were included in the historic site's condition assessments to provide an ecologically relevant, landscape-scale context for reporting resource conditions. NPS NPScape metrics were used to report on the landscape-scale measures, providing a framework for conceptualizing human effects (e.g., housing densities, road densities, etc.) on landscapes surrounding the site (NPS 2014a,b).

2.2.2. Resource Descriptions

Landscape-scale resources such as viewsheds, dark night sky, and natural soundscapes provide important visitor experiences at national parks. Natural and historic features on the visible landscape, sounds of nature or culturally-related activities, and a starry sky influence the enjoyment, appreciation, and understanding of a park. Golden Spike NHS offers outstanding scenic views to its visitors, helping create a connection between its historic past and current natural state. The NHS's Foundation Document addresses the potential for opportunities to promote awareness about the importance of night skies to help preserve this, and other landscape-scale resources (NPS 2017a).

Two categories of air quality areas (Class I and II) have been established through the authority of the Clean Air Act of 1970 (42 U.S.C. §7401 et seq. (U.S. Federal Register. 1970)). Golden Spike NHS is designated as a Class II airshed, but it is important to note that even though the CAA gives Class I areas the greatest protection against air quality deterioration, NPS management policies do not distinguish between the levels of protection afforded to any park of the National Park System (NPS 2006). Haze, ozone, and wet deposition for nitrogen, sulfur, and mercury are monitored for the NHS. There is one ozone-sensitive plant species present at the historic site, Utah serviceberry (*Amelanchier utahensis*), which is commonly located in the foothills, canyon slopes, and lower mountains of the Rocky Mountains (Coles et al. 2011).

In 2007 the NCPN contracted to map the vegetation in Golden Spike NHS (Coles et al. 2011). Golden Spike NHS's semiarid climate supports sagebrush grasslands primarily composed of Basin big sagebrush, graystem rabbitbrush (*Chrysothamnus nauseosus* var. *gnaphalodes*), and purple three-awn (*Aristida purpurea*) (Fertig 2009). Additional floristic surveys and studies have been conducted at Golden Spike NHS, four of which specifically targeted Passey's onion, (*Allium passeyi*) (Boyce 1980, Phillips et al. 2008, Phillips et al. 2010, and Phillips et al. 2011)— an endemic plant at the historic site. Passey's onion was first discovered in 1964 by Howard Passey, a soil scientist for the Soil Conservation Service at a site near Golden Spike NHS (Boyce 1980). In 1980, Benjamin Boyce, a park technician, located and mapped three large populations in and around the historic site (Boyce 1980). Until Boyce's discovery in Golden Spike NHS, Passey's onion had only been known from the original location.

The only sagebrush–obligate bird species that currently occurs in the historic site is the Brewer's sparrow (*Spizella breweri*), but sage thrasher (*Oreoscoptes montanus*) and sagebrush sparrow (*Artemisiospiza nevadensis*) may be present. The NHS supports several additional birds throughout its different habitat types. A total of 71 birds have been confirmed at the NHS. In addition, 27 mammals, and 17 reptiles and amphibians have been confirmed as present through the inventory efforts conducted by Haymond et al. (2003) (for mammals), Platenberg and Graham (2003) (for herpetofauna), and Oliver (2006) (for herpetofauna).

2.2.3. Resource Issues Overview

Like many places, the Southwest is already experiencing the impacts of climate change. According to Kunkel et al. (2013), the historical climate trends (1895-2011) for the southwest (including the states of Arizona, California, Colorado, Nevada, New Mexico, and Utah) have seen an average annual temperature increase of 0.9 °C (34 °F) (greatest in winter months) and more than double the number of four-day periods of extreme heat. The western U.S., especially the Southwest, has also experienced decreasing rainfall (Prein et al. 2016). Since 1974 there has been a 25% decrease in precipitation, a trend that is partially counteracted by increasing precipitation intensity (Prein et al. 2016).

Monahan and Fischelli (2014) evaluated which of 240 NPS parks have experienced extreme climate changes during the last 10-30 years, including Golden Spike NHS. Twenty-five climate variables (i.e., temperature and precipitation) were evaluated to determine which ones were either within <5th percentile or >95th percentile relative to the historical range of variability (HRV) from 1901-2012. Results for Golden Spike NHS were reported as follows:

- Three temperature variables were "extreme warm" (minimum temperature of the coldest month, mean temperature of the driest quarter, mean temperature of the warmest quarter).
- No temperature variables were "extreme cold."
- No precipitation variables were "extreme dry."
- No precipitation variables were "extreme wet."

Results for the temperature of each year between 1901-2012, the averaged temperatures over progressive 10-year intervals, and the average temperature of 2003-2012 (the most recent interval) are shown in Figure 2.2.3-1. The blue line shows temperature for each year, the gray line shows temperature averaged over progressive 10-year intervals (10-year moving windows), and the red asterisk shows the average temperature of the most recent 10-year moving window (2003–2012). The most recent percentile is calculated as the percentage of values on the gray line that fall below the red asterisk. The results indicate that recent climate conditions have already begun shifting beyond the HRV, with the 2003-2012 decade representing the warmest on record for the historic site.

Climate predictions are that the Southwest will likely continue to become warmer and drier with climate change (Garfin et al. 2014, Monahan and Fisichelli 2014). Kunkel et al. (2013) estimate that temperatures could rise between 2.5 °C (37 °F) and 4.7 °C (40 °F) for 2070-2099 (based on climate patterns from 1971-1999). Monahan and Fisichelli (2014) state that "climate change will manifest itself not only as changes in average conditions, but also as changes in particular climate events (e.g., more intense storms, floods, or drought). Extreme climate events can cause widespread and fundamental shifts in conditions of park resources."

Climate change may increase the historic site's vulnerability to the introduction and spread of invasive species (Hellmann et al. 2008). A study of plant response to climate change on the Colorado Plateau suggests that increased aridity will likely lead to the loss of native grasses and the expansion of shrubs (Munson et al. 2011). In the case of Golden Spike NHS, non-native grasses dominate much of the native sagebrush communities, and native forbs and grasses are nearly absent (Monaco 2003). The prevalence of non-native plants in the historic site is largely the result of 150 years of human disturbance (Coles et al. 2011). Agriculture and ranchlands that surround the historic site today also contribute to the spread of non-native plants and serve as source populations (NR-EPMT 2016).

Impacts to habitat due to non-native plants, development, agriculture, and forestry activities pose threats to the wildlife within Golden Spike NHS. Of the threats specific to Golden Spike NHS and other sagebrush habitats across the west, is the loss of native sagebrush communities. Surveys for Brewer's sparrow and sage sparrow may help determine the quality of sagebrush habitat. While currently absent from the historic site, the greater sage–grouse (*Centrocercus urophasianus*), in particular, is sensitive to sagebrush habitat quality. Cheatgrass and conifer encroachment into sagebrush shrublands, wildfire, and human

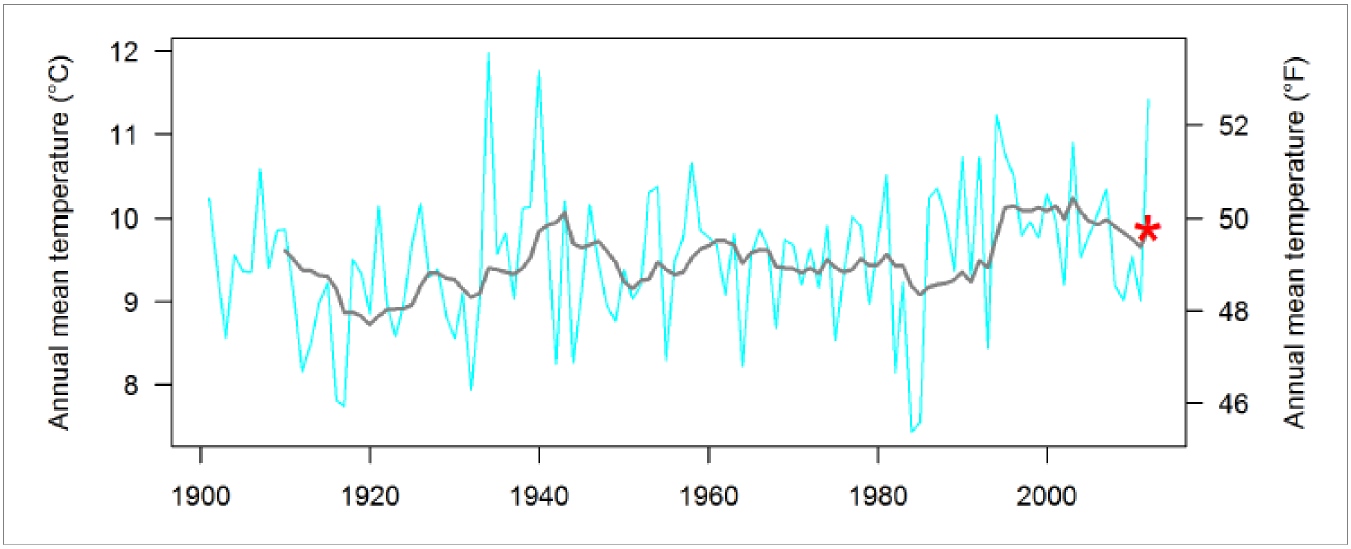


Figure 2.2.3-1. Time series used to characterize the historical range of variability and most recent percentile for annual mean temperature at Golden Spike NHS (including areas within 30-km [18.6-mi] of the park's boundary). Figure Credit: Monahan and Fisichelli (2014).

development are all threats to sage–grouse and other sagebrush–dependent species (UDNR 2016).

Another threat is roadkill of wildlife due to vehicle strikes. Golden Spike NHS's annual visitation has been steadily increasing since 2014, with a record high of 67,811 visitors in 2017 (NPS Public Use Statistics Office 2018), representing an 11.5% increase from 2016. With increased visitation comes increased vehicular use on the roads within the park, which poses a threat to the NHS's wildlife.

Details pertaining to these and additional resource threats, concerns, and data gaps are included in each Chapter 4 condition assessment and in Chapter 5.

2.3. Resource Stewardship

2.3.1. Management Directives and Planning Guidance

In addition to the historic site's purpose, significance, and fundamental resources and values, and other potential resources/ecological drivers of interest, the NPS Washington (WASO) level programs guided the selection of key natural resources for this condition assessment. This included the NCPN, I&M NPScape Program for landscape-scale measures, Air Resources Division for air quality, and the Natural Sounds and Night Skies Program for the soundscape and night sky assessments.

<u>NCPN I&M Program</u>

In an effort to improve overall national park management through expanded use of scientific knowledge, the I&M Program was established to collect, organize, and provide natural resource data as well as information derived from data through analysis, synthesis, and modeling (NPS 2011a). The primary goals of the I&M Program are to:

- inventory the natural resources under NPS stewardship to determine their nature and status;
- monitor park ecosystems to better understand their dynamic nature and condition and to provide reference points for comparisons with other altered environments;
- establish natural resource inventory and monitoring as a standard practice throughout the National Park System that transcends traditional program, activity, and funding boundaries;
- integrate natural resource inventory and monitoring information into NPS planning, management, and decision making; and
- share NPS accomplishments and information with other natural resource organizations and form partnerships for attaining common goals and objectives (NPS 2011a).

To facilitate this effort, 270 parks with significant natural resources were organized into 32 regional networks. Golden Spike NHS is part of the NCPN, which includes 15 additional parks. Through a rigorous multi-year, interdisciplinary scoping process, NCPN selected a number of important physical, chemical, and/or biological elements and processes for long-term monitoring. These ecosystem elements and processes are referred to as 'vital signs', and their respective monitoring programs are intended to provide high-quality, long-term information on the status and trends of those resources (NPS NCPN 2018).

Park Planning Reports

Natural Resource Condition Assessment

The structural framework for NRCAs is based upon, but not restricted to, the fundamental and other important values identified in a park's Foundation Document or General Management Plan. NRCAs are designed to deliver current science-based information translated into resource condition findings for a subset of a park's natural resources. The NPS State of the Park (SotP) and Resource Stewardship Strategy (RSS) reports rely on credible information found in NRCAs as well as a variety of other sources (Figure 2.3.1-1).

Foundation Document

Foundation documents describe a park's purpose and significance and identify fundamental and other important park resources and values. A foundation document was completed for Golden Spike NHS in 2017 (NPS 2017a) and was used to identify some of the primary natural features throughout the park for the development of its NRCA.

State of the Park

A State of the Park (SotP) report is intended for non-technical audiences and summarizes key findings of park conditions and management issues, highlighting recent park accomplishments and activities. NRCA condition findings are used in SotP reports, and each Chapter 4 assessment includes a SotP condition summary, with an overall summary by topic presented in Chapter 5.

Resource Stewardship Strategy

A Resource Stewardship Strategy (RSS) uses past and current resource conditions to identify potential

Figure 2.3.1-1. The relationship of NRCAs to other National Park Service planning reports.

management targets or objectives by developing comprehensive strategies using all available reports and data sources including NRCAs. National Parks are encouraged to develop an RSS as part of the park management planning process. Indicators of resource condition, both natural and cultural, are selected by the park. After each indicator is chosen, a target value is determined and the current condition is compared to the desired condition. An RSS has not been completed for the historic site.

2.3.2. Status of Supporting Science

Available data and reports varied depending upon the resource topic. The existing data used to assess the condition of each indicator and/or to develop reference conditions are described in each of the Chapter 4 assessments.

Visitors viewing locomotive, Jupiter, at Golden Spike NHS. Photo Credit: © M. Brunson.

Chapter 3. Study Scoping and Design

The Natural Resource Condition Assessment (NRCA) for Golden Spike National Historic Site (NHS) was coordinated by the National Park Service (NPS) Intermountain Region Office (IMR), Utah State University (USU), and the Colorado Plateau Cooperative Ecosystem Studies Unit through task agreements, P14AC00749 and P15AC01212. The NRCA scoping process was a collaborative effort between the staffs of Golden Spike NHS and NPS Northern Colorado Plateau Inventory and Monitoring Network (NCPN), the NPS IMR NRCA Coordinator, and USU's NRCA project team.

3.1. Preliminary Scoping

Preliminary scoping for Golden Spike's NRCA occurred during two conference calls with Golden Spike NHS Superintendent, Leslie Crossland. Prior to the call, USU staff reviewed Golden Spike NHS's Foundation Document (NPS 2017a), the national historic site's and Northern Colorado Plateau Inventory and Monitoring Network's websites (NPS 2017b, NPS NCPN 2016b, respectively), and the NPS integrated resource management applications: IRMA portal (NPS 2017c). The NPS Natural Resource Stewardship and Science Directorate (NRSS) divisions provided data for the NHS's night sky, soundscape, and air quality condition assessments (NPS 2017d).

Based on the information gathered from these various sources, an initial list of potential focal resources for the NHS's NRCA was developed and discussed during the conference calls. The resources were reviewed, discussed, and refined, and a final list was developed that served as USU's study plan for the historic site's NRCA report. No NRCA workshop was held at the NHS due to limited park staffing.

3.2. Study Design

3.2.1. Indicator Framework, Focal Study Resources and Indicators

An NRCA report includes current condition assessments of key natural resource topics for each park. For the purposes of Golden Spike NHS's NRCA, 10 focal resources were selected for evaluation. The indicators and measures selected for each of the 10 natural resources are listed in Tables 3.2.1-1 , -2, and -3. This list of resources *does not* include every natural resource of interest to NHS staff, rather the list is comprised of the natural resources and processes that were of greatest interest or concern to park staff at the time of this effort.

Table 3.2-1-1. Golden Spike NHS natural resource condition assessment framework based on the NPS Inventory & Monitoring Program's Ecological Monitoring Framework for landscapes patterns and processes.

Resource	Indicators	Measures
Viewshed	Scenic and Historic Integrity	Conspicuousness of Non-contributing Features
	Scenic and Historic Integrity	Extent of Development
	Scenic and Historic Integrity	Conservation Status
Night Sky	Sky Brightness	All-sky Light Pollution Ratio
Soundscape	Geospatial Model	L_{50} Impact

Table 3.2.1-2. Golden Spike NHS natural resource condition assessment framework based on the NPS Inventory & Monitoring Program's Ecological Monitoring Framework for air and climate.

Resource	Indicators	Measures
Air Quality	Visibility	Haze Index
	Ozone	Human Health
	Ozone	Vegetation Health
	Wet Deposition	Nitrogen
	Wet Deposition	Sulfur
	Wet Deposition	Mercury
	Wet Deposition	Predicted Methylmercury Concentration

Golden Spike's NRCA focal resources are grouped using the NPS Inventory & Monitoring (I&M) Program's "NPS Ecological Monitoring Framework" (NPS 2005), which is endorsed by the Washington Office NRCA Program as an appropriate framework for listing resource components, indicators/measures, and resource conditions. Additionally, the NCPN Vital Signs Plan (O'Dell et al. 2005) and the RM-77 NPS Natural Resource Management Guideline (NPS 2004a) are all organized similarly to the I&M framework.

3.2.2. Reporting Areas

The primary focus of the reporting area for each condition assessment was within Golden Spike NHS's legislative boundary; however, some of the analyses encompassed areas beyond the park's border. Natural resources assessed at the landscape level included viewshed and night sky. The NPS NRSS Natural

Table 3.2.1-3. Golden Spike NHS natural resource condition assessment framework based on the NPS Inventory & Monitoring Program's Ecological Monitoring Framework for biological integrity.

Resource	Indicators	Measures
Vegetation Communities	Vegetation Intactness	Percent Vegetation Mapped as Natural.
	Vegetation Intactness	Ratio of Non-native to Total Plant Species
	Vegetation Intactness	Vegetation Condition Class
Passey's Onion	None developed	None developed
Non-native Invasive Plants	Rate of Invasion	New Non-native Plants Detected (%)
	Potential to Alter Native Plant Communities	NatureServe Invasive Species Impact Rank
	Prevalence	Patch Dynamics
	Prevalence	Frequency by Vegetation Type or Area (% of plots)
	Prevalence	Cover by Vegetation Type or Area (%)
Birds	Species Occurrence	Presence / Absence
	Species Occurrence	Presence / Absence of Species of Conservation Concern
Mammals	Species Occurrence	Species Presence / Absence
	Species Occurrence	Species Nativity
	Species Occurrence	Species of Conservation Concern
Herpetofauna	Species Occurrence	Species Presence / Absence
	Species Occurrence	Species Nativity
	Species Occurrence	Species of Conservation Concern

Sounds and Night Skies Division provided the data and reports for the night sky assessment. USU staff completed the GigaPan panoramas for the NHS's viewshed assessment during one site visit in May 2018.

3.2.3. General Approach and Methods

The general approach to developing the condition assessments included reviewing literature and data and/or speaking to subject matter expert(s) for assistance in condition reporting. Following the NPS NRCA guidelines (NPS 2010a), each Chapter 4 condition assessment includes five standard sections (listed below), with a condensed literature cited section included at the end of the full report.

1. The background and importance section of each condition assessment provides information regarding the relevance of the resource to the park.

2. The data and methods section describes the existing datasets and methodologies used for data collection, which are the indicators and measures used to evaluate current resource conditions.

3. The reference conditions section describes the good, moderate concern, and significant concern thresholds used to evaluate the condition of each measure evaluated.

4. The condition and trend section provides a discussion for each indicator/measure based on the reference condition(s). Condition icons are presented in a standard format consistent with *State of the Park* reporting (NPS 2012) and serve as visual representations of condition/trend/level of confidence for each measure. Table 3.2.3-1 shows the condition/trend/confidence level scorecard used for each assessment. Table 3.2.3-2 provides examples of conditions, trends, and confidence levels and associated interpretations. The level of confidence in the assessment ranges from high to low and is symbolized by the border thickness around the condition circle. Circle colors convey condition. Red circles signify that a resource is of significant concern; yellow circles signify that a

Table 3.2.3-1. Indicator symbols used to indicate condition, trend, and confidence in the assessment.

Condition Status		Trend in Condition		Confidence in Assessment	
	Resource is in good condition.		Condition is Improving.		High
	Resource warrants moderate concern.		Condition is unchanging.		Medium
	Resource warrants significant concern.		Condition is deteriorating.		Low
	An open (uncolored) circle indicates that current condition is unknown or indeterminate; this condition status is typically associated with unknown trend and low confidence.				

Table 3.2.3-2. Example indicator symbols and descriptions of how to interpret them.

Symbol Example	Description of Symbol
	Resource is in good condition; its condition is improving; high confidence in the assessment.
	Condition of resource warrants moderate concern; condition is unchanging; medium confidence in the assessment.
	Condition of resource warrants significant concern; trend in condition is unknown or not applicable; low confidence in the assessment.
	Current condition is unknown or indeterminate due to inadequate data, lack of reference value(s) for comparative purposes, and/or insufficient expert knowledge to reach a more specific condition determination; trend in condition is unknown or not applicable; low confidence in the assessment.

resource is of moderate concern; and green circles denote that the resource is in good condition. A circle without any color, which is often associated with the low confidence symbol-dashed line, signifies that there is insufficient information to make a statement about condition; therefore, condition is unknown.

Arrows inside the circles signify the trend of the measure. An upward pointing arrow signifies that the measure is improving; double pointing arrows signify that the measure's condition is currently unchanging; a downward pointing arrow indicates that the measure's condition is deteriorating. No arrow denotes an unknown trend.

5. The sources of expertise section includes the individuals or programs that were consulted. Assessment author(s) are also listed for each condition assessment.

After the report is published, a disk containing a digital copy of the final report, copies of the literature cited (with exceptions listed in a READ ME document), original GigaPan viewshed images, reviewer comments and writer responses if comments weren't incorporated into the assessment, and any unique GIS datasets created for the purposes of the NRCA was sent to Golden Spike NHS staff and the NPS IMR NRCA Coordinator per agreement stipulations.

Chapter 4. Natural Resource Conditions

Chapter 4 delivers current condition reporting for the 10 important natural resources and indicators selected for Golden Spike NHS's NRCA report. The resource topics are presented following the National Park Service's (NPS) Inventory & Monitoring Program's NPS Ecological Monitoring Framework that is presented in Chapter 3.

Indian paintbrush and sagebrush at Golden Spike NHS. Photo Credit: © M. Brunson.

4.1. Viewshed

4.1.1. Background and Importance

The conservation of scenery was established in the National Park Service (NPS) Organic Act of 1916 ("… to conserve the scenery and the wildlife therein…"), reaffirmed by the General Authorities Act, as amended, and addressed generally in the NPS 2006 Management Policies sections 1.4.6 and 4.0 (Johnson et al. 2008). Although no management policy currently exists exclusively for scenic or viewshed management and preservation, parks are still required to protect scenic and viewshed quality as one of their most fundamental resources. According to Wondrak-Biel (2005), aesthetic conservation, interchangeably used with scenic preservation, has been practiced in the NPS since the early twentieth century. Aesthetic conservation strives to protect scenic beauty for park visitors to better experience the values of the park. The need for scenic preservation management is as relevant today as ever, particularly with the pervasive development pressures that challenge park stewards to conserve scenery today and for future generations.

Viewsheds are considered an important part of the visitor experience at Golden Spike National Historic Site (NHS), and features on the visible landscape influence a visitor's enjoyment, appreciation, and understanding of the area's significance (NPS 2017a). Much of the landscape surrounding Golden Spike NHS is undeveloped, providing visitors the opportunity to immerse themselves in a historical landscape that looks much like it did in 1869 when the Union Pacific Railroad and the Central Pacific Railroad came together forming the U.S.'s first transcontinental railroad (NPS 2017a). Visitors to Golden Spike NHS are provided opportunities to literally "visualize" their connection to this important time in American history. The views offered at Golden Spike NHS represent much more than just scenery; they represent a way to better understand the connection between the past and the present. Inherent in virtually every aspect of this assessment is how features on the visible landscape influence the enjoyment, appreciation, and understanding of the historic site by visitors.

4.1.2. Data and Methods

The indicator (scenic and historic integrity) and measures (conspicuousness of non-contributing features, extent of development, and conservation status) used for assessing the condition of Golden Spike NHS's viewshed were based on studies related to perceptions people hold toward various features and attributes of scenic landscapes. The scenic and historic integrity indicator is defined as the state of naturalness or, conversely, the state of disturbance created by human activities or alteration (U.S. Forest Service (USFS 1995). Integrity focuses on the features of the landscape related to non-contributing human

View of the Great Salt Lake salt flats and South Promontory Mountains. Photo Credit. © M. Brunson.

alteration/development. In general, there has been a wealth of research demonstrating that people tend to prefer natural landscapes over human-modified landscapes (Zube et al. 1982, Kaplan and Kaplan 1989, Sheppard 2001, Kearny et al. 2008, Han 2010). Human-altered components of the landscape (e.g., roads, modern buildings, power lines, and other features) that do not contribute to the natural scene are often perceived as detracting from the scenic character of a viewshed. Despite this generalization for natural landscape preferences, studies have also shown that not all human-made structures or features have the same impact on visitor preferences. Visitor preferences can be influenced by a variety of factors including cultural and historical background, familiarity with the landscape, and their environmental values (Kaplan and Kaplan 1989, Virden and Walker 1999, Kaltenborn and Bjerke 2002, Kearney et al. 2008).

While we recognize that visitor perceptions of an altered landscape are highly subjective, and that there is no completely objective way to measure these perceptions, research has shown that there are certain landscape types and characteristics that people tend to prefer over others. Substantial research has demonstrated that human-made features on a landscape were perceived more positively when they were considered in harmony with the landscape (e.g., Kaplan and Kaplan 1989, Gobster 1999, Kearney et al. 2008). Kearney et al. (2008) showed that survey respondents tended to prefer development that blended with the natural setting through use of colors, fine scale features, and vegetative screening. These characteristics, along with distance from non-contributing features, and movement and noise associated with observable features on the landscape, are discussed below.

Key Observation Points

Three key observation points were selected by Utah State University staff and were chosen based on viewsheds that are accessible to the public, are located upon a prominent landscape feature, and are inclusive of historic resources, natural resources, and scenic views (Figure 4.1.2-1). We used panoramic images collected at these three locations in addition to GIS analyses of modeled visible areas overlaid with housing density, road density, and land management datasets to evaluate viewshed conditions from the historic site.

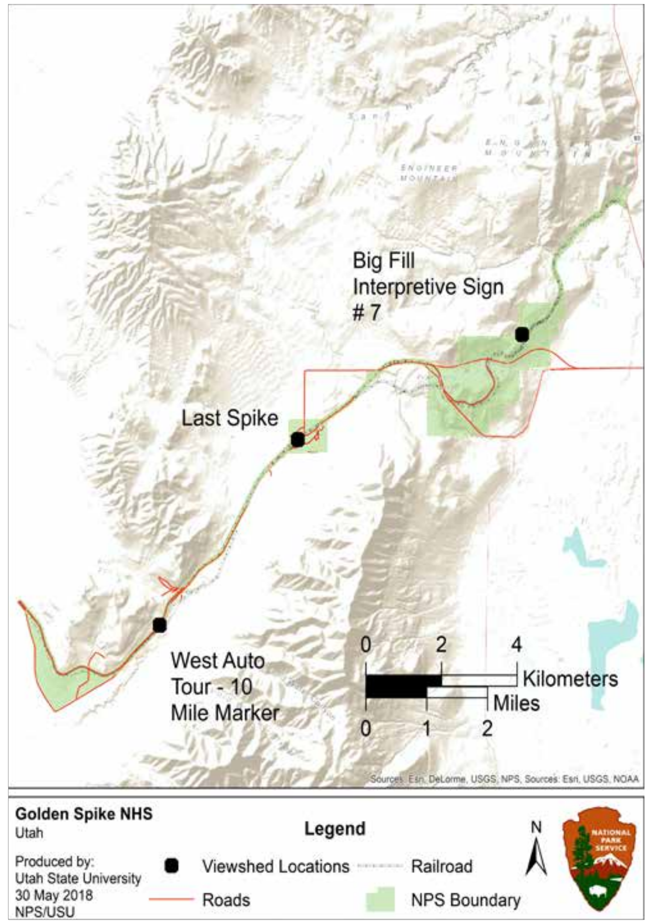


Figure 4.1.2-1. Viewshed locations.

Conspicuousness of Non-Contributing Features

GigaPan Images

We used a Canon PowerShot digital camera mounted to a GigaPan Epic 100 system to collect a series of panoramic images from each of the three key observation points on 23 May 2018. At each location, a set of photos was collected from the four cardinal directions (i.e., north to east, east to south, south to west, and west to north). The images for each direction were then stitched together into a single high-resolution panoramic image using GigaPan Stitch software. These photos portray the viewshed from an observer's perspective and provide a means of assessing the non-contributing features on the landscape. Non-contributing features were qualitatively evaluated based on groups of characteristics of human-made features as follows: (1) distance from a given key observation point, (2) size, (3) color and shape, and (4) movement and noise.

Distance. The impact that individual human-made features have on perception is substantially influenced by the distance from the observer to the feature(s).

Viewshed assessments using distance zones or classes often define three classes: foreground, middle ground, and background. For this assessment, we have used the distance classes that have been recently used by the NPS:

- *Foreground* = 0-0.8 km (0-0.5 mi) from key observation point
- *Middle ground* = 0.8-5 km (0.5-3 mi) from key observation point
- *Background* = 5-97 km (3-60 mi) from key observation point.

Over time, different agencies have adopted minor variations in the specific distances used to define these zones, but the overall logic and intent has been consistent.

The foreground is the zone where visitors should be able to distinguish variation in texture and color, such as the relatively subtle variation among vegetation patches, or some level of distinguishing clusters of tree boughs. Large birds and mammals would likely be visible throughout this distance class, as would small or medium-sized animals at the closer end of this distance class (USFS 1995). Within the middle ground there is often sufficient texture or color to distinguish individual trees or other large plants (USFS 1995). It is also possible to still distinguish larger patches within major plant community types (such as riparian areas), provided there is sufficient difference in color shades at the farther distance. Within the closer portion of this distance class, it still may be possible to see large birds when contrasted against the sky, but other wildlife would be difficult to see without the aid of binoculars or telescopes. The background distance class is where texture tends to disappear and colors flatten. Depending on the actual distance, it is sometimes possible to distinguish between major vegetation types with highly contrasting colors (for example, forest and grassland), but any subtle differences within these broad land cover classes would not be apparent without the use of binoculars or telescopes, and even then, may be difficult.

Size

Size is another characteristic that may influence how conspicuous a given feature is on the landscape, and how it is perceived by humans. For example, Kearney et al. (2008) found human preferences were lower for man-made developments that tended to dominate the view, such as large, multi-storied buildings and were more favorable toward smaller, single family dwellings. In another study, Brush and Palmer (1979) found that farms tended to be viewed more favorably than views of towns or industrial sites, which ranked very low on visual preference. This was consistent with other studies that have reported rural family dwellings, such as farms or ranches, as quaint and contributing to rural character (Schauman 1979, Sheppard 2001, Ryan 2006), or as symbolizing good stewardship (Sheppard 2001).

We considered the features on the landscape surrounding Golden Spike NHS as belonging to one of six size classes (Table 4.1.2-1), which reflect the preference groups reported by studies. Using some categories of perhaps mixed measures, we considered size classes within the context of height, volume, and length.

Color and Shape

Studies have shown that how people perceive a human-made feature in a rural scene depends greatly on how well it seems to fit or blend in with the environment (Kearney et al. 2008, Ryan 2006). For example, Kearney et al. (2008) found preferences for homes that exhibit lower contrast with their surroundings as a result of color, screening vegetation, or other blending factors (Figure 4.1.2-2). It has been shown that colors lighter in tone or higher in saturation relative to their surroundings have a tendency to attract attention (contrast with their surroundings), whereas darker colors (relative to their surroundings) tend to fade into the background (Ratcliff 1972, O'Connor 2008). This was consistent with the findings of Kearney et al. (2008) who found that darker color was one of the factors contributing to a feature blending in with its environment and therefore preferred.

Table 4.1.2-1. Six size classes used for conspicuousness of human-made features.

Size	Low Volume	Substantial Volume
Low Height	Single family dwelling (home, ranch house)	Small towns, complexes
Substantial Height	Radio and cell phone towers	Wind farms, oil derecks
Substantial Length	Small roads, wooden power lines, fence lines	Utility corridors, highways, railroads

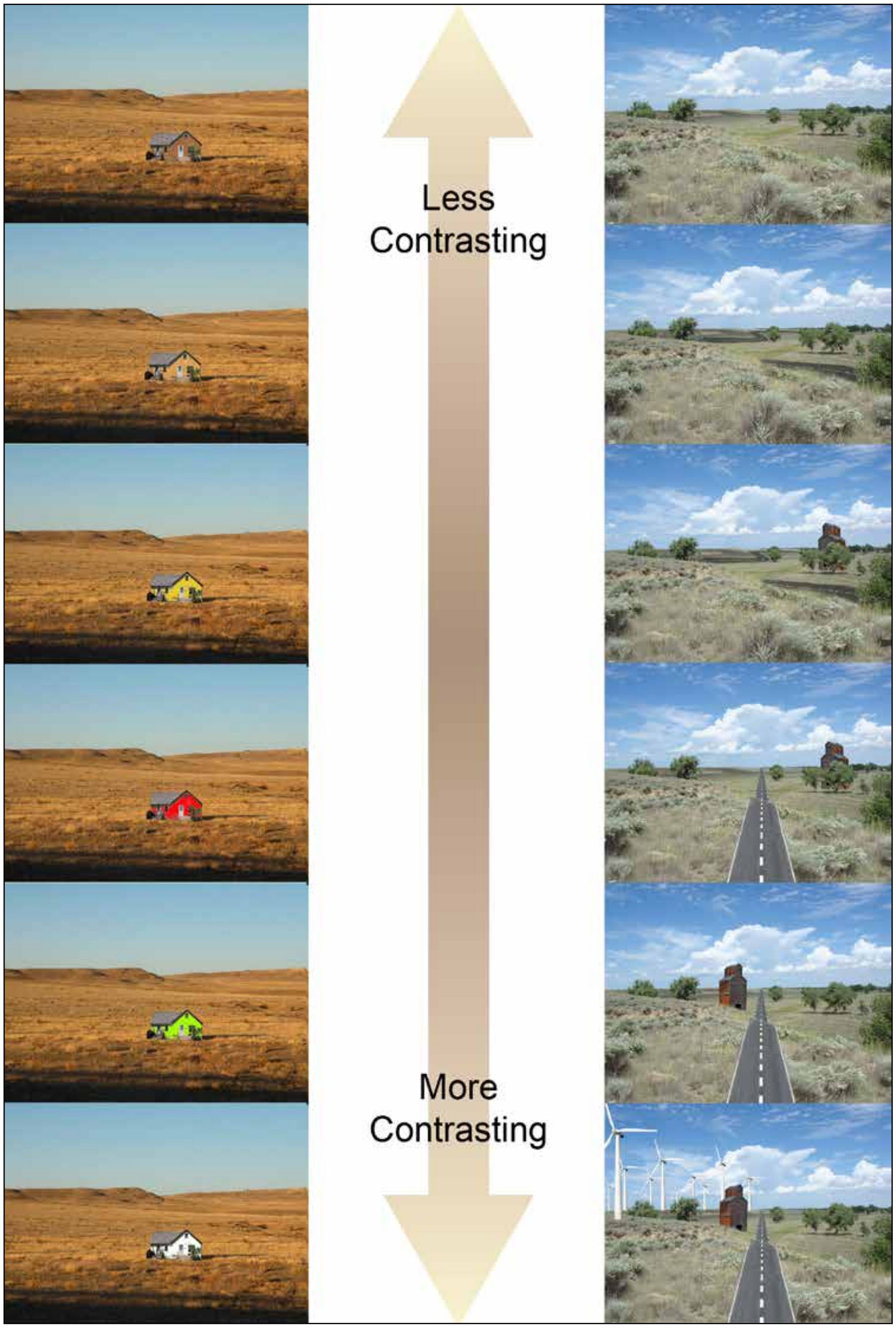


Figure 4.1.2-2. Graphic illustration of how color (left) and shape (right) can influence whether features were in harmony with the environment, or were in contrast.

Some research indicates that color can be used to offset other factors, such as size, that may evoke a more negative perception (O'Connor 2009). Similarly, shapes of features that contrast sharply with their surroundings may also influence how they are perceived (Ribe 2005). The Visual Resource Management Program of the Bureau of Land Management (BLM 2016), for example, places considerable focus on design techniques that minimize visual conflicts with features such as roads and power lines by aligning them with the natural contours of the landscape. Based on these characteristics of contrast, we considered the color of a feature in relative harmony with the landscape if it closely matched the surrounding environment, or if the color tended to be darker relative to the environment. We considered the shape of a feature in relative harmony with the landscape if it was not in marked contrast to the environment.

Movement and Noise

Motion and sound can both have an influence on how a landscape is perceived (Hetherington et al. 1993), particularly by attracting attention to a particular area of a viewshed. Movement and noise parameters can be perceived either positively or negatively, depending on the source and context. For example, the motion of running water generally has a very positive influence on perception of the environment (Carles et al. 1999), whereas noise from vehicles on a highway may be perceived negatively. In Carles et al.'s 1999 study, sounds were perceived negatively when they clashed with aspirations for a given site, such as tranquility. We considered the conspicuousness of the impact of movement and noise to be consistent with the amount present (that is, little movement or noise was inconspicuous, obvious movement or noise was conspicuous).

Hierarchical Relationship among Conspicuousness Measures

The above-described characteristics do not act independently with respect to their influence on the conspicuousness of features; rather, they tend to have a hierarchical effect (Figure 4.1.2-3). For example, the color and shape of a house would not be important to the integrity of the park's viewshed if the house was located too far away from the key observation point. Thus, distance becomes the primary characteristic that affects the potential conspicuousness. Therefore, we considered potential influences on conspicuousness in the context of a hierarchy based on the distance characteristics having the most impact on the integrity of the viewshed, followed by the size characteristic, then both the color and shape, and movement and noise characteristics.

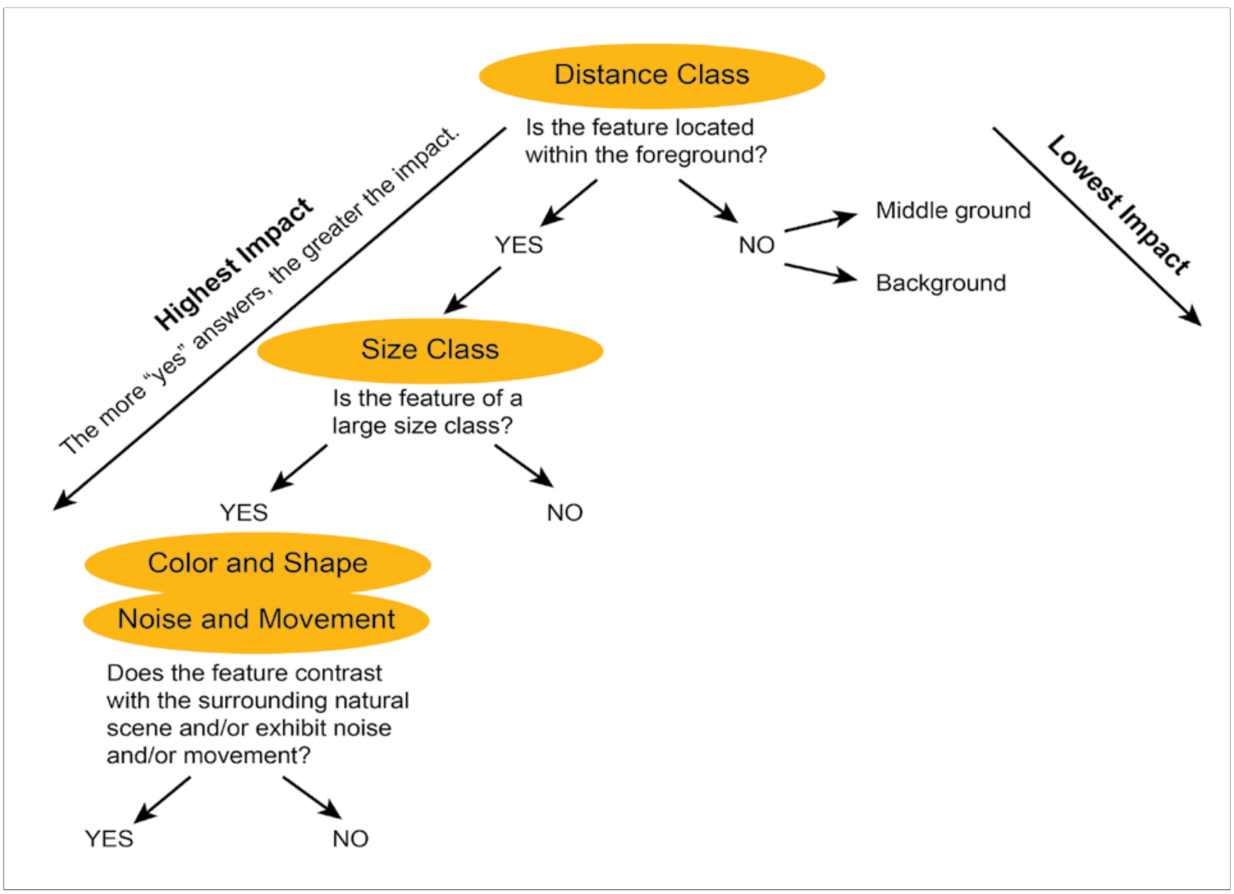


Figure 4.1.2-3. Conceptual framework for hierarchical relationship of characteristics that influence the conspicuousness of features within a viewshed.

Viewshed Analysis

Viewshed analyses were conducted to evaluate areas that were visible and non-visible from a given observation point using ArcGIS's Spatial Analyst Viewshed tool. We identified the viewshed area of analysis (AOA) as a 98 km (61 mi) area surrounding each of the three key observation points. The viewshed analyses were calculated for this area since it represents the distance to which the average observer may distinguish manmade features depending on the abovementioned characteristics (USFS 1995). We used the USGS's National Elevation Datasets (NED) at 1/3 arc-second resolution (approximately 10 m/32.8 ft resolution) to determine which areas should be visible from each observation point based on elevation within the AOA (USGS 2018a). The viewshed analysis for each location was used to support the GigaPan images described for the previous measure. The three AOAs were then combined to create a composite viewshed. Composite viewsheds are a way to show multiple viewsheds as one, providing an overview of the visible/non-visible areas across all observation points. The analysis assumes that the viewsheds were not hindered by non-topographic features such as vegetation; the observer was at ground level viewing from a height of 1.68 m (5.5 ft), which is the average height of a human; and visibility did not decay due to poor air quality. Additional details are listed in Appendix B. The composite viewshed was used to support the following two measures (i.e., extent of development and conservation status).

<u>Extent of Development</u>

The extent of development provides a measure of the degree to which the viewshed was altered from its natural (reference) state, particularly the extent to which intrusive or disruptive elements such as structures and roads may diminish the "naturalness" of the view (USFS 1995, Johnson et al. 2008).

NPScape Data

NPScape is a landscape dynamics monitoring program that produces and delivers GIS data, maps, and statistics that are integral to understanding natural resource conservation and conditions within a landscape context (NPS 2016a, Monahan et al. 2012). NPScape data include seven major categories (measures), three of which were used in the viewshed condition assessment: housing, roads, and conservation status. These metrics were used to evaluate resource conditions from a landscape-scale perspective and to provide information pertaining to threats and conservation opportunities related to scenic views surrounding Golden Spike NHS (NPS 2016b). NPScape data were consistent, standardized, and collected in a repeatable fashion over time, and yet were flexible enough to provide analyses at many spatial and temporal scales. The NPScape datasets used in this analysis were described in the sections that follow.

Road Density

The U.S. Census Bureau's TIGER/Line (Topologically Integrated Geographic Encoding and Referencing) shapefiles (U.S. Census Bureau 2017) were used to calculate the road density within the monument's AOA. TIGER/Line products were last updated 1 January 2017 (U.S. Census Bureau 2017). We downloaded the All Roads shapefile, which includes primary, secondary, local neighborhood roads, rural roads, city streets, and vehicular trails (4WD) (U.S. Census Bureau 2017). New road density rasters, feature classes, and statistics were generated from these data. Finally, the road density output was overlaid with the composite viewshed from the three key observation locations in order to visualize density within the historic site's viewshed.

Housing Density

The NPScape 2010 housing density metrics were derived from Theobald's (2005) Spatially Explicit Regional Growth Model, SERGoM 100 m (328 ft) resolution housing density rasters. SERGoM forecasts changes on a decadal basis using county specific population estimates and variable growth rates that are location-specific. The SERGoM housing densities were grouped into six classes as shown in Table 4.1.2-2. NPScape's housing density standard operating procedure (NPS 2014a) and toolset were used to clip the raster to the monument's AOA then to recalculate the housing densities. The 2010 output was overlaid with the composite viewshed from the three

Table 4.1.2-2. Housing density classes.

Grouped Housing Density Class	Housing Density Class (units / km^2)
Urban-Regional Park	Urban-Regional Park
Commercial / Industrial	Commercial / Industrial
Urban	1,235
Suburban	146-1,234
Exurban	7-145
Rural and Private Undeveloped	0-6

key observation locations in order to visualize housing density within the historic site's viewshed. Using the output from this analysis, we also calculated the percent change in housing density from 1970 to 2010 using ArcGIS Spatial Analyst's Raster Calculator tool.

Conservation Status
According to Monahan et al. (2012), "the percentage of land area protected provides an indication of conservation status and offers insight into potential threats (e.g., how much land is available for conversion and where it is located in relation to the NPS boundary), as well as opportunities (e.g., connectivity and networking of protected areas)." The USGS's GAP Analysis Program's Protected Area Database (PAD) provides GIS data on public land ownership and conservation lands in the U.S. (USGS GAP 2016). The lands included in the PAD were assigned one of four GAP Status codes based on the degree of protection and management mandates. Golden Spike NHS is considered GAP Status 1, which is described as follows, along with the remaining three categories:

GAP Status 1: Lands that have permanent protection from conversion of natural land cover and are managed for biodiversity and disturbance events.

GAP Status 2: Lands that have permanent protection from conversion of natural land cover and are managed for biodiversity but disturbance events are suppressed.

GAP Status 3: Lands that have permanent protection from conversion of natural land cover and are managed for multiple uses, ranging from low intensity (e.g., logging) to high intensity (e.g., mining).

GAP Status 4: No known mandate for protection and include legally mandated easements (USGS 2012).

NPScape's conservation status toolset was used to clip the PAD-US version 1.4 (USGS GAP 2016) to the historic site's AOA, and then to recalculate the GAP Status and broad land ownership categories (e.g., federal, state, tribal, etc.) within the AOA (NPS 2014c). Finally, the conservation status output was overlaid with the composite viewshed from the three key observation locations in order to determine which GAP Status lands and lands by agency were most likely to be visible from the historic site.

4.1.3. Reference Conditions
We used qualitative reference conditions to assess the scenic and historic integrity of Golden Spike NHS's viewshed, which are presented in Table 4.1.3-1. Measures were described for resources in good condition, moderate concern condition, or significant concern condition.

4.1.4. Condition and Trend
Conspicuousness of Non-contributing Features
Viewshed Analysis
The GIS viewshed analysis for each of the three key observation points is shown in Figure 4.1.4-1. The viewshed from the West Auto Tour route was the largest based on the DEM used. Within the middle ground, the landscape to the northeast to the south is visible to the average observer. In a narrow band to the southwest, the viewshed extended at least 98 km (61 mi). The foreground is not shown due to the scale of the map for this location. The viewshed for the Big Fill location was limited and only extended

Table 4.1.3-1. Reference conditions used to assess viewshed.

Indicators	Measures	Good	Moderate Concern	Significant Concern
Scenic and Historic Integrity	Conspicuousness of Non-contributing Features	The distance, size, color and shape, and movement and noise of the non-contributing features blended into the landscape.	The distance, size, color and shape, and movement and noise of some of the non-contributing features were conspicuous and detracted from the natural and historic aspects of the landscape.	The distance, size, color and shape, and movement and noise of the non-contributing features dominated the landscape and significantly detracted from the natural and historic aspects of the landscape.
	Extent of Development	Road and housing densities were low, with minor to no intrusion on the viewshed.	Road and housing densities were moderate, with some intrusion on the viewshed.	Road and housing densities were high with significant intrusion on the viewshed.
	Conservation Status	Scenic conservation status was high. The majority of land area in the historic site's viewshed was considered GAP Status 1 or 2.	Scenic conservation status was moderate. The majority of land area in the historic site's viewshed was considered GAP Status 3.	Scenic conservation status was low. The majority of land area in the historic site's viewshed was considered GAP Status 4.

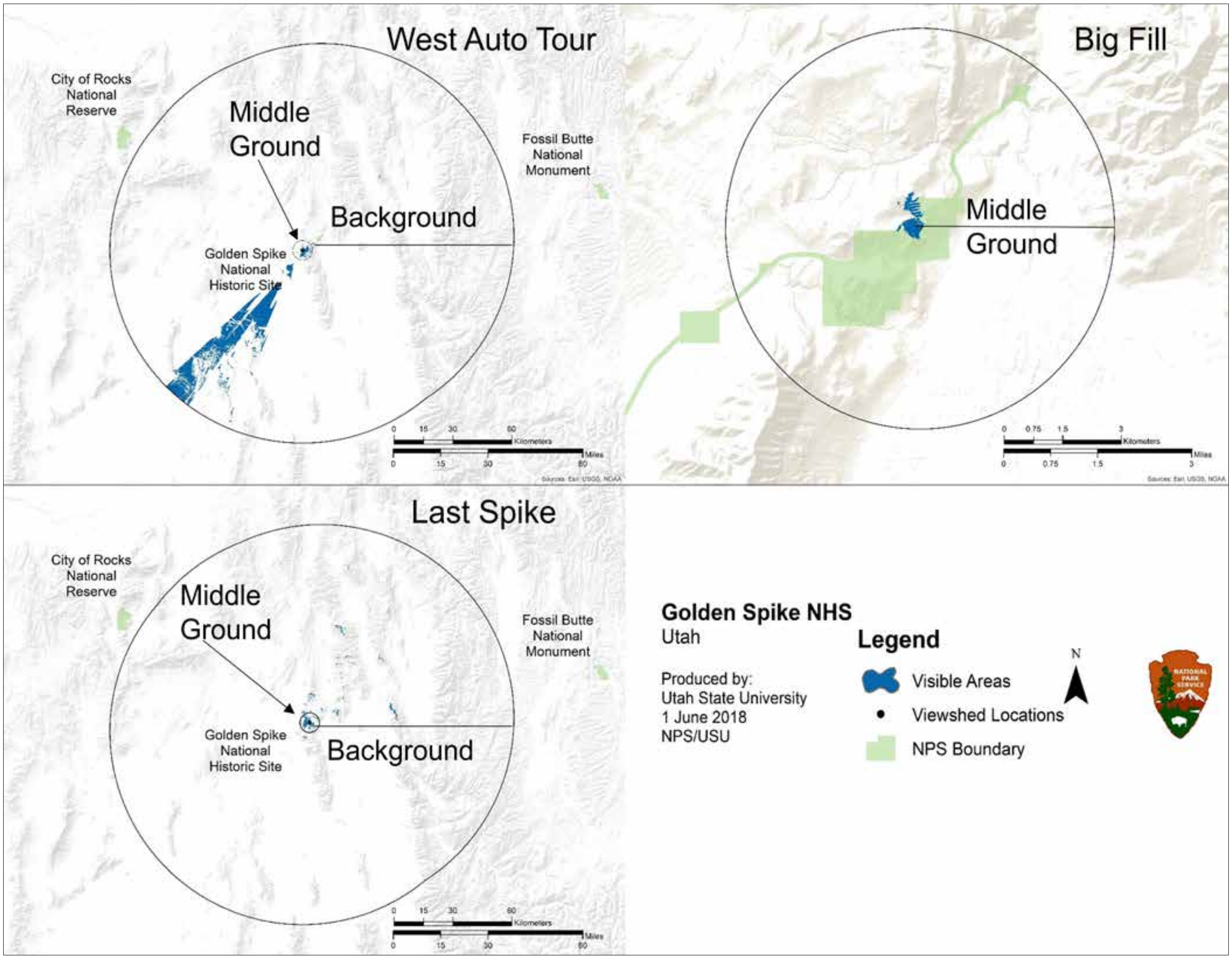


Figure 4.1.4-1. The viewshed analysis from each of the three key observation locations.

to the foreground and a small portion of the middle ground, primarily to the north. From this location, the background is not visible. The viewshed at the Last Spike location was patchy in both the middle ground and background with much of the middle ground visible to the west and some of the background visible to the northeast. As with the West Auto Tour location, the foreground is not shown due to the scale of the map.

Below, we qualitatively assessed whether the GIS analyses for each of the three key observation locations shown in Figure 4.1.4-1 agree with the panoramic images. We also describe non-contributing features in each set of panoramas.

West Auto Tour Viewshed

The stitched GigaPan images for the West Auto Tour location are shown in Figures 4.1.4-2 and -3. In three of the panoramas, the gravel road is a distinct foreground feature. The road is located atop the Central Pacific Railroad grade, and although the tracks have been removed, the grade is considered a historical contributing feature of the landscape (Homstad et al. 2003). A gravel surface was added to protect the road from erosion (Homstad et al. 2003). Although the gravel itself is a non-contributing feature, it minimizes the amount of airborne dust that would otherwise impair views from this location. The pullout visible in the south to west viewshed (Figure 4.1.4-3 top image) marks the historic event of 16 km (10 mi) of track laid in one day (Homstad et al. 2003).

All panoramas from this location show an undeveloped landscape with sagebrush (*Artemisia* spp.) shrublands in the foreground and hilly topography in the middle ground and background. The most distant views occur to the southwest, which is consistent with the GIS

Figure 4.1.4-2. The north to east (top) and east to south (bottom) viewshed from the West Auto Tour.

