National Park Service
U.S. Department of the Interior

Natural Resource Stewardship and Science

Little Bighorn Battlefield National Monument

Natural Resource Condition Assessment

Natural Resource Report NPS/ROMN/NRR—2014/891

ON THE COVER
Indian Memorial at Little Bighorn Battlefield National Monument. Mike Britten photo.

Little Bighorn Battlefield National Monument

Natural Resource Condition Assessment

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Fort Collins, Colorado

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Executive Summary

The Natural Resource Condition Assessment (NRCA) Program, administered by National Park Service's (NPS) Water Resources Division, aims to provide documentation about current conditions of important park natural resources through a spatially explicit, multi-disciplinary synthesis of existing scientific data and knowledge. The NRCA for Little Bighorn Battlefield National Monument began in 2012, and 11 focal study natural resources were chosen for the assessment. These resources were organized into three categories that ranged in contexts from broader to narrower, including landscape-scale, supporting environment (i.e., physical resources), and biological integrity, which included wildlife and vegetation topics.

Just three years after the June 25-26, 1876 Battle of the Little Bighorn, the Secretary of War preserved the Custer Battlefield site as a National Cemetery. In 1926, the Reno-Benteen Battlefield was added. On July 1, 1940, the site was transferred from the Department of War to the National Park Service to manage, and in 1946 was designated Custer Battlefield National Monument. In 1991, Congress authorized a name change to Little Bighorn Battlefield National Monument. The Monument preserves, protects, and interprets the historic, cultural, and natural resources, including lands pertaining to the Battle of the Little Bighorn.

The landscape scale resources chosen for this assessment included viewshed, night sky, and soundscape. The condition of these resources can influence visitor experience and enjoyment, and is often critical to visitors' understanding of the events that occurred on the site. Overall, these resources are in moderate condition, with the exception of the viewshed, which is considered to be good-moderate. Human activities/developments occurring either within the Monument or nearby, but outside of the Monument's boundaries (e.g., interstates/highways, and congested parking lots), are contributing to views, night-time light pollution, and noises that are not consistent with the Monument's visitor goal of creating contemplative areas.

The Monument's supporting physical environment resource topics included air quality, geology, stream ecological integrity, and groundwater. Geology and groundwater are lacking specific data to provide insight into current condition and trend at the Monument. Data exist, however, for air quality and stream ecological integrity. Air quality monitoring is multifaceted and includes visibility, ozone, and wet deposition for total nitrogen, which all warranted moderate concern; whereas total sulfur is in good condition. The stream ecological integrity monitoring program is also multifaceted and interdisciplinary, with an overall good condition for the Little Bighorn River adjacent to the Monument.

The resource topics related to vegetation included riparian habitat, grasslands, and exotic plants. There were three indicators for riparian habitat (hydrology, vegetation, and erosion/deposition), and all of the specific measures indicate a good condition, with a stable trend. Grasslands are in a moderate condition due to the widespread presence of exotic annual bromes. There were four indicators of condition for exotic plants, all of which are of moderate concern. Finally, the wildlife resource topics included only landbirds. There was one indicator for landbirds, with three specific measures of condition (in a temporal, spatial, and conservation context). Each individual measure and the overall condition for landbirds is good.

Acknowledgements

We wish to thank Jeff Albright, program lead of the Natural Resource Condition Assessment Program, Water Resources Program Center, National Park Service, who provided programmatic insight and guidance on project development and review. The authors are grateful to the staff at the National Park Service Natural Resource Stewardship and Science Directorate for their technical expertise, guidance, and reviews of their respective subjects. We are extremely grateful to all subject matter experts who provided valuable information pertaining to their respective areas of research and expertise. Their input helped to create a relevant, scientifically based document that provided new insights into the communities and processes found and occurring throughout the Monument. Finally, we would like to express our gratitude and thanks to Little Bighorn Battlefield National Monument staff, especially Melena Stichman, Biological Science Technician, whose input and reviews were very appreciated. We also thank Ellen Waldhart for her valuable input regarding exotic plant information at the Monument. We also wish to thank Rocky Mountain Inventory and Monitoring GIS staff for their help with providing data and information. To all those remaining who reviewed and commented on this report, thank you. Your contributions have increased its professional value.

NPS-MIKE BRITTEN

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 frameworks;[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 reference conditions and values, NRCAs also report on trends, when appropriate (i.e., when the underlying data and methods support such reporting), as

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

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.

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

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 timeframe 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 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

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A NRCA is intended to provide useful science-based information products in support of all levels of park planning.

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/NRCondition_Assessment_Program/Index.cfm.

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)

NPS

A NRCA uses a variety of data to assess the condition of a park's natural resources.

6 A 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-condition data provided by NRCAs will be most 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.

NPS: MIKE BRITTEN

Indian Memorial at Little Bighorn Battlefield National Monument

Chapter 2: Introduction and Resource Setting

2.1. Introduction

2.1.1. Enabling Legislation/Executive Orders

The Little Bighorn Battlefield National Monument's legislation and executive orders span more than 130 years (Thomson 2011). An excerpt, taken from Thomson (2011), summarizes the legislation and orders that have created today's Monument:

- "August 1, 1879—Custer Battlefield National Cemetery (today's Little Bighorn Battlefield National Monument) was officially recognized and designated Custer Battlefield National Cemetery, a national cemetery of the Fourth Class by General Order No. 78, Headquarters of the Army.
- December 7, 1886—Executive Order No. 337443 established an approximately one square mile boundary for Custer Battlefield National Cemetery.
- April 14, 1926—Congress created the Reno/Benteen Battlefield.
- In 1930, all rights, titles, and interests of the Crow Indians, from whose land the battlefield was created, transferred to the U.S. government.
- August 10, 1939—Congress authorized a public historical museum.
- June 3, 1940—Executive Order No. 8428 transferred management of Custer Battlefield National Cemetery to the National Park Service (NPS) effective July 1, 1940.
- March 22, 1946—Public Law 79- 332 re-designated Custer National Cemetery as Custer Battlefield National Monument.
- January 3, 1991—Congress redesignated Custer Battlefield National Monument as Little Bighorn Battlefield National Monument, and authorized a memorial to honor American Indian participation in the Battle of the Little Bighorn."

The Monument preserves the site of the Battle of the Little Bighorn, which was fought June 25-26, 1876 between the 7th U.S. Cavalry, led by Lt. Col. George Armstrong Custer with the help of Arikara and Crow Indian scouts, and the encamped Sioux, Cheyenne, and Arapaho, led by spiritual leader Sitting Bull.

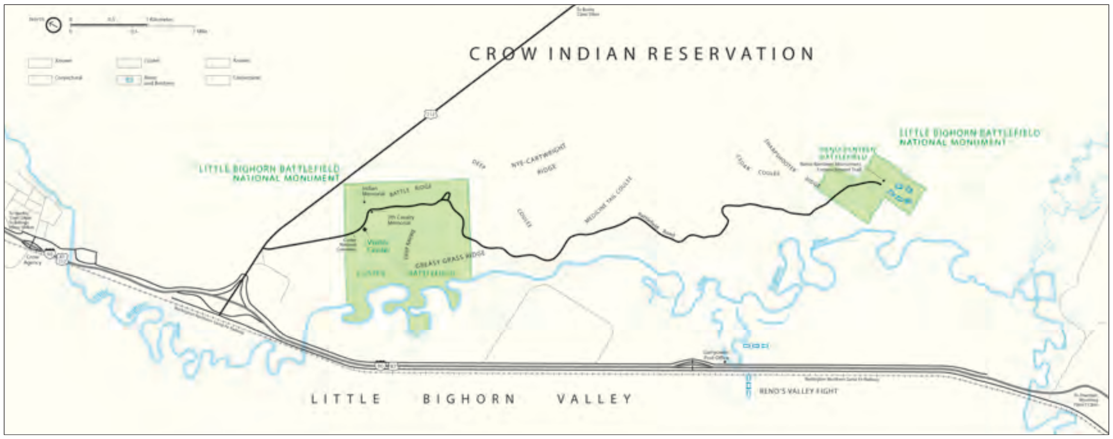

Figure 2.1.2-1. Setting of Little Bighorn Battlefield NM

The Monument's General Management Plan (NPS 1986/1995) states that its primary purpose is

> "to preserve and protect the historic and natural resources pertaining to the Battle of the Little Bighorn and to provide visitors with a greater understanding of those events which led up to the battle, the encounter itself, and the various effects the encounter had on the two cultures involved" (Thomson 2011).

2.1.2. Geographic Setting

Little Bighorn Battlefield National Monument contains 765.34 acres (309.72 hectares), in two units-Custer and Reno-Benteen, located within the boundaries of the Crow Indian Reservation. The two units are connected by the Battlefield Tour Road, which is a four mile long, narrow two-lane road. The Monument is located in Big Horn County in southeastern Montana, 65 miles south of Billings, Montana, and 73 miles north of Sheridan, Wyoming.(Figure 2.1.2-1). The meandering Little Bighorn River runs along the western boundary of the Monument, and grassland and shrubland covered rolling hills characterize the landscape (Rice et al. 2012). The Little Bighorn area has been the home of many Native American tribes since prehistoric times (Greene 2008). The Crow Indian Reservation was established by the Treaty of 1851, and the Monument is located within the reservation boundaries.

2.1.3. Visitation Statistics

Visitation data for Little Bighorn Battlefield are available for 1979-2012. The total number of visitors each year ranged from 183,311 (in 1980) to 425,995 (in 2002). The number of visitors in 2013 was 277,883. Visitation data by month are available for the same period of time. Although there has been substantial monthly variation by year, the three months receiving the greatest average number of visitors over the 34 year period were June, July, and August (Figure 2.1.3-1) (NPS Public Use Statistics Office 2013).

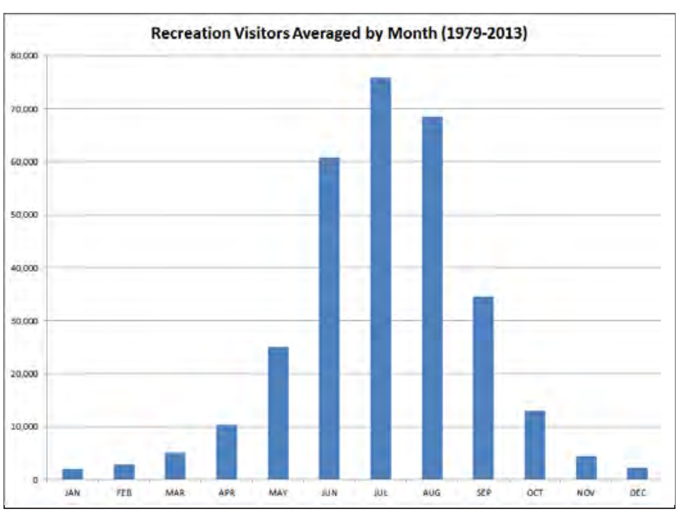

Figure 2.1.3-1. Average number of visitors to Little Bighorn Battlefield NM by month, 1979-2013.

2.2. Natural Resources

A summary of the natural resources at Little Bighorn Battlefield NM is presented in this section and represents information known prior to the completion of this condition assessment. New data were gathered and compiled throughout this assessment process as a result of meetings, consultations, and literature reviews pertaining to each natural resource topic. Therefore, some of the information presented in section 2.2 may have been included in subsequent chapters or omitted depending upon new findings.

2.2.1. Ecological Units and Watersheds

Little Bighorn Battlefield NM is primarily composed of mixed-grass prairie. The ravines throughout the uplands serve as a microclimate for woody vegetation (Rice et al. 2012). The Little Bighorn River habitat and floodplain is comprised of a wide range of herbaceous and woody plants (e.g., willows, cottonwoods), especially ones capable of forming root masses that are able to withstand frequent to moderately frequent flooding.

Figure 2.2.1-1. Little Bighorn Battlefield NM is within the Lower Little Bighorn River watershed of the Little Bighorn subbasin.

The Little Bighorn River and surrounding area are characterized by broadly terraced river valleys with irregularly eroded uplands, comprised of alluvial soils (Smoak 2012). This landscape originated from repeated surges of glacial melt water and sediment deposition associated with the Pinedale Glaciation and post glacial period (Vuke et al. 2000a). The primary landforms include expansive floodplains, fluvial terrace levels, and meandering river channels exhibiting point bar/cutbank morphology (Martin et al. 2012).

One of these meandering rivers is the Little Bighorn-a free flowing, perennial river and a tributary of the larger Bighorn River. The Little Bighorn originates in the Wolf Mountains in Wyoming and flows into Montana. It is dominated by snowmelt discharge with some influence from summer thunderstorms (Martin et al. 2012). It stretches approximately 222 km (138 miles) and is part of the Big Horn Subbasin (Figure 2.2.1-1).

2.2.2. Resource Descriptions

(Italicized text in the following section are excerpts from resource descriptions in Rice et al. 2012 describing some key resources of the Monument.)

<u>Topography, Geology, and Soils</u>

Various geomorphic landforms dominate the landscape of Little Bighorn Battlefield National Monument. The primary form consists of ridges dissected by ravines and coulees. "Coulee" is a French term applied in the western United States to a small stream (or the bed of such a stream) that is often intermittent. During the Battle of the Little Bighorn, ridges provided views across the broad valley and defensible high ground for soldiers of the 7th Cavalry. Ravines and coulees, which cut into the ridges, allowed for the secluded advance of Indian attackers. The steep banks on the east side of the Little Bighorn River form an abrupt edge, limiting access (and escape) from the floodplain. Some of the most conspicuous topographic features are the prominent stream terraces, which primarily line the west side of the Little Bighorn River valley. Unlike the ridges and coulees, these features did not figure significantly in the actions taken during the Battle of the Little Bighorn. However, the flat-topped terraces that sit above the Little Bighorn River served as suitable camping grounds for the warriors and their families at the time of the battle.

Elevation in the Monument ranges from approximately 915 m. (3,000 ft.) near the river, to 1,035 meters (3,400 ft.) at higher points of the Reno-Benteen unit. The topography of the site supports several non-perennial streams (NPS 2010). The transition between the uplands and Little Bighorn River floodplain at the Custer Battlefield unit is abrupt, with steep cliffs along *most of the southwest boundary. These cliffs are maintained by natural erosion processes. Small ravines start on the upper slopes, run to the southwest, and are deeply cut by the time they reach the floodplain. The Reno-Benteen Battlefield unit is entirely in the uplands.*

The uplands are formed in the Cretaceous Bearpaw and Judith River formations. The higher elevation Bearpaw Formation to the northeast is a marine sedimentary rock, primarily shale, while the lower uplands to the southwest are part of the sedimentary late Cretaceous Judith River Group (Vuke et al. 2000a,b, NPS 2006). The Judith River Formation can contain fossilized dinosaurs. Along the floodplain, the Cretaceous sediments are covered by Quaternary alluvium composed of unconsolidated gravel, sand, silt, and clay. The alluvium, which typically is less than 9 m thick, forms the principal aquifer in the Little Bighorn River basin (Tuck, 2003). Upland soils range from deep to very shallow, and from clay to loamy fine sands. Silty clay loams are the predominant texture class. Across both units the lower slopes and shales have deep soils, which are prone to both wind and water erosion (NPS 2006, 2007).

The bedrock that underlies the Monument represents sediments originally deposited in a seaway that inundated North America from the Arctic to the Tropics. Vuke et al. (2000a, b) mapped six Upper Cretaceous formations in the vicinity of the Monument. Of the six Upper Cretaceous units, only the Bearpaw and Judith River formations are exposed in the National Monument. More recent units deposited during the Quaternary Period (the past 2.6 million years) are terrace and landslide deposits and alluvium; however, no landslide deposits occur within the national monument.

<u>Hydrology</u>

The Monument is situated along the lower reaches of the Little Bighorn River, which drains an area of about 3,370 km^2. Lodge Grass and Pass creeks are the main perennial tributaries and Owl and Reno creeks are the largest ephemeral tributaries. The monument sits on terraces above the floodplain of the Little Bighorn River. A small area (approximately 0.20 km^2) along the western boundary of the monument extends onto the floodplain of the river, with the legal park boundary designated by the high water mark on the right (or east) bank of the river. There are no perennial or ephemeral streams flowing through the monument. There are several ephemeral springs and at least one alkaline seep in the Custer unit.

<u>Air Quality</u>

Little Bighorn Battlefield NM is designated as a Class II air quality area . The Monument has an on-site wet deposition monitoring station that has been monitoring total nitrogen and sulfur wet deposition since 1984 from which long-term trends can be assessed.

<u>Wildlife</u>

Mammals: A survey for bats was conducted by Wolfe and Kozlowski (n.d.) during July and August 2005-2006. Five species were detected and are listed in the order of approximate numerical importance: little brown myotis (*Myotis lucifugus*), big brown bat (*Eptesicus fuscus*), silver-haired bat (*Lasionycteris noctivagans*), long-legged myotis (*M. volans*), and hoary bat (*Lasiurus cinereus*). According to Wolfe and Kozlowski (n.d.), *"these species complements may be conservative and are dominated by generalist species that often use buildings for colonial roosting sites."*

A survey for small mammals was conducted by Pearson et al. (2006) during the summers of 2002 and 2003. A total of twelve small mammal species were captured and identified. Additionally seven non-small mammals were observed during the 2002-2003 mammal inventory.

Reptiles/Amphibians: A survey was conducted by Pilliod et al. (2003) during 2001-2002, documenting 1 reptile and no amphibians; however, no standing water was present during the time of surveys. The reptile was the Racer (*Coluber constrictor*). Monument personnel have seen other species of snakes, including Gopher (or Bull) Snakes (*Pituophis catenifer*) and Rattlesnakes (*Crotalis viridis*). They just weren't confirmed during the formal survey.

During the 2002-2003 small mammal inventory, Pearson et al. (2006) observed the following species: Tiger salamander (*Ambystoma tigrinum*), Snapping turtle (*Chelydra serpentina*), Greater short-horned lizard (*Phrynosoma hernandesi*), Eastern racer (*Coluber constictor*), and Western rattlesnake (*Crotalus viridis*).

Fish: Montana Cooperative Fishery Research Unit, USGS Department of Ecology, Montana State University conducted an inventory of fish found in the Little Bighorn River at the Monument (Bramblett and Zale 2002). *A total of 1,826 individual fish, of which 1,812 (99 %) were native species. The only nonnative species captured was common carp. The species in order of abundance summed for all three reaches were: flathead chub (29%), shorthead redhorse (19% of catch), fathead minnow (19%), longnose dace (12%), mountain sucker (7%), brassy minnow (7%), channel catfish (4%), white sucker (2%), common carp (1%), and river carpsucker (< 1%). The abundant native fish populations and the presence of large predators indicate a healthy stream ecosystem.*

Breeding Landbirds: The last known avian monitoring that occurred on Little Bighorn Battlefield NM was conducted in 2006 (Bock and Bock 2006). Beginning in 2012, biologists with the Rocky Mountain Bird Observatory began monitoring for breeding landbirds throughout the Monument. A total of 74 bird species have been reported to occur within the Monument, ten of which are designated as species of continental concern, continental stewardship, or regional concern by Partner's in Flight for Bird Conservation Region 17 were detected on Little Bighorn Battlefield NM, indicating that the Monument represents some important habitat for potentially vulnerable avian species.

Vegetation

The uplands areas of the Monument consist of relatively intact native mixed-grass prairie. The narrow ravines dissecting the uplands form a favorable microclimate for woody vegetation and are termed woody draws. The Little Bighorn River floodplain is dominated by native riparian trees and shrubs. The Monument also has urban park-like landscaped areas that encompass Custer National Cemetery and various buildings. Major factors affecting the native vegetation are wildfire and fire suppression, lack of intensive grazing on the native grass prairie, flow regulation of the Little Bighorn River, erosion, and a moderate level of exotic plant invasion (Britten et al. 2007).

The upland grassland dominants include bluebunch wheatgrass (Agropyron spicatum = Pseudoroegneria spicata) and rhizomatous western wheatgrass (Agropyron smithii = Pascopyrum smithii). Needle and thread grass (Stipa comata = Hesperostipa comata), green needlegrass (Stipa viridula = Nassella viridula), and prairie sand reedgrass (Calamovilfa longifolia) are common in more clumped distributions. Several short graminoids are common but occur with low cover values and even more patchy distributions; these include threadleaf sedge (Carex filifolia), sideoats grama (Bouteloua curtipendula), and blue grama (Bouteloua gracilis). Two exotic annual bromes, cheatgrass (Bromus tectorum) and Japanese brome (B. japonicus, B. arvensis) are frequent in these uplands. Select forbs occur in the understory of the grasses, including prairie coneflower (Ratibida columnaris) and narrow-leaf coneflower (Echinacea angustifolia). Wyoming big sagebrush (Artemisia tridentata ssp. wyomingensis) is the most abundant upland shrub. However, vegetation monitoring done over a two decade period by Bock and Bock (2006) after a 1983 wildfire in the Custer unit and a 1991 wildfire in the Reno-Benteen unit did not document any reestablishment of big sagebrush in the burn zones. Bock and Bock (2006) concluded that the current presence of big sagebrush is a Native American grazing-era disclimax. NPS crews located juvenile

ROBERT SHANTZ

Rough-winged Swallow nesting along Little Bighorn River.

sagebrush in 2007 immediately adjacent to the remnant stand of mature plants in the NE portion of the Custer Unit – survival and current status is unknown. Native American horse herds made extensive use of this area in the Nineteenth Century. Black greasewood (Sarcobatus vermiculatus) and skunkbush sumac (Rhus trilobata (syn. aromatica)) are common as scattered individuals or in low cover clumped distributions.

Woody draws can support small stands of western snowberry (Symphoricarpos occidentalis), Rocky Mountain juniper (Juniperus scopulorum), common chokecherry (Prunus virginiana), and box elder (Acer negundo). The transition zone from the lowest reaches of the woody draws to the floodplain can support more dense green ash (Fraxinus pennsylvanica) and choke cherry (Prunus virginiana).

The largest dominants on the floodplain are green ash along with eastern or Great Plains cottonwood (Populus deltoides). Common chokecherry (Prunus virginiana) and box elder (Acer negundo) are common. Diagnostic short, woody species on the floodplain include silver sage (Artemisia cana), silver buffaloberry (Shepherdia argentea), and sandbar or coyote willow (Salix exigua). The exotics salt cedar (Tamarix sp.) and Russian olive (Elaeagnus angustifolia) have made a few small inclusions on the floodplain.

<u>Night Sky and Soundscape</u>
No formal studies on the Monument's night sky and soundscape have been conducted to date. Informal studies were conducted on both night sky and soundscape for this NRCA, and results are presented in subsequent chapters. Activities on land surrounding the Monument (e.g., highway traffic, local development and operations) have the potential to influence the soundscape and viewsheds.

2.2.3. Resource Issues Overview
The natural environment and availability of resources has impacted the lifestyles of humans who have used the area for the past thousands of years. The site and surrounding area have been affected by hunting, grazing, cultivation, water diversion, development, introduction of non-native species, and extirpation (local extinction) of native species such as bison. The Monument is unique from other areas in eastern Montana in that it is no longer subject to cattle grazing and is largely free of human- related disturbance (visitor access is restricted to paved portions of the Monument and along short trails), however, changes to the vegetative and wildlife communities are nevertheless expected to occur over time. The spread of exotic plant species, alterations in the vegetation community resulting from climate change, changing hydrologic patterns, disease, natural disturbance (e.g., fire and flooding), and succession all are likely to influence the wildlife and vegetation communities of the Monument. Little Bighorn Battlefield NM is a small national park and, even though it is protected, landcover and land use changes around the park and in the region would be expected to influence the various species found in the Monument and impact the Monument's water resource-Little Bighorn River. Water resources also face numerous and varied threats, including impacts from climate change, atmospheric deposition, altered hydrology, acid mine drainage, agriculture, pollution from boats, non-native species, erosion, improper sewage plant or drain field operations, and storm water runoff, and the Little Bighorn River is no exception to these potential threats.

2.3. Resource Stewardship

2.3.1. Management Directives and Planning Guidance
In addition to NPS staff recommendations, the Washington (WASO) level programs guided the selection of key natural resources for this condition assessment. This included Rocky Mountain Inventory and Monitoring Network (ROMN) Program, Air Resources Division for air quality, Water Resources Division for riparian habitat, and the Natural Sounds and Night Skies Program for the soundscape and night sky sections. In addition, NPScape data, developed by the Inventory & Monitoring's Washington Office, were used in the viewshed analysis.

ROMN Program

In an effort to improve overall park management through expanded use of scientific knowledge, the Inventory & Monitoring (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 2011). 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 2011).

To facilitate this effort, 270 parks with significant natural resources were organized into 32 regional networks. Little Bighorn Battlefield NM is part of the ROMN, which also includes five additional parks. Through a rigorous multi-year, interdisciplinary scoping process, each network 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. For the ROMN, notable core vital signs were identified. Inventories on a wide variety of natural resource topics have been completed, and long-term monitoring programs are currently underway.

Resource Stewardship Strategy

National Parks are encouraged to develop a Resource Stewardship Strategy Resource Stewardship Strategy (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 yet been started for Little Bighorn Battlefield NM. The NRCA will provide valuable information for the RSS process. Management plans may then be developed based upon information from the RSS and NRCA to outline actions to be taken over the next 15 to 20 years that will help achieve or maintain the desired condition(s) for each indicator.

2.3.2. Status of Supporting Science

Available data and reports varied significantly depending upon the resource topic. The existing data used for each indicator to assess condition or to develop reference conditions are described in each indicator summary in Chapter 4. The purpose of the ROMN is to provide scientifically credible, long-term ecological information for natural resource protection and management through natural resource inventories and monitoring of vital signs of ecosystem health. (Britten et al. 2007). In addition to data from the ROMN Program and research by other scientists and programs, subject matter experts provided significant information pertaining to riparian habitat, grassland ecology, and exotic plants. Washington level programs, including night sky, soundscape, riparian habitat, and air quality also provided a wealth of information for this NRCA.

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MIKE BRITTEN

Upland vegetation assessment at Little Bighorn Battlefield NM.

Chapter 3: Study Scoping and Design

This NRCA is a collaborative project between the NPS' Little Bighorn Battlefield NM staff, the Rocky Mountain Inventory and Monitoring Network (ROMN), and the Southern Plains Inventory and Monitoring Network (SOPN). Stakeholders in this project include the Monument's resource management staff and management, ROMN and SOPN staff. The purpose of the condition assessment is to provide a "snapshot-in-time" evaluation of the condition of a select set of the monument's natural resources that were identified and agreed upon by the project team. Project findings will aid monument staff in the following objectives:

- Develop near-term management priorities.
- Engage in watershed or landscape scale partnership and education efforts.
- Conduct park planning (e.g., compliance, Resource Stewardship Strategy, resource management plans).

The approach we used to select natural resource topics was to assess the fundamental and important values of the Monument as identified in its General Management Plan (GMP) (1995) as well as to consider broader natural resource topics as identified by the Monument's Resource Management Plan (2007) and the NPS' Natural Resource Program Center. The resources assessed are limited to natural-based topics, but cultural resources were also taken into consideration within the context of the chosen natural resource topics, especially since the monument was established for its cultural significance.

3.1. Preliminary Scoping

The selection of resources to assess resulted from an initial meeting at the Monument on September 19, 2010 and subsequent discussions and correspondence. These meetings and discussions focused on:

1. Confirming the purpose of the Monument and its related significance statements and related values.
2. Identifying important natural and cultural resources and concerns for each topic.
3. Identifying data sources and gaps for each resource topic.

Certain constraints were placed on this NRCA, including the following:

- Condition assessments are conducted using existing data and information.
- Identification of data needs and gaps is driven by the project framework categories.

- A preliminary study framework was developed as a result of the meetings and discussions, which listed the chosen resources and the degree of assessment (e.g., full or limited) based upon existing data and information.

Specific project expectations and outcomes included the following:

- For key natural resource components, consolidate available monument data, reports, and spatial information from appropriate sources including: monument resource staff, scientific literature, NatureBib, NPSpecies, Inventory and Monitoring data, and available third-party sources. Enlist the help of subject matter experts for each resource topic when appropriate and feasible (refer to Appendix A for subject matter expert list).
- Define an appropriate description of reference condition for each of the key natural resource components and indicators so statements of current condition can be developed for the NRCA report.
- Where applicable, develop GIS products and graphic illustrations that provide spatial representation of resource data, ecological processes, resource stressors, trends, or other valuable information that can be better interpreted visually.
- Conduct analysis of specific existing data sets to develop descriptive statistics about key natural resource indicators.
- Discuss the issue of key natural resource indicators that are not contained within the Monument or controlled directly by Monument management activities (e.g., viewshed condition). There are important stressors that impact key natural resource components in the monument but are not under NPS jurisdiction.

Monument natural resource staff participated in project development and planning, and additional Monument staff reviewed interim and final products and participated in assessment meetings. Monument staff, I&M staff, and additional writer/editors data mined information for their assigned resource topics. For a complete list of team members, please refer to Appendix A.

3.2. Study Design

3.2.1. Indicator Framework, Focal Study Resources and Indicators

The Monument's NRCA utilizes an assessment framework adapted from "The State of the Nation's Ecosystems 2008: Measuring the Lands, Waters, and Living Resources of the United States", by the H. John Heinz III Center for Science, Economics and the Environment. This framework was endorsed by the National NRCA Program as an appropriate framework for listing resource components, indicators/measures, and resource conditions.

Each NRCA project represents a unique assessment of key natural resource components that are important to the specific park that is being assessed. As a result, the project framework is developed by the project participants to reflect the key resources of the park. For the purpose of this NRCA, 11 key Monument resources were identified and are listed under the "Resource" column in Table 3.2.1-1. This list of topics is not all inclusive of every natural resource at the Monument, but it includes natural resources and processes that were of greatest concern at the time of this assessment.