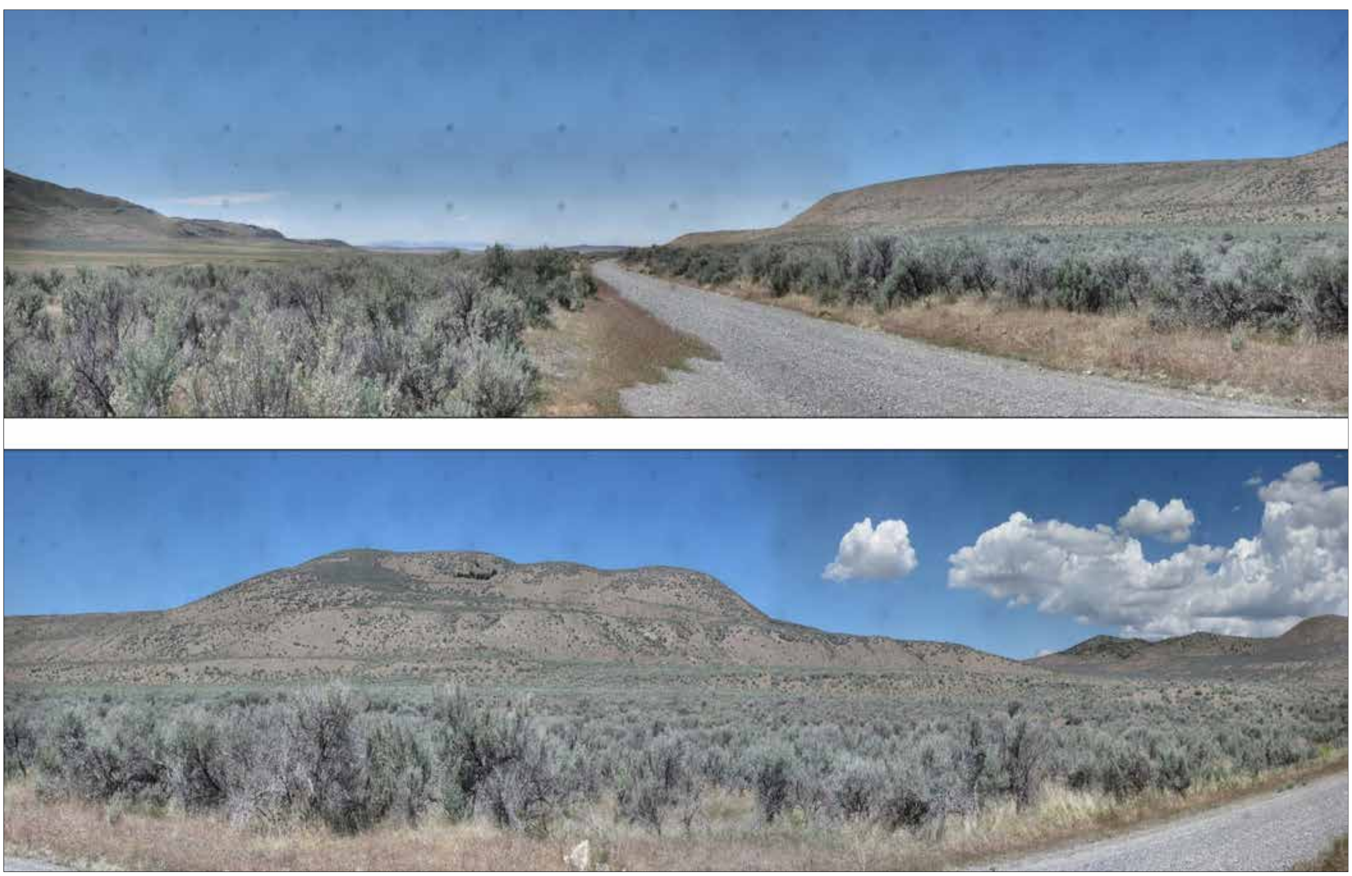


Figure 4.1.4-3. The south to west (top) and west to north (bottom) viewshed from the West Auto Tour.

Undated historic photo of the 10 miles of track laid in one day along the West Auto Tour route. Photo Credit: NPS.

analysis. There were no distinctive non-contributing features in these photos. For the most part, vegetation is a contributing feature; however, non-native cheatgrass (*Bromus tectorum*) is visible along the roadside and may detract from the historic viewshed depending on a visitor's knowledge and regard for native vegetation.

Last Spike Viewshed

The Last Spike viewshed in Figures 4.1.4-4 and -5 contain several features that contribute to the historic landscape, such as the railroad tracks and the box elder (*Acer negundo*) tree, which was planted to provide shade during the settlement period (Homstad et al. 2003). The visitor center, visible in the top image in Figure 4.1.5-5, is part of the Mission 66 era and is not considered part of the historic landscape. However, the structure does provide a point of contact for visitors, interpretive information, and houses significant historic artifacts (Homstad et al. 2003).

Non-contributing features include telegraph poles, a metal amphitheater for interpretive events, fencing, and a gravel access road in the foreground and a ranger house in the middle ground. An earthen berm was constructed to shield the maintenance building and engine house from the Last Spike site, which would otherwise be visible to the east (Homstad et al. 2003). Although the earthen berm is a non-contributing feature, its presence helps to improve the historic

Figure 4.1.4-4. The north to east (top) and east to south (bottom) viewshed from the Last Spike.

Figure 4.1.4-5. The south to west (top) and west to north (bottom) viewshed from the Last Spike.

viewshed by blocking non-historic buildings with natural landscape features. To the north and in the background, a historic grain silo is visible. As with the previous location, vegetation has changed with the invasion of non-native species, particularly cheatgrass. From this location, the most distant viewshed occurs to the northeast. In the other directions, the more distant viewsheds are blocked by nearby topography. These results are consistent with the GIS viewshed analysis.

Undated historic photo along the reconstructed tracks near the Last Spike Site looking east. Photo Credit: NPS.

Big Fill Viewshed

The viewshed from the Big Fill site occurs in the foreground and middle ground except to the east where Blue Creek meanders against a backdrop of the Promontory Mountain range (Figures 4.1.4-6 and -7). In the bottom of the lower image in Figure 4.1.4-7, the lighter soils represent the borrow pit from which materials were extracted for use in railroad construction (Homstad et al. 2003). In addition to these natural and historic landscape features, roads and the industrial facilities of the Orbital ATK's rocket fuel plant and AutoLiv's pyrotechnics processing facility are visible, but because these non-contributing features are in the background, they detract less from the viewshed than they would if they were in the middle or foreground. The GIS viewshed analysis is generally consistent with the panoramic images, which show limited viewsheds to the north, although in the photos, the views to the east appear more distant than the viewshed analysis indicates.

Figure 4.1.4-6. The north to east (top) and east to south (bottom) viewshed from the Big Fill.

Figure 4.1.4-7. The south to west (top) and west to north (bottom) viewshed from the Big Fill.

Undated historic photo north of the Central Pacific Railroad's "Big Fill" site. Photo Credit: NPS.

Summary
Overall, the viewsheds at the three locations in Golden Spike NHS are intact. There are few non-contributing features and the visible non-contributing features detract little from the overall viewshed because of either distance, color, or context (e.g., visitor center). Although non-native plants, such as cheatgrass are visible, the overall cover is dominated by native sagebrush shrubs, which is representative of the historic landscape (Coles et al. 2011). Therefore, the condition is good. Confidence in the condition rating is high. Although some comparisons can be made to older photographs, the panoramas were not collected at the same locations. Therefore, trend could not be determined. Rather, these images provide baseline data that can be used to compare to future panoramas.

Extent of Development
Road Density
Figure 4.1.4-8 shows road density by various classes. Total road density within the 98 km (61 mi) AOA surrounding the historic site was 1.07 km/km^2. Road

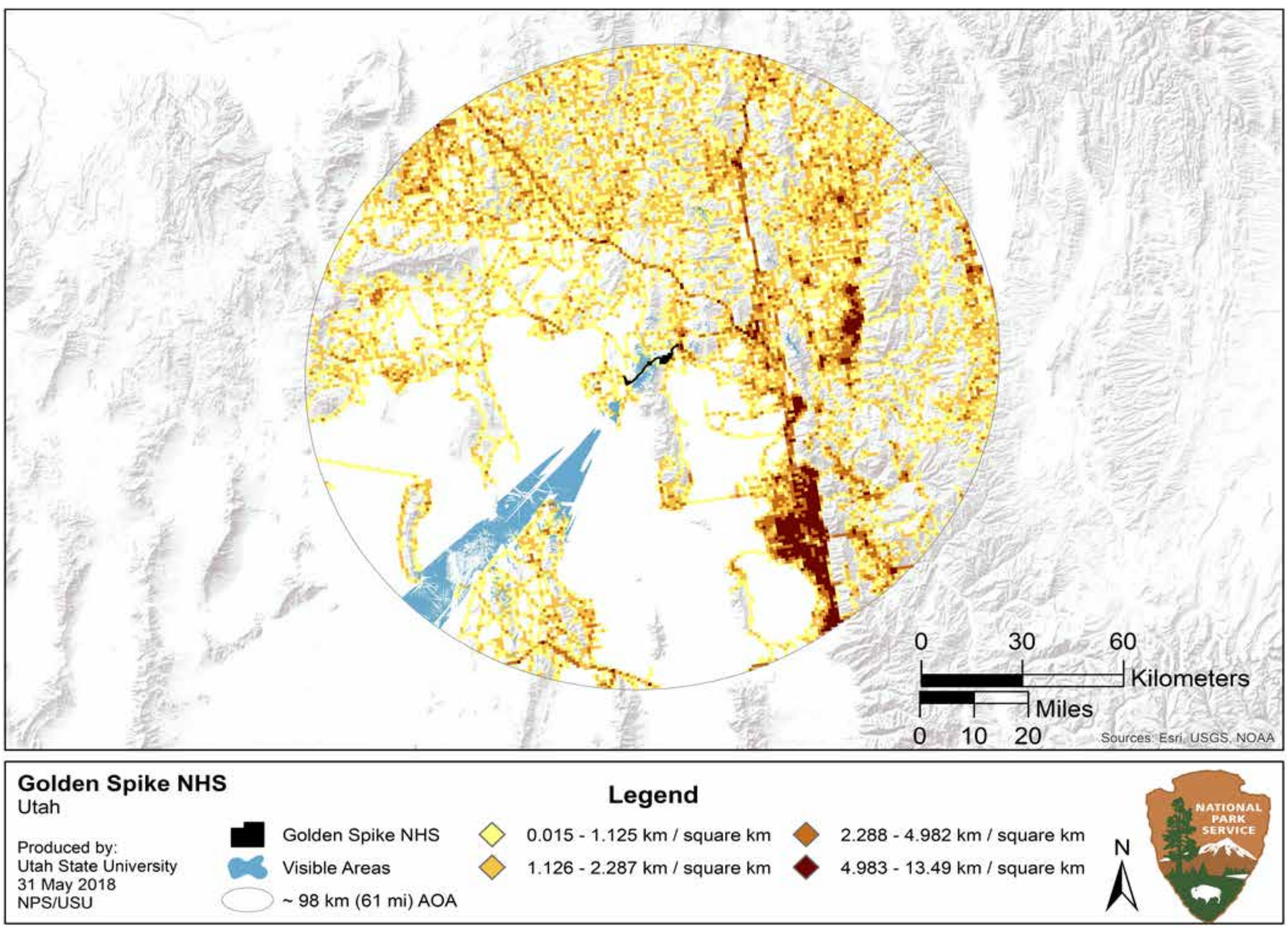


Figure 4.1.4-8. Road density and visible areas in and around Golden Spike NHS.

density within the historic site's viewshed was less dense than it was elsewhere in the AOA, with few to no roads across much of the viewshed. The low road density in the AOA suggests that roads probably do not detract significantly from viewshed quality elsewhere in the historic site. This is supported by the panoramic images, which contained few roads, some of which are considered historic.

Housing Density

Based on data compiled in NPScape (Monahan et al. 2012), housing densities surrounding the historic site were low (Table 4.1.4-1). The majority of all housing consisted of rural and private undeveloped lands (89%). The white spaces within the 98 km (61 mi) boundary shown in Figure 4.1.4-9 indicate no census data; thus, housing densities could not be calculated for these areas. However, these data originated with the U.S. Census Bureau, and units with unknown densities were probably not reported, which likely indicates undeveloped areas. Most of the historic site's viewshed was located within these white spaces. From 1970 to 2010, 73% of the AOA showed no change in housing density, while 27% of the AOA showed an increase in housing density. Less than 1% of the AOA declined in housing density.

Table 4.1.4-1. Housing densities within a 98 km (61 mi) buffer around Golden Spike NHS.

Density Class	Area (km^2)	Percent
Rural and Private Undeveloped	13,206	89
Exurban	1,018	7
Suburban	221	1.5
Urban	7	<1
Urban-Regional Park	131	1
Commercial/Industrial	185	1.3
Total Area	14,768	100

Summary

Road density was low and housing density was almost entirely rural or private undeveloped. Since housing density around Golden Spike NHS was low, consisting of mostly private undeveloped land and low density

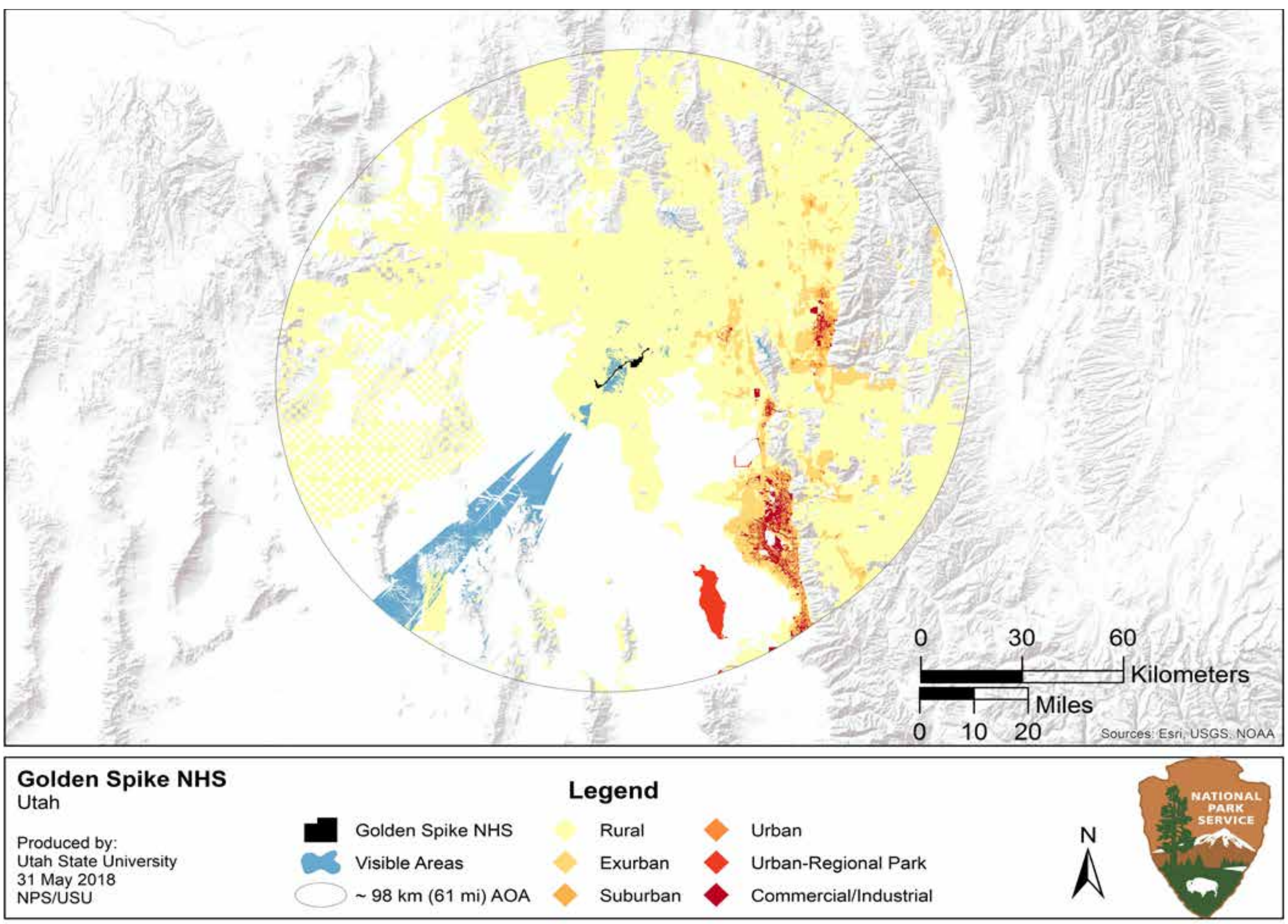


Figure 4.1.4-9. A map of housing density within and around Golden Spike NHS.

housing, the condition is good. However, confidence is medium because most of the site's viewshed is located in areas without U.S. Census data. Trend in housing density, which is related to road density, was mostly unchanging, but some areas have increased in housing density.

Conservation Status

Figure 4.1.4-10 shows the amount of land within the composite viewshed and AOA. Of the total AOA, 65% was categorized in one of the four GAP status classes. Nearly half (41.2%) of land area within the AOA was within GAP Status 3, or permanently protected lands managed for multiple uses (e.g., mining or logging). Only 3.4% of land within the AOA was GAP Status 1 (permanently protected lands managed for biodiversity and natural processes) or GAP Status 2 (permanently protected lands managed for biodiversity but with suppression of disturbances). Finally, 20% of land was considered GAP status 4 (no known protections). The remaining 35.4% of land was not classified in any of the GAP status categories, which indicates private land. Golden Spike NHS's viewshed is primarily within GAP Status 3 and 4 lands.

Figure 4.1.4-11 shows the management agencies that administer land within the AOA. The U.S. Forest Service administers the largest land area within the AOA (21%), followed by the State of Utah (20%), and the Bureau of Land Management (19%). Most of the remaining lands (~40%) within the AOA are private (i.e., white spaces). Areas visible from the historic site were located largely within State or Department of Defense lands.

While there were some areas where scenic conservation status was high, many of the land management agencies responsible for the lands that were visible from the three observation locations were within GAP Status 3-4. Therefore, we consider conservation status to be of moderate concern. Trend is unknown. Although confidence in the GAP Status and land management agency data is high, the viewshed analysis has medium confidence. A finer scale DEM coupled with an offset to

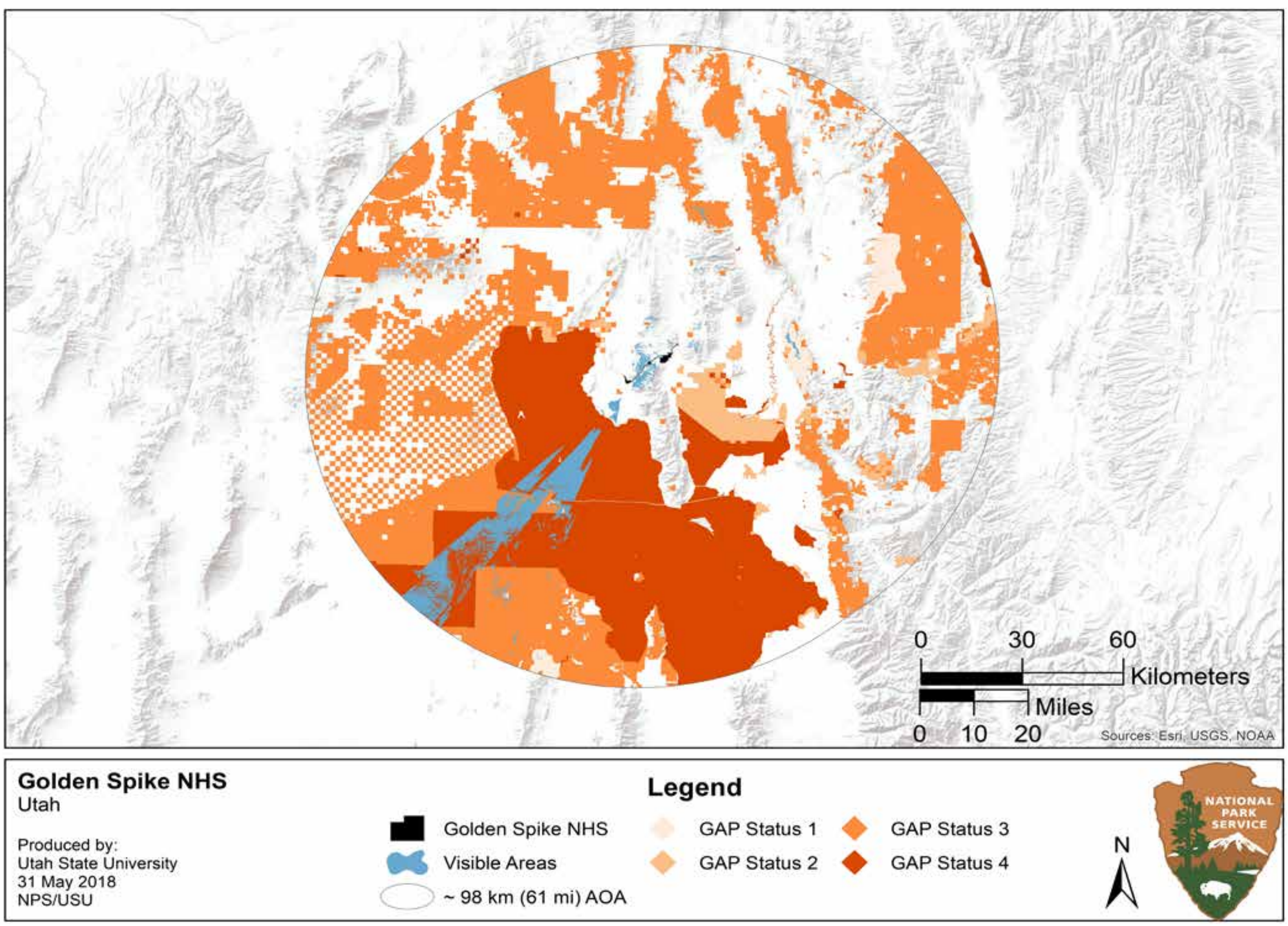


Figure 4.1.4-10. A map of GAP status lands within and around Golden Spike NHS.

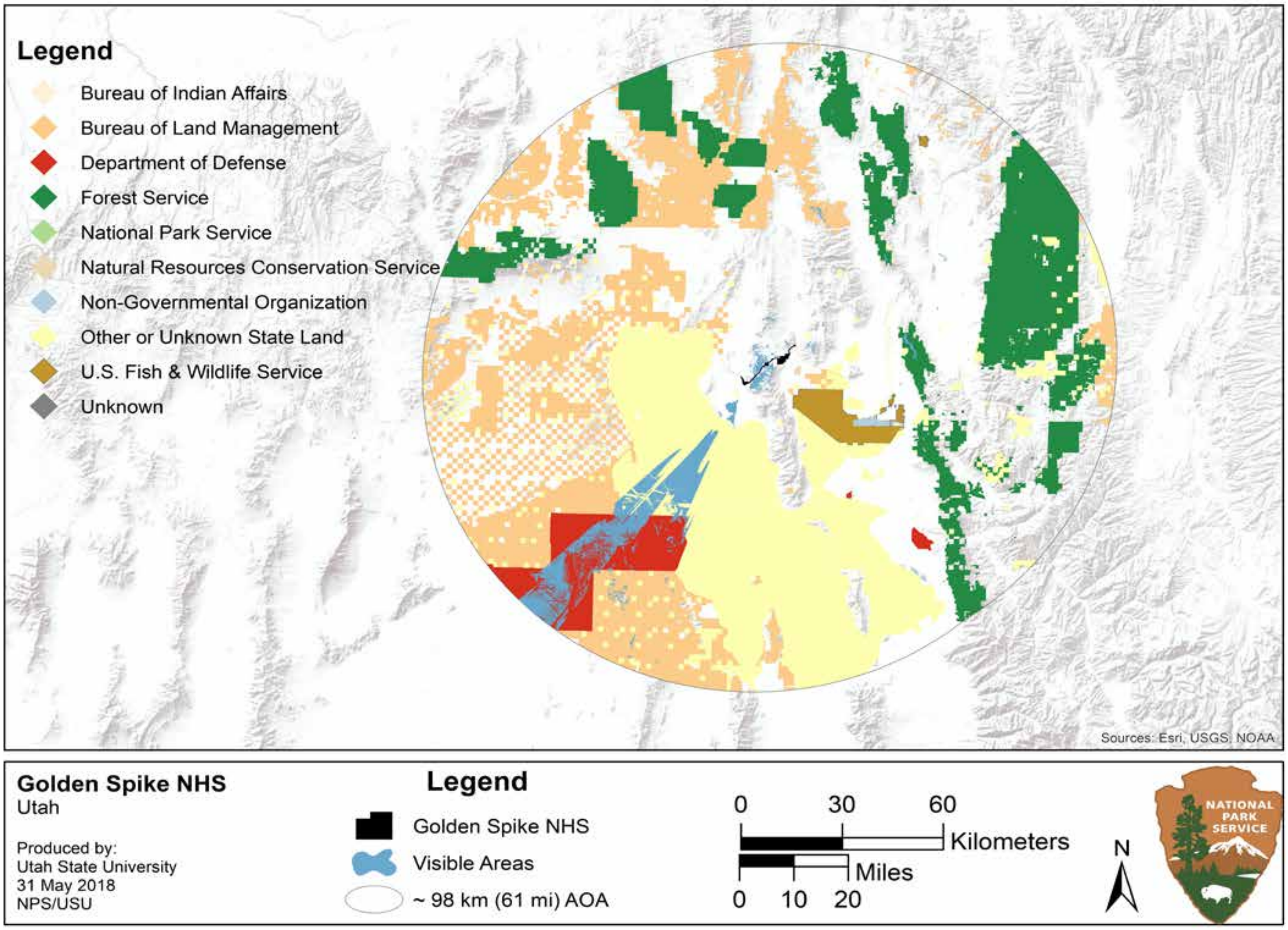


Figure 4.1.4-11. A map of lands managed by various agencies within and around Golden Spike NHS.

account for vegetation height would possibly increase accuracy. Although vegetation in and around Golden Spike NHS does not generally limit the viewshed since the dominant cover type is sagebrush grasslands. Nevertheless, the confidence in the condition rating for this measure is medium.

Overall Condition, Trend, Confidence Level, and Key Uncertainties

Based on this assessment, the viewshed condition at Golden Spike NHS is good (Table 4.1.4-2). There were few non-contributing features in the historic site's viewshed as observed from the three key observation locations, and those that were present blended relatively well with the natural landscape or were generally too distant to be conspicuous except for a few features at the Last Spike. Because this assessment represents baseline conditions, we could not report on trend. Two of the three measures were assigned medium confidence and one was assigned high confidence. Factors that influence confidence level include age of the data (<5 years unless the data were part of a long-term monitoring effort), repeatability, field data versus modeled data, and whether data can be extrapolated to other areas in the historic site. We assigned medium confidence to extent of development and conservation status measures because the viewshed analysis was based entirely on modeled data with a relatively coarse scale DEM and did not account for vegetation or other factors that may have influenced the viewshed analysis. Thus, the overall confidence is medium. The viewshed analysis should not be used for planning purposes until ground-truthed.

Threats, Issues, and Data Gaps

Potential threats to Golden Spike NHS's viewshed include development within the AOA; increased air and vehicle traffic; increased visitation; and atmospheric dust and smog as a result of climate change (NPS 2017a). The haze index, which is a measure of visibility as described in the air quality assessment, warrants

Table 4.1.4-2. Summary of the viewshed indicators, measures, and condition rationale.

Indicators	Measures	Condition/ Trend/ Confidence	Rationale for Condition
Scenic and Historic Integrity	Conspicuousness of Non-contributing Features		There were few non-contributing features in the historic site's viewshed as observed from the three key observation locations, and those that were present blended relatively well with the natural landscape or were too distant to be conspicuous. Non-contributing features included fencing, roads, an amphitheater, the visitor center, and development outside NPS boundaries. Trend is unknown and confidence is high.
	Extent of Development		The composite viewshed shows that areas to southwest were most visible. Due to rolling topography, the viewshed was limited to mostly the foreground and middle ground from the three observation locations. The majority of all housing consisted of rural and private undeveloped lands (89%). Total road density (1.07 km/km^2) indicates a rural landscape. Since 1970, 73% of the AOA increased in housing density while 27% remained unchanged. Based on these results, the condition for this measure is good. Trend is unchanging and confidence is medium.
	Conservation Status		While there were some areas where scenic conservation status was high, many of the land management agencies responsible for the lands that were visible from Golden Spike NHS's key observation points allow for extractive uses or were private lands, therefore, we consider conservation status to be of moderate concern. Because of uncertainties with the viewshed analysis, confidence is medium. Trend is unknown.
Overall Condition	Summary of All Measures		There were few non-contributing features in the historic site's viewshed. The housing and road density analyses show that the region surrounding the site was mostly rural, but most of the landscape in the AOA was GAP Status 3 or 4 and open to future extractive uses that could alter the viewshed. However, the current condition of the viewshed in Golden Spike NHS is good with an unknown trend. Confidence is medium.

moderate concern at Golden Spike NHS. Factors that influence air quality may also influence the viewshed. Other threats include the deterioration of cultural features as a result of natural processes; unauthorized use by hunters, vandals, cattle, and vehicles; erosion; fire; light pollution from nearby communities; and potential solar development within the viewshed (NPS 2017a).

The current U.S. Census Bureau data show that Utah is the fastest growing state in the nation (U.S. Census Bureau 2016a). However, the absence of reliable sources of water in the AOA may limit development (NPS 2017a). Data gaps include the need for a visual resource inventory, remote sensing of the grounds (LIDAR), a complete set of aerial photographs, and fine scale land use documentation surrounding the historic site (NPS 2017a).

4.1.5. Sources of Expertise

Assessment author was Lisa Baril, wildlife biologist and science writer, Utah State University. Subject matter expert reviewers for this assessment are listed in Appendix A. Note that the measures and methods used for assessing the condition of the national historic site's viewshed are different from the measures/methods recommended by the NPS Visual Resources Program in the Air Resources Division under 2018 draft guidance that post-dates this viewshed assessment. Please contact the NPS Visual Resource Program for more information: visual_resources@nps.gov.

4.2. Night Sky

4.2.1. Background and Importance

Natural dark skies are a valued resource within the National Park Service (NPS) (NPS 2006), which highlight the importance of a natural photic environment to ecosystem function, and the importance of the natural lightscape for aesthetics. The NPS Natural Sounds and Night Skies Division (NSNSD) makes a distinction between a lightscape—which is the human perception of the nighttime scene, including both the night sky and the faintly illuminated terrain, and the photic environment—which is the totality of the pattern of light at night at all wavelengths (Moore et al. 2013).

Lightscapes are an aesthetic and experiential quality that is integral to natural and cultural resources. A 2007 visitor survey conducted throughout Utah national parks found that 86% of visitors thought the quality of park night skies was "somewhat important" or "very important" to their visit (NPS 2010b). Additionally, in an estimated 20 national parks, stargazing events are the most popular ranger-led program (NPS 2010b). However, the value of a dark night sky goes far beyond visitor experience and scenery. The photic environment affects a broad range of species, is integral to ecosystems, and is a natural physical process (Longcore and Rich 2004).

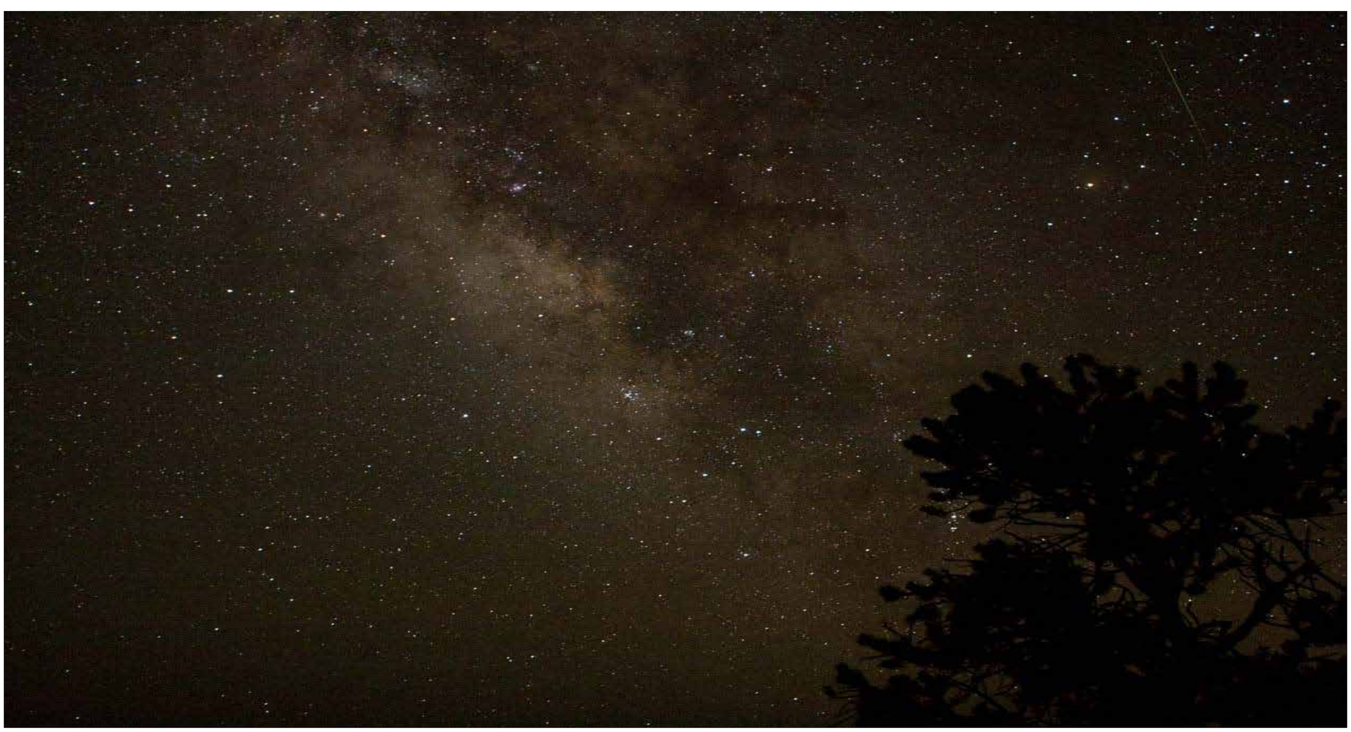
Natural light intensity varies during the day-night (diurnal) cycle, the lunar cycle, and the seasonal cycle. Organisms have evolved to respond to these periodic changes in light levels in ways that control or influence movement, feeding, mating, emergence, seasonal breeding, migration, hibernation, and dormancy. Plants also respond to light levels by flowering, vegetative growth, and their direction of growth (Royal Commission on Environmental Pollution 2009). Given the effects of light on living organisms, it is likely that the introduction of artificial light into the natural light/darkness regime will disturb the normal routines of many plants and animals (Royal Commission on Environmental Pollution 2009), as well as diminish stargazing recreational opportunities offered to national park visitors.

4.2.2. Data and Methods

In this assessment, we assess the night sky environment in Golden Spike National Historic Site (NHS) using a single measure of sky brightness, the all-sky light pollution ratio. The all-sky light pollution ratio (ALR) is the "single parameter most useful for assessing the quality of a park's nighttime environment," according to the NSNSD (Moore et al. 2013).

<u>All-sky Light Pollution Ratio</u>

The all-sky light pollution ratio (ALR) is the average anthropogenic sky luminance presented as a ratio over



The Milky Way as observed in a national park. Photo Credit: NPS Natural Sounds and Night Skies Division.

natural conditions. This metric is a convenient and robust measure that averages the light flux over the entire sky (measuring all that is above the horizon and omitting the terrain). Recent advances in modeling the natural components of the night sky allow separation of anthropogenic light from natural features, such as the Milky Way. It is most accurately obtained from ground-based measurements with the NPS Night Skies Program's photometric system, however, it can also be modeled with moderate confidence when such measurements are not available, as is the case for Golden Spike NHS.

Modeled ALR data were based on 2015 National Oceanic and Atmospheric Administration (NOAA) and National Aeronautics and Space Administration (NASA) Day/Night Band data collected by the Visible Infrared Imaging Radiometer Suite instrument located on the Suomi National Polar Orbiting Partnership satellite (NASA 2017). While modeled data provide useful overall measurements, especially when site visits cannot be made, they are less accurate than ground-based measurements.

A natural night sky has an average brightness across the entire sky of 78 nL (nanolamberts, a measure of luminance), and includes features such as the Milky Way, Zodiacal light, airglow, and other starlight. This is figured into the ratio, so that an ALR reading of 0.0 would indicate pristine natural conditions where the anthropogenic component was 0 nL. A ratio of 1.0 would indicate that anthropogenic light was 100% as bright as the natural light from the night sky.

4.2.3. Reference Conditions

Table 4.2.3-1 summarizes the condition thresholds for good, moderate concern, and significant concern conditions for the measure of sky brightness. The ideal night sky reference condition, regardless of how it's measured, is one devoid of any light pollution. However, results from night sky data collection throughout more than 90 national parks suggest that a pristine night sky is very rare (NPS 2010b). Golden Spike NHS is considered a non-urban NPS unit, or NPS unit with at least 90% of its property located outside an urban area (Moore et al. 2013). Light pollution is expected to be lower in non-urban than in urban units. As a result, thresholds that separate reference conditions for non-urban units are more stringent than reference conditions for urban units. The threshold for night skies in good condition is an ALR < 0.33 and the threshold for warranting moderate concern is ALR 0.33-2.00. An ALR >2.00 would warrant significant concern (Moore et al. 2013).

Table 4.2.3-1. Reference conditions used to assess the night sky at Golden Spike NHS.

Indicator	Measure	Good	Moderate Concern	Significant Concern
Sky Brightness*	All-sky Light Pollution Ratio (ALR)	ALR < 0.33 (< 26 nL average anthropogenic light in sky)	ALR 0.33-2.00 (26-156 nL average anthropogenic light in sky)	ALR > 2.00 (>156 nL average anthropogenic light in sky)

*National Park Service Natural Sounds and Night Skies Division thresholds for non-urban parks. Non-urban parks are those with at least 90% of their land located outside an urban area (Moore et al. 2013).

4.2.4. Condition and Trend

<u>All-sky Light Pollution Ratio</u>

Modeling data from August 2015 shows a mean region-wide ALR of 0.96, and a park-wide ALR of 1.02, which is 96% and 102% brighter than average natural conditions (NSNSD 2015), falling within the moderate concern condition rating. At this level, the Milky Way is visible overhead, but fine details are lost, and dim celestial objects may not be visible (Moore et al. 2013).

The western end of the historic site is darker than the eastern portion as the light from nearby population centers becomes more visible. Figure 4.2.4-1 shows the modeled ALR for the region surrounding Golden Spike NHS and the extent of the light domes cast by cities located in the region. The figure shows that the historic site is most influenced by lights from Penrose, Utah located 21 km (13 mi) west and by the lights between Penrose and the historic site. Lights from Logan and Ogden, Utah, which are located 61 km (38 mi) and 67 km (41 mi) from the historic site, respectively, are also visible. Figure 4.2.4-2 shows the modeled ALR zoomed in to the historic site.

<u>Overall Condition, Trend, Confidence Level, and Key Uncertainties</u>

A single measure, all-sky light pollution ratio, was used to assess the night sky at Golden Spike NHS (Table 4.2.4-1). The ALR values warrant moderate concern. The all-sky light pollution ratio is considered the best single parameter for measuring lightscapes; however, these data were modeled and may not reflect actual

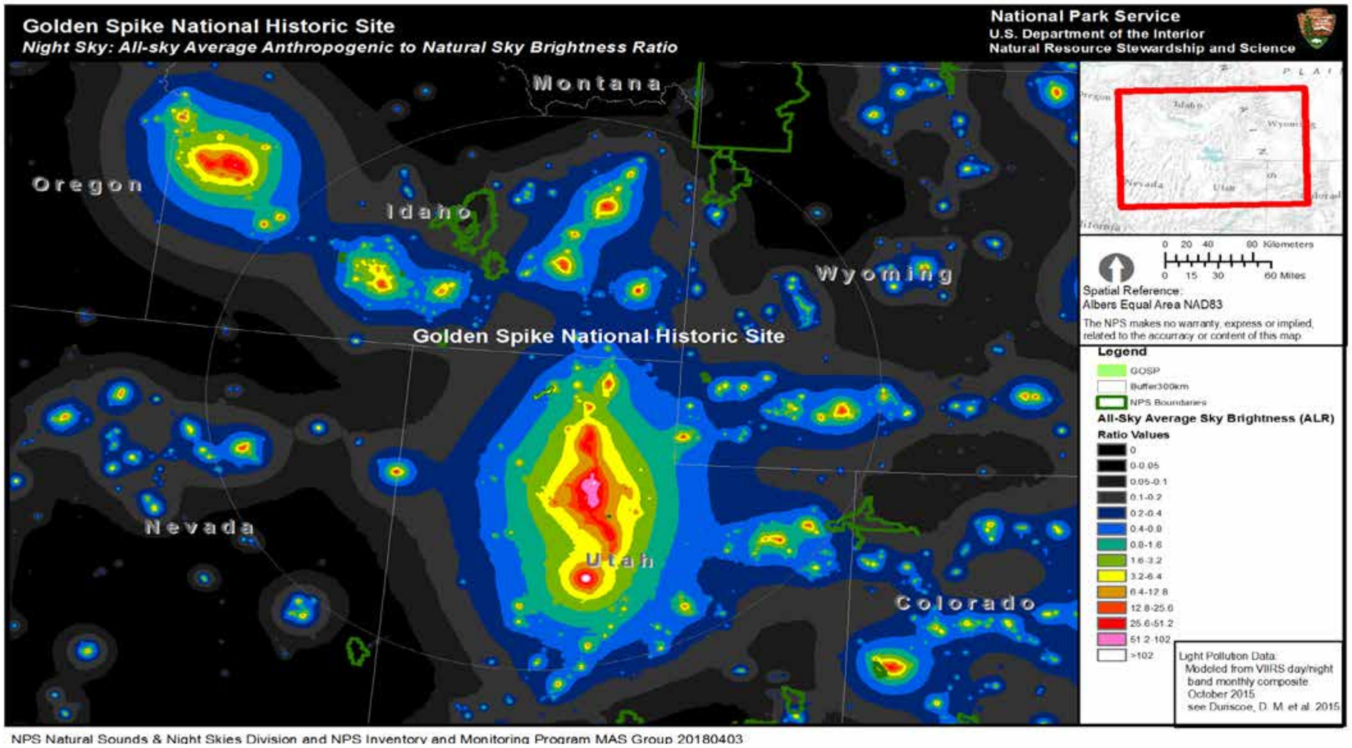


Figure 4.2.4-1. Modeled ALR map for region surrounding Golden Spike NHS. Figure Credit: NPS Natural Sounds and Night Skies Division.

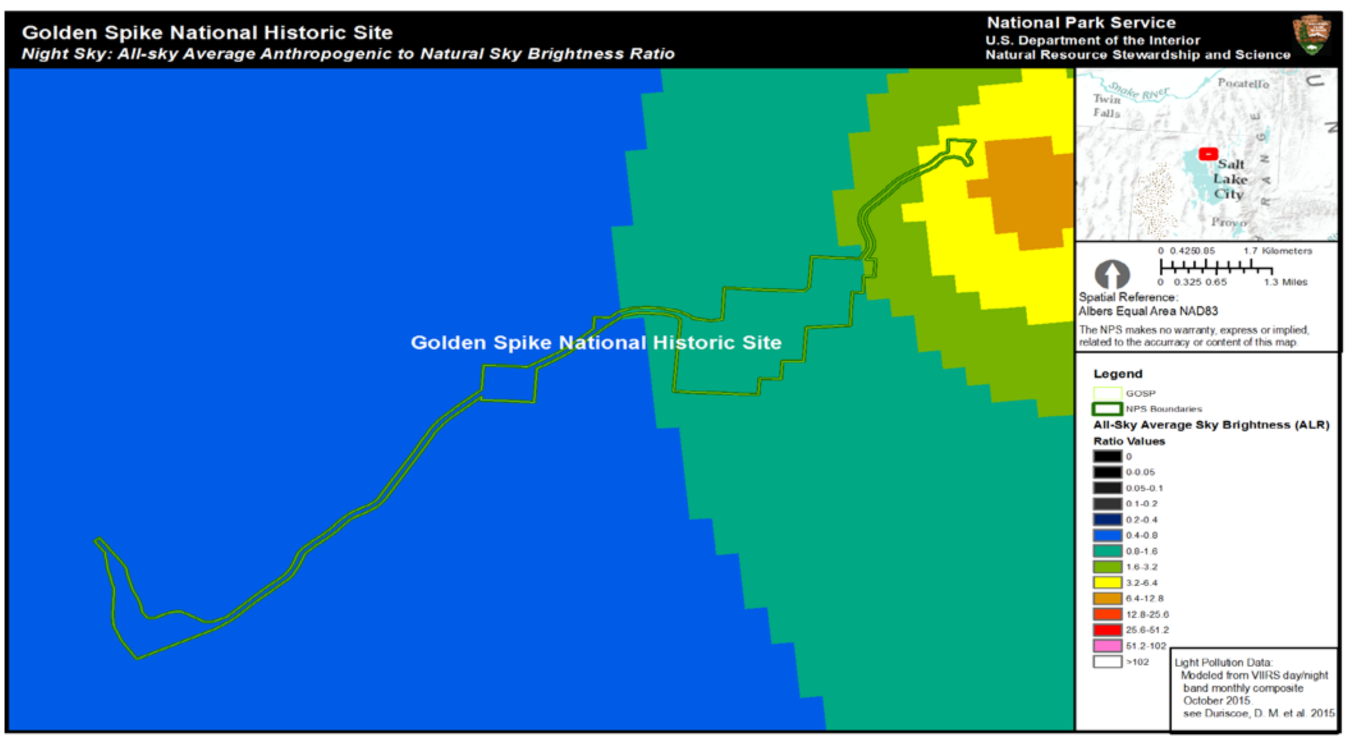


Figure 4.2.4-2. Modeled ALR map for Golden Spike NHS. Figure Credit: NPS Natural Sounds and Night Skies Division.

Table 4.2.4-1. Summary of night sky indicators, measures, and condition rationale.

Indicators of Condition	Measures	Condition/ Trend/ Confidence	Rationale for Condition
Sky Brightness	All-sky Light Pollution Ratio (ALR)		Modeled park-wide ALR values were 96% (region-wide) and 102% (park-wide) brighter than average natural conditions. These values are consistent with a moderate concern condition rating for non-urban NPS units such as Golden Spike NHS. Confidence in this condition rating is medium since the data are based on modeled estimates rather than field data. Trend could not be determined.
Overall Condition	Summary of Measure		Overall, the night sky at Golden Spike NHS warrants moderate concern. However, the condition was based on a single measure. The all-sky light pollution ratio is considered the best single measure to assess the nighttime environment, but additional field data for baseline conditions are lacking. The historic site's Foundation Document highlights the need for partnerships with nearby communities and private landowners in order to improve or at least maintain the existing night sky environment.

conditions within the NHS, therefore, the confidence level is medium. Trend could not be determined. A key uncertainty is whether the modeled ALR value reflects actual conditions within the historic site.

Threats, Issues, and Data Gaps

Although population density in Utah is relatively low, it is the fastest growing state in the U.S. (U.S. Census Bureau 2016). As a result of increased population growth, there has been an overall increase in outdoor lighting in local communities and regional cities. Additional threats include the transport of air pollutants and nighttime air traffic. Although NPS staff at the historic site have little control over regional air and light pollution, managers are committed to developing partnerships with nearby communities to implement energy conservation strategies that will minimize light pollution within the historic site (NPS 2017a). The NHS's Foundation Document addresses the potential for opportunities to raise awareness about the importance of night skies in order to achieve this goal (NPS 2017a). The primary data gap is that baseline *in situ* data for the historic site are lacking.

4.2.5. Sources of Expertise

The NPS Natural Sounds and Night Skies Division helps parks manage the night sky in a way that protects park resources and the visitor experience. They provide technical assistance to parks in the form of monitoring, data collection and analysis, and in developing baselines for planning and reporting purposes. For more information, see http://nps.gov/nsnsd. Assessment author is Lisa Baril, science writer, Utah State University. Sources of expertise include the reviewers listed in Appendix A.

4.3. Soundscape

4.3.1. Background and Importance

Our ability to see is a powerful tool for experiencing our world, but sound adds a richness that sight alone cannot provide. In many cases, hearing is the only option for experiencing certain aspects of our environment, and an unimpaired acoustical environment is an important part of overall National Park Service (NPS) visitor experience and enjoyment, as well as vitally important to overall ecosystem health.

In a 1998 survey of the American public, 72% of respondents identified opportunities to experience natural quiet and the sounds of nature as an important reason for having national parks (Haas and Wakefield 1998). Additionally, 91% of NPS visitors "consider enjoyment of natural quiet and the sounds of nature as compelling reasons for visiting national parks" (McDonald et al. 1995). Despite this desire for quiet environments, noise continues to intrude upon natural areas and has become a source of concern in national parks (Lynch et al. 2011).

A park's natural soundscape is an inherent component of "the scenery and the natural and historic objects and the wildlife" protected by the Organic Act of 1916. NPS Management Policies (§ 4.9) (2006) require preservation of parks' natural soundscapes and restoration of degraded soundscapes to natural conditions wherever possible. Additionally, the NPS is required to prevent or minimize degradation of natural soundscapes from noise (i.e., any unwanted sound). Although the management policies currently refer to the term soundscape as the aggregate of all natural sounds that occur in a park, differences exist between the physical sound sources and human perceptions of those sound sources. Physical sound resources (e.g., wildlife, waterfalls, wind, rain, and cultural or historic sounds), regardless of their audibility, at a particular location, are referred to as the acoustical environment, while the human perception of that acoustical environment is defined as the soundscape. Clarifying this distinction will allow managers to create objectives for safeguarding both the acoustical environment and the visitor experience.

In addition, sound plays a critical role for wildlife communication. Activities such as courtship, predation, predator avoidance, and effective use of habitat rely on the ability to hear, with studies showing that wildlife can be adversely affected by intrusive sounds. While the severity of impacts varies depending on the species and other conditions, documented responses of wildlife to noise include increased heart rate, startle responses, flight, disruption of behavior, separation of mothers and young, and interference

The historic Union Pacific No. 119 locomotive at the Winter Steam Festival in Golden Spike NHS. Photo Credit: NPS.

with communication (Selye 1956, Clough 1982, USFS 1992, Anderssen et al. 1993, NPS 1994, Dooling and Popper 2007, Kaseloo 2006). Researchers have also documented wildlife avoidance behaviors due to increased noise levels (McLaughlin and Kunc 2013, Shannon et al. 2015). In addition, a recent publication showed that even plant communities can be adversely affected by noise because key pollinators and species that disperse seeds avoid certain areas (Francis et al. 2012).

Sound Characteristics
Humans and wildlife perceive sound as an auditory sensation created by pressure variations that move through a medium such as water or air. Sound is measured in terms of frequency (pitch) and amplitude (loudness) (Templeton and Sacre 1997, Harris 1998).
Frequency, measured in Hertz (Hz), describes the cycles per second of a sound wave and is perceived by the ear as pitch. Humans with normal hearing can hear sounds between 20 Hz and 20,000 Hz, but most people are sensitive to frequencies between 1,000 Hz and 6,000 Hz. High frequency sounds are more readily absorbed by the atmosphere or scattered by obstructions than low frequency sounds. Low frequency sounds diffract more effectively around obstructions, therefore, travel farther.

The amplitude (or loudness) of a sound, measured in decibels (dB), is logarithmic, which means that every 10 dB increase in sound pressure level (SPL) represents a tenfold increase in sound energy. This also means that small variations in SPL can have significant effects on the acoustical environment. For instance, a 6 dB reduction in background noise level would produce a 4x increase in listening area (Figure 4.3.1-1). Changes in background noise level cause changes in listening opportunity. These lost opportunities will approach a halving of alerting distance and a 75% reduction of listening area for each 6 dB increase in affected band level (Barber et al. 2010). SPL is commonly summarized in terms of dBA (A-weighted SPL). This metric significantly discounts sounds below 1,000 Hz and above 6,000 Hz to approximate the variation in human hearing sensitivity.

4.3.2. Data and Methods
The soundscape assessment for Golden Spike National Historic Site (NHS) was based on the single measure, the L_{50} impact, “most useful for assessing a park’s acoustic environment” according to the NPS Natural Sounds and Night Skies Division (NSNSD) (Turina et al. 2013).

L_{50} Impact
The geospatial model estimates sound pressure levels for the continental United States by using actual acoustical measurements combined with a multitude of explanatory variables such as location, climate, landcover, hydrology, wind speed, and proximity to noise sources (e.g., roads, railroads, and airports). The 270 m (886 ft) resolution model predicts daytime sound levels during midsummer. It should be noted that while the model excels at predicting acoustic conditions over large landscapes, it may not reflect recent localized changes such as new access roads or development.

Model parameters useful for assessing a park’s acoustic environment include the understanding of a) natural conditions, b) existing acoustic conditions including both natural and human-caused sounds, and c) the impact of human-caused sound sources in relation to natural conditions. The L_{50} impact condition demonstrates the influence of human activities to the acoustic environment and is calculated by zeroing all anthropogenic factors in the model and recalculating ambient conditions. It is effectively the difference between existing and natural conditions.

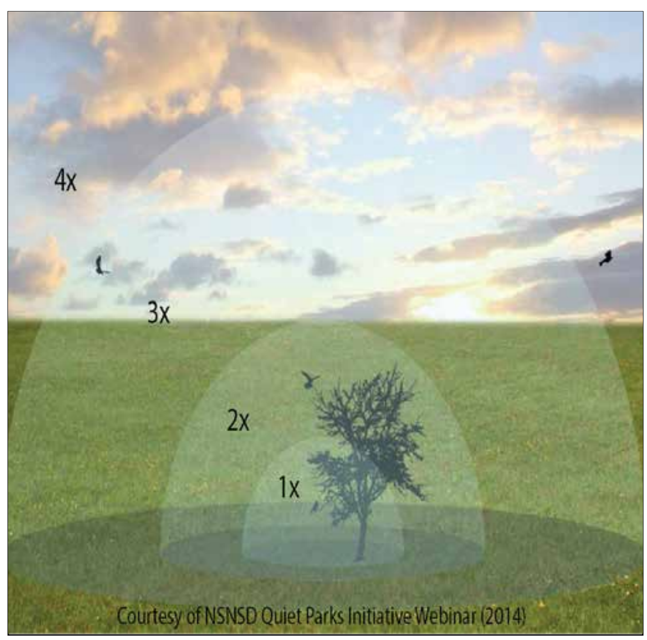


Figure 4.3.1-1. A 6 dB reduction in background noise level would produce a 4x increase in listening area. Figure Credit: © Ted E. Dunn.

4.3.3. Reference Conditions

Reference conditions for the L_{50} impact measure were developed by Turina et al. (2013) and are presented in Table 4.3.3-1. Golden Spike NHS is a non-urban park, which are those with at least 90% of their land located outside an urban area (Turina et al. 2013). Reference conditions for non-urban parks are more stringent than those in urban settings because there is a greater expectation of a noise-free environment in more remote areas (Turina et al. 2013). An L_{50} impact of 1.5 or less, which corresponds to a reduction in listening area of ≤30%, would be considered good condition, while an L_{50} impact of more than 3.0, which corresponds to a reduction in listening area of >50%, would warrant significant concern.

4.3.4. Condition and Trend

L_{50} Impact

Figure 4.3.4-1 shows the modeled median impact sound level map for the historic site and the surrounding area. The modeled average impact was 4.6 dBA above natural conditions, but ranged from 2.3 dBA in the least impacted areas to 10.9 dBA in the most impacted areas (Table 4.3.4-1). The map depicts the areas most influenced by human-caused sounds as lighter areas. The natural and existing acoustic environment condition maps for the historic site are shown in Figures 4.4.4-2 and -3, respectively.