Reference conditions were identified with the intent of providing a benchmark to which the current condition of each indicator/measure could be compared. Generally, this condition represents a historical reference in which human activity and disturbance were not major drivers of population and ecological processes. Attempts were made to utilize existing research and documentation to identify reference conditions; however, many of the indicators lack a quantifiable reference condition according to literature and data reviewed for this project. When a specific reference condition for the monument was unknown, an attempt was made to include state and federal standards or data from other relevant locations in order to provide some context for interpreting condition.

Table 3.2.1-1. Final Little Bighorn Battlefield National Monument Natural Resource Condition Assessment framework

Resource	Assessment Level	Indicators and Measures
I. Landscape Condition Context		
Viewshed	Full Assessment	• Scenic and Historic Integrity • Intactness • Conspicuousness of noncontributing features • Housing density • Road density
Night Sky	Limited Assessment	• Zenith Sky Brightness (2 measures) • Sky Quality
Soundscape	Limited Assessment	• Sound Sources • Sound Characteristics
II. Supporting Environment		
Air Quality	Full Assessment	• Visibility haze index • Level of ozone • Atmospheric wet deposition in total N and total S
Geology	Limited Assessment	• No indicators or measures were identified
Stream Ecological Integrity	Full Assessment	• Water in Situ Chemistry (4 measures) • Physiochemistry-Water & Sediment (4 measures) • Stream Productivity (2 measures) • Biological Communities (3 measures)
Groundwater	Limited Assessment	• Change in groundwater level
III. Biological Integrity		
Vegetation		
Riparian Habitat	Full Assessment	• Hydrology (5 measures) • Vegetation (7 measures) • Erosion/deposition (5 measures)
Grasslands	Full Assessment	• Hydrology Soil/Site Stability and Hydrologic Function (6 measures) • Biotic Integrity (5 measures)
Exotic Plants	Full Assessment	• NatureServe Invasive Species Impact Rank • Invasiveness Score-Colorado Natural Heritage Program • Proportion of Interior Sites Infested With High Priority Species • Proportion of Monument and Battlefield Tour Road Infested With High Priority Species
Wildlife		
Breeding Landbirds	Full Assessment	• Species occurrence (3 measures)

3.2.2. Reporting Areas

All areas throughout the Monument are included in the Historic Zone where all activities are such that they preserve, protect, and interpret cultural resources and their setting (NPS 1995). Four subzones are within the Historic Zone including 1) Natural Subzone, which comprises the majority of the monument(~73%), 2) Cultural Resource Subzone, comprising approximately 20% of the area, 3) Development Subzone, comprising approximately 6% of the area, and 4) Special-Use Subzone, which includes the National Cemetery (NPS 1995). These zones were considered within the context of each resource topic as deemed necessary.

3.2.3. General Approach and Methods

This study involved reviewing existing literature and data for each of the resource topics listed, and, where appropriate, analyzing the data to provide summaries or to create new spatial representations. After gathering data regarding current condition of indicators and measures, a qualitative statement was developed comparing the current condition(s) at the monument to the reference condition(s) when possible.

Data Mining

Data and literature were found in multiple forms: NPS reports and monitoring plans (park, regional, and national level), other reports from various state and federal agencies, published and unpublished research documents, non-governmental organization reports, databases, and tabular data. Spatial data were provided by the Monument, ROMN and SOPN staff, and by the Natural Resource Program Center. Data and literature acquired throughout the data mining process were inventoried and analyzed for thoroughness, relevancy, and quality pertaining to the indicators identified in the project framework. All reasonably accessible and relevant data were used to conduct this assessment.

Subject Matter Experts

Several researchers and subject matter experts were consulted while developing this assessment. Consultations ranged from on-site visits to personal communication, and reviews of resource sections. A full list of the team of experts can be found in Appendix A.

Data Analyses and Development

Data analysis and development/writing tasks were performed for specific resource topics based on the data mining process and recommendations provided by NPS staff. Data analyses and development were resource specific, and the methodology for individual analyses can be found within each section of chapter four.

Geographic Information System (GIS) technology was utilized to graphically depict the status and distribution of considered resources when possible.

Final Assessments

Final assessments were made by incorporating comments provided by subject matter experts, reviewers, and monument staff during the review of draft chapters. Additionally, continued contact with monument staff to address questions and comments pertaining to each resource topic was maintained throughout the data analysis and report writing phase to ensure accurate representation of staff knowledge. The final assessments represent the most relevant and timely data available for each resource topic based on the recommendations and insight provided by monument staff, researchers, subject matter experts, and assessment writers.

Indicator/Measures Assessment Format

Indicator assessments are presented in a standard format that is consistent with *State of the Park* reporting (NPS 2012). The major components are as follows:

The condition/trend/level of confidence graphic provides a visual representation for each resource indicator and intended to give readers a quick interpretation of the authors' assessments of condition. The level of confidence ranges from high-low and indicates how confident we are with the data used to determine condition. The written statements of condition, located under the "*Condition and Trend*" heading in each resource topic section, provides a more in-depth description of each indicator and associated measure(s)' condition. Figure 3.2.3-1 shows the condition/trend/confidence level scorecard used to describe each indicator/measure.

Circle colors provide indication of condition or concern. Red circles signify that a resource is of significant concern; yellow circles signify that a resource is of moderate concern; and green circles denote that an indicator is currently in good condition. A circle without any color, (which are always associated with the low confidence symbol-dashed line), signify that there is insufficient information to make a statement about concern or condition of the indicator, therefore unknown.

Arrows inside the circles signify the trend of the indicator/measure condition. Upward pointing arrows signify that the indicator is improving; right pointing arrows signify that the indicator's condition is currently unchanging; downward pointing arrows indicate that the indicator's condition is deteriorating. No arrow denotes that the

Condition Status		Trend in Condition		Confidence in Assessment	
	Warrants Significant Concern		Condition is Improving		High
	Warrants Moderate Concern		Condition is Unchanging		Medium
	Resource is in Good Condition		Condition is Deteriorating		Low

Figure 3.2.3-1. Condition, trend, and level of confidence key used in the Little Bighorn Battlefield NM NRCA.

trend of the indicator's condition is currently unknown. Figure 3.2.3-2 is an example of a final condition graphic used in the indicator assessments.

Figure 3.2.3-2. An example of a good condition, unchanging trend, and high confidence level graphic used in NRCAs.

Background and Importance
This NRCA section provides information regarding the relevance of the resource to the Monument. This section also explains the characteristics of the resource to help the reader understand subsequent sections of the document.

Data and Methods
This section describes the existing datasets used for evaluating the indicators/measures. Methods used for processing or evaluating the data are also discussed where applicable. The indicators/measures are listed in this section as well, describing how we measured or qualitatively assessed the natural resource topic.

Reference Conditions
This section explains the reference conditions that were used to evaluate the current condition for each indicator. Additionally, explanations of available data and literature that describe the reference conditions are located in this section.

Condition and Trend
This section provides a summary of the condition and trend of the indicator/measure at the Monument based on available literature, data, and expert opinions. This section highlights the key elements used in defining the overall condition and trend designation, represented by the condition/trend graphic, located at the beginning of each resource topic.

The level of confidence and key uncertainties are also included in the condition and trend section. This provides a summary of the unknown information and uncertainties due to lack of data, literature, and expert opinion, as well as our level of confidence about the presented information.

Sources of Expertise
Individuals who were consulted for the resource topics are listed in this section. A short paragraph describing their background is also included.

Literature Cited
This section lists all of the referenced sources. A DVD is included in the final report with copies of all literature cited unless the citation was from a book. When possible, links to websites are also included.

3.3. Literature Cited

National Park Service. 1995. Little Bighorn Battlefield National Monument general management and development concept plans. Denver, Colorado: Rocky Mountain Regional Office. 26pp.

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Chapter 4: Natural Resource Conditions

In this chapter, we present the background and importance, methods, and condition assessment for each focal study resource that we considered for Little Bighorn Battlefield NM. In many cases, we did not have a quantitative measure for the indicators but tried to present meaningful categorical measures qualitatively that reflect the condition. We also explained why each indicator was chosen and what we considered as a good, moderate or significant concern reference condition for each indicator. We provide a summary of all focal study resource indicators and their page numbers for explanations of our methods and natural resource conditions in Table 4.1.

Table 4.1. Page numbers where the description, methods, and condition for each indicator are presented within this chapter.

Resource	Indicator	Description/ Methods	Condition
I. Landscape Condition Context			
Viewshed	Scenic and Historic Integrity	24	33
	Intactness	26	33
	Conspicuousness of noncontributing features	27	33
	Housing density	31	37
	Road density	31	37
Night Sky	Zenith Sky Brightness	44	48
	Sky Quality	45	48
Soundscape	Sound Sources	54	58
	Sound Characteristics	55	60
Air Quality	Visibility haze index	67	69
	Level of ozone	68	70
	Atmospheric wet deposition in total N and total S	68	71
Geology	No indicators or measures were identified		
Stream Ecological Integrity	Water in Situ Chemistry (4 measures)	86	96
	Physiochemistry-Water & Sediment (4 measures)	87	97
	Stream Productivity (2 measures)	87	98
	Biological Communities (3 measures)	90	99
Groundwater	Change in groundwater level	115	117
III. Biological Integrity			
Vegetation			
Riparian Habitat	Hydrology (5 measures)	125	129
	Vegetation (7 measures)	126	131
	Erosion/deposition (5 measures)	127	132
Grasslands	Hydrology Soil/Site Stability and Hydrologic Function (6 measures)	143	149
	Biotic Integrity (5 measures)	146	149

Table 4.1. Page numbers where the description, methods, and condition for each indicator are presented within this chapter (cont.).

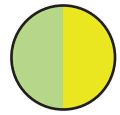
Resource	Indicator	Description/ Methods	Condition
Vegetation (cont).			
Exotic Plants	NatureServe Invasive Species Impact Rank	162	166
	Invasiveness Score-Colorado Natural Heritage Program	162	166
	Proportion of Interior Sites Infested With High Priority Species	164	167
	Proportion of Monument and Battlefield Tour Road Infested With High Priority Species	166	168
Wildlife			
Landbirds	Species occurrence	180	196

4.1. Viewshed

Indicators/Measures

- Scenic and Historic Integrity
- Intactness
- Conspicuousness of noncontributing features
- Housing density
- Road density

Condition - Trend - Confidence Level



Good to Moderate - Unknown - Medium

4.1.1. Background and Importance

The conservation of scenery is established in the National Park Service (NPS) Organic Act ("… to conserve the scenery and the wildlife therein…"), reaffirmed by the General Authorities Act, as amended, and addressed generally in the NPS Management Policies (Section 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 Biel (2005), aesthetic conservation, interchangeably used with scenic preservation, has been practiced in the NPS since the early twentieth century. Aesthetic conservation strove 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.

Just three years after the June 25-26, 1876 Battle of the Little Bighorn, the Secretary of War preserved the Custer Battlefield site as a National Cemetery. In 1926, the Reno-Benteen Battlefield was added. On July 1, 1940, the site was transferred from the Department of War to the National Park Service to manage, and in 1946 was designated Custer Battlefield National Monument. In 1991, Congress authorized a name change to Little Bighorn Battlefield National Monument. The Monument preserves, protects, and interprets the historic, cultural, and natural resources,

PHOTO CREDIT: NINA CHAMBERS

One view at Little Bighorn Battlefield National Monument looking into the riparian area from Weir Point.

including lands pertaining to the Battle of the Little Bighorn. As the management plan states (NPS 2007): "The cultural landscape and historic scene are integral to the site's significance and its interpretation."

Little Bighorn Battlefield National Monument includes 765.34 acres consisting of two separate units, Custer Battlefield and Reno-Benteen, separated by a 4.1-mile paved road. The Monument is surrounded by the Crow Indian Reservation and the majority of these lands are allotted lands, or are under private ownership, therefore, encroachment on the cultural landscape is a concern (NPS 2007). Most parks exist within a landscape matrix of mixed ownership, and to a large extent cannot control the land use surrounding them. Johnson et al. (2008) refers to this phenomenon as a "borrowed landscape," meaning that the park is impacted—either positively or negatively—by the lands surrounding them and beyond their direct management control. Primary components of the Monument include the Custer Battlefield and Reno-Benteen Battlefield, the national cemetery, the museum and archives, and the Indian memorial.

<u>Visitor Experience</u>

Inherent in virtually every aspect of this assessment is how features on the visible landscape influence the enjoyment, appreciation, and understanding of the Monument by visitors. The indicators we use for condition of the viewshed are based on studies related to perceptions people hold toward various features and attributes of the viewsheds. We also focus on how the historic integrity of the viewshed enhances the opportunity for visitors to better understand the historical significance that the Monument had in shaping our country.

From a cultural and historical perspective, the views are not just about the scenery, but rather an important way to understand the Battle at Little Bighorn. Visualizing the battle as it played out on the landscape is a critical part of the visitor experience. Numerous views of landscape features are interpreted at the Monument, including: the Little Bighorn River floodplain (Indian encampment), multiple ridges (from where Calvary scouts and Indian warriors advanced, attacked, and retreated), coulees and ravines (advances and retreats important to the battle), and hills (where Custer made his last stand). Being able to experience and see these features in a condition similar to when the battle took place not only enhances understanding about the mechanics of the battle, but also creates a personal and emotional response by interacting with the landscape.

4.1.2. Data and Methods

Viewsheds are considered in this assessment within two interrelated contexts: natural scenic integrity and historic integrity. Impacts that degrade one aspect likely degrade the other as well. For example, modern structures or roadways visible on the landscape not only detract from the natural scenic integrity of the viewshed, but also diminish the sense of place that a historically authentic landscape evokes. Depending on the context, scenic and historic integrity may be distinct, or there may be so little practical difference that they are the same. In the case of Little Bighorn Battlefield National Monument, there is so much overlap that we treat them together (Figure 4.1.2-1). We qualitatively assess how features on the landscape contribute (or not) to the scenic and historic integrity of the site.

Indicators/Measures

Scenic and Historic Integrity

The overall indicator of viewshed condition we use in this assessment is a combination of scenic and historic integrity. For this overall indictor we used two ground-based measures from two key vantage points as well as two Geographic Information System (GIS)-based measures, all of which are described in greater detail below.

Scenic integrity is defined as, the state of naturalness or, conversely, the state of disturbance created by human activities or alteration (USFS 1995). This focuses on the features of the landscape related to human influence.

Historic integrity is the authenticity of a site's historic identity, evidenced by the survival of

Figure 4.1.2-1. At Little Bighorn Battlefield, scenic and historic integrity are intertwined such that some man-made features, such as these grave sites, are generally perceived to contribute to, rather than detract from, the sites integrity.

physical characteristics that existed during its historic period. Historic integrity is based on those features of the cultural and natural landscape, from the perspective of an observer, that contribute to the sense of place and enhance the visitor experience. In this assessment, we focus on those features that have a visual impact and contribute to the story of the Battle at Little Bighorn. We evaluate features as contributing, enhancing the scenic and historic features of the landscape, or noncontributing, detracting from the scenic and historic integrity.

We measure scenic and historic integrity using measures from two primary perspectives: (1) ground observation from key vantage points using panoramic images, and (2) an aerial perspective using GIS representation. Our ground-based assessment focuses on specific man-made features that can be seen from key vantage points and whether or not those features are contributing or noncontributing to the scenic and/or historic integrity of the view. For noncontributing features, we further assess the characteristics that make them more or less conspicuous; which influences the level of impact that they might have. In contrast, our GIS-based measures focus on housing density and road density within the Monument, as well as to augment the assessment by providing the spatial orientation of key features.

Ground-based Measures of Integrity from Specific Vantage Points

We used two primary measures to assess scenic and historic integrity based on specific features on the landscape that can be seen from key vantage points. These measures are intactness of the view and the conspicuousness of noncontributing features, both of which are described in greater detail below. Each of these were assessed from two key vantage points where most visitors view the landscape as part of their experience at the Monument.

Viewshed Vantage Points

The two main vantage points within the Monument used in this analysis were Last Stand Hill/Wooden Leg Hill in the Custer unit and the rifle pits area in the Reno-Benteen unit (Figure 4.1.2-2). The views from these points play a major role either in their scenic quality as well as the historic context.

Last Stand/Wooden-Leg Hill-- Divided by the park road, Last Stand Hill overlooks the southern portion of the Monument, including a glimpse of the national cemetery; and Wooden Leg Hill, on the other side of the road, overlooks the landscape to the north and a glimpse of the Indian Memorial site.

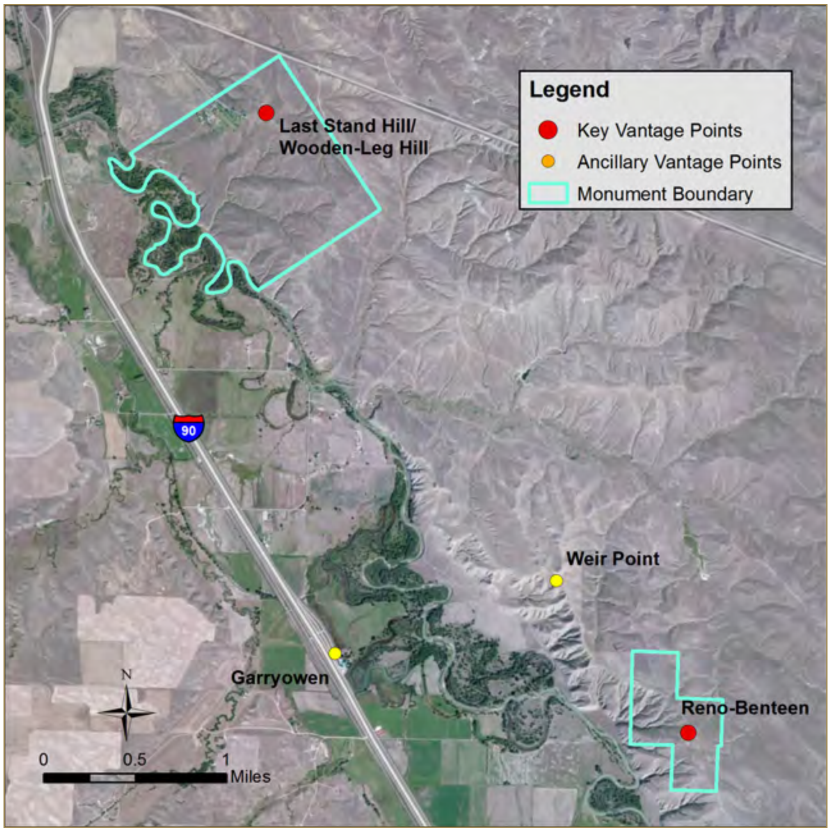


Figure 4.1.2-2. The two key vantage points used in this assessment, and two additional vantage points that are important to the Monument because of their contribution to the story of the Monument were included.

This is an important location because of its historical significance.

Reno-Benteen-- Furthest from the more developed area of the Monument (the entrance, administration buildings, visitor center, and restrooms), the Reno-Benteen unit includes a paved trail for visitors to experience the rolling hills of the landscape and see cultural features, such as the rifle pits, that remain from the battle.

Ancillary Views
We used the two key vantage points described above because they are sites that evoke a "sense of place" in an historic context. There are however, additional vantage points that are important to the Monument. These additional views were not included in the assessment with respect to applying our full measures of integrity, but their condition is addressed less formally later in this chapter in their individual contexts. These views include two sites (Weir Point and Garryowen) that have an important historic contexts. Each are described below:

Weir Point -- The interpretive sign for Weir Point is located along the road cut into the knob—creating hills on both sides of the road. The view from there is quite limited, unless visitors climb to the top of one of the knobs, where much of the battlefield landscape is revealed. No formal trail exists for visitors to access the knobs, and this kind of impact on the grasslands should probably not be encouraged.

Garryowen -- Garryowen is the site of the opening attack of the battle between the Seventh Cavalry and the Lakota, Cheyenne, and Arapahoe. It is located on the opposite side of the river facing the Monument, looking toward Weir Point. There are private museums and camp areas at Garryowen, and it is very close to the highway. The general management plan for the Monument (NPS 1995) called for the visitor center to be relocated there to address parking issues (it is unclear if this remains a viable or desirable option today).

Indicators/Measures

Intactness

The extent of intactness provides a measure of the degree to which the viewshed is unaltered from its original (reference) state, particularly the extent to which intrusive or disruptive elements may diminish the character of the scene (USFS 1995, Johnson et al. 2008).

We used a series of panoramic images to portray the viewshed from an observer's perspective from each vantage point. These images were taken using a Canon PowerShot digital camera and the GigaPan Epic 100 system, a robotic camera mount coupled with stitching software (Figure 4.1.2-3). A series of images are automatically captured and the individual photographs are stitched into a single high-resolution panoramic image. These photographs provided a means of illustrating the indicators related to viewshed integrity.

We recognize that visitor perceptions of an altered landscape are highly subjective,

Figure 4.1.2-3. The GigaPan system takes a series of images that are stitched together to create a single panoramic image.

and there is no completely objective way to measure this. Research has shown, however, that there are certain landscape types and characteristics that people tend to prefer over others. In general, there is a wealth of research demonstrating that people tend to prefer natural over human-modified landscapes (Zube et al. 1982, Kaplan and Kaplan 1989, Sheppard 2001, Kearny et al. 2008, Han 2010). We believe this is especially true of visitors to national parks. Therefore, natural appearance or a rural setting is considered consistent with the goals of scenic integrity and obvious human-altered components of the landscape (e.g., roads, buildings, powerlines, and other features) are considered to detract from the scenic and historic character of the viewshed.

Despite this generalization for natural landscape preferences, studies have 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 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). This is important when considering park historic structures (or in the case of Little Bighorn Battlefield NM, the markers and monuments) in the context of viewshed analysis.

Indicators/Measures

Conspicuousness of Noncontributing Features

Substantial research has demonstrated that human-made features on a landscape are perceived more positively when they are considered in harmony with the landscape (e.g., Kaplan and Kaplan 1989, Gobster 1999, Kearney et al. 2008). For example, Kearney et al. (2008) showed that survey respondents tended to prefer development that blended with the natural setting through use of colors, smaller scale, and vegetative screening. For this indicator, we focused on four characteristics, or groups of characteristics, that have been demonstrated to contribute to the conspicuousness of man-made features: (1) distance from a given vantage point, (2) size, (3) color and shape, and (4) movement and noise. A general relationship between these characteristics and their influence on conspicuousness is presented in Table 4.1.2-1 and more detailed descriptions of these human-made features are presented below.

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 (Figure 4.1.2-4). For this assessment, we have used the distance classes that have been recently used by the National Park Service:

- Foreground = 0-½ mile from vantage point
- Middle ground = ½-3 miles from vantage point
- Background = 3-60 miles from vantage point. Over time, different agencies have adopted minor variations in the different specific distances use to define these zones, but the overall logic and intent has been consistent.

Table 4.1.2-1. Characteristics that influence how less conspicuous human-made features are within a viewshed and the general effect.

Characteristic	Less Conspicuous	More Conspicuous
Distance	Distant from the vantage point	Close to the vantage point
Size	Small relative to the landscape	Large relative to the landscape
Color and Shape	Colors and shapes that blend into the landscape	Colors and shapes that contrast with the landscape
Movement and Noise	Lacking movement or noise	Exhibits obvious movement or noise

Figure 4.1.2-4. An example of approximate distance classes used in this assessment.

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 grasslands), 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 among 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 dominates the landscape, and how it is perceived. For example, Kearney et al. (2008) found human preferences were lower for human-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

Table 4.1.2-2. A matrix describing the six size classes used for visible human-made features.

	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

than views of towns or industrial sites, which ranked very low on visual preference. This is 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 Little Bighorn Battlefield NM as belonging to one of six size classes (Table 4.1.2-2), 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 (see Figure 4.1.2-5). 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'Conner 2008). This is 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. Some research has indicated that color can be used to offset other factors, such as size, that may evoke a more negative perception (O'Conner 2009). Similarly, shapes of features that contrast sharply with their surroundings

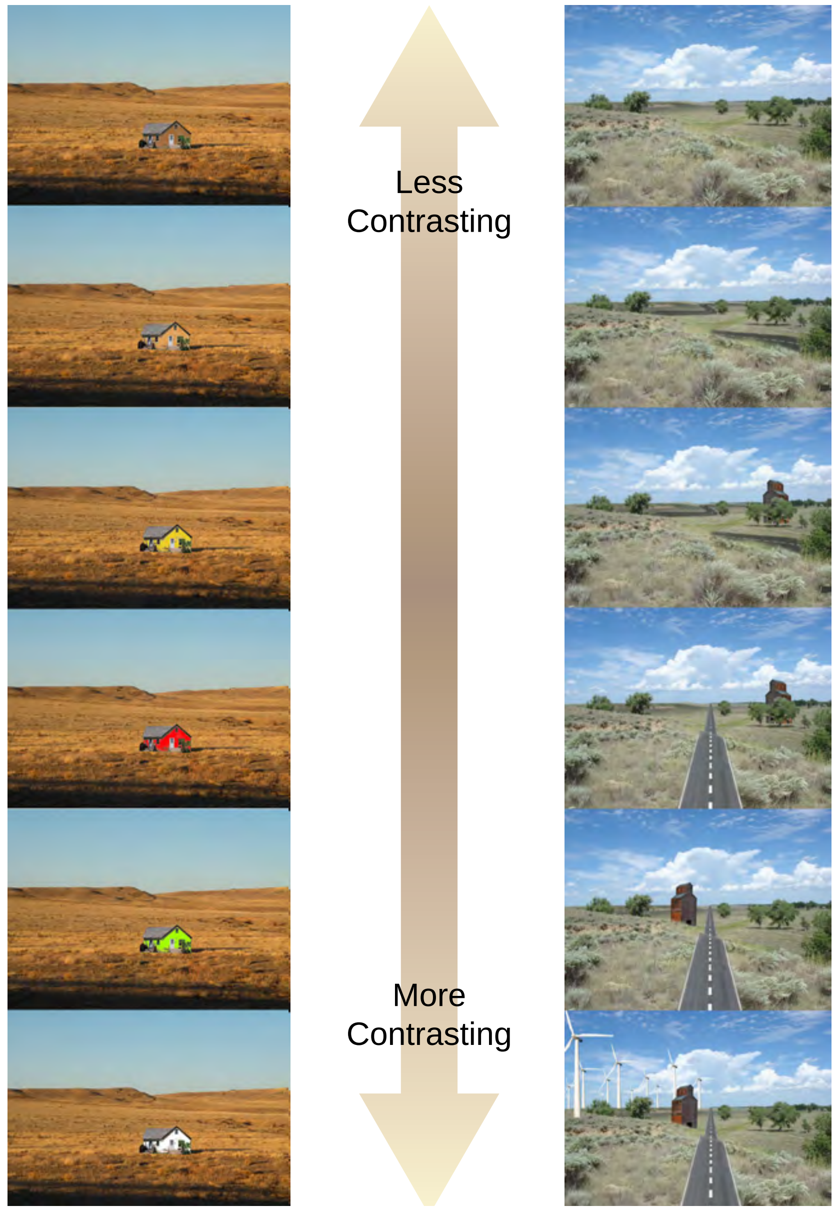


Figure 4.1.2-5. Graphic illustration of how color (left) and shape (right) can influence whether features are in harmony with the environment, or are in contrast.

may also have an influence on how they are perceived. This has been a dominant focus within visual resource programs of land management agencies (Ribe 2005). In forest management, negative perceptions related to

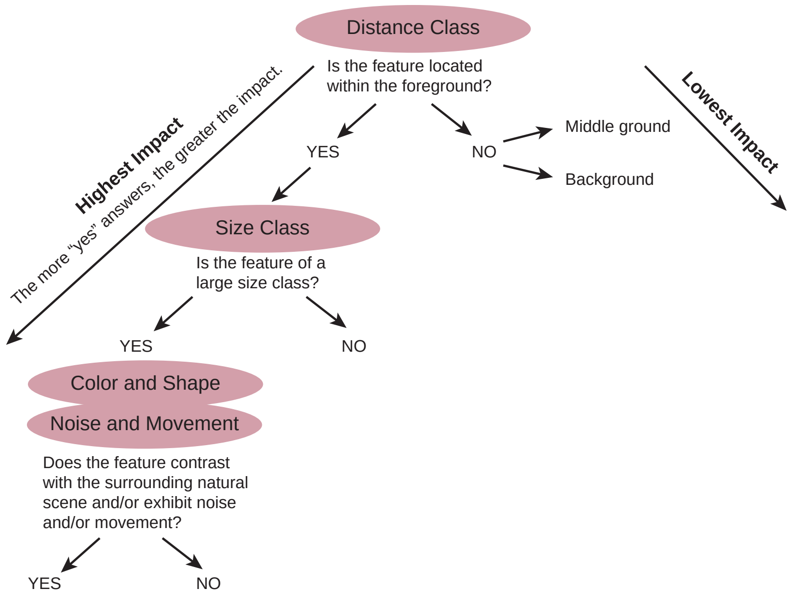


Figure 4.1.2-6. Conceptual framework for hierarchical relationship of characteristics that influence the conspicuousness of features within a viewshed.

the contrasting shapes of forest harvest with their surroundings (for example, clear cuts) was so strong that it was explicitly addressed in the National Forest Management Act of 1976 calling for "cuts shaped and blended to the extent practicable with the natural terrain" (16 USCA 1604g3Fiii). The Visual Resource Management Program of the BLM (BLM 1980) similarly 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. For example, the color and shape of a house would not be important to the integrity of the Monument's viewshed if the house was located too far away from the vantage 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 characteristic (Figure 4.1.2-6).

GIS-based Analyses and Measures

GIS Viewshed Analyses

Viewshed analyses were conducted to depict the total visible area seen from each of the two key vantage points. Aerial maps of each of the vantage points were generated based on digital elevation models (DEMs) to predict the area visible from a given vantage point taking into account changes in elevation and other obstructions such as tree, mountain, or building heights. Ground verification indicated that the initial viewshed analyses tended to underestimate the visible area. Consequently, we adjusted the analyses by experimenting with different offsets that adjust the height of the observer or the surrounding landscape. After several iterations, we found that a 10 m offset for the

Table 4.1.3-1. Qualitative reference condition classes used for scenic and historic integrity within the viewshed at Little Bighorn Battlefield National Monument.