Summary statistics of the L_{50} values for the natural and existing conditions are also provided in Table 4.3.4-1. Average values represent the average L_{50} value occurring within the historic site boundary, and since this value is a mean, visitors may experience sound levels higher and lower than the average L_{50}. A one decibel change is not readily perceivable by the human ear, but any addition to this difference could begin to impact a visitor's ability to hear natural sounds or interpretive programs.

Mennitt et al. (2013) suggest that in a natural environment, the average summertime L_{50}, which is the sound level exceeded half of the time (and is a fair representation of expected conditions) is not expected to exceed 41 dBA (although acoustical conditions vary by area and depend on vegetation, landcover, elevation, climate, and other factors). The modeled estimates for Golden Spike NHS were well below 41 dBA. Mennitt et al. (2013) also state that "an impact of 3 dBA suggests that anthropogenic noise is noticeable at least 50% of the hour or more." The modeled average impact result for the historic site was more than 3 dBA (it was 4.6 dBA); thus, the L_{50} impact warrants significant concern according to the reference thresholds developed by Turina et al. (2013) for non-urban parks. The impact value of 4.6 dBA corresponds to a reduction in listening area of 65.3%. Since these data were modeled, confidence is medium. Trend could not be determined based on these data.

Overall Condition, Trend, Confidence Level, and Key Uncertainties

Overall, the soundscape at Golden Spike NHS warrants significant concern based on the single sound model measure (Table 4.3.4-2). This measure was assigned medium confidence because data were modeled. Trends could not be determined. A key uncertainty is whether the model agrees with *in situ* sound levels in the historic site. As previously stated, while the model excels at predicting acoustic conditions over large landscapes, it may not reflect recent localized changes such as new access roads or development.

Threats, Issues, and Data Gaps

The Golden Spike NHS soundscape resource summary (Wood 2015) reported that the historic site's acoustic environment is threatened by noise from park facilities and operations; nearby development, transportation, and aircraft; and from visitor activities, including idling vehicles, music, and electronics. As development outside and along the periphery of the historic site increases, anthropogenic noise is expected to increase over the long-term.

In non-urban parks such as Golden Spike NHS, anthropogenic impacts to the soundscape are

Table 4.3.3-1. Reference conditions used to assess the sound levels at Golden Spike NHS.

Indicator	Measure	Good	Moderate Concern	Significant Concern
Geospatial Model*	L_{50} Impact (Mean L_{50} impact [dBA])	≤ 1.5 *Listening area reduced by ≤30%*	> 1.5 and ≤ 3.0 *Listening area reduced by 30-50%*	> 3.0 *Listening area reduced by > 50%*

* National Park Service Natural Sounds and Night Skies Division thresholds for non-urban parks. Non-urban parks are those with at least 90% of their land located outside an urban area (Turina et al. 2013).

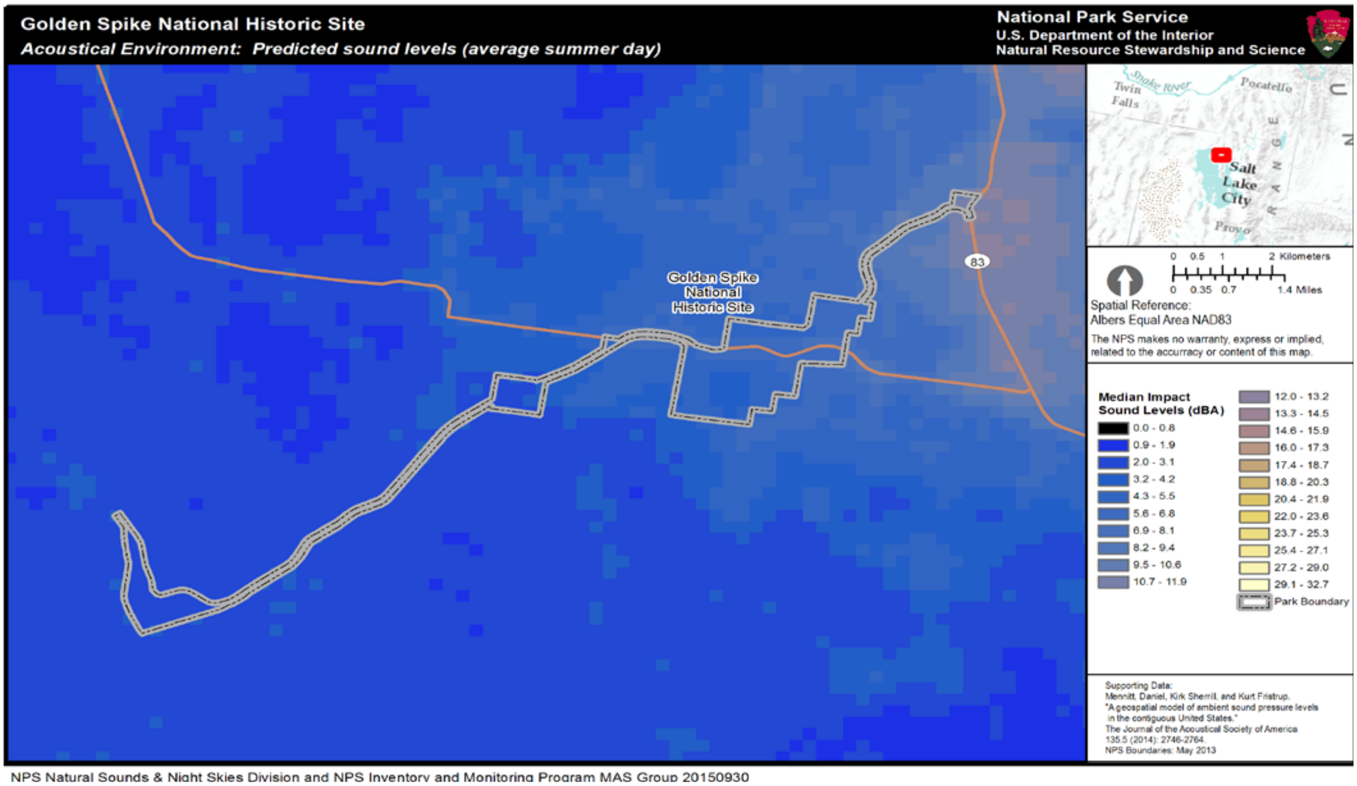


Figure 4.3.4-1. The modeled L_{50} impact sound level at Golden Spike NHS. Lighter colors represent higher impact areas. Figure Credit: NPS NSNSD / Emma Brown.

expected to be lower than in urban parks. Natural soundscapes are important for enhancing the historic character of the site, which includes the sounds of steam locomotives (NPS 2017). The preservation of the natural and historic soundscape is also important to the visitor experience and can help visitors identify with and visualize the history of the area. However, noise intrusions from both within and outside the historic site have the potential to impact the visitor experience. The soundscape resource summary addresses the potential for opportunities to reduce noise from park operations, conduct visitor outreach, and collaborate with partners and neighbors to manage noise sources that may affect resources in the historic site (Wood 2015).

In 2004, the Utah Department of Environmental Quality (UDEQ) issued a Class I waste disposal permit to the private company Allos Environmental for a site located on the southern peninsula tip of Promontory Point (UDEQ 2018). The site is approximately 40 km (25 mi) south of Golden Spike NHS. While the site itself poses no threat to the soundscape at Golden Spike NHS, the truck route is likely to pass near the historic site along East Promontory Road

Table 4.3.4-1. Summary of the modeled minimum, maximum, and average L_{50} measurements in Golden Spike NHS.

Acoustical Environment	Min. (dBA)	Max. (dBA)	Avg. (dBA)
Natural	24.8	27.06	25.6
Existing	27.4	36.96	30.2
Impact	2.3	10.9	4.6

Source: Data were provided by E. Brown, NPS NSNSD.

(Allos Environmental 2018). As of the writing of this assessment, the owners have not transported any waste to the site (UDEQ 2018). However, the company will begin accepting municipal waste in the fall of 2018, and the effects of the increased, large vehicle traffic noise on the NHS's soundscape is unknown. Additionally, in 2017, Allos Environmental applied for a Class V waste disposal permit, which is currently under review (UDEQ 2018). Class V permits allow for regional waste and waste originating from outside the State of Utah; however, this waste will be transported via the Union Pacific Railroad's main line that runs through Ogden, Utah rather than nearby the historic site (Allos Environmental 2018).

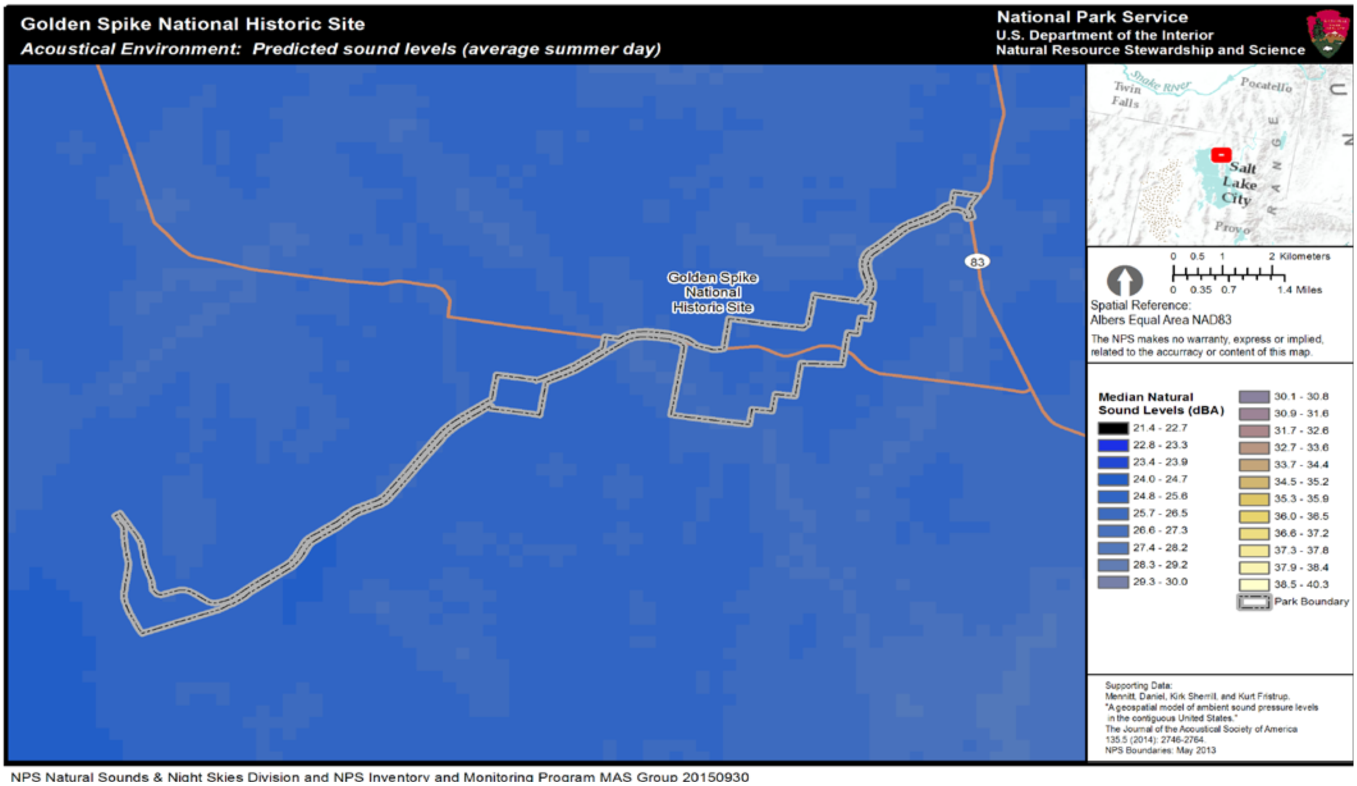


Figure 4.3.4-2. The modeled L_{50} natural sound level at Golden Spike NHS. Lighter colors represent higher impact areas. Figure Credit: NPS NSNSD / Emma Brown.

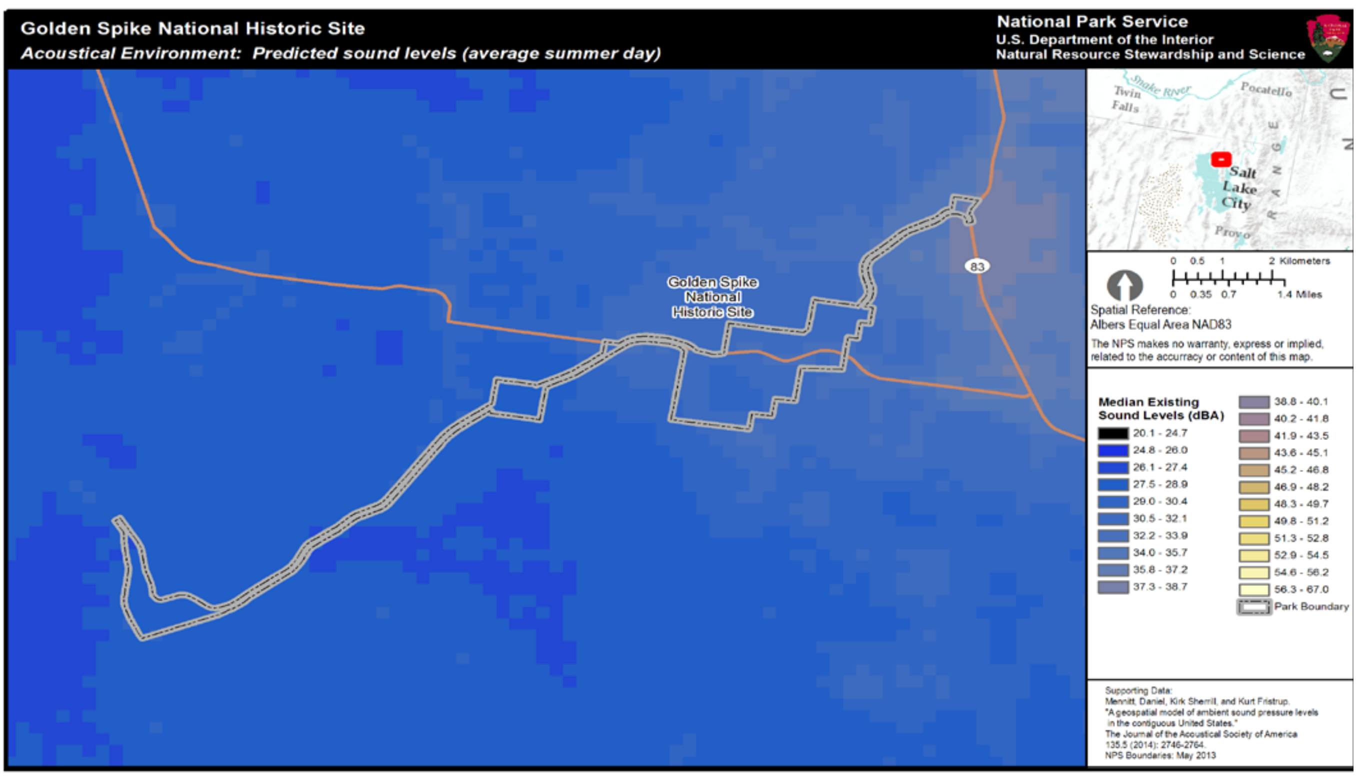


Figure 4.3.4-3. The modeled L_{50} existing sound level at Golden Spike NHS. Lighter colors represent higher impact areas. Figure Credit: NPS NSNSD / Emma Brown.

Table 4.3.4-2. Summary of the soundscape indicators, measures, and condition rationale.

Indicators of Condition	Measures	Condition/ Trend/ Confidence	Rationale for Condition
Geospatial Model	L_{50} Impact		The modeled average impact sound level for the national historic site was 4.6 dBA above natural conditions, but ranged from 2.3 dBA in the least impacted areas to 10.9 dBA in the most impacted areas. Since the modeled average impact result for the historic site was more than 3 dBA, the L_{50} Impact warrants significant concern. This level (4.6 dBA) of sound impact corresponds to a reduction in listening area of ~65%. Because these data were modeled, confidence is medium. No trend data were available.
Overall Condition	Summary of Measure		Overall, we consider the soundscape at Golden Spike NHS to warrant significant concern with medium confidence and an unknown trend. The L_{50} impact model estimated a median reduction in listening area of ~65% across the historic site, or a mean impact of 4.6 dBA. A key uncertainty is whether the model agrees with *in situ* sound levels, and baseline acoustic data for the historic site are lacking.

In addition to influencing the human experience of the landscape, anthropogenic sound (and its frequency) can influence the behavior and ability of wildlife to function naturally on the landscape. With respect to the effects of noise, there is compelling evidence that wildlife can suffer adverse behavioral and physiological changes from noise and other human disturbances, but the ability to translate that evidence into quantitative estimates of impacts is presently limited (Shannon et al. 2015). In a review of literature addressing the effects of noise on wildlife published between 1990 and 2013, wildlife responses to noise were observed beginning at about 40 dBA, and further, 20% of papers showed impacts to terrestrial wildlife at or below noise levels of 50 dBA (Shannon et al. 2015). Wildlife response to noise was found to be highly variable between taxonomic groups. Furthermore, response to noise varied with behavior type (e.g., singing vs. foraging) (Shannon et al. 2015). One of the most common and readily observed biological responses to human noise is change in vocal communication. Birds use vocal communication primarily to attract mates and defend territories, but anthropogenic noise can influence the timing, frequency, and duration of their calls and songs (Shannon et al. 2015). Similar results have been found for some species of mammals, amphibians, and insects, which also rely on vocal communication for breeding and territorial defense. Other changes include changes in time spent foraging, ability to orient, and territory selection (Shannon et al. 2015).

Recommendations have been made for human exposure to noise, but no guidelines exist for wildlife and their habitats. The majority of research on wildlife has focused on acute noise events, so further research needs to be dedicated to chronic noise exposure (Barber et al. 2010). In addition to wildlife, standards have not yet been developed to assess the quality of physical sound resources (the acoustic environment), separate from human or wildlife perception. Scientists are also working to differentiate between impacts to wildlife that result from the noise itself or the presence of the noise source (Barber et al. 2010). Data gaps include the lack of baseline acoustic conditions and acoustic goals for the historic site (Wood 2016).

4.3.5. Sources of Expertise

NPS NSNSD scientists help parks preserve and restore acoustic environments, increase scientific understanding, and inspire public appreciation of acoustic resources. For more information, see http://nps.gov/nsnsd. Emma Brown, Acoustical Resource Specialist with the NSNSD, provided an NRCA soundscape template used to develop this assessment and the sound model statistics and maps. Assessment author was Lisa Baril, Biologist and Science Writer, Utah State University. Sources of expertise include the reviewers listed in Appendix A.

4.4. Air Quality

4.4.1. Background and Importance

The National Park Service's (NPS) Organic Act, Air Quality Management Policy 4.7.1 (NPS 2006), and the Clean Air Act (CAA) of 1970 (U.S. Federal Register 1970), guide the NPS to protect air quality and any air quality related values (e.g., scenic, biological, cultural, and recreational resources) within national parks that may be impaired from air pollutants.

One of the main purposes of the CAA is "to preserve, protect, and enhance the air quality in national parks" and other areas of special national or regional natural, recreational, scenic, or historic value. The CAA includes special programs to prevent significant air quality deterioration in clean air areas and to protect visibility in national parks and wilderness areas (NPS-Air Resources Division [ARD] 2006).

Two categories of air quality areas have been established through the authority of the CAA: Class I and II. The air quality classes are allowed different levels of permissible air pollution, with Class I receiving the greatest protection and strictest regulation. The CAA gives federal land managers responsibilities and opportunities to participate in decisions being made by regulatory agencies that might affect air quality in the federally protected areas they administer (NPS-ARD 2005).

Class I areas include parks that are larger than 2,428 ha (6,000 acres) or wilderness areas over 2,023 ha (5,000 acres) that were in existence when the CAA was amended in 1977 (NPS-ARD 2010). Because of its small size, Golden Spike National Historic Site (NHS) is designated as a Class II airshed. However, it is important to note that even though the CAA gives Class I areas the greatest protection against air quality deterioration, NPS management policies do not distinguish between the levels of protection afforded to any park of the National Park System (NPS 2006).

Air Quality Standards

Air quality is deteriorated by many forms of pollutants that either occur as primary pollutants, emitted directly from sources such as power plants, vehicles, wildfires, and wind-blown dust, or as secondary pollutants, which result from atmospheric chemical reactions. The CAA requires the U.S. Environmental Protection Agency (USEPA) to establish National Ambient Air Quality Standards (NAAQS) (40 CFR part 50) to regulate these air pollutants that are considered harmful to human health and the environment (USEPA 2017a). The two types of NAAQS are primary and secondary, with the primary standards establishing limits to protect human health, and the secondary standards establishing limits to protect public welfare from air pollution effects, including decreased

A golden eagle soaring over Golden Spike NHS. Photo Credit: NPS.

visibility, and damage to animals, crops, vegetation, and buildings (USEPA 2017a).

The NPS ARD (NPS-ARD) air quality monitoring program uses USEPA's NAAQS, natural visibility goals and ecological thresholds as benchmarks to assess current conditions of visibility, ozone, and atmospheric deposition throughout Park Service areas. Visibility affects how well (acuity) and how far (visual range) one can see (NPS-ARD 2002), but air pollution can degrade visibility. Particulate matter (e.g. soot, dust, and sulfate and nitrate particles) and certain gases in the atmosphere can create haze and reduce visibility.

Ozone is a gaseous constituent of the atmosphere produced by reactions of nitrogen oxides (NO_x) from vehicles, powerplants, industry, fire, and volatile organic compounds from industry, solvents, and vegetation in the presence of sunlight (Porter and Wondrak-Biel 2011). It is one of the most widespread air pollutants (NPS-ARD 2003), and the major constituent in smog. Ozone can be harmful to human health. Exposure to ozone can irritate the respiratory system and increase the susceptibility of the lungs to infections (NPS-ARD 2013a).

Ozone is also phytotoxic, causing foliar damage to plants (NPS-ARD 2003). Ozone penetrates leaves through stomata (openings) and oxidizes plant tissue, which alters physiological and biochemical processes (NPS-ARD 2013b). Once the ozone is inside the plant's cellular system, the chemical reactions can cause cell injury or even death (NPS-ARD 2013b) but more often reduces the plant's resistance to insects and diseases, limits growth, and lowers reproductive capability (NPS-ARD 2015).

Foliar damage requires the interplay of several factors, including the sensitivity of the plant to the ozone, the level of ozone exposure, and the exposure environment (e.g., soil moisture). The highest ozone risk for plants exists when a species is highly sensitive to ozone, the exposure levels of ozone significantly exceed the thresholds for foliar injury, and the environmental conditions, particularly adequate soil moisture, foster gas exchange and the uptake of ozone by plants (NPS-ARD 2013b).

Air pollutants can be deposited to ecosystems through rain and snow (wet deposition) or dust and gases (dry deposition). Nitrogen and sulfur air pollutants are commonly deposited as nitrate, ammonium, and sulfate ions and can have a variety of effects on ecosystem health, including acidification, fertilization or eutrophication. Mercury or toxins can also be deposited to ecosystems (NPS-ARD 2010, Fowler et al. 2013). Atmospheric deposition can also change soil pH, which in turn affects microorganisms, understory plants, and trees (NPS-ARD 2010). Certain ecosystems are more vulnerable to nitrogen or sulfur deposition than others, including high-elevation ecosystems in the western United States, upland areas in the eastern part of the country, areas on granitic bedrock, coastal and estuarine waters, arid ecosystems, and some grasslands (NPS-ARD 2013a). Increases in nitrogen have been found to promote invasions of fast-growing non-native annual grasses (e.g., cheatgrass [*Bromus tectorum*]) and forbs (e.g., Russian thistle [*Salsola tragus*] at the expense of native species (Allen et al. 2009, Schwinning et al. 2005). Increased grasses can increase fire risk (Rao et al. 2010), with profound implications for biodiversity in non-fire adapted ecosystems. Nitrogen may also increase water use in plants like big sagebrush (*Artemisia tridentata*) (Inouye 2006).

According to the USEPA (2017b), in the United States, roughly two thirds of all sulfur dioxide (SO_2) and one quarter of all nitrogen oxides (NO_x) come from electric power generation that relies on burning fossil fuels. Sulfur dioxide and nitrogen oxides are released from power plants and other sources, and ammonia is released by agricultural activities, feedlots, fires, and catalytic converters. In the atmosphere, these transform to sulfate, nitrate, and ammonium, and can be transported long distances across state and national borders, impacting resources (USEPA 2017b), including at Golden Spike NHS.

Mercury and other toxic pollutants (e.g., pesticides, dioxins, PCBs) accumulate in the food chain and can affect both wildlife and human health. Elevated levels of mercury and other airborne toxic pollutants like pesticides in aquatic and terrestrial food webs can act as neurotoxins in biota that accumulate fat and/or muscle-loving contaminants. Sources of atmospheric mercury include by-products of coal-fire combustion, municipal and medical incineration, mining operations, volcanoes, and geothermal vents. High mercury concentrations in birds, mammals, amphibians, and fish can result in reduced foraging efficiency, survival, and reproductive success (NPS-ARD 2013a).

Additional air contaminants of concern include pesticides (e.g., DDT), industrial by-products (PCBs), and emerging chemicals such as flame retardants for fabrics (PBDEs). These pollutants enter the atmosphere from historically contaminated soils, current day industrial practices, and air pollution (Selin 2009).

4.4.2. Data and Methods

The approach we used to assess the condition of air quality within Golden Spike NHS's airshed was developed by the NPS-ARD for use in Natural Resource Condition Assessments (NPS-ARD 2018a). NPS-ARD uses three indicators with a total of seven measures. The indicators are visibility (one measure), level of ozone (two measures), and wet deposition (four measures) (Table 4.4.2-1). NPS-ARD uses all available data from NPS, USEPA, state, and/or tribal monitoring stations to interpolate air quality values, with a specific value assigned to the maximum value within each park. Even though the data were derived from all available monitors, data from the closest stations "outweigh" the rest.

Haze Index

Visibility is monitored through the Interagency Monitoring of Protected Visual Environments (IMPROVE) Program (NPS-ARD 2010) and annual average measurements for Group 50 visibility are averaged over a 5-year period at each visibility monitoring site with at least 3-years of complete annual data. Five-year averages are then interpolated across all monitoring locations to estimate 5-year average values for the contiguous U.S. The maximum value within Golden Spike NHS's boundaries is reported as the visibility condition from this national analysis. There were no on-site or nearby monitors with which to assess trend.

Table 4.4.2-1. Summary of indicators and their measures.

Indicators	Measures
Visibility	Haze Index
Level of Ozone	Human Health, Vegetation Health
Wet Deposition	Nitrogen, Sulfur, Mercury, Predicted Methylmercury Concentration

The following two measures describe the methods for determining ozone levels for human health and vegetation. Ozone is monitored across the U.S. through air quality monitoring networks operated by the NPS, USEPA, states, and others. Aggregated ozone data were acquired from the USEPA Air Quality System (AQS) database. Note that prior to 2012, monitoring data were also obtained from the USEPA Clean Air Status and Trends Network (CASTNet) database. No ozone data were available from monitors within 10 km (7 mi) of the park, which is the distance which NPS-ARD considers representative for calculating trends (Taylor 2017).

Human Health: Annual 4th-highest 8-hour Concentration

The primary NAAQS for ground-level ozone was set by the USEPA, and is based on human health effects. The 2008 NAAQS for ozone was a 4th-highest daily maximum 8-hour ozone concentration of 75 parts per billion (ppb). On 1 October 2015, the USEPA strengthened the national ozone standard by setting the new level at 70 ppb (USEPA 2017a). The NPS-ARD assesses the status for human health risk from ozone using the 4th-highest daily maximum 8-hour ozone concentration in ppb. Annual 4th-highest daily maximum 8-hour ozone concentrations were averaged over a 5-year period at all monitoring sites. Five-year averages were interpolated for all ozone monitoring locations to estimate 5-year average values for the contiguous U.S. The ozone condition for human health risk at the park was the maximum estimated value within its boundaries derived from this national analysis.

Vegetation Health: 3-month Maximum 12-hour W126

Exposure indices are biologically relevant measures used to quantify plant response to ozone exposure. These measures are better predictors of vegetation response than the metric used for the human health standard. One annual index is the W126, which preferentially weighs the higher ozone concentrations most likely to affect plants and sums all of the weighted concentrations during daylight hours (8am-8pm). The highest 3-month period that occurs from March to September was reported in "parts per million-hours" (ppm-hrs) and was used for vegetation health risk from ozone condition assessments. Annual maximum 3-month 12-hour W126 values were averaged over a 5-year period at all monitoring sites with at least three years of complete annual data. Five-year averages were interpolated for all ozone monitoring locations to estimate 5-year average values for the contiguous U.S. The estimated current ozone condition for vegetation health risk at the park was the maximum value within its boundaries derived from this national analysis.

The following measures describe the methods for collecting wet deposition data. Atmospheric wet deposition was monitored across the United States as part of the National Atmospheric Deposition Program/National Trends Network (NADP/NTN) for nitrogen and sulfur wet deposition and at the Mercury Deposition Network (MDN) for mercury wet deposition.

<u>Nitrogen and Sulfur</u>
Wet deposition was used as a surrogate for total deposition (wet plus dry), because wet deposition was the only nationally available monitored source of nitrogen and sulfur deposition data. Values for nitrogen (N) from ammonium and nitrate and sulfur (S) from sulfate wet deposition were expressed as amount of N or S in kilograms deposited over a one-hectare area in one year (kg/ha/yr). For nitrogen and sulfur condition assessments, wet deposition was calculated by multiplying nitrogen (from ammonium and nitrate) or sulfur (from sulfate) concentrations in precipitation by a normalized precipitation. Annual wet deposition was averaged over a 5-year period at monitoring sites with at least three years of annual data. Five-year averages were then interpolated across all monitoring locations to estimate 5-year average values for the contiguous U.S. For individual parks, minimum and maximum values within park boundaries were reported from this national analysis. To maintain the highest level of protection in the park, the maximum value was assigned a condition status. Nitrogen and sulfur conditions were derived by interpolating measured values from multiple monitoring stations farther than 16 km (10 mi). NPS-ARD considers stations located farther than this distance outside the range that is representative for calculating trends (Taylor 2017).

<u>Mercury and Predicted Methylmercury Concentration</u>
The condition of mercury was assessed using a mercury risk status assessment matrix that combines estimated 3-year average mercury wet deposition (ug/m^2/yr) and the predicted surface water methylmercury concentrations at NPS Inventory & Monitoring parks. It is important to consider both mercury deposition inputs and ecosystem susceptibility to mercury methylation when assessing mercury condition, because atmospheric inputs of elemental or inorganic mercury must be methylated before they are biologically available and able to accumulate in food webs (NPS-ARD 2013a). Thus, mercury condition cannot be assessed according to mercury wet deposition alone. Other factors like environmental conditions conducive to mercury methylation (e.g., dissolved organic carbon, wetlands, pH) must also be considered (Taylor 2017).

Annual mercury wet deposition measurements were averaged over a 3-year period at all NADP-MDN monitoring sites with at least three years of annual data. Three-year averages were then interpolated across all monitoring locations using an inverse distance weighting method to estimate 3-year average values for the contiguous U.S. The maximum estimated value within park boundaries derived from this national analysis was used in the mercury risk status assessment matrix.

Conditions of predicted methylmercury concentration in surface water were obtained from a model that predicts surface water methylmercury concentrations for hydrologic units throughout the U.S. based on relevant water quality characteristics (i.e., pH, sulfate, and total organic carbon) and wetland abundance (U.S. Geological Survey [USGS] 2015). The predicted methylmercury concentration at a park was the highest value derived from the hydrologic units that intersect the park. This value was used in the mercury risk status assessment matrix.

NPS-ARD considers wet deposition monitoring stations located farther than 16 km (7 mi) outside the range that is representative for calculating trends (Taylor 2017). There were no representative wet deposition monitoring stations for the historic site.

4.4.3. Reference Conditions
The reference conditions against which current air quality parameters were assessed are identified by Taylor (2017) for NRCAs and listed in Table 4.4.3-1.

<u>Haze Index</u>
A visibility condition estimate of less than 2 dv above estimated natural conditions indicates a “good” condition, estimates ranging from 2-8 dv above natural conditions indicate a “moderate concern” condition, and estimates greater than 8 dv above

Table 4.4.3-1. Reference conditions for air quality parameters.

Indicator and Measure	Very Good	Good	Moderate Concern	Significant Concern
Visibility Haze Index	–	< 2	2-8	>8
Ozone Human Health (ppb)	–	≤ 54	55-70	≥ 71
Ozone Vegetation Health (ppm-hrs)	–	<7	7-13	>13
Nitrogen and Sulfur Wet Deposition (kg/ha/yr)	–	< 1	1-3	>3
Mercury Wet Deposition ((µg/m²/yr)	< 3	≥ 3 and < 6	≥ 6 and < 9	≥ 9
Predicted Methylmercury Concentration (ng/L)	< 0.038	≥ 0.038 and .< 0.053	≥ 0.053 and < 0.075	≥ 0.075

Source: Taylor (2017)

Note: NPS-ARD includes very good and very high standards. In order to conform with NRCA guidance, very low was considered good and very high was considered significant concern condition.

natural conditions indicate "significant concern." The NPS-ARD chose reference condition ranges to reflect the variation in visibility conditions across the monitoring network.

Human Health: Annual 4th-highest 8-hour Concentration

The human health ozone condition thresholds were based on the 2015 ozone standard set by the USEPA (2017a) at a level to protect human health: 4th-highest daily maximum 8-hour ozone concentration of 70 ppb. The NPS-ARD rates ozone condition as: "good" if the ozone concentration was less than or equal to 54 ppb, which is in line with the updated Air Quality Index breakpoints; "moderate concern" if the ozone concentration was between 55 and 70 ppb; and of "significant concern" if the concentration was greater than or equal to 71 ppb.

Vegetation Health: 3-month Maximum 12-hour W126

The W126 condition thresholds were based on information in the USEPA's Policy Assessment for the Review of the Ozone NAAQS (USEPA 2014). Research has found that for a W126 value of:

- ≤ 7 ppm-hrs, tree seedling biomass loss is ≤ 2 % per year in sensitive species; and
- ≥13 ppm-hrs, tree seedling biomass loss is 4-10 % per year in sensitive species.

ARD recommends a W126 of < 7 ppm-hrs to protect most sensitive trees and vegetation; this level was considered good; 7-13 ppm-hrs was considered to be of "moderate" concern; and >13 ppm-hrs was considered to be of "significant concern" (Taylor 2017).

Nitrogen and Sulfur

The NPS-ARD selected a wet deposition threshold of 1.0 kg/ha/yr as the level below which natural ecosystems are likely protected from harm. This was based on studies linking early stages of aquatic health decline with 1.0 kg/ha/yr wet deposition of nitrogen both in the Rocky Mountains (Baron et al. 2011) and in the Pacific Northwest (Sheibley et al. 2014). Parks with less than 1 kg/ha/yr of atmospheric wet deposition of nitrogen or sulfur compounds are assigned "good" condition, those with 1-3 kg/ha/yr are assigned a "moderate concern" condition, and parks with depositions greater than 3 kg/ha/yr are considered to be of "significant concern."

Mercury and Predicted Methylmercury Concentration

Ratings for mercury wet deposition and predicted methylmercury concentrations can be evaluated using the mercury condition assessment matrix shown in Table 4.4.3-2 to identify one of three condition categories. Condition adjustments may be made if the presence of park-specific data on mercury in food webs is available and/or data are lacking to determine the wet deposition rating (Taylor 2017).

4.4.4. Condition and Trend

The values used to determine conditions for all air quality indicators and measures are listed in Table 4.4.4-1.

Haze Index

The estimated 5-year (2011-2015) values for Golden Spike NHS's (2.3 dv) visibility condition fell within the moderate concern condition rating, which indicates visibility was degraded from the good reference condition of <2 dv above the natural condition (Taylor 2017). There were not sufficient on-site or nearby

Table 4.4.3-2. Mercury condition assessment matrix.

Predicted Methylmercury Concentration Rating	Mercury Wet Deposition Rating				
	Very Low	Low	Moderate	High	Very High
Very Low	Good	Good	Good	Moderate Concern	Moderate Concern
Low	Good	Good	Moderate Concern	Moderate Concern	Moderate Concern
Moderate	Good	Moderate Concern	Moderate Concern	Moderate Concern	Significant Concern
High	Moderate Concern	Moderate Concern	Moderate Concern	Significant Concern	Significant Concern
Very High	Moderate Concern	Moderate Concern	Significant Concern	Significant Concern	Significant Concern

Source: Taylor (2017).

monitors with which to determine trends. Confidence in this measure is medium because estimates were based on interpolated data from more distant visibility monitors. Visibility impairment primarily results from small particles in the atmosphere that include natural particles from dust and wildfires and anthropogenic sources from organic compounds, NO_x and SO_2. The contributions made by different classes of particles to haze vary by region but often include ammonium sulfate, coarse mass, and organic carbon. Ammonium sulfate originates mainly from coal-fired power plants and smelters, and organic carbon originates primarily from combustion of fossil fuels and vegetation. Sources of coarse mass include dust from roads, agriculture, construction sites, mining operations, and other similar activities. Data on the contribution of visibility impairing particulates for the historic site were not available.

Human Health: Annual 4th-highest 8-hour Concentration

Ozone data used for this measure were derived from estimated five-year (2011-2015) values of 69.2 parts per billion (ppb) for the 4th highest 8-hour concentration, which resulted in a condition rating warranting moderate concern for human health (NPS-ARD 2016). Trend could not be determined because there were not sufficient on-site or nearby monitoring data. The level of confidence is medium because estimates were based on interpolated data from more distant ozone monitors.

Vegetation Health: 3-month Maximum 12-hour W126

Ozone data used for this measure of the condition assessment were derived from estimated five-year (2011-2015) values of 13.2 parts per million-hours (ppm-hrs) for the W126 Index. This value warrants significant concern (NPS-ARD 2016). Trend could not be determined because there were not sufficient on-site or nearby monitoring data. Our level of confidence in this measure is medium because estimates were based on interpolated data from more distant ozone monitors.

There is one ozone-sensitive plant species in Golden Spike NHS. The species is Utah serviceberry

Table 4.4.4-1. Condition and trend results for air quality indicators at Golden Spike NHS.

Visibility (dv)	Ozone: Human Health (ppb)	Ozone: Vegetation Health (ppm-hrs)	N (kg/ha/yr)	S (kg/ha/yr)	Mercury (µg/m²/yr)	Mercury (ng/L)
Moderate Concern (2.3) (2011-2015)	Moderate Concern (69.2) (2011-2015)	Significant Concern (13.2) (2011-2015)	Significant Concern (2.6*) (2011-2015)	Good (0.8) (2011-2015)	Moderate Concern (6.8-7.2) (2013-2015)	n/a

* Value is within the range normally considered moderate concern, but ecosystems at the historic site may be particularly sensitive to nitrogen-enrichment effects. Thus, the condition has was elevated to significant concern (NPS-ARD 2016).

Source: NPS-ARD (2016, 2018b)

(*Amelanchier utahensis*), but it is not considered a bioindicator (Bell, In Review). Bioindicators are species that can reveal ozone stress in ecosystems by producing distinct visible and identifiable injuries to plant leaves (Bell, In Review).

<u>Nitrogen</u>

Wet N deposition data used for the condition assessment were derived from estimated five-year average values (2011-2015) of 2.6 kg/ha/yr. This would normally result in a condition rating of moderate concern; however, the condition rating was elevated to significant concern because ecosystems at Golden Spike NHS may be more vulnerable to the adverse effects of excess nitrogen deposition (NPS-ARD 2016). No trends could be determined given the lack of nearby monitoring stations. Confidence in the condition is medium because estimates were based on interpolated data from more distant deposition monitors. For further discussion of N deposition, see the section entitled "Additional Information for Nitrogen and Sulfur" below.

<u>Sulfur</u>

Wet S deposition data used for the condition assessment were derived from estimated five-year average values (2011-2015) of 0.8 kg/ha/yr, which resulted in a good condition rating (NPS-ARD 2016). No trends could be determined given the lack of nearby monitoring stations. Confidence in the assessment is medium because estimates were based on interpolated data from more distant deposition monitors. For further discussion of sulfur, see below.

Additional Information on Nitrogen and Sulfur

Sullivan et al. (2011) studied the risk from acidification from acid pollutant exposure and ecosystem sensitivity for Northern Colorado Plateau Network (NCPN) parks, which includes Golden Spike NHS. Pollutant exposure included the type of deposition (i.e., wet, dry, cloud, fog), the oxidized and reduced forms of the chemical, if applicable, and the total quantity deposited. The ecosystem sensitivity considered the type of terrestrial and aquatic ecosystems present at the parks and their inherent sensitivity to the atmospherically deposited chemicals.

These risk rankings were considered low for estimated acid pollutant exposure, low for ecosystem sensitivity, and moderate for park protection for an overall summary risk of low (Sullivan et al. 2011). The effects of acidification can include changes in water and soil chemistry that impact ecosystem health.

Sullivan (2016) also developed risk rankings for nutrient N pollutant exposure and ecosystem sensitivity to nutrient N enrichment. These risk rankings were considered low for nutrient N pollutant exposure and very high for ecosystem sensitivity to nutrient N enrichment. Potential effects of nitrogen deposition include the disruption of soil nutrient cycling and impacts to the biodiversity of some plant communities, including arid and semi-arid communities, grasslands, and wetlands.

Using three datasets, Landscape Fire and Resource Management Planning Tools Project (LANDFIRE), National Wetlands Inventory (NWI) cover data, and National Land Cover Data (NLCD), nitrogen-sensitive vegetation for the historic site was identified (E&S Environmental Chemistry, Inc. 2009). In Golden Spike NHS, the LANDFIRE dataset mapped 784 ha (1,937 ac) of arid and semi-arid, and 148 ha (366 ac) of grassland and meadow nitrogen-sensitive areas (Figure 4.4.4-1). These two nitrogen-sensitive plant communities account for 86% of the historic site. No nitrogen-sensitive communities were identified by NWI or NLCD.

Since the mid-1980s, nitrate and sulfate deposition levels have declined throughout the United States (NADP 2018a). Regulatory programs mandating a reduction in emissions have proven effective for decreasing both sulfate and nitrate ion deposition, primarily through reductions from electric utilities, vehicles, and industrial boilers. In 2007, the NADP/NTN began passively monitoring ammonium ion concentrations and deposition across the U.S. in order to establish baseline conditions and trends over time (NADP 2018b). In 2012 hotspots of ammonium deposition were concentrated in the midwestern states in large part due to the density of agricultural and livestock industries in that region (NADP 2018b). The area surrounding Casa Grande Ruins NM, however, shows relatively low ammonium, sulfate, and nitrate concentrations and deposition levels (NADP 2018a,b). It seems reasonable to expect a continued improvement or stability in sulfate and nitrate deposition levels because of CAA requirements, but since ammonium levels are not currently regulated by the EPA, they may continue to remain high in certain areas (NPS-ARD 2010). However, once baseline

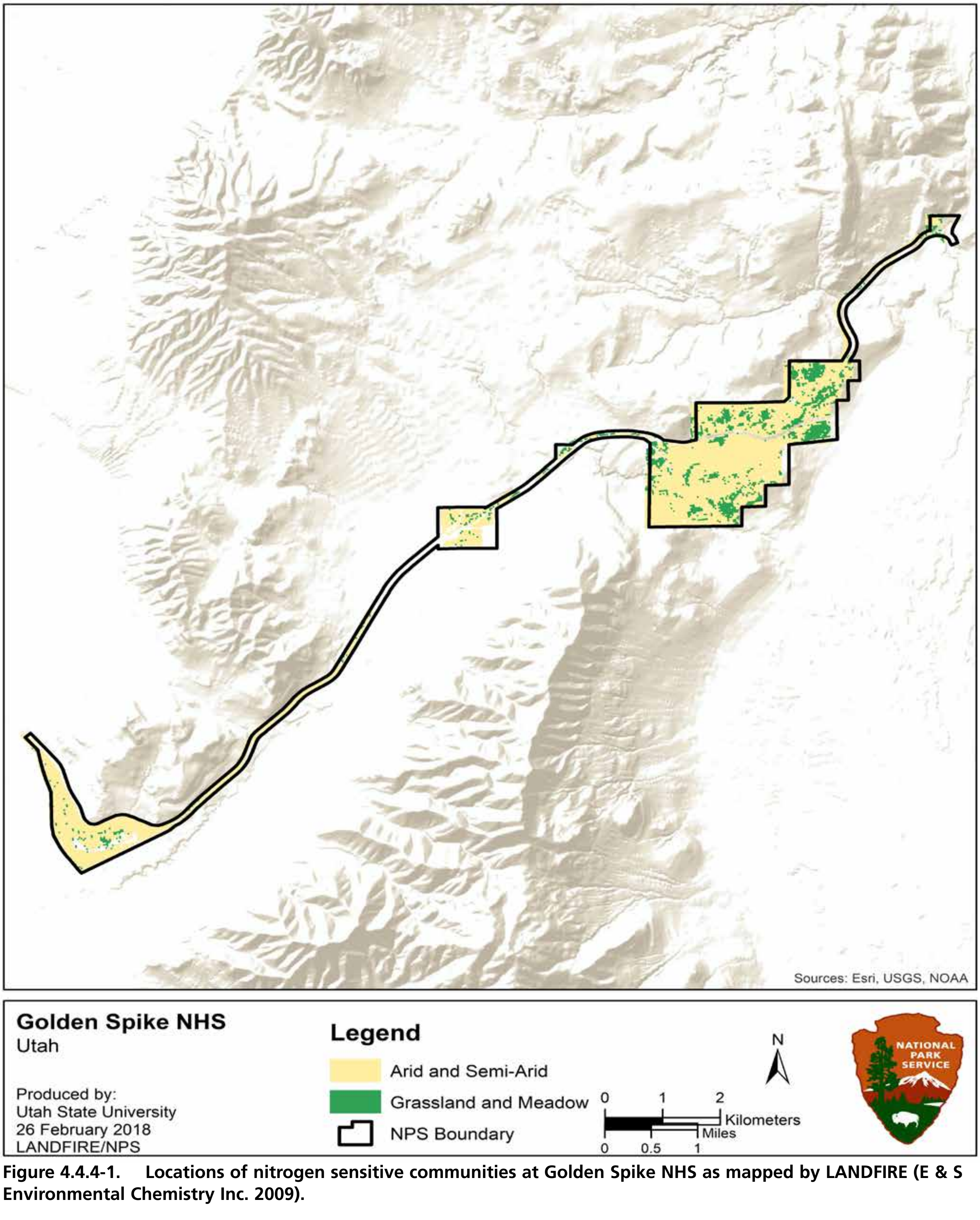


Figure 4.4.4-1. Locations of nitrogen sensitive communities at Golden Spike NHS as mapped by LANDFIRE (E & S Environmental Chemistry Inc. 2009).

conditions for ammonia are established, those data may be used to support regulatory statutes.

Because rainfall in the arid southwest is low, there is relatively little wet S or N deposition (Sullivan 2016). Dry S and N deposition is more common in arid ecosystems but difficult to quantify because many factors influence deposition, including the mix of air pollutants present, surface characteristics of soil and vegetation, and meteorological conditions (Weathers et al. 2006). Sparse vegetation may increase the exposure of sols to direct dry deposition of atmospheric pollutants (Sullivan 2016).

<u>Mercury and Predicted Methylmercury Concentration</u>
The 2013–2015 estimated wet mercury deposition was moderate at Golden Spike NHS, ranging from 6.8 to 7.2/m²/yr (NPS-ARD 2018b). Predicted methylmercury concentration data, however, were unavailable (NPS-ARD 2018b). Wet mercury deposition and predicted methylmercury ratings are usually combined to determine an overall condition status for mercury/toxics. Therefore, the mercury/toxics condition is unknown and confidence is low. Trend could not be determined.

<u>Overall Condition, Trend, Confidence Level, and Key Uncertainties</u>
For assessing the condition of air quality, we used three air quality indicators with a total of seven measures, which are summarized in Table 4.4.4-2. Based on these indicators and measures, the overall condition of air quality at Golden Spike NHS warrants significant concern. The overall confidence level is medium since the values for all measures were collected from more distant monitors, which also represents a key uncertainty since the values may not accurately reflect conditions within the historic site. An additional key uncertainty of the air quality assessment is knowing the effect(s) of air pollution, especially of nitrogen deposition, on ecosystems within the historic site.

<u>Threats, Issues, and Data Gaps</u>
Clean air is fundamental to protecting human health, the health of wildlife and plants within parks, and for protecting the aesthetic value of lands managed by the NPS (NPS 2006). The majority of threats to air quality within the historic site originate from outside its boundaries. Stressors to air quality include both naturally-occurring events and anthropogenic activities. Emissions from power and industrial plants, factories, mining operations, dry cleaning facilities, vehicles, and agriculture can negatively affect air quality (NPS-ARD 2005, Porter and Wondrak Biel 2011). Coal-burning power plants are a major source of mercury in remote ecosystems (Landers et al. 2008). Across the NCPN region, there are numerous coal-burning power plants (Sullivan 2016). Mercury emissions may threaten ecosystems within the historic site, including invertebrates. Mercury is not monitored across NCPN parks, but data from the Mercury Deposition Network for other areas in the southwest, including a monitor near Salt Lake City, Utah, suggest that mercury concentrations in rainfall are high (Sullivan 2016). A study examining mercury concentrations in fish from 21 national parks in the western U.S., found that in Capitol Reef NP and Zion NP in Utah, speckled dace (*Rhinichthys osculus*) contained mercury levels that exceeded those associated with biochemical and reproductive effects in fish and reproductive impairment in birds (Eagles-Smith et al. 2014). This was particularly concerning since speckled dace forage on invertebrates, yet exhibited concentrations that were greater than larger, predatory fish species such as lake trout (*Salvelinus namaycush*) (Eagles-Smith et al. 2014).

Climate change and local weather patterns also influence the dispersal of atmospheric particulates. The western U.S., and the Southwest in particular, has experienced increasing temperatures and decreasing rainfall (Prein et al. 2016). Since 1974 there has been a 25% decrease in precipitation, a trend that is partially counteracted by increasing precipitation intensity (Prein et al. 2016). In Golden Spike NHS, the annual average temperature has significantly increased (Monahan and Fisichelli 2014). One effect of climate change is a potential increase in wildfire activity (Abatzoglou and Williams 2016). Fires contribute a significant amount of trace gases and particles into the atmosphere that affect local and regional visibility and air quality (Kinney 2008). Natural wildfires have increased across the western U.S., and the potential for the number of wildfires to grow is high as climate in the Southwest becomes warmer and drier (Abatzoglou and Williams 2016). Warmer conditions can also increase the rate at which ozone and secondary particles form (Kinney 2008). Declines in precipitation may also lead to an increase in wind-blown dust (Kinney 2008). Because of their small particle size, airborne particulates from fires, motor vehicles, power plants, and wind-blown dust may remain in the atmosphere

Table 4.4.4-2. Summary of air quality indicators, measures, and condition rationale.

Indicators	Measures	Condition/ Trend/ Confidence	Rationale for Condition
Visibility	Haze Index		Visibility warrants moderate concern at Golden Spike NHS. This is based on NPS ARD benchmarks and the 2011-2015 estimated visibility on mid-range days of 2.3 deciviews (dv) above estimated natural conditions. No trend information was available because there were not on-site or nearby visibility monitoring data. Confidence is medium because estimates were based on interpolated data from more distant visibility monitors.
Level of Ozone	Human Health: Annual 4th-Highest 8-hour Concentration		Human health risk from ground-level ozone warrants moderate concern at Golden Spike NHS. This status is based on NPS ARD benchmarks and the 2011-2015 estimated ozone of 69.2 parts per billion (ppb). No trend information was available because there were not sufficient on-site or nearby ozone monitoring data. The level of confidence is medium because estimates are based on interpolated data from more distant ozone monitors.
	Vegetation Health: 3-month maximum 12hr W126		Vegetation health risk from ground-level ozone warrants significant concern. This status is based on NPS ARD benchmarks and the 2011-2015 estimated W126 metric of 13.2 parts per million-hours (ppm-hrs). The W126 metric relates plant response to ozone exposure. No trend information was available because there were not sufficient on-site or nearby ozone monitoring data. The confidence level is medium because estimates are based on interpolated data from more distant ozone monitors.
Wet Deposition	N in kg/ha/yr		Although the nitrogen wet deposition estimate (2.6 kilograms per hectare per year (kg/ha/yr)) was within the moderate concern range, the condition was elevated to significant concern because ecosystems at the historic site may be particularly sensitive to excess nitrogen deposition. Nitrogen deposition may disrupt soil nutrient cycling and affect biodiversity of some plant communities, including arid and semi-arid communities, grasslands, and wetlands. No trend information was available because there were not sufficient on-site or nearby deposition monitoring data. The confidence level is medium because estimates are based on interpolated data from more distant deposition monitors.
	S in kg/ha/yr		Wet sulfur deposition is in good condition. This status is based on NPS ARD benchmarks and the 2011-2015 estimated wet sulfur deposition of 0.8 kilograms per hectare per year (kg/ha/yr). No trend information was available because there are not sufficient on-site or nearby deposition monitoring data. The level of confidence is medium because estimates are based on interpolated data from more distant deposition monitors.
	Mercury		The 2013–2015 estimated wet mercury deposition was moderate at the park, ranging from 6.8-7.2 micrograms per square meter per year. This deposition corresponds to a moderate concern condition. The level of confidence in the measure is medium because wet deposition estimates were based on interpolated data rather than in-park studies. Trend is unknown.
	Predicted Methylmercury Concentration		The predicted methylmercury concentration in park surface waters unknown. Therefore, the mercury/toxic condition, which normally combines wet mercury deposition and predicted methylmercury concentration, cannot be determined.
Overall Condition	Summary of All Measures		Overall, we consider air quality at the historic site to be of significant concern. Certain aspects, however, warrant moderate concern (i.e., haze index and human health ozone levels), and one is in good condition (e.g., wet sulfur deposition). Overall, confidence in the assessment is medium. The overall trend is unknown.

Note: Condition summary text was primarily excerpted from NPS-ARD (2016, 2018b).

for days, traveling potentially hundreds of miles before settling out of the atmosphere (Kinney 2008).

4.4.5. Sources of Expertise

The NPS Air Resources Division oversees the national air resource management program for the NPS. Together with parks and NPS regional offices, they monitor air quality in park units, and provide air quality analysis and expertise related to all air quality topics. Information and text for the assessment was obtained from the NPS-ARD website and provided by Jim Cheatham, Park Planning and Technical Assistance, ARD. The assessment was written by Lisa Baril, biologist and science writer at Utah State University.