Class	Scenic & Historic Integrity
High Integrity *(Good Condition)*	Some noncontributing features or developments are visible, but the vast majority of the landscape is dominated by natural or historic features. Even if some development has occurred, the scene appears largely intact. The integrity of the historic context is well preserved such that an observer can easily visualize the historic aspect of the viewshed. As such, the features that contribute to the historic integrity are well preserved (even as ruins) and the noncontributing features are non-existent or sufficiently minimal so as to not detract from the historic sense of place.
Moderate Integrity *(Moderate Concern)*	Noncontributing features or developments occupy a moderate portion of the landscape, but sufficient intactness retains much of its integrity. The integrity of the historic context is also largely preserved such that an observer can visualize the historic aspect of the viewshed.
Low Integrity *(Significant Concern)*	The vast majority of the landscape is dominated by noncontributing features or developments, such that little integrity or "sense of place" remains. The integrity of the historic context is essentially lost either from the contributing factors not being well preserved or the noncontributing features overwhelming the potential to visualize the historic aspect of the viewshed.

surrounding landscape provided the best depiction of the visible area from each vantage point. Complete details of the viewshed analysis process are listed in Appendix B.

Indicators/Measures

Housing and Road Densities

Roads and houses are typically the most common noncontributing features within rural landscapes. Thus, we used data provided by NPScape (NPS 2012) to provide estimates of road and housing densities within the vicinity (approximately 30 km) of the Monument. NPScape was developed by the NPS Natural Resource Stewardship and Science Directorate by compiling and analyzing landscape-scale U.S. Census Bureau data that linked measurable attributes of landscape (i.e., road density, population and housing density, and others) to resources within natural resource-based parks, resulting in the NPScape database (Budde et al. 2009, Gross et al. 2009).

Use of GIS for Illustrating Spatial Relationships
We also used GIS to show the spatial patterns of prominent features on the landscape that are visible from the primary vantage points at the Monument, providing an aerial or "bird's eye" view. These prominent features include roads and structures, as well as other developments that might influence the scenic integrity of the viewshed. We limited this approach to an area of 30 km from Monument since features at greater distances have relatively less impact on scenic or historic integrity than those in greater proximity.

4.1.3. Reference Conditions

The basis for determining condition in an assessment such as this is a comparison between current condition and some reference. For Little Bighorn Battlefield, we used a qualitative reference state for the scenic and historic integrity of the viewshed (Table 4.1.3-1).

As previously discussed, the scenic and historic integrity at Little Bighorn Battlefield overlap considerably. From the historic perspective, the reference state is based on a particular period relevant to the Monument—in the case of the Little Bighorn Battlefield, the time of the battle (1876). Natural landforms and ecological communities also greatly influenced the tactical aspects of the Battle of the Little Bighorn. These natural features contribute to visitor understanding and appreciation of the site and historical events.

The Cultural Landscape Inventory (NPS 2010:64) states:

> Topography played a crucial role in battle strategy and outcome, and it has experienced minimal modification

Table 4.1.3-2. Condition classes that describe intactness of a viewshed.

Good	Pristine	No man-made structures or developments are visible within the viewshed.
	Minimally Developed	Man-made structures or developments are present, but the vast majority of the landscape is dominated by natural features.
Moderate	Moderately Developed	Man-made structures or developments occupy a moderate portion of the landscape.
Significant Concern	Highly Developed	The vast majority of the landscape is dominated by man-made structures or developments.

Table 4.1.3-3. Condition classes that describe housing and road density.

Condition Class	Description
Good	Undeveloped or rural, agricultural (farm and ranch) housing. Housing densities are primarily < 1.5 units /km^2. Small concentrated areas of higher densities may be found, but usually not in proximity to the observation point and are relatively inconspicuous. Majority of the roads are small, rural roads.
Moderate	Housing densities are more prominent in the landscape (generally between 1.5-6 units per km^2), but the scenic and historic values are largely maintained. A mix of road classes, but predominantly small roads and larger or busy roads are not in the foreground.
Significant Concern	Higher density ex-urban to suburban development (generally densities > 6 units per km^2, such that the scenic and historic value is either lost or close to being lost. Major roads and highways are conspicuous in the view.

since 1876. As a result, topography at Little Bighorn continues to remain significant and contributes strongly to the historic scene of the Monument.

Vegetation within both the battlefield and national cemetery districts also contributes to the historic integrity. The relatively intact grass and sagebrush prairie vegetation creates a visual scene of high integrity. Plantings in the cemetery, while highly artificial in the context of the surrounding prairie, is strongly representative of national cemetery landscape treatment and retains its own historic integrity.

The battlefields have been preserved since the time of battle, and the native ecological communities are largely intact, contributing to high scenic and historic integrity (NPS 2010). The native grassland vegetation (foreground) and intact riparian vegetation (middleground) are especially critical to maintaining this condition.

Intactness is intended to convey something about the proportion of the visible landscape that has preserved its naturalness relative to that 1876 landscape. The four qualitative condition classes we used from intactness are presented in Table 4.1.3-2.

Housing and road densities are also intended to provide information about how well the scenic quality and historic sense of place have been preserved, but do so using a GIS-based measure of some specific noncontributing features (houses and roads). However, densities certainly help tell part of the story, but do not provide the full story. For example, two scenes may have equal overall road densities but if one has only rural roads in the distance and the other has a busy interstate highway close to the observation point, the latter will clearly be considered more degraded in terms of their scenic and historic value. Thus we use housing and road densities as a general reference but take into account other factors in a more qualitative sense described in Table 4.1.3-3.

4.1.4. Condition and Trend

Ground-based Assessment

Overall, the scenic and historic integrity of the viewsheds at Little Bighorn Battlefield

Table 4.1.4-1. Summary of viewshed condition assessed at each key vantage point.

Vantage Point	Noncontributing Features	Assessment	Condition
Last Stand Hill (Figure 4.1.5-1)	• Park road, trail • Visitor center and parking lot • Rural housing • Agricultural fields • Highway (I-90) • Highway exchange (I-90/212) • Communication tower	The viewshed is predominantly of high scenic and historic integrity. The foreground is dominated by grassland and historical markers; the middle ground is dominated by the riparian area and floodplain of the Little Bighorn River. Noncontributing features are primarily located in the middle ground, and most are inconspicuous. Exceptions to this are the visitor center and parking lot, and the business development associated with the highway exchange.	Good to moderate
Wooden Leg Hill (Figure 4.1.5-2)	• Rural housing • Grazing pasture, fences • Ranch roads • Paved 2-lane road	The viewshed from this vantage point is of high scenic and historic integrity. The view is dominated by native grassland, and foothills in the background. The most conspicuous feature is the roads in the middle ground, and while they contribute movement, the amount of traffic is minimal, and they are mitigated by their small size and contours with the landscape.	Good
Reno-Benteen (Figure 4.1.5-3)	• Park road, trail, parking lot • Rural housing • Farms and ranches, buildings • Ranch roads • Agricultural fields, fences • Highway (I-90) • Railroad track, trains	The viewshed from this vantage point is of moderate to high scenic and historic integrity. While the majority of the view is dominated by native grassland and rural character, there is a good deal of development in the middle ground that creates movement (highway, roads, railway, and tractors on fields) and disrupts the sense of place.	Good to moderate

National Monument is fairly high and in good to moderate condition. The landscape surrounding Little Bighorn Battlefield National Monument remains largely rural. However, the location of the Monument so near the intersection of two highways is somewhat problematic because of the associated commercial development and infrastructure. The topography mitigates this impact in much of the Monument. Memorial monuments and grave markers (or markers for fallen soldiers and braves, that are not grave markers, but look similar), likely also contribute to the sense of place and visitor experience.

Assessment from Key Vantage Points

We considered the condition of the view from *Last Stand Hill* to be moderate to good (Table 4.1.4-1). From this vantage point, the most conspicuous features that could impact the integrity of the view is the park development (Figure 4.1.4-1). Particularly during periods of high visitation the features and activity could certainly detract from both the scenic integrity and "sense of place" in the historic context. The other main impact is the agricultural and rural development, particularly to the south of the Monument. Despite these developments, the natural vegetation communities, primarily grasslands and riparian vegetation, are dominant influences on the viewshed and contribute and the sense of place is largely retained. Aside from park infrastructure, little if any development is in the foreground, and much of the closest development in the middle ground is shielded by the riparian vegetation associated with the Bighorn River. Thus, most of the remaining non-contributing features

Figure 4.1.4-1. Panoramic views to the south (top) and west (bottom) from Last Stand Hill.

Figure 4.1.4-2. Panoramic views to the north (top) and east (bottom) from Wooden-Leg Hill.

the are non-contrasting (or of low contrast), mostly follow contours of the topography, and are of sufficient distance to minimize impact.

From *Wooden-Leg Hill* looking the opposite direction from Last Stand Hill, the scenic and historic integrity are quite good (Figure 4.1.4-2). Although some rural development is visible, it is generally neither extensive or conspicuous. The natural vegetation communities, primarily grasslands, are the dominant influence on the viewshed and contribute well to the sense of place.

We also considered the view from the Reno Benteen vantage point to be in moderate to good condition. Although further from the developed areas near the Monument entrance, this site is closer to the agricultural and rural development (Figure 4.1.4-3). However, there has been a substantial volume of research demonstrating that man-made features on a landscape are perceived more positively when they are considered in harmony with the landscape (Kaplan and Kaplan 1989; Gobster 1999; Kearney 2008; others). For example, Kearney et al. (2008) showed that respondents tended to prefer development that blended with the natural setting through use of colors, smaller scale, and vegetative screening.

The development visible from Reno Benteen is less shielded from view by the riparian vegetation than at Last Stand Hill; thus making it more conspicuous. However, rural development, such as farms and ranches are often perceived as being relatively harmonious with the landscape because of their role in stewardship (Schauman 1979; Sheppard 2001; Ryan 2006). A primary issue here is that

Figure 4.1.4-3. Panoramic views in each direction from the Reno-Benteen vantage point.

such development is not consistent with the historic landscape at the time of the battle, thus may detract somewhat from the "sense of place".

Ancillary Views

Additional views at Weir Point and Garryowen were assessed in the field to provide information to the park. They were not included in the condition assessment because they receive relatively low visitation or are sites not typically sought out for their view by visitors.

Weir Point: Unlike the other two ancillary vantage points we considered, Weir Point is a target destination for its view, particularly because if its historic context. It does not however, receive the level of visitation that is experienced at the two key vantage points. From the standpoint of integrity, the viewshed from this vantage point is similar in many respects to that of Reno-Benteen. The view is dominated by natural grasslands to the north and east, and has a mix of natural grasslands, pasture, and agricultural fields to the south and west (Figure 4.1.4-4). From this view, the topography of the hills, ravines, and river plain are easily seen, and the development in the river corridor is less conspicuous.

Garryowen: The viewshed from this vantage point is of relatively low scenic and historic integrity. While the agricultural and rural character is only somewhat noncontributing, it dominates the foreground, making it very conspicuous (Figure 4.1.4-5). This site also is directly adjacent to the highway frontage road and very near a gas station/convenience store. The features contributing to scenic and historic integrity—the riparian area and the

Figure 4.1.4-4. Panoramic views in each direction from Weir Point.

Figure 4.1.4-5. Views toward the Monument to the north (top) and east (bottom) from the Garryowen vantage point..

bluffs of the Monument—are in the middle ground and background.

GIS-based Assessment
We began our GIS-based assessment by modeling the areas visible or not visible from the two key vantage points. At Last stand Hill and Wooden-Leg Hill, most of the visible area lies to the west into the Bighorn Valley (Figure 4.1.4-6). The foreground, middle ground, and start of the background extends to the ridge that separates the Bighorn and Little Bighorn Rivers (Figure 4.1.4-7), while in other directions, the view is limited by local topography

Views from Reno-Benteen are similar in that they are most extensive to the west, but they are also more limited than from Last Stand Hill because they are at a site lower in elevation; thus are more restricted by topography (Figure 4.1.4-8) It is important to keep in mind, however, that these estimates of visible area are approximations based on Digital evaluation models. Although, we have checked them on the ground to verify that they are approximately correct, it should not be assumed that they are exactly correct for the purposes of planning specific projects. Such cases may require further verification, and adjustment if necessary, for the specific context intended.

Housing and Road Densities
Based on the data complied in NPScape (Budde et al. 2009 and Gross et al. 2009). housing densities surrounding the Monument are relatively low (Figure 4.1.4-9), with > 68% of the square km units .with known densities being undeveloped (Table 4.1.4-2). Since these data originated from the U.S., Census, units with unknown densities were not likely report; thus likely also undeveloped.

Similarly, road densities are also relatively low (Figure 4.1.4-10), with the majority of the square km have < 1.125 km of roads per square km. While the Monument is near the intersection of two highways, most of the area has only rural paved and unpaved roads.

The low densities of housing and roads supports the assessment made from vantage

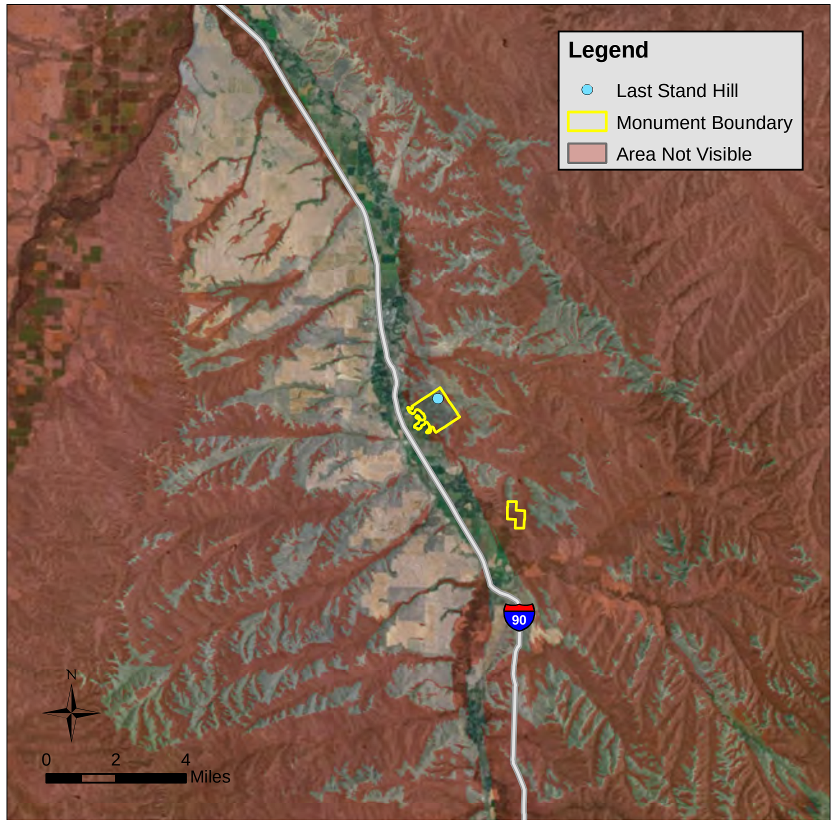


Figure 4.1.4-6. Area visible and not visible from Last Stand Hill and Wooden Leg Hill based on GIS analysis.

Figure 4.1.4-7. Most views from Little Bighorn Battlefield NM to the west extend in the middle and immediate background to a nearby ridge while still enable views of the distant mountains.

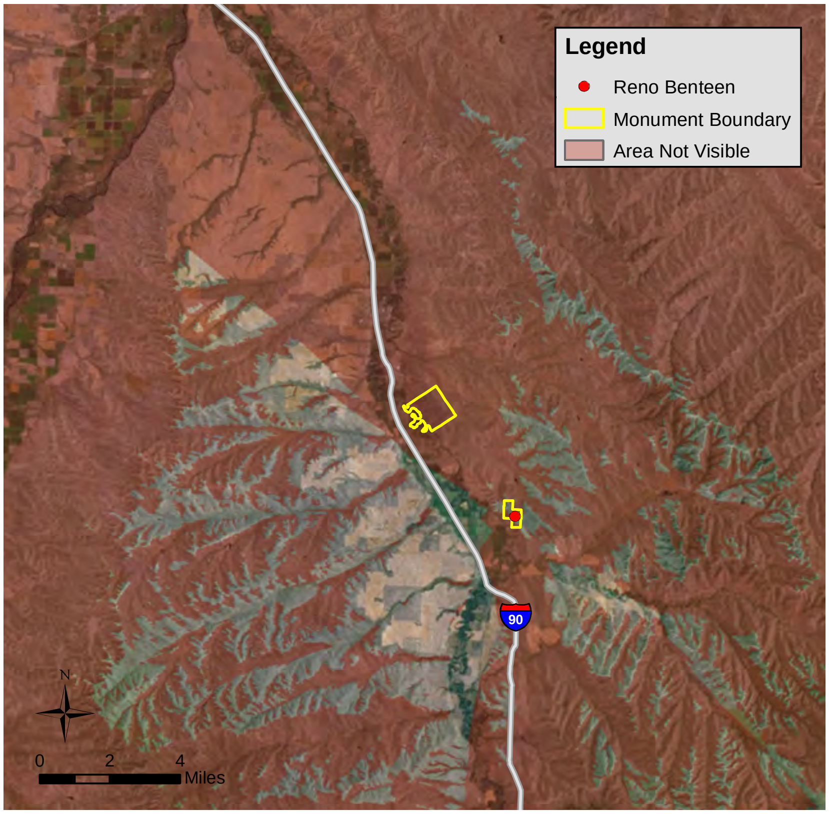


Figure 4.1.4-8. Area visible and not visible from Reno-Benteen based on GIS analysis.

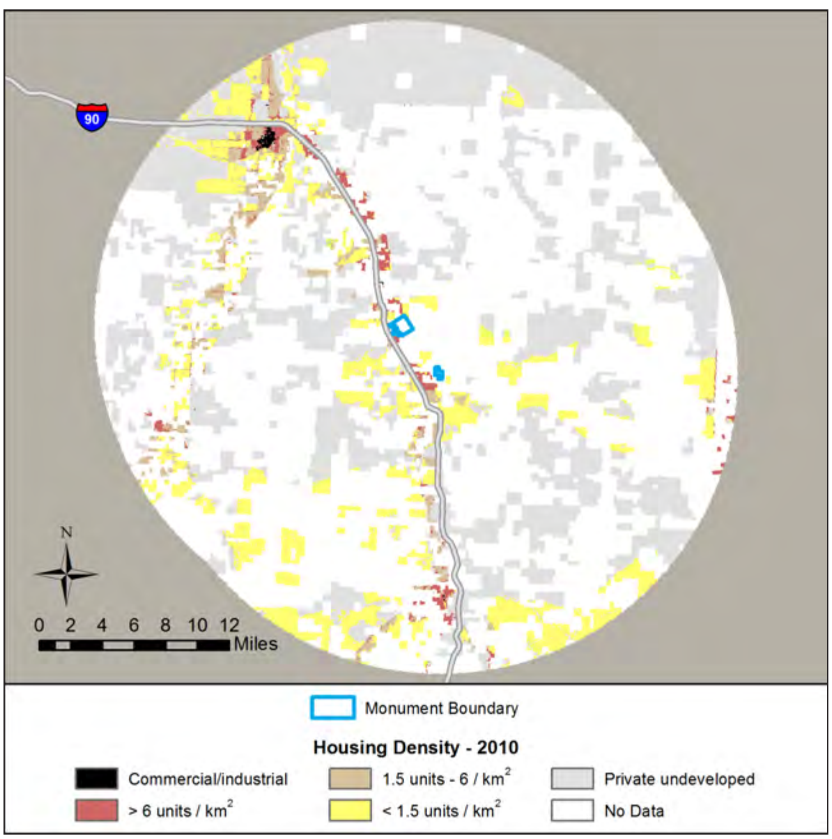


Figure 4.1.4-9. Housing densities (housing units / km2) based on data compiled in NPScape (Budde et al. 2009 and Gross et al. 2009).

Table 4.1.4-2. Housing and road densities within 30 km of Little Bighorn NM in 2010 as estimated using NPScape (Budde et al. 2009 and Gross et al. 2009).

Density Class	Area (km²)	Percent
Housing Densities		
No Data	2038	60.69%
Private undeveloped	924	27.52%
< 1.5 units / square km	289	8.61%
1.5 - 6 units / square km	69	2.05%
> 6 units / square km	34	1.01%
Commercial / Industrial	4	0.12%
Road Densities		
No Data	116	23.29%
< 0.015	1	0.20%
0.015 - 1.125	162	32.53%
1.126 - 2.287	157	31.53%
2.288 - 4.982	46	9.24%
4.983 - 13.49	16	3.21%

Note: The source data from NPScape included some areas with missing data, which were excluded from these totals.

points in that views from the Monument tend to be dominated by native vegetation rather than houses or roads. Thus, we do not consider the current densities of housing or roads to be of major concern for the viewshed at the present time.

Spatial Relationships among Features

To augment the assessment, we also used the combined viewshed from our two key vantage points (i.e., are visible from either vantage point) to show the spatial relationships of the primary noncontributing features (Figure 4.1.4-11) and some of the primary historic features or events (Figure 4.1.4-12).

<u>Overall Condition</u>

Based on this assessment, the viewshed condition at Little Bighorn Battlefield NM is good to moderate. While the majority of the landscape has remained in good condition since the time of the battle, there has been some development both within and outside the Monument that can detract from the sense of place derived from the viewshed. Outside the Monument, most development, and the highest potential for future development is along the I-90 corridor. This tends to be the middleground of the viewshed, thus does have some impact. Within the Monument, administrative and visitor facilities, including vehicle traffic, has the highest potential to impact the viewshed, particularly during periods of high visitation and corresponding activity.

4.1.5. Sources of Expertise

For assessing the condition of this resource, we relied primary on literature on this topic. We did however, use the GIS expertise from Melanie Meyers, while she was working with the Intermountain Region, as well as the values and predictions from the U.S. Census.

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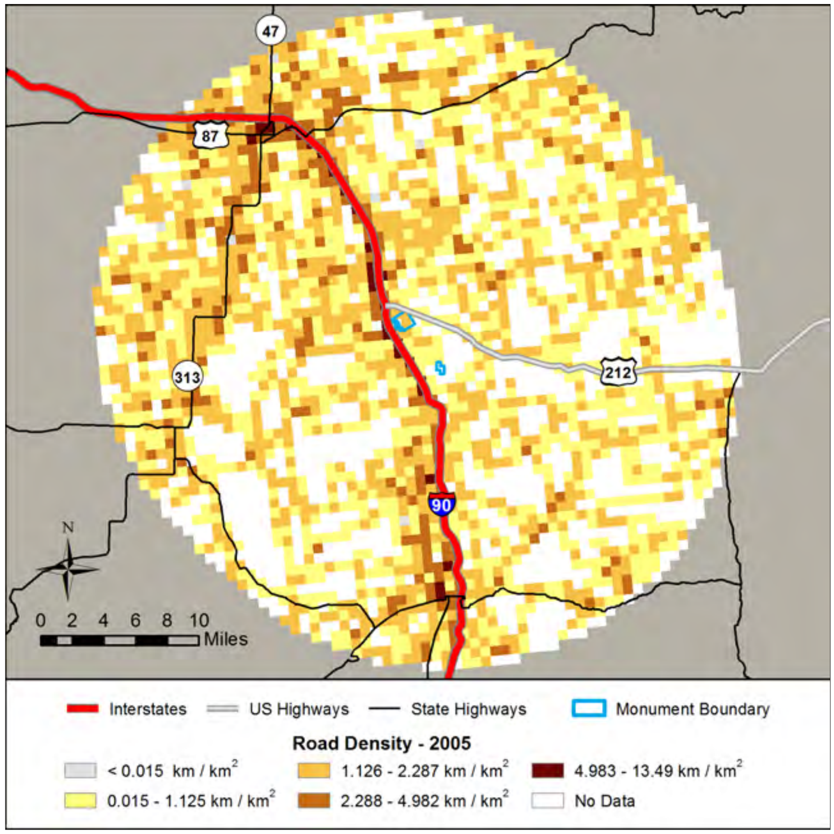

Figure 4.1.4-10. Road densities (km of roads / km2) based on data compiled in NPScape (Budde et al. 2009 and Gross et al. 2009).

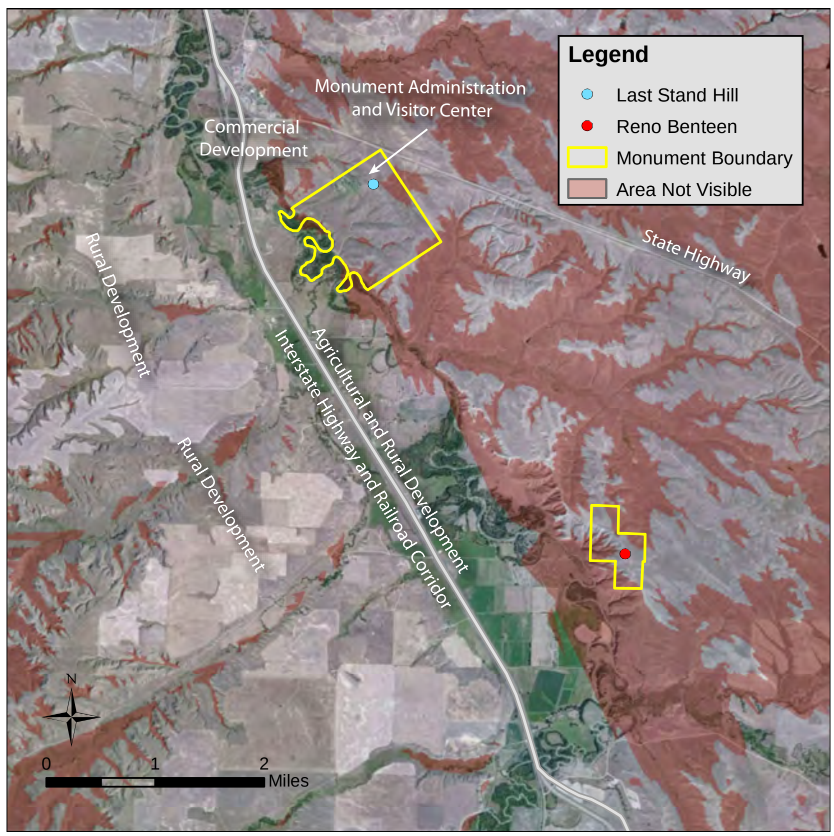

Figure 4.1.4-11. Prominent non-contributing features within view of one or more key vantage point.

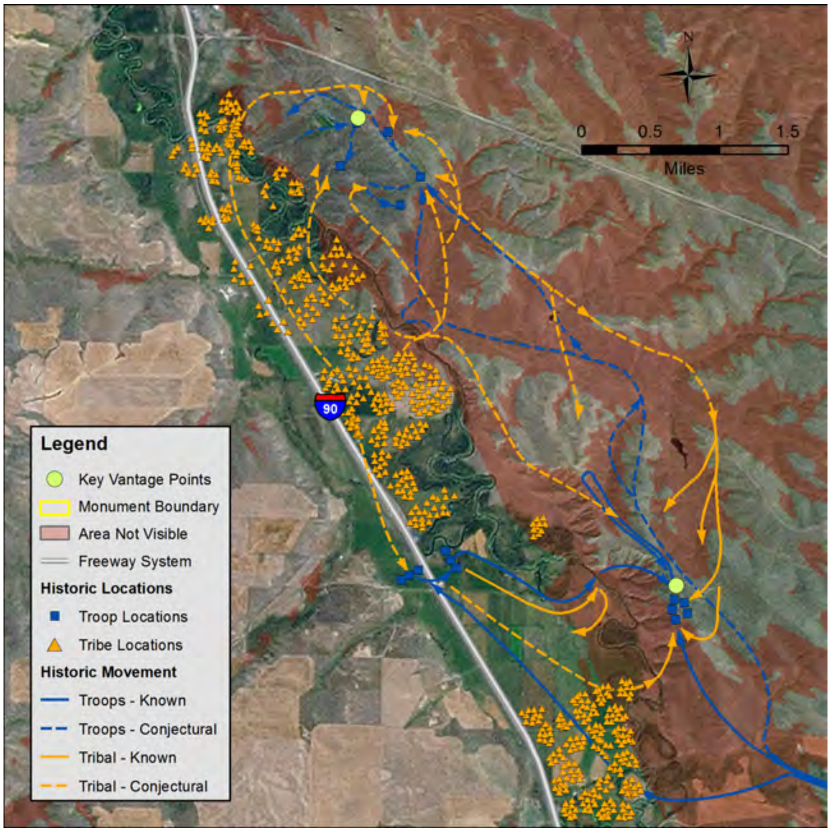

Figure 4.1.4-12. Prominent contributing historic features within view of one or more key vantage point.

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4.2. Night Sky

Indicators/Measures

- Zenith Sky Brightness (2 measures)
- Sky Quality

Condition – Trend – Confidence Level

Moderate - Insufficient Data - High

4.2.1. Background and Importance

Natural dark skies are a valued resource within the NPS, reflected in NPS management policies (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 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 *photoic 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 are integral to natural and cultural resources (Moore et al. 2013). 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. Additionally, in an estimated 20 national parks, stargazing events are the most popular ranger-led program (NPS 2010).

The values of night skies 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 (Moore et al. 2013). 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 modulate movement, feeding, mating, emergence, seasonal breeding, migration, hibernation, and dormancy. Plants also respond to light levels by flowering, vegetative growth, and even 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.

Little Bighorn Battlefield National Monument (NM) is primarily a cultural resource park, and the cultural significance of dark night skies should be recognized as part of the cultural landscape. The Monument is a memorial to the battle between George Custer and the United States Cavalry and the Northern Plains tribes (Cheyenne, Lakota, and Arapaho) led by Lakota spiritual leader, Sitting Bull. The Plains Tribes were nomadic and didn't always camp in the same locations, but they closely followed the seasons, the movement of the sun, and the night sky. Much of their culture was shaped by celestial observation. For example, while there is some disagreement over the antiquity of North American medicine wheels and their purpose, most agree they had some astronomical function. The most famous and intact wheel is located in the Bighorn Mountains of Wyoming, not far from Little Bighorn Battlefield NM, which was probably built around 1760 and connected to observation of the summer solstice (Krupp 1983, Mizrach 2012). During the time of the battle (June 24-26, 1876) NASA estimates that the moon was a waning crescent with the new moon approaching on June 30 (NASA 2012). One can only speculate, but perhaps the dark night sky assisted the Plains Tribes as they moved in the dark shadows of the ravines to the bluffs where the Cavalry were stationed.

It is said that Sitting Bull had a vision predicting the battle. Mizrach (2012) writes that: The Lakota often made a special war shield following a Vision Quest. The design on the shield was supposed to offer them special protection and guidance. Many of the shields found by ethnographers contain celestial designs, usually depicting the sun, the Pleiades, the Little Dipper, Castor and Pollux, the Pole Star, and the Morning Star. Vision questers were often directed to make the focus of their visions the central element of their shields. The fact that they frequently chose astronomic elements shows what their attention was often directed toward (Carlson 1990, Mizrach 2012).

The Monument today is located on the Crow Indian Nation. The Crow, as well as the Cheyenne, Lakota, and other Tribes, have traditional stories tied to the night skies. It was the custom to tell stories in the winter when night fell earlier and the family was gathered together around a fire (Moroney 2011). Many of the stories of the stars and constellations are told as analogies to family. The Sun is referred to as Grandfather, or Old Man; and the Moon is Grandmother, or Old Woman. One Crow story tells of an abandoned baby that was surrounded by seven buffalo—those seven buffalo became the seven stars in the Big Dipper who watched over the boy (the North Star) by circling him (Moroney 2011). The Pleiades constellation has many Native American stories about its origins. The Arapaho and Cheyenne believed that everything came from the earth—even the stars in the sky. The story of the Quillwork Girl and her Seven Brothers (McHenry 2012) tells of a girl and her brothers who escape a monster buffalo to live in the sky. In part of the story, the wind blows so hard it breaks a branch of a cottonwood tree and from the broken limb fly out stars to land in the sky and keep the girl and her seven brothers (who stay together as the Pleiades constellation) company.

Another Crow story, The Twins and the Hand Star (Moroney 2011), talk about a father praying in a sweat lodge to bring his lost twin sons and their mother back to him. The twins become the planets Venus and Jupiter who playfully chase each other around the sky; and their mother and her things (her mortar, hatchet, and comb) become the Hand constellation (also known as Orion).

Protecting the night sky resources at Little Bighorn Battlefield NM benefits the natural resources, is important for visitor experience, has cultural and historical significance, and is important within the current cultural context of the park.

4.2.2. Data and Methods

The NPS Natural Sounds and Night Skies Division goals of measuring night sky brightness are to describe the quality of the lightscape, quantify how much it deviates from natural conditions, and how it changes with time due to changes in natural conditions, as well as artificial lighting in areas within and outside of the national parks (Duriscoe et al. 2007).

Based on new guidance (Moore et al. 2013), the NPS Natural Sounds and Night Skies Division recommends that the all-sky Anthropogenic Light Ratio (ALR) is the best single parameter for characterizing the overall sky condition. Additional indicators and measures may be considered in an assessment of night sky condition, but the ALR measure is the primary data source for condition assessment.

We conducted a supplemental rapid assessment of the Monument's night sky condition on August 20, 2012 using quantitative (Sky Quality Meter) and qualitative (Bortle Dark Sky Scale) assessments commonly used by amateur astronomers to evaluate the potential quality for star gazing.

This rapid assessment was supplementary and interim until a more rigorous assessment was completed by the NPS Night Skies Program on May 7, 2013.

Indicators/Measures

Zenith Sky Brightness (2 measures)

The anthropogenic light ratio (ALR) is the average anthropogenic sky luminance presented as a ratio over natural conditions. It is a useful metric to average the light flux over the entire sky (measuring all that is above the horizon and omitting the terrain). Recent advances in modeling of the natural components of the night sky allow the separation of anthropogenic light from natural features, such as the Milky Way. This metric is a convenient and robust measure. 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. Ground-based measures were taken for Little Bighorn NM in May 2013.

CCD camera images assess brightness, including maximum sky brightness, minimum sky brightness, and two measures of integrated sky brightness. The maximum sky brightness is typically found in the core of urban light domes (i.e., the semicircular-shaped light along the horizon caused by the scattering of urban light). The minimum sky brightness is typically found at or near the zenith (i.e., straight overhead). The integrated night sky brightness is calculated from both the entire celestial hemisphere as well as a measure of the integrated brightness masked below 20° altitude to avoid site-to-site variations introduced by terrain and vegetation blocking.

Sky brightness describes the amount of light in the night sky. One method of assessing sky brightness uses a Unihedron Sky Quality Meter (SQM) that samples the night sky in a broad spectrum band roughly corresponding to the entire human visual range. The SQM measures an aggregate average brightness for the entire sky that is skewed to zenith brightness over an 80 degree field of view (Moore 2012). Readings were taken at three locations within Little Bighorn Battlefield National Monument starting an hour and a half after sunset; a new crescent moon set about 20 minutes before the time of the first reading.

Indicators/Measures

Sky Quality

The Bortle Dark Sky Scale (Appendix C) was proposed by John Bortle (Bortle 2001) based on 50 years of astronomical observations. Bortle's qualitative approach uses a nine-class scale that requires a basic knowledge of the night sky and no special equipment (Bortle 2001, Moore 2001, White et al. 2012, Table 4.2.2-1). The Bortle scale uses both stellar objects and familiar descriptors to distinguish among the different classes. Another advantage of the Bortle scale is that it is suitable for conditions ranging from the darkest skies to the brightest urban areas (Moore 2001, Figure 4.2.2-1).

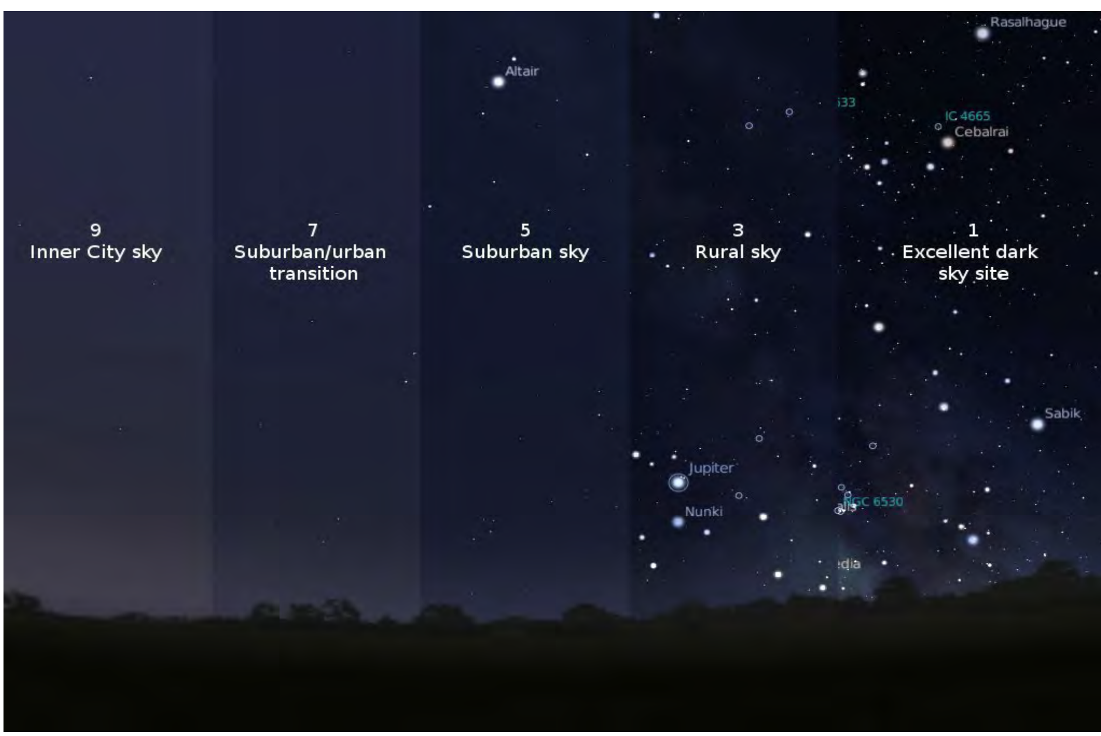

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Figure 4.2.2-1. Composite image illustrating the range of night sky conditions based on the Bortle Dark Sky Scale.

Table 4.2.2-1. Bortle Dark Sky Scale*

Bortle Scale	Milky Way (MW)	Astronomical Objects	Zodiacal Constellations	Airglow and Clouds	Nighttime Scene
Class 1 Excellent Dark Sky Site	MW shows great detail, and appears 40° wide in some parts; Scorpio-Sagittarius region casts an obvious shadow	Spiral galaxies (M33 and M81) are obvious objects; the Helix nebula is visible with the naked eye	Zodiacal light is striking as a complete band, and can stretch across entire sky	The horizon is completely free of light domes, very low airglow	Jupiter and Venus annoy night vision, ground objects are barely lit, trees and hills are dark
Class 2 Typical Dark Site	MW shows great detail and cast barely visible shadows	The rift in Cygnus star cloud is visible; the Prancing Horse in Sagittarius and Fingers of Ophiuchus dark nebulae are visible, extending to Antares	Zodiacal band and gegenschein are visible	Very few light domes are visible, with none above 5° and fainter than the MW; airglow may be weakly apparent, and clouds still appear as dark voids	Ground is mostly dark, but object projecting into the sky are discernible
Class 3 Rural Sky	MW still appears complex; dark voids and bright patches and a meandering outline are visible	Brightest globular clusters are distinct, pinwheel galaxy visible with averted vision	Zodiacal light is easily seen, but band of gegenschein is difficult to see or absent	Airglow is not visible, and clouds are faintly illuminated except at zenith	Some light domes evident along horizon, ground objects are vaguely apparent
Class 4 Rural-Suburban Transition	MW is evident from horizon to horizon, but fine details are lost	Pinwheel galaxy is a difficult object to see; deep sky objects such as M13 globular cluster, Northern Coalsack dark nebula, and Andromeda galaxy are visible	Zodiacal light is evident, but extends less than 45° after dusk	Clouds are just brighter than the sky, but appear dark at zenith	Light domes are evident in several directions (up to 15° above the horizon), sky is noticeably brighter than terrain
Class 5 Suburban Sky	MW is faintly present, but may have gaps	The oval of Andromeda galaxy is detectable, as is the glow in the Orion nebula, Great rift in Cygnus	Only hints of zodiacal light may be glimpsed	Clouds are noticeably brighter than sky	Light domes are obvious to casual observers, ground objects are easily seen
Class 6 Bright Suburban Sky	MW only apparent overhead, and appears broken as fainter parts are lost to sky glow	Cygnus, Scutum, and Sagittarius star fields just visible	Zodiacal light is not visible; constellations are seen, and not lost against a starry sky	Clouds appear illuminated and reflect light	Sky from horizon to 35° glows with grayish color, ground is well lit
Class 7 Suburban-Urban Transition	MW may be just barely seen near the zenith	Andromeda galaxy (M31) and Beehive cluster (M44) are rarely glimpsed	Zodiacal light is not visible, and brighter constellations are easily seen	Clouds are brilliantly lit	Entire sky background appears washed out, with a grayish or yellowish color
Class 8 City Sky	MW not visible	Pleiades are easily seen, but few other objects are visible	Zodiacal light not visible, constellations are visible but lack key stars	Clouds are brilliantly lit	Entire sky background has uniform washed out glow, with light domes reaching 60° above the horizon
Class 9 Inner City Sky	MW not visible	Only the Pleiades are visible to all but the most experienced observers	Only the brightest constellations are discernible	Clouds are brilliantly lit	Entire sky background has a bright glow, ground is illuminated

*Table 4.2.2-1 also incorporates the Bortle Dark Sky Scale Key for the Summer Sky for Latitudes 30° to 50° N, White et al. 2012.

Table 4.2.3-1. Night sky condition class summary.

Condition Class	ALR*	SQM	Bortle Scale
Good	ALR <0.33 (<26 nL average anthropogenic light in sky)	≥21.60	1-3
Moderate	0.33-2.0 (26-156 nL average anthropogenic light in sky)	21.2-21.59	4
Significant concern	ALR >2.0 (>156 nL average anthropogenic light in sky)	<21.2	5-9

*at least half of the park's geographic area should meet the standard described

4.2.3. Reference Conditions

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 2010). A natural night sky has an average brightness across the entire sky of 80 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% brighter than the natural light from the night sky. For a summary of condition assessment categories for all night sky indicators, see Table 4.2.3-1.

<u>Anthropogenic Light Ratio</u>

The threshold for night skies in good condition is an ALR <0.33 and the threshold for a moderate condition is ALR 0.33-2.0. An ALR >2.0 suggests significant concern (Moore et al. 2013).

<u>Zenith Sky Brightness</u>

Reference conditions for night sky brightness can vary moderately based on the time of night (time after sunset), time of the month (phase of the moon), time of the year (the position of the Milky Way), and the activity of the sun which can increase "airglow"—a kind of faint aurora. For the *minimum* night sky brightness measure, the darkest part of a natural night sky is generally found near the zenith. A value of 22.0 magnitudes per square arc second (msa) is considered to represent a pristine sky, though it may vary naturally by more than +0.2 to -0.5 depending on natural conditions (Duriscoe 2013 [submitted]). Lower (brighter) values indicate increased light pollution and a departure from natural conditions. The astronomical magnitude scale is logarithmic, so a change of 2.50 magnitudes corresponds to a difference of l0x (100%); thus a 19.5 msa sky would be 10x brighter than natural conditions. *Minimum* night sky brightness values of 21.4 to 22.0 msa, are generally considered to represent natural (unpolluted) conditions (Duriscoe et al. 2007).

The *maximum* night sky brightness is often found within the Milky Way of a natural sky. A typical measurement from the Sagittarius region of the Milky Way in a natural sky yields 19.2 msa. Other regions of the Milky Way are somewhat dimmer, or around 20.0-21.0 msa. A value brighter than 19.0 msa will result in impairment to human night vision and may be noticeable by casting faint shadows or causing glare. A value lower (brighter) than 17.0 represents very bright areas of the night sky and would significantly impair human night vision and cast obvious shadows. Values for the brightest portion of the sky are of interest to the NPS because they represent unnatural intrusions on the nightscape, will prevent human dark-adapt vision, and may have effects on wildlife (Duriscoe et al. 2007).

<u>Bortle Dark Sky Scale</u>

A night sky with a Bortle Dark Sky Scale class 1 is considered in the best possible condition (Bortle 2001); unfortunately, a sky that dark is so rare that few observers have ever witnessed it (Moore 2001). Non-urban park skies with a Bortle class 3 or darker are considered to be in good condition,

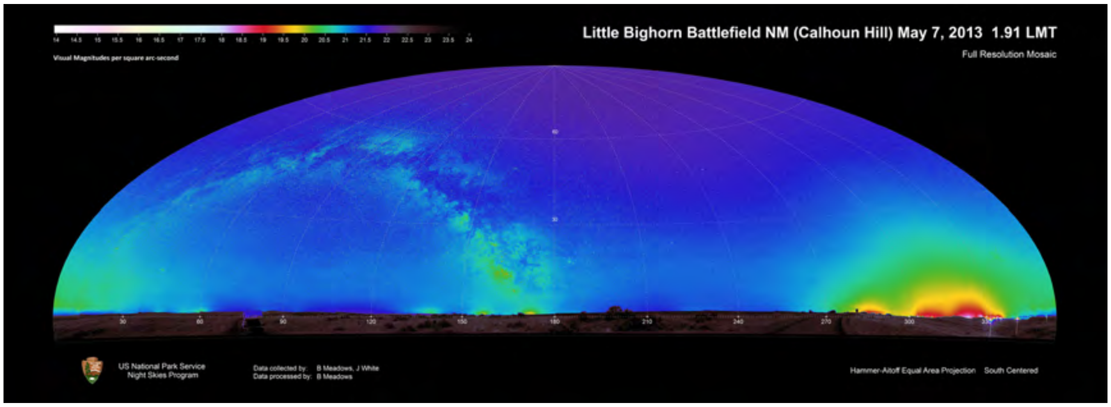

Figure 4.2.4-1. Light dome image produced by the NPS Night Skies Program.

Table 4.2.4-1. Summary of night sky indicators and measures, and assessment of night sky condition at Little Bighorn Battlefield National Monument, May 7, 2013.

Indicator	Measure	Description	Condition
Anthropogenic Light Ratio	0.35	This ground-based measurement has a high level of confidence. The value indicates moderate condition, but is on the edge of moderate and good.	Moderate
Zenith Sky Brightness	21.64	Sky brightness indicates moderate condition, based on the impact from light domes from nbearby cities and towns, and more local point sources.	Moderate
Bortle Scale Class	3	A Bortle class 3 indicates good condition and a typical rural sky. The Bortle Scale is a qualitative measure of sky quality.	Good

class 4 of moderate condition, and class 5 are considered poor condition. At class 4 and higher, many night-sky features are obscured from view due to artificial lights (either within or outside the park). Skies class 7 and higher have a significantly degraded aesthetic quality that may introduce ecological disruption (Moore et al. 2013). It is important to note that such degraded conditions may be restored toward a more natural state by modifying outdoor lighting, depending on the surrounding conditions that exist outside the park.

4.2.4. Condition and Trend

Ground-based data provided by the NPS Night Skies Program shows an ALR of 0.35, indicating moderate condition. This value indicates that Little Bighorn Battlefield NM is right on the edge of good and moderate condition (Figure 4.2.4-1).

SQM measured at Calhoun Hill Road (0.65 miles southeast of the visitor's center) was 21.64, and a Bortle class 3 was estimated (Table 4.2.4-1).

A supplementary rapid assessment was conducted at Little Bighorn Battlefield NM. Bortle class assessments and SQM readings were made at three locations within the park: in the Reno-Benteen unit, at Last Stand Hill in the Custer unit, and near the visitor center; where the park has outdoor lighting and is probably one of the brightest places in the park. The Bortle Scale estimates were class 2 in both the Reno-Benteen unit and at Last Stand Hill; and a class 3 at the visitor center. The SQM readings varied between 20.91 and 21.31 msa depending on the location and time, indicating moderate condition or of significant concern.

<u>Local and Regional Context</u>

Little Bighorn Battlefield NM is located about 18 miles from the small town of Hardin, Montana, the county seat of Big Horn County, with a population of approximately 3,500 people (U.S. Census Bureau 2010). Highways are visible from the park on three sides.

The largest towns in the region are Sheridan, Wyoming, which is located about 70 miles to the south (and a population of approximately 17,500); and Billings, Montana, which is about 65 miles to the north (population of about 105,000) (Figure 4.2.4-2). Nighttime light from both of these cities were visible.

Other sources of artificial light includes businesses, homes, ranch buildings near the park, and lighting of park buildings. These lights impact the night sky quality of the park to varying degrees.

<u>Overall Condition</u>
For assessing the condition of the Monument's night sky, we used ground-based measurements in addition to a rapid assessment of a qualitative indicator (Bortle Dark Sky Scale) and quantitative measures (sky brightness, anthropogenic light ratio). These indicators are summarized and interpreted in Table 4.2.4-2. The overall condition of the Monument's night sky is moderate.

<u>Uncertainties</u>
The Bortle Dark Sky Scale and sky brightness estimates have inherent uncertainties and error. The principle drawback of the Bortle Scale is that it relies upon human visual observers. Differences in visual acuity, experience and knowledge, as well as time and effort expended can influence the estimates (Bortle 2001, Moore 2001). The sky brightness measures taken with the SQM suffers similar operator bias based on the level of experience in using the SQM and assessing the surrounding conditions. While the CCD system is highly precise, it can also be affected by vagaries in the atmosphere and in fluctuations in natural night sky brightness. Research is underway to minimize the influences of these factors upon the quantification of artificial light; and existing data can eventually be post-processed to this new standard (C. Moore, NPS, pers. comm.).

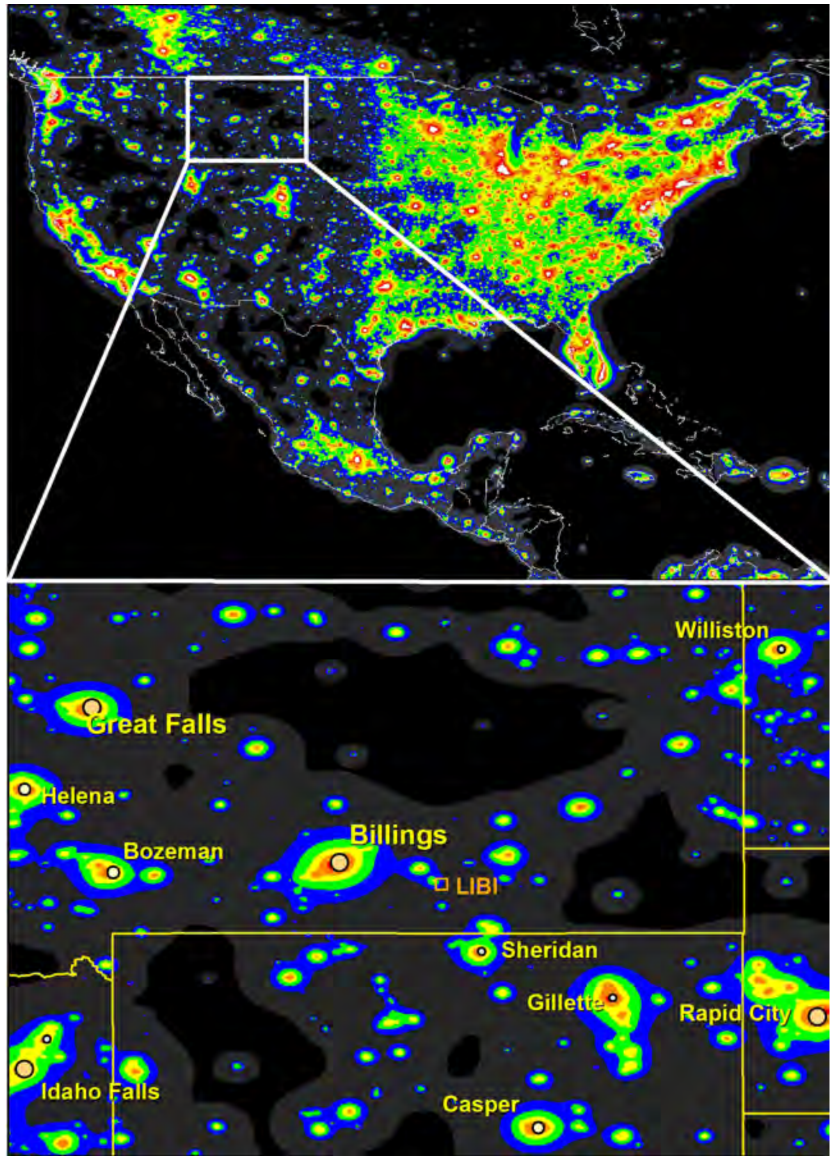

Figure 4.2.4-2. Artificial brightness in North America and the location of Little Bighorn Battlefield NM (Cinzano et al. 2001).

4.2.5. Sources of Expertise
Chad Moore, Natural Sounds and Night Skies Division, part of the NPS Natural Resource Stewardship & Science Directorate provided information pertaining to night sky data collection methodology and interpretation of results. Moore earned a master's degree in earth science in 1996 and began working for the NPS shortly thereafter. Moore is the Night Skies Program manager, a small team of scientists that measure, restore, and promote the proper management of the night sky resource. He and team member, Dan Duriscoe have developed an automated all-sky camera capable of precise measurement of light pollution. Since 2001 the team has collected sky quality inventories at over 110 U.S. national parks.

Lynn Powers, President of the Southwest Montana Astronomical Society (SMAS), assisted in the rapid assessment at Little Bighorn Battlefield National Monument. Lynn is enrolled in the Master of Science in Science Education program at Montana

Table 4.2.4-2. Summary of the night sky indicators and their contributions to the overall night sky Natural Resource Condition Assessment.

Measure	Description of How the Indicator Contributes to the Overall Resource Condition	General Contribution of this Indicator to the Overall Resource Condition
Anthropogenic Light Ratio	Anthropogenic light ratio (ALR) is a quantitative measure that presents the ratio of the average anthropogenic sky luminance to the average natural sky luminance.	Based on data collected by the NPS Night Skies Program, the condition of the night sky at the monument is in moderate condition; on the border between good and moderate.
Zenith Sky Brightness	This is a quantitative measure that assesses the sky brightness using readings from a sky quality meter (SQM).	SQM readings indicated moderate condition.
Bortle Dark Sky Scale	This is a qualitative measure that uses a scale divided into nine classes. It is a relatively easy measure to use for night sky conditions and requires no special equipment. The scale is based on observing features of the night sky including the Milky Way, constellations, and the nighttime scene.	The monument's night sky was assessed to be consistent with its rural surroundings and lack of light pollution. This is considered good condition.

State University, and is one of three Solar System Ambassadors for Montana sponsored by the National Aeronautics and Space Administration (NASA) Jet Propulsion Laboratory. The SMAS is a nonprofit organization dedicated to the study of the universe for recreational and scientific purposes, and promoting interest in amateur astronomy.

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4.3. Soundscape

Indicators/Measures

- Sound Sources
- Sound Characteristics

Condition - Trend - Confidence Level

Moderate Concern - Insufficient Data - Low

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 NPS visitor experience and enjoyment as well as vitally important to overall ecosystem health.

Visitors to national parks often indicate that an important reason for visiting the parks is to enjoy the relative quiet they can offer. 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" (Figure 4.3.1-1) (McDonald et al. 1995). Despite this desire for quiet environments, anthropogenic noise continues to intrude upon natural areas and has become a source of concern in national parks (Lynch et al. 2011).

Sound also plays a critical role in intraspecies communication, courtship and mating, predation and predator avoidance, and effective use of habitat. Studies have shown that wildlife can be adversely affected by sounds that intrude on their habitats. While the severity of the impacts varies depending on the species being studied and other conditions, research strongly supports the fact that wildlife can suffer adverse behavioral and physiological changes from intrusive sounds (noise) and other human disturbances. Documented responses of wildlife to noise include increased heart rate, startle responses, flight, disruption of behavior, and separation of mothers and young (Selye 1956, Clough 1982, USDA 1992, Anderssen et al. 1993, NPS 1994).

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 the NPS to preserve parks' natural soundscapes and restore degraded soundscapes to natural conditions wherever possible. Additionally, NPS is required to prevent or minimize degradation of the natural soundscapes from noise (i.e., inappropriate/undesirable human-caused sound). Although the management policies currently refer to the term soundscape as the aggregate of all natural sounds that occur in a park, NPS' Natural Sounds and Night Skies Division (NSNSD) aims to update

MIKE BRITTEN

Figure 4.3.1-1. Lark buntings are found within Little Bighorn Battlefield NM and contribute to its natural sounds.

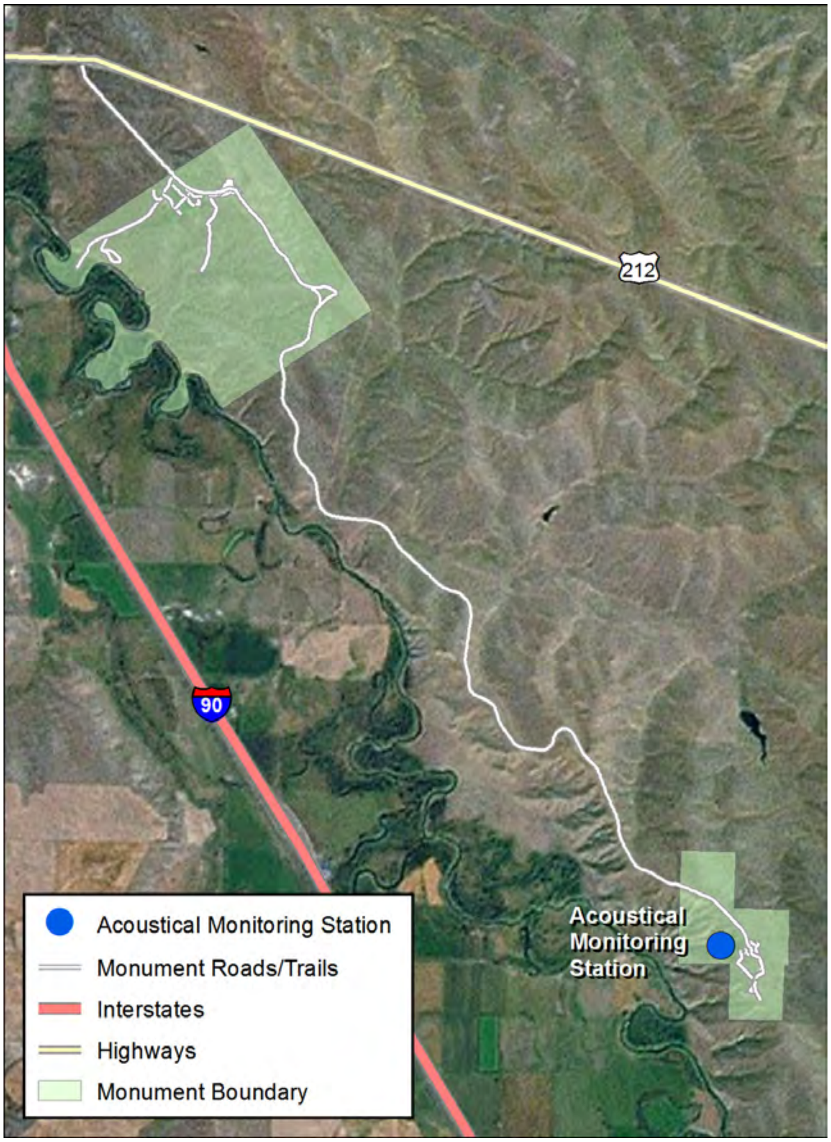

Figure 4.3.2-1. Accoustical monitoring station at Little Bighorn Battlefield NM.

this terminology. Because the NPS works to protect and enhance park resources and visitor experiences, NSNSD differentiates between the physical sound sources and human perceptions of those sounds. Currently, NSNSD refers to the physical sound resources (i.e., wildlife, waterfalls, wind, rain, and cultural or historical sounds), regardless of their audibility, at a particular location, 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.