4.5. Vegetation Communities

4.5.1. Background and Importance

Golden Spike National Historic Site (NHS) encompasses 1,107 ha (2,735.28 ac) (federal and private land) and occurs in the Great Basin's northeastern corner within the larger Basin and Range physiographic province (Coles et al. 2011). The historic site lies at a low point between Utah's Promontory Mountains and the North Promontory Mountains at an elevation ranging from 1,375 m (4,320 ft) to 1,609 m (5,280 ft) (Coles et al. 2011). Although at a low point relative to the surrounding landscape, Golden Spike NHS features hills, valleys, ridges, and even a small canyon; however, stream channels are almost entirely absent, except for a small reach of Blue Creek at the historic site's extreme eastern end (Coles et al. 2011).

Golden Spike NHS's semiarid climate supports sagebrush grasslands primarily composed of Basin big sagebrush (*Artemisia tridentata* var. *tridentata*), graystem rabbitbrush (*Chrysothamnus nauseosus* var. *gnaphalodes*), and purple three-awn (*Aristida purpurea*) (Fertig 2009). However, non-native plants are prevalent and include cheatgrass (*Bromus tectorum*), crested wheatgrass (*Agropyron cristatum*), and Scotch thistle (*Onopordum acanthium*) (Perkins 2017). The prevalence of non-native plants in the historic site is largely the result of 150 years of human disturbance (Coles et al. 2011). Agriculture and ranchlands that surround the historic site today also contribute to the spread of non-native plants thereby serving as source populations (NR-EPMT 2016). The quality, structure, and composition of vegetation is one of Golden Spike NHS's most significant management issues (Coles et al. 2011).

4.5.2. Data and Methods

We used one indicator (vegetation intactness) with three measures to assess vegetation communities in Golden Spike NHS. The three measures evaluate the degree to which plant communities represent natural conditions. The measures include the percent of vegetation mapped in the historic site that is considered natural; the ratio of non-native plants to total plant species; and vegetation condition class, which is a measure of departure from historic plant communities. Each of these measures is described in more detail below.

<u>Percent of Vegetation Mapped as Natural</u>

In 2007 the National Park Service's (NPS) Northern Colorado Plateau Network (NCPN) Inventory and Monitoring Program mapped vegetation in Golden Spike NHS (Coles et al. 2011). The NPS used NatureServe's ecological system classification as a framework for organizing plant community

Native needle-and-thread bunchgrass community in Golden Spike NHS. Photo Credit: NPS.

data. An ecological system is defined as "a group of plant associations from two or more alliances that tend to coexist in a given landscape due to similar ecologic processes, substrates, and/or environmental conditions" (Coles et al. 2011). Vegetation was mapped by using 1:12,000-scale, true color aerial imagery (Coles et al. 2011). Observers delineated vegetation communities based on distinctive signatures in the imagery and then visited these areas in the field to collect information on species, structure, and physiognomic characteristics (e.g., elevation, aspect, slope) (Coles et al. 2011). Based on these data, vegetation map classes, which include fine-scale vegetation associations and alliances, were defined for the historic site (Coles et al. 2011). From these data, we determined the proportion of the historic site's area that was dominated by native plant species as defined by the map classes.

Ratio of Non-native to Total Plant Species

Non-native plants were addressed in a separate assessment; however, we utilized data from that assessment to help interpret the naturalness of vegetation in Golden Spike NHS. In 2006, Fertig (2009) reviewed existing literature and museum specimens in order to develop a list of vascular plants for the historic site. The museum and literature review was supplemented by field work conducted during 2006-2007 to verify existing reports and to locate new species (Fertig 2009). Appendix A in Fertig (2009) lists all plants known to occur in the historic site as of 2007, including non-native species and the year in which they were first documented. In 2012, Fertig et al. (2012) published an update to the original annotated checklist, which included additional species identified during subsequent studies through 2011. We cross-referenced these lists with 2002 vegetation mapping project data (Monaco 2003), NCPN non-native plant data collected from 2008 to 2016 (Perkins and Weissinger 2009, Perkins 2011, Perkins 2013, Perkins 2015, and Perkins 2017), the NPSpecies list for the historic site (2018), and data reported by the Northern Rockies Exotic Plant Management Team (NR-EPMT) from 2006 to 2017 (NR-EPMT 2014, 2015, 2016, and 2017). Using these data, we determined the total plant species, both native and non-native, known to occur in the historic site. Note that data from the 2007 NPS Vegetation Inventory (Coles et al. 2011) were already incorporated into Fertig et al. (2012). We then calculated the ratio of non-native to total plant species.

Vegetation Condition Class

The Vegetation Condition Class (VCC) raster Version LF 1.4.0 for the contiguous U.S. was downloaded from the LANDFIRE website (LANDFIRE 2014). LANDFIRE is a multi-agency program that "provides landscape scale geospatial products to support cross-boundary planning, management, and operations" across the U.S. (LANDFIRE 2014). The VCC indicates the level at which the current vegetation has departed from historical reference conditions. The VCC layer was previously known as the Fire Regime Condition Class layer but was renamed to more accurately reflect the output (LANDFIRE 2014). VCC was derived from modeled reference conditions, a layer of biophysical settings, and modeled vegetation succession data (LANDFIRE 2014). Vegetation was classified into one of five departure categories from historical reference conditions as follows: low to moderate (17–33% departure), moderate to low (34–50% departure), moderate to high (51–66% departure), high (67–83% departure) and, very high (84–100% departure). Using these data, we determined the proportion of the historic site in each class.

4.5.3. Reference Conditions

Reference for measures in good, moderate concern, and significant concern conditions are included in Table 4.5.3-1.

4.5.4. Condition and Trend

Percent of Vegetation Mapped as Natural

Within eight ecological systems, 40 classes were mapped in the historic site, including 10 classes that were related to land use (e.g., structures, roads, railroads, corrals, and other features) (Table 4.5.4-1). For simplicity, we grouped these 10 land use classes as one class in Table 4.5.4-1. Eighteen of the 30 vegetation map classes were dominated by non-native species, and 93.3% of the total historic site's area was dominated by these non-native vegetation communities. Non-native species were so dominant in these classes, that many of them were named for the non-native species that occurred there. The most common map class was big sagebrush/cheatgrass (*Artemisia tridentata*/*Bromus tectorum*) shrubland, which represented 27.8% of the historic site's total area. Cheatgrass grassland was mapped across 21.9% of the site, crested wheatgrass-cheatgrass grassland was mapped over 14% of the unit's area, and cheatgrass-snakeweed (*Gutierrezia sarothrae)* disturbed vegetation was mapped over 13.3%. Together, these four map classes

Table 4.5.3-1. Reference conditions used to assess vegetation communities at Golden Spike NHS.

Indicators	Measures	Good	Moderate Concern	Significant Concern
Vegetation Intactness	Percent Vegetation Mapped as Natural	At least 70% of vegetation was mapped as natural.	Natural vegetation comprised 50% to 69% of all vegetation.	Less than 50% of the vegetation was mapped as natural.
	Ratio of Non-native to Total Plant Species	≤1:10 (≤10%)	1:10 (>10%) to <1:4 (<25%)	≥1:4 (≥25%)
	Vegetation Condition Class	Most of the historic site was mapped as low to moderate (17-33%) departure.	Most of the historic site was mapped as moderate to low (34-50) or moderate to high (51-66%) departure with few areas mapped as high (67-83%) or very high (84-100%) departure.	Most of the historic site was mapped as high (67-83%) or very high (81-100%) departure.

represented 77% of the historic site. None of the native vegetation communities represented more than 1.3% of Golden Spike NHS, and together they represented only 3.6% of the historic site with the remaining 3.1% mapped as non-vegetated areas. These results warrant significant concern. Confidence is medium because the map was created in 2007; however, long-term data on non-native plants in the historic site indicate that they continue to be widespread (Perkins 2017). Trend is unknown.

Ratio of Non-native to Total Plant Species

A total of 176 species have been documented in Golden Spike NHS, 61 of which are non-native (Table 4.5.4-2). The ratio of non-native species to total plant species is 7:20, or 35%. This falls within the significant concern condition rating. In the non-native plants assessment, we also examined the rate of non-native plant invasion over time based on the year in which a given species was first documented. Although the years do not necessarily, and probably don't, represent the year of introduction, the data provide an index to how the proportion of total plants that are non-native has changed over time. The results, which are further described in the non-native plants assessment, reveal that this proportion was between 31% and 35% for the last 26 years, which suggests an unchanging trend, possibly due to non-native species already filling most available niches at the historic site. Confidence is high because the baseline plant list developed by Fertig (2009) and Fertig et al. (2012) is continuously updated

Table 4.5.4-1. Vegetation map classes, total area, and percent of Golden Spike NHS.

Ecological System	Map Class Common Name	Total Area (ha (ac))	% Area	Dominated by Non-native Plants
Great Basin Pinyon-Juniper (*Pinus* spp.-*Juniperus* spp.)Woodland	Juniper/Cheatgrass (*Juniperus spp./Bromus tectorum*) Open Woodland	0.8 (2.0)	0.1	Yes
Rocky Mountain Lower Montane-Foothill Shrubland	Chokecherry (*Prunus* spp.) Shrubland	0.4 (1.1)	0.0	–
Inter-Mountain Basins Big Sagebrush (*Artemisia* spp.) Shrubland	Big Sagebrush/Bluebunch Wheatgrass (*Artemisia tridentata/Pseudoroegneria spicata*) Shrubland	15.3 (37.7)	1.3	–
	Big Sagebrush/Cheatgrass (*Artemisia tridentata/Bromus tectorum*) Shrubland	317.8 (785.3)	27.8	Yes
	Big Sagebrush/Crested Wheatgrass (*Artemisia tridentata/ Agropyron cristatum*) Shrubland	29.4 (72.8)	2.6	Yes
	Big Sagebrush/Curly Bluegrass (*Artemisia tridentata tridentata/Poa secunda*) Shrubland	0.1 (0.3)	0.0	–
	Big Sagebrush (*Artemisia tridentata*)/Floodplain Shrubland	4.4 (11.0)	0.4	–
	Big Sagebrush/Great Basin Wildrye *(Artemisia tridentata/ Leymus cinereus)* Shrubland	0.1 (0.3)	0.0	–
	Big Sagebrush/Tall Wheatgrass (*Artemisia tridentata/ Thinopyrum ponticum*) Shrubland	0.7 (1.8)	0.1	Yes

Source: Coles et al. (2011).

Table 4.5.4-1 continued. Vegetation map classes and area for Golden Spike NHS.

Ecological System	Map Class Common Name	Total Area (ha (ac))	% Area	Dominated by Non-native Plants
Inter-Mountain Basins Semi-Desert Shrub-Steppe	Matrimony Vine (*Lycium barbarum*) Shrubland	1.2 (2.9)	0.1	Yes
	Rubber Rabbitbrush/Cheatgrass (*Ericameria nauseosa/ Bromus tectorum*) Shrubland	38.0 (93.8)	3.3	Yes
	Rubber Rabbitbrush/Crested Wheatgrass (*Ericameria nauseosa/Agropyron cristatum*) Shrubland	0.7 (1.7)	0.1	Yes
	Yellow Rabbitbrush/Cheatgrass (*Chrysothamnus viscidiflorus/Bromus tectorum*) Shrubland	5.7 (14.1)	0.5	Yes
	Yellow Rabbitbrush (*Chrysothamnus viscidiflorus*)/Native Bunchgrass Shrubland	5.9 (14.5)	0.5	–
Inter-Mountain Basins Greasewood (*Sarcobatus* spp.) Flat	Great Basin Wildrye (*Leymus cinereus*) Grassland	0.5 (1.3)	0.0	–
Inter-Mountain Basins Wash	Greasewood (*Sarcobatus* spp.) Disturbed Shrubland	1.1 (2.8)	0.1	Yes
	Saltgrass - Squirreltail (*Distichlis spicata - Elymus elymoides*) Floodplain Grassland	0.5 (1.1)	0.0	–
	Tamarisk - Greasewood (*Tamarisk* spp. - *Sarcobatus* spp.) Floodplain Shrubland	1.1 (2.6)	0.1	Yes
Inter-Mountain Basins Semi-Desert Grassland	Annual Forbs Disturbed Vegetation	0.6 (1.5)	0.1	Yes
	Bluebunch Wheatgrass (*Pseudoroegneria spicata*) Grassland	23.8 (58.9)	2.1	–
	Cheatgrass (*Bromus tectorum*) - Native Bunchgrass Grassland	75.1 (185.5)	6.6	Yes
	Cheatgrass - Russian Thistle (*Bromus tectorum - Salsola* spp.) Disturbed Vegetation	1.0 (2.4)	0.1	Yes
	Cheatgrass - Snakeweed (*Bromus tectorum - Gutierrezia sarothrae*) Disturbed Vegetation	152.0 (375.5)	13.3	Yes
	Cheatgrass (*Bromus tectorum*) Grassland	250.6 (619.2)	21.9	Yes
	Crested Wheatgrass - Cheatgrass (*Agropyron cristatum - Bromus tectorum*) Grassland	160.3 (396.0)	14.0	Yes
Inter-Mountain Basins Cliff and Canyon	Curly Bluegrass (*Poa secunda*) Grassland	0.9 (2.1)	0.1	–
	Mixed Native Bunchgrass Grassland	0.1 (0.3)	0.0	–
	Needle-and-Thread (*Hesperostipa comata*) Grassland	12.0 (29.6)	1.0	–
Inter-Mountain Basins Cliff and Canyon	Tall Wheatgrass (*Thinopyrum ponticum*) Grassland	4.1 (10.1)	0.4	Yes
	Sparsely Vegetated Limestone Outcrop	3.9 (9.6)	0.3	–
Other (Land Use Features)	Roads, Structures, Borrow Pit etc.	35.7 (88.2)	3.1	–
Total	–	1,144 (2,826)	100	–

Source: Coles et al. (2011).

through NCPN surveys for non-native species and NR-EPMT control efforts.

Vegetation Condition Class

A majority (89.5%) of the historic site was mapped as moderate to low vegetation departure (34-50% departure) (Table 4.5.4-3). Only 0.2% and 1% of the historic site was mapped as high (67-83% departure) and moderate to high (51-66% departure) vegetation departure, respectively. The remaining portions of the site were mapped as burnable/non-burnable urban and agricultural areas; however, 9.3% of the historic site was mapped as agriculture, which is a 100% departure from natural conditions. In total, approximately 10% of the historic site was mapped as high or moderate to high vegetation departure when including these agricultural areas. These latter classes only comprised 9.3% of the historic site. Based on reference conditions,

Table 4.5.4-2. Non-native plant species documented in Golden Spike NHS.

Scientific Name	Common Name
Aegilops cylindrica	Jointed goatgrass
Agropyron cristatum	Crested wheatgrass
Alyssum alyssoides	Pale madwort
Alyssum desertorum	Desert madwort
Amaranthus albus	Tumble pigweed
Amaranthus blitoides[1]	Prostrate pigweed
Arabidopsis thaliana	Mouse-ear cress
Atriplex rosea	Tumbling orach
Asperugo procumbens[1]	Catchweed
Bassia prostrata[2]	Forage kochia
Bromus briziformis	Rattlesnake chess
Bromus diandrus	Ripgut brome
Bromus japonicus	Japanese chess
Bromus tectorum	Cheatgrass
Camelina microcarpa	Little-pod false flax
Cardaria draba	Whitetop
Carduus nutans	Musk thistle
Centaurea diffusa[1]	Diffuse knapweed
Chenopodium album[1]	Lambsquarters
Chondrilla juncea	Rush skeletonweed
Cirsium arvense	Canada thistle
Convolvulus arvensis	Field bindweed
Descurainia sophia	Flixweed
Draba verna	Spring whitlow-grass
Elymus hispidus[2]	Intermediate wheatgrass
Elymus elongatus (syn. *Thinopyrum ponticum* used in Monaco (2003)	Tall wheatgrass
Elymus repens	Quackgrass
Eremopyrum triticeum	Annual wheatgrass
Erodium cicutarium	Stork's-bill
Euclidium syriacum	Syrian mustard
Halogeton glomeratus	Halogeton
Holosteum umbellatum	Holosteum
Hordeum murinum	Rabbit barley
Isatis tinctoria[2]	Dyer's woad
Lactuca serriola	Prickly lettuce
Lepidium latifolium[3]	Perennial pepperweed
Lepidium perfoliatum	Clasping pepperwort
Linaria dalmatica	Dalmatian toadflax
Lycium barbarum	Matrimony-vine

[1] Species not listed in NPSpecies but that are confirmed for the historic site.

[2] Species listed in the literature for the historic site but have not been corroborated with a voucher specimen (Fertig 2009).

[3] Species listed as probably present in NPSpecies only.

Table 4.5.4-2 continued. Non-native plant species documented in Golden Spike NHS

Scientific Name	Common Name
Malcolmia africana	African mustard
Marrubium vulgare	Common horehound
Medicago sativa[1]	Alfalfa
Melilotus officinalis	Yellow sweet-clover
Onopordum acanthium	Scotch thistle
Poa bulbosa	Bulbous bluegrass
Poa pratensis	Kentucky bluegrass
Polygonum aviculare	Knotweed
Ranunculus testiculatus	Bur buttercup
Rumex crispus	Curly dock
Salsola paulsenii[2]	Barbwire Russian-thistle
Salsola tragus (syn. *S. kali* as reported in Monaco (2003)	Russian thistle
Sisymbrium altissimum	Tumble mustard
Tamarix ramosissima	Saltcedar
Taraxacum officinale	Common dandelion
Thlaspi arvense[1]	pennycress
Tragopogon dubius	Common salsify
Triticum aestivum	Wheat
Verbascum blattaria	Moth mullein
Verbascum thapsus	Common or wooly mullein
Veronica biloba	Two-lobe speedwell

[1] Species not listed in NPSpecies but that are confirmed for the historic site.

[2] Species listed in the literature for the historic site but have not been corroborated with a voucher specimen (Fertig 2009).

[3] Species listed as probably present in NPSpecies only.

these results warrant moderate concern. Trend is unknown. Although natural vegetation has declined over time with significant areas having been converted to agriculture and communities dominated by non-native plants, these changes occurred over a period of 150 years and have likely stabilized. Confidence is low because the data have not been ground-truthed.

Overall Condition and Trend, Confidence Level, and Key Uncertainties

Since 2007, more recent non-native plant surveys have been used to update Golden Spike NHS's vegetation map. While these updates may not be comprehensive, combined, the available data suggest significant concern is warranted (Table 4.5.4-4). Non-native plants are numerous and widespread, and vegetation appears to have shifted beyond the range of natural variation. Trend could only be determined for one of the three measures, the one measure suggested

Table 4.5.4-3. Proportion of Golden Spike NHS in each vegetation condition class.

Class Description (% Departure)	Proportion of Total Area
High (67-83%)	0.2
Moderate to High (51-66%)	1
Moderate to Low (34-50%)	89.5
Burnable Agriculture (n/a)	1.7
Burnable Urban (n/a)	3.1
Non-burnable Agriculture (n/a)	0.5
Non-burnable Urban (n/a)	4.0

unchanging conditions. Therefore, we did not assign an overall trend.

Confidence in the overall condition rating is medium because two of the three measures were assigned medium confidence. Factors that influence confidence in the condition rating include age of the data (<5 yrs unless the data are part of a long-term monitoring effort), repeatability, field data vs. modeled data, and whether data can be extrapolated to other areas in the historic site. The primary key uncertainty with the data used in this assessment is whether the 2007 vegetation maps represent current conditions.

Threats, Issues, and Data Gaps

Non-native species are the historic site's most significant threat to native vegetation. Historically, the landscape was dominated by native sagebrush-bunchgrass communities with a variety of forbs in the understory (Coles et al. 2011). Fire, which historically occurred every 0 to 35 years, maintained these sparse sagebrush shrublands (Bastian 2004). Sparse shrublands allowed for the growth of native forbs and grasses in the understory (Bastian 2004). However, fire suppression in the wake of European settlement increased sagebrush density and reduced the cover of native grasses and forbs (Coles et al. 2011), but introductions were more about overgrazing, drought and the lack of native, annual grasses (so, therefore, an open niche which allowed for the colonization of non-native species (Staver 2004, Schupp no date).

Cheatgrass is one of the historic site's most widespread and difficult to control non-native species because its seeds germinate during autumn and seedling roots grow throughout the winter when native plants are dormant (Summerhays 2011). Come spring, cheatgrass outcompetes native grasses for limited water and soil nutrients (Summerhays 2011).

Table 4.5.4-4. Summary of the vegetation community indicators, measures, and condition rationale.

Indicators of Condition	Measures	Condition/ Trend/ Confidence	Rationale for Condition
Vegetation Intactness	Percent Vegetation Mapped as Natural.		Fifteen of the 30 vegetation map classes were dominated by non-native species. Of the total historic site's area, 90.7% (93% of vegetated area) was mapped as one of these non-native plant communities. The most common non-native communities were big sagebrush/cheatgrass shrubland (27.8%), cheatgrass grassland (21.9%), crested wheatgrass-cheatgrass grassland (14%), and cheatgrass-snakeweed disturbed vegetation (13.3%). Only 6.2% of the historic site was mapped as natural. These results warrant significant concern, but confidence is medium since the mapping project occurred in 2007. Trend is unknown.
	Ratio of Non-native to Total Plant Species		Of the 176 vascular plant species known to occur in the historic site, 61 (35%) are non-native. This is a ratio of 7:20, which warrants significant concern. Confidence is high because the plant list was thoroughly researched and new plant species discoveries are published regularly through NR-EPMT and NCPN monitoring efforts. This ratio has remained relatively stable over the last 26 years. Thus, trend is unchanging.
	Vegetation Condition Class		A majority (89.5%) of the historic site was mapped as moderate to low vegetation departure, which corresponds to a 34% to 50% departure from natural conditions. These results warrant moderate concern, but because the data have not been ground-truthed, confidence is low and trend is unknown.
Overall Condition	Summary of All Measures		Overall, the results of these three measures of vegetation intactness indicate significant concern. Vegetation is the historic site's most significant management issue. Non-native plants are common and widespread and native vegetation is rare. A key uncertainty is how plant communities have changed since the mapping effort in 2007. The Northern Rockies Exotic Plant Management Team has, however, made progress in suppressing several non-native species of particular concern. We did not assign an overall trend because there were not sufficient data.

Furthermore, cheatgrass dries out by mid-June, which has implications for increased fire frequency and severity (Bastian 2004). Increased fire frequency reduces the soil seed bank of native species, whereas fire stimulates cheatgrass growth further exacerbating the effects of this invasive grass (Summerhays 2011).

Although any ecosystem or region is susceptible to invasion by non-native species, Golden Spike NHS's position in the landscape increases its vulnerability. The historic site is surrounded on all sides by private ranches with invasive plants that continue to recolonize the site despite control efforts (NR-EPMT 2016). Without the efforts of the NR-EPMT, however, these species would likely be more widespread. The NR-EPMT has treated non-native species at Golden Spike NHS since 2006 (NR-EPMT 2014). Eradicating Dyer's woad (*Isatis tinctoria*), suppressing rush skeletonweed (*Chondrilla juncea)*, and controlling Scotch thistle are the team's primary goals (NR-EPMT 2015). The NR-EPMT has also treated patches of Dalmatian toadflax (*Linaria dalmatica*), common mullein (*Verbascum thapsus*), moth mullein (*Verbascum blattaria*), whitetop (*Cardaria draba*), field bindweed (*Convolvulus arvensis*), perennial pepperweed (*Lepidium latifolium*), Canada thistle (*Cirsium arvense*), and quackgrass (*Elymus repens*) encountered while treating the primary species of concern. Russian thistle (*Salsola tragus*) was also treated in 2015 (NR-EPMT 2015). Many of these species appear to occur sporadically or in pulses with variation in weather patterns; however, the NR-EPMT estimated that both moth mullein and field bindweed are steadily increasing, and there is concern that these two species may come to dominate large portions of the historic site in the next 10 years (NR-EPMT 2016).

Climate change may increase the historic site's vulnerability to the introduction and spread of invasive species (Hellmann et al. 2008). The western U.S., and especially the Southwest, has experienced increasing temperatures and decreasing rainfall (Prein et al. 2016). Since 1974 there has been a 25% decrease in precipitation, a trend that is partially counteracted by increasing precipitation intensity (Prein et al. 2016). Monahan and Fisichelli (2014a) evaluated which of 240 NPS units have experienced extreme climate changes during the last 10-30 years. The results of this study for Golden Spike NHS were summarized in Monahan and Fisichelli (2014b). Extreme climate changes were defined as temperature and precipitation conditions exceeding 95% of the historical range of variability. The results for Golden Spike NHS indicate a trend toward warmer but not necessarily drier conditions (Monahan and Fisichelli 2014b). The cold winters may limit the growing season for some non-native species (Coles et al. 2011), but climate change could increase the historic site's favorability for invasive plants through direct effects or by shifting native species out of their ranges (Hellmann et al. 2008).

A study of plant response to climate change on the Colorado Plateau suggests that increased aridity will likely to lead to the loss of native grasses and the expansion of shrubs (Munson et al. 2011). In the case of Golden Spike NHS, non-native grasses dominate much of the native sagebrush communities, and native forbs and grasses are nearly absent (Monaco 2003). Once established, invasive plants can be extremely difficult to control and most will never be completely eradicated (Mack et al. 2014).

4.5.5. Sources of Expertise

Assessment author was Lisa Baril, Biologist and Science Writer, Utah State University. Sources of expertise include the reviewers listed in Appendix A.

4.6. Passey's Onion (*Allium passeyi*)

4.6.1. Background and Importance

Passey's onion (*Allium passeyi*) is a narrow endemic species that grows at an elevation of 1,400 m to 1,600 m (4,900 ft to 5,200 ft). It's a small perennial herb that is found on shallow, stony soils overlying ancient lake deposits, otherwise known as dolomitic limestone bedrock (NatureServe 2017). Winter and early spring moisture trapped in the bedrock supports growth and reproduction from March to June (NatureServe 2017).

Passey's onion was first discovered in 1964 by Howard Passey, a soil scientist for the Soil Conservation Service (now known as the Natural Resources Conservation Service), at a site near Golden Spike National Historic Site (NHS) (Boyce 1980). In 1980, Benjamin Boyce, a park technician, located and mapped three large populations in and around the historic site (Boyce 1980). Until Boyce's discovery in Golden Spike NHS, Passey's onion had only been known from the original location.

The Utah Native Plant Society lists Passey's onion as a watch list species (UNPS 2016). Watch list species are those that could become a species of concern if conditions change and populations decline or become threatened (UNPS 2016). In 2007, the U.S. Fish and Wildlife Service was petitioned to list Passey's onion as either threatened or endangered, but the species was ultimately not listed because of insufficient evidence linking threats to the species or its habitat (USFWS 2007, 2009). Although there are few known populations of Passey's onion within its range, one population consisted of more than 100,000 plants (UNPS 2016). Another colony was estimated to contain over a million individuals (Boyce 1980). However, threats to these populations are poorly understood (UNPS 2016).

4.6.2. Data and Methods

There have been several floristic surveys and studies at Golden Spike NHS, four of which specifically targeted Passey's onion (Boyce 1980, Phillips et al. 2008, Phillips et al. 2010, and Phillips et al. 2011). Boyce (1980) describes the discovery and population size of Passey's onion in the historic site, while the remaining studies compared three *Allium* species, including populations of Passey's onion in Golden Spike NHS, along an altitudinal gradient. The studies included a genetic comparison of three *Allium* species (Phillips et al. 2008), an analysis of germination characteristics for the three species (Phillips et al. 2010), and a study on the demography, reproduction, and dormancy by elevation for the three species (Phillips et al. 2011). For

Passey's onion specimens collected in 1960 (left) and 1980 (right). Photo Credits: © New York Botanical Garden (left) and © Utah State University (right).

the purposes of this assessment, we only included data on Passey's onion. A brief description of each study is provided below.

Boyce (1980)
In 1980, Boyce identified potential search areas in the historic site based on site descriptions provided by Holmgren (1974) and Welsh (1979) as cited in Boyce (1980). Based on known environmental growing conditions for Passey's onion, Boyce used topographic maps and soil surveys to identify search areas at the historic site. The author describes the habitat, colony size, and estimates of the population size for each colony. Boyce (1980) provided only coarse scale location information that identified colony location by section corners as identified by the Public Land Survey System. The area of a section corner measures approximately 16 ha (40 ac) (USGS 2018b). The section corners were mapped using Box Elder County's interactive mapping data (http://gis.boxeldercounty.org/) (Figure 4.6.2-1).

Phillips et al. (2008)
The purpose of the study was to describe genetic diversity within and among populations of Passey's onion. In 2005, leaf samples were collected from a site in Golden Spike NHS, from two sites on Anderson Hill in Box Elder County where the species was originally described, and from Blue Creek, also in Box Elder County (Figure 4.6.2-1). These locations represent an altitudinal gradient from low (Golden Spike NHS) to high (Blue Creek) (Table 4.6.2-1).

Phillips et al. (2010)
From 2003 to 2005, Phillips et al. (2010) studied the germination characteristics of Passey's onion along the three altitudinal gradients as previously described. The purpose of the experiment was to determine whether seed dormancy was correlated with elevation. The authors compared germination response to cold moist chilling at three different temperatures and seven chilling duration intervals. Seeds were chilled at -2°C (28°F), 3°C (37°F), and 8°C (46°F) for 0, 4, 8, 12, 16, 20, and 24 weeks. The effect of elevation was tested at 3°C (37°F) only. Results were examined by the proportion of total seeds that germinated by temperature, chilling duration, and elevation. Data from Golden Spike NHS plants were collected in 2005 only.

Table 4.6.2-1. Summary of Passey's onion in sampling sites during 2003 to 2006.

Site	Elevation Class	Elevation (m)
Golden Spike	Low	1,546
Anderson Hill	Mid	1,622
Blue Creek	High	1,744

Source: Phillips et al. (2011).

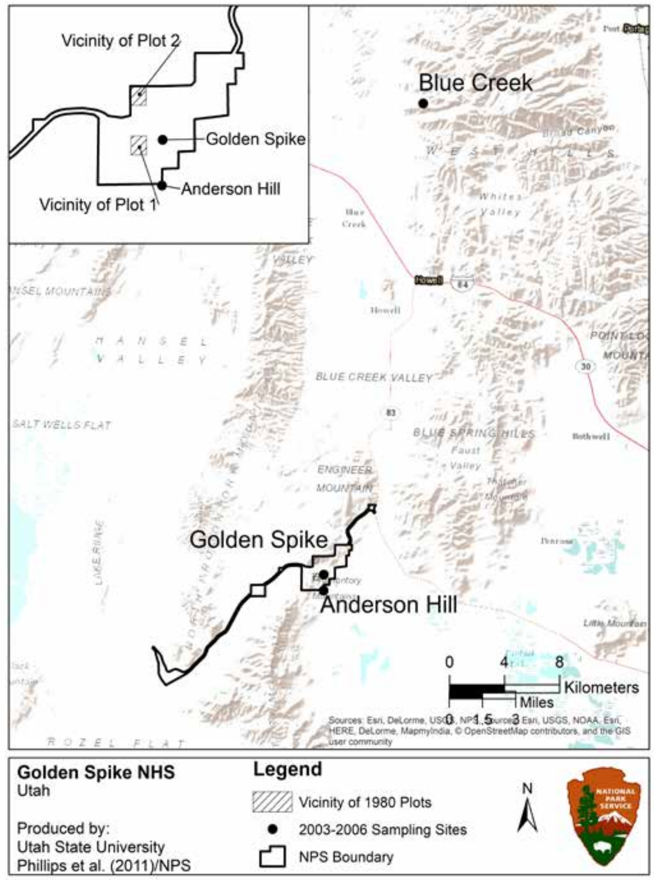


Figure 4.6.2-1. Passey's onion sampling locations in 1980 and the early 2000s.

Phillips et al. (2011)
The purpose of this study was to evaluate the demography, reproduction, and dormancy along an altitudinal gradient at the three sites described previously. Three plots were established at each elevation. Plots were either 0.5 m x 0.5 m (1.6 ft x 1.6 ft) or 1.0 m x 1.0 m (3.3 ft x 3.3 ft) depending on plant density (i.e., larger plots were used where plant densities were low). Within plots, observers counted the number of individuals, which were classified as either seedlings, juveniles or non-flowering plants, and reproductive adults based on the number of leaves and the presence/absence of flowers. Reproductive variables included the mean number of flowers per umbel, the fruit set (mean number of flowers per plant producing fruit), and an estimate of the number of seeds produced per square meter. Data were collected

every 7-10 days throughout the growing season. Ten plants in each plot were also tagged and monitored for time of emergence, growth, and leaf area. These plants were monitored every 7-10 days during the growth period and every 21-35 days during summer dormancy.

4.6.3. Reference Conditions

Although the four studies described in this assessment provide important information on the ecology of Passey's onion in and around Golden Spike NHS, they do not inform current condition. Reference conditions would ideally be based on a comparison of population size over time. While both Boyce (1980) and Phillips et al. (2011) provided population size estimates for Passey's onion in the historic site, they are not estimates for the same populations nor the same methods.

4.6.4. Condition and Trend

Boyce (1980)

Two Passey's onion colonies were located in and around the historic site. One of these colonies occurred along the historic site's border both within and outside of Golden Spike NHS. Both colonies were located above 1,463 m (4,800 ft). The author divided the two colonies into three plots for discussion purposes. Plot 1 occurred entirely within the historic site, while plots 2 and 3 occurred within and outside of the historic site, respectively. Plot 1 contained approximately 10,131 plants within a 493 m^2 area (5,307 ft^2) (Table 4.6.4-1). Plot 2 contained 211,275 plants within a 6,750 m^2 area (72,656 ft^2). The density of plants averaged 20.5 plants/m^2 (220.6 plants/ft^2) in plot 1 and 31.3 plants/m^2 (336.9 plants/ft^2) in plot 2. Colony size data were not reported for plot 3; however, the author estimated densities of 150-200 plants/m^2 (1,614-2,152 plants/ft^2) in plot three and as many as a million individuals.

Plots were largely bare of other vegetation, and soils were described as thin (0 to 16 cm [0 - 6 in]) and composed of weathered limestone on the Sandall soil series. The Sandall soil series is "part of the loamy-skeletal carbonatic, mesic family..." Boyce (1980). Although there were few other plants in the plots, Boyce (1980) observed big sagebrush (*Artemisia tridentata*) growing on the fringes of the colonies with several small individuals growing within the colonies. Non-native and invasive cheatgrass (*Bromus tectorum*) was also found growing throughout the plots. Lastly, the author noted that not all plants appeared to flower every year, with many plants that showed leaf growth but no evidence of reproduction.

Table 4.6.4-1. Summary of Passey's onion in Golden Spike NHS during 1980.

Plot	Elevation (m)	Patch Area (m^2)	Population Size
Plot 1	1,524-1,533	493	10,131
Plot 2	1,554-1,615	6,750	211,275

Source: Boyce (1980).

Phillips et al. (2008)

Data from the genetic study indicated that asexual propagation, although possible for Passey's onion, likely played a minor role in reproduction. Within-population genetic variation in Passey's onion accounted for 83% of total variation, while among population genetic variation accounted for only 17% of total variation. Between population variation was likely the result of isolation and distance, but populations separated by at least 1.0 km (0.6 mi) were genetically very similar, indicating good gene flow between populations.

Phillips et al. (2010)

For all three temperatures, the proportion of seeds that germinated increased with the number of weeks of moist chilling; however, 3°C (37°F) produced the best germination results (Table 4.6.4-2). Although 3°C (37°F) was the most favorable temperature for germination, seeds were also capable of germinating at -2°C, which suggests that even under colder conditions, at least some Passey's onion seeds survive. These results indicate that Passey's onion seeds require at least 16 weeks at 3°C (37°F) for the majority of seeds to break dormancy, and that a dormant period of at least 24 weeks produces the best germination results. However, at least a portion of seeds in each population were non-dormant.

Table 4.6.4-2. Proportion of seeds that germinated by temperature and number of weeks of moist chilling.

Chilling Temperature (°C)	Number of Continuous Chilling Weeks						
	0	4	8	12	16	20	24
-2	13	3a	6ab	5b	9ab	11ab	21a
3	–	7e	23d	43c	57b	85a	88a
8	–	10b	15b	15b	21b	31a	35a

Note: Within each row, mean germination values followed by the same letters were not significantly different (Tukey's HSD alpha = 0.05). Data were arsine transformed prior to pairwise comparisons.

Source: Phillips et al. (2010).

At all three elevations, the proportion of seeds that germinated increased with the number of weeks of moist chilling (Table 4.6.4-3). However, among the three elevation classes, the low elevation site at Golden Spike NHS produced the highest germination rates with the fewest number of weeks of cold chilling. This suggests that the proportion of non-dormant seeds at low elevation sites is greater than at high elevation sites. In fact, the proportion of non-dormant seeds collected declined with increasing elevation from about 24% at the lowest site (Golden Spike NHS) to 7% at the highest site (Blue Creek). Note that none of the seeds germinated from low or mid elevation sites in 2004. Thus, only the high elevation site could be compared across the two years. The authors suggest that in sites with long, predictable winters there is a higher level of selection against the trait for non-dormant seeds. Seed dormancy is an adaptation for species occurring in areas with a predictable seasonal climate (Phillips et al. 2008).

Table 4.6.4-3. Proportion of seeds that germinated at 3° C by elevation and weeks of moist chilling.

Elevation	Number of Continuous Chilling Weeks						
	0	4	8	12	16	20	24
Low (2004)	–	–	–	–	–	–	–
Low (2005)	24c	36bc	40bc	68a	68a	72a	72a
Mid (2004)	–	–	–	–	–	–	–
Mid (2005)	19cd	6d	24bcd	54ab	48abc	59a	60a
High (2004)	6c	4c	12c	17c	44b	77a	60ab
High (2005)	8b	5b	68a	73a	63a	72a	71a

Note: Within each row, mean germination values followed by the same letters were not significantly different (Tukey's HSD alpha = 0.05). Data were arsine transformed prior to pairwise comparisons.

Source: Phillips et al. (2010).

Phillips et al. (2011)

Population size was smaller at the low elevation site, an estimated 6,894 plants, (Golden Spike NHS) when compared to 48,620 plants at the high elevation site (Blue Creek) (Table 4.6.4-4). Not surprisingly, Passey's onion flowered earlier at Golden Spike NHS (low elevation) than plants at mid or high elevation sites, but there was no difference in flowering date for mid and high elevation sites within years sampled. In Golden Spike NHS, the average flowering date in 2004 was June 10, but plants failed to flower at the historic site in 2005, and at the mid-elevation site only a few individuals flowered (Table 4.6.4-4).

In general, the high elevation population exhibited a greater mean number of flowers per umbel and seed set compared to low and mid elevation sites (Table 4.6.4-4). The percent of flowers setting seed averaged 73.8% at the high elevation site compared to 32.0% and 47.1% at the mid and low elevation sites, respectively. The timing of leaf growth and senescence, on the other hand, showed little variation with elevation. Another difference among the populations was that leaves emerged two weeks later in the high elevation population (March 31) than the other two sites (March 13). Plants were dormant by June 21 at all three sites. Another key difference in growth was that leaf area increased with increasing elevation from 476 mm^2 (0.7 in^2) at the low elevation site in Golden Spike NHS, to 590 mm^2 (0.9 in^2) at the mid-elevation site, and 758 mm^2 (1.2 in^2) at the high elevation site.

Overall Condition and Trend, Confidence Level, and Key Uncertainties

There were no current data with which to assess Passey's onion, although the data presented in this assessment provide good baseline information for future comparisons (Table 4.3.4-2). As a result, the condition and trend were unknown and confidence was low. A key uncertainty is whether populations of Passey's onion at Golden Spike NHS remain as robust

Table 4.6.4-4. Summary of Passey's onion demographics.

Elevation Class	Population Size (# plants)	Flowering Date	Flowers/Umbel (SD)	Fruit Set (SD)	Seeds/m^2
Low (2004)	6,894	–	–	–	–
Low (2005)	–	June 10	17.0 (2.52)	8.0 (3.51)	192
Mid (2004)	26,879	June 16	16.5 (2.50)	2.5 (2.50)	40
Mid (2005)	–	June 27	17.3 (1.31)	8.3 (1.97)	264
High (2004)	48,620	June 16	23.0 (2.10)	17.8 (1.60)	118
High (2005)	–	June 27	19.7 (1.30)	13.9 (1.49)	1,464

Source: Phillips et al. (2011).

Table 4.6.4-5. Summary of Passey's onion indicators, measures, and condition rationale.

Indicators	Measures	Condition/ Trend/ Confidence	Rationale for Condition
Overall Condition	Summary of Measure		In 1980 there were two Passey's onion colonies in Golden Spike NHS numbering in the tens to hundreds of thousands. In 2004, an estimate for one colony in the historic site numbered in the thousands. Although lower than the 1980s estimates, these populations are not located in the same areas. While studies from the early 2000s provide valuable natural history data, there were no current data with which to assess Passey's onion in Golden Spike NHS. The condition and trend at this time is unknown. Because the condition is unknown, confidence is low.

as they were in 1980. In 2004-2005, the population sampled in the historic site was estimated at 6,894 plants. This figure is substantially lower than colony sizes reported by Boyce (1980), but because the same colonies have not been surveyed over time using the same methods, determining population change was not possible.

Threats, Issues, and Data Gaps

NatureServe classified Passey's onion as a globally imperiled species (G1), but this assessment is based on the assumption that it is endemic to Box Elder County (NatureServe 2017).

Passey's onion appears to be restricted to an unusual microhabitat, growing in dense stands on seasonally moist shallow lithographic soils in rocky areas (NatureServe 2017), and there have not been any additional populations of Passey's onion located more than approximately 64 km (40 mi) from the epicenter of the currently known range. Although, this species is threatened by grazing and possibly recreational vehicles (UNPS 2016), NatureServe (2017) states that there are few other threats. Although this assumption may not be accurate, it is encouraging that the geographic range over which Passey's onion occurs is larger than originally thought.

Some possible threats include invasive plants and climate change. The introduction and spread of invasive plants is influenced by road corridors, trails, and disturbances. The non-native plants assessment in this report reveals that at least 61 non-native species occur in the historic site. Cheatgrass is particularly widespread (Perkins 2017). Boyce (1980) noted the prevalence of cheatgrass within Passey's onion colonies, but the effects of cheatgrass and other non-native species on Passey's onion are unknown.

Climate change could also change the historic site's favorability for Passey's onion. Monahan and Fisichelli (2014a) evaluated which of 240 NPS units have experienced extreme climate changes during the last 10-30 years. Extreme climate changes were defined as temperature and precipitation conditions exceeding 95% of the historical range of variability. The results for Golden Spike NHS indicated a trend toward warmer but not necessarily drier conditions (Monahan and Fisichelli 2014b). However, warmer temperatures may increase the rate of evapotranspiration and deplete the sources of water trapped in bedrock on which Passey's onion depends. Warmer temperatures could also change the proportion of seeds that germinate in a given year, and may eventually lead to loss of the soil seed bank. The most recent studies in this assessment were conducted during drought conditions, but it is unknown how drought conditions affected the results.

Given that there are no current data for Passey's onion, the resource itself is considered a data gap. Knowledge regarding the current location and abundance of Passey's onion in the historic site is lacking, and more work is needed to evaluate the condition for Passey's onion at Golden Spike NHS.

4.6.5. Sources of Expertise

Assessment author was Lisa Baril, Biologist and Science Writer, Utah State University. Sources of expertise include the reviewers listed in Appendix A.

4.7. Non-native and Invasive Plants

4.7.1. Background and Importance

Vegetation in Golden Spike National Historic Site (NHS) is dominated by sagebrush grasslands that are primarily composed of Basin big sagebrush (*Artemisia tridentata* var. *tridentata*), graystem rabbitbrush (*Chrysothamnus nauseosus* var. *gnaphalodes*), and purple three-awn (*Aristida purpurea*) (Cole et al. 2011). However, non-native plants are common, especially in disturbed areas. Cheatgrass (*Bromus tectorum*), crested wheatgrass (*Agropyron cristatum*), and tumble mustard (*Sisymbrium altissimum*) are some of the most common non-native species (Perkins 2017). Although the area surrounding the historic site is sparsely populated, Golden Spike NHS has been subject to significant anthropogenic disturbances in the past (Coles et al. 2011). Over the last 150 years, human activities in the historic site, mostly associated with construction of the railroad, grazing, and agricultural activities have contributed to the introduction and spread of non-native plants there (Coles et al. 2011).

In areas outside the historic site, non-native species have been directly linked to the replacement of dominant native species (Tilman 1999), the loss of rare species (King 1985), changes in ecosystem structure, alteration of nutrient cycles and soil chemistry (Ehrenfeld 2003), shifts in community productivity (Vitousek 1990), reduced agricultural productivity, and changes in water availability (D'Antonio and Mahall 1991).

The damage caused by non-native plants to natural resources is often irreparable. Non-native species are second only to habitat destruction as a threat to wildland biodiversity (Wilcove et al. 1998). Consequently, the dynamic relationships among plants, animals, soil, and water established over many thousands of years are at risk of being destroyed in a relatively brief period. For the National Park Service (NPS), the consequences of these invasions present a significant challenge to the management of the agency's natural resources "unimpaired for the enjoyment of future generations" (NPS 2006). NPS units, like land managed by other organizations, are deluged by new non-native species arriving through predictable (e.g., road, trail, and riparian corridors), sudden (e.g., long-distance dispersal through cargo containers and air freight), and unexpected anthropogenic pathways (e.g., weed seeds in restoration planting mixes).

Nonnative plants claim an estimated 1,862 ha (4,600 ac) of public land each year in the United States (Asher and Harmon 1995), significantly altering local flora. For example, non-native plants comprise an estimated 43% and 36% of the flora of the states of Hawaii and New York, respectively (Rejmanek and Randall 1994). Non-native plants infest an estimated 1 million ha

Non-native cheatgrass interspersed with sagebrush in Golden Spike NHS. Photo Credit: NPS.

(2.6 million ac) of the 33.5 million ha (83 million ac) managed by the NPS (Welch et al. 2014). Prevention and early detection are the principal strategies for successful invasive non-native plant management.

4.7.2. Data and Methods

We used three indicators, with a total of five measures, to determine the current condition of non-native plants at Golden Spike NHS (Table 4.7.2-1). The indicators we used included rate of invasion (one measure), potential to alter native plant communities (one measure), and prevalence of non-native plants (three measures). We relied on several studies to evaluate these measures. Although not the first effort, Fertig (2009) published a comprehensive checklist of vascular flora for the historic site in 2009 and an update to the checklist in 2012 (Fertig et al. 2012). In 2002 Monaco (2003) examined vegetation dynamics within the historic site, in addition to conducting a wildfire risk assessment based on the occurrence of non-native plants (Monaco 2004). In 2007 the NPS Vegetation Inventory Program completed a comprehensive vegetation map of the site (Coles et al. 2011), and since 2008 the NCPN has monitored and mapped select non-native invasive plants there (Perkins 2017). Lastly, the NPS Northern Rocky Mountain Exotic Plant Management Team (NRM-EPMT) has treated a subset of non-native and invasive plants at Golden Spike NHS since 2006 with a management focus of keeping new invaders from becoming established.

<u>New Non-native Plants Detected</u>

In 2006, Fertig (2009) reviewed existing literature and museum specimens to develop a list of vascular plants for the historic site. The museum and literature review was supplemented by field work conducted during 2006-2007 to verify existing reports and to locate new species (Fertig 2009). Appendix A in Fertig (2009) lists all plants known to occur in the historic site as of 2007, including non-native species and the year in which they were first documented. In 2012, Fertig et al. (2012) published an update to the original annotated checklist, which included additional species identified during subsequent studies through 2011. We cross-referenced these lists with Monaco (2003), NCPN non-native plant data collected from 2008 to 2016, and NRM-EPMT control data collected from 2006 to 2017. Note that data from the NPS Vegetation Inventory (Coles et al. 2011) were already incorporated into Fertig et al. (2012).

Table 4.7.2-1. Summary of indicators and their measures.

Indicators	Measures
Rate of Invasion	New Non-native Species
Potential to Alter Native Plant Communities	NatureServe Invasive Species Impact Rank
Prevalence	Patch Dynamics, Frequency, Cover

All species were cross-referenced for synonyms in the USDA Plants database (USDA 2018) to ensure that each species was only counted once. If two species were referred to by synonyms in different reports, we included both names. We cross-referenced this final list with NPSpecies to determine which, if any, species had been reported for the historic site but were not listed by any of the sources used to create the initial list (NPS 2018). The rate of invasion was calculated as the proportion of cumulative plant species documented by decade that are considered non-native.

<u>NatureServe Invasive Species Impact Rank</u>

The NatureServe database (NatureServe Explorer 2018), which is based on the Invasive Species Assessment Protocol developed by Morse et al. (2004), is a ranking system that categorizes and lists non-native plants for large areas, such as regions (e.g., Great Plains) or states (e.g., Utah) according to their overall impact on native biodiversity. The invasiveness rank protocol assesses four major categories for each species (ecological impact, current distribution and abundance, trend in distribution and abundance, and management difficulty) for a total of 20 questions (Morse et al. 2004). A subrank score is developed for each category then an overall Invasive Species Impact Rank or I-Rank score is developed for each species. Based upon the I-Rank value, each species is then placed into one of four categories: species that cause high, medium, low, or insignificant negative impacts to native biodiversity within the area of interest (Morse et al. 2004). We used the rounded I-Rank if a species was split between two rankings (e.g., high/medium), unless the rounded I-Rank was unknown. Rounded I-Ranks usually occurred when a species was split between two categories that were not near each other in the ranking system (e.g., high/low). We also identified species known to occur at the historic site that were listed as noxious by the Utah Department of Agriculture and Food (UDAF 2017) and those considered priority species targeted by the NCPN for monitoring in 2016 (Perkins 2017).

Patch Dynamics, Frequency, Cover

Although patch size and number, frequency, and percent cover are separate measures, all three were collected during NCPN non-native plant monitoring surveys. NCPN staff monitored non-native plants in Golden Spike NHS in 2008, 2010, 2012, 2014, and 2016. The purpose of these surveys was to monitor Priority Invasive Exotic Plants (IEPs) in the historic site for changes over time in existing species and to detect new arrivals (Perkins 2017). The NCPN developed a list of IEPs in 2008 and have refined this list prior to each survey effort since then. As of 2016, there were 24 species and genera on the list (Table 4.7.2-2). Not all species on the list occur in Golden Spike NHS. The purpose of limiting the non-native plants surveyed to a subset of existing and potential species is to maximize efficiency and accuracy for detecting the species of greatest concern to managers, including new arrivals. Non-target species were also sometimes recorded, but since species not on the list were not consistently recorded, we restricted this analysis to only target species or non-target species that were specifically identified and consistently surveyed (Perkins 2017).

Table 4.7.2-2. The 2016 priority invasive exotic plant species list developed by the NCPN.

Species	Common Name
Cardaria sp.	Whitetop
Carduus nutans	Musk thistle
Centaurea diffusa	Diffuse knapweed
Centaurea maculosa	Spotted knapweed
Centaurea repens	Russian knapweed
Centaurea solstitialis	Yellow starthistle
Centaurea virgata	Squarrose knapweed
Chondrilla juncea	Rush skeletonweed
Cirsium arvense	Canada thistle
*Convolvulus arvensis**	Field bindweed
Crupina vulgaris	Common crupina
Elymus repens	Quackgrass
Euphorbia esula	Leafy spurge
Hypericum perforatum	Common St. John's wort
Isatis tinctoria	Dyer's woad
Lepidium latifolium	Broad-leaf pepperwort
Linara dalmatica	Dalmatian toadflax
Marrubium vulgare	Horehound
Onopordum acanthium	Scotch thistle
Salvia aethiopsis	Mediterranean sage
Senecio jacobaea	Tansy ragwort
Taeniatherum caput-medusae	Medusahead
Tribulus terrestris	Puncturevine
Verbascum blattaria	Moth mullein

* Not on list in 2010-2012.

Source: Perkins (2017).

Priority IEPs were surveyed by the NCPN along monitoring routes and in quadrats established along transects located on monitoring routes. Quantitative data such as frequency and percent cover were collected in quadrats, while the monitoring routes were surveyed to increase the spatial coverage for detecting IEPs. The same 12 monitoring routes were surveyed each year for a total distance per year of 19.5 km (12.1 mi) except in 2008 (26.7 km [16.6 mi]) and 2010 (16.1 km [10.0 mi]). All primary pathways for invasion (i.e., roads, trails, and major drainages) were surveyed for the target species. The number of patches and patch size data were collected along monitoring routes in one of five size classes as follows:

1. One to a few plants (used for isolated single plants or very small patches (≤ 2 m^2 [22 ft^2]),
2. A few plants roughly 40 m^2 (431 ft^2),
3. 40-400 m^2 (431-4,306 ft^2),
4. 400-1,00 m^2 (4,306-10,764 ft^2),
5. 1,000-2,000 m^2 (10,764-21,528 ft^2).

Transects were established every 0.5 km (0.3 mi) along monitoring routes, and three, 1.0-m^2 (10.8 ft^2) quadrats were established along each transect. However, if no Priority IEPs were observed for three consecutive transects, then transects were established every 1.0 km (0.6 mi). Thus, the number of transects and quadrats varied by year from 32 transects and 96 quadrats in 2010 to 40 transects and 120 quadrats in 2014. Percent cover data in quadrats were collected in one of the following cover classes: <1, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11-25, 26-50, or >50%. Frequency data were collected for the Priority IEPs across all quadrats. Monitoring methods differed slightly in 2008, whereby all invasive species were recorded and quadrats were embedded in 177 m^2 (1,905 ft^2) macroplots centered 5 m (16 ft) from the monitoring route (Perkins 2017). For further details refer to Weissinger and Perkins 2009 and Perkins 2011, 2013, 2014, and 2017. Additionally, the IEP protocol is summarized in Perkins et al. (2016).

4.7.3. Reference Conditions

Table 4.7.3-1 summarizes the condition thresholds for measures in good condition, those warranting moderate concern, and those warranting significant concern.

4.7.4. Condition and Trend

New Non-native Plants Detected

By 1975 only one species had been reported for Golden Spike NHS. The area was designated as a national historic site in 1957, transferred to the NPS in 1965, and expanded to its current size in 1980 (NPS 2017). The relatively recent addition of this unit to the NPS is consistent with the lack of early non-native plant detections there. A total of 176 species have been documented and reported for the historic site, including 61 non-native species (Table 4.7.4-1). Overall, non-native species currently represent about 35% of the park's total flora. All but three non-native species and six native species are corroborated with voucher specimens.