<u>Sound Characteristics</u>

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, and are most 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.

Indicators/Measures

Sound Sources

Besides the pitch of a sound, we also perceive the amplitude (or loudness) of a sound. This metric is decibels (dB). The decibel scale is logarithmic, meaning 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 increase in a noise source will double the distance at which it can be heard, increasing the affected area by a factor of four. 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

<u>Acoustical Monitoring at the Monument</u>

The Natural Sounds and Night Skies Division collected baseline acoustical data at the Monument beginning in April 2013. One acoustical monitoring system was deployed for 49 days from 4/24/13-6/12/13 at a location within the Reno-Benteen Unit only (Figure 4.3.2-1). A brief report, including a portion of the baseline data collected, was used for this assessment (NSNSD 2013). A full acoustical monitoring report will be submitted to Monument staff at a later date.

The types of sounds heard throughout the Monument were not identified in the NSNSD (2013) briefing report, but will be included in the full report. Instead, we provide a qualitative discussion about the most common sounds heard and their appropriateness relative to locations throughout the Monument based upon management zone designations.

Qualitative Sound Classes

Whether or not a given sound contributes to or detracts from the soundscape condition depends largely on whether or not that sound is appropriate for the context. Little Bighorn Battlefield NM was established because of its historic significance. Its designated purpose is "to preserve and protect the historic and natural resources pertaining to the Battle of the Little Bighorn and to provide visitors with a greater understanding of those events which led up to the Battle, the encounter itself, and the various effects the encounter had on the two cultures involved" (Thomson 2011). As such, sounds that contribute to the education and enjoyment of the site's visitors are considered appropriate.

If this were a wilderness setting, natural verses anthropogenic sounds might be a pertinent distinction for how a sound is perceived. However, the context and setting at the Monument is quite different in that there are elements of the historic and educational context that contribute to its soundscape. Thus, in addition to the natural sounds that contribute to the sense of place of a prairie setting, the anthropogenic sounds that are part of the educational experience also contribute to the sense of place. For example, sounds produced by gatherings of people for an interpretive talk contribute to the understanding and appreciation of the historic context and enjoyment of the Monument. Thus, for the purpose of this indicator, we considered sounds that were consistent with the historic and educational contexts to contribute to the Monument's soundscape condition.

In contrast, some anthropogenic sounds, such as low flying aircraft, vehicles, or excessive human voices (e.g., yelling) may detract from the "sense of place" of the site's historic context and can consequently be perceived negatively and are considered as noise.

For these reasons, we considered sound types as belonging to one of three classes: (1) natural sounds, (2) appropriate anthropogenic sounds, and (3) anthropogenic noise. The first two classes were considered as having a neutral or positive influence on condition; whereas excessive noise was considered to have a negative effect, contributing to a lower condition assessment of this resource. Some common examples of expected sounds at the Monument are listed in Table 4.3.2-1.

Additionally, the locations where the sounds were heard, based upon the Monument's designated management zones, affected the soundscape condition. Each management zone has designated activities and associated common sound types. These factors were taken into consideration throughout this assessment.

Indicators/Measures

Sound Characteristics

Two sound characteristics, loudness and pitch, were evaluated in April 2013 by NSNSD

Table 4.3.2-1. Expected sound types for each sound class at Little Bighorn Battlefield NM.

Natural Sounds	Appropriate Anthropogenic Sounds	Anthropogenic Noises
• Birds • Insects • Wind • Rustling Leaves • Rain/Thunder • Flowing Water	• Interpretive programs • Visitor conversations • Flag flapping	• Trains • Planes • Automobiles/Horns • Mowing • Raised voices/yelling

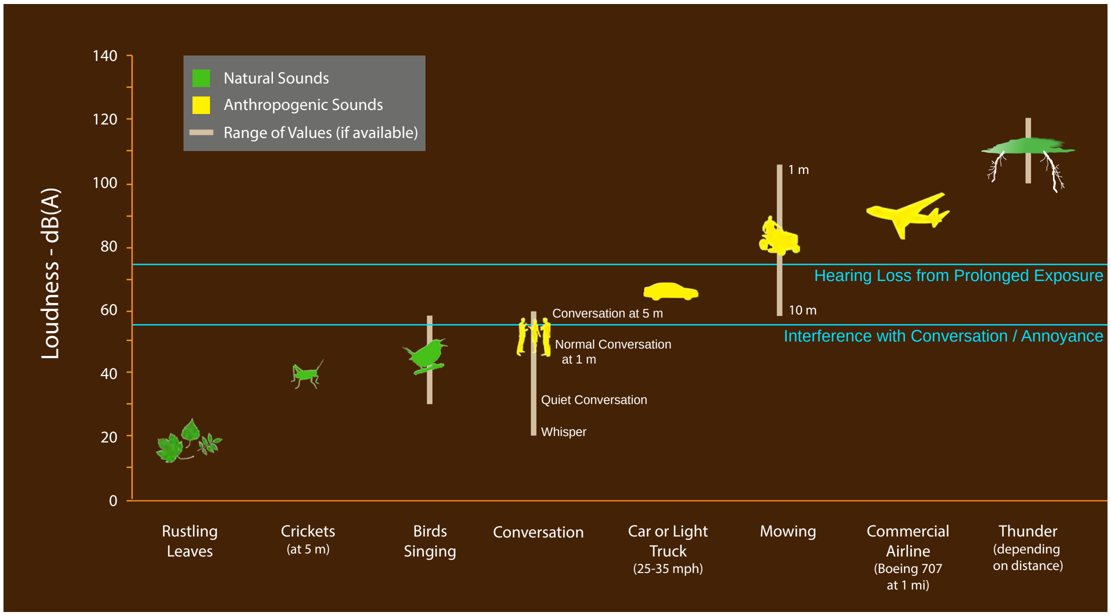

Figure 4.3.2-2. Approximate sound levels for sounds likely to be heard at Little Bighorn Battlefield NM.

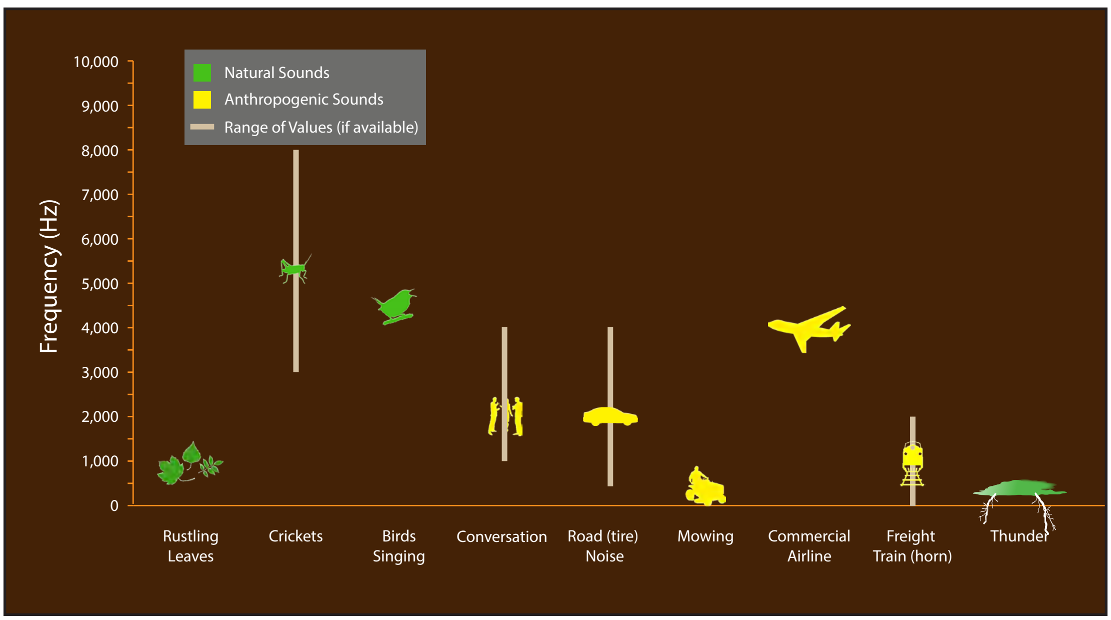

Figure 4.3.2-3. Approximate sound frequencies for sounds likely to be heard at Little Bighorn Battlefield NM.

at one acoustical monitoring location within the Reno-Benteen Unit. Percent time above both frequency and decibel ranges were recorded for 49 days from 0700-1900 (day time hours) and from 1900-0700 (night time hours). Figures 4.3.2-2 and -3 show common sounds and approximate decibel and frequency ranges that could be expected at the Monument for reference purposes.

4.3.3. Reference Conditions

For this assessment, our reference criteria can be roughly divided into 4 categories: (1) effects of noise on human health and well being, (2) effects of noise on wildlife, (3) the effects of noise on the quality of visitor experience, and (4) effect of location.

Effects of Noise on Human Health

There have been numerous studies on the effects of noise on human health and probably the most commonly studied effects are cardiovascular from exposure to noise. The World Health Organization (Berglund et al. 1999) suggest that even prolonged exposure to noise levels below 75dB will not result in noise induced hearing loss. They also conclude that prolonged exposure to air and road traffic noises above 65-70 dB are associated with cardiovascular effects, but this is from exposure times that far exceed what is likely to be encountered during a park visit. The threshold levels for responses such as raising of blood pressure are much lower. However, these human health responses, at the levels of noise exposure at the Monument are not likely to cause any physical damage Thus, for the most part, noise levels exceeding thresholds for damage to human health are not of high concern at the Monument. The most likely exception to this is Monument staff operating machinery (e.g., mowers, tractors, etc.), although damage to human health is not of high concern, this does not imply that there are no physiological responses to noise.

Effects of Noise on Wildlife

Research has indicated that the effects of noise on wildlife populations can vary widely among species and conditions, although birds have probably been most widely studied. Most effects fall into one of three categories: (1) behavioral and/or physiological effects, (2) damage to hearing from acoustic over-exposure, and (3) interference with communication (Dooling and Popper 2007). Since birds are probably more resistant to hearing loss or damage from noise than are humans (Dooling and Popper 2007) the threshold identified for damage to human hearing should be adequate to also account for damage to wildlife hearing. Similarly, the noise levels that interfere with human communication are also similar to the thresholds identified for interference with communication and/or annoyance.

For example, Dooling and Popper (2007) suggest that it is unlikely that a traffic noise level below an overall level of about 50-60 dB(A) would have much of an effect on acoustic communication or the biology of a bird in a quiet suburban area (see also Kaseloo 2006). Because the thresholds for wildlife appear to be similar to the thresholds we identified for visitor experience and because the responses by wildlife are varied and complex, we have assumed for the purposes of this assessment that a degraded condition for visitors would also likely have potential impacts to wildlife.

Effects of Noise on the Quality of Visitor Experience

An essential component of the designated purpose of Little Bighorn Battlefield NM relative to the soundscape is to provide visitors with a greater understanding of the Battle itself and those events that led up to it. A key element of this is maintaining a sense of place of the Battle such that visitors can visualize being back in time experiencing these same events.

From the natural setting of the Monument, with sounds from the wind or birds singing to the interpretive sounds of the day to day activities at the Monument, all are part of the education and enjoyment of visiting the Monument. However, it is difficult to imagine the 1870 Battle while traffic is driving by or when a car horn is honking. Thus, we consider condition of the soundscape relative to a visitor being able to gain a sense of place in the Monument's setting and an enjoyable educational experience at the Monument. Condition is deteriorated when anthropogenic noise interrupts normal conversation, when such noise is frequent enough or loud enough to detract from the sense of place and/or to be annoying to visitors trying to appreciate the historic and natural context of the park.

Effect of Location (Management Zone) on Reference Condition.

Inherent in our condition assessment is how sounds are perceived by visitors and whether or not they contribute or detract from the their education and enjoyment of the site. Whether or not sounds are perceived negatively depends not only on the type of sound but also where it is heard. For example, a visitor is probably going to be less disturbed by noises from vehicles if they are in the parking lot than if they are in the cemetery or along one of the trails. Consequently, we take into consideration where sounds are likely heard within the Monument and the expectations of different sounds based on management zones as defined in its General Management Plan (NPS 1995) when considering the condition of the soundscape.

The Monument identified management zones in its Final General Management Plan (NPS 1995), with an overarching historic zone, which encompasses the entire park

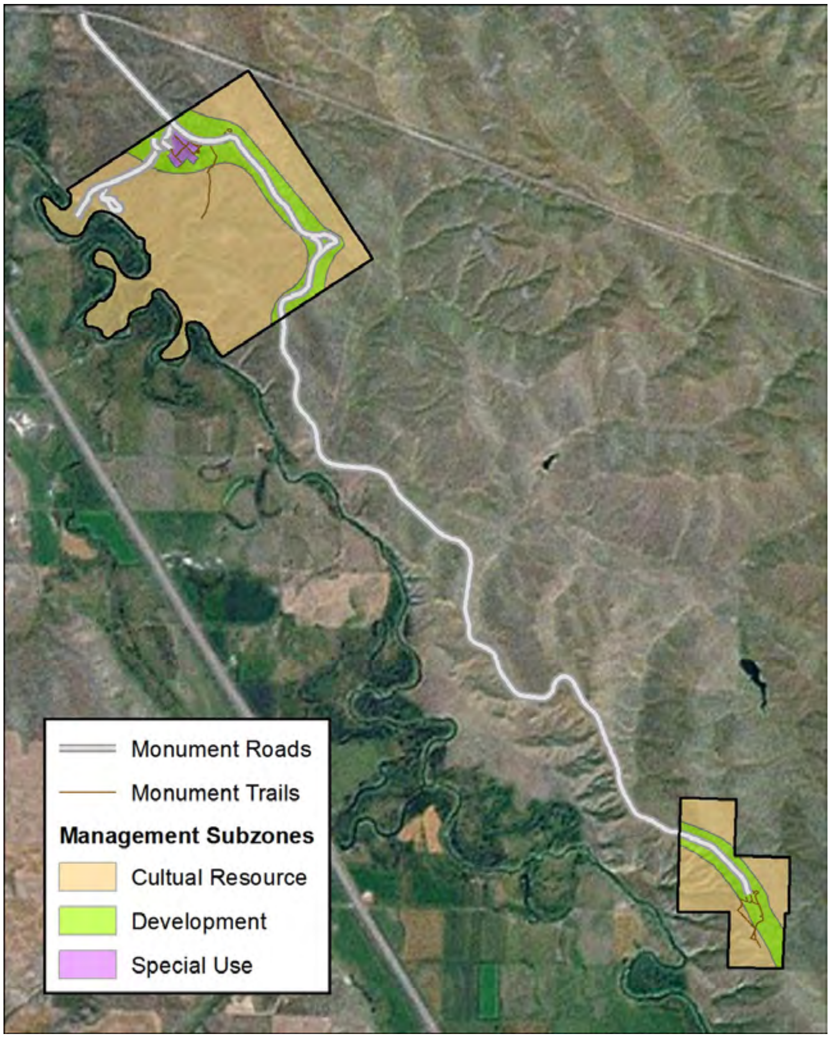

Figure 4.3.3-1. Three management subzones are located within the Monument's authorized boundary (NPS 1995).

where all activities are managed to preserve, protect, and interpret cultural resources and their settings (Figure 4.3.3-1). This main zone contains the following four subzones: natural, cultural, development, and special-use. The Monument's current boundary includes all subzones except natural, which is located within the proposed boundary expansion thus excluded from this assessment.

Cultural Resource Subzone: Contains ~20% of the land within the Monument and preserves the archeological sites and cultural values are emphasized within this zone.

Development Subzone: Contains ~6% of the land within the Monument, and this zone's emphasis is oriented towards facilities necessary to provide for visitor use and park management.

Special-Use Subzone: The National Cemetery is located in this zone and management is oriented towards maintenance of the National Cemetery.

Reference Conditions

The reference conditions for each indicator's measure(s) are described in Table 4.3.3-2. We considered the soundscape in good condition to be one that is consistent with designated activity-related noises within each management zone and where no excessive sound sources are present in any area of the Monument, regardless of zone designation. Additionally, noise-free intervals would be quite common, even including the higher use zones due to seasonality of visitation and/or low visitation and daily visitor use patterns.

A moderate soundscape condition is one where the designated uses for a higher activity zone(s) (e.g. development) begin to infiltrate into a lower use zones (e.g., cultural), noise-free intervals become only moderately common and noises and associated characteristics (i.e., higher pitch and increased decibel levels) begin to be heard throughout all management zones.

A significant concern soundscape condition is when noises become incongruent with Monument designated activities/purpose and/or are disruptive. Noises generated by military overflights, fast moving traffic, etc., infiltrate into all park areas regardless of designated use or purpose.

4.3.4. Condition and Trend

Types of Sounds at the Monument

The most common natural sounds most likely heard within the Monument include weather related sounds (i.e., wind, rain, thunder), wildlife sounds, primarily bird songs or calls, and at rare times complete stillness (i.e. natural quiet). These types of sounds are congruent with the desired visitor experience at the Monument, which is to help visitors connect to the power of place and to provide places for contemplation and reflection (Thomson 2011).

The various noise producing sounds most likely heard within the Monument include

Table 4.3.3-2. Reference condition classes used to assess soundscape condition at Little Bighorn Battlefield NM.

Indicator	Measure	Good	Moderate	Significant Concern
Sound Source	Types Within Management Zones	Dominant sounds are consistent with Monument's designated purpose. Natural ambient sounds such as wind, leaves rustling, birds singing, thunder claps, etc. and sounds related to cultural and visitor activities are expected. Some sources of noise (e.g., automobiles) are acceptable in the development zone provided they are consistent with the expectations for that zone and are audible for a small percentage of the time.	The dominant sounds are generally consistent with Monument's designated purpose, but anthropogenic noise is occurring more frequently and noise from the development zone is beginning to infiltrate into the cultural zone. An historic sense of place is still maintained, but is periodically interrupted by audible noises.	A high percentage of the audible sounds heard are from anthropogenic noise such that the cultural and natural sense of place, therefore, the education and enjoyment of visitors is compromised.
Sound Characteristics	Loudness (amplitude)	Natural and context appropriate sounds are consistent with the expected sound levels of the Monument. Visitors typically maintain quiet to normal conversation levels (e.g., 40-50 dB, and interpreters talking to larger groups rarely exceed 55-60 dB. There is a sightly higher tolerance for noise levels in the development zone, but should rarely exceed 60 dB.	Natural and anthropogenic sounds levels are generally consistent with Monument's designated purpose, but anthropogenic noise > 55 dB) is beginning to be heard in all management zones so as to cause occasional interference with normal conversation and annoyance among some visitors. Anthropogenic noise greater than approximately 65 dB is still quite rare.	The cultural and natural sense of place is compromised due to frequent loud anthropogenic noise. Communication among interpreters and visitors is frequently interrupted by loud noise impacting visitor enjoyment and educational experience. Noise levels that might interfere with wildlife behavior and auditory signals, disrupt conversation or evoke annoyance (e.g., exceeding 55-60 dB) may occur.
	Frequency (pitch)	Sound frequencies are consistent with natural and appropriate human-made sounds. High frequency noises (e.g., high pitched screaming, some automobile horns, etc) rarely occur, and if they do, they mostly occur in the development zone.	High frequency noise is becoming more common in the development zone and is starting to penetrate more of the cultural zone. The sense of place is still maintained but interruption by high pitched noise is becoming more common.	High frequency noise is becoming common in all three zones such that the sense of place is becoming compromised.

traffic noise from vehicles traveling along roads (i.e., Interstate 90, Highway 212, exchange for I-90/Hwy. 212, and Battlefield Tour Road (342), which bisects both units within the Monument), vehicles accessing Monument parking lots, activity from services provided just outside the Monument's boundary, human activities occurring within the Monument (i.e., interpretive programs, conversations, etc.), maintenance operations, agricultural-related noises, and trains traveling along the Burlington Northern Railroad that is located to the west of the Monument, running parallel to I-90 (Figure 4.3.4-1).

According to Thomson (2011), Last Stand Hill is the most popular area to visit in the Monument and "offers a place for contemplation." Last Stand Hill is located adjacent to parking lots where visitors have access to the National Cemetery, visitor center, the Indian Memorial, and the Last Stand Hill Monument. It is also adjacent to the Battlefield Tour Road, which extends 5 miles south to the Reno-Benteen unit. With the Battlefield Tour Road bisecting this area, traffic has the potential to be quite loud at times, especially when tour buses or motorcycles pass. The visitor center parking lot and rest rooms are also located within this subzone and are adjacent to Last Stand Hill.

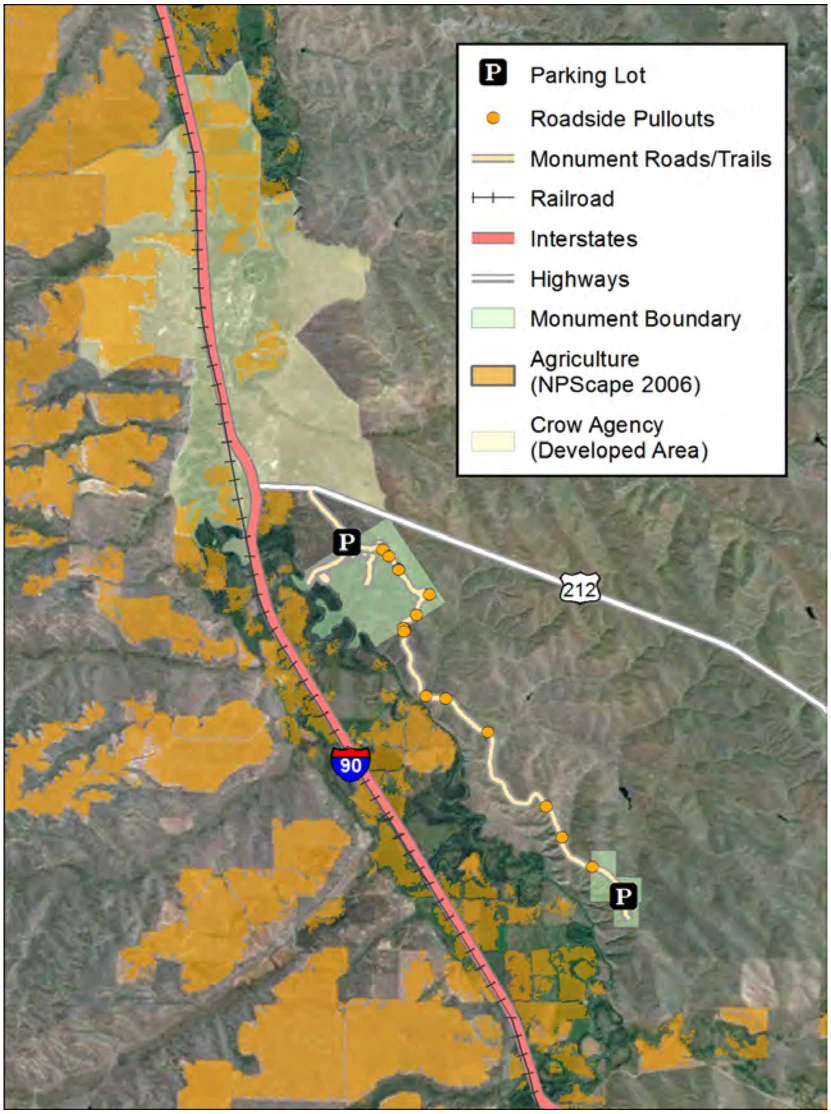

Figure 4.3.4-1. Noise producing sources surrounding the Monument affect the soundscape.

Vehicles starting and idling, in addition to large groups of people arriving in buses add to the noise sources throughout this area.

Even though Last Stand Hill is located within the development subzone, the high visitor activity, especially during the summer season, may conflict with the concept of offering a place for contemplation.

Noises heard within the Reno-Benteen Unit are likely less compared to the Last Stand Hill area, however certain noises, especially from traveling vehicles and airplanes are generally pervasive and travel far distances. No formal ranger programs are held at the Reno-Benteen defense area (Thomson 2011) so high concentrations of people only occur if a bus or several vehicles transporting visitors occur simultaneously at this site. Vehicle noises along the Battlefield Tour Road and in the small parking lot where the road terminates can be heard, but not likely to the same degree as the noises surrounding Last Stand Hill.

Traffic noise from I-90 can be heard but from a distance at Reno-Benteen, whereas traffic noises generated outside the Monument's boundary are more prevalent at Last Stand Hill due to its proximity to Highway 212 (Figure 4.3.4-2). Additional seasonal activities that likely contribute to the anthropogenic noises heard throughout the Monument include agricultural activities (e.g., ranching and farming) that occur to the west of the Monument's boundary.

Noises generated from Monument staff activities, including human voices/conversations and operational activities, such as mowing, are likely kept to a minimum compared to other anthropogenic noise-producing sounds.

<u>Sound Characteristics (Reno-Benteen Unit only)</u>

The results for sound pressure levels during the April-May 2013 monitoring showed that in general, louder noises occurred during the day time hours (7am-7pm) versus at night (7pm-7am). None of the sounds exceeded the speech interference level for a normal conversation (60 dBA) and very few sounds recorded exceeded the speech interference level for interpretive programs (52 dBA). Instead, the majority of sounds were recorded at levels that would not cause interference even in sleeping individuals for both day and night recordings.

Lower frequency sounds were associated with louder sounds. The range of higher frequency sounds were most likely a result of bird vocalizations and were associated with the quieter sounds recorded. Lower frequency sounds have a tendency to travel farther, such as noise from transportation, and may not be as masked during the nighttime hours. Although, this may be irrelevant since the Monument closes to visitors in the

Figure 4.3.4-2. Montana State Highway 212 is in close proximity to the Custer Unit, contributing to anthropogenic noises heard within the Monument.

evening, therefore they do not experience the nighttime soundscape.

Recordings were not taken from within the Custer Unit so sound decibel and frequency measures will not be discussed for that location.

Overall Condition

For assessing the condition of the Monument's soundscape, we used two indicators, which are summarized in Table 4.3.4-1. The condition of the Monument's soundscape is based on both the types of sounds heard that might be detrimental to Monument resources (e.g., wildlife), as well as human perception of the acoustical environment, as it relates to a visitor's experience (i.e., Is a given location conducive to contemplation?). The types of designated activities within Monument include viewing Last Stand Hill and the Indian Memorial area, driving the Battlefield Tour Road that leads to the Reno-Benteen Unit, attending a roving interpretive talk at Last Stand Hill, and hiking the designated trails throughout both units. The remaining area of the Monument is designated as the cultural resource subzone where activities are designed to preserve and protect the resources that make the Monument unique.

While natural sounds have the ability to mask anthropogenic noises and associated characteristics, especially during the windier months, it is likely that the close proximity of developments, including highways, activity within parking lots, and activities just to the north, outside the Monument's boundary ,overall increase the noise levels and negatively impact the condition of the Monument's soundscape (Figure 4.3.4-3).

Excessive noises likely exhibit seasonal and temporal fluctuations that follow daily use patterns and the seasonality of visitation (i.e., busier summer and shoulder seasons of April and September). During high visitation ,noise-free intervals are likely uncommon and associated noise characteristics such as rate of occurrence, longer durations, and decibel levels likely increase. We would consider the Monument's soundscape condition to be more degraded if Last Stand Hill and Reno-Benteen defense areas were not located within the development subzone. Typically though, development zones allow for increased and concentrated activities that are accompanied by anthropogenic noises. Since these areas are designated as such, we consider the Monument's soundscape to be of moderate condition. We do not have

Table 4.3.4-1. Summary of the soundscape indicators/measures and their contributions to the overall soundscape condition assessment.

Indicator/Measure	Description of How the Indicator(s) Contributes to the Overall Resource Condition	General Contribution of this Indicator or Measure to the Overall Resource Condition.
Sound Sources	The types of sounds impact a park's soundscape, but obviously not all sounds are equal. Natural and cultural sounds are usually preferred by park visitors but some anthropogenic noises are expected based upon the area of the park in which they occur.	The loudest noises that likely occur in the Monument are from traffic and human conversations. The Monument is separated into two units: Custer and Reno-Benteen, with Last Stand Hill located in the Custer Unit adjacent to a concentrated area of noise-producing activities, which is inconsistent with providing a place for contemplation, therefore we consider this indicator to be in moderate condition.
Sound Characteristics (Reno-Benteen Unit only)	Noise is comprised of several characteristics including loudness and pitch, which contribute to the way a sound is perceived.	Sound levels and frequencies were recorded in 2013 at a location within the Reno-Benteen Unit. The majority of levels and frequencies appeared to be consistent with a quieter location, however, we expect that given the close proximity of developments adjacent to the popular visitor sites, within the Custer Unit, the decibel levels will likely be louder and the frequencies will most likely be higher pitched.

Figure 4.3.4-3. Activities surrounding Last Stand Hill contribute to increased noise levels.

acoustical monitoring data to support a trend assessment at this time.

Level of Confidence and Key Uncertainties

This soundscape assessment uses the "snapshot" results provided by NSNSD for Reno-Benteen Unit only. Sound sources will be identified once the full acoustical monitoring report is submitted, but for the purposes of this assessment, we qualitatively described the most likely sound sources heard throughout the Monument. Thus, we have assigned a low confidence level for the results. Additionally, the soundscape is not mutually exclusive from visual impacts associated with anthropogenic activity. Activities that impact one resource most likely impact another resource, and in this instance, the concentrated activity surrounding Last Stand Hill degrades both the Monument's soundscape and viewshed.

4.3.5. Sources of Expertise

The NPS Natural Sounds and Night Skies Division scientists provided a brief report of the 2013 acoustical monitoring efforts and help parks manage sounds in a way that balances the various expectations of park visitors with the protection of park resources. They provide technical assistance to parks in the form of acoustical monitoring, data collection and analysis, and in developing acoustical baselines for planning and reporting purposes.

The NSNSD also provided a NRCA soundscape template, which we largely used to develop Little Bighorn Battlefield NM's soundscape assessment. For more information, see http://www.nature.nps.gov/sound/.

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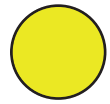
4.4. Air Quality

Indicators/Measures

- Visibility haze index
- Level of ozone
- Atmospheric wet deposition in total N and total S

Condition – Trend – Confidence Level



Moderate Concern - Refer to Text - Medium

4.4.1. Background and Importance

Under the direction of the 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), the NPS has a responsibility to protect air quality and any air quality related values (e.g., scenic, biological, cultural, and recreational resources) 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 major national parks and wilderness areas (NPS-ARD 2012a).

Different categories of air quality areas have been established through the authority of the CAA: Class I, II, and III. Like most National Park Service areas, Little Bighorn Battlefield National Monument is designated as a Class II airshed (Figure 4.4.1-1).

These 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 2012b).

It's 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 level of protection afforded to any unit of the National Park System (NPS 2006).

NINA CHAMBERS

Figure 4.4.1-1. Little Bighorn Battlefield National Monument is a Class II airshed.

Figure 4.4.1-2. A clear day at Little Bighorn Battlefield National Monument.

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 Environmental Protection Agency (EPA) 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 (EPA 2012a). 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 visibility, damage to animals, crops, vegetation, and buildings (EPA 2012a).

The NPS Air Resources Division (NPS-ARD) air quality monitoring program uses EPA'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. Both particulate matter (e.g., soot and dust) and certain gases and particles in the atmosphere, such as sulfate and nitrate particles, can create haze and reduce visibility.

Visibility can be subjective and value-based (e.g., a visitor's reaction viewing a scenic vista while observing a variety of forms, textures, colors, and brightness) (Figure 4.4.1-2) or it can be measured objectively by determining the size and composition of particles in the atmosphere that interfere with a person's ability to see landscape features (Malm 1999). The viewshed section (4.1) of this assessment addresses the subjective aspects of visibility, whereas, this section addresses measurements of particles and gases in the atmosphere affecting visibility.

Ozone is a gaseous constituent of the atmosphere produced by reactions of nitrogen oxides (NO_x) from vehicles, power plants, industry, and fire and volatile organic compounds from industry, solvents, and vegetation in the presence of sunlight (Porter and 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, and it is also phytotoxic, causing foliar damage to plants (NPS-ARD 2003). The foliar damage requires the interplay of several factors, including the interaction of the plant to the ozone, the level of ozone exposure, and the exposure environment. The highest ozone risk exists when the species of plants are 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 (Kohut 2007).

Ozone penetrates leaves through stomata (openings) and oxidizes plant tissue, which alters the physiological and biochemical processes (NPS-ARD 2012c). Once the ozone is inside the plant's cellular system, the chemical reactions can cause cell injury or even death (NPS-ARD 2012c), but more often reduces the plant's resistance to insects and diseases, reduces growth, and reduces reproductive capability (NPS-ARD 2012d).

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, and accumulation of toxins (NPS-ARD 2010a). Atmospheric deposition can also change soil pH, which in turn, affects microorganisms, understory plants, and trees (NPS-ARD 2010a). 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 2010b). Increases in N have been found to promote invasions of fast-growing annual grasses (e.g., cheatgrass) and exotic species (e.g., Russian thistle) at the expense of native species (Brooks 2003, 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. N may also increase water use in plants like big sagebrush (Inouye 2006).

According to the EPA, in the United States, roughly two thirds of all SO_2 and one quarter of all 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 in remote areas, including Little Bighorn Battlefield National Monument (EPA 2012b).

4.4.2. Data and Methods

The approach we used for assessing the condition of air quality within the monument's airshed was developed by the NPS-ARD for use in Natural Resource Condition Assessments (NPS-ARD 2010b, 2010c). Interpolated values generated by NPS-ARD, averaged over five years were used to assess condition. NPS-ARD used all available data from NPS, EPA, state, tribal, and local monitors to generate the interpolated values across the contiguous U.S., with a specific value assigned to the center of each park. These values provided estimates for visibility, ozone, and atmospheric wet deposition in the absence of onsite monitoring. Even though the data are derived from all available monitors, the data from the closest monitor will "outweigh" the rest.

Indicators/Measures

Visibility Haze Index

Visibility is monitored by the Interagency Monitoring of Protected Visual Environments (IMPROVE) Program (NPS-ARD 2010a). The NPS-ARD assesses visibility based on the deviation of the current Group 50 visibility conditions from estimated Group 50 natural visibility conditions; (i.e., those estimated for a given area in the absence of human-caused visibility impairment, EPA-454/B003-005). Group 50 is defined as the mean of the visibility observations falling within the range of the 40th through the 60th percentiles, as expressed in terms of a Haze Index in deciviews (dv). A factor of the haze index is light extinction, which is used as an indicator to assess the quality of scenic vista and is proportional to the amount of light lost due to scattering or absorption by particles in the air as light travels a distance of one million meters (NPS-ARD 2003). The haze index for visibility condition is calculated as follows:

Visibility Condition/Haze Index (dv) =
current Group 50 visibility – estimated
Group 50 visibility
(under natural conditions)

The deciview scale scores pristine conditions as a zero and increases as visibility decreases (NPS-ARD 2010b).

Indicators/Measures

Level of Ozone

Ozone is monitored as part of the NPS Gaseous Pollutant Monitoring Program, in partnership with the EPA's CASTNet Program (Porter and Biel 2011). The assessment for ozone levels at the monument was made by referencing NPS ARD's five-year interpolated value average tables.

Indicators/Measures

Atmospheric wet deposition in total N and total S

Atmospheric deposition can be monitored in both wet and dry forms, but for the purposes of this assessment, we will use wet deposition monitoring data only because most areas of the country do not have dry deposition data available, including the monument.

Atmospheric wet deposition is monitored across the United States as part of the National Atmospheric Deposition Program/ National Trends Network (NADP/NTN; NPS-ARD 2003). The values for wet deposition condition are expressed as the average amount of nitrogen (N) or sulfur (S) in kilograms deposited over a one-hectare area in one year (kg/ha/yr) (NPS-ARD 2003).

Wet deposition data have been collected on-site at the monument since 1984 following the protocols set forth by the NADP/NTN. The protocol changed in 1994, however, the change did not affect NH_4 and only slightly affected NO_3 and SO_4, (NADP 2012a) so data pre- and post-1994 can be compared (NPS-ARD 2010a). The monument's wet deposition monitoring station is equipped with a standardized precipitation collector and rain

SOURCE: HTTP://NADP.SWS.UIUC.EDU/SITES/SITEINFO.ASP?NET+NTN&ID=MT00

Figure 4.4.2-1. Wet deposition monitoring station for Little Bighorn Battlefield NM.

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

Air Quality Indicator	Significant Concern	Moderate	Good
Visibility	>8 dv	2-8 dv	< 2 dv
Ozone	≥ 76 ppb	61-75 ppb	≤ 60 ppb
Wet deposition (total N and total S)	>3 kg/ha/yr	1-3 kg/ha/yr	< 1 kg/ha/yr

Source: NPS-ARD 2010b

gauge (Figure 4.4.2-1). Weekly samples are collected and processed following a standard operating procedure established by Dossett and Bowersox (1999). The samples are sent to the Central Analytical Laboratory (CAL), Illinois State Water Survey for processing and data from the field observer report forms are entered into a relational database. The results of the analyses are then loaded into NADP's database, merged with descriptive information and posted at http://nadp.sws.uiuc.edu/sites/siteinfo.asp?id=NM12&net=NTN (NADP 2012b).

4.4.3. Reference Conditions

The reference conditions against which current air quality indicators are assessed are identified by NPS ARD (2010b) for NRCAs and listed in Table 4.4.3-1.

Visibility

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 "moderate" condition, and estimates greater than 8 dv above natural conditions indicate "significant concern." Although the dv ranges of these categories were selected somewhat subjectively, the NPS-ARD chose them to reflect the variation in visibility conditions across the monitoring network as closely as possible.

Ozone

The ozone standard set by the EPA at a level to protect human health, 75 parts per billion (ppb) averaged over an eight-hour period, is used as a benchmark for rating current ozone condition. The three-year average of the fourth-highest daily maximum eight-hour average ozone concentrations measured at each monitor in an area must not exceed 75 ppb in order to be in compliance with the EPA standard.

The NPS-ARD rates ozone condition as "good" if the ozone concentration is less than or equal to 60 ppb, "moderate" if the ozone concentration is between 61 and 75 ppb, and of "significant concern" if the concentration is greater than or equal to 76 ppb.

Wet Deposition

The NPS-ARD considers parks with less than 1 kg/ha/yr of atmospheric wet deposition of nitrogen or sulfur compounds to be in "good" condition, those with 1-3 kg/ha/yr to be in "moderate" condition, and parks with wet deposition greater than 3 kg/ha/yr to be of "significant concern."

4.4.4. Condition and Trend

Condition for all air quality indicators are listed in Table 4.4.4-1.

Visibility

All visibility data were derived from NPS ARD Air Atlas interpolated five-year average values (2001-2005, 2005-2009) (NPS-ARD 2012e). The five-year interpolated values average for the monument's visibility condition fell within the moderate condition rating, which indicates visibility is degraded from the good

Table 4.4.4-1. Condition results for air quality indicators at Little Bighorn Battlefield National Monument.

Data Span	Ozone	Visibility	Total N (kg/ha)	Total S (kg/ha)
2001-2005	Moderate	Moderate	Moderate	Good
2005-2009	Moderate	Moderate	Moderate	Good

Table 4.4.4-2. Ozone-sensitive plants found at Little Bighorn Battlefield National Monument (NPS-ARD 2006).

Scientific Name	Common Name	Bioindicator
Apocynum androsaemifolium	Spreading dogbane	Yes
Artemisia ludoviciana	White sagebrush	Yes
Asclepias syriaca	Common milkweed	Yes
Fraxinus pennsylvanica	Green ash	No
Prunus virginiana	Choke cherry	No
Rhus trilobata	Skunkbush	Yes

reference condition of <2 dv above the natural condition. No visibility trend was reported specifically for Little Bighorn Battlefield, but in considering the overall trend of visibility throughout national parks, NPS-ARD analyzed visibility data for 157 parks during the period of 1999-2008. Only five of the parks showed a significant degrading trend on either clear or hazy days, with none of those parks located west of the Mississippi River, except for Hawaii (NPS-ARD 2010a). The majority of the parks measured during the haziest days revealed no visibility trend (NPS-ARD 2010a).

Ozone

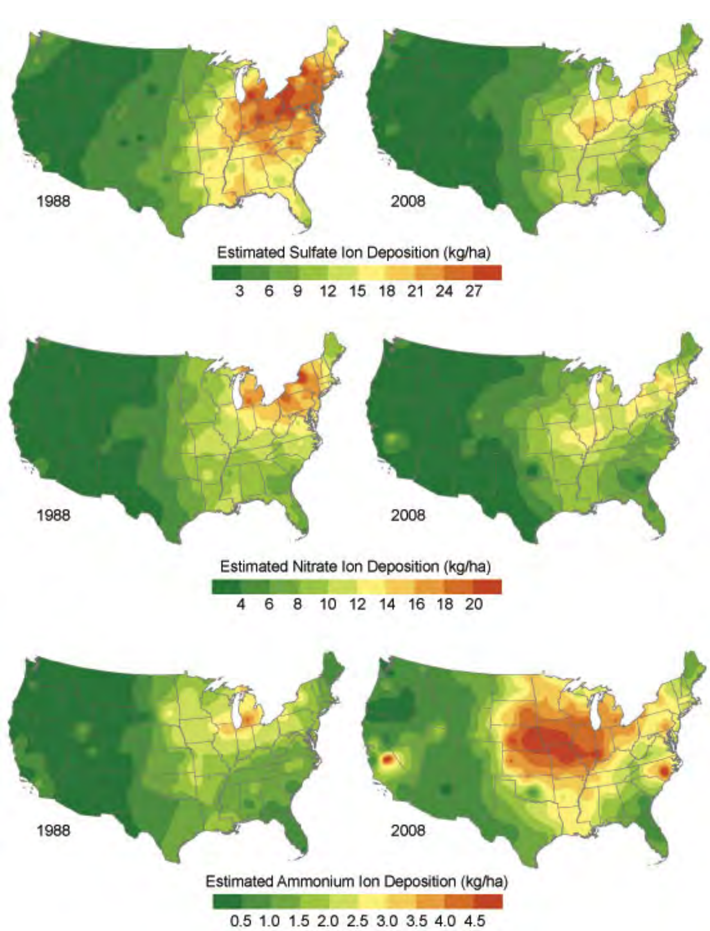
All ozone data for the monument were derived from the five-year interpolated values average (NPS-ARD 2012f), which resulted in a moderate ozone condition ranking for Little Bighorn Battlefield NM.

Six plant species found within the monument have been identified as ozone-sensitive (NPS-ARD 2006) and four of those are ozone bioindicators (Table 4.4.4-2). "Sensitive" means that they typically exhibit foliar injury at or near ambient ozone concentrations or are species for which ozone foliar injury symptoms have been documented in the field by more than one expert observer. In order to be considered as an ozone bioindicator most of the following criteria must be met.

- species exhibit foliar symptoms in the field at ambient ozone concentrations that can be easily recognized as ozone injury by subject matter experts
- species ozone sensitivity has been confirmed at realistic ozone concentrations in exposure chambers
- species are widely distributed regionally
- species are easily identified in the field (NPS-ARD 2012g).

An example of Spreading dogbane foliar damage from ozone is shown in Figure 4.4.4-1. Plants in the monument have not been assessed for ozone injury, but a risk assessment concluded that the risk of plant injury from ozone was low at the monument based on the fact that exposure levels were relatively low (Kohut 2007).

Figure 4.4.4-1. Healthy leaves of Spreading dogbane, left; and leaves exhibiting ozone injury, right.



SOURCE: HTTP://WWW.NATURE.NPS.GOV/AIR/MONITORING/WETMON.CFM

Figure 4.4.4-2. Change in wet deposition levels From 1988-2008 throughout the United States

Wet Deposition

The data for atmospheric wet deposition condition were derived from NPS-ARD's 2001-2009 interpolated values (NPS-ARD 2012h), which incorporated the monument's onsite NADP wet deposition monitoring results. The average value for total nitrogen resulted in a moderate condition rating and the condition rating was good for total sulfur.

Sullivan et al. (2011 a,b), studied the risk from acidification (from nitrogen and sulfur) or nutrient nitrogen effects (from nitrogen) for the monument. They took a slightly different approach with their assessment by considering three factors that influence nutrient enrichment and acidification from atmospheric deposition: pollutant exposure, ecosystem sensitivity, and park protection mandates. Pollutant exposure included the type of deposition (i.e., wet, dry, cloud, or fog), the oxidized and reduced forms of the chemical, if applicable, and the total quantity deposited. The ecosystem sensitivity determined the type of terrestrial and aquatic ecosystems present at the monument and their inherent sensitivity to the atmospherically deposited chemicals. And finally, the park protection mandates and NPS Organic Act considered whether the park had a special air protection designation due to being a wilderness area or a Class I airshed. Based upon these three factors, an overall risk summary rating for each national park was assigned.

The monument was considered to be at a low risk for acidic deposition (Sullivan et al. 2011a) and at a low risk for atmospheric nutrient enrichment from nitrogen (Sullivan et al. 2011b). Because these are relative, not absolute, rankings of risk, the condition estimates should also be considered when evaluating overall risk to resources at the monument from atmospheric deposition.

In general, nitrate, sulfate, and ammonium deposition levels have changed over the past 20 years throughout the United States (Figure 4.4.4-2). Regulatory programs that mandated 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, although a rise in ammonium ion deposition has occurred in large part due to the agricultural and livestock industries (NPS-ARD 2012i). A study conducted by Lehmann and Gay (2011), indicated a potential increase in nitrate precipitation concentrations from 1985-2009 in areas extending from northern Montana to southern Texas. The observed increase in nitrate at the monument was not statistically significant, but increases in the region are cause for concern. On the other hand, sulfate concentrations have declined between 1985-2009 (Lehmann and Gay 2011).

Table 4.4.4-3. Summary of the air quality indicators and their contributions to the overall air quality Natural Resource Condition Assessment.

Indicator	Description of How the Indicator(s) Contributes to the Overall Resource Condition	General Contribution of this Indicator to the Overall Resource Condition
Visibility haze index	Visibility affects how well and how far one can see and is negatively affected by air pollution. Particulate matter, gases, and particulates can create haze, thereby reducing visibility. NPS visitor studies have shown the importance visitors place on their ability to view the scenic vistas within and throughout national parks.	A five-year average of interpolated visibility values were derived to determine that the condition of visibility is of moderate concern at the Monument.
Level of ozone	Ozone is an atmospheric gas that is produced by reactions of nitrogen oxides and is one of the most widespread air pollutants. Ozone can be harmful to human health as well as to vegetation by causing foliar damage, which sometimes leads to the death of the affected plant.	A five-year average of interpolated ozone values were derived to determine that the condition of ozone is of moderate concern at the Monument. In addition, six plants have been identified as ozone sensitive, four of which are bioindicators.
Atmospheric wet deposition, total N and total S	Air pollutants can be deposited to ecosystems through rain and snow, which is referred to as wet atmospheric deposition. Nitrogen (N) and sulfur (S) air pollutants are commonly deposited into ecosystems and sometimes result in acidification, fertilization, eutrophication, or accumulation of toxins.	A five-year average of interpolated atmospheric wet deposition values were derived to determine that the condition of total nitrogen is of moderate concern and the condition of total sulfur is of good condition at the Monument.

It seems reasonable to expect a continued improvement in sulfate deposition levels because of Clean Air Act requirements, however, at this time, ammonium levels are not regulated by the EPA and may continue to rise as a result (NPS-ARD 2010a)

Overall Condition and Trend

For assessing the condition of air quality, we used three air quality indicators/measures. Our indicators for this resource were intended to capture different aspects of air quality, and a summary of how they contributed to the overall air quality condition is in Table 4.4.4-3.

We consider the overall condition of air quality at Little Bighorn Battlefield NM to be of a moderate concern and because there are numerous monitors for all three indicators, the interpolations for condition are likely very representative.

Trends for air quality indicators can only be derived if a monitor considered representative of the park is located near enough or onsite monitoring occurs. A monitor is considered representative if it is located within 10 miles for ozone and within 100 km for visibility. The only trend data available for the monument are for atmospheric wet deposition.

It is important to note that air quality trends and conditions are derived differently, with the concentration of pollutant in precipitation used for trend, and the total deposition measured reaching the ground for condition (Figure 4.4.4-3).

Atmospheric wet deposition condition is based on total nitrogen and total sulfur deposited on ecosystems and measured in kg/ha to reflect the total deposition that the ecosystem is receiving. The condition values are based on a five-year average of interpolated values. Whereas, air quality trends can only be determined for parks where on-site monitoring occurs or monitors are located within the required distances. The metrics for trend data are measured in the concentrations of nitrate, ammonium, and sulfate in mg/L as opposed to deposition in

Table 4.4.4-4. Atmospheric wet deposition trend results from concentrations of pollutants in rain and snow.

1999-2008* (10-year)	Improving Trend	No Trend	No Trend**

*NPS ARD 2010a

**Indicated possible improvement but not statistically valid

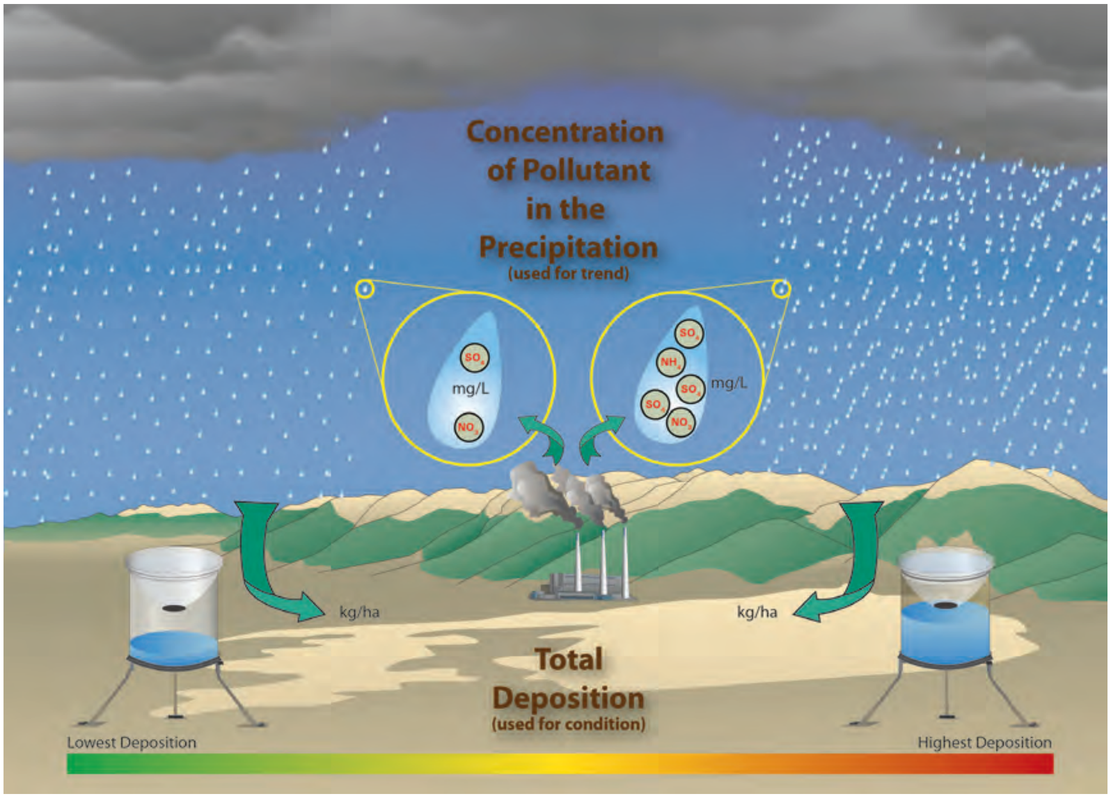


Figure 4.4.4-3. Atmospheric wet deposition condition and trends are assessed differently.

kg/ha, to remove variability caused by very high or very low precipitation years.

Of the air quality trends reported by NPS-ARD from 1999-2008 for the monument's atmospheric wet deposition, there were varied trends between all three ions (NPS-ARD 2010a). For NPS-ARD's longer-term trend period (1990-2008), no trend was reported for NO_3, an improving trend for SO_4 and a degrading trend for NH_4 that reflect trends in atmospheric concentrations of NO_x, SO_2, and NH_3 (E. Porter, NPS Air Resources Division, pers. comm.). The trend results for NH_4, NO_3, SO_4 are summarized in Table 4.4.4-4. The shorter-term trend spanning 1999-2008 indicates no trend for NH_4 and SO_4 and an improving trend for $NO_{3.}$

<u>Level of Confidence/Key Uncertainties</u>

The key uncertainty of the air quality condition assessment is knowing the effect(s) of air pollution, especially nitrogen deposition, on ecosystems at Little Bighorn Battlefield National Monument.

4.4.5. Sources of Expertise

The National Park Service's 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; provide air quality analysis and expertise related to all air quality topics.

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4.5. Geology

Indicators/Measures

- No indicators or measures were identified

Condition - Trend - Confidence Level

Insufficient Data - Insufficient Data - Low

This section is extracted from the Little Bighorn Battlefield National Monument Geologic Resources Inventory report (KellerLynn 2011). For more information, go to http://www.nature.nps.gov/geology/inventory

4.5.1. Background and Importance

The bedrock that underlies Little Bighorn Battlefield National Monument (NM) is from the Upper Cretaceous Period (about 100 million to 65.5 million years ago) and represents sediments (mud and sand) originally deposited in a seaway that inundated west-central North America. Surficial units consist of alluvium (gravel, sand, silt, and clay) that streams deposited during the Quaternary Period (the past 2.6 million years). These rocks and unconsolidated deposits give rise to the landforms that influenced the actions taken during the Battle of the Little Bighorn (KellerLynn 2011).

Geology, and associated soils, are the basis for vegetation communities, the hydrology, and the basic landforms and topography for an area, that then support the biotic communities. Soils, hydrology, and landform also influence human settlement patterns, and how people use the land—for farming, ranching, hunting, fishing, and other basic land uses. The geologic landforms also played a key role in the Battle of the Little Bighorn.

4.5.2. Data and Methods

This limited assessment summarizes the findings from a geologic resources inventory (KellerLynn 2011) conducted by the National Park Service Geologic Resources Division. The inventory included scoping meetings with park staff and geologic experts to identify geologic issues, features, and processes. A digital geologic map was also produced, and the report helps provide interpretation of the features on the map. For more information about the geologic resources inventory, visit http://www.nature.nps.gov/geology/inventory.

4.5.3. Reference Conditions

No reference condition has been defined.

4.5.4. Condition and Trend

Specific indicators and measures related to soil erosion are presented in section 4.9 on grasslands. Based on the level of assessment that has been done to date, no specific areas of geologic concern have been identified.

The following discussion on geologic issues and geologic processes are excerpts summarized from the geologic inventory (KellerLynn 2011).

<u>Geologic Issues</u>

Flooding

The Little Bighorn River forms the southwestern boundary of the Custer Battlefield unit of Little Bighorn Battlefield NM. Overbank flows (flooding) represent an important floodplain function for low-gradient rivers such as the Little Bighorn River. During periods of overbank flow, significant detention storage of floodwaters can occur, moisture levels of floodplain soils and underlying aquifers are recharged, and fine sediments are deposited on floodplain surfaces. Flooding may occur due to high rainfall, high rainfall in combination with snowmelt runoff, and as a result of ice jams during spring runoff. Erosion from a heavy-precipitation event in May 2011 (that likely exceeded the 500-year floodplain) significantly damaged the Deep Ravine Trail within the Monument (Figure 4.5.4-1). The main concern regarding flooding is the potential loss of artifacts on the floodplain and riverbanks of the Little Bighorn River,

Figure 4.5.4-1. The flood of May 2011 created serious erosion.

and may require some type of stabilization to preserve potential collection sites.

Channel migration may occur due to flooding or human disturbance. Based on interpretation of aerial photographs taken in 1939, most sections of the Little Bighorn River had a sinuous, single-thread channel, with well-vegetated riverbanks and floodplains (Figure 4.5.4-2). By the early 1960s, more than one-half (approximately 53%) of the 193 km (120 mi) of the main stem of the Little Bighorn River had been modified via channel relocation, riprap, channel clearing, and diking.

In the immediate vicinity of Little Bighorn Battlefield NM, a large portion of the meander belt has been prevented from continued fluvial processes by the construction of I-90 and the Burlington Northern Railroad grade. In addition, on the west side of the valley, the river has been diverted from its natural channel to an artificial channel along the east side of the valley, about 3.2 km (2 mi) above its confluence with the Bighorn River at Hardin.

The primary causes of substantive changes in the Little Bighorn River channel are (1) the widespread removal of streamside vegetation for agricultural and grazing purposes, (2) continued grazing of existing and reestablishing streamside vegetation, and (3) disturbance of the riverbanks and beds by bulldozer activity (in an attempt to increase channel stability by constructing berms, which actually increased the potential for long-term bank erosion, sediment transport, and channel instability).

The primary meander belt of this segment of the Little Bighorn River has occupied the river-right side of the valley since the time of the Battle of the Little Bighorn. The river continues to rework the older deposits in the

Figure 4.5.4-2. The steep banks of the Little Bighorn River.

river valley, abandoning established meanders and forming new ones. Evidence of this ongoing process is readily apparent in satellite imagery, aerial photos, and published maps, where numerous meanders and oxbows are visible.

Although channel migration is predominantly a natural phenomenon, this ongoing process has raised concern for the preservation of cultural resources within the Monument. On the length of the river that runs along the boundary of the Custer Battlefield unit, there is a well-developed meander that is very close to being abandoned through channel migration. This meander is the most upstream (farthest south) position of the three distinctive meander loops currently along the National Monument's boundary. The alluvial deposit through which this meander is cutting likely contains cultural artifacts that would be lost as a result of channel migration and oxbow formation.

Erosion

The primary agent of erosion across the Little Bighorn landscape is sheet flow. Sheet flow—the movement of water across a sloping surface—causes sheet erosion, which is also referred to as "sheetwash," "slope wash," or "surface wash." Sheet flow is the even removal of thin layers of surface material from an extensive area of gently sloping land. Broad continuous sheets of running water, rather than streams flowing in well-defined channels, are the agents of erosion. However, sheet flow can grade into channelized flow as the water movement becomes progressively more concentrated into particular down-slope routes, such as coulees. For this reason, the distinction between "sheet flow" and "channelized flow" is sometimes indefinite.

Hydraulic piping causes the formation of narrow conduits, tunnels, or "pipes" through which soluble or granular soil material is removed. These two processes—sheet flow and piping—can dramatically degrade upland soils. Once soil piping begins, it is very difficult to alleviate. Consequently, during a geomorphic evaluation of channel migration at Little Bighorn Battlefield NM, investigators recommended "careful management of the uplands," especially those areas adjacent to the river valley. A soil resources inventory and database for the park was completed by the National Park Service (2006), and the grasslands section (4.9) includes a discussion on soils.