The total number of species documented in the site rose dramatically in the 1990s with two separate studies of the historic site's flora. These were the most extensive studies to have occurred by that time. By 1999 more than half (59%) of the non-native species known to occur in the unit had been documented (Figure 4.7.4-1). From 2000 to 2016, 24 new non-native species were documented for the historic site. Although the rate of invasion has remained relatively stable over the last 26 years (since about 1990), the proportion of total plant species that are non-native is relatively high at 31% to 35% for each of the last three decades, especially considering that only data from 2010 to 2016 are included in the last decade. Diffuse knapweed (*Centaurea diffusa*), discovered in 2016, is the most recent addition to the historic site (Perkins 2017), but quackgrass (*Elymus repens*), perennial pepperweed (*Lepidium latifolium*), and pennycress (*Thlaspi arvense*) are also recent additions (i.e., 2015).

There were several non-native species that were first reported as new non-native species in Fertig (2009), Coles et al. (2011), Fertig et al. (2012), Weissinger and Perkins (2009), and in Monaco (2003) (as cited by NRM-EPMT), including jointed goatgrass (*Aegilops cylindrica*) and knotweed (*Polygonum aviculare*). Several native species were also originally reported by Monaco (2003). Additionally, intermediate wheatgrass (*Elymus hispidus*) was first reported in 1995 by Fertig (2009) but reported as a new species in 2008 by Perkins and Weissinger (2009). Clasping pepperwort (*Lepidium perfoliatum*) was first confirmed in 1994 as

Table 4.7.3-1. Reference conditions used to assess non-native plants.

Indicators	Measures	Good	Moderate Concern	Significant Concern
Rate of Invasion	New Non-native Plants Detected (%)	The rate of new non-native plant discoveries has remained stable or has declined. Furthermore, the rate of invasion is relatively low (i.e., < 1-3 %).	The rate of new non-native plant discoveries has remained stable but is modest (i.e., 4-6%) and/or the rate has increased modestly over time.	The rate of new non-native plant discoveries has remained stable but exceeds 5% and/or has increased substantially over time.
Potential to Alter Native Plant Communities	NatureServe Invasive Species Impact Rank	No non-native species with a high innate ability to alter ecosystem structure and function and/or only a few species with a medium or low ability to alter ecosystem structure and function are present.	Many non-native species with medium and/or one or two species with a high ability to alter ecosystem structure and function are present.	Many non-native species with medium and/or many species with high ability to alter ecosystem structure and function are present.
Prevalence	Patch Dynamics	The number and size of priority invasive species patches is relatively low has declined or remained stable over time.	The number and size of priority invasive species patches is intermediate and/or has increased modestly over time.	The number and size of priority invasive species patches is relatively high and/or has increased substantially over time.
	Frequency by Vegetation Type or Area (% of plots)	<25%	25-50%	>50%
	Cover by Vegetation Type or Area (%)	<1%	1-4%	>4%

Table 4.7.4-1. Non-native plant species documented in Golden Spike NHS.

Scientific Name	Common Name	NatureServe Invasive Species Impact Rank	Year Documented	2016 NCPN Priority Species	Source
Aegilops cylindrica	Jointed goatgrass	Medium/Insignificant	2002	–	Monaco (2003)
Agropyron cristatum	Crested wheatgrass	Not Assessed	1994	–	Fertig (2009)
Alyssum alyssoides	Pale madwort	Not Assessed	1994	–	Fertig (2009)
Alyssum desertorum	Desert madwort	Not Assessed	1995	–	Fertig (2009)
Amaranthus albus	Tumble pigweed	Not Assessed	2006	–	Fertig (2009)
Amaranthus blitoides[1]	Prostrate pigweed	Not Assessed	2002	–	Monaco (2003)
Arabidopsis thaliana	Mouse-ear cress	Not Assessed	1995	–	Fertig (2009)
Atriplex rosea	Tumbling orach	High/Low	2006	–	Fertig (2009)
Asperugo procumbens[1]	Catchweed	Not Assessed	2002	–	Monaco (2003)
Bassia prostrata[2]	Forage kochia	Low	2005	–	Fertig (2009)
Bromus briziformis	Rattlesnake chess	Insignificant	1995	–	Fertig (2009)
Bromus diandrus	Ripgut brome	Not Assessed	1995	–	Fertig (2009)
Bromus japonicus	Japanese chess	Not Assessed	1994	–	Fertig (2009)
Bromus tectorum	Cheatgrass	High	1994	–	Fertig (2009)
Camelina microcarpa	Little-pod false flax	Not Assessed	2010	–	Perkins (2011)
Cardaria draba	Whitetop	Not Assessed	2015	X	EPMT (2015)
Carduus nutans	Musk thistle	High/Low	2008	X	Perkins and Weissinger (2009)
Centaurea diffusa[1]	Diffuse knapweed	High	2016	X	Perkins (2017)
Chenopodium album[1]	Lambsquarters	Not Assessed	2002	–	Monaco (2003)
Chondrilla juncea	Rush skeletonweed	Medium/Insignificant	2014	X	EPMT (2014)
Cirsium arvense	Canada thistle	High	2008	X	Perkins and Weissinger (2009)
Convolvulus arvensis	Field bindweed	Medium	1995	X	Fertig (2009)
Descurainia sophia	Flixweed	Medium	1994	–	Fertig (2009)
Draba verna	Spring whitlow-grass	Low	1995	–	Fertig (2009)
Elymus hispidus[2]	Intermediate wheatgrass	Medium/Insignificant	1995	–	Fertig (2009)
Elymus elongatus (syn. *Thinopyrum ponticum* used in Monaco (2003))	Tall wheatgrass	Low	1995	–	Fertig (2009)
Elymus repens	Quackgrass	High	2015	X	EPMT (2015)
Eremopyrum triticeum	Annual wheatgrass	Not Assessed	1975	–	Fertig (2009)
Erodium cicutarium	Stork's-bill	Medium	1994	–	Fertig (2009)
Euclidium syriacum	Syrian mustard	Not Assessed	1995	–	Fertig (2009)
Halogeton glomeratus	Halogeton	High	1994	–	Fertig (2009)
Holosteum umbellatum	Holosteum	Not Assessed	1995	–	Fertig (2009)
Hordeum murinum	Rabbit barley	High/Low	1994	–	Fertig (2009)
Isatis tinctoria[2]	Dyer's woad	High/Low	1995	X	Fertig (2009)
Lactuca serriola	Prickly lettuce	Low	1995	–	Fertig (2009)
Lepidium latifolium	Perennial pepperweed	High	2015	X	EPMT (2015)
Lepidium montanum[1]	Clasping pepperweed	Not Assessed	2002	–	Monaco (2003)
Lepidium perfoliatum	Clasping pepperwort	Low	1994	–	Fertig (2009)

[1] Species that are not listed by NPSpecies but are confirmed for the historic site.

[2] Species listed in the literature for the park but have not been corroborated with a voucher specimen (Fertig 2009).

Note: X = species present.

Table 4.7.4-1 continued. Non-native plant species documented in Golden Spike NHS.

Scientific Name	Common Name	NatureServe Invasive Species Impact Rank	Year Documented	2016 NCPN Priority Species	Source
Linaria dalmatica	Dalmatian toadflax	Not Assessed	2002	X	Monaco (2003)
Lycium barbarum	Matrimony-vine	Not Assessed	1995	–	Fertig (2009)
Malcolmia africana	African mustard	Not Assessed	1995	–	Fertig (2009)
Marrubium vulgare	Common horehound	Medium	1994	X	Fertig (2009)
Medicago sativa[1]	Alfalfa	Insignificant	2002	–	Monaco (2003)
Melilotus officinalis	Yellow sweet-clover	Medium	1995	–	Fertig (2009)
Onopordum acanthium	Scotch thistle	Not Assessed	2002	X	Monaco (2003)
Poa bulbosa	Bulbous bluegrass	Not Assessed	1994	–	Fertig (2009)
Poa pratensis	Kentucky bluegrass	Medium	1994	–	Fertig (2009)
Polygonum aviculare	Knotweed	Low	2002	–	Monaco (2003)
Ranunculus testiculatus	Bur buttercup	Not Assessed	1995	–	Fertig (2009)
Rumex crispus	Curly dock	Low	1995	–	Fertig (2009)
Salsola paulsenii[2]	Barbwire Russian-thistle	Low	1994	–	Fertig (2009)
Salsola tragus (syn. *S. kali* as reported in Monaco (2003))	Russian thistle	Not Assessed	1995	–	Fertig (2009)
Sisymbrium altissimum	Tumble mustard	Not Assessed	1994	–	Fertig (2009)
Tamarix ramosissima	Saltcedar	High	2002	–	Monaco (2003)
Taraxacum officinale	Common dandelion	Not Assessed	1995	–	Fertig (2009)
Thlaspi arvense[1]	pennycress	Low	2015	–	EPMT (2015)
Tragopogon dubius	Common salsify	Medium	1995	–	Fertig (2009)
Triticum aestivum	Wheat	Not Assessed	1995	–	Fertig (2009)
Verbascum blattaria	Moth mullein	Not Assessed	2002	X	Monaco (2003)
Verbascum thapsus	Common or wooly mullein	Medium	1995	–	Fertig (2009)
Veronica biloba	Two-lobe speedwell	Not Assessed	2006	–	Fertig (2009)

[1] Species not listed in NPSpecies but that are confirmed for the historic site.

[2] Species listed in the literature for the historic site but have not been corroborated with a voucher specimen (Fertig 2009).

Note: X = species present.

reported in Fertig (2009) but was reported as a new species by Perkins and Weissinger (2009) in 2008. Table 4.7.4-1 reflects the earliest report for each species.

We cross-referenced the species listed in Table 4.7.4-1 with NPSpecies. NPSpecies lists 91 non-native plants, 53 of which were included in Table 4.7.4-1. The 38 species listed by NPSpecies but not included in Table 4.7.4-1 are listed as unconfirmed and appeared on the “potential list” in Fertig (2009) except for pin-leaf seepweed (*Suaeda linifolia*), which was only listed by NPSpecies. Seven species included in Table 4.7.4-1 were not included in NPSpecies. Five of these species were reported by Monaco (2003) and two were only recently discovered by NCPN and EPMT staff during annual monitoring and control efforts.

Since the proportion of total plant species that are non-native was high at 31% to 35% over the last several decades, the condition is of significant concern for the historic site. Although the dates presented in Table 4.7.4-1 do not necessarily reflect the date of introduction, they do provide an index for the rate of invasion, but only for the past two or three decades since little to no botanical work was completed prior to that. Confidence is medium. Trend is unchanging.

NatureServe Invasive Species Impact Rank

Of the 61 non-native species listed in Table 4.7.4-1, 28, or nearly half (47%), have not been assessed by NatureServe. Three of the 61 species are considered noxious by the State of Utah (UDAF 2017). These are diffuse knapweed, Dyers woad (*Isatis tinctoria*), and dalmatian toadflax (*Linaria dalmatica*). All

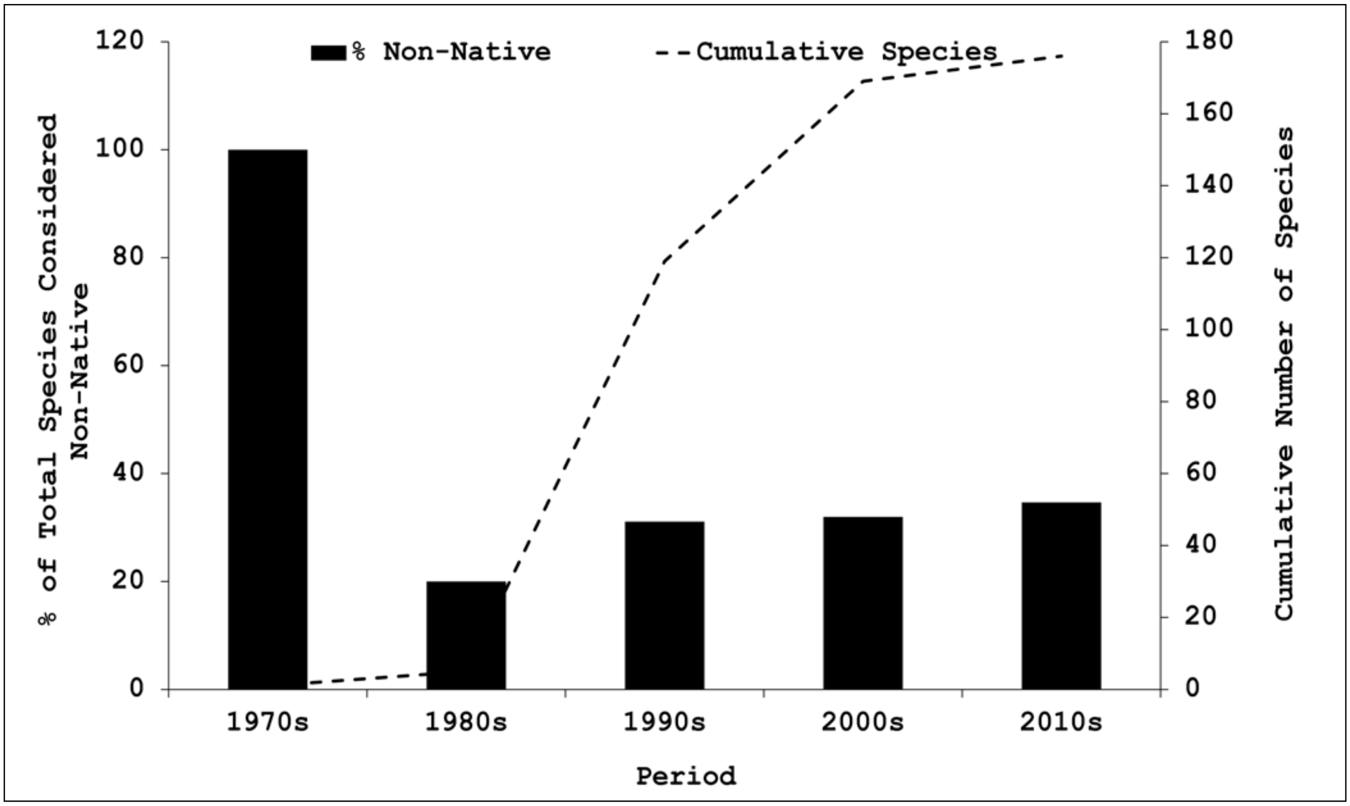


Figure 4.7.4-1. The proportion of total species that are considered non-native by decade from 1975 to 2016.

three species are considered Class 2 control species, which are high priority species for the State. Of the 31 species assessed by NatureServe, one was given an insignificant rank (3%), 8 (26%) were given a low rank, 8 (26%) were given a medium rank, seven (23%) were given a high rank, three (10%) were given a medium/insignificant rank, and four (13%) were given a high/low rank. Species with a high impact rank include cheatgrass, Canada thistle (*Cirsium arvense*), and diffuse knapweed. However, species ranked highest by NatureServe aren't necessarily those most in need of control in Golden Spike NHS. NatureServe takes into account a variety of factors and provides an assessment based on a species impact throughout its current distribution. Locally, some species are more problematic than others. Species of local concern are addressed by NCPN monitoring and NRM-EPMT control efforts. Of the 24 Priority IEPs identified by NCPN, 13 (54%) are known to occur in the historic site (Table 4.7.4-1). Since roughly half of ranked species (49%) were ranked as high or medium by NatureServe, three species are considered noxious by the State of Utah, and more than a half (54%)of NCPN's Priority species occur in Golden Spike NHS, we consider this measure to warrant significant concern. Confidence is high. Trend does not apply to this measure.

Patch Dynamics

Of the 12 primary pathways surveyed, most patches of Priority IEP species were mapped along major drainages and, to a lesser extent, roads (Table 4.7.4-2). Target non-native species were the least prevalent along trails; however, the number of non-native patches per km of trail increased from 0.0 in 2010 to 5.0 in 2016. The number of patches per km also increased along roads, but was relatively low during 2010 and 2012. Target non-native plants declined somewhat along major drainages.

There were five species that were considered Priority IEPs during all five sampling periods (Table 4.7.4-3). Across years, the total number of patches for these five species remained relatively stable, except in 2012 when there were only six total patches. The mean number of patches per sampling year was 48. The number of patches was highest in 2014 with 77 patches. In 2016, and for the first time since monitoring began, all five species were located along monitoring routes. Diffuse knapweed exhibited the fewest patches (1) and Scotch thistle (*Onopordum acanthium*) exhibited the highest number of patches (29) in 2016. Recall that diffuse knapweed was discovered in 2016. Rush skeletonweed (*Chondrilla juncea*) was not observed

Table 4.7.4-2. Number of patches per kilometer of non-native plants.

Area	2008	2010	2012	2014	2016
Roads	4.7	1.2	0.3	6.7	6.7
Trails	–	0.0	1.1	3.0	5.0
Major Drainages	17.2	14.2	0.0	9.7	12.5
# Target IEP Species	6 of 26	3 of 25	2 of 25	9 of 26	9 of 24

Sources: Perkins and Wiessinger 2009; and Perkins 2011, 2013, 2015, 2017.

along monitoring routes until 2014 when 32 patches were mapped. This is a surprisingly high number of patches since rush skeletonweed was not known to occur in the historic site until 2014. However, only 13 rush skeletonweed patches were mapped in 2016, which is likely the result of NRM-EPMT control efforts (described in the summary of NRM-EPMT section). Dyer's woad (*Isatis tinctoria*) occurred in all survey years except 2012, and the number of patches declined over time from a high of 28 patches in 2008 to just three patches in 2016. In contrast, the number of Scotch thistle patches increased slightly over time. When considering all five species, however, these results suggest relatively unchanging conditions for the total number of patches but with a shift in species dominance.

Across sample years most patches were small (< 40 m^2 [431 ft^2]) with relatively few patches mapped in the larger size classes (Table 4.7.4-3). In addition, the number of patches declined with size class in all years, which suggests that patches of these five priority IEPs are staying relatively small. However, there has been a slight increase in the number of patches in larger size classes (i.e., 4 and 5) over time (Figure 4.7.4-2). Although the total number of patches has remained relatively stable, the total number of patches is somewhat high and there has been a slight increase in the number of larger patches. These results warrant moderate concern. Confidence is high. Trend appears unchanging overall.

Frequency (%)

None of the Priority IEPs were encountered in quadrats during 2010, 2012, 2014, or 2016. In 2008, only one Priority IEP was detected in quadrats. This species was field bindweed (*Convolvulus arvensis*), which was not on the Priority IEP list in 2010 or 2012 (Perkins 2017). However, non-target IEPs were detected on 100% of quadrats during 2008, 2010, and 2016; and in

Table 4.7.4-3. Priority species observed and patch size along monitoring routes during five years of monitoring by NCPN.

Species	Year	Total Patches	Patch Size Class*				
			1	2	3	4	5
Diffuse knapweed	2008	0	0	0	0	0	0
	2010	0	0	0	0	0	0
	2012	0	0	0	0	0	0
	2014	0	0	0	0	0	0
	2016	1	1	0	0	0	0
Dyer's woad	2008	28	20	4	3	1	0
	2010	25	12	5	5	1	2
	2012	0	0	0	0	0	0
	2014	4	2	0	1	1	0
	2016	3	1	2	0	0	0
Moth mullein	2008	0	0	0	0	0	0
	2010	1	0	0	1	0	0
	2012	4	0	2	2	0	0
	2014	6	3	2	1	1	0
	2016	6	0	0	1	2	3
Rush skeletonweed	2008	0	0	0	0	0	0
	2010	0	0	0	0	0	0
	2012	0	0	0	0	0	0
	2014	32	14	9	4	2	3
	2016	13	10	3	0	0	0
Scotch thistle	2008	26	8	8	10	0	0
	2010	20	7	6	6	1	0
	2012	2	1	1	0	0	0
	2014	28	6	10	7	1	4
	2016	29	11	16	2	0	0
Total	2008	59	30	13	15	1	0
	2010	46	19	11	12	2	2
	2012	6	1	3	2	0	0
	2014	77	26	23	15	6	7
	2016	52	23	21	3	2	3

* Patch size classes: 1: one to a few plants (used for isolated single plants or very small patches (≤ 2 m^2 [22 ft^2]), 2: a few plants roughly 40 m^2 (431 ft^2), 3: 40-400 m^2 (431-4,306 ft^2), 4400-1,00 m^2 (4,306-10,764 ft^2), 5: 1,000-2,000 m^2 (10,764-21,528 ft^2).

Source: Perkins (2017).

2014 at least one non-native species was recorded in 95% of all quadrats. The species consistently recorded on transects that were not target species were crested wheatgrass, cheatgrass, and tumble mustard and were not target species because they were so widespread. NCPN does not consider them as priority species because there is little management can do but

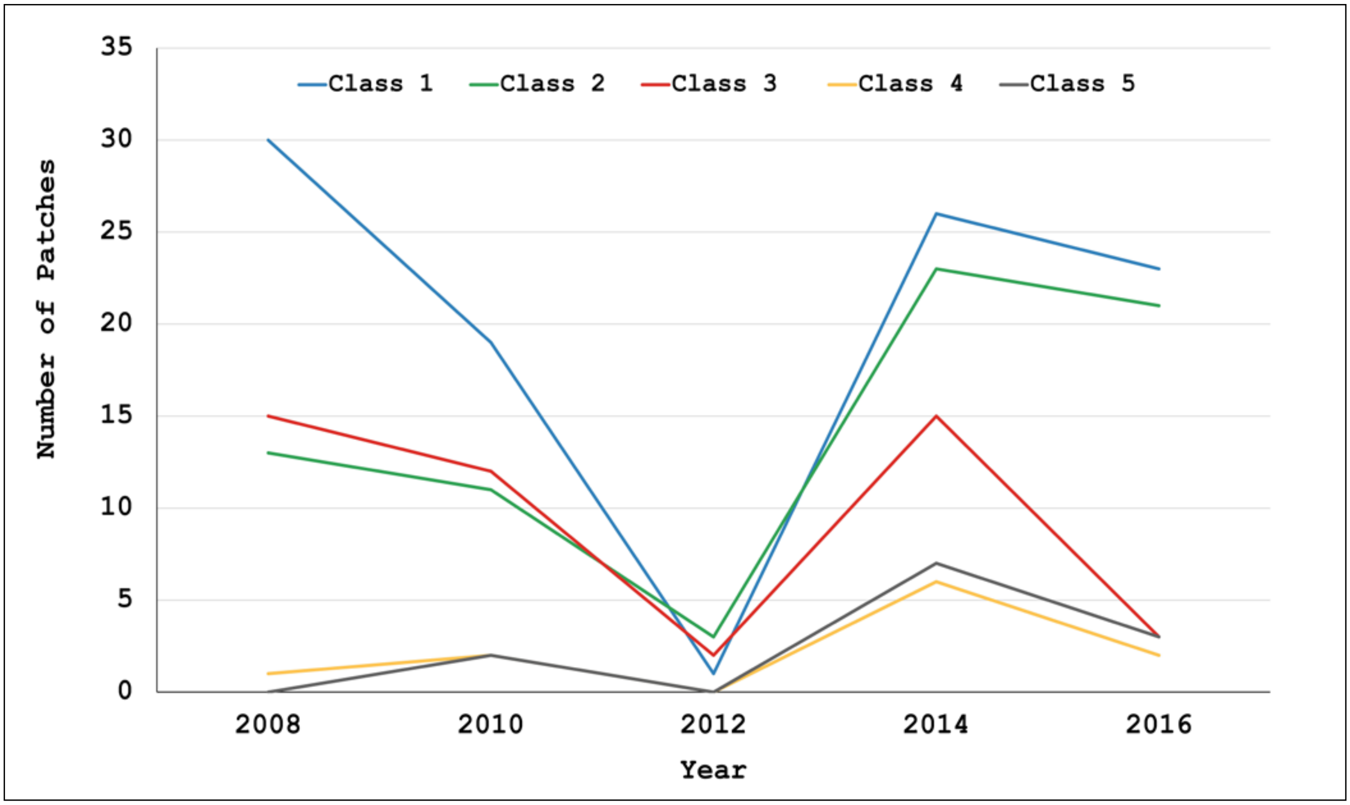


Figure 4.7.4-2. **Number of patches by size class for five priority non-native species.**

acknowledge the fact that they still have a major effect on the community and is a concern to the park. Thus, priority species are limited to species the park could still control.

Because these species were consistently recorded across years (except for 2012 when these data were not collected), we included these species in evaluating the condition for this measure. Since frequency was between 95% and 100% of quadrats sampled, the condition for this measure warrants significant concern. Confidence is high. Trend is unchanging.

Cover (%)

As stated for frequency, none of the Priority IEPs occurred in quadrats so cover for these species was 0%; however, percent cover for crested wheatgrass, cheatgrass, and tumble mustard was recorded consistently over time. Figure 4.7.4-3 shows that all three species declined in cover over time but that total cover averaged greater than 4% in all years, which warrants significant concern. Because these species were consistently recorded across years (except for 2012), we included these species in evaluating the condition for this measure. Although trend in cover improved, it's important to note that apparent declines may be related to lower precipitation in recent years. In a high precipitation year, these species are expected to respond rapidly (Perkins 2017). Therefore, trend should be interpreted with caution but we consider it stable at this time. Confidence is high.

Summary of EPMT Control Efforts

The NRM-EPMT has visited Golden Spike NHS annually since 2006 with the goals of targeting three key non-native species and providing rapid response in controlling new non-native species (NRM-EPMT 2014, 2015, 2016, 2017). The NRM-EPMT has focused primarily on eradicating Dyer's woad, suppressing rush skeletonweed, and controlling Scotch thistle. Unfortunately, all three species remain in the historic site, primarily because of large infestations occurring on adjacent private lands (NRM-EPMT 2016). These infestations are sources for which non-native populations in the historic site are continuously recolonized. Therefore, eradication may not be possible. The NRM-EPMT has also treated patches of Dalmatian toadflax, common mullein (*Verbascum thapsus*), moth mullein (*Verbascum blattaria*), whitetop (*Cardaria draba*), field bindweed, perennial pepperweed, Canada thistle, and quackgrass encountered while treating the primary species of

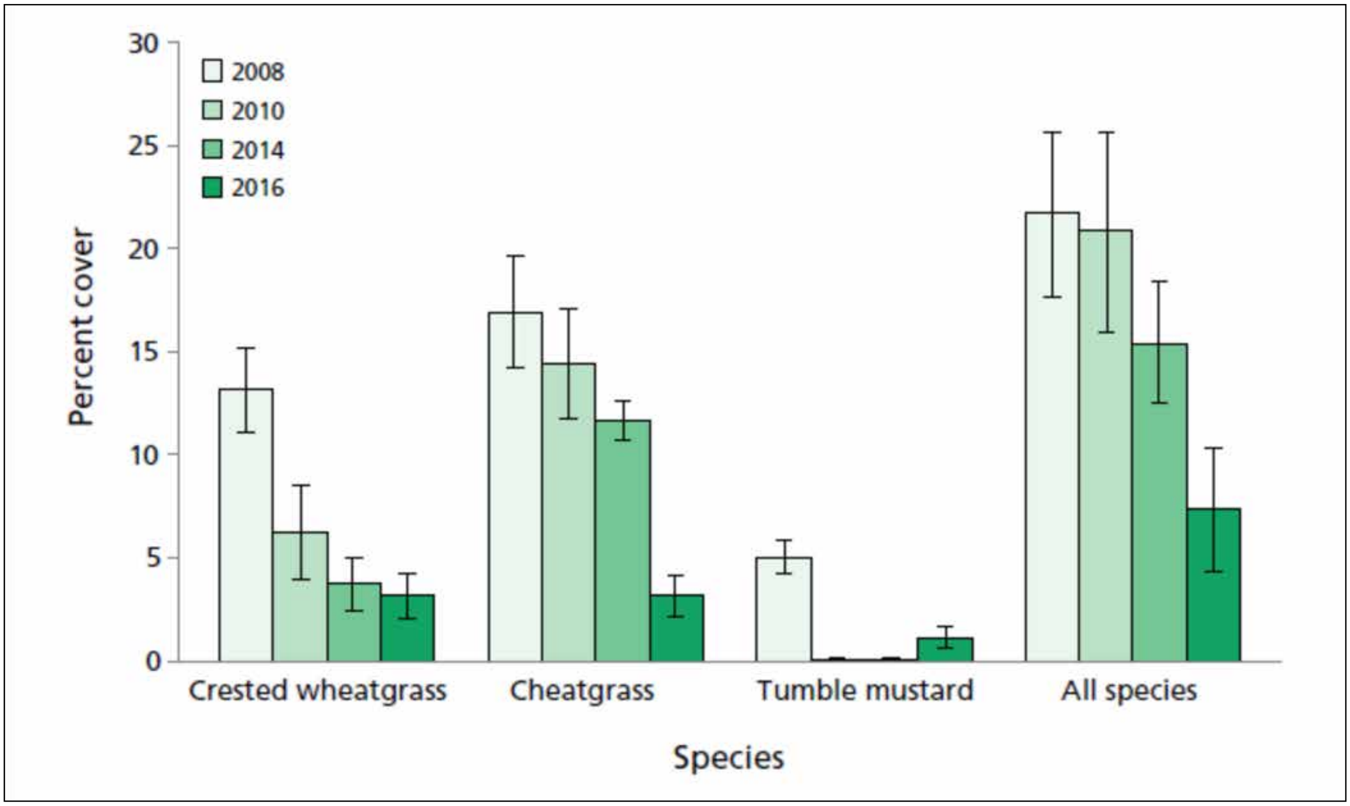


Figure 4.7.4-3. **Percent cover for three non-native species. Figure Credit: © Perkins (2017).**

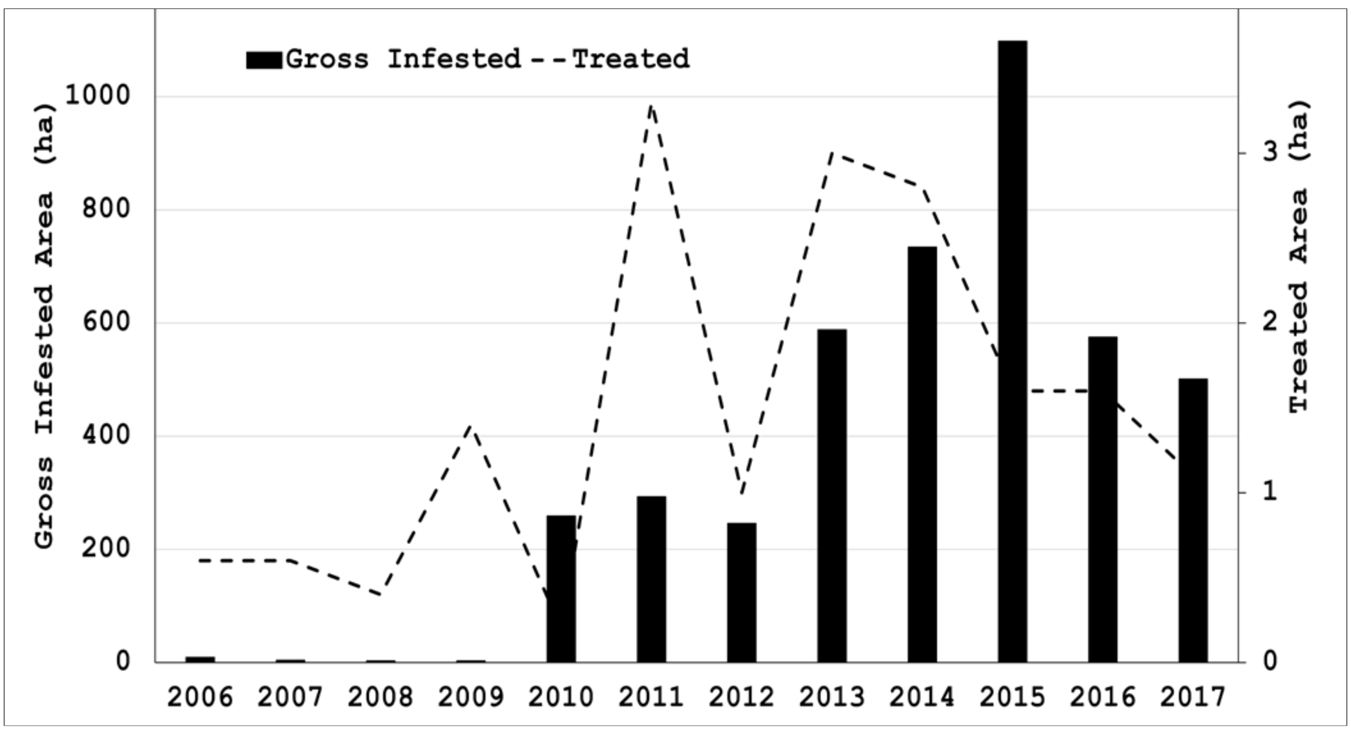


Figure 4.7.4-4. **Summary of Northern Rocky Mountain Exotic Plant Management Team control efforts.**

concern. Russian thistle (*Salsola tragus*) was also experimentally treated in 2015 (NRM-EPMT 2015). Many of these species appear to occur sporadically or in pulses with variation in weather patterns; however, the NRM-EPMT estimated that both moth mullein and field bindweed are steadily increasing, and there is concern that these two species may come to dominate large portions of the historic site in the next 10 years (NRM-EPMT 2016).

The gross infested area is measured as the area in which the target species were mapped, including the spaces in between the target species. The area is mapped using a GPS (usually as polygons) but can also be line features where target species occur along roads or riparian areas. The annual gross infested area has increased from 2006 to 2015 and then declined in 2016 and 2017 (Figure 4.7.4-4). The infested area that was treated was highly variable and peaked in 2011, declined sharply in 2012, and then rose again in 2013. Infested acres fluctuate depending on whether the NRM EPMT are able to survey larger areas of the historic site and/or work with other partners like county weed specialists interested in assisting with weed suppression. Since 2013, the treated area has declined. This decline is likely due to the suppression of Dyer's woad. At one point, it was estimated to cover 20% of the historic site, but the NRM-EPMT treatment efforts have significantly suppressed this species (NRM-EPMT 2017). In contrast, rush skeletonweed has proven more problematic since green-up for this species is highly variable (NRM EPMT 2017) and proper treatment timing is late June through late July when the NRM EPMT isn't typically available to assist. The NRM-EPMT works across 17 parks in the northern Rocky Mountains region and is not always available when this and other non-native species of concern are most visible/treatable. However, the NRM-EPMT makes every effort to visit the historic site at the best time for maximum effectiveness and their efforts appear to have been successful in suppressing Dyer's woad and to a lesser degree rush skeletonweed and Scotch thistle (Table 4.7.4-3).

<u>Overall Condition, Trend, Confidence Level, and Key Uncertainties</u>

Overall, we consider the condition of non-native and invasive plants to warrant significant concern in Golden Spike NHS. This condition rating was based on three indicators and five measures, which are summarized in Table 4.7.4-4. Those measures for which confidence in the condition rating was high were weighted more heavily than measures with medium or low confidence; however, all but one measure warrants significant concern and only one measure was assigned medium confidence. Factors that influence confidence in the condition rating include age of the data (<5 years unless the data are part of a long-term monitoring effort), repeatability, field data vs. modeled data, and whether data can be extrapolated to other areas in the historic site. Based on these factors, nearly all measures were assigned high confidence. This is because three of the five measures were based on long-term, repeatable NCPN invasive plant monitoring data.

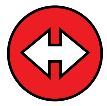
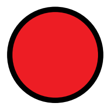
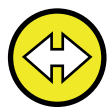
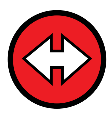
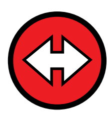
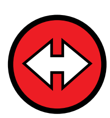
The primary key uncertainty with the data used in this assessment concerns the rate of invasion measure. This measure utilized data on when a species was first reported, which does not necessarily represent the year in which it was introduced. Furthermore, the number of non-native species detected occurred in pulses, which reflects when studies occurred rather than indicating pulses of invasion. Nevertheless, these data provide a useful index to the rate of invasion for the historic site from the 1990s on, but they do not reflect anything about the time period before that since little botanical work was done.

<u>Threats, Issues, and Data Gaps</u>

The introduction and spread of invasive plants is influenced by road corridors, trails, and disturbances. In Golden Spike NHS, major drainages are the primary pathway for dispersal, but roads also provide a dispersal pathway. Although any ecosystem or region is susceptible to invasion by non-native species, Golden Spike NHS's position in the landscape increases its vulnerability. The historic site is surrounded on all sides by private ranches with invasive plants that continue to recolonize the site despite control efforts. Without the efforts of the NRM-EPMT, however, these species would likely be more widespread.

Climate change may increase the historic site's vulnerability to the introduction and spread of invasive species (Hellmann et al. 2008). The western U.S., and especially the Southwest, has experienced increasing temperatures and decreasing rainfall (Prein et al. 2016). Since 1974 there has been a 25% decrease in precipitation, a trend that is partially counteracted by increasing precipitation intensity (Prein et al. 2016). Monahan and Fischelli (2014a) evaluated which of 240

Table 4.7.4-4. Summary of non-native and invasive plants indicators, measures, and condition rationale.

Indicators of Condition	Measures	Condition/ Trend/ Confidence	Rationale for Condition
Rate of Invasion	New Non-native Plants Detected (%)		By 1999 more than half (59%) of the 61 non-native plants had been documented in the historic site. From 2000 to 2016, 24 new non-native species have been documented there. Although the rate of invasion has remained relatively stable over the last 26 years (31%-35%), the proportion of total plant species that are non-native is relatively high at 35%. For these reasons the measure warrants significant concern. Trend appears unchanging. Confidence is medium.
Potential to Alter Native Plant Communities	NatureServe Invasive Species Impact Rank		Since roughly half of all ranked species (49%) were ranked as high or medium by NatureServe, three species are considered noxious by the State of Utah, and more than half of NCPN's priority species occur in Golden Spike NHS, we consider this measure to warrant significant concern. Confidence is high. Trend does not apply to this measure.
Prevalence	Patch Dynamics		The total number of patches for five priority species remained relatively stable over time (mean of 48). Most patches were small and large patches were rare. However, there are a relatively high number of overall patches, and although in low numbers, there has been a slight increase in the number of patches in larger size classes (i.e., 4 and 5). These results warrant moderate concern. Confidence is high. Trend appears unchanging.
	Frequency (%)		No priority invasive species were recorded in quadrats along transects; however, three non-priority species were consistently recorded among years except 2012. These species were cheatgrass, crested wheatgrass, and tumble mustard. Frequency for these non-priority species ranged from 95% to 100% during 2008 to 2016. Although these species were not priorities since they cannot be easily controlled, NCPN acknowledge that they are still species of significant management concern. Therefore, the condition for this measure is of significant concern. Trend is unchanging and confidence is high.
	Cover (%)		As with frequency, no priority species occurred in quadrats along transects. Therefore, cover for priority species was 0% in all years. Cover for three non-priority species, however, was consistently recorded during all years except 2012. Cover for each species declined over time but averaged greater than 4% across all years of surveys. These results warrant significant concern. Confidence is high. Although the condition improved, it's important to note that apparent declines may be related to lower precipitation in recent years so we consider trend to be stable. In a high precipitation year, these species are expected to respond rapidly.
Overall Condition, Trend, and Confidence	Summary of All Measures		The total number of non-native species (61) and the proportion of total plants that are non-native (35%) is high for this small isolated unit. However, the high number of non-native species is not surprising given the historic site's long history of disturbance coupled with invasive species issues on surrounding ranchlands. Long-term monitoring and control efforts, however, are mitigating the effects of invasive species and preventing the spread of new occurrences. The overall trend appears unchanging. Confidence in the overall condition rating is high.

NPS units have experienced extreme climate changes during the last 10-30 years. The results of this study for Golden Spike NHS were summarized in Monahan and Fisichelli (2014b). Extreme climate changes were defined as temperature and precipitation conditions exceeding 95% of the historical range of variability. The results for Golden Spike NHS indicate a trend toward warmer but not necessarily drier conditions (Monahan and Fisichelli 2014b). The cold winters may limit the growing season for non-native species (Coles et al. 2011), but climate change could increase the historic site's favorability for non-native plants through direct effects or by shifting native species out of their ranges (Hellmann et al. 2008).

A study of plant response to climate change on the Colorado Plateau suggests that increased aridity will likely to lead to the loss of native grasses and the expansion of shrubs (Munson et al. 2011). In the case of Golden Spike NHS, non-native grasses dominate much of the native sagebrush communities, and native forbs and grasses are nearly absent (Monaco 2003). In the birds assessment, we reviewed possible habitat for sage grouse (*Centrocercus urophasianus*) and found that 94% of the site's sagebrush-grasslands are dominated by cheatgrass (86%) and crested wheatgrass (8%). Cheatgrass spreads rapidly, outcompeting native bunchgrasses, and because cheatgrass germinates in autumn, it begins growing rapidly in spring, drying out before native grasses have gone to seed (Arndt and Black 2011). As a result, cheatgrass increases the risk of wildfire, and areas infested with cheatgrass burn more often and at greater severity than natural systems, which can destroy sagebrush habitat (Monaco 2004). Once established, invasive plants can be extremely difficult to control and most will never be completely eradicated (Mack et al. 2014).

4.7.5. Sources of Expertise

Assessment author is Lisa Baril, science writer, Utah State University. Sources of expertise include the reviewers listed in Appendix A.

4.8. Birds

4.8.1. Background and Importance

Hundreds of species of birds occur in the American Southwest, as do some of the best birdwatching opportunities. Birdwatching is a popular, long–standing recreational pastime in the United States and forms the basis of a large and sustainable industry (Sekercioglu 2002). Birds are a highly visible component of many ecosystems. They are considered good indicators of ecosystem health because they can respond quickly to changes in resource and environmental conditions (Canterbury et al. 2000, Bryce et al. 2002). Relative to other vertebrates, birds are also highly detectable and can be efficiently surveyed with the use of numerous standardized methods (Bibby et al. 2000, Buckland et al. 2001). Like other wildlife, birds are also inherently valuable. The high aesthetic and spiritual values that humans place on native wildlife are acknowledged in the National Park Service's (NPS) Organic Act: "to conserve . . . the wildlife therein . . . unimpaired for the enjoyment of future generations."

4.8.2. Data and Methods

This condition assessment addresses bird species richness and composition at Golden Spike National Historic Site (NHS) through the use of data/information from the U.S. Geological Survey/ NPS Northern Colorado Plateau Inventory and Monitoring Network (USGS/NCPN) inventory and the current NPSpecies list for the historic site, as well as other observation efforts. We used one indicator of condition, species occurrence, with two measures, focusing on which bird species have been documented at the historic site. The first measure is simply presence/absence of bird species, and the second measure focuses on the species that occur at the site that are considered species of conservation concern.

Presence/Absence

To assess species occurrence (presence/absence of bird species at the historical site) we used the 2001–2002 USGS/NCPN bird surveys, as well as the current NPSpecies list of birds (NPS 2018) and other bird observations recorded within the park via eBird [2018a]). The list of bird species from NPSpecies (NPS 2018), which includes species recorded during the 2001–2002 surveys, served as our foundation list of species documented within the historic site. Because only one set of surveys (with standardized methods) exists for birds within the historic site, we were unable to conduct a temporal comparison of species presence/absence over time (e.g., comparing species observed in 2001–2002 to results of more recent surveys). Instead, the 2001–2002 surveys serve as a baseline for which future comparisons can be made.

Lark sparrows are common breeding birds at Golden Spike NHS. Photo Credit: © Robert Shantz.

Primary Data Sources
The USGS conducted an avian inventory at Golden Spike NHS during 2001 and 2002. The primary objective of the work was to provide a baseline inventory of birds within the historic site, with a goal of documenting at least 90% of the species present (Johnson et al. 2003). Objectives were also to identify the occurrence of species of concern and to determine the abundance and distribution of species present. Breeding season visits were conducted from mid–May to mid–July, and non–breeding, winter visits were conducted from December to February. Plant communities within (and immediately adjacent to) the national historic site include disturbed grasslands dominated by invasive cheatgrass (*Bromus tectorum*) and Great Basin sagebrush–steppe (*Artemisia* spp.) grasslands with scattered junipers (Johnson et al. 2003).

Over the two years, a total of 108 variable circular plot (VCP) point count surveys were conducted across 36 point count stations during both breeding seasons. Point counts were established primarily in grasslands, which is the dominant vegetation type in the historic site, but also in aspen and conifer stands as well. In the 2001 breeding season, the researchers also conducted four incidental surveys (to emphasize habitat not sampled thoroughly during point counts), and four crepuscular and nighttime surveys (i.e., tape playback surveys). In the 2002 breeding season, six incidental surveys and four crepuscular and nighttime surveys were conducted at locations throughout the historic site.

During each VCP count, all birds seen or heard during the 7–minute sampling period were recorded. Information recorded included the species, mode of detection, and distance to the bird from the observer. During all surveys, researchers also made observations on breeding behavior, designating birds as confirmed breeder, probable breeder, or migrant. Johnson et al. (2003) provided information on species richness, relative abundance, and density of the most common breeding birds. We present some of this information in the condition assessment.

The second critical resource for this assessment was the list of birds for the historic site from NPSpecies (NPS 2018; obtained from IRMA in February 2018). NPSpecies relies on previously published surveys, such as those included in this assessment, and expert opinion. This NHS's list contains most of the species recorded by Johnson et al. (2003) in 2001–2002 with the exception of four species. These species were included in Appendix C.

Our final source of information was a list of birds compiled for the historic site from eBird. eBird is an online checklist program that was launched in 2002 by the Cornell Lab of Ornithology and National Audubon Society (eBird 2018b). eBird reports on the occurrence (presence or absence) of bird species, as well as other information, using data from checklists provided by recreational and professional bird watchers. A cumulative list of bird species was available for Golden Spike NHS based on observations from a number of individuals (i.e., eBird 2018a). eBird data for the historic site spans the years 1983–mid–February 2018. We excluded ducks, shorebirds, and wading birds from the eBird checklist since many of these species were noted as being observed at a location referred to as the "ATK ponds" adjacent to the historic site. Since there are no ponds located within the historic site, it is unlikely that species from these bird groups have been observed there, although they may fly over the area. From the eBird list we retained songbirds that are associated with wetlands and riparian areas (e.g., common yellowthroat [*Geothlypis trichas*] and marsh wren [*Cistothorus palustris*]) because there is a small patch of stream habitat (Blue Creek) "at the far east end of the Central Pacific grade and at the visitor center/residential area" (Johnson et al. 2003). It's important to note that not all of the observations provided in eBird could be verified for the historic site, but it is highly likely that reported species were at least very close to the boundary. Additionally, flyovers are also likely to have been reported in eBird, especially for raptors and swallows.

Presence of Species of Conservation Concern
The second measure used in this assessment focused on the species that occur or have occurred at Golden Spike NHS that are considered species of conservation concern at either national or regional scales. Note that we use the phrase "species of conservation concern" in a general sense; it is not specifically tied to use by any one agency or organization. We took our final list of species for the national historic site and compared it to multiple species of conservation concern lists (e.g., a federal list of endangered and threatened species, those designated by the Utah Division of Wildlife

Resources [UDWR] as wildlife species of concern). The specific lists we used are described below.

Species of Conservation Concern Background

There have been a number of agencies and organizations that focus on the conservation of bird species. Such organizations may differ, however, in the criteria they use to identify and/or prioritize species of concern based on the mission and goals of their organization. They also range in geographic scale from global organizations, such as the International Union for Conservation of Nature (IUCN), who maintains a "Red List of Threatened Species," to local organizations or chapters of larger organizations. This has been, and continues to be, a source of potential confusion for managers and others who need to make sense of and apply the information. In recognition of this, the U.S. North American Bird Conservation Initiative (NABCI) was created in 1999; it represents a coalition of government agencies, private organizations, and bird initiatives in the United States working to ensure the conservation of North America's native bird populations. Although there remain a number of sources at multiple geographic and administrative scales for information on species of concern, several of which are presented below, the NABCI has made great progress in developing a common biological framework for conservation planning and design.

One of the developments from the NABCI was the delineation of Bird Conservation Regions (BCRs) (North American Bird Conservation Initiative 2016). Bird Conservation Regions are ecologically distinct regions in North America with similar bird communities, habitats, and resource management issues (Figure 4.8.2–1). Golden Spike NHS is located within the Great Basin BCR (BCR–9; Figure 4.8.2–2).

Conservation Organizations Listing Species of Conservation Concern

Below we identify some of the organizations/efforts that list species of conservation concern; these are the listings we used for this condition assessment. Appendix D presents additional details on each of the organizations/efforts.

- U.S. Fish & Wildlife Service: Under the Endangered Species Act (ESA), the USFWS lists species as threatened, endangered, or candidates for listing (USFWS 2018).
- UDWR: The UDWR prepared and maintains the Utah Sensitive Species List for vertebrate and invertebrate species. The list includes species for which a State conservation agreement exists, wildlife species of concern, and species that are federally listed and candidates for federal listing (UDWR 2015). Wildlife species of concern are species that have scientific evidence substantiating a threat to their continued population viability (UDWR 2015). The idea behind the designation is that timely conservation actions taken for each species will avoid the need to list them under the federal ESA in the future.
- USFWS: This agency also developed lists of birds of conservation concern according to the USFWS Region, and BCR (USFWS 2008). These listings include both migratory and non–migratory bird species (beyond those already designated as federally threatened or endangered). Bird species considered for inclusion on the lists include: nongame birds; game birds without hunting seasons; and ESA candidate, proposed endangered or threatened, and recently delisted species.
- North American Bird Conservation Initiative (NABCI): A team of scientists from this group identified U.S. bird species most in need of conservation action (NABCI 2016). A Watch

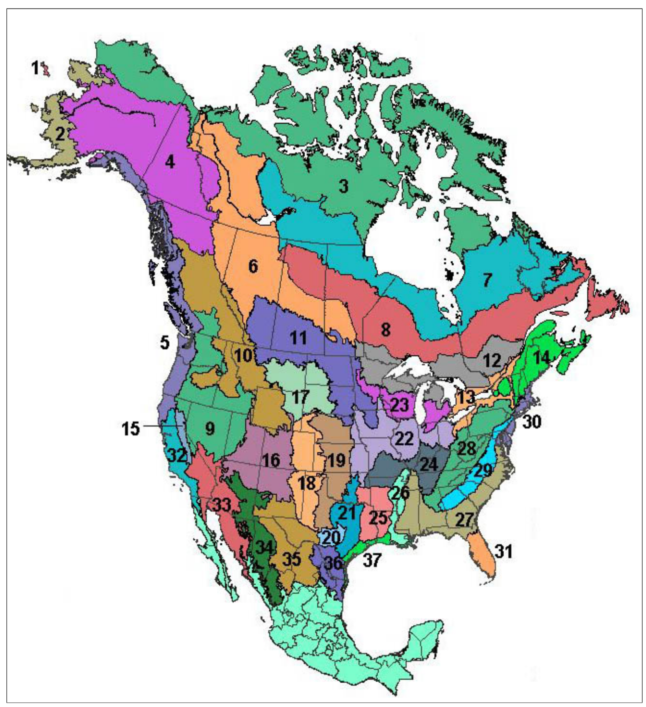


Figure 4.8.2-1. Bird Conservation Regions in North America. Figure Credit: © USFWS (2008).

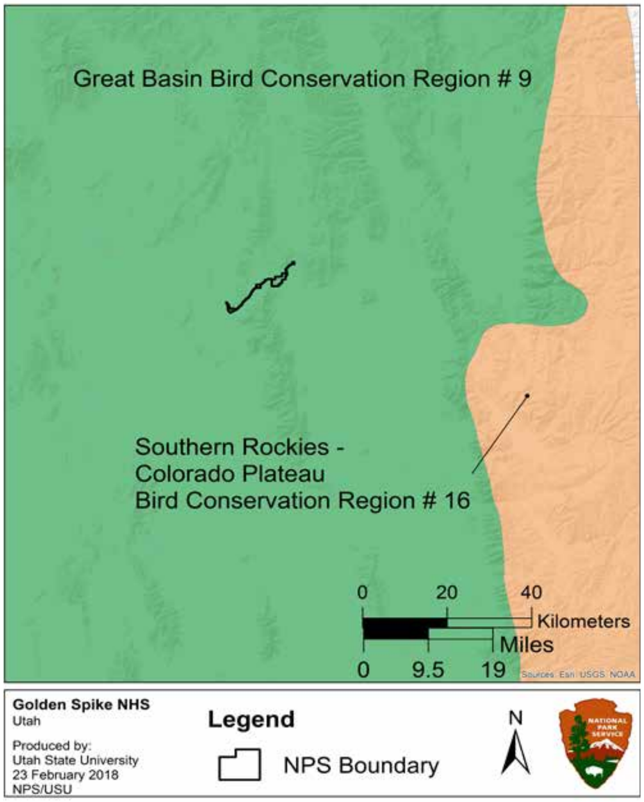


Figure 4.8.2-2. Golden Spike NHS is located in the Great Basin Bird Conservation Region (#9).

List is published every few years. For the first time since the initial list was published in 2009, all 1,154 native bird species that occur in Canada, the U.S., and Mexico were evaluated by a team of experts. The 2016 list contains 432 Watch List species (NABCI 2016).

- Partners in Flight (PIF): This is a cooperative effort among federal, state, and local government agencies, as well as private organizations. PIF has adopted BCRs as the geographic scale for updated regional bird conservation assessments. At the scale of the individual BCRs, there are species of Continental Importance (U.S.–Canada Concern [UCC] and U.S.–Canada Stewardship [UCS]) and Regional Importance (Regional Concern [RC] and Regional Stewardship [RS]). We included only the UCC and RC species in our assessment. The list for BCR 9 was obtained online (Partners in Flight 2016).

4.8.3. Reference Conditions

No specific reference conditions were developed for the two measures used in this assessment. This is because no two similar studies or surveys to compare species occurrence exist (e.g., to examine changes in species occurrence over time), and no comparable recent information (from standardized surveys) was available. However, the information presented from the 2001–2002 USGS/NCPN avian inventory provides a good baseline for future monitoring and assessment of birds at the historic site. In other words, if standardized surveys of birds are conducted in the future, the new survey results could be compared to the survey/inventory results from the early 2000s. For our assessment, some of the other, observational information sources provided an indication of the bird species using the historic site in recent years.

4.8.4. Condition and Trend

Presence/Absence

NPSpecies listed 97 bird species at the historic site, 71 of which were listed as "present", 21 were listed as "probably present", and five were considered "unconfirmed" (NPS 2018). According to Johnson et al. (2003), 97 species were also noted on the historic site's master bird list prior to the 2001-2002 study, including species considered to be "probably present". Johnson et al. (2003) reported adding 11–18 species to the master list, including greater sage-grouse (*Centrocercus urophasianus*), sandhill crane (*Antigone canadensis*), and canyon wren (*Catherpes mexicanus*). Between the 2001-2002 inventory and the number of species on the original master list as reported by Johnson et al. (2003), a total of 108 to 115 species have been reported for Golden Spike NHS.