Energy Development

Montana is rich in fossil fuels, and coal-fired power plants dominate Montana's electricity market. There are five plants currently operating in Montana, all of which are relatively near Little Bighorn Battlefield NM. The primary concern with energy development for the Monument is the protection of resources (soils, vegetation, and water). Emissions from coal-fired power plants are principally an issue for air quality.

However, the use of coal for energy is also a geologic issue with respect to sources of coal and locations of mines. The primary source of the coal used in Montana's coal-fired power plants is the Paleocene (65.5 million to 55.8 million years ago) Fort Union Formation of the Powder River Basin. This formation crops out approximately 24 km (15 mi) east of Little Bighorn Battlefield NM.

Land Use and Development

The primary concern for development within and adjacent to Little Bighorn Battlefield NM is that contemporary structures and roadways threaten the Battlefield's historic character and viewshed (see section 4.1). In addition, land-use changes and development can disrupt geologic features and processes. Construction and associated ground-disturbing activities can result in increased erosion, runoff, and sedimentation into fluvial systems; exacerbated eolian processes (e.g., dust storms); soil compaction; and the formation of ruts. Resistance to compaction in the soils at Little Bighorn Battlefield is low (i.e., the soils have one or more features that favor the formation of a compacted layer), and the susceptibility to rut formation is severe (i.e., ruts form readily). Soil compaction reduces vegetation and increases runoff, potentially changing species characterization. Soil ruts restrict the movement of water, robbing the surrounding areas of moisture they would otherwise receive. Additionally, construction

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Figure 4.5.4-3. Road construction near Weir Point created a significant slope cut.

in floodplains (e.g., buildings and bridges) can impact fluvial processes. Also, improved road access can increase the threat to (and loss of) resources such as fossils as a result of erosion and theft.

Notable development within Little Bighorn Battlefield NM includes road construction, which created a major cut slope near Weir Point in 1938–1940, and leveling a portion of Reno Hill for a parking lot. The Monument's cultural landscapes inventory reports a rather heavy-handed approach to road building was seen frequently during an era not yet enlightened to sensitive treatment of historic landscapes. Development at this time degraded several primary landforms/landscape features, including the original contours of Last Stand Hill, the demolition of several smaller hillocks along Battle Ridge, the re-alignment of Medicine Tail Ford from its 1876 channel, a major road cut at Weir Point, and the flattening of significant landforms near the Reno-Benteen Memorial (Figure 4.5.4-3).

Geologic Features and Processes

Landforms

The topography of Little Bighorn Battlefield NM is dominated by ridges that rise above the floodplain of the Little Bighorn River. Ravines and coulees dissect these ridges (Figure 4.5.4-4). During the Battle of the Little Bighorn, the ridges provided views across the broad valley and, also, provided defensible high ground for soldiers of the 7th Cavalry. Ravines and coulees, which cut into the ridges, allowed for the secluded advance of Indian attackers. The incised ravines and coulees also provided access routes to the higher ground for the retreating soldiers under Reno's command.

Stream terraces are one of the most conspicuous geologic features in the Little Bighorn River valley. These terraces represent past floodplain surfaces, which formed as a result of downcutting of the river in response to a drop in base level. The ages of the terraces are evidence that the river has flowed in this general location for more than a million years, situating itself long before the battle in 1876, and remaining there since. The lowest (youngest) terrace deposit is about 20,000 years old, and the highest (oldest) is about

Figure 4.5.4-4. Ravines and terraces are conspicuous landform features at Little Bighorn Battlefield NM.

1.4 million years old. Unlike the ridges and coulees, terraces did not figure significantly into the actions taken during the Battle of the Little Bighorn. However, the warriors and their families from the various tribes selected these broad, flat surfaces as the location for their camps.

Paleontological Resources

The Bearpaw Formation and Judith River Formation, which underlie Little Bighorn Battlefield NM, both host fossils. The Bearpaw Formation contains marine fauna such as bivalves, gastropods, scaphopods, and ammonites, as well as fossil lobster, crabs, and cephalopods. Four dinosaur specimens from the Bearpaw Formation were found in south-central Montana; these specimens represent the first dinosaur material to be reported from the Bearpaw Formation.

To date, the most notable fossil discovery at Little Bighorn Battlefield NM comes from the Bearpaw Formation. In 1977, an NPS employee found a short-necked plesiosaur (*Dolichorhynchops osborni* Williston) during a routine excavation of a grave in Custer National Cemetery. The find is significant because this extinct group of marine reptiles is poorly understood, and well-preserved specimens like this are rare.

The other rock unit at the Monument that has the potential to yield fossils is the Upper Cretaceous Judith River Formation. The Judith River Formation hosts bony fish and shark remains, dinosaur fossils, soft-shelled turtles, and mammals. Terrestrial and shallow marine records of both the Judith River and Two Medicine formations in Montana include the occurrence of carbonaceous plant debris, wood fragments, shell debris, freshwater clams, gastropods, shark teeth, fish bones, marine reptile bones, and dinosaur remains.

Building Stone

In addition to being significant cultural resources, building stone are also geologic resources; that is, any rock suitable for use in construction and chosen for its properties of durability, attractiveness, and economy (Figure 4.5.4-5). However, geologic information about the building stones at Little Bighorn Battlefield NM is sparse. Identifying geologic information about the building stones at Little Bighorn would be an interesting geologic exercise that could

Figure 4.5.4-5. Stone monuments, such as the 7th Cavalry Memorial (left) and stone markers (right) are geologic and cultural resources.

promote an understanding of both natural and cultural resources.

4.5.5. Sources of Expertise

This section was reviewed by Bruce Heise, Geologist at the National Park Service Geological Resources Division.

4.5.6. Literature Cited

KellerLynn, K. 2011. Little Bighorn Battlefield National Monument: Geologic resources inventory report. Natural Resource Report NPS/NRSS/GRD/NRR—2011/407. National Park Service, Fort Collins, Colorado.

National Park Service. 2006. Soil resources inventory (SRI) soil survey geographic (SSURGO) for Little Bighorn National Monument, Montana, 2005–2006. Project 1048921. National Park Service, Inventory & Monitoring Program, Fort Collins, Colorado.

4.6. Stream Ecological Integrity

Indicators/Measures

- Water in Situ Chemistry (4 measures)
- Physiochemistry-Water & Sediment (4 measure categories)
- Stream Productivity (2 measures)
- Biological Communities (3 measures)

Condition – Trend - Confidence Level

Good – Unknown - Medium

The stream ecological integrity condition assessment is excerpted from Schweiger et al. 2012a: Draft Stream Ecological Integrity at Little Bighorn Battlefield National Monument and is a considerable simplification of the full report. Note: Indicators related to habitat, except for streamflow, were omitted from this section since a technical request for a riparian habitat rapid assessment was fulfilled, specifically for the purposes of this NRCA.

4.6.1. Background and Importance

The ecology of streams and rivers is both intimately linked with and reflective of the watersheds they drain (Hynes 1972). A defining feature of streams and rivers is their dependence on the landscape in which they reside for inputs of energy and nutrients (Naiman 1992; Hunsaker 1995). Streams support a broad spectrum of ecological services including nutrient processing, hydrologic cycling, critical habitat for facultative (e.g., beavers) and obligate (e.g., stoneflies) species and multiple socio-economic functions for humans (e.g., water sources, fisheries). Moreover, because streams are typically highly sensitive to stressors at both local and landscape scales, they are one of the most useful types of ecosystems for long term ecological monitoring (Figure 4.6.1-1).

Despite the many services they provide, streams are among the most significantly altered ecosystems in North America. Streams

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Figure 4.6.1-1 A long term stream ecological integrity monitoring program has been implemented for the Little Bighorn River.

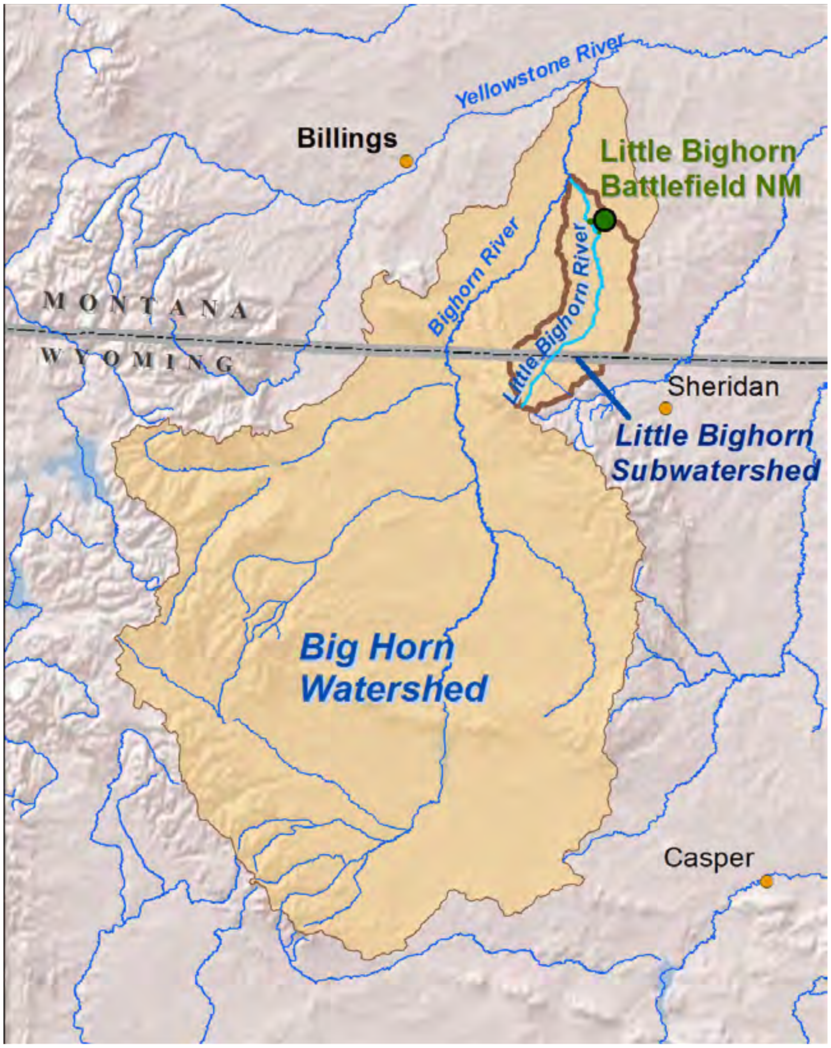

Figure 4.6.1-2 The Little Bighorn subwatershed drains an area of approximately 3,370 km².

face numerous and varied threats, including impacts from climate change, atmospheric deposition, altered hydrology, acid mine drainage, agriculture, pollution from boats, non-native species, erosion, improper sewage plant or drain field operations, and storm water runoff.

Stream Resource

Little Bighorn Battlefield National Monument is located within the Little Bighorn River Valley in south-central Montana near the town of Crow Agency. The 3.08 km^2 Monument sits on terraces above the floodplain of the Little Bighorn River. A small area (approximately 0.20 km^2) along the western boundary of the monument extends onto the floodplain of the river, with the legal park boundary designated by the high water mark on the right (or east) bank of the river.

The Monument is situated along the lower reaches of the Little Bighorn River, which drains an area of about 3,370 km^2 (Figure 4.6.1-2). The river originates in the Wolf Mountains in Wyoming and drains north for a distance of about 130 km through foothills and a broad alluvial valley. The confluence of the northward-flowing river with the Bighorn River is near Hardin, Montana, to the northeast of the Monument. Lodge Grass and Pass Creeks are the main perennial tributaries and Owl and Reno Creeks are the largest ephemeral tributaries. There are no perennial or ephemeral streams flowing through the Monument. There are several ephemeral springs and at least one alkaline seep in the Custer unit.

Stream Ecological Integrity (SEI) monitoring at the Monument directly or indirectly addresses five of Rocky Mountain Inventory and Monitoring Network's (ROMN) 12 high priority Vital Signs. In general, streams and rivers are fundamental components of the ecological and cultural context of ROMN parks like Little Bighorn Battlefield (Seastedt et al. 2004); (Hauer et al. 2000); (Hauer et al. 2007); (Mast et al. 2005); (Stottlemyer et al. 1997). They are often what visitors come to see, what they remember when they leave, or especially in the case of the Monument, form an important backdrop to the historical events preserved by the park. The NPS recognizes that aquatic resources are some of the most critical and biologically productive resources in the national park system and that they are vulnerable to degradation from activities both within and external to parks.

4.6.2. Data and Methods

ROMN SEI monitoring was conducted at Little Bighorn Battlefield NM during 2007-2010, using SEI protocol developed by Schweiger et al. 2012b, which focuses on the "ecological integrity" of streams. Ecological integrity is the capacity to support and maintain a balanced, integrated and adaptive community of organisms having a species composition, diversity, and functional organization comparable to that of natural habitats of the region (Karr 1991). It is a complex, multidimensional concept and usually a single indicator or vital sign is insufficient to characterize it. Therefore, the SEI protocol is a multi-faceted approach to monitoring streams as guided by a detailed protocol (Schweiger 2012b). The SEI protocol describes an integrated approach to understanding the states and trend in stream ecological condition, capturing the strengths of both fixed-site water quality-based approaches and probability surveys. The SEI protocol includes elements of regulatory monitoring (e.g., in support of the Clean Water Act); however, the Montana Department of Environmental Quality has the ultimate authority over the Little Bighorn River.

In addition to ROMN monitoring data, ongoing continuous/real-time monitoring of stream flows by the USGS at the nearby Hardin, MT gauge and the episodic work by the NPS Water Resource Division will also be used to assess indicator condition.

<u>Sample Design and Scale of Inference</u>

The spatial extent of SEI data collection at the Monument is an approximately 1200 meter long sample reach defined by series of subsample locations (Figure 4.6.2-1). The reach extends from the last meander bend of the river before it leaves the Custer unit to near the northern boundary of the park (Figure 4.6.2-2). The SEI sample design was a hand-picked (not randomly selected) ROMN sentinel site approach (see Britten et al. 2007 for a complete overview of ROMN sample design strategies). Because the sample reach was not selected at random and we do not sample additional locations in the park, in a strict sense the inference of SEI monitoring is limited to this reach or even select points within it. However, the total extent of the Little Bighorn River within the Monument is only around 7.2 km (both units) and we feel our sample reach is largely representative of this extent. Therefore, we generally interpret SEI results at the scale of the park.

Temporal scales of inference are generally limited to the time of sampling for many responses (especially chemistry) and may only represent conditions at the time of sampling. Thus, rare and short-term events such as floods typically are not captured in our water physiochemistry measures. However, water and sediment chemistry samples are routinely collected several times per year in order to build a database that represents the range of conditions that occur at the sampled site(s). Other parameters may be more readily inferred to a longer time frame. Specifically, while biological responses are collected at base flow (as this is when most species are at a more identifiable life-stage and potentially more stressed by stream flow levels) these responses often integrate longer time periods (i.e., lifespans or the time required for an assemblage to develop).

<u>Indicators:</u>

Water and Sediment Physiochemistry

Water and sediment physiochemistry have a long-standing tradition as a way to monitor the condition of a stream; however, they are just part of the way we estimate "water quality" within the SEI protocol. The sampling methodology we use for water physiochemistry has implications for data interpretation. Episodic grab samples represent conditions at the point and time of sampling; they do not represent the condition of the entire water body, spatially or temporally. We collected multiple water physiochemistry samples on the limbs of the hydrograph (rising, peak, falling, base and winter) in order to better understand the range of conditions that can occur across a water year.

A water year is defined as the 12-month period October 1, for any given year through September 30, of the following year. The water year is designated by the calendar year in which it ends and which includes 9 of the 12 months. Thus, the year ending September 30, 1999 is called the "1999" water year. Thus, important diel patterns in some water quality parameters are not captured. Over the duration of the SEI pilot at the Monument we gradually increased sampling frequency from 1 to 4 times per year in an attempt to capture all of these phases of the water cycle.

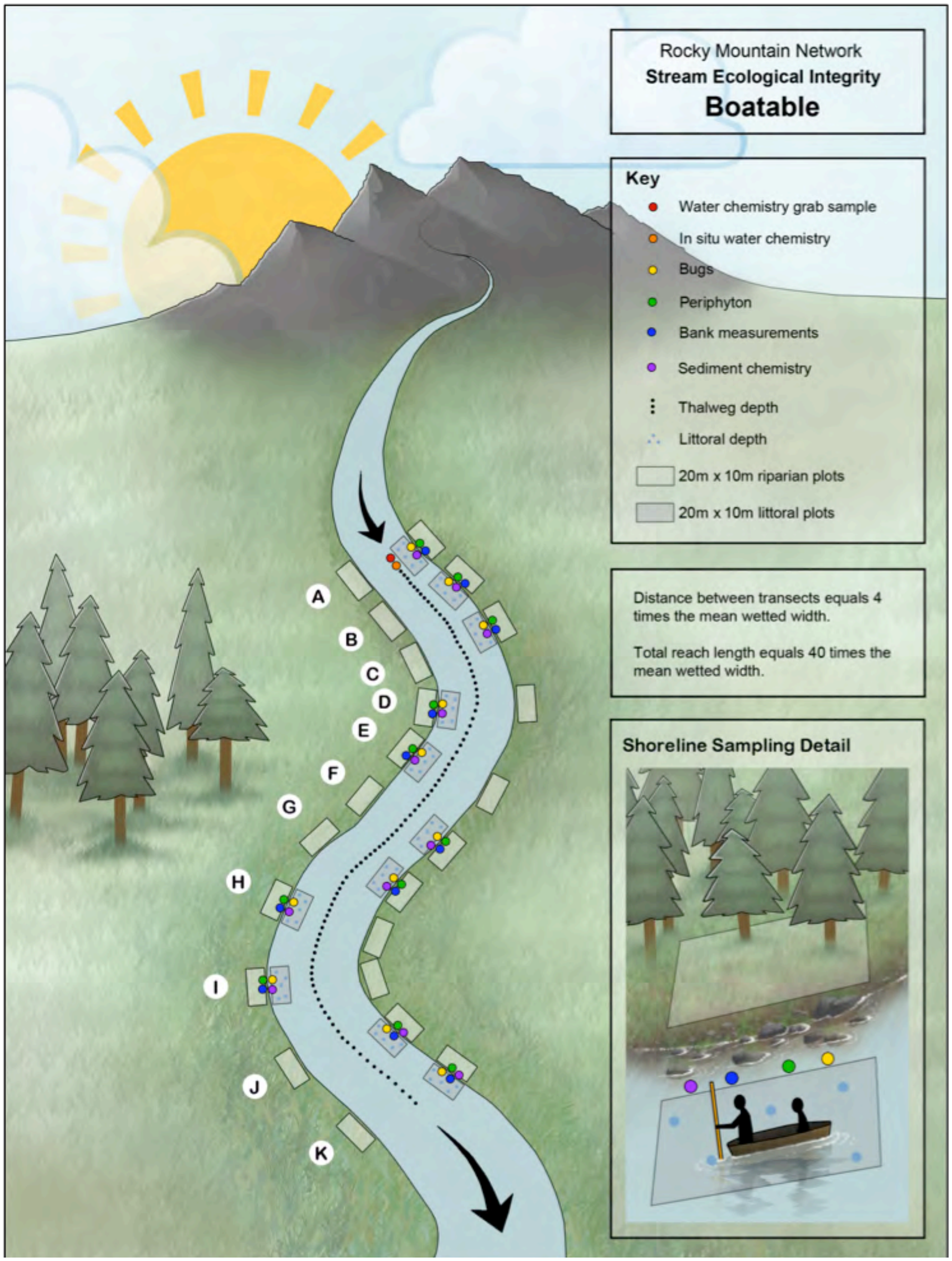

Figure 4.6.2-1 ROMN SEI sample reach in oblique profile. Stream flow is from the top to bottom of the figure. Sub sample locations, riparian plot and thalweg profile are all shown. Inset picture shows select details for shoreline sampling.

Indicators/Measures

Water in Situ Chemistry (4 measures)

Four in situ (measured within the stream channel) core field parameters (temperature, pH, specific conductance, and dissolved oxygen) were measured with a handheld multi-parameter probe (also known as a sonde). In 2007 and 2008 data were collected with an In Situ 9500. Beginning in 2009, all data were collected with a YSI ProPlus. These two instruments were compared in the lab before deployment, following NPS Water Resources Division (WRD) guidance, but were not used congruently in the field due to budget restrictions. We also collected continuous data on stream temperature using

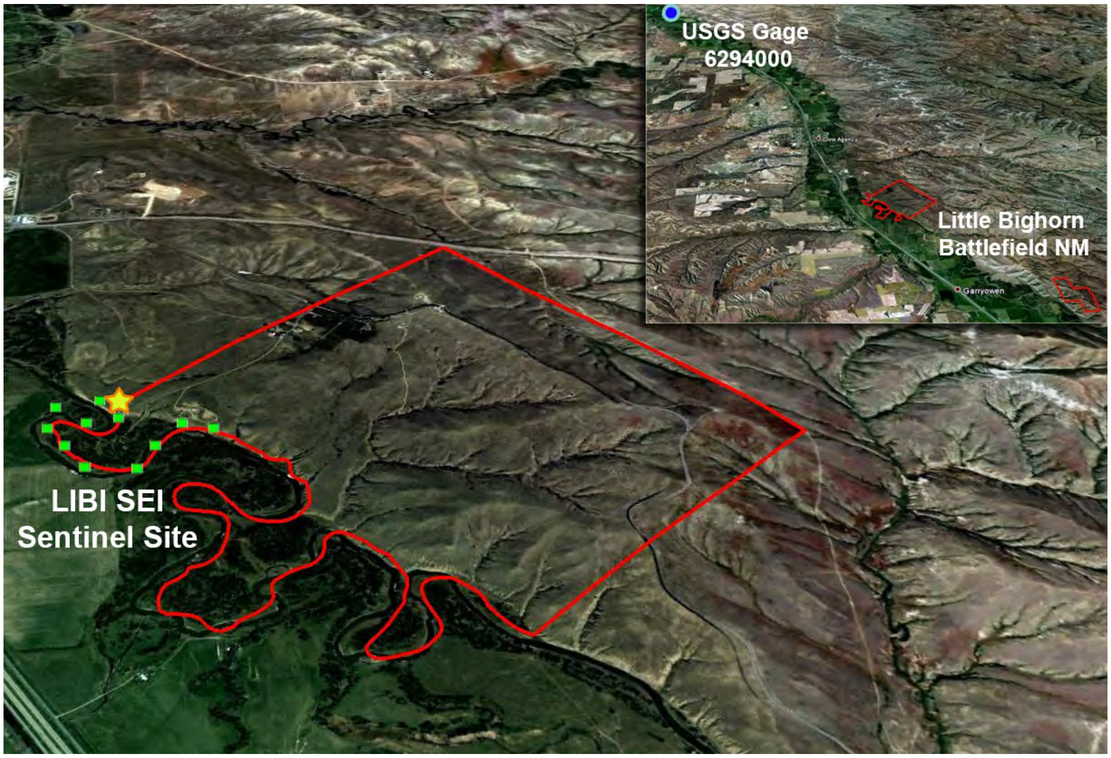

Figure 4.6.2-2 Oblique views looking North of the Little Bighorn River at Little Bighorn National Battlefield (only the Custer Battlefield unit is shown in in the larger image), and the small town of Crow Agency in the background.

Map includes the ROMN SEI sample site (yellow star), the SEI sample reach (green squares) and the USGS gauge near Hardin, MT. Stream flow is from the foreground of the image. Inset shows LIBI (both units of the park) and the USGS gauge location (blue dot) approximately 22 km in the background.

small sensors submerged in the channel near the bridge. All field methods follow NPS WRD protocols for quality assurance (i.e., calibration routines and criteria).

Water temperature is a critical variable controlling many ecosystem processes, both physical and biological, and it can impact almost all functions within an ecosystem (Allan 2004). Rates of most physical, chemical, and biological processes are strongly influenced by temperature. It is also a critical parameter for tracking climate change response in park ecosystems.

Water pH (the measure of water hydrogen ion concentration) has many physical and biological effects. Most aquatic species occur within specific habitat envelopes of pH conditions and changes in pH will likely result in changes in species assemblages.

Specific conductance is the ability of a water body to conduct an electric current and is directly correlated with dissolved ion concentrations in water bodies. In essence, the more dilute the water, the lower the concentrations of dissolved salts and thus the lower the conductance. Changes in conductance suggest changes in major ions or nutrients, such as potassium, calcium, and other anions and cations.

Dissolved oxygen is closely linked to physical and biological processes. For instance, respiration, photosynthesis, and atmospheric exchange (through turbulence in rapids and riffles) are the principle processes that affect or are affected by dissolved oxygen concentrations. In addition to high water temperatures, high microbial activity, which is driven by organic pollution, drives demand for dissolved oxygen resulting in anoxic conditions. High oxygen levels are especially critical for the metabolism of aquatic insects and salmonid eggs.

Indicators/Measures

Water Physiochemisty (several measures)
Sediment Chemistry (several measures)
Stream Productivity (2 measures)

Water and Sediment Grab Samples

Given the similar parameters collected, analytical methods, and application and interpretation of criteria, we group water and sediment physiochemistry together. We use the less common term "physiochemistry" because we include both physical (i.e., temperature) and chemical (i.e., nutrients) parameters in the group. We measured almost 60 parameters selected based on a variety of considerations. Parameters included 11 nutrients (and carbon), 11 major ions, 12 trace elements (both dissolved and total recoverable metals) in water and 13 metals in sediment. Water samples were taken using single location, depth-integrated thalweg methods (at low flow) or equal width/ depth-integrated samples taken from the bridge at higher flows. Bulk bed sediment samples were composited from 7 to 10 individual samples of fine-grained bed sediment collected by scooping material from the surfaces of representative deposits along pool or low-velocity areas at each transect location or at ad hoc locations near where water samples were collected. Sediments were not sieved.

Samples were analyzed at four laboratories depending on the sample date and parameter. In 2008 all samples went to the Flathead Lake Biological Station (FLBS) lab. In 2009 and 2010, all nutrient samples, majors and some trace elements went to the University of Colorado Kiowa lab. Most trace elements in water during 2009 and all sediment parameters in 2009 and 2010 were analyzed by the US EPA Region 8 lab. A few trace elements in 2010 were analyzed by the Environmental Testing Corporation lab. Each lab was selected given expertise and operational constraints within the SEI protocol development at the Monument. Each lab followed rigorous internal quality assurance quality control that ensured comparability across lab results. Future monitoring at the Monument will use the Kiowa and EPA labs only.

Sampled nutrients include the dominant forms of nitrogen and phosphorous both total and dissolved). We also sampled organic and total dissolved carbon. Nutrients may be limiting in aquatic ecosystems, controlling ecosystem productivity, as well as being indicators of eutrophication caused by external stressors (e.g., atmospheric deposition or visitor use activities). Total organic carbon and dissolved organic carbon are essential components of the carbon cycle in streams and their watershed. Dissolved organic matter may impact contaminant transport and drinking water quality.

Major ions include two predominant anions (sulfate and chloride) and four cations (calcium, sodium, potassium, and magnesium). These six ions, along with carbonates, make up most of the ions in stream water. These ions are important indicators of the watershed context of the stream, with different ion concentrations reflecting variation in geology, vegetation, and weathering processes. However, sulfate is also common as an indicator of pollution (e.g., from mining waste or agricultural runoff). We also include total suspended solids (TSS). High concentrations of particulate matter can cause increased sedimentation and siltation in a stream, which in turn can impact important habitat areas for aquatic life. Suspended particles also provide attachment places for other pollutants, such as metals and bacteria.

Trace elements in water include those that typically occur only in minute concentrations, such as metals. However, contamination of a stream with trace metals is not always detectable in the water column because they may have precipitated or adsorbed to organic particulates or fine sediments. Therefore, we also sample sediments deposited from the water column to detect trace metal contaminants. Many metal ions are lethal to fish and other aquatic life forms. Metals often are bio-concentrated, leading to increasing concentrations in species higher in the food chain. We include total mercury in the suite of parameters analyzed for in the sediment samples. Mercury has no known metabolic purpose and is toxic to living organisms. In humans, mercury adversely affects the central nervous system. Mercury can be converted from inorganic compounds, which we measure, to organic forms such as methylmercury, which is easily absorbed by organisms, but harder and more expensive to monitor.

Stream Productivity

Two measures of stream productivity were created from the composite periphyton samples: Chlorophyll-a and ash free dry mass (AFDM). Known volumes were filtered from the composite samples in the field and frozen for later analysis.

AFDM and Chlorophyll-a samples were processed using standard methods (APHA 1995). Filters were pre- and post-weighed after combustion in a muffle furnace for AFDM. Chlorophyll-a was extracted and analyzed via fluorescence. AFDM and Chlorophyll-a concentration per unit area were generated using the area and volume of sample collected and volume of sample filtered.

We present the stream productivity measures within the water chemistry section as they are used as indicators of general nutrient loads within a stream. Nutrient concentration is correlated with ecosystem disturbance (e.g., deforestation and agriculture) as periphyton production declines with increasing river size and turbidity (Naiman et al. 1993). The stream productivity measures complement the species list-based diatom metrics listed below and may be especially important in studies that address potential nutrient enrichment or toxicity.

Auxiliary Data for Water Phsiochemistry:

The USGS gauge station 06294000 on the Little Bighorn River near Hardin, MT has a large amount of high quality data available from USGS. While there are some concerns with the distance of this site from the Monument, we elected to harvest, analyze and interpret a large amount of data for this report. We use these data largely to assess long term trends.

Water physiochemistry data were retrieved from the NWIS database for the Hardin, MT gauge station 06294000 over variable periods of record from 1970 - 2011. This included 24 nutrient, trace element and major ions parameters used by the USGS (generally for the same reasons as within the SEI protocol). Also, we harvested episodic stream temperature data, collected annually every few months from 1969 to the present. Only data publically available and thus passing all USGS QAQC checks were used. However, following (Mast 2007) we elected to retain trace-element results although it is documented that dissolved concentrations in USGS samples collected prior to 1992 may have been contaminated during sample collection and processing (USGS Office of Water Quality Technical Memorandum 91.10).