The differences in numbers reported in the Johnson et al. (2003) report are a result of conflicting data presented in the tables and text. For example, on page 22, Johnson et al. (2003) listed 15 new species, but on page 66 the authors state that the "2001–2002 inventory added six species to the list" and on the same page the authors state that 11 new species were observed in the historic site. Furthermore, the birds listed on pages 22 and on page 66 include different species for a combined total of 18 apparently new species. An additional two species that did not appear on either page 22 or 66 were listed in Appendix 7c in Johnson et al. (2003). Despite these discrepancies, the data presented in Johnson et al. (2003) is still useful.

During the 2001-2002 surveys, Johnson et al. (2003) observed a total of 63 species across all survey efforts and estimated that 82.3% of all bird species previously reported for the historic site were detected during the study. The majority (38 species, or 60%), were observed during breeding season point counts, 16 additional species were observed during incidental surveys, three additional species (four in total) were observed during nocturnal surveys, and six additional species were observed during winter, non–breeding surveys. Sensitive species, including burrowing owl (*Athene cunicularia*), short–eared owl (*Asio flammeus*), and greater sage grouse, were observed during these surveys. All but four species reported by Johnson et al. (2003) for Golden Spike NHS were included in NPSpecies (Appendix C). These species were western tanager (*Piranga ludoviciana*), Cassin's finch (*Haemorhous cassinii*), Wilson's snipe (*Gallinago delicata*), and white-tailed kite (*Elanus leucurus*).

The eBird list for the historic site contained 128 species, but after removing ducks, shorebirds, and wading birds the list contained 98 species, including 19 species that have not been previously reported at the historic site. Some of these species were confirmed with a photograph, but the vast majority of these records have not been confirmed. As previously stated, it's possible that species reported by eBird were not actually observed within the historic site and some species may have been flyovers (e.g., raptors). Nevertheless, eBird is a useful resource on which to supplement existing data and to refine the species list if birds can be confirmed by NPS staff or with a photograph and specific location by the observer.

The combined lists from NPSpecies, eBird, and Johnson et al. (2003) yielded a total of 119 species for the historic site (Appendix C). Seven non–native species were included on this master list in Appendix C, four of which are confirmed as "present" in the historic site, two are considered "probably present", and one species (Eurasian collared–dove [*Streptopelia decaocto*]) was only reported in eBird. The high number of non–native species reported for the historic site is not surprising since the unit has been heavily disturbed with non–native grasses dominate in some areas. Furthermore, the historic site contains a high amount of edge habitat owing to its linear configuration along the railroad track. The surrounding habitat includes "large undeveloped swaths of ranchland" (NPS 2017).

The ten species recorded in the highest numbers (in descending order) in each habitat type during the USGS/NCPN point counts are shown in Table 4.8.4-1, representing 13 different species. The numbers in parentheses for each species are average abundance

Table 4.8.4-1. Species with the greatest average abundance in USGS VCP point count surveys in two habitat types (and overall) at Golden Spike NHS.

Average Abundance		
Grassland	Mix Sage/ Grassland	Total
Western meadowlark (3.59)	Western meadowlark (4.00)	Western meadowlark (3.71)
Cliff swallow (1.45)	Mourning dove (1.15)	Cliff swallow (1.10)
Lark sparrow (1.29)	Brewer's sparrow (0.93)	Lark sparrow (1.03)
Mourning dove (0.94)	Brewer's blackbird (0.89)	Mourning dove (1.00)
Long–billed curlew (0.93)	Horned lark (0.67)	Long–billed curlew (0.75)
Horned lark (0.67)	California gull (0.63)	Horned lark (0.67)
Brewer's sparrow (0.49)	Lark sparrow (0.37)	Brewer's sparrow (0.61)
Rock wren (0.42)	Chukar (0.33)	Rock wren (0.34)
Common raven (0.35)	Long–billed curlew (0.30)	Common raven (0.33)
Chukar (0.07)	Common raven (0.30)	Brewer's blackbird (0.28)

Source: Johnson et al. (2003).

(i.e., [the total # of individuals detected] / [the total # of point count surveys conducted in that habitat type]; Johnson et al. 2003). The last column in the table shows the species with the greatest average abundance overall. The majority of species listed in Table 4.8.4–1 are associated with grasslands or open habitat such as western meadowlark (*Sturnella neglecta*) and Brewer's sparrow (*Spizella breweri*).

Johnson et al. (2003) also estimated the density of species that had more than 40 detections. Combining the data for both habitats, they estimated density for six species: Brewer's sparrow, lark sparrow (*Chondestes grammacus*), long–billed curlew (*Numenius americanus*), horned lark (*Eremophila alpestris*), mourning dove (*Zenaida macroura*), and western meadowlark. The density estimates (Table 4.8.4–2) represent baseline data for comparison with future monitoring results. Western meadowlark, lark sparrow, and horned lark were the species with the highest densities.

Table 4.8.4-2. Estimated densities of bird species at Golden Spike NHS based on USGS point count surveys.

Species	Estimated Density (# per ha)	95% Confidence Interval
Brewer's sparrow (all habitats)	1.89	1.35–2.63
Lark sparrow (all habitats)	4.64	3.25–6.62
Long–billed curlew (all habitats)	0.52	0.26–1.06
Horned lark (all habitats)	4.70	2.66–8.29
Mourning dove (grassland)	1.65	1.09–2.25
Mourning dove (sage/grass mix)	0.75	0.48–1.19
Western meadowlark (grassland)	6.66	5.00–8.87
Western meadowlark (sage/grass mix)	8.77	6.12–12.31

Source: Johnson et al. (2003).

Because only one set of standardized surveys has been conducted to date, and those surveys are approximately 15 years old, we cannot assign a current condition for birds within the historic site. Therefore, we consider condition (and trends) unknown at this time. However, the lists of species observed eBird indicate that many of the species have been observed in recent years.

Presence of Species of Conservation Concern

Twenty–five of the 119 species listed in Appendix C are considered species of conservation concern by at least one organization (Table 4.8.4-3). Sixteen of the 25 species were listed by more than one effort (i.e., Johnson et al. 2003 and eBird) or database (i.e., NPSpecies). According to NPSpecies (2018), 17 species listed in Table 4.8.4-3 are considered "present" and three species are considered "probably present". Four additional species were reported in eBird or by Johnson et al. (2003) but not in NPSpecies (2018).

- USFWS / Listed Species: No federally threatened or endangered species occur in Golden Spike NHS (USFWS 2018).
- UDWR: Seven species are on the Utah Sensitive Species List, including greater sage grouse, long–billed curlew, and short–eared owl. All seven species are wildlife species of concern for the State.
- USFWS/Birds of Conservation Concern: Eighteen of the species have been identified by USFWS as having the greatest conservation need at a USFWS Regional or BCR geographic scale (USFWS 2008). Fourteen of the species are listed for the region, and 12 are listed for the BCR. Eight of the species are listed for both.
- NABCI: There are three species that are included on the NABCI 2016 Watch List.
- PIF: Fifteen of the bird species are listed by PIF as either CC or RC (recall we did not include the stewardship categories). Two of the species were listed as UCC species and 14 were listed as RC species. Only one species (greater sage grouse) was listed for both categories.

In summary, Golden Spike NHS provides habitat for a number of species considered species of conservation concern (Table 4.8.4-3).

Greater Sage Grouse

One species of concern that NHS staff are interested in is the greater sage-grouse (hereafter sage-grouse). This species is of significant management concern in Utah and other western states (USFWS 2016b). Since Golden Spike NHS is predominantly sagebrush (*Artemisia* spp.) habitat, it is reasonable to infer that sage-grouse could reside in the historic site; however, only a single sage-grouse has ever been reported there (Johnson et al. 2003). A likely explanation for their absence is lack of suitable habitat or barriers to dispersal. Therefore, we reviewed the literature along with vegetation data for the historic site in order to determine whether Golden Spike NHS is likely to support sage-grouse as Utah's population grows.

Historically, greater sage–grouse were abundant across Utah and other parts of the western U.S. wherever sagebrush dominated (Schroeder et al. 1999). Greater sage–grouse are dependent on sagebrush habitat, which they use for nesting, foraging, and wintering habitat. During the late brood–rearing season, access to wet meadows is important as sagebrush–grasslands become drier and food availability diminishes (Arndt and Black 2011). Adult sage-grouse forage on a variety of forbs during the summer months as well as certain sagebrush species during winter, and young sage-grouse are dependent on invertebrates (Shroeder et al. 1999). Sagebrush canopy cover of between

Table 4.8.4-3. Species of conservation concern reported at Golden Spike NHS, according to one or more government agencies or organizations.

Common Name	State [1]	U.S. Fish and Wildlife Service		NABCI	Partners in Flight National Conservation Strategy [2]		Notes: Occurrence designation from NPSpecies (2018)
	UDWR	Region 6	BCR 9	2016 Watch List	BCR 9 UCC	BCR 9 RCC	also see Appendix G
American kestrel	–	–	–	–	–	x	Present
Bald eagle	WSC	x	x	–	–	–	Present
Barn swallow	–	–	–	–	–	x	Present
Brewer's sparrow	–	–	x	–	–	x	Present
Burrowing owl	WSC	x		–	–	–	Present
Calliope hummingbird	–	–	x	–	–	–	Present
Cassin's finch	–	x	–	–	x	–	Reported by Johnson et al. (2003) only.
Ferruginous hawk	WSC	x	x	–	–	x	Probably Present
Golden eagle	–	x	x	–	–	x	Present
Grasshopper sparrow	WSC	x	–	–	–	–	Probably Present
Green–tailed towhee	–	–	x	–	–	x	Present
Greater Sage–grouse	WSC	–	x	–	x	x	Reported by Johnson et al. (2003) only.
Lark sparrow	–	–	–	–	–	x	Present
Loggerhead shrike	–	x	x	–	–	–	Present
Long–billed curlew	WSC	x	x	x	–	–	Present
McCown's longspur	–	x	–	x	–	–	Reported in eBird only.
Northern rough–winged swallow	–	–	–	–	–	x	Present
Peregrine falcon	–	x	x	–	–	–	Reported in eBird only.
Pine siskin	–	–	–	–	–	x	Present
Prairie falcon	–	x	–	–	–	–	Present
Sagebrush sparrow	–	x	x	–	–	x	Probably Present
Sage thrasher	–	x	x	–	–	x	Present
Sharp–tailed grouse	–	–	–	–	–	x	Present
Short–eared owl	WSC	x	–	–	–	x	Present
Willet	–	–	–	x	–	–	Present

[1] Utah Division of Wildlife Resources Codes: WSC = Wildlife Species of Concern

[2] PIF NCS Categories: UCC = U.S.–Canada Concern; RC = Regional Concern

Note: X = species present.

15–25% with a substantial understory of native bunchgrasses and forbs is considered ideal habitat for breeding (Arndt and Black 2011). The sage–grouse habitat guide for the State of Utah outlines in detail the requirements for sage–grouse at different times during their life cycle (Arndt and Black 2011). The document can serve as a guide to help managers better understand whether Golden Spike NHS provides the necessary habitat for sage–grouse.

Although sage–grouse have been reported for Golden Spike NHS, their historic abundance and breeding status are unknown. NPSpecies lists greater sage–grouse as a year–round resident, but sage-grouse were not reported by eBird, and park staff have noted their absence (NPS, L. Crossland, Superintendent, NRCA scoping phone call with K. Struthers, 15 November 2017).

Utah supports approximately 8% of the total sage–grouse population in the U.S. according to the State's 2013 greater sage–grouse management plan (UDWR 2013). Sage–grouse populations are highest in the northern, western, and central parts of Utah, but habitat is highly discontinuous across their current range as a result of the State's natural topography, land use patterns, and human population (UDWR 2013). Utah State has identified 11 Sage–Grouse Management Areas (SGMAs) where densities are high. Together, these 11 SGMAs support more than 90% of Utah's sage–grouse population (UDWR 2013). Since 1980 the male sage–grouse count at leks has increased from approximately 2,000 to more than 4,000 in 2009 (UDWR 2016). Counts have remained relatively stable since that time and slightly exceed management objectives for the State (UDWR 2016). Although Golden Spike NHS is not located within a SGMA, the Box Elder SGMA occurs to the west and north of the historic site and the Rich–Morgan–Summit SGMA occurs to the east of the historic site (Figure 4.8.4–1). The SGMAs are between 25 km (16 mi) and 68 km (42 mi) from the historic site. One study found that sage-grouse migrated between 13.1 km (8.1 mi) and 25.4 km (15.8 mi) between spring, summer, and winter ranges; however, some birds migrated as far as 75.6 km (47.0 mi) (Knerr 2007).

Although sage-grouse are capable of long-distance dispersal, significant barriers lie between the SGMAs and the historic site. The North Promontory Mountains to the north, the Hansel Mountain Range to the northwest, and significant mountainous habitat to the east pose potential barriers to dispersal (Fedy et al. 2014). Furthermore, sage-grouse avoid major highways, other paved roads, agriculture, forested areas, and rivers (Fedy et al. 2014). From a strictly geographic standpoint, these barriers make the occurrence of sage-grouse in Golden Spike NHS unlikely.

Within the historic site, sagebrush-grasslands represent approximately 34% of the unit's area (Figure 4.8.4–2). Basin big sagebrush (*A. tridentata* ssp. *tridentata*) was the dominant species mapped, but black sagebrush (*A. nova*) was also mapped in some areas by the NPS

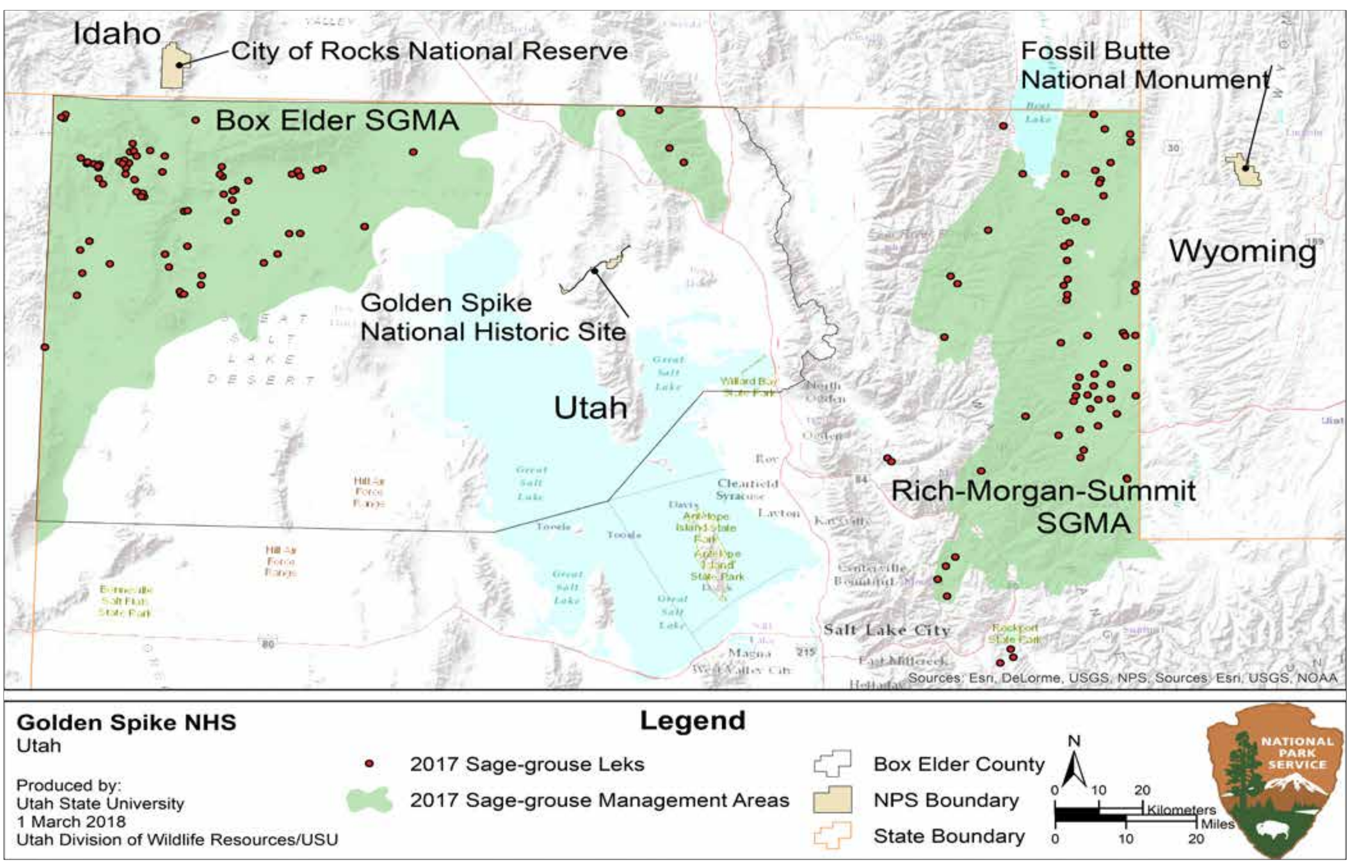


Figure 4.8.4-1. Map of Utah's sage–grouse management areas closest to Golden Spike NHS.

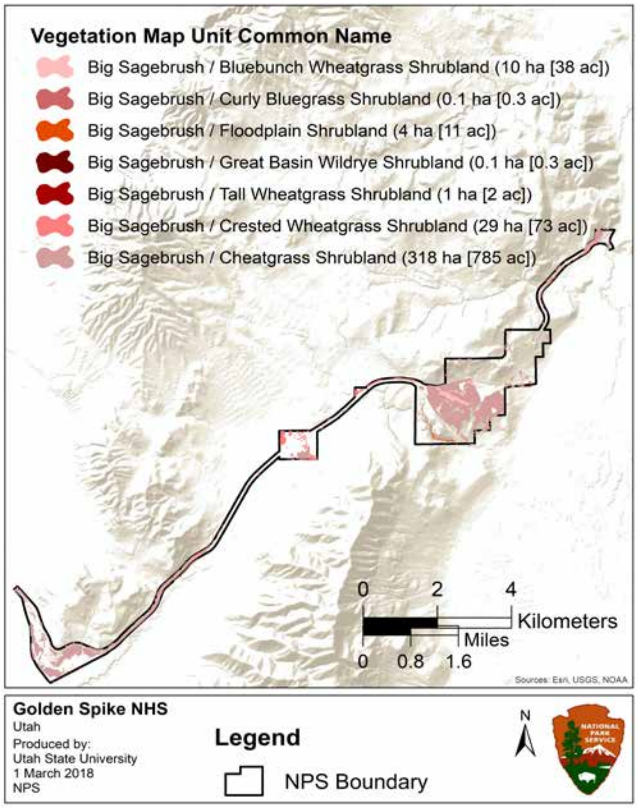


Figure 4.8.4-2. Map of sagebrush habitat in Golden Spike NHS.

Vegetation Inventory Program in 2007 (Coles et al. 2011). Basin big sagebrush exhibits a tall, tree–like structure that does not provide quality nesting habitat for sage–grouse (Arndt and Black 2011). In addition, Basin big sagebrush is less palatable to sage–grouse than other species of sagebrush. Sage–grouse, however, do forage on Basin big sagebrush during particularly harsh winters when preferred species are unavailable as a result of deep snow cover (Arndt and Black 2011). Black sagebrush is generally shorter in stature than Basin big sagebrush and is utilized by sage–grouse as winter forage and brood–rearing habitat during summer. In some places, black sagebrush is considered a critical winter food source (Arndt and Black 2011). In Utah, Wyoming big sagebrush (*A. tridentada* ssp. *wyomingensis*) provides most of the food and habitat for the State's sage–grouse population, but this species was not mapped in Golden Spike NHS (Arndt and Black 2011, Coles et al. 2011).

Although Basin big sagebrush and black sagebrush may provide some habitat for sage–grouse, most (94%) of the sagebrush habitat mapped in Golden Spike NHS occurs with non–native cheatgrass (*Bromus tectorum*) (86%) and crested wheatgrass (*Agropyron cristatum*) (8%) (Coles et al. 2011). In 2016, cheatgrass was estimated to cover approximately 3.13% of the historic site and occurred in 92% of all transects monitored (Perkins 2017). Only about 6% of sagebrush–dominated areas at the historic site were comprised of native grasses, which included bluebunch wheatgrass (*Pseudoroegneria spicata*), Great Basin wildrye (*Leymus cinereus*), and tall wheatgrass (*Thinopyrum ponticum*) (Coles et al. 2011). Although sage–grouse do utilize crested wheatgrass and other areas with non–native plants, the usefulness of non–native habitats depends on their configuration with other natural habitats (Schroeder et al. 1999). Cheatgrass, however, is particularly problematic for sage–grouse and the habitat on which they depend. Cheatgrass spreads rapidly, outcompeting native bunchgrasses, and because cheatgrass germinates in autumn, it begins growing rapidly in spring, drying out before native grasses have gone to seed (Arndt and Black 2011). As a result, cheatgrass increases the risk of wildfire, and areas infested with cheatgrass burn more often and at greater severity than natural systems, which can destroy sagebrush habitat (Arndt and Black 2011).

In addition to native bunchgrasses, forbs are an important component of sage–grouse diet, and young are dependent on insects associated with succulent forbs in addition to the forbs themselves (Schroeder et al. 1999). Of the 22 species or genera of forbs sage–grouse are known to utilize in Utah, including non–native species (Arndt and Black 2011), half were documented by Monaco (2002) during a vegetation survey of the historic site from 2000 to 2002. These species include non–native alfalfa (*Medicago sativa*), non–native sweet clover (*Melilotus officinalis*), and native western yarrow (*Achillea millifolium*). A repeat survey of Monaco (2002) is scheduled for 2020–2022, which may help evaluate current conditions for potential sage–grouse habitat at the historic site (Utah State University, T. Monaco, Ecologist, e–mail message, 2 March 2018). NPSpecies includes 15 of the 22 species or genera listed by Arnt and Black (2011).

The absence of the preferred species of sagebrush, the high proportion of cheatgrass in sagebrush shrublands, and low understory cover of native forbs reduces the likelihood of sage–grouse occurrence in the historic site. Furthermore, wet meadow habitat that is important during the late brooding season is lacking in the historic site (Coles et al. 2011). NPS staff may consider partnering with the West Box Elder Coordinated Resource Management group and the East Box Elder Adaptive Resources Management Sage–Grouse Local Working Group in Box Elder County, Utah to better understand the potential for sage–grouse habitat in Golden Spike NHS.

Overall Condition, Trend, Confidence Level, and Key Uncertainties

For assessing the condition of the national historic site's birds, we used one indicator with two measures, which are summarized in Table 4.8.4–4. Without additional standardized data to compare between years, the condition and overall trend of birds at Golden Spike NHS is unknown.

While NCPN does not conduct bird monitoring at Golden Spike NHS, they do monitor birds at other NCPN parks and have reported on trend for 10 species during 2005 to 2012. A brief description of this effort is included here. In 2012, McLaren and Blakesley (2013) estimated densities for 58 species detected throughout NCPN parks and then estimated population trends based on 24 species recorded from 2005–2012 that were of conservation or management concern. Trends were determined for 10 species, three of which occur in sagebrush habitat. However, only two of the three species are listed for Golden Spike NHS. The two species are black–billed magpie (*Pica hudsonia*) and sagebrush sparrow (*Artemisiospiza nevadensis*), both of which exhibited population declines. Only the sagebrush sparrow was listed as a species of conservation concern in Table 4.8.4–3. Note that this species was formerly known as the sage sparrow (*A. belli*), which was split into the Bell's sparrow (*A. belli*) occurring along the California coast and the sagebrush sparrow occurring in the Great Basin and northwestern states (eBird 2014). According to McLaren and Blakesley (2013), "as additional years of data accumulate, trend analysis will become less sensitive to short–term fluctuations in population density and long–term trends underlying annual fluctuations will be revealed." These results can help inform trends on selected species at Golden Spike NHS as well.

The key uncertainties in this assessment are with the age of the data from Johnson et al. (2003), and the general lack of other studies. A substantial amount of information was available in association with the USGS/NCPN inventory surveys, including a map showing point count survey locations within the national historic site, which can be used to repeat the study.

Threats, Issues, and Data Gaps

There several threats that are common to many bird species, including those that use the national historic site. Migratory and other bird species face threats throughout their range, including: loss or degradation

Table 4.8.4-4. Summary of birds indicators, measures, and condition rationale.

Indicator of Condition	Measures	Condition/ Trend/ Confidence	Rationale for Condition
Species Occurrence	Presence/ Absence of Bird Species		Condition (and trend) under this measure is considered unknown due to the lack of recent standardized bird surveys and comparable datasets. However, a total of 119 bird species are on a list compiled for the national historic site from three main sources. The standardized surveys of Johnson et al. (2003) recorded a total of 63 species in two main habitat types within the monument. A total of 97 species were listed by NPSpecies, and 128 species were listed by eBird, although we only included 98 species for which we had reasonable confidence of their occurrence in the historic site. Overall however, we have low confidence in the measure because of the lack of current data.
	Presence of Species of Conservation Concern		Of the 119 bird species on our list for the national historic site, 25 are species of conservation concern. While Golden Spike NHS provides habitat for a number of species in need of conservation, there are few details on their current occurrence there. For example, greater sage–grouse are a species of concern, but they do not currently occur at the historic site, and historical observations for this species are nearly absent. Therefore, we consider condition under this measure to be unknown (with an unknown trend). Confidence is low because of the unknown condition.
Overall Condition	Summary of All Measures		We used one indicator, with two measures, to assess the condition of birds at Golden Spike NHS. Although some information was available for each measure, we considered the condition of birds under each measure to be unknown. Therefore, overall condition is unknown, trend is unknown, and confidence level is low.

of habitat due to development, agriculture, non-native invasive plants, and forestry activities; collisions with vehicles and man–made structures (e.g., buildings, wind turbines, communication towers, and electrical lines); poisoning; and landscape changes due to climate change (USFWS 2016a). As discussed previously, the federal Migratory Bird Treaty Act protects more than 1,000 species of birds, and many of these species are experiencing population declines because of increased threats within their range (USFWS 2016a). Of the threats specific to Golden Spike NHS and other sagebrush habitats across the west, is the loss of native sagebrush communities. The only sagebrush–obligate species that currently occurs in the historic site is the Brewer's sparrow (*Spizella breweri*), but sage thrasher (*Oreoscoptes montanus*) and sagebrush sparrow may be present. Surveys for these species may help determine the quality of sagebrush habitat. Sage–grouse in particular are sensitive to sagebrush habitat quality. Cheatgrass and conifer encroachment into sagebrush shrublands, wildfire, and human development are all threats to sage–grouse and other sagebrush–dependent species (UDNR 2016).

The largest data gaps concerning birds within the historic site are the lack of demographic data and the absence of an inventory with standardized surveys since the early 2000s. Although observations obtained by eBird provided some recent indications of species occurrence, it would have been desirable to have current standardized surveys like those conducted by Johnson et al. (2003).

4.8.5. Sources of Expertise

Assessment author is Lisa Baril, science writer, Utah State University. Sources of expertise include the reviewers listed in Appendix A.

4.9. Mammals

4.9.1. Background and Importance

Utah's range of elevations and geology create diverse habitats that support a wide variety of species. Utah ranks number 10 in the nation for highest biodiversity and fifth for highest endemism (Utah Wildlife Action Plan Joint Team [UWAPJT] 2015). However, it also ranks 17th in actual species extinctions (UWAPJT 2015). Its arid climate and limited water resources present challenges to the practice of wildlife conservation (UWAPJT 2015).

After the development of the nation's first transcontinental railroad at Golden Spike National Historic Site (NHS), and during the railroad's operational period, the character of the surrounding area, including the vegetation composition rapidly changed (Homstad et al. 2003). People settled, cleared, plowed, and planted agricultural crops (Homstad et al. 2003). Additionally, settlers introduced large herds of cattle, which grazed along the hillslopes surrounding the railroad (Homstad et al. 2003).

Fast forward to present day, and ranchlands and agricultural lands still surround the NHS (NPS 2017a). Both current and historic land use practices have shifted the distribution of native plants from grasses to shrubs (Homstad et al. 2003), and non-native plants are wide-spread at Golden Spike (Perkins 2017), altering the functional habitat that wildlife rely upon to meet their survival needs. This, in turn, has affected the types of wildlife species that occur within and around the NHS.

4.9.2. Data and Methods

To assess the condition of mammals at Golden Spike NHS, we used one indicator, species occurrence, with a total of three measures: species presence/absence, species nativity, and species of conservation concern.

<u>Species Occurrence</u>

The most recent inventories of mammals at Golden Spike NHS were conducted by the U.S. Geological Survey (USGS) throughout NCPN national parks (Haymond et al. 2003) and by Oliver (2006), although results from Oliver (2006) only included herpetofaunal species for the NHS so will be discussed in the herpetofauna condition assessment.

The goal of the Haymond et al. (2003) work was to document the occurrence of at least 90% of the mammals expected within Golden Spike NHS and other national parks during their two years of field sampling. Additional objectives of the inventory included providing baseline information for future monitoring and describing the distribution and abundance of species of management interest (e.g.,

Long-tailed weasel along the railroad tracks at Golden Spike NHS. Photo Credit: NPS.

endangered species, exotic species). The initial list of species developed was based on primary references that listed specimens previously "examined" (Haymond et al. 2003). In order to observe as many species as possible, especially small terrestrial mammals, bats, and carnivores, different sampling methods were used: live-trapping, mist-netting, acoustic surveys, scat and track surveys, and opportunistic observations. Details of each method are included in Haymond et al. (2003).

At Golden Spike NHS, surveys occurred in July and August 2001 and in June and July 2002. In 2001, the survey effort included 36 person days, 863 trap nights, and one net night using mist nets, acoustic surveys, and traplines. In 2002, the survey effort included 10 person days, 6 net nights, 7.6 acoustic hours, and 54.1 km (33.6 mi) of track-scat survey and spotlighting (Haymond et al. 2003).

Species Presence / Absence

To evaluate the condition of the presence/absence of mammals at the NHS, we compared the species recorded by Haymond et al. (2003) during 2001 and 2002 to the NHS's NPSpecies list of mammals (NPS 2018). NPSpecies is an online database maintained by the National Park Service (NPS), and relies on previously published surveys, such as those included in this assessment, and expert opinion about species presence or probable presence for a given national park. The historic site's list of mammals includes 34 species with the following occurrence designations: 27 present and 11 probably present. An additional 25 species are listed as unconfirmed (NPS 2018) and were omitted from the condition evaluation of species presence/absence. The unconfirmed species are further discussed in the data gaps section.

Species Nativity

The 34 mammal species considered present or probably present were evaluated to determine nativity using the NPSpecies 'nativeness' designation (NPS 2018). If any non-native species was identified, it was evaluated for its impact(s) to native species, especially those of conservation concern.

Species of Conservation Concern

We used the national historic site's NPSpecies list of mammals and compared it to the Utah Division of Wildlife Resources (UDWR) 2017 *Utah Sensitive Species List*. The UDWR maintains this list for vertebrate and invertebrate species, including ones that are federally listed, candidates for federal listing, and those for which a state conservation agreement exists (UDWR 2017a). The list also includes "wildlife species of concern," which are species that have scientific evidence substantiating a threat to their continued population viability (UDWR 2017a). The idea behind this last designation is that timely conservation actions taken for each species will avoid the need to list them in the future under the provisions of the federal Endangered Species Act of 1973 (39 FR 1171). Utah's state listed species by county for Box Elder County where the NHS is located was also reviewed to determine whether certain mammal species of concern occurred in the county but not in the NHS (UDWR 2017b).

Table 4.9.3-1. Reference conditions used to assess mammals.

Indicators	Measures	Good	Moderate Concern	Significant Concern
Species Occurrence	Species Presence /Absence	All or nearly all of the species recorded during early surveys/ observations in the historic site were recorded during later surveys.	Several species recorded during early surveys were not recorded during later surveys (particularly if the species had previously been considered common at the historic site).	A substantial number of species recorded during early surveys were not recorded during later surveys (particularly if the species had previously been considered common at the historic site).
	Species Nativity	Non-native species are absent.	Non-native species are present but are limited by habitat type and/or do not outcompete native species for resources.	Non-native species are widespread, indicating available habitat, and outcompete native species for resources.
	Species of Conservation Concern	No reference conditions were developed.	No reference conditions were developed.	No reference conditions were developed.

4.9.3. Reference Conditions

Reference conditions for the three species occurrence measures are shown in Table 4.9.3-1 and are described for resources in good, moderate concern, and significant concern conditions. Note that no reference conditions were developed for the species of conservation concern measure since it is largely descriptive of the species that are present (i.e., species presence/absence measure), but is worth including a discussion since the NHS land is a protected area and can serve as habitat for some types of species survival needs.

4.9.4. Condition and Trend

Species Presence / Absence

Table 4.9.4-1 lists the species and number recorded during Haymond et al. (2003) field seasons for the national historic site. Of the 34 species listed as present or probably present on the NHS's species list, Haymond et al. (2003) captured or observed 24 (or 70.6%) of those species. Seven species (20.6%) were recorded during both field season surveys in 2001 and 2002. The remaining 17 were recorded during one field season only.

In 2001, the most common species captured or observed by Haymond et al. (2003) included species in the rodent family, deer mice (*Peromyscus maniculatus*), Great Basin pocket mouse (*Perognathus parvus*), and western harvest mouse (*Reithrodontomys megalotis*). In 2002, the most common species observed were in the rodent family and again included deer mice and the Great Basin pocket mouse. In general, the level of effort for rodent trapping exceeded the mist-netting effort, which may account for the higher number of rodents versus bats (Haymond et al. 2003) in addition to a higher number of rodents at the NHS.

Haymond et al. (2003) suggested that acquiring additional records of bats will be difficult at the historic site and that echolocation detectors may be the most efficient means of survey. Bats are also dependent on the availability of water sources, which affects capture success (Kunz and Kurta 1988, K. N. Geluso personal communication as cited in Haymond et al. 2003). Furthermore, Haymond et al. 2003 suggested that "shrews and lagomorphs (i.e., hares, rabbits, pikas) should be documented with specimens where possible." However, after two years of field surveys, species occurrence on NCPN parks was lowest for the smaller parks, including Golden Spike NHS.

Almost 78% of the carnivore species listed as present or possibly present was documented during the survey effort, including larger species such as mountain lion (*Puma concolor*), coyote (*Canis latrans*), and bobcat (*Lynx rufus*). Of the two ungulates, only American pronghorn (*Antilocapra americana*) was observed. Mule deer (*Odocoileus hemionus*) was not observed in either 2001 or 2002 but has been listed as expected in the NHS's General Management Plan (NPS 1978), Statement for Management (NPS 1985), and most recently, its Foundation Document (NPS 2017a). In the West, the mule deer population and distribution have been declining, according to the Western Association of Fish and Wildlife Agencies (WAFWA) (no date). Several alterations in the mule deer's habitat have occurred such as lack of fire to promote grasses and the introduction of non-native plants (WAFWA no date). In addition, warming climate, with the last 10 years being the warmest on record for many areas, including the NHS (Monahan and Fisichelli 2014), has and will likely continue to impact wildlife species in ways that have yet to be revealed. So perhaps, through WAFWA's partnerships and conservation efforts, mule deer populations will stabilize and be restored to areas where it was once common, including the NHS.

While extensive, the Haymond et al. (2003) surveys are now 16-17 years old and unfortunately, no subsequent surveys have occurred to compare the presence/absence of species at the NHS. Due to the lack of data comparison, we consider the condition and trend for this measure to be unknown, with low confidence.

The presence of bobcat at Golden Spike NHS was confirmed during the 2002 mammals survey. Photo Credit: © R. Shantz.

Table 4.9.4-1. Mammal species list for Golden Spike NHS.

Group	Common Name	Scientific Name	Haymond et al. (2003) 2001 Field Season	Haymond et al. (2003) 2002 Field Season	NPSpecies (NPS 2018) Occurrence
Ungulates	American pronghorn	*Antilocapra americana*	1	–	Present
	Mule deer	*Odocoileus hemionus*	–	–	Present
Carnivores	American badger	*Taxidea taxus*	1	–	Present
	Bobcat	*Lynx rufus*	–	2	Present
	Coyote	*Canis latrans*	1	2	Present
	Long-tailed weasel	*Mustela frenata*	1	–	Present
	Mountain lion	*Puma concolor*	–	2	Present
	Northern raccoon	*Procyon lotor*	–	1	Present
	Red fox	*Vulpes vulpes*	1	–	Present
	Striped skunk	*Mephitis mephitis*	–	–	Present
	Western spotted skunk	*Spilogale gracilis*	–	–	Probably Present
Lagomorphs	Black-tailed jackrabbit	*Lepus californicus*	–	1	Present
	Desert cottontail	*Sylvilagus audubonii*	–*	–	Probably Present
	Mountain (or Nuttall's) cottontail	*Sylvilagus nuttallii*	1*	–	Present
	White-tailed jackrabbit	*Lepus townsendii*	–	–	Probably Present
Bats	Big brown bat	*Eptesicus fuscus*	2	–	Present
	Fringed myotis	*Myotis thysanodes*	–	–	Probably Present
	Little brown myotis	*Myotis lucifugus*	3	3	Present
	Long-legged myotis	*Myotis volans*	–	–	Probably Present
	Western pipistrelle	*Pipistrellus hesperus*	3	1	Present
	Western small-footed myotis	*Myotis ciliolabrum*	3	3	Present
Rodents	Bushy-tailed woodrat	*Neotoma cinerea*	1	–	Present
	Common muskrat	*Ondatra zibethicus*	–	1	Present
	Deer mouse	*Peromyscus maniculatus*	64	27	Present
	Great Basin ground squirrel	*Spermophilus mollis*	–	–	Present
	Great Basin pocket mouse	*Perognathus parvus*	17	4	Present
	Long-tailed vole	*Microtus longicaudus*	1	–	Present
	Montane vole	*Microtus montanus*	2	–	Present
	North American porcupine	*Erethizon dorsatum*	–	–	Present
	Northern pocket gopher	*Thomomys talpoides*	1	–	Probably Present
	Ord's kangaroo rat	*Dipodomys ordii*	3	1	Present
	Sagebrush vole	*Lemmiscus curtatus*	–	–	Probably Present
	Western harvest mouse	*Reithrodontomys megalotis*	6	3	Present
	Yellow-bellied marmot	*Marmota flaviventris*	1	–	Present

* *Sylvilagus* species captured.

Note: Numbers in Haymond et al. (2003) columns represent the number captured.

Even though the Haymond et al. (2003) surveys are older, the information provides a solid baseline for future assessment of mammal species occurrence at the national historic site.

Species Nativity

None of the species that have been recorded or are considered probably present at the NHS are non-native. Furthermore, of the 25 unconfirmed species, only one (house mouse, *Mus musculus*) is non-native. This measure is in good condition given the lack of non-native species observations, but with low confidence since the survey data are 16-17 years old. Current trend is unknown.

Species of Conservation Concern

Of the 34 mammal species that are present or probably present at the NHS, only one, fringed myotis (*Myotis thysanodes*), is identified as a species of conservation concern in Utah (UDWR 2017a), although it has yet to be confirmed as present at the NHS. Oliver (2000) states that this bat is uncommon throughout most of Utah with a few exceptions where it can be locally abundant. O'Farrell and Studier (1980) observed this species being easily disturbed by human presence and that disturbance of maternity colonies may be a significant threat (as cited in Oliver 2000). The fringed myotis occupies a wide range of habitats, those of which are found at the historic site, which is why it is listed as probably present on the NHS's species list.

Three additional unconfirmed species at the NHS, kit fox (*Vulpes macrotis*), Townsend's big-eared bat (*Corynorhinus townsendii*), and pygmy rabbit (*Brachylagus idahoensis*), are species of concern in Box Elder County (UDWR 2017b) but have not been recorded in the historic site. All unconfirmed species are listed in Table 4.9.4-2.

No reference conditions were developed for species of conservation concern since it's largely descriptive of the species presence/absence measure, therefore, no

Table 4.9.4-2. Unconfirmed mammal species for Golden Spike NHS.

Group	Common Name	Scientific Name
Carnivores	Gray fox	*Urocyon cinereoargenteus*
	Kit fox	*Vulpes macrotis*
	American mink	*Mustela vison*
	Ringtail	*Bassariscus astutus*
	American black bear	*Ursus americanus*
Lagomorphs	Pygmy rabbit	*Lepus californicus*
	Snowshoe hare	*Sylvilagus audubonii*
Bats	Pallid bat	*Antrozous pallidus*
	Townsend's big-eared bat	*Corynorhinus townsendii*
	Spotted bat	*Euderma maculatum*
	Silver-haired bat	*Lasionycteris noctivagans*
	Hoary bat	*Lasiurus cinereus*
	California myotis	*Myotis californicus*
	Long-eared myotis	*Myotis evotis*
	Yuma myotis	*Myotis yumanensis*
Rodents	Meadow vole	*Microtus pennsylvanicus*
	Northern grasshopper mouse	*Onychomys leucogaster*
	Brush mouse	*Peromyscus boylii*
	Western jumping mouse	*Zapus princeps*
	House mouse	*Mus musculus*
	White-tailed antelope squirrel	*Ammospermophilus leucurus*
	Rock squirrel	*Spermophilus variegatus*
Shrews	Masked shrew	*Sorex cinereus*
	Merriam's shrew	*Sorex merriami*
	Vagrant shrew	*Sorex vagrans*

Table 4.9.4-3. Summary of mammal indicators, measures, and condition rationale.

Indicators of Condition	Measures	Condition/ Trend/ Confidence	Rationale for Condition
Species Occurrence	Species Presence / Absence		The current condition of mammals presence/absence is unknown because the last and only group-wide inventory of mammals was conducted between 16 and 17 years ago (2001-2002). Without a follow-up survey, comparison of species presence/ absence cannot be made. No information on trend is available, and our confidence level is low.
	Species Nativity		No non-native mammals have been documented at the national historic site, therefore, we consider this measure to be in good condition with an unknown trend since we don't know the status of current species. Even though the inventory conducted by Haymond et al. (2003) was extensive, we have low confidence in the current condition rating since data are 16-17 years old.
	Species of Conservation Concern	–	Only one species that is considered probably present at the national historic site is of conservation concern. An additional three species of conservation concern are present in Box Elder County, but listed on the NHS' mammals list as unconfirmed. Condition for this measure was not rated since it is largely descriptive of the species that are present.
Overall Condition	Summary of All Measures		While we don't have data to compare presence/absence of mammals over time, the fact that no non-native species are present is good, however, the overall condition and trend are unknown at this time. The national historic site is surrounded by private land so represents a protected area in an area of potential development.

condition rating was assigned. However, the historic site has the potential to provide habitat for some mammals, which is especially important given the fact that Golden Spike NHS is completely surrounded by private lands (NPS 2017a). Also, extirpations have already taken place on the Colorado Plateau or on adjacent regions such as the Rockies or Great Basin in the last 100 year, including grizzly bear (*Ursus arctos*), bison (*Bison bison*), and gray wolf (*Canis lupus*). These species would have been likely at the NHS according to historic range maps (Stegner et al. 2017).

<u>Overall Condition, Trend, Confidence Level, and Key Uncertainties</u>

To assess the condition of mammals at the national historic site, we used one indicator with three measures, which are summarized in Table 4.9.4-3. Overall, we consider the condition and trend of mammals at the NHS to be unknown. It is difficult to determine the condition of a resource with only one dataset, especially given the fact that the Haymond et al. (2003) surveys occurred between 16 and 17 years ago. In addition, several key uncertainties related to the survey effort confound the ability to evaluate the condition of species presence. For example, according to Haymond et al. (2003), "the less common species can be very difficult to document and absolute absence is difficult to prove." Another uncertainty with species inventories is that certain populations fluctuate over time, and the authors believe that rodent populations were low in Utah during the field seasons of 2001 and 2002 when the surveys occurred. Also, prior to the 2001 field season, portions of the NHS burned and the effects on the survey results are unknown (Haymond et al. 2003). And finally, there is uncertainty with knowing which species to include on the possibly or likely present lists for a survey location. These lists are based on references and an investigator's knowledge of mammals within a given region. This may result in a "too inclusive" list of species for smaller parks, such as Golden Spike NHS.

<u>Threats, Issues, and Data Gaps</u>

Park size undoubtedly influences species diversity, and given the small size and linear nature of the NHS, mammal diversity is likely lower than what occurs at larger NCPN parks (Haymond et al. 2003). However, most protected areas are not large enough to encompass self-contained ecosystems to fully support the resources found within their boundaries (Coggins 1987 as cited in Monahan et al. 2012). This is especially true for the more vagile species, such as ungulates and carnivores.

The Utah Wildlife Action Plan identifies coarse-scale vegetation units that generally meet the needs of most wildlife species throughout Utah when those habitats are intact and functioning normally (UWAPJT 2015).

Threats associated with each vegetation unit, and the ones corresponding to Golden Spike NHS as they relate to the conservation of wildlife include non-native invasive plants, improper grazing (both current and historic practices), inappropriate fire frequency and interval, habitat alteration, and habitat fragmentation from transportation corridors such as roads. The plan suggests that conditions can be improved for many wildlife species by allowing fire to return to a more natural regime, reduce inappropriate grazing practices, promote vegetation restoration, especially native forbs, and regulate developments based on wildlife species ecological needs (UWAPJT 2015).

A data gap for mammals at the historic site is determining whether the 25 unconfirmed species and the 10 species that were not recorded during the Haymond et al. (2003) survey effort (but are listed as either present or probably present) are actually at the site or should be eliminated as a possibility. Additional survey efforts, either conducted by the previous investigators or other researchers, would help address this data gap. However, the uncommon or rare species would need more targeted surveys to document their presence or absence (Haymond et al. 2003).

4.9.5. Sources of Expertise

This assessment was based on a past inventory for mammals at Golden Spike NHS. Kim Struthers, science writer/editor and NRCA coordinator with Utah State University, wrote the assessment.

4.10. Herpetofauna

4.10.1. Background and Importance

The American Southwest is well known for its abundance and diversity of reptiles. The region is less well known for its amphibians, but they are abundant in some habitats, particularly during favorable weather conditions. Amphibians and reptiles as a group are referred to as herpetofauna.

Herpetofauna are important members of aquatic and terrestrial ecosystems. Amphibians and reptiles constitute an important part of the food web. They serve as prey for many animals, including mammals, birds, and other herpetofauna. They are beneficial for pest control too in that they consume insects and other invertebrates, and species traditionally considered to be pests to the agriculture industry, such as mice, rats, squirrels, starlings, and more. Amphibians are indicators of wetland ecosystem health. They are sensitive to a variety of threats due to their permeable skin and complex life histories, thus, can serve as early indicators of ecosystem change when monitored over long time scales. Like other wildlife, herpetofauna are also of aesthetic value to visitors of national parks.

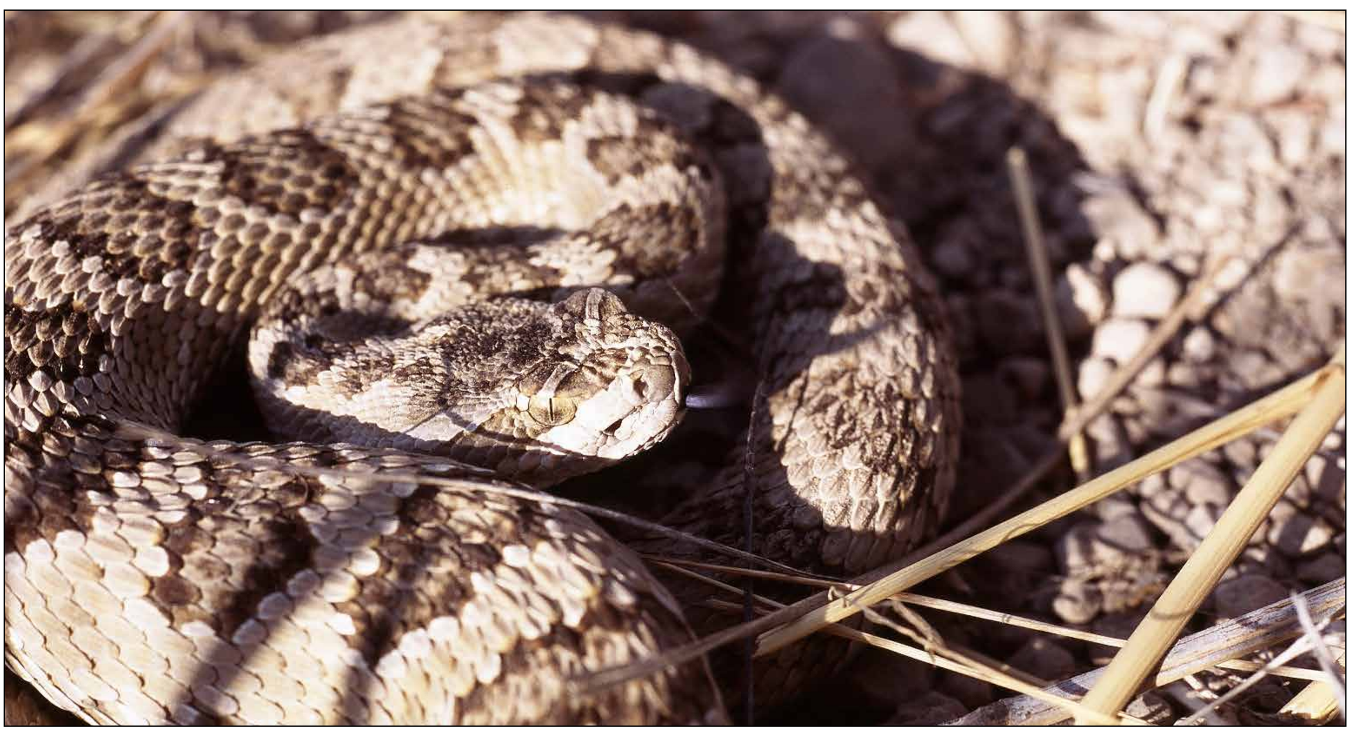
4.10.2. Data and Methods

To assess the condition of the herpetofauna at Golden Spike National Historic Site (NHS), we used one indicator of condition, species occurrence, with a total of three measures: species presence/absence, species nativity, and species of conservation concern.

<u>Species Presence / Absence</u>

The most recent inventories of herpetofauna at Golden Spike NHS were conducted by the U.S. Geological Survey (USGS) (Platenberg and Graham 2003) and by the Utah Division of Wildlife Resources (UDWR) (Oliver 2006) throughout the National Park Service's (NPS) Northern Colorado Plateau Inventory & Monitoring Network (NCPN) parks. The goal of the Platenberg and Graham (2003) work was to document the occurrence of at least 90% of the herpetofauna expected within Golden Spike NHS and other national parks during their two years of field sampling in 2001 and 2002. An additional objective of the inventory was to provide baseline information for the distribution and abundance of species of management interest (e.g., endangered species, species of special concern). The goal of the UDWR effort was to target vertebrate species considered to be present or probably present but lacking voucher evidence (i.e., preserved specimen or photograph). Species that were considered unconfirmed were not prioritized but were recorded if encountered (Oliver 2006).

The primary sampling method used by USGS was based on surveyors walking and searching for the



***Crotalus viridis viridis* x *Crotalus oreganus lutosus* at Golden Spike NHS. Photo Credit: © G. Oliver.**

presence of herpetofauna (Platenberg and Graham 2003). Areas surveyed were based on habitat types where herpetofauna had been previously encountered and that were accessible (Platenberg and Graham 2003). Nighttime searches were also conducted using spotlights for locating breeding amphibians in riparian areas and along accessible roads (Platenberg and Graham 2003). Additional details pertaining to the survey methods are in Platenberg and Graham (2003).

The USGS survey efforts at Golden Spike NHS occurred in June and August 2001 and in April and August 2002. In 2001, 21 surveys during three site visits were conducted. In 2002, the survey effort included 19 surveys during two field visits, including three night drives and one nighttime wetlands survey (Platenberg and Graham 2003). During August 22-23, 2005, the UDWR surveyed Golden Spike NHS using a variety of methods during their field investigations, including day/night visual encounters while walking or driving and turning objects over in search of inactive species (Oliver 2006).

We compared the species recorded by Platenberg and Graham (2003) and Oliver (2006) to the NHS' NPSpecies list of herpetofauna (NPS 2018), which includes 15 confirmed species and four unconfirmed species (NPS 2018). Even though the majority of the historic site's herpetofauna species were documented by Platenberg and Graham (2003) and Oliver (2006), which largely populated the NHS's NPSpecies database, we believed the entire list of species was worth including for reference purposes, especially to highlight the unconfirmed species.

Species Nativity

The herpetofauna species documented by Platenberg and Graham (2003) and Oliver (2006) or not recorded during the surveys but listed as present in NPSpecies (NPS 2018) were evaluated to determine nativity. If a non-native species was present, it was evaluated for its impact(s) to native species, especially those of conservation concern.

Species of Conservation Concern

We used the national historic site's list of herpetofauna and compared it to UDWR's *2017 Utah Sensitive Species List*. The UDWR maintains this list for vertebrate and invertebrate species, including ones that are federally listed, candidates for federal listing, and those for which a state conservation agreement exists (UDWR 2017a). The list also includes "wildlife species of concern," which are species that have scientific evidence substantiating a threat to their continued population viability (UDWR 2017a). The idea behind this last designation is that timely conservation actions taken for each species will avoid the need to list them in the future under the provisions of the U.S. Fish and Wildlife Service's Endangered Species Act of 1973 (39 FR 1171). Utah's state listed species by county was also reviewed to determine whether certain herpetofauna species of concern that are listed as unconfirmed at the NHS occur in Box Elder County, the county in which Golden Spike NHS is located (UDWR 2017b).

4.10.3. Reference Conditions

Reference conditions for the three measures are shown in Table 4.10.3-1 and are described for resources in good, moderate concern, and significant concern conditions.

Table 4.10.3-1. Reference conditions used to assess herpetofauna.

Indicators	Measures	Good	Moderate Concern	Significant Concern
Species Occurrence	Species Presence /Absence	All or nearly all of the species recorded during early surveys/ observations in the historic site were recorded during later surveys.	Several species recorded during early surveys were not recorded during later surveys (particularly if the species had previously been considered common at the historic site).	A substantial number of species recorded during early surveys were not recorded during later surveys (particularly if the species had previously been considered common at the historic site).
	Species Nativity	Non-native species are absent.	Non-native species are present but are limited by habitat type and/or do not outcompete native species for resources.	Non-native species are widespread, indicating available habitat, and outcompete native species for resources.
	Species of Conservation Concern	No reference conditions were developed.	No reference conditions were developed.	No reference conditions were developed.

4.10.4. Condition and Trend

Species Presence / Absence

Table 4.10.4-1 lists the 21 herpetofauna species (five amphibian and 16 reptiles) that have either been recorded within the NHS by Platenberg and Graham (2003), Oliver (2006), NHS personnel, or are expected to be present at the historic site but remain unconfirmed (NPS 2018).

In 2001, Platenberg and Graham (2003) recorded a total of 11 species (four amphibians, three lizards, and four snakes). In 2002, 11 observations were made during the field surveys, which were the same species as those observed in 2001. Four species, two of which were new (i.e., western skink (*Eumeces skiltonianus*) and desert horned lizard (*Phrynosoma platyrhinos*)), and the western rattlesnake (*Crotalus viridis*) (see footnote in Table 4.10.4-1 regarding the common and scientific names used for this species) and eastern racer (*Coluber constrictor*) were recorded at the NHS in 2002. The skink was captured in a ranger's residence mouse trap and the racer was killed by a vehicle and salvaged (Platenberg and Graham 2003).

Even though three different habitat types were surveyed throughout the national historic site, the majority of observations were made around the ranger's residence, visitors center, and along the road despite the fact that these areas received the lowest number of survey hours (Platenberg and Graham 2003).

In 2002, much less effort was devoted to a park-wide survey as a result of trying to quickly locate target species. In addition, the smaller NCPN parks such as Golden Spike NHS received fewer hours of

Table 4.10.4-1. Amphibians and reptiles species list for Golden Spike NHS.

Group	Common Name	Scientific Name	Platenberg and Graham (2003) 2001 and 2002 Field Seasons	Oliver (2006) 2005 Field Season	NPSpecies (NPS 2018) Occurrence
Amphibians	Boreal chorus frog	*Pseudacris maculata or triseriata*	–	–	Unconfirmed
	Great Basin spadefoot	*Spea intermontana*	X	–	Present
	Northern leopard frog	*Rana pipiens*	X	–	Present
	Tiger salamander	*Ambystoma tigrinum*	X	–	Present
	Woodhouse's toad	*Bufo woodhousii*	X	–	Present
Reptiles	Common gartersnake	*Thamnophis sirtalis*	–	–	Unconfirmed
	Common sagebrush lizard	*Sceloporus graciosus*	X	–	Present
	Desert horned lizard	*Phrynosoma platyrhinos*	X	–	Present
	Eastern racer	*Coluber constrictor*	X	X	Present
	Gophersnake	*Pituophis catenifer*	X	X	Present
	Great Basin rattlesnake	*Crotalus viridis lutosus*	X	–	–
	Hybrid rattlesnake	*Crotalus viridis viridis* x *Crotalus oreganus lutosus* hybrid	–	X	Present
	Night snake	*Hypsiglena torquata*	–	–	Unconfirmed
	Prairie rattlesnake*	*Crotalus viridis*	X	–	Present
	Side-blotched lizard	*Uta stansburiana*	X	X	Present
	Striped whipsnake	*Masticophis taeniatus*	X	–	Present
	Terrestrial gartersnake	*Thamnophis elegans*	–	–	Unconfirmed
	Western rattlesnake*	*Crotalus oreganus*	–	–	Present
	Western skink	*Eumeces skiltonianus*	X	–	Present
	Western whiptail	*Cnemidophorus tigris*	X	–	Present
	Yellow-bellied racer	*Coluber constrictor mormon*	X	–	–

* Platenberg and Graham (2003) state that a western rattlesnake was identified by park staff but list the scientific name for prairie rattlesnake (*Crotalus viridis*). Both are listed on the historic site's NPSpecies list (NPS 2018), but we recorded the observation based on the scientific name provided in the report.

Note: X = species present.

survey time since, in general, smaller parks support lower abundances of diurnal reptiles (Platenberg and Graham 2003).

During the 2005 field survey conducted by Oliver (2006), four species (one lizard and three snakes) were observed; three were already documented by Platenberg and Graham (2003), and one was a new and noteworthy discovery. Oliver (2006) describes this discovery at the NHS as follows:

> One of the most interesting discoveries was that of a rattlesnake in GOSP [Golden Spike NHS] that is morphologically intermediate between *Crotalus oreganus lutosus* (the Great Basin race of the western rattlesnake) and *Crotalus viridis viridis* (the prairie [or type] race of the prairie rattlesnake). Photographs of rattlesnakes from earlier NPS work in GOSP (before recent split of *Crotalus viridis* [*sensu lato*] into two species, *Crotalus viridis* [*sensu stricto*] and *Crotalus oreganus*) show more than one typical *Crotalus oreganus lutosus* and what appears to be a typical *Crotalus viridis viridis*, demonstrating that both species occur in GOSP. The author has been carefully examining rattlesnakes from various parts of Utah for the last 7 years; among the many Utah rattlesnakes examined, the rattlesnake captured in 2005 in GOSP is the only individual that is considered to represent a hybrid. It is well known that in captivity almost all species of rattlesnakes are capable of producing hybrid offspring, but hybridization in rattlesnakes in nature seldom occurs.

Only two of the reptiles observed during the Platenberg and Graham (2003) survey effort, Great Basin rattlesnake (*Crotalus viridis lutosus*) and yellow-bellied racer (*Coluber constrictor mormon*) were not listed on the NHS's species list (NPS 2018). An additional four species on the historic site's NPSpecies list are unconfirmed and were not detected during any of the surveys. A discussion of these unconfirmed species is included in the Threats, Issues, and Data Gaps section.

Even though the 2002 and 2005 efforts were targeted surveys, the estimated completeness of herpetofauna inventory for the NHS is 93%, based on the historic site's habitat structure, range distribution maps, and park observation records (Platenberg and Graham 2003), representing one of the most complete herpetofauna surveys throughout the NCPN parks. The results exceeded the original goal of documenting the occurrence of at least 90% of the amphibians and reptiles expected to occur at the NHS (Platenberg and Graham 2003). Regardless of this fact, we assigned an unknown condition and trend due to lack of follow-up surveys to compare species presence/absence over time.

<u>Species Nativity</u>
None of the species that have been recorded or that are unconfirmed at the NHS are non-native; therefore, this measure is in good condition, although given the age of the datasets, and without follow-up surveys to identify new species, we assign low confidence. Trend is unknown due to lack of a more recent survey to determine if new non-natives are present.

<u>Species of Conservation Concern</u>
Of the herpetofauna species that have been observed or are considered present at the NHS, none are identified as species of conservation concern (UDWR 2017a). In addition, no species listed as unconfirmed at the NHS is listed as a species of concern in Box Elder County (UDWR 2017b). No reference conditions were developed for this measure since it's largely descriptive of the species presence/absence measure, therefore, no condition rating was assigned.

<u>Overall Condition, Trend, Confidence Level, and Key Uncertainties</u>
To assess the condition of herpetofauna at the national historic site, we used one indicator with three measures, which are summarized in Table 4.10.4-2. Based on the lack of follow-up surveys and/or herpetofauna monitoring at the NHS, we consider the overall condition and trend of amphibians and reptiles as unknown, with low confidence. The primary reason for uncertainty is the age of the surveys. This does not take away from the value of the information obtained in the studies, but it leads to lower confidence in our assessment of current condition.

<u>Threats, Issues, and Data Gaps</u>
There are four unconfirmed species at the NHS, boreal chorus frog (*Pseudacris maculata*), common garter snake (*Thamnophis sirtalis*), western terrestrial garter snake (*T. elegans*), and night snake (*Hypsiglena*

Table 4.10.4-2. Summary of herpetofauna indicators, measures, and condition rationale.

Indicators of Condition	Measures	Condition/ Trend/ Confidence	Rationale for Condition
Species Occurrence	Species Presence / Absence		The current condition of herpetofauna presence/absence is unknown because the last park-wide inventory of herpetofauna was conducted 17 years ago (2001), and no recent surveys are available from which to compare current condition of presence/absence. No information on trend is available, and our confidence level is low.
	Species Nativity		No non-native herpetofauna species have been documented at the national historic site, therefore, we consider this measure to be in good condition with an unknown trend. Even though the 2001-2002 inventory conducted by Platenberg and Graham (2003) was extensive, and a targeted survey was conducted by Oliver in 2005, we have low confidence in the current condition rating since the data are 13-17 years old.
	Species of Conservation Concern	–	No amphibians or reptiles of conservation concern are present at the national historic site. Furthermore, the four unconfirmed species at the NHS are not listed as sensitive species in Box Elder County. The condition for this measure was not rated since it is largely descriptive of the species that are present.
Overall Condition	Summary of All Measures		While we don't have data to compare presence/absence of herpetofauna for the historic site, it is noteworthy that no non-native species have been observed and that there is protected habitat throughout the historic site to support amphibians and reptiles. Overall, we rate the condition and trend as unknown, with low confidence.

torquata). Platenberg and Graham (2003) state that the boreal chorus frog was observed near the NHS in 2002 and believe that it is possible that it occurs within the NHS. The two garter snakes' distribution ranges include the NHS, although they have not been observed within the area (Stebbins 1985 as cited by Platenberg and Graham 2003). And finally, the last unconfirmed species, the night snake, is found throughout the Southwest including Utah and occupies many types of habitat, including grasslands, deserts, and sagebrush flats. However, the NHS's NPSpecies entry for night snake was last modified in 2007 and states that per Platenberg & Graham (2003), "Habitat may not be suitable for this species. Not known from park, no historical records." Lack of information for these species represents a data gap.

A major threat to the NHS's wildlife is climate change. The U.S. Environmental Protection Agency (USEPA) (2016) produced a publication about what climate change means for Utah. It states that over the last century, Utah has warmed about two degrees Fahrenheit, which will likely increase the need for water, but reduce the supply. In addition, the rate of evapotranspiration will likely increase, further decreasing water availability. Reptiles have scaly skin, allowing them to survive without water, but amphibians are smooth and scaleless, and the absence of water on their skin for a prolonged period can result in death.

Another threat is roadkill due to vehicle strikes such as the eastern racer that was struck and collected as a voucher specimen. Golden Spike NHS's annual visitation has been steadily increasing since 2014, with a record high of 67,811 visitors in 2017 (NPS Public Use Statistics Office 2018), representing an 11.5% increase from 2016. With increased visitation comes increased vehicular use on the roads within the park, which not only impacts herpetofauna species, but also poses a threat to other wildlife.

4.10.5. Sources of Expertise

This assessment was based on past surveys for herpetofauna at Golden Spike NHS. Kim Struthers, science writer/editor and NRCA coordinator with Utah State University, wrote the assessment.

148th anniversary of the wedding of the rails champagne toast at Golden Spike NHS. Photo Credit: NPS.

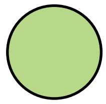
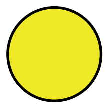
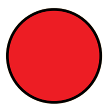
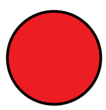
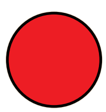
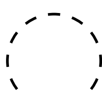
Chapter 5. Discussion

Managing the natural resources at Golden Spike National Historic Site (NHS) is inextricably tied to its cultural purpose, significance, and fundamental resources and values (FRVs). It is most often within this interdisciplinary perspective that managers consider potential actions and alternatives when addressing resource issues or needs. Of the 10 natural resources evaluated for Golden Spike NHS's NRCA, viewshed is listed as one of its fundamental resources and values. While the area surrounding the NHS has experienced a long history of land use impacts from livestock grazing and agricultural activities, developments are relatively sparse. The high quality viewsheds help visitors imagine the historic landscape as it looked over 100 years ago, with the exception of the presence of widespread non-native plants. However, "the visual aspect of these vegetation changes [due to non-native plants] does not appear to have significantly altered the cultural landscape" (NPS 2017a).

Several of the remaining resources evaluated for the NHS's NRCA are identified as 'other important resources and values,' emphasizing the significance of maintaining or improving conditions and the underlying processes to support the NHS's purpose. A summary of the overall condition findings for the 10 topics and their relationship to the park's resource and value statements, which are taken from the NHS's Foundation Document (NPS 2017a) and numbered below, is presented in Table 5.1:

1. Viewshed and Historic Landscape
2. Archeological Features
3. Last Spike Site, May 10th Event, and Reenactments
4. Replica Locomotives
5. Step Back in Time
6. Natural Resources (several resources are listed)
7. Museum Collections and Archives.

Table 5-1. Natural resource condition summary for Golden Spike NHS.

Core Statements		Resource	Overall Condition	Overall Condition Discussion
Fundamental Resource	Other Important Resource			
X	X	Viewshed		There are few non-contributing features in the historic site's viewshed. The housing and road density analyses show that the region surrounding the site is mostly rural, but most of the landscape in the area analyzed is open to future extractive uses that could alter the scenic views. However, the current condition of the viewshed in Golden Spike NHS is good with an unknown trend. Confidence is medium.
–	–	Night Sky		Overall, the night sky at Golden Spike NHS warrants moderate concern. However, the condition is based on a single measure. The all-sky light pollution ratio is considered the best single measure to assess the nighttime environment, but additional field data for baseline conditions are lacking. The site's Foundation Document highlights the need for partnerships with nearby communities and private landowners to improve or at least maintain the existing night sky environment.
–	–	Soundscape		Overall, we consider the soundscape at Golden Spike NHS to warrant significant concern with medium confidence and unknown trend. The L_{50} impact model estimated a median reduction in listening area of ~65% across the historic site, or a mean impact of 4.6 dBA. The model included factors such as roads, landcover types, and proximity to airports. A key uncertainty is whether the model agrees with *in situ* sound levels, and baseline acoustic conditions for the historic site are lacking.
–	–	Air Quality		Overall, we consider air quality at the historic site to be of significant concern. Certain aspects, however, warrant moderate concern (i.e., haze index and human health ozone levels), and one is in good condition (e.g., wet sulfur deposition). Overall, confidence in the assessment is medium, with an unknown trend.
–	X	Vegetation Communities		The results of the three measures of vegetation intactness indicate significant concern. Vegetation is the historic site's most significant management issue. Non-native plants are common and widespread and native vegetation is rare. However, the Northern Rockies Exotic Plant Management Team has made progress in suppressing several non-native species of particular concern. We did not assign an overall trend because there were not sufficient data.
–	–	Passey's Onion		While studies from the early 2000s provide valuable natural history data, there are no current data with which to assess Passey's onion in Golden Spike NHS. The condition and trend at this time is unknown. Because the condition is unknown, confidence is low.
–	–	Non-native Invasive Plants		The total number of non-native species (61) and the proportion of total plants that are non-native (35%) is high for this small park. However, the high number of non-native species is not surprising given the historic site's long history of disturbance coupled with invasive species issues on surrounding ranchlands. Long-term monitoring and control efforts, however, are mitigating the effects of invasive species and preventing the spread of new occurrences. The overall trend appears unchanging. Confidence in the overall condition rating is high.

Note: Fundamental and other important resources and values statements are excerpted from NPS (2017a) and are denoted by an 'X.'

Table 5.1 continued. Natural resource condition summary for Golden Spike NHS.

Core Statements: Fundamental Resource	Core Statements: Other Important Resource	Resource	Overall Condition	Overall Condition Discussion
–	X	Birds		We used one indicator, with two measures, to assess the condition of birds at Golden Spike NHS. Although some information is available for each measure, we consider the condition of birds under each measure to be unknown. Therefore, overall condition is unknown, trend is unknown, and confidence level is low.
–	X	Mammals		While we don't have data to compare presence/absence of mammals over time, the fact that no non-native species are present is good, however, the overall condition and trend are unknown. The national historic site is surrounded by private land so represents a protected area within a larger area of potential development.
–	X	Herpetofauna		While we don't have data to compare presence/absence of herpetofauna for the historic site, it is noteworthy that no non-native species have been observed. Also noteworthy is the only known example of a morphologically intermediate between *Crotalus oreganus lutosus* (the Great Basin race of the western rattlesnake) and *Crotalus viridis viridis* (the prairie [or type] race of the prairie rattlesnake) found at Golden Spike NHS. Overall, we rate the condition and trend as unknown, with low confidence.

Note: Fundamental and other important resources and values statements are excerpted from NPS (2017a) and are denoted by an 'X.'

While current conditions were evaluated separately for each of the 10 topics, we provide an alternative summary in this chapter, grouping resources into three broad categories. These categories include landscape-scale, vegetation, and wildlife. Taken together as a whole, combining resources provides a more practical, interconnected interpretation of data gaps for potential management actions or study proposals. From this perspective, an action or proposal is more likely to maintain or improve conditions for more than one resource per given effort. For each of the three groups, we summarize the pertinent data gaps, proposal or project ideas, and identify the resource(s) addressed by each proposal or project idea.

LANDSCAPE-SCALE RESOURCES— viewshed, night sky, soundscape, and air quality

Knowledge or data gaps:

A) Dark Sky Preservation
An overall increase in outdoor lighting in local communities and regional cities increases light pollution.

B) Augment Partnerships
Partnerships are necessary for preserving landscape level resources from impacts.

C) Scenic Resources
The viewsheds are integral to the park's cultural and historical significance. Poor visibility impacts a visitor's ability to see and haze is of moderate concern at the park.

Gaps: A, B, C

Dark Sky Management
Sustainable outdoor lighting includes the following principles: light only if needed, or where and when needed; use warm white or amber light; use the minimum amount of light needed; and use energy-efficient lights. Management actions such as these will help preserve the dark night sky.

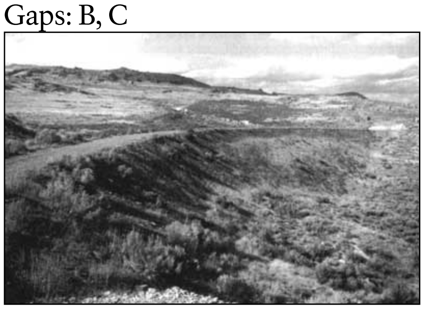
Addresses Resources
- Night Sky
- Wildlife

Gaps: A, B, C

Partnership Inventory
Inventorying existing partnership activities within an ecologically-relevant area would provide information from which park resources could be managed cooperatively on a landscape-scale. With a small staff, working with partners is necessary for achieving conservation goals.

Addresses Resources
- All resources

Gaps: B, C



From top: Night sky, Last spike reenactors, scenic view of Big Fill. Photo Credits: NPS

Visual Resource Inventory
Develop a systematic inventory of scenic resources to integrate visual resource management with overall park management. The inventory would provide a baseline for monitoring changes over time and inform the conservation of important views. Finally, it also could inform discussions with developers and stakeholders about how development within the shared viewed landscape could occur while retaining the valued characteristics of important views (excerpted from NPS 2017a).

Addresses Resources
- Viewshed
- Night Sky
- Air Quality

VEGETATION RESOURCES— vegetation communities, Passey's onion, and non-native plants

Knowledge or data gaps:

A) Lack of Reference Conditions for Vegetation Response to Climate Change
To effectively adapt to climate change, a framework is needed to understand the connection between multiple variables, including cultural resources.

B) Effective Weed Management.
Given the widespread non-native invasive plants throughout the historic site, having the resources to control the highest priority areas and new introductions from the surrounding landscape is necessary.

C) Passey's Onion Management
Lacking current data and basic ecological information for Passey's onion, which is only found at Golden Spike NHS.

Gaps: A, B, C

<u>Linking Vegetation Data & Climate Metrics</u>
Developing a framework to understand the effects of climate change trends and events on vegetation, with emphasis on cultural landscapes, is crucial for understanding management implications.

<u>Addresses Resources</u>
- Vegetation Communities
- Passey's onion
- Non-native Invasive Plants

Gaps: B, C

<u>Passey's Onion Study/Monitoring</u>
Information about the ecology, needs, and threats to Passey's onion is a data gap. Knowledge regarding the current location and abundance throughout the historic site is lacking, and more work is needed to evaluate the condition. Knowing locations will help prioritize non-native plant efforts.

<u>Addresses Resources</u>
- Passey's onion
- Non-native Invasive Plants

Gaps: B, C

From top: Native needle-and-thread bunchgrass community, Passey's onion, non-native cheatgrass. Photo Credits: NPS.

<u>Weed Management Strategy</u>
Implement a strategic decision making process for effective weed management. The 2011 Multi-park Invasive Plant Management Plan (NPS 2011b) provides species based prioritization and addressed National Environmental Policy Act (NEPA) compliance to conduct weed treatments. However, the plan did not develop a place based approach. This could be useful to the Exotic Plant Management Team as they annually suppress several high priority species at the historic site.

<u>Addresses Resources</u>
- Vegetation Communities
- Passey's onion
- Non-native Invasive Plants

WILDLIFE RESOURCES— birds, mammals, and herpetofauna

Knowledge or data gaps:

A) Select Species Management
Lacking current data and basic ecological information for bird species of interest at Golden Spike NHS.

B) Herpetofauna Data
Lacking current datat o know condition of herpetofauna.

C) Mammal Data
Lacking current data to know condition of mammals and 25 species are still unconfirmed.

Gap: A

Habitat Monitoring for Wildlife Conditions
The condition of habitat often serves as an indication of the health and abundance of wildlife species. A few select bird species could be prioritized for management or potential management (e.g., sage grouse) by historic site staff.

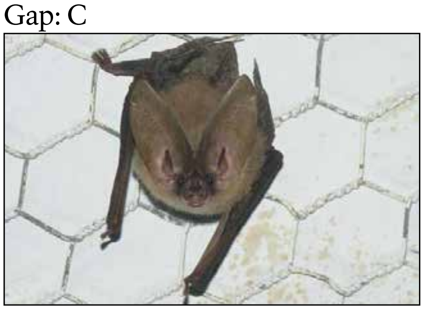
Addresses Resources
- Birds

Gap: B

Conduct Follow-up Inventory
Some possible monitoring of habitat quality as a proxy for herpetofauna condition (as a group) would help inform current conditions for reptiles and amphibians at the park.

Addresses Resources
- Herpetofauna

Gap: C



From top: Golden eagle, *Crotalus viridis viridis* x *Crotalus oreganus lutosus*, Townsend's big-eared bat. Photo Credits: Top: NPS, Middle: Oliver, Bottom: @ R. Shantz.

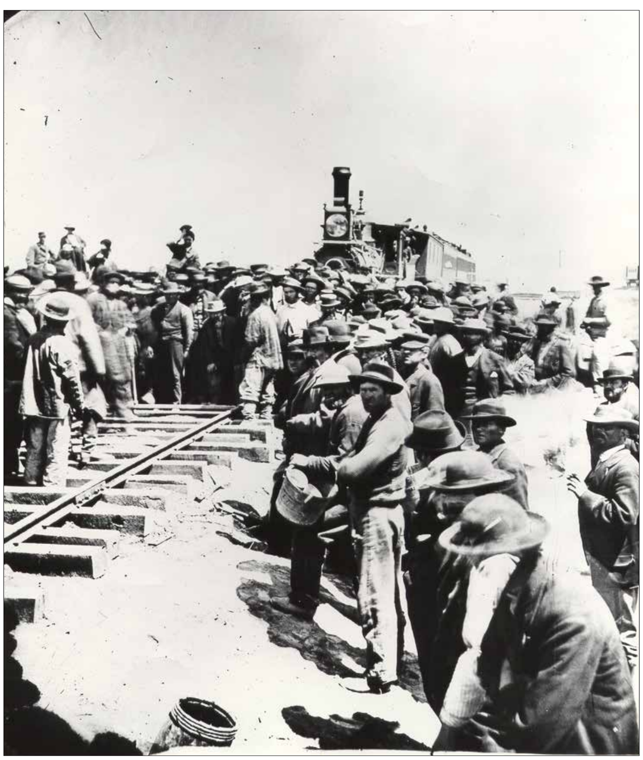
Status of Mammals
Additional survey efforts, either conducted by the previous investigators or other researchers, would help address the unknown condition and unconfirmed species data gaps. However, the uncommon or rare species would need more targeted surveys to document their presence or absence. Echolocation detectors may be the most efficient means of survey for detecting bats throughout the park.

Addresses Resources
- Mammals

Climate Change

Natural resources and associated processes are highly dynamic and require a range of variability paradigm to understand and appropriately frame management goals. Cultural landscape resources also require adaptive and resilient management strategies. When a fundamental driver such as climate begins to rapidly change, changes to natural and cultural resource conditions are inevitable. Identifying near-term priorities, in addition to embracing new challenges and opportunities, is necessary for implementing an effective adaptive management strategy.

As the National Park Service Climate Change Action Plan 2012-2014 suggests, developing robust partnerships, strengthening communication strategies, and providing climate change science to parks are a few ways to take action. With temperatures already increasing and the amount of precipitation decreasing, a warmer and drier landscape will mean a decrease in water resources, both surface and groundwater. Species on the edge of their range or confined to specialized habitats will likely be most vulnerable to these types of climate changes. Cultural landscapes' character defining feature relationships to historic and projected climate variables, as well as their sensitivity to projected climate variables, will affect



The last spike site at Golden Spike NHS. Photo Credit: NPS.

> *"Today's rapid climate change challenges national parks in ways we've never seen before."*
>
> *— Climate Change Response Program, National Park Service*

their adaptability and preservation. What is unclear, and represents a significant data gap and uncertainty, is how intensely resources will respond.

The IPCC (2014) states that "many species will be unable to track suitable climates under mid- and high-range rates of climate change during the 21st century ([with] medium confidence). Lower rates of change will pose fewer problems. Some species will adapt to new climates. Those that cannot adapt sufficiently fast will decrease in abundance or go extinct in part or all of their ranges." Figure 5-1 shows climate change impacts, adaptation, and vulnerability for eight groups of organisms. The maximum speed at which organisms can move relative to changing environmental conditions will be a significant factor in determining their ability to persist. As shown in the figure, trees are the most vulnerable group to changing temperature and precipitation patterns due to their inability to move (disperse) quickly. IPCC uses a standard set of climate change scenarios referred to as Representative Concentration Pathways (RCPs). Using climate model simulation, these scenarios are developed and describe different pathways of greenhouse gas emissions and atmospheric concentrations, air pollutant emissions and land use. The IPCC (2014) described information in Figure 5-1 in their *Summary for Policymakers, Figure SPM.5* caption as follows:

> Maximum speeds at which species can move across landscapes (based on observations and models; vertical axis on left), compared with speeds at which temperatures are projected to move across landscapes (climate velocities for temperature; vertical axis on right). Human interventions, such as transport or habitat fragmentation, can greatly increase or decrease speeds of movement. White boxes with black bars indicate ranges and medians of maximum movement speeds for trees, plants, mammals,

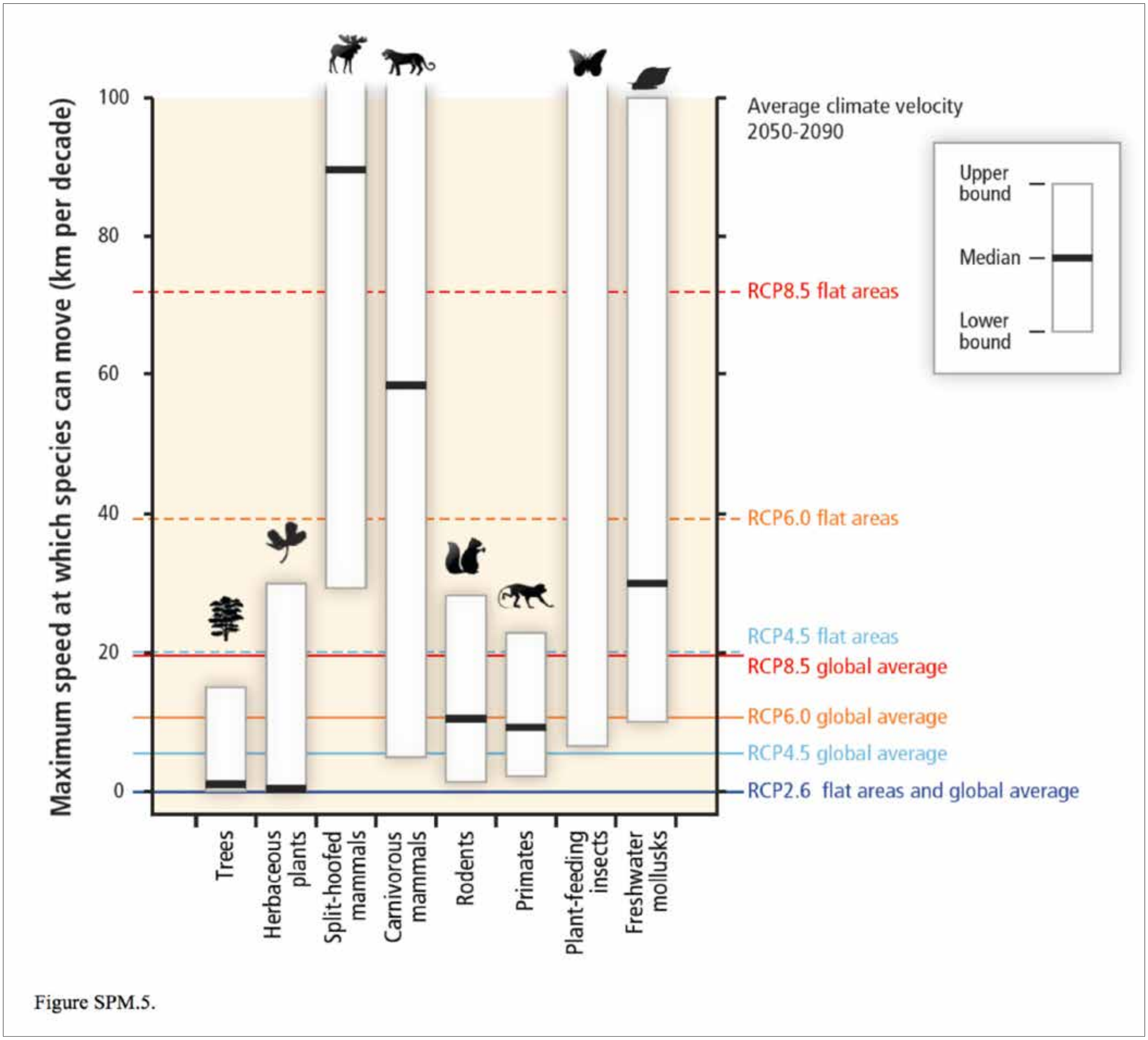


Figure 5-1. **Graph of climate change impacts, adaptation, and vulnerability for eight groups of organisms based on the maximum speed at which the organism can move. Figure Credit: © IPCC (2014).**

> plant-feeding insects (median not estimated), and freshwater mollusks. For RCP2.6, 4.5, 6.0, and 8.5 for 2050–2090, horizontal lines show climate velocity for the global-land-area average and for large flat regions. Species with maximum speeds below each line are expected to be unable to track warming in the absence of human intervention.

In addition to climate change impacts to natural resources, the Cultural Resources Climate Change Strategy (CRCCS) identifies four broad goals for management response to cultural resources: science, adaptation, mitigation, and communication (Melnick et al. 2016). CRCCS recommends including "impacts on the capacity of the cultural landscape features to convey significance and integrity, as well as prioritizing cultural landscape characteristics and contributing features for management actions."

As Golden Spike NHS managers try to formulate cultural and natural conservation goals in the midst of these rapidly changing conditions, access to scientifically-credible information to help inform management actions will be extremely beneficial. The NHS's Foundation Document (NPS 2017a) identifies planning for adaptation to climate change as a priority need for the park.

As temperature continues to rise as it has at Golden Spike NHS, with the last decade representing the warmest on record for years 1901-2012 (Monahan and Fisichelli 2014), changes are inevitable. Evidence-based information will help to communicate the complex climate change effects and impacts to the public and park staff, especially since all aspects of Golden Spike NHS's natural and cultural resources, operations, and visitor experiences will likely be affected (Monahan and Fisichelli 2014).

Literature Cited

Abatzoglou, J. T. and A. P. Williams. 2016. Impact of anthropogenic climate change on wildfire across western US forests. Proceedings of the National Academy of Sciences 113: 11770-11775. Available at: http://www.pnas.org/content/113/42/11770 (access 19 March 2018).

Allen, E. B., L. E. Rao, R. J. Steers, A. Bytnerowicz, and M. E. Fenn. 2009. Impacts of atmospheric nitrogen deposition on vegetation and soils in Joshua Tree National Park. Pages 78–100 in R.H. Webb, L.F. Fenstermaker, J.S. Heaton, D.L. Hughson, E.V. McDonald, and D.M. Miller, editors. The Mojave Desert: Ecosystem processes and sustainability. University of Nevada Press, Las Vegas, Nevada.

Allos Environmental. 2018. Promontory Point. Available at: https://allosenv.com/locations/promontory-point/about (accessed 20 June 2018).

American Ornithological Society (AOS). 2018. Checklist of North and Middle American birds. Available at: http://www.americanornithology.org/content/checklist-north-and-middle-american-birds (accessed 19 February 2018).

Anderssen, S.H., R.B. Nicolaisen, and G.W. Gabrielsen. 1993. Autonomic response to auditory stimulation. Acta Paediatrica 82:913-918.

Arndt, K. and T. A. Black. 2011. Sage-grouse habitat in Utah: a guide for landowners and managers. Utah State University, Logan, Utah. Available at: https://www.sagegrouseinitiative.com/about/for-landowners/ (accessed 1 March 2018).

Asher, J. A., and D. W. Harmon. 1995. Invasive exotic plants are destroying the naturalness of U.S. Wilderness areas. International Journal of Wilderness 1:35–37.

Barber, J.R., K. R. Crooks, K. M. Fristrup. 2010. The costs of chronic noise exposure for terrestrial organisms. 2010. Trends in Ecology and Evolution 25.3:180-189.

Baron, J. S., C. T. Driscoll, J. L. Stoddard, and E. E. Richer. 2011. Empirical critical loads of atmospheric nitrogen deposition for nutrient enrichment and acidification of sensitive U.S. lakes. Bioscience. American Institute of Biological Sciences, 61:602-613.

Bastian, H. 2004. Golden Spike National Historic Site Wildland and Prescribed Fire Monitoring Plan. National Park Service. Available at: https://irma.nps.gov/DataStore/Reference/Profile/2227553 (accessed 31 March 2018).

Bell, M. D. In Review. Ozone Sensitive Plant Species on National Park Service and U.S. Fish and Wildlife Service Lands: An Update to Results from the 2003 Baltimore Ozone Workshop. Natural Resource Report NPS/NRARD/NRR-X/Y. Available at: https://irma.nps.gov/NPSpecies/Reports/Systemwide/Ozone-Sensitive%20Species%20in%20a%20Park (accessed 19 March 2018).

Bibby, C. J, N. D. Burgess, D. A. Hill, and S. Mustoe. 2000. Bird census techniques. Second ed. London: Academic Press.

Boyce, B. N. 1980. The Passey onion: Its history, discovery, and current status at Golden Spike National Historic Site. Report to the Park Superintendent. July 21.

Brush, Robert O.; Palmer, James F. 1979. Measuring the impact of urbanization on scenic quality: land use change in the northeast. In: Elsner, Gary H., and Richard C. Smardon, technical coordinators. 1979. Proceedings of our national landscape: a conference on applied techniques for analysis and management of the visual resource [Incline Village, Nev., April 23-25, 1979]. Gen. Tech. Rep. PSW-GTR-35. Berkeley, CA. Pacific Southwest Forest and Range Exp. Stn., Forest Service, U.S. Department of Agriculture: p. 358. Available at: https://www.fs.fed.us/psw/publications/documents/psw_gtr035/psw_gtr035_08_brush.pdf(accessed 12 June 2018).

Bryce, S. A., R. M. Hughes, and P. R. Kaufmann. 2002. Development of a bird integrity index: Using bird assemblages as indicators of riparian condition. Environmental Management 30:294–310.

Buckland, S. T., D. R. Anderson, K. P. Burnham, J. L. Laake, D. L. Borchers, and L. Thomas. 2001. Introduction to distance sampling: Estimating abundance of biological populations. Oxford, U.K.: Oxford University Press.

Bureau of Land Management (BLM). 2016. Visual Resource Management. U.S. Department of the Interior, Bureau of Land Management. Washington, DC. Available at: https://www.blm.gov/programs/recreation/recreation-programs/visual-resource-management (accessed 12 June 2018).

Canterbury, G. E., T. E. Martin, D. R. Petit, L. J. Petit, and D. F. Bradford. 2000. Bird communities and habitat as ecological indicators of forest condition in regional monitoring. Conservation Biology 14:544–558.

Carles, L. J., I. L. Barrio, and J. Vicente de Lucio. 1999. Available at: https://ac.els-cdn.com/S0169204698001121/1-s2.0-S0169204698001121-main.pdf?_tid=577af21a-72c4-4d29-af75-eacc8a5db7ad&acdnat=1528844083_4d740e01c5c907a4c75a93c85eb6c271 (accessed 12 June 2018), Sound influence on landscape values. Landscape and Urban Planning 43:191-200.

Clough, G. 1982. Environmental effects on animals used in biomedical research. Biological Reviews 57:487-523.

Coggins, G.C. 1987. Protecting the wildlife resources of national parks from external threats. Land and Water Law Review, 22, 1-27 as cited in Monahan et al. 2012.

Coles, J., A. Wight, J. Von Loh, K. Schulz, and A. Evenden. 2011. Vegetation classification and mapping project report, Golden Spike National Historic Site. Natural Resource Technical Report NPS/NCPN/NRTR—2011/508. National Park Service, Fort Collins, Colorado. Available at: https://science.nature.nps.gov/im/inventory/veg/project.cfm?ReferenceCode=2177124 (accessed 5 March 2018).

D'Antonio, C. M., and B. E. Mahall. 1991. Root profiles and competition between the invasive, exotic perennial, *Carpobrotus edulis*, and two native shrub species in California coastal scrub. American Journal of Botany 78:885–894.

Dooling, R., and A. Popper. 2007. The effects of highway noise on birds. Rockville, MD: Environmental BioAcoustics LLC.

E&S Environmental Chemistry, Inc. 2009. Nitrogen screening project - sensitive vegetation. Available at: https://irma.nps.gov/DataStore/Reference/Profile/2170016 (accessed 19 March 2018).

Eagles-Smith, C. A., J. J. Willacker, Jr., and C. M. Flanagan Pritz. 2014. Mercury in Fishes from 21 National Parks in the Western United States - Inter- and Intra-Park Variation in Concentrations and Ecological Risk. U.S. Geological Survey Open-File Report 2014-1051. Available at: http://dx.doi.org/10.3133/ofr20141051 (accessed 7 February 2018).

eBird. 2014. Sagebrush and Bell's sparrows. Available at: https://ebird.org/news/mccreedysage/ (accessed 5 March 2018).

eBird. 2018a. eBird checklist for Golden Spike National Historic Site. Ithaca, New York. Available at: https://ebird.org/hotspot/L292432. eBird. (accessed 23 February 2018).

eBird. 2018b. About eBird: Global tools for birders, critical data for science. Available at: http://ebird.org/content/ebird/about/. (accessed 23 February 2018). Birds

Ehrenfeld, J. G. 2003. The effects of exotic plant invasions on soil nutrient cycling processes. Ecosystems 6:503–523.

ESRI. 2016. Using viewshed and observer points for visibility analysis. Available at: http://desktop.arcgis.com/en/arcmap/10.3/tools/spatial-analyst-toolbox/using-viewshed-and-observer-points-for-visibility.htm (accessed 15 June 2018).

Evenden, A., M. Miller, M. Beer, E. Nance, S. Daw, A. Wight, M. Estenson, and L. Cudlip. 2002. Northern Colorado Plateau vital signs network and prototype cluster, plan for natural resources monitoring: Phase I report, October 1, 2002.

[Two volumes]. National Park Service, Northern Colorado Plateau Network, Moab, UT.

Fedy, B. C., K. E. Doherty, C. L. Aldridge, M. O'Donnell, J. L. Beck, B. Bedrosian, D. Gummer, M. J. Holloran, G. D. Johnson, N. W. Kaczor, C. P. Kirol, C. A. Mandich, D. Marshall, G. Mckee, C. Olson, A. C. Pratt, C. C. Swanson and B. L. Walker. 2014. Habitat prioritization across large landscapes, multiple seasons, and novel areas: An example using greater sage-grouse in Wyoming. Wildlife Monographs. 190: 1-39. Available at: http://fedylab.uwaterloo.ca/peer-reviewed/ (accessed 10 April 2018).

Fertig, W. 2009. Annotated checklist of vascular fl ora: Golden Spike National Historic Site. Natural Resource Technical Report NPS/NCPN/NRTR—2009/206. National Park Service, Fort Collins, Colorado. Available at: https://irma.nps.gov/DataStore/DownloadFile/154114 (accessed 25 March 2018).

Fertig, W., S. Topp, M. Moran, T. Hildebrand, J. Ott, and D. Zobell. 2012. Vascular plant species discoveries in the Northern Colorado Plateau Network: update for 2008–2011. Natural Resource Technical Report NPS/NCPN/NRTR—2012/582. National Park Service, Fort Collins, Colorado. Available at: https://irma.nps.gov/DataStore/DownloadFile/448793 (accessed 25 March 2018).

Fowler, D., J. A. Pyle, J. A. Raven, and M. A. Sutton. 2013. The global nitrogen cycle in the twenty-first century: Introduction. Philosophical Transactions of the Royal Society B: Biological Sciences, 368(1621), 20130165. Available at: http://doi.org/10.1098/rstb.2013.0165 (accessed 19 March 2018).

Francis, Clinton D., N.J. Kleist, C.P. Ortega, and A. Cruz. 2012. Noise pollution alters ecological services: enhanced pollination and disrupted seed dispersal. Proc. R. Soc. B. Vol. 279. No. 1739. The Royal Society. Available at: http://rspb.royalsocietypublishing.org/content/early/2012/03/15/rspb.2012.0230 (accessed 5 February 2018).

Garfin, G., G. Franco, H. Blanco, A. Comrie, P. Gonzalez, T. Piechota, R. Smyth, and R. Waskom. 2014. Ch. 20: Southwest, in J. M. Melillo, T. C. Richmond, and G. W. Yohe, eds. Climate Change Impacts in the United States: The Third National Climate Assessment. U.S. Global Change Research Program, 462-486. doi:10.7930/J08G8HMN. Available at: http://nca2014.globalchange.gov/report/regions/southwest%0D (accessed 28, April 2018).

Gobster, P. H. 1999. An ecological aesthetic for forest landscape management. Landscape Journal 18: 65-64. Available at: https://www.nrs.fs.fed.us/pubs/jrnl/1999/nc_1999_Gobster_001.pdf (accessed 5 July 2018).

Johnson, G. W., J. D. Anderson, and D. Godwin. 2008. A guidebook for the Blue Ridge Parkway Scenery Conservation System. Draft. National Park Service, Asheville, North Carolina.

Haas G.E., and T.J. Wakefield. 1998. National parks and the American public: a summary report of the National Parks Conservation Association, conducted by Colorado State University, Fort Collins, Colorado.

Han, K. T. 2010. An exploration of relationships among responses to natural scenes: Scenic beauty, preference and restoration. Environment and Behavior 42(2):243-270. Available at: http://journals.sagepub.com/doi/pdf/10.1177/0013916509333875 (accessed 12 June 2018).

Harris, C. M. 1998. Handbook of Acoustical Measurements and Noise Control, 3rd edition. McGraw-Hill, New York.

Haymond, S., M.A. Bogan, and E.W. Valdez. 2003. 2001-2002 Mammalian inventory final report for selected Northern Colorado Plateau Network Parks. U.S. Geological Survey, submitted to National Park Service.

Hellmann, J. J., J. E. Byers, B. G. Bierwagen, and J. S. Dukes. 2008. Five potential consequences of climate change for invasive species. Conservation Biology 22: 534-543.

Hetherington, J., T.C. Daniel. and T.C. Brown. 1993. Is motion more important than it sounds?:

The medium of presentation in environmental perception research. J. Environmental Psychology. 13: 283-291. Available at: https://ac.els-cdn.com/S0272494405802518/1-s2.0-S0272494405802518-main.pdf?_tid=5d297fef-c860-48fa-ae83-bdcfa0055f73&acdnat=1528843994_43083a491d397cdc4d7616c73ebb27ec (accessed 12 June 2018).

Holmgren, N. H. and A. H. Holmgren. 1974. Three new species from the Great Basin. Brittonia 26: 309-311 as cited in Boyce (1980).

Homstad, C., J. Caywood, and P. Nelson. 2003. Cultural landscape report: Golden Spike National Historic Site, Box Elder County, Utah. National Park Service. Available at: http://npshistory.com/series/archeology/rmr/16/index.htm (accessed 12 June 2018).

Hunt, C. B. 1974. Natural regions of the United States and Canada. W.H. Freeman, San Francisco. 725 p. as cited in Evenden et al. (2002).

Intergovernmental Panel on Climate Change (IPCC). 2014. Climate change 2014: impacts, adaptation, and vulnerability. Available at: http://www.ipcc.ch/report/ar5/wg2/(accessed 7 December 2017).

Inouye, R.S. 2006. Effects of shrub removal and nitrogen addition on soil moisture in sagebrush steppe. Journal of Arid Environments. 65: 604–618.

Johnson, G. W., J. D. Anderson, and D. Godwin. 2008. A guidebook for the Blue Ridge Parkway Scenery Conservation System. Draft. National Park Service, Asheville, North Carolina.

Johnson M.J., M. Stuart, J. Holmes, and M. Barr. 2003. 2001-02 Avian inventory final report for Northern Colorado Plateau National Parks (Cedar Breaks NM, Fossil Butte NM, Golden Spike NHM, Timpanogos NM). Final report to the National Park Service Northern Colorado Plateau Network. USGS/Southwest Biological Science Center/Colorado Plateau Research Station/Northern Arizona University. Available at: https://irma.nps.gov/DataStore/DownloadFile/151974 (accessed 19 February 2018).

Kaltenborn, B. P. and T. Bjerke. 2002. Associations between environmental value orientations and landscape preferences. Landscape and Urban Planning 59:1-11. Available at: https://ac.els-cdn.com/S0169204601002432/1-s2.0-S0169204601002432-main.pdf?_tid=58a229e9-12df-4fe5-9834-258c0f299877&acdnat=1528842715_9b5e22325aafdfc66c14857da015d9f6 (accessed 12 June 2018).

Kaplan, R. and S. Kaplan. 1989. The experience of nature: A Psychological Perspective. Cambridge University Press, Cambridge, UK.

Kaseloo PA. 2006. Synthesis of noise effects on wildlife populations. In: Proceedings of the 2005 International Conference on Ecology and Transportation, Eds. Irwin CL, Garrett P, McDermott KP. Center for Transportation and the Environment, North Carolina State University, Raleigh, NC: pp. 33-35.

Kearney, A. R., G. A. Bradley, C. H. Petrich, R. Kaplan, S. Kaplan, and D. Simpson-Colebank. 2008. Public perception as support for scenic quality regulation in a nationally treasured landscape. Landscape and Urban Planning 87:117-128. Available at: https://ac.els-cdn.com/S0169204608000819/1-s2.0-S0169204608000819-main.pdf?_tid=78b4e600-fb1d-427d-ab10-28eb37f6555e&acdnat=1528842315_384e92af69d9909e257f8e12761ab290 (accessed 12 June 2018).

King, W. B. 1985. Island birds: Will the future repeat the past? Pages 3–15 in P. J. Moors, ed., Conservation of Island Birds. International Council for Bird Preservation. Cambridge: Cambridge University Press.

Kinney, P. L. 2008. Climate change, air quality, and human health. American Journal of Preventative Medicine 35: 459-467. Available at: http://www.ajpmonline.org/article/S0749-3797(08)00690-9/abstract (accessed 19 March 2018).

Knerr, J. 2007. Greater sage-grouse ecology in Western Box Elder County, Utah. Master's Thesis. Utah State University, Logan, Utah. Available at: https://digitalcommons.usu.edu/cgi/viewcontent.cgi?referer=https://www.google.com/&httpsr

edir=1&article=3272&context=wild_facpub (accessed 19 February 2018).

Kunkel, K. E, L. E. Stevens, S. E. Stevens, L. Sun, E. Janssen, D. Wuebbles, K. T. Redmond, and J. G. Dobson. 2013. Regional climate trends and scenarios for the U.S. national climate assessment. Part 5. Climate of the Southwest U.S. National Oceanic and Atmospheric Administration, Technical Report NESDIS 142-5, Washington, DC. Available at: https://www.ncdc.noaa.gov/news/us-regional-climate-trends-and-scenarios (accessed 7 July 2017).

Kunz, T. H., and A. Kurta. 1988. Capture methods and holding devices. Pp. 1-30 in: Ecological and behavioral methods for the study of bats, T. H. Kunz, ed. Smithsonian Institution Press, Washington, D. C. as cited in Haymond et al. (2003).

Landers, D. H., S. M. Simonich, D. Jaffe, L. Geiser, D. H. Campbell, A. Schwindt, C. B. Schreck, M. L. Kent, W. Hafner, H. E. Taylor, K. J. Hageman, S. Usenko, L. K. Ackerman, J. Schrlau, N. Rose, T. Blett, and M. M. Erway. 2010. The Western Airborne Contaminant Project (WACAP): an interdisciplinary evaluation of the impacts of airborne contaminants in Western U.S. National Parks. Environmental Science and Technology 44: 855-859. Available at: https://pubs.acs.org/doi/abs/10.1021/es901866e (accessed 7 February 2018).

LANDFIRE. 2014. Data products version table. Available at: https://www.landfire.gov/version_comparison.php?mosaic=Y (accessed 19 July 2017).

Lehmann, C.M.B., and D.A. Gay. 2011. Monitoring long-term trends of acidic wet deposition in U.S. precipitation: Results from the National Atmospheric Deposition Program. Power Plant Chemistry (13)7: 378-385.

Longcore, T. and C. Rich. 2004. Ecological light pollution. Frontiers in Ecology and the Environment 2: 191-198.

Lynch, E., D. Joyce, and K. Fristrup. 2011. An assessment of noise audibility and sound levels in U.S. National Parks. Landscape Ecology 26:1297-1309.

Mac, M.J., P.A. Opler, C.E.P. Haecker, and P.D. Doran, editors. 1998. Status and Trends of the Nation's Biological Resources - Southwest. U.S. Geological Survey, Biological Resources Division as cited by Haymond et al. 2003.

Mack, R. N., D. Simberloff, W. M. Lonsdale, H. Evans, M. Clout, and F. A. Bazzaz. 2000. Biotic invasions: causes, epidemiology, global consequences, and control. Ecological Applications 10: 689-710. Available at: http://www.tsusinvasives.org/dotAsset/3c962e29-b1ab-46bc-a3d0-fb99fefa1f2d.pdf (accessed 31 March 2018).

McDonald, C. D., R.M. Baumgartner, and R. Iachan. 1995. National Park Service aircraft management studies (US Department of Interior Rep. No. 94-2). Denver, CO: National Park Service.

McLaren, M. F., and J. A. Blakesley. 2013. Landbird monitoring in the Northern Colorado Plateau Network: 2012 field season. Natural Resource Technical Report NPS/NCPN/NRTR—2013/765. National Park Service, Fort Collins, Colorado Available at: https://irma.nps.gov/DataStore/Reference/Profile/2195870 (accessed 28 February 2018).

McLaughlin, K.E. and H.P. Kunc. 2013. Experimentally increased noise levels change spatial and singing behavior. Biology letters 9.1 (2013): 20120771.

Melnick, Robert Z. and Nadja Quiroz. "Study of Climate Change Impacts on Cultural Landscapes in the Pacific West Region, National Park Service, Phase II: Preliminary Vulnerability Assessments." Cultural Landscape Research Group, University of Oregon, 2017. Available at: https://irma.nps.gov/DataStore/DownloadFile/587873 (accessed 12 July 2018).

Monaco, T. A. 2003. Vegetation dynamics within Golden Spike National Historic Site. Utah State University, Logan, Utah.

Monaco, T. A. 2004. Noxious weeds and wildfire risk at Golden Spike National Historic Site. Utah State University, Logan, Utah.

Monahan, W. B. and N. A. Fisichelli. 2014a. Climate exposure of U.S. national parks in a new era of change. PLos ONE 9 (7): e101302. Available at: http://journals.plos.org/plosone/article?id=10.1371/journal.pone.0101302 (accessed 25 March 2018).

Monahan, W. B. and N. A. Fisichelli. 2014b. Recent climate change exposure of Golden Spike National Historic Site. Available at: https://irma.nps.gov/DataStore/Reference/Profile/2212872 (accessed 19 March 2018).

Monahan, W. B., J. E. Gross, L. K. Svancara, and T. Philippi. 2012. A guide to interpreting NPScape data and analyses. Natural Resource Technical Report NPS/NRSS/NRTR—2012/578. National Park Service, Fort Collins, Colorado. Available at: https://irma.nps.gov/DataStore/DownloadFile/448392 (accessed 12 June 2018).

Moore, C. A., J. M. White, and F. Turina. 2013. Recommended indicators of night sky quality for NPS state of the park reports, interim guidance. Natural Sounds and Night Skies Division, WASO-Natural Resource Stewardship and Science. July 10, 2013.

Morse, L.E., J.M. Randall, N. Benton, R. Hiebert, and S. Lu. 2004. An invasive species assessment protocol: evaluating non-native plants for their impact on biodiversity. Version 1. NatureServe, Arlington, Virginia. Available at: http://www.natureserve.org/biodiversity-science/publications/invasive-species-assessment-protocol-evaluating-non-native-plants (accessed 25 March 2018).

Munson, S. M., J. Belnap, C. D. Schelz, M. Moran, and T. W. Carolin. On the brink of change: plant responses to climate on the Colorado Plateau. Ecosphere 2: art68. Available at: https://esajournals.onlinelibrary.wiley.com/doi/pdf/10.1890/ES11-00059.1 (accesssed 25 March 2018).

National Aeronautics and Space Administration (NASA). 2017. NASA Day/night band product. Available at: http://viirsland.gsfc.nasa.gov/Products/DNB.html (accessed 15 February 2018).

National Park Service (NPS). 1916. Organic Act (16 USC1). Available at: http://www.nature.nps.gov/naturalsounds/laws_policies (accessed 22 September 2016).

National Park Service (NPS). 1978. Golden Spike National Historic Site general management plan.

National Park Service (NPS). 1985. Golden Spike National Historic Site statement for management.

National Park Service (NPS). 1994. Report to Congress. Report on effects of aircraft overflights on the National Park System. Sound

National Park Service (NPS). 2004. Natural Resource Management Reference Manual #77. Available at: http://www.nature.nps.gov/rm77/(accessed 28 April 2018).

National Park Service (NPS). 2005. NPS ecological monitoring framework. Available at: https://www.nps.gov/orgs/1439/nrca-framework.htm#framework (accessed 29 April 2018).

National Park Service (NPS). 2006. Management Policies 2006: The guide to managing the National Park System. Washington, D.C. 180 pp. Available at: https://www.nps.gov/policy/mp/Index2006.htm (accessed 2 February 2018).

National Park Service (NPS). 2010a. Standard NRCA report outline – annotated version 3.1. 5p. Available at: https://www.nps.gov/orgs/1439/upload/NRCA_Report_Outline_annotated_ver3-1_508.pdf (accessed 29 April 2018).

National Park Service (NPS). 2010b. Stargazing in parks. NPS Natural Resource Program Center Air Resources Division Night Sky Program. Available at: http://npshistory.com/publications/sound/stargazing.pdf (accessed 15 February 2018).

National Park Service (NPS). 2011a. Program brief: Inventory and monitoring program. U.S. Department of the Interior, National Park Service, Natural Resource Program Center, Inventory and Monitoring Division, Fort Collins, Colorado.

National Park Service (NPS). 2011b. Northern Rocky Mountains invasive plant management plan. Available at: https://parkplanning.nps.gov/

document.cfm?parkID=64&projectID=20520&documentID=39098 (accessed 15 July 2018).

National Park Service (NPS). 2012-2014. Climate change action plan. Available at: https://www.nps.gov/orgs/ccrp/upload/NPS_CCActionPlan.pdf (9 November 2017).

National Park Service (NPS). 2012. A call to action: preparing for a second century of stewardship and engagement. Washington, D.C. Available at: https://www.nps.gov/calltoaction/ (accessed 29 April 2018).

National Park Service (NPS). 2014a. NPScape standard operating procedure: housing measure – current and projected housing density. Version 2015-04-14. National Park Service, Natural Resource Stewardship and Science. Fort Collins, Colorado. Available at: https://irma.nps.gov/DataStore/DownloadFile/466248 (accessed 12 June 2018).

National Park Service (NPS). 2014b. NPScape standard operating procedure: roads measure – road density, distance from roads, and area without roads. Version 2015-04-23. National Park Service, Natural Resource Stewardship and Science. Fort Collins, Colorado. Available at: https://irma.nps.gov/DataStore/DownloadFile/521765 (accessed 12 June 2018).

National Park Service (NPS). 2014c. NPScape standard operating procedure: conservation status measure – protected area and ownership/governance. Version 2014-01-06. National Park Service, Natural Resource Stewardship and Science. Fort Collins, Colorado. Available at: https://irma.nps.gov/DataStore/DownloadFile/466244 (accessed 12 June 2018).

National Park Service (NPS). 2016a. NPScape: monitoring landscape dynamics of U.S. National Parks. Natural Resource Program Center, Inventory and Monitoring Division. Fort Collins, Colorado. Available at: http://science.nature.nps.gov/im/monitor/npscape/(accessed 12 June 2018).

National Park Service (NPS). 2016b. Metric GIS data. Available at: http://science.nature.nps.gov/im/monitor/npscape/gis_data.cfm?tab=1 (accessed 12 June 2018).

National Park Service (NPS). 2017a. Foundation Document: Golden Spike National Historic Site. National Park Service, Denver, Colorado.

National Park Service (NPS). 2017b. Golden Spike National Historic Site, Utah. Available at: https://www.nps.gov/gosp/index.htm (accessed 12 December 2017).

National Park Service (NPS). 2017c. Integrated resource management applications: IRMA portal. Available at: https://irma.nps.gov/App/ (accessed 12 December 2017).

National Park Service (NPS). 2017d. Natural Resource Stewardship and Science Directorate. Available at: https://nature.nps.gov/aboutus.cfm (accessed 12 December 2017).

National Park Service (NPS). 2018. NPSpecies list. Available at: https://irma.nps.gov/NPSpecies/ (accessed 16 February 2018).

National Park Service Air Resources Division (NPS-ARD). 2002. Air quality in the national parks, second edition. Lakewood, Colorado.

National Park Service Air Resources Division (NPS-ARD). 2003. Air atlas summary tables for I&M parks. Available at: http://www.nature.nps.gov/air/Permits/ARIS/networks/docs/SummariesAirAtlasRevised11072003.pdf (accessed 19 March 2018).

National Park Service Air Resources Division (NPS-ARD). 2005. Redesignation of clean air areas. Available at: http://www.nature.nps.gov/air/Regs/redesig.cfm (accessed 19 March 2018).

National Park Service Air Resources Division (NPS-ARD). 2009. Wet deposition monitoring. Available at: http://www.nature.nps.gov/air/Monitoring/wetmon.cfm (accessed 19 March 2018).

National Park Service Air Resources Division (NPS-ARD). 2010. Air quality in national parks: 2009 annual performance and progress report.

Natural Resource Report NPS/NRPC/ARD/NRR—2010/266. National Park Service, Denver, Colorado. Available at: https://www.nature.nps.gov/air/Pubs/pdf/gpra/AQ_Trends_In_Parks_2009_Final_Web.pdf (accessed 19 March 2018).

National Park Service Air Resources Division (NPS-ARD). 2013a. Effects of air pollution. Available at: https://www.nature.nps.gov/air/aqbasics/effects.cfm (accessed 17 September 2017).

National Park Service Air Resources Division (NPS-ARD). 2013b. Ozone effects on vegetation. Available at: http://www.nature.nps.gov/air/AQBasics/ozoneEffects.cfm (accessed 17 September 2017).

National Park Service Air Resources Division (NPS-ARD). 2016. Air quality in parks. Available at: http://www.nature.nps.gov/air/Permits/aris/index.cfm (accessed 19 March 2018).

National Park Service Air Resources Division (NPS-ARD). 2018a. Draft guidance for evaluating air quality in Natural Resource Condition Assessments. National Park Service, Denver, Colorado.

National Park Service Air Resources Division (NPS-ARD). 2018b. Mercury/toxics data and information for Golden Spike NHS, provided by Jim Cheatham, NPS Air Resources Division, to Lisa Baril, Utah State University, via email on 2 February 2018.

National Park Service (NPS) Natural Sounds and Night Skies Division (NSNSD). 2015. Night skies photic environment resource summary, Golden Spike National Historic Site. National Park Service. Denver, Colorado. Available at: https://irma.nps.gov/DataStore/Reference/Profile/2225927 (accessed 15 February 21018).

National Park Service Northern Colorado Plateau Network (NCPN). 2018. Natural resources monitoring at Golden Spike National Historic Site. Available at: https://www.nps.gov/im/ncpn/gosp.htm (accessed 28 April 2018).

National Park Service (NPS) Public Use Statistics Office. 2018. NPS visitor use statistics. Annual park visitation (all years). Available at: https://irma.nps.gov/Stats/Reports/ReportList (accessed 28 April 2018).

NatureServe. 2017. NatureServe Explorer. Available at: http://explorer.natureserve.org/ranking.htm (accessed 25 March 2018).

North American Bird Conservation Initiative (NABCI), U.S. Committee. 2016. State of North America's birds 2016. Available at: http://www.stateofthebirds.org/2016/ (accessed 28 February 2018).

Northern Rocky Mountain Exotic Plant Management Team (NRM-EPMT). 2014. Annual partner parks report. National Park Service.

Northern Rocky Mountain Exotic Plant Management Team (NRM-EPMT). 2015. Annual partner parks report. National Park Service.

Northern Rocky Mountain Exotic Plant Management Team (NRM-EPMT). 2016. Annual partner parks report. National Park Service.

Northern Rocky Mountain Exotic Plant Management Team (NRM-EPMT). 2017. Annual partner parks report. National Park Service.

O'Connor, Z. 2008. Facade colour and aesthetic response: examining patterns of response within the context of urban design and planning in Sydney, University of Sydney: Sydney, Australia. Available at: https://www.researchgate.net/publication/265928881_Facade_colour_and_aesthetic_response_Examining_patterns_of_response_within_the_context_of_urban_design_and_planning_policy_in_Sydney (accessed 12 June 2018).

O'Connor, Z. 2009. Facade colour and judgements about building size. In D. Smith, P. Green-Armytage, M. A. Pope, and N. Harkness (Eds.) AIC 2009: Proceedings of the 11th Congress of the International Colour Association, Sydney. Available at: https://aic11.wildapricot.org/page-18077 (accessed 12 June 2018).

O'Farrell, M. J., and E. H. Studier. 1980. *Myotis thysanodes*. Mammalian Species 137: 1–5 as cited in Oliver 2000.

Oliver, G. 2000. The bats of Utah. A literature review. Utah Division of Wildlife Resources. Salt Lake City. Publication Number 00–14. Available at: https://wildlife.utah.gov/pdf/bats.pdf (accessed 8 June 2018).

Oliver, G.V. 2006. Vertebrate species in Utah Northern Colorado Plateau Network Parks. Utah Natural Heritage Program. NPS Cooperative Agreement No. H1341040002, Annual Report, 15 March 2006.

Panjabi, A. O., P. J. Blancher, R. Dettmers, and K. V. Rosenberg, Version 2012. Partners in Flight Technical Series No. 3. Rocky Mountain Bird Observatory. Available at: http://www.rmbo.org/pubs/downloads/Handbook2012.pdf (accessed 2 March 2018).

Panjabi , A. O., P. J. Blancher, W. E. Easton, J. C. Stanton D. W. Demarest, R. Dettmers, and K. V. Rosenberg. The Partners in Flight Handbook on Species Assessment. Version 2017. Partners in Flight Technical Series No. 3. Bird Conservancy of the Rockies. Available at: http://www.birdconservancy.org/resourcecenter/publications/ (accessed 2 March 2018).

Partners in Flight. 2016. Avian Conservation Assessment Database, version 2017. Available at: http//pif.birdconservancy.org/ACAD (accessed 28 February 2018).

Perkins, D. W., and R. Weissinger. 2009. Invasive exotic plant monitoring at Golden Spike National Historic Site: 2008 pilot field season. Natural Resource Technical Report NPS/NCPN/NRTR—2009/226. National Park Service, Fort Collins, Colorado. Available at: https://irma.nps.gov/DataStore/DownloadFile/154125 (accessed 25 March 2018).

Perkins, D. 2011. Invasive exotic plant monitoring at Golden Spike National Historic Site: 2010 field season.Natural Resource Technical Report NPS/NCPN/NRTR—2011/458. National Park Service, Fort Collins, Colorado. Available at: https://irma.nps.gov/DataStore/DownloadFile/429792 (accessed 25 March 2018).

Perkins, D. 2013. Invasive exotic plant monitoring in Golden Spike National Historic Site: 2012 field season. Natural Resource Technical Report NPS/NCPN/NRTR—2013/748. National Park Service, Fort Collins, Colorado. Available at: https://irma.nps.gov/DataStore/DownloadFile/469876 (accessed 25 March 2018).

Perkins, D. W. 2015. Invasive exotic plant monitoring at Golden Spike National Historic Site: field season 2014. Natural Resource Report NPS/NCPN/NRR—2015/945. National Park Service, Fort Collins, Colorado. Available at :https://irma.nps.gov/DataStore/DownloadFile/521267 (accessed 25 March 2018).

Perkins, D.W., K. Edvarchuk, S. Dewey, H. Thomas, and A. Wight. 2016. Invasive exotic plant monitoring protocol narrative for Northern Colorado Plateau Network parks: Version 1.02. Natural Resource Report NPS/NCPN/NRR—2016/1340. National Park Service, Fort Collins, Colorado. Available at: https://irma.nps.gov/DataStore/DownloadFile/560987 (accessed 25 March 2018).

Perkins, D. W. 2017. Invasive exotic plant monitoring at Golden Spike National Historic Site: Field season 2016. Natural Resource Report NPS/NCPN/NRR—2017/1513. National Park Service, Fort Collins, Colorado. Available at: https://irma.nps.gov/DataStore/DownloadFile/583309s (accessed 25 March 2018).

Phillips, N. C., S. R. Larson, and D. T. Drost. 2008. Detection of genetic variation in wild populations of three Allium species using amplified fragment length polymorphisms. Horticultural Science 43: 637-643.

Phillips, N. C., D. T. Drost, W. A. Varga, L. M. Shultz, and S. E. Meyer. 2010. Germination characteristics along altitudinal gradients in three intermountain *Allium* spp. (Amaryllidaceae). Seed Technology 32: 15-25.

Phillips, N. C., D. T. Drost, W. A. Varga, L. M. Shultz. 2011. Demography, reproduction, and dormancy along altitudinal gradients in three intermountain Allium species with contrasting abundance and distribution. Flora 206: 164-171.

Platenberg, R. and T. Graham. 2003. Northern Colorado Plateau Network herpetofauna inventory: 2002 annual report. USGS Canyonlands Field Station, Southwest Biological Science Center, Moab, Utah.

Porter, E., and A. Wondrak-Biel. 2011. Air quality monitoring protocol and standard operating procedures for the Sonoran Desert, Southern Plains, and Chihuahuan Desert networks. Version 2.00. Natural Resource Report NPS/SODN/NRTR—2011/390. National Park Service, Fort Collins, Colorado. Available at: https://www.nps.gov/articles/air-quality-monitoring-in-southwest-networks.htm (accessed 20 March 2018).

Prein, A. F., G. J. Holland, R. M. Rasmussen, M. P. Clark, and M. R. Tye. 2016. Running dry: the U.S. Southwest's drift into a drier climate. Geophysical Research Letters 43: 1-8. Available at: https://agupubs.onlinelibrary.wiley.com/doi/pdf/10.1002/2015GL066727 (accessed 25 March 2018).

Rao, L.E., E.B. Allen, and T. Meixner. 2010. Risk-based determination of critical nitrogen deposition loads for fire spread in southern California deserts. Ecological Applications 20:1320–1335.

Ratcliff, F. 1972. Contour and contrast. Scientific American 226: 91-101.

Rejmanek, M., and M. J. Pitcairn. 2002. When is eradication of exotic pest plants a realistic goal? Pages 249–253 in C. R. Veitch and M. N. Clout, eds., Turning the tide: The eradication of invasive species. IUCN SSC Invasive Species Specialist Group. Gland, Switzerland and Cambridge, U.K.: IUCN. Available at: http://www.issg.org/pdf/publications/turning_the_tide.pdf (accessed 25 March 2018).

Ribe, R. G. 2005. Aesthetic perceptions of green-tree retention harvests in vista views: The interaction of cut level, retention pattern, and harvest shape. Landscape and Urban Planning 73:277-293. Available at: https://ac.els-cdn.com/S0169204604000970/1-s2.0-S0169204604000970-main.pdf?_tid=6a25338a-5a06-4fad-9e86-02d0dced5171&acdnat=1528843748_53da57c16256545515c14d57af35f20a (accessed 12 June 2018).

Rich, T. D., C. J. Beardmore, H. Berlanga, P. J. Blancher, M. S. W. Bradstreet, G. S. Butcher, D. W. Demarest, E. H. Dunn, W. C. Hunter, E. E. Iñigo-Elias, J. A. Kennedy, A. M. Martell, A. O. Panjabi, D. N. Pashley, K. V. Rosenberg, C. M. Rustay, J. S. Wendt, T. C. Will. 2004. Partners in Flight North American Landbird Conservation Plan. Cornell Lab of Ornithology. Ithaca, NY. Available at: https://www.partnersinflight.org/resources/north-american-landbird-conservation-plan/ (accessed 5 March 2018).

Royal Commission on Environmental Pollution. 2009. Artificial light in the environment. The Stationery Office Limited, London.

Ryan, R. L. 2006. Comparing the attitudes of local residents, planners, and developers about preserving rural character in New England. Landscape and Urban Planning 75: 5-22. Available at: https://ac.els-cdn.com/S0169204604001847/1-s2.0-S0169204604001847-main.pdf?_tid=799ab432-b37a-4eed-ad70-9a3e76831396&acdnat=1528843136_3b06220b7408280574a7bab59eaad68b (accessed 12 June 2018).

Schauman, S. 1979. The countryside visual resource. In Proceedings of our national landscape: a conference on applied techniques for analysis and management of the visual resource, General Technical Report PSW-35, Pacific Southwest Forest and Range Experiment Station, Forest Service, USDA, Berkeley, California. Available at: https://www.fs.fed.us/psw/publications/documents/psw_gtr035/psw_gtr035_01_schauman.pdf (accessed 12 June 2018).

Schroeder, M. A., J. R. Young and C. E. Braun. 1999. Greater Sage-Grouse (*Centrocercus urophasianus*), version 2.0. In The Birds of North America (P. G. Rodewald, editor). Cornell Lab of Ornithology, Ithaca, New York, USA. Available at: https://doi.org/10.2173/bna.425 (accessed 5 March 2018).

Schupp, E.W. no date. Cheatgrass (*Bromus tectorum*). Available at: https://www.usu.edu/weeds/

plant_species/weedspecies/cheatgrass.html (accessed 10 July 2018).

Schwinning, S., B.I. Starr, N.J. Wojcik, M.E. Miller, J.E. Ehleringer, and R.L. Sanford. 2005. Effects of nitrogen deposition on an arid grassland in the Colorado plateau cold desert. Rangeland Ecology and Management. 58: 565–574.

Sekercioglu, C. H. 2002. Impacts of birdwatching on human and avian communities. Environmental Conservation 29:282–289.

Selin, N.E. 2009. Global biogeochemical cycling of mercury: a review. Annual Review of Environment and Resources 34:43.

Selye, H. 1956. The stress of life. New York: McGraw-Hill.

Shannon, G., M. F. McKenna, L. M. Angeloni, K. R. Crooks, K M. Fristrup, E. Brown, K. A. Warner, M. D. Nelson, and C. White. 2015. A synthesis of two decades of research documenting the effects of noise on wildlife. Biological Reviews. Available at: http://onlinelibrary.wiley.com/doi/10.1111/brv.12207/abstract (accessed 5 February 2018).

Sheibley, R. W., M. Enache, P. W. Swarzenski, P. W. Moran, and J. R. Foreman, 2014. Nitrogen deposition effects on diatom communities in lakes from three national parks in Washington State. Water, Air, & Soil Pollution 225:1857.

Sheppard, S. R. J. 2001. Beyond visual resource management: Emerging theories of an ecological aesthetic and visible stewardship. In Sheppard, S. R. J. and H. W. Harshaw, Eds., Forests and Landscapes: Linking Ecology, Sustainability and Aesthetics. CABI Publishing, New York.

Staver, C. 2004. Introduced species summary project cheatgrass (*Bromus tectorum*). Available at: http://www.columbia.edu/itc/cerc/danoff-burg/invasion_bio/inv_spp_summ/Bromus_tectorum.html (accessed 10 July 2018).

Stebbins, R.C. 1985. Western Reptiles and Amphibians, 2nd ed. Houghton Mifflin Co, Boston as cited in Platenberg and Graham (2003).

Stegner, M.A., D.S. Karp, A.J. Rominger, and E.A. Hadly. 2017. Can protected areas really maintain mammalian diversity? Insights from a nestedness analysis of the Colorado Plateau. Biological Conservation 209: 546-553.

Sullivan, T. J., G. T. McPherson, T. C. McDonnell, S. D. Mackey, and D. Moore. 2011. Evaluation of the sensitivity of inventory and monitoring national parks to acidification effects from atmospheric sulfur and nitrogen deposition: Northern Colorado Plateau Network (NCPN). Natural Resource Report NPS/NRPC/ARD/NRR—2011/366. National Park Service, Denver, Colorado. Available at: https://irma.nps.gov/DataStore/Reference/Profile/2170555 (accessed 19 March 2018).

Sullivan, T. J. 2016. Air quality related values (AQRVs) for Northern Colorado Plateau Network (NCPN) parks: Effects from ozone; visibility reducing particles; and atmospheric deposition of acids, nutrients and toxics. Natural Resource Report NPS/NCPN/NRR—2016/1169. National Park Service, Fort Collins, Colorado. Available at: https://irma.nps.gov/DataStore/Reference/Profile/2229121 (accessed 19 March 2018).

Summerhays, J. C. R. 2011. Effects of non-surface-disturbing treatments for native grass revegetation n cheatgrass (Bromus tectorum L.) metrics and soil ion availabilities. Master's Thesis. Utah State University, Logan, Utah. Available at: https://digitalcommons.usu.edu/etd/?utm_source=digitalcommons.usu.edu%2Fetd%2F1024&utm_medium=PDF&utm_campaign=PDFCoverPages (accessed 31 March 2018).

Templeton, D. and Sacre. 1997. Acoustics in the built environment: Advice for the design team. 2nd edition. D. Templeton (editor). Architectural Press: Boston, Massachusetts.

Theobald, D.M. 2005. Landscape patterns of exurban growth in the USA from 1980 to 2020. Ecology and Society 10:32. Available at: https://www.ecologyandsociety.org/vol10/iss1/art32/ (accessed 12 June 2018).

Tilman, D. 1999. The ecological consequences of changes in biodiversity: A search for general principles. Ecology 80:1455–1474. Available at: http://esa.org/history/Awards/papers/Tilman_D_MA.pdf (accessed 25 March 2018).

Turina, F., E. Lynch, and K. Fristrup. 2013. Recommended indicators and thresholds of acoustic resources quality NPS State of the Park reports interim guidance- December 2013. National Park Service Natural Sounds and Night Skies Division.

U.S. Census Bureau. no date. Quick facts. Available at: https://www.census.gov/quickfacts/fact/table/boxeldercountyutah,kanecountyutah,garfieldcountyutah,US/PST045217 (accessed 15 February 2018).

U.S. Census Bureau. 2016. Utah was nation's fastest-growing state, Census Bureau Reports. Available at: https://www.census.gov/newsroom/press-releases/2016/cb16-214.html (accessed 15 February 2018).

U.S. Census Bureau. 2017. 2016 TIGER/Line Shapefiles: Roads. Available at: https://www.census.gov/cgi-bin/geo/shapefiles/index.php?year=2016&layergroup=Roads (accessed 29 March 2017).

U.S. Environmental Protection Agency (USEPA). 2014. Policy assessment for the review of the ozone national ambient air quality standards. EPA-452/R-14-006. U.S. Environmental Protection Agency, Research Triangle Park, North Carolina. Available at: http://www.epa.gov/ttn/naaqs/standards/ozone/data/20140829pa.pdf (accessed 19 March 2018).

U.S. Environmental Protection Agency (USEPA). 2016. What climate change means for Utah. Available at: https://19january2017snapshot.epa.gov/sites/production/files/2016-09/documents/climate-change-ut.pdf (accessed 27 June 2018).

U.S. Environmental Protection Agency (USEPA). 2017a. National ambient air quality standards (NAAQS). Available at: https://www.epa.gov/criteria-air-pollutants (accessed 17 September 2017).

U.S. Environmental Protection Agency (USEPA). 2017b. Acid rain. Available at: https://www.epa.gov/acidrain/what-acid-rain (accessed 19 March 2018).

U.S. Federal Register. 1970. Clean Air Act. Public Law 95-124. Pages 5673-5965. Available at: http://www2.epa.gov/laws-regulations/summary-clean-air-act (accessed 28 April 2018).

U. S. Fish and Wildlife Service (USFWS). 2007. Petition to list 206 Mountain-Prairie Region species. Available at: https://ecos.fws.gov/ecp0/profile/speciesProfile?spcode=Q019 (accessed 6 March 2018).

U.S. Fish and Wildlife Service (USFWS). 2009. Partial 90-day finding to list 206 species in the Midwest and Western United States as Threatened or Endangered with Critical Habitat. Available at: https://ecos.fws.gov/ecp0/profile/speciesProfile?spcode=Q019 (accessed 6 March 2018).

U.S. Fish and Wildlife Service (USFWS). 2008. Birds of conservation concern 2008. United States Department of Interior, Fish and Wildlife Service, Division of Migratory Bird Management, Arlington, Virginia. Available at: https://www.fws.gov/birds/management/managed-species/birds-of-conservation-concern.php (accessed 2 March 2018).

U.S. Fish and Wildlife Service (USFWS). 2016a. Threats to birds, migratory birds mortality-questions and answers. Available at: https://www.fws.gov/birds/bird-enthusiasts/threats-to-birds.php (last accessed 2 February 2018).

U.S. Fish and Wildlife Service (USFWS). 2016b. Greater sage-grouse. Available at: https://www.fws.gov/greatersagegrouse/ (accessed 10 April 2018).

U.S. Fish and Wildlife Service (USFWS). 2018. Listed species believed to or known to occur in Utah. Environmental Conservation Online System. Available at: https://ecos.fws.gov/ecp0/reports/species-listed-by-state-report?state=UT&status=listed (accessed 2 February 2018).

U.S. Forest Service (USFS). 1992. Report to Congress. Potential impacts of aircraft overflights of National Forest System Wildernesses.

U.S. Forest Service (USFS). 1995. Landscape aesthetics: a handbook for scenery management. Agricultural Handbook 710. Available at: https://www.fs.fed.us/cdt/carrying_capacity/landscape_aesthetics_handbook_701_no_append.pdf (accessed 12 June 2018).

U.S. Geological Survey (USGS). 2012. A summary of the relationship between GAP Status Codes and IUCN Definitions. Available at: http:// gapanalysis.usgs.gov/blog/iucn-definitions/(accessed 12 June 2018).

U.S. Geological Survey (USGS). 2014. Water resources of the United States, boundary descriptions and names of regions, subregions, accounting units and cataloging units. Available at: http://water.usgs.gov/GIS/huc_name.html#Region15 (accessed 28 April 2018).

U.S. Geological Survey (USGS). 2015. Predicted surface water methylmercury concentrations in National Park Service Inventory and Monitoring Program Parks. Last modified February 20, 2015. U.S. Geological Survey. Wisconsin Water Science Center, Middleton, WI. Available at: http://wi.water.usgs.gov/mercury/NPSHgMap.html (accessed 19 March 2018).

U.S. Geological Survey (USGS), Gap Analysis Program (GAP). 2016. Protected Areas Database of the United States (PAD-US), version 1.4 Combined Feature Class. Available at: http://gapanalysis.usgs.gov/padus/data/download/ (accessed 12 June 2018).

U.S. Geological Survey (USGS). 2018a. The National Map viewer. Available at: http://viewer.nationalmap.gov/basic/?basemap=b1&category=ned,nedsrc&title=3DEP%20View#productGroupSearch (accessed 12 June 2018).

U.S. Geological Survey (USGS). 2018b. The Public Lands Survey System (PLSS). Available at: https://nationalmap.gov/small_scale/a_plss.html (accessed 30 March 2018). Passey's onion

Utah Department of Agriculture and Food (UDAF). 2018. State of Utah noxious weed list. Available at: http://ag.utah.gov/plants-pests/s-weeds/37-plants-and-pests/599-noxious-weed-list.html (accessed 22 March 2018).

Utah Department of Environmental Quality (UDEQ). 2018. Frequently asked questions: Promontory Point Landfill. Available at: https://www.documentcloud.org/documents/4411810-Utah-DEQ-FAQ-Promontory-Point-Resources-Landfill.html (accessed 20 June 2018).

Utah Department of Natural Resources (UDWR). 2016. Implementing Utah's greater sage-grouse conservation plan: 2016 report. Salt Lake City, Utah. Available at: https://wildlife.utah.gov/learn-more/greater-sage-grouse.html (accessed 1 March 2018).

Utah Division of Natural Resources (UDWR). 2017a. Available at: https://dwrcdc.nr.utah.gov/ucdc/ViewReports/SS_List.pdf (accessed 21 June 2018).

Utah Division of Natural Resources (UDWR). 2017b. Utah's state listed species by county. Available at: https://dwrcdc.nr.utah.gov/ucdc/ViewReports/sscounty.pdf (accessed 21 June 2018).

Utah Division of Wildlife Resources (UDWR). 2013. Conservation plan for greater sage-grouse in Utah.. Available at: https://wildlife.utah.gov/learn-more/greater-sage-grouse.html (accessed 19 February 2018).

Utah Division of Wildlife Resources (UDWR). 2015. Utah sensitive species list. Available at: https://wildlife.utah.gov/habitat/ (accessed 19 February 2018).

Utah Native Plant Society (UNPS). 2016. Utah rare plant list. Calachortiana No. 3. Available at: https://www.utahrareplants.org/rpg_species.html#All (accessed 12 July 2017).

Utah Wildlife Action Plan Joint Team (UWAPJT). 2015. Utah Wildlife Action Plan: a plan for managing native wildlife species and their habitats to help prevent listing under the Endangered Species Act. Publication number 15-14. Utah Division of Wildlife Resources, Salt Lake City, Utah. Available at: https://wildlife.utah.gov/learn-more/wap2015.html (accessed 12 July 2018).

Virden, R. J. and G. J. Walker. 1999. Ethnic/racial and gender variations among meanings given to, and preferences for, the natural environment. Leisure Sciences 21:219-239. Available at: https://www.tandfonline.com/doi/pdf/10.1080/014904099273110?needAccess=true (accessed 18 June 2018).

Vitousek, P. M. 1990. Biological invasions and ecosystem processes: towards an integration of population biology and ecosystem studies. Oikos 57:7–13.

Welsh, S. L. 1979. Illustrated manual of proposed endangered and threatened plants of Utah. 193-194 as cited in Boyce (1980).

Wood, L. J. 2015. Acoustic environment and soundscape resource summary, Golden Spike National Historic Site. National Park Service, Natural Sounds and Night Skies Division, Denver, Colorado. Available at: https://irma.nps.gov/DataStore/Reference/Profile/2225914 (accessed 14 February 2018)

Weathers, K. C., S. M. Simkin, G. M. Lovett, and S. E. Lindberg. 2006. Empirical modeling of atmospheric deposition in mountainous landscapes. Ecological Applications. 16:1590-1607. Available at: http://www.caryinstitute.org/sites/default/files/public/reprints/Weathers_EmpiricalModel_2006.pdf (accessed 7 February 2018).

Welch, B.A., Geissler, P.H., and Latham, Penelope, 2014, Early detection of invasive plants—principles and practices: U.S. Geological Survey Scientific Investigations Report 2012–5162, 193 pp. Available at: http://dx.doi.org/10.3133/sir20125162. (accessed 25 March 2018).

Western Association of Fish and Wildlife Agencies (WAFWA) (no date). Mule deer: changing landscapes, changing perspectives. Available at: https://www.wafwa.org/Documents%20and%20Settings/37/Site%20Documents/Working%20Groups/Mule%20Deer/Publications2/Mule%20Deer%20Changes.pdf (accessed 26 May 2018).

Wilcove, D. S., D. Rothstein, J. Dubow, A. Phillips, and E. Losos. 1998. Quantifying threats to imperiled species in the United States. Bioscience 48:607–615. Available at: https://www.fws.gov/southwest/es/documents/R2ES/LitCited/LPC_2012/Wilcove_et_al_1998.pdf (accessed 25 March 2018).

Witwicki, D. 2013. Climate monitoring in the Northern Colorado Plateau Network: annual report 2011. Natural Resource Technical Report NPS/NCPN/NRTR—2013/664. National Park Service, Fort Collins, Colorado.

Wondrak-Biel, A. 2005. Aesthetic conservation and the National Park Service. Yellowstone Science 13(3):1.

Zube, E. H., J. L. Sell, and J. G. Taylor. 1982. Landscape perception: Research, application, and theory. Landscape Planning 9:1-33. Available at: https://ac.els-cdn.com/0304392482900090/1-s2.0-0304392482900090-main.pdf?_tid=d1ab9034-4231-47db-8d93-b1a4917cdb0f&acdnat=1528842097_bc8895fea2d5aa6d1b90278b149c0d80 (accessed 12 June 2018).

Appendix A. Report Reviewers

Table A-1. Report reviewers.

Name	Affiliation and Position Title	Section(s) Reviewed or Other Role
Jeff Albright	National Park Service Water Resources Division, Natural Resource Condition Assessment Series Coordinator	Washington-level Program Manager
Phyllis Pineda Bovin	National Park Service Intermountain Region Office, Natural Resource Condition Assessment Coordinator	Regional Program Level Coordinator and Peer Review Manager
Kelly Adams and Todd Wilson	National Park Service, Grants and Contracting Officers	Executed agreements
Fagan Johnson	National Park Service Inventory & Monitoring Division, Web and Report Specialist	Washington-level Publishing and 508 Compliance Review
Dusty Perkins	National Park Service Northern Colorado Plateau Inventory and Monitoring Network, Program Manager	Birds, Non-native Invasive Plants, Vegetation Communities, Passey's Onion, Mammals and Herpetofauna Assessments and Chapter 5
Mark Meyer	National Park Service Air Resources Division, Visual Resource Specialist	Viewshed Assessment
Li-Wei Hung	National Park Service Natural Sounds and Night Skies Division, Night Sky Research Scientist	Night Sky Assessment and Data
Emma Brown	National Park Service Natural Sounds and Night Skies Division, Acoustical Resource Specialist	Soundscape Assessment
Debra Miller	National Park Service Intermountain Region Office, Air Resource Specialist	Air Quality Assessment
Donna Shorrock	U.S. Forest Service Rocky Mountain Regional Office, Regional Vegetation Ecologist, Research Natural Areas Coordinator	Vegetation Communities Assessment
Michael Piep	Assistant Curator/ Collections Manager Intermountain Herbarium, Utah State University	Passey's Onion Assessment
Steven Bekedam	National Park Service Intermountain Region Northern Rocky Mountain Exotic Plant Management Team, Supervisory Botanist / Liaison	Non-native Invasive Plants Assessment
Kristen Philbrook	National Park Service Intermountain Region Office, Wildlife Biologist	Birds and Mammals Assessments
Jennifer Williams	National Park Service Biological Resources Division, Partners in Amphibian and Reptile Conservation Federal Coordinator	Herpetofauna Assessment

Appendix B. Viewshed Analysis Steps

The process used to complete Golden Spike National Historic Site's viewshed analyses is listed below.

Downloaded 12 of the 1/3 arc second national elevation dataset (NED) grid (roughly equivalent to a 30 m digital elevation model [DEM]) from U.S. Geological Survey's National Map Viewer (http://viewer.nationalmap.gov/basic/?basemap=b1&category=ned,nedsrc&title=3DEP%20View#productGroupSearch) (USGS 2018a) and created a mosaic dataset. The x and y values for the NED are in arc seconds while the z data are in meters. The DEMs were reprojected into NAD83 Albers Meter to get all data in meters and into a geographic extent that covered the entire area.

Prepared observation point layers for viewshed analyses by importing GPSd points for all vantage point locations selected for viewshed analysis. Exported data to a shapefile. Added field named "OFFSETA" (type = double) to shapefile and set value to an observer height of 1.68 m (~5'6"). ESRI (2016) provides a useful overview of the visibility analysis.

Ran Viewshed Analysis using the Viewshed Tool in ESRI's ArcGIS 10.2, Spatial Analyst Toolbox, ran viewsheds using the following inputs.

- Input raster = 1/3 arc second NED
- Input point observer feature = obs_point.shp.

The rasters were reclassified into visible areas only to create the maps. The Observer Point Tool in Spatial Analyst was used, creating a composite viewshed, which showed all combined visible areas. A 98 km (61 mi) buffer was created surrounding the park, reprojected into the Albers Equal Area Conic USGS projection, then used as the area of analysis (AOA) for the NPS NPScape's housing, road, and conservation status tools as described in NPS 2014a,b,c. A text attribute field was added to the AOA for the area of analysis identifier.

Housing (CONUS, Density, SERGoM, 1970 - 2100, Metric Data 9.3 File Geodatabase (Theobald 2005), U.S. Census Bureau 2017 TIGER/Line Shapefiles: Roads) (U.S. Census Bureau 2017), and conservation status (NPS 2014c, USGS GAP 2016) GIS datasets were downloaded from NPScape (NPS 2016b) and the USGS GAP (USGS GAP 2016) websites. Standard Operating Procedures for all three tools were followed based on NPScape instructions (NPS 2014a,b,c).

Appendix C. Golden Spike NHS Bird List.

Listed in the table below are the bird species reported for Golden Spike National Historic Site (NHS) according to NPSpecies (NPS 2018), Johnson et al. (2003), and a subset of birds reported in eBird (2018a). Some species reported in eBird were observed in a nearby pond adjacent to the historic site. Because this habitat type does not occur in the historic site, we removed species associated with wetlands (e.g., ducks and shorebirds). Scientific names were updated with the current taxonomy used by the American Ornithological Society (AOS 2018). A total of 119 species are contained in the table, but only the NPSpecies list is certified (i.e., vetted for accuracy). The table contains an additional 22 species that were by Johnson et al. (2003) or eBird. NPSpecies listed 97 bird species at the historic site, 71 of which were listed as "present", 21 were listed as "probably present", and five were considered "unconfirmed".

Table C-1. Bird species list for Golden Spike NHS.

Common Name	Scientific Name	Occurrence	Abundance	NPSpecies Tags	eBird
American crow	*Corvus brachyrhynchos*	Probably Present	–	–	–
American goldfinch	*Spinus tristis*	Present	Unknown	–	x
American kestrel	*Falco sparverius*	Present	Common	Breeder	x
American pipit	*Anthus rubescens*	–	–	–	x
American robin	*Turdus migratorius*	Present	Common	Breeder	x
American tree sparrow	*Spizelloides arborea*	Probably Present	–	–	x
Ash-throated flycatcher	*Myiarchus cinerascens*	Probably Present	–	–-	x
Bald eagle	*Haliaeetus leucocephalus*	Present	Unknown	Management Priority	x
Bank swallow	*Riparia riparia*	Unconfirmed	–	–	x
Barn owl	*Tyto alba*	Probably Present	–	–	x
Barn swallow	*Hirundo rustica*	Present	Common	Resident	x
Black-billed magpie	*Pica hudsonia*	Present	Common	Breeder	x
Black-chinned hummingbird	*Archilochus alexandri*	Present	Unknown	–	x
Black-throated gray warbler	*Dendroica nigrescens*	Unconfirmed	–	–	–
Black-throated sparrow	*Amphispiza bilineata*	Probably Present	–	–	–
Brewer's sparrow	*Spizella breweri*	Present	Common	Breeder	x
Brewer's blackbird	*Euphagus cyanocephalus*	Present	Common	Breeder	x
Broad-tailed hummingbird	*Selasphorus platycercus*	Present	Unknown	–	–
Brown-headed cowbird	*Molothrus ater*	Present	Common	Breeder	x
Bullock's oriole	*Icterus bullockii*	Present	Uncommon	Resident	–
Burrowing owl	*Athene cunicularia*	Present	Uncommon	Breeder	x
Bushtit	*Psaltriparus minimus*	–	–	–	x
California gull	*Larus californicus*	Present	Common	Migratory	x
California quail	*Callipepla californica*	Present	Uncommon	Breeder	x
Calliope hummingbird	*Selasphorus calliope*	Present	Occasional	–	–
Canada goose	*Branta canadensis*	Present	Uncommon	Migratory	x
Canyon wren	*Catherpes mexicanus*	Present	Uncommon	Breeder	–
Cassin's finch[1]	*Haemorhous cassinii*	–	–	–	–
Cedar waxwing	*Bombycilla cedrorum*	Unconfirmed	–	–	–
Chipping sparrow	*Spizella passerina*	–	–	–	x

* Indicates a non-native species.

[1] Species that were listed only by Johnson et al. (2003).

[2] Originally known as sage sparrow (*A. belli*), this species has been split into the Bell's sparrow and the sagebrush sparrow. The latter species is the most likely given range descriptions (eBird 2014).

Note: X = species present.

Table C-1 continued. ***Bird species list for Golden Spike NHS.***

Common Name	Scientific Name	Occurrence	Abundance	NPSpecies Tags	eBird
Chukar*	*Alectoris chukar*	Present	Uncommon	Breeder	x
Cliff swallow	*Petrochelidon pyrrhonota*	Present	Abundant	Breeder	x
Common grackle	*Quiscalus quiscula*	Probably Present	–	–	x
Common Name	*Scientific Name*	Occurrence	Abundance	NPSpecies Tags	eBird
Common nighthawk	*Chordeiles minor*	Present	Uncommon	Resident	x
Common poorwill	*Phalaenoptilus nuttallii*	Present	Abundant	Resident	–
Common raven	*Corvus corax*	Present	Common	Resident	x
Common yellowthroat	*Geothlypis trichas*	–	–	–	x
Cooper's hawk	*Accipiter cooperii*	Unconfirmed	–	–	x
Dark-eyed junco	*Junco hyemalis*	Present	Unknown	–	x
Downy woodpecker	*Picoides pubescens*	Probably Present	–	–	–
Eastern kingbird	*Tyrannus tyrannus*	Probably Present	–	–	x
Eurasian collared-dove*	*Streptopelia decaocto*	–	–	–	x
European starling*	*Sturnus vulgaris*	Present	Common	Breeder	x
Ferruginous hawk	*Buteo regalis*	Probably Present	–	–	x
Franklin's gull	*Leucophaeus pipixcan*	Probably Present	–	–	x
Golden eagle	*Aquila chrysaetos*	Present	Uncommon	Breeder	x
Grasshopper sparrow	*Ammadromus savannarum*	Probably Present	–	–	x
Gray partridge*	*Perdix perdix*	Present	Uncommon	Resident	x
Gray-crowned rosy-finch	*Leucosticte tephrocotis*	–	–	–	x
Great blue heron	*Ardea herodias*	Present	Common	Resident	x
Great horned owl	*Bubo virginianus*	Present	Uncommon	Breeder	x
Greater sage-grouse	*Centrocercus urophasianus*	Present	Rare	Resident	–
Green-tailed towhee	*Pipilo chlorurus*	Present	Unknown	–	–
Horned lark	*Eremophila alpestris*	Present	Common	Breeder	x
House finch	*Haemorhous mexicanus*	Present	Common	Breeder	x
House sparrow*	*Passer domesticus*	Probably Present	–	–	x
Juniper titmouse	*Baeolophus ridgwayi*	Unconfirmed	–	–	–
Killdeer	*Charadrius vociferus*	Present	Rare	Breeder	x
Lapland longspur	*Calcarius lapponicus*	Probably Present	–	–	x
Lark bunting	*Calamospiza melanocorys*	Probably Present	–	–	x
Lark sparrow	*Chondestes grammacus*	Present	Common	Breeder	x
Lazuli bunting	*Passerina amoena*	Present	Unknown	–	–
Loggerhead shrike	*Lanius ludovicianus*	Present	Common	Resident	x
Long-billed curlew	*Numenius americanus*	Present	Common	Breeder	x
Long-eared owl	*Asio otus*	Probably Present	–	–	x
Mallard	*Anas platyrhynchos*	Present	Uncommon	Resident	–
Marsh wren	*Cistothorus palustris*	–	–	–	x
McCown's longspur	*Rhynchophanes mccownii*	–	–	–	x
Merlin	*Falco columbarius*	–	–	–	x
Mountain bluebird	*Sialia currucoides*	–	–	–	x
Mourning dove	*Zenaida macroura*	Present	Common	Breeder	x

* Indicates a non-native species.

[1] Species that were listed only by Johnson et al. (2003).

[2] Originally known as sage sparrow (*A. belli*), this species has been split into the Bell's sparrow and the sagebrush sparrow. The latter species is the most likely given range descriptions (eBird 2014).

Note: X = species present.

Table C-1 continued. Bird species list for Golden Spike NHS.

Common Name	Scientific Name	Occurrence	Abundance	NPSpecies Tags	eBird
Nashville warbler	*Oreothlypis ruficapilla*	–	–	–	x
Northern flicker	*Colaptes auratus*	Present	Common	Resident	x
Northern harrier	*Circus hudsonius*	Present	Common	Resident	x
Northern mockingbird	*Mimus polyglottos*	Present	Uncommon	Resident	x
Northern rough-winged swallow	*Stelgidopteryx serripennis*	Present	Common	Resident	x
Northern shrike	*Lanius borealis*	Probably Present	–	–	x
Orange-crowned warbler	*Vermivora celata*	Present	Rare	Migratory	x
Peregrine falcon	*Falco peregrinus*	–	–	–	x
Pine siskin	*Spinus pinus*	Present	Unknown	Migratory	x
Prairie falcon	*Falco mexicanus*	Present	Common	Resident	x
Red-necked phalarope	*Phalaropus lobatus*	Present	Rare	Migratory	–
Red-tailed hawk	*Buteo jamaicensis*	Present	Common	Resident	x
Red-winged blackbird	*Agelaius phoeniceus*	Present	Unknown	–	x
Ring-necked pheasant*	*Phasianus colchicus*	Present	Common	Resident	x
Rock pigeon*	*Columba livia*	Probably Present	–	–	x
Rock wren	*Salpinctes obsoletus*	Present	Common	Breeder	x
Rough-legged hawk	*Buteo lagopus*	Present	Uncommon	Resident	x
Ruby-crowned kinglet	*Regulus calendula*	–	–	–	x
Sage thrasher	*Oreoscoptes montanus*	Present	Common	Breeder	x
Sagebrush sparrow[2]	*Artemisiospiza nevadensis*	Probably Present	–	–	x
Sandhill crane	*Antigone canadensis*	Present	Uncommon	Migratory	x
Savannah sparrow	*Passerculus sandwichensis*	Probably Present	–	–	x
Say's phoebe	*Sayornis saya*	Present	Common	Breeder	x
Sharp-tailed grouse	*Tympanuchus phasianellus*	Present	Unknown	–	x
Short-eared owl	*Asio flammeus*	Present	Common	Resident	x
Snow bunting	*Plectrophenax nivalis*	–	–	–	x
Snowy egret	*Egretta thula*	Present	Uncommon	Resident	x
Song sparrow	*Melospiza melodia*	Probably Present	–	–	x
Spotted towhee	*Pipilo maculatus*	Present	Uncommon	Resident	x
Swainson's hawk	*Buteo swainsoni*	Present	Unknown	–	x
Tree swallow	*Tachycineta bicolor*	–	–	–	x
Turkey vulture	*Cathartes aura*	Present	Uncommon	Resident	x
Vesper sparrow	*Pooecetes gramineus*	Present	Rare	Resident	x
Violet-green swallow	*Tachycineta thalassina*	Present	Unknown	Resident	x
Western kingbird	*Tyrannus verticalis*	Present	Common	Resident	x
Western meadowlark	*Sturnella neglecta*	Present	Abundant	Breeder	x
Western tanager[1]	*Piranga ludoviciana*	–	–	–	–
Western wood-pewee	*Contopus sordidulus*	–	–	–	x
White-crowned sparrow	*Zonotrichia leucophrys*	Present	Unknown	Resident	x
White-tailed kite[1]	*Elanus leucurus*	–	–	–	–
Wild turkey	*Meleagris gallopavo*	–	–	–	x

* Indicates a non-native species.

[1] Species that were listed only by Johnson et al. (2003).

[2] Originally known as sage sparrow (*A. belli*), this species has been split into the Bell's sparrow and the sagebrush sparrow. The latter species is the most likely given range descriptions (eBird 2014).

Note: X = species present.

Table C-1 continued. Bird species list for Golden Spike NHS.

Common Name	Scientific Name	Occurrence	Abundance	NPSpecies Tags	eBird
Willet	*Tringa semipalmata*	Present	Uncommon	Resident	x
Wilson's snipe[1]	*Gallinago delicata*	–	–	–	–
Wilson's warbler	*Cardellina pusilla*	Present	Unknown	Migratory	x
Woodhouse's scrub-jay	*Aphelocoma woodhouseii*	Probably Present	–	–	x
Yellow warbler	*Setophaga petechia*	Present	Rare	Resident	–
Yellow-headed blackbird	*Xanthocephalus xanthocephalus*	Present	Unknown	–	–
Yellow-rumped warbler	*Setophaga coronata*	–	–	–	x

* Indicates a non-native species.

[1] Species that were listed only by Johnson et al. (2003).

[2] Originally known as sage sparrow (*A. belli*), this species has been split into the Bell's sparrow and the sagebrush sparrow. The latter species is the most likely given range descriptions (eBird 2014).

Note: X = species present.

Appendix D. Background on Bird Species of Conservation Concern Lists

This appendix provides background information on the organizations and efforts to determine species of birds that are in need of conservation. The information presented here supports the Data and Methods section of the birds assessment. This appendix contains some of the same, but additional, information as that section of the report.

One component of the bird condition assessment was to examine species occurrence in a conservation context. We compared the list of species that occur at Golden Spike National Historic Site (NHS) to lists of species of conservation concern developed by several organizations. There have been a number of such organizations that focus on the conservation of bird species. Such organizations may differ, however, in the criteria they use to identify and/or prioritize species of concern based on the mission and goals of their organization. They also range in geographic scale from global organizations such as the International Union for Conservation of Nature (IUCN), who maintains a "Red List of Threatened Species," to local organizations or chapters of larger organizations. This has been, and continues to be, a source of potential confusion for managers and others who need to make sense of and apply the applicable information. In recognition of this, the U.S. North American Bird Conservation Initiative (NABCI) was started in 1999; it represents a coalition of government agencies, private organizations, and bird initiatives in the U.S. working to ensure the conservation of North America's native bird populations. Although there remain a number of sources at multiple geographic and administrative scales for information on species of concern, the NABCI has made great progress in developing a common biological framework for conservation planning and design.

One of the developments from the NABCI was the delineation of Bird Conservation Regions (BCRs) (North American Bird Conservation Initiative 2016). Bird Conservation Regions are ecologically distinct regions in North America with similar bird communities, habitats, and resource management issues.

The purpose of delineating these BCRs was to:

- facilitate communication among the bird conservation initiatives;
- systematically and scientifically apportion the U.S. into conservation units;
- facilitate a regional approach to bird conservation;
- promote new, expanded, or restructured partnerships; and
- identify overlapping or conflicting conservation priorities.

D.1. Conservation Organizations Listing Species of Conservation Concern

Below we present a summary of some of the organizations that list species of conservation concern and briefly discuss the different purposes or goals of each organization.

U.S. Fish & Wildlife Service

The Endangered Species Act, passed in 1973, is intended to protect and recover imperiled species and the ecosystems upon which they depend. It is administered by the U.S. Fish and Wildlife Service (USFWS) and the Commerce Department's National Marine Fisheries Service (NMFS). USFWS has primary responsibility for terrestrial and freshwater organisms, while the responsibilities of NMFS are mainly marine wildlife, such as whales, and anadromous fish.

USFWS Birds of Conservation Concern

The USFWS has responsibilities for wildlife, including birds, in addition to endangered and threatened species. The Fish and Wildlife Conservation Act, as amended in 1988, further mandates that the USFWS "identify species, subspecies, and populations of all migratory nongame birds (i.e., Birds of Conservation Concern) that, without additional conservation actions, are likely to become candidates for listing under the Endangered Species Act" (USFWS 2008). The agency's 2008 effort, *Birds of Conservation Concern*, is one effort to fulfill the Act's requirements. The report includes both migratory and non-migratory bird species (beyond those federally-listed as threatened or endangered) that USFWS considers the highest conservation priorities. Three geographic scales are included--National, USFWS Regional, and the NABCI BCRs. The information used to compile the lists came primarily from the following three bird conservation plans: the Partners in Flight (PIF) North American Landbird Conservation Plan, the U.S. Shorebird Conservation Plan, and the North American Waterbird Conservation Plan. The scores used to assess the species are based on factors such as population trends, distribution, threats, and abundance.

North American Bird Conservation Initiative

A group of experts from the North American Bird Conservation Initiative (NABCI) determined U.S. bird species most in need of conservation action (NABCI 2016). The NABCI publishes a Watch List every few years in conjunction with a state of the birds report. The Watch List contains 432 species, some of which are protected by the ESA. However, some species not protected by the ESA are in critical need of attention to prevent them from becoming endangered or threatened. By producing the Watch List, NABCI hopes to encourage conservation of species, especially those under the greatest threat of extinction. The NABCI team assessed all birds in the continental U.S., Canada, and Mexico using the PIF Species Assessment Database (www.rmbo.org/pifassessment/; Panjabi et al. 2012). According to Panjabi et al. (2012), "each species is assigned global scores for 6 factors, assessing largely independent aspects of vulnerability at the range-wide scale" by examining population size, breeding distribution, non-breeding distribution, threats to breeding, threats to non-breeding, and population trend. Species are included on the Watch List if they exhibit a threshold of high combined vulnerability across all these factors.

Partners in Flight

Partners in Flight is a cooperative effort among federal, state, and local government agencies, as well as private organizations. One of its primary goals, relative to listing species of conservation concern, is to develop a scientifically based process for identifying and finding solutions to risks and threats to landbird populations. Their approach to identifying and assessing species of conservation concern is based on biological criteria to evaluate different components of vulnerability (Panjabi et al. 2012). Each species is evaluated for six components of vulnerability: population size, breeding distribution, non-breeding distribution, threats to breeding, threats to non-breeding, and population trend. The specific process is presented in detail in the species assessment handbook (Panjabi et al. 2012).

The PIF assessments are conducted at multiple scales. At the broadest scale, the North American Landbird Conservation Plan (Panjabi et al. 2012) identifies what PIF considers "Continental Watch List Species" and "Continental Stewardship Species." Continental Watch List Species are those that are most vulnerable at the continental scale, due to a combination of small and declining populations, limited distributions, and high threats throughout their ranges (Panjabi et al. 2012). Continental Stewardship Species are defined as those species that have a disproportionately high percentage of their world population within a single Avifaunal Biome during either the breeding season or the non-migratory portion of the non-breeding season.

More recently, PIF has adopted BCRs, the common planning unit under the NABCI, as the geographic scale for updated regional bird conservation assessments. These assessments are available via an online database (http://rmbo.org/pifassessment) maintained by the Rocky Mountain Bird Observatory. At the scale of the individual BCRs, these same principles of concern (sensu Continental Watch List Species) or stewardship (sensu Continental Stewardship Species) are applied at the BCR scale. The intention of this approach is to emphasize conservation of species where it is most relevant, as well as the recognition that some species may be experiencing dramatic declines locally even if they are not of high concern nationally, etc. There are two categories (concern and stewardship) each for Continental and Regional levels. The details of the criteria for inclusion in each can be found in Panjabi et al. (2012), and a general summary is as follows. Note that the assessment protocol has been updated (Panjabi et al. 2017), but the database for BCRs reflect 2012 data and have not been updated using the 2017 methods. In our Chapter 4 bird assessment, we did not use the two stewardship categories.

Criteria for Species of Continental Importance (see Panjabi et al. 2012 for details)

A. U.S.-Canada Concern (UCC)

- Meet criteria for PIF Watch List.
- Occur regularly in significant numbers in the BCR.
- Future conditions are not expected to improve.

B. U.S.-Canada Stewardship (UCS)

- Species is listed in PIF North American Plan (Rich et al. 2004).
- High importance of the BCR to the species.
- Future conditions are not expected to improve.

Criteria for Species of Regional Importance

Regional scores are calculated for each species according to which season(s) they are present in the BCR. The formulae include a mix of global and regional scores pertinent to each season (see Panjabi et al. 2012 for details). The criteria for each category are:

A. Regional Concern (RC)

- Regional combined score > 13.
- High regional threats or moderate regional threats combined with moderate or large regional population declines.
- Occurs regularly in significant numbers in the BCR.

B. Regional Stewardship (RS)

- High importance of the BCR to the species.
- Future conditions are not expected to improve.
- Native to North America.

Utah Division of Wildlife Resources

The Utah Division of Wildlife Resources (UDWR) prepared and maintains the Utah Sensitive Species List for vertebrate and invertebrate species. The list includes species for which a State conservation agreement exists, wildlife species of concern, and species that are federally listed and candidates for federal listing (UDWR 2015). Wildlife species of concern are species for which there is scientific evidence substantiating a threat to their continued population viability (UDWR 2015). The idea behind the designation is that timely conservation actions taken for each species will avoid the need to list them under the federal ESA in the future.

NPS 431/148844, October 2018

National Park Service
U.S. Department of the Interior

Natural Resource Stewardship and Science
1201 Oak Ridge Drive, Suite 150
Fort Collins, Colorado 80525

www.nature.nps.gov

EXPERIENCE YOUR AMERICA™