The NPS WRD ran a stream gauge at the Monument from water years 1999 to 2006. The NPS gauge, while not contemporaneous with SEI monitoring in the park, did generate daily water temperatures, which we directly used and interpreted the temperature data as WRD considers these data appropriate for our purposes.

The results from these auxiliary data are reported in Schweiger et al's. 2012a full report.

Hydrology or the amount/timing of stream flow is one of the most important aspects of stream habitat and a key long term monitoring response for the ROMN SEI protocol.

ROMN Monitoring

ROMN focused their stream flow analysis on the continuous record of stream discharge available from the nearby USGS gauge in Hardin, MT. Given the complexity of stream flow (and the amount of data analysis required to understand it) across the diversity of stream types in an ecoregion, ROMN did not interpret any aspect of discharge in the Little Bighorn River relative to values from other sites in the ecoregion and only made qualitative assessments of stream flow in the river using the USGS gauge data near Hardin, MT.

Auxiliary Data for Stream Flow:

We use USGS gauge station 06294000 daily stream discharge data from 1953 through 2011 for this indicator.

The NPS WRD ran a stream gauge at the Monument from water years 1999 to 2006. The NPS gauge, while not contemporaneous with SEI monitoring in the park, did generate daily stream discharge. As of 2012, WRD considers the discharge data provisional and we therefore only use these data in comparison to the USGS gauge at Hardin, MT to establish the validity of applying the USGS data to the Monument.

Indicators/Measures

Biological Communities (3 measures)

Macroinvertebrates

Stream macroinvertebrates, also known as benthos, include crustaceans, mollusks, aquatic worms and most importantly (because of their dominance and ecological function), the immature forms of aquatic insects such as stonefly and mayfly nymphs. The term "benthic" means "bottom-living," as these organisms usually inhabit stream bottoms for at least part of their life cycle.

Macroinvertebrates are among the most widely used organisms for bioassessment because they can be sampled relatively efficiently and effectively (Resh and Jackson 1993); they are widespread in aquatic environments (Merritt and Cummins 1996); there are a large number of species that have a wide range of responses to environmental impacts (Resh et al 1995), and since they are relatively sedentary, they can be used to determine the spatial extent of impacts. In addition, since macroinvertebrates are relatively long-lived, community response can integrate the high temporal variability associated with traditional physical and chemical analyses (Rosenberg and Resh 1996).

ROMN SEI benthos sample collection and processing follow from well-established and standardized US EPA, USGS and MT DEQ methods and are described in detail in Schweiger et al. (2012b). Quantitative benthos samples were composited from eleven 1ft^2 subsamples taken at each transect along the reach using a D-net with 500 um mesh net. Each subsample was collected over a constant time (30 seconds). Samples were preserved in 95% ETOH for later identification. Samples were spread on a gridded tray or Caton-type splitter and picked from a randomly selected subset of grid cells until 600 organisms were removed (a search for large, rare specimens was also conducted in the whole sample). At least 10x magnification was used to sort invertebrates from debris. All specimens were identified to the lowest practical level or as specified in Schweiger et al (2012b). Voucher specimens, including head capsule mounts for midges, are housed with NPS. Nomenclature follows the Integrated Taxonomic Information System. All identifications were cross-walked to Operational Taxonomic Units (OTUs) as developed by the state of Montana Department of Environmental Quality (Jessup et al. 2006) used to standardize identifications to a consistent level for some analyses and to NPS NPspecies nomenclature.

We assess SEI biological data at the Monument as follows: 1) comparison of macroinvertebrate and diatom metrics to thresholds developed by MT DEQ and other agencies/researchers, 2) narrative interpretation of the taxonomic composition of samples, and 3) comparison to thresholds we derive from reference sites in the Northern Great Plains Ecoregion.

The state of Montana has been a leader in the development and implementation of diatom and macroinvertebrate stream bioassessment, including developing metrics and thresholds for their interpretation (Bukantis et al, 1998; Bramblett et al 2003; Feldman, 2006; Jessup et al 2006; MT DEQ 2006, 2011; (Teply 2005; Teply 2006; Suplee et al 2008; MT DEQ 2011; Teply 2010a; Teply 2010b). Macroinvertebrate and diatom assemblages exhibit predictable responses to different types of environmental stress. Consequently, the sensitivity of individual metrics varies with the type of pollution. Some metrics are useful as estimators of metals pollution while others are more sensitive to organic/nutrient enrichment, excessive sediment deposition, or partial dewatering. Although biological metrics and thresholds alone are not sufficient to allow the state to determine if designated uses are being met, they are used by MT DEQ in screening sites and in determining if sufficient credible data exists to list a site as impaired and placed on the Clean Water Act 303(d) list of threatened water bodies (see MT DEQ 2006, 75-5-103(30) MCA).

Periphyton

Periphyton has important functions in aquatic habitats as producers of organic matter and plays a vital role in inorganic nutrient retention, transfer and cycling

(Stevenson and Smol 2003). Periphyton are useful indicators of environmental condition because they respond rapidly and are sensitive to a number of anthropogenic disturbances, including habitat destruction, contamination by nutrients, metals, herbicides, hydrocarbons, and acidification (e.g., Hill et al., 2003). In streams where flow and substratum characteristics create efficient interactions between water and the benthic periphyton assemblage, benthic algae typically reflect recent water chemistry (Lowe and Pan 1996). Periphyton assemblage composition is strongly influenced by land-water interactions, and also by stream size and the level of human disturbance.

Periphyton includes algae, fungi, bacteria and protozoa associated with channel substrates. Periphyton can be further grouped into growth forms, either as microalgae (microscopic, appearing as pigmented accumulations or films attached to submerged surfaces, typically single-celled algae) or macroalgae (visible without magnification, typically filamentous). Note that, while all periphyton algae taxa are included in SEI monitoring, diatoms (algae with hard, silica "shells") may be more useful as ecological indicators because they are found in abundance in most stream ecosystems, have a well understood range in tolerance to stressors, and are the focus of other similar monitoring efforts in the west (Spaulding et al. 2010).

ROMN SEI periphyton sample collection and processing follow from well-established and standardized US EPA, USGS and MT DEQ methods and are described in detail in Schweiger et al. (2012). Periphyton samples were composited from eleven subsamples taken at each transect along the reach. The specific method used depended on the dominant substrate type present at the chosen microhabitat. For erosional habitat, a piece of cobble within 50 cm of the surface was randomly chosen and a small known area of the 'sunny side' was scraped of all benthic algae. For depositional habitat a small area of organic and mineral fines was vacuumed up with a syringe. A known volume from this composite was preserved with M-fixative (Lugols and dilute formalin) for later identification. The composite field samples were well mixed in the lab, sub-sampled, cleaned via nitric acid digestion and mounted on four slides using Naphrax. A Palmer-Maloney counting chamber count of 300 soft bodied algae cells at 400X and a proportional count of 600 diatom valves (300 cells) along a scribed line with a random start was then conducted. A 100x scan and count of all valves present of the entire slide for *Didymosphenia geminata* and any novel taxa not in the focal search was conducted. All specimens were identified to species. Voucher slides are housed with NPS. Nomenclature follows the Montana Diatom Database (Bahls 2004) as there is not well developed taxonomic data in ITIS for algae. Any taxon that is identified in ITIS is crosswalked to our nomenclature. Moreover all taxa are crosswalked to NPS's NPspecies nomenclature although many diatoms and algae are not yet included in NPspecies.

<u>Aquatic Invasive Species</u>

SEI samples of macroinvertebrate and periphyton allow us to include the presence (or even abundance) of aquatic taxa that are considered invasive in Montana. The Montana Department of Fish, Wildlife and Parks (MTFWP) maintains a list of species of concern in the state. Most of these taxa are vertebrates (that we do not collect) or plants. However, there are invertebrate taxa on the list including the zebra or quagga mussel (*Dreissena polymorpha* and *Dreissena rostriformis*), the New Zealand mudsnail (*Potamopyrgus antipodarum*) and the rusty crayfish (*Orconectes rusticus*). Another important species of concern (although not on MTFWP list yet) is the diatom *Didymosphenia geminata*, commonly referred to as didymo or rock snot. The Little Bighorn River at the Monument is not likely viable habitat for didymo. However, we will still monitor for its presence in our samples as there are locations higher in the watershed that are suitable habitat and the species has displayed a tendency to adapt to changing conditions.

<u>Auxiliary Biological Data</u>

We collected data for a subset of biological and habitat metrics from several state and federal monitoring program sites in the Northwestern Great Plains ecoregion

For biological data (currently limited to macroinvertebrates) this includes 28 sites sampled as part of the EMAP Western Pilot Project (Stoddard et al. 2005) from 2000 to 2003, 18 sites in larger rivers similar to the Little Bighorn sampled by MT DEQ from 2001 – 2005(Bollman 2006), 45 sampled by the state as part of a recent reference condition development process (Suplee et al. 2005), and 34 sites sampled from 2000 to 2003 by Utah State University as part of the US EPA Science to Achieve Results (STAR) program (Hawkins et al 2003). Five of the sites are treated in multiple sources (i.e., a few EMAP sites became MT DEQ reference sites) reducing the total sample size compared to the Monument's SEI data to 120. Field and analytical methods for these programs were largely comparable to SEI protocols. To be included, external source data had to be from the Northwestern Great Plains ecoregion in Montana, have a multi-habitat sampling method, (for benthos) a minimum 300 organism lab count (for SEI we count at least 600) and a minimum of genus level identification of insects, (including Chironomids). Jessup et al. (2006) show that, for at least the current MMI and O:E metrics, bioassessment based on MT DEQ and EPA essentially results in similar interpretation. We restricted biological data to the state of Montana given the available thresholds from MTDEQ and the use of data that only occurred in the State.

4.6.3. Reference Conditions

<u>Water and Sediment Physiochemistry</u>
Table 4.6.3-1 includes several criteria for water and sediment physiochemistry from MT DEQ (2010). Given the large number of existing regulatory criteria we generally do not compare SEI water physiochemistry data from the Monument to thresholds derived from the surrounding ecoregion (as we do with biological measures). However, for sulfate and chloride, both known to be useful indicators of general anthropogenic disturbance (Stoddard et al 2005) but that do not have MT DEQ criteria, we do make qualitative comparisons to ecoregional thresholds.

<u>Stream Productivity</u>
Chlorophyll-a typically ranges from 0.5 to 2% of total algal biomass at a typical stream (APHA 1995), but this ratio varies with taxonomy, light, and nutrients. Ash-free dry mass is also a measure of the organic matter in samples, but in contrast to chlorophyll-a, where only photosynthetic algae are the source, AFDM also includes bacteria, fungi, small fauna, and organic detritus.

<u>Hydrology: Stream Flow</u>
Montana does not have streamflow criteria. Given the complexity of streamflow (and the amount of data analysis required to understand it) across the diversity of stream types in an ecoregion, we do not interpret any aspect of discharge in the Little Bighorn relative to values from other sites in the ecoregion and we only make qualitative assessments of streamflow in the Little Bighorn using the USGS gauge data near Hardin, MT.

<u>Macroinvertebrates</u>
The primary way in which we analyze biological data is via metrics generated from models (Table 4.6.3-2). This follows from a long tradition in stream monitoring and assessment (e.g., Kolkwitz and Marsson 1908) known as bioassessment (Barbour et al. 2000). Bioassessment assumes that the composition of biological communities reflects the overall ecological integrity of a system. Evidence suggests it may detect stressors that other approaches fail to reveal (Karr and Dudley 1981, Karr and Chu 1997).

MT DEQ and other partners have used a variety of bioassessment metrics to help interpret stream water quality over the last two decades (MT DEQ 2012) and we analyze SEI biological data using a subset of these. We focus on the most current metrics given the higher levels of precision and their usage by MT DEQ in regulatory applications. However, we also feel that many older metrics that may have no current formal regulatory usage or may be more regional in scale have

Table 4.6.3-1. Water and sediment physiochemistry criteria for the Little Bighorn River. Criteria (except as indicated) are August 2010 MT DEQ chronic aquatic-life values with human-health values in parentheses (MT DEQ 2010). Criteria are thresholds for impairment with values above criteria indicating impairment (except as indicated).

Temperature, water (°C)	--
Oxygen, dissolved (mg/L)	<5.0, <3.01
pH (standard units)	6.5 to 9.02
Specific conductance (µS/cm)	1500,10003
Alkalinity, dissolved (mg/L as $CaCO_3$)	--
Calcium, dissolved (mg/L)	--
Chloride, dissolved (mg/L)	4.414
Fluoride, dissolved (mg/L)	(4.0)
Hardness, dissolved (mg/L as $CaCO_3$)	--
Magnesium, dissolved (mg/L)	--
Potassium, dissolved (mg/L)	--
Silica, dissolved (mg/L as SiO_2)	--
Sodium, dissolved (mg/L)	--
Sulfate, dissolved (mg/L)	112.94
Total Suspended Solids (mg/l)	--
Ammonia, dissolved (mg/L as N)	0.95
Nitrite + Nitrate, dissolved (mg/L as N)	.02(10)6
Nitrite, dissolved (mg/L as N)	(1)
Nitrate, dissolved (mg/L as N)	(10)
Nitrogen, total (mg/L as N)	1.17

Nitrogen, total (mg/L as N)	1.17
Orthophosphate, dissolved (mg/L as P)	--
Phosphorous, total (mg/L as P)	.127
Carbon, organic, dissolved (mg/L as C)	--
Carbon, organic, total (mg/L as C)	--
Chlorophyll a in periphyton (mg/m^2)	1208
Ash Free Dry Mass in periphyton (mg/m^2)	358
Aluminum, total (µg/L)	--
Arsenic, total (µg/L)	150(10)
Barium, total (µg/L)	(1000)
Beryllium, total (ug/L)	(4)
Cadmium, total (µg/L)	.5(5)9
Chromium, total (µg/L)	(100)
Copper, total (µg/L)	20(1,300)9
Iron, total (µg/L)	1000(300)9,10
Lead, total (µg/L)	9.7(15)9
Manganese, total (µg/L)	5010
Selenium, total (µg/L)	5(50)
Zinc, total (µg/L)	252(2,000)9

Aluminum, dissolved (µg/L)	87
Arsenic, dissolved (µg/L)	150(10)11
Barium, dissolved (µg/L)	--
Beryllium, dissolved ug/L)	--
Cadmium, dissolved (µg/L)	.44(4.33)11
Chromium, dissolved (µg/L)	(86)11
Copper, dissolved (µg/L)	3.6(1,248)11
Iron, dissolved (µg/L)	--
Lead, dissolved (µg/L)	.35(9.7)11
Manganese, dissolved (µg/L)	--
Selenium, dissolved (µg/L)	5(50)11
Zinc, dissolved (µg/L)4	36.5(1972)11
Aluminum, total (mg/kg)	--
Arsenic, total (mg/kg)	9.79,3312
Barium, total (mg/kg)	--
Beryllium, total (mg/kg)	--
Cadmium, total (mg/kg)	.99,4.98,12
Chromium, total (mg/kg)	--
Copper, total (mg/kg)	31.6,149,12
Lead, total (mg/kg)	35.8,128,12
Iron, total (mg/kg)	--
Mercury, total (mg/kg)	0.180,1.060,12
Selenium, total (mg/kg)	--
Silver, total (mg/kg)	--
Zinc, total (µg/L)	--

All criteria are MT DEQ (2010) chronic aquatic life values with human health standards in parentheses except as follows:

[1] Freshwater Aquatic Life Standards for DO are warm water 1 day minima for early life stages followed by other life stages. They are instantaneous water column concentrations to be achieved at all times (MT DEQ, 2010);

[2] pH criterion excludes natural pH outside the stated range but requires that pH must be maintained within the range (MT DEQ, 2010);

[3] Conductivity standard is a growing season instantaneous maximum followed by a monthly average as developed for the Tongue River mainstem and is applied informally and with caution to the Monument;

[4] Thresholds for sulfate and chloride are from the 50th percentile of the distribution of reference sites in the Northwestern Great Plains Ecoregion;

[5] MT DEQ (2010) ammonia criteria is a table value lookup for a chronic value for total recoverable ammonia nitrogen at a pH of 8.4 at 20° and assuming early fish life stages are present;

[6] Nitrite + Nitrate is provisional and for a base flow in the Northwestern Great Plains Ecoregion (MT DEQ, 2008) - the human health standard is from MT DEQ (2010)

[7] Total nutrient criteria are for base flow in the Northwestern Great Plains Ecoregion (MT DEQ 2011);

[8] Nutrient assessment support criteria from MT DEQ (2011) for two level 4 ecoregions within the Northwestern Great Plains Ecoregion that DO NOT include the Monument and are therefore used with caution;

[9] Table values calculated at a median hardness of 272 mg/L as $CaCO_3$;

[10] Human health value is a secondary standard based on aesthetic properties such as taste, odor, and staining and is more conservative than chronic standards;

[11] Values for dissolved trace elements are derived from MT DEQ total values using formulas from US EPA (2009) and a median hardness of 272 mg/L as $CaCO_3$;

[12] Sediment criteria are consensus based Threshold of Effect Concentrations (TECs) followed by Probable Effect Concentrations (PEC) values from MacDonald et al (2000). TECs are concentrations below which no effect on sediment dwelling organisms are expected, whereas PECs are the concentrations at which negative effects on sediment dwelling organisms are judged more likely to occur than not.

Table 4.6.3-2. Reference conditions for macroinvertebrates.

Metric	Significant Concern	Moderate	Good	Range and Interpretation
Plains Multimetric Index*			>37	0 – 100; low values suggest lower stream integrity
RIVPACS O:E (P > 0.5, P > 0.0)*			>0.8	0 – 1+; low values suggest lower stream integrity
RIVPACS BC (P > 0.5, P > 0.0)*	--	--	--	0 – 1+; high values suggest lower stream integrity
Plains Multimetric Index (classic)**	<25	75 – 25	>75	0 – 100; low values suggest lower stream integrity
Karr Benthic Index of Biotic Integrityˇ, [1]	<16	44-38, 36-28, 26-18	>46	0 – 100; low values suggest lower stream integrity
Hilsenhoff Biotic Index (Nutrients)^, [1]	>8.5		<3.5	0 - ~10; low values suggest higher nutrient conc.
Fine Sediment Biotic Index***, [1]	<3	7-6, 5-4	>8	0 - ~10; low values suggest more fine sediment
Temperature Index[2]	--	--	--	0 - ~20; low values suggest colder stream temp.
Metal Tolerance Index****, [2]	>8.9		<4.0	0 - ~10; low values suggest higher metal conc.
EPT Taxa Richness[2]	--	--	--	0 - ~15; low values suggest fewer EPT taxa
Percent Tanypodinae[2]	--	--	--	0 – 100; low values suggest lower %
Percent Orthocladiinae of Chironomidae[2]	--	--	--	0 – 100; low values suggest lower %
Predator Taxa Richness[2]	--	--	--	0 - ~15; low values suggest fewer predator taxa
Percent Filterers and Collectors[2]	--	--	--	0 – 100; low values suggest lower %

* Values and criteria are PRA and are currently used (except BC) by MT DEQ; Values above or equal to the given value are "Not Impaired" and support designated use(s) when evaluated by MT DEQ, values less than the given value are "Impaired" and do not support designated uses, O:E criteria are for the p > 0.5 model;

[1]No criterion for the metric alone; classic or other metric useful for general stream bioassessment atthe Monument;

[2]No criterion for the metric alone; component metric in Plains MMI (Jessup et al 2006);

** Values and criteria are scoring proportions and were used by MT DEQ; (Bukantis 1998; MT DEQ 2005) values above 75 indicate "Full support –standards not violated", values between 25 and 75 indicate "Partial support–moderate impairment–standards violated", values less than 25 indicate "Non-support–severe impairment-standards violated";

*** Criteria values have not been used by MT DEQ; values above 8 are fine sediment intolerant, 7-6 are moderately intolerant to fine sediment, 5-4 are moderately tolerant to fine sediment and <3 fine sediment tolerant (Relyea 2000);

**** Criteria values are not used by MT DEQ and were developed for the upper Clark Fork River; values above 8.9 indicate metals tolerance, with intolerance decreasing by units of 1 to a metals intolerant (or reference) class < 4.0 (McGuire, 1987, 1989; Ingman and Kerr, 1989);

ˇ Criteria values are not used by MT DEQ; classes are: Excellent, Good, Fair, Poor, Very Poor (Karr 1998);

^ Criteria values are not used by MT DEQ; classes are: Excellent no apparent organic pollution, Very Good slight organic pollution, Good some organic pollution, Fairly significant organic pollution, Fairly Poor significant organic pollution, Very significant organic pollution, Severe organic pollution (Hilsenhoff 1988);

EPT = Ephemeroptera, Plecoptera and Trichopetera (families of macroinvertebrates)

general interpretative value for our purposes and we include select examples of these.

For benthos, we focus on two metrics: a Multimetric Index (MMI; also known as an Index of Biotic Integrity) and metrics derived from the River Invertebrate Prediction and Classification (RIVPACS) model. We include component metrics of the MMI to aid in its interpretation.

EPA Environmental Monitoring and Assessment Program (EMAP) (Stoddard et al. 2005) signal to noise (S:N) are for a slightly different Montana Plains Multimetric Index and O:E model. EMAP S:N are based on 1524 unique sites and 90 repeat visits (years 2000-2004). Higher S:N values suggest the metric had more signal or true information than variation due to crews, season, and other sources (Kaufmann et al. 1999; Stoddard et al. 2005). Note-EMAP S:N reference condition is not shown in Table 4.6.3-2.

Thresholds from sources other than MT DEQ do exist for biological metrics we use (i.e., Hilsenhoff 1988; Karr 1998; Relyea 2000). These were derived using a variety of approaches, including the professional opinion of the ecologist who developed the

Table 4.6.3-3. Reference conditions for periphyton

Metrics	Significant Concern	Moderate	Good	Range and Interpretation
Sediment Increasers, Warm Water[a]			<17.92	0 – 100; low values suggest less sediment
Nutrient Increasers, Warm Water[a]			<11.21	0 – 100; low values suggest lower nutrient conc.
Shannon Diversity[b]	<1	2.5-1.75, 1.75 - 1	>2.5	0 – ~5; low values suggest lower diatom diversity
Siltation Index[b]	>60	20-39, 40 60	<20	0 – 100; low values suggest less sediment
Pollution Index[b]	<1.5	2.5-2, 2-1.5	>2.5	0 - ~15; low values suggest lower nutrient conc.
Montana Diatom Multimetric Index[c]	<1	2-3,1-2	>4	N/A

[a] Values currently used by MT DEQ; PRA values above or equal to the given criteria are "Impaired" due to sediment and do not support designated uses when evaluated by DEQ, values less than the given value are "Not Impaired" due to sediment and support designated uses when evaluated by DEQ, note that criteria are expressed as PRA;

[b] Values were historically used by MT DEQ (Bukantis and others, 1998); metric values above the first number have no stress/siltation/pollution/disturbance and "Excellent" biological integrity, "None" impairment, or "Full support" for designated uses; values in the second range have minor stress/siltation/pollution/disturbance and "Good" biological integrity, "Minor" impairment and "Partial support" for designated uses; values in the third range have moderate stress/siltation/pollution/disturbance and "Fair" biological integrity, "Moderate" impairment and partial support of designated uses; values below the fourth number have severe stress/siltation/pollution/disturbance and "Poor" biological integrity, "Severe" impairment or stress and "Non-support" for designated uses

[c] Values were historically used by MT DEQ; metric values = 4 have excellent biological integrity and no overall impairment, metric values between 2 and 3 have good biological integrity and minor overall impairment, metric values between 1and 2 have fair biological integrity and moderate overall impairment, metric values = 1 have poor biological integrity and severe overall impairment, (Bukantis and others, 1998).

metrics. These may lack specific applications to Montana streams or may be appropriate for only a general interpretation of metric scores and we therefore apply these with caution.

Periphyton (Diatoms)

For diatoms, we use two approaches: increaser models and a suite of individual metrics that describe specific aspects of community structure. The individual diatom metrics are also summarized into a single value (similar to a MMI) in Table 4.6.3-3.

The number and quality of diatom metrics and thresholds have been rapidly increasing over the last decade in Montana largely through work by MT DEQ and its partners. We chose metrics to interpret SEI data largely following MT DEQ guidance. We use existing criteria and other thresholds to help interpret diatom data and the ecological integrity of the Little Bighorn at the Monument. Future work will present comparisons (for select metrics) to reference conditions derived from sites in the surrounding ecoregion.

4.6.4. Condition and Trend

Schweiger et al's. 2012 full report contains summaries of how SEI data were analyzed and can be found on pages 31-37 of the full report.

Water and Sediment Physiochemistry

From 2007 to 2010 a total of eight sample events occurred at the Monument's SEI sentinel site. There is some variation in the methods used for these sample events, with no sample event for 2008.

Table 4.6.4-1 presents a summary of the status of SEI water and sediment physiochemistry results for 2007 – 2010. For water physiochemistry measures we report a minimum, maximum and median value. We use a median (vs. a mean) because of lower bounds of zero, censored values, and often very skewed distributions typical of these data (Mast 2007). All imputation models to deal with non-detects in SEI physiochemistry data were significant and statistics in the Table reflect these adjustments.

Table 4.6.4-1. Summary of 2007 -2010 water and sediment physiochemistry for the Little Bighorn River at the Monument. Bold type indicates values that were above a chronic aquatic-life criterion at least once during 2008 - 2010. Dark gray values indicate values above a human health criterion at least once during 2008 - 2010.

Constituent or property	No. analyses[0]	Minimum value	Median value	Maximum value
Field Properties				
Temperature, water (°C)	6[x]	5.80	17.21	21.97
Oxygen, dissolved (mg/L)	6[x]	**4.42**	9.22	12.28
pH (standard units)	6[x]	8.05	8.55	8.90
Specific conductance (µS/cm)	6[x]	378.17	527.19	767.39
Major constituents, dissolved				
Alkalinity, dissolved (mg/L as $CaCO_3$)	8	189.36	205	239.19
Calcium, dissolved (mg/L)	7	54.83	63.97	76.91
Chloride, dissolved (mg/L)	8	1.37	2.14	3
Fluoride, dissolved (mg/L)	3(2)	.27**	.27**	.27**
Hardness, dissolved (mg/L as $CaCO_3$)	7	173	272	327
Magnesium, dissolved (mg/L)	8	17.62	27.8	37
Potassium, dissolved (mg/L)	7	.98	1.77	2.68
Silica, dissolved (mg/L as SiO_2)	8	4.23	5.91	7.54
Sodium, dissolved (mg/L)	7	11.39	24.05	56.55
Sulfate, dissolved (mg/L)	8	45.51	98.79	**227.66**
Total Suspended Solids (mg/l)	4	6	26.06	63.8
Nutrients in water or periphyton, dissolved and/or total recoverable				
Ammonia, dissolved (mg/L as N)**	8(6)	.004*	.006*	.02
Nitrite + Nitrate, dissolved (mg/L as N)	8(4)	.0005*	.002*	**.07**
Nitrite, dissolved (mg/L as N)	7(4)	.0005*	.001*	.005
Nitrate, dissolved (mg/L as N)	7(1)	.0003*	.003	.06
Nitrogen, total (mg/L as N)	8	.08	.14	.26
Orthophosphate, dissolved (mg/L as P)	8(4)	.0006*	.001*	.004
Phosphorous, total (mg/L as P)	8	.002	.005	.01
Carbon, organic, dissolved (mg/L as C)	8	2.61	2.9	12.76
Carbon, organic, total (mg/L as C)	4	1.5	2.5	2.6
Chlorophyll a in periphyton (mg/m^2)	2	.03	10.08	20.14
Ash Free Dry Mass in periphyton (mg/m^2)	2	.62	1.73	2.84
Metals in water, total recoverable				
Aluminum, total (µg/L)	7(2)	74.2*	1020*	2920
Arsenic, total (µg/L)^	8(8)	--	--	--
Barium, total (µg/L)	4	50	57	73
Beryllium, total (ug/L)^	4(4)	--	--	--
Cadmium, total (µg/L)^	3(3)	--	--	--
Chromium, total (µg/L)**	4(4)	--	--	--
Copper, total (µg/L)^	8(8)	--	--	--
Iron, total (µg/L)	8(1)	20.37*	**601***	**4860**
Lead, total (µg/L)**	8(8)	--	--	--

Non-detect Notes

0 Values for sample size are total N with the number used in models in parentheses;

* Value or median contains predicted results from ROS model;

** > 80% of results at Detection Limit(s), results tenuous;

^ All results at Detection Limit(s), no model possible;

Other Notes:

x N for field properties is the number of events (the number of discrete data values within each event ranges from 1 to ~100);

--, not detected; No., number; mg/L, milligrams per liter; µg/L, micrograms per liter; °C, degrees Celsius; µS/cm, microsiemens per centimeter at 25°C; CaCO3, calcium carbonate; N, nitrogen; P, phosphorous.

In situ Water Chemistry (field properties)

In situ water chemistry (field measured parameters) at SEI sentinel events in the Monument over the period 2007 – 2010 showed a fairly high degree of variation. There were few exceedances of criteria and none that met all details of the procedures for applying the regulations.

Instantaneous water temperature ranged from around 5 to over 21 C. Available temperature criteria for a class B-2 river like the Little Bighorn are focused on point source discharges and are not easily applied to SEI data. However, we feel that episodic temperatures in 2007-2010 were generally not excessively hot or cold for a low-gradient river like the Little Bighorn.

For an additional analyses of water temperature data collected in the Little Bighorn using the SEI protocol, from the NPS WRD gauge and from the USGS Hardin, MT gauge, please refer Schweiger et al's. (2012) full report.

Specific conductance (SC) ranged from 378 to 767 µS/cm with a median around 527 µS/cm. Specific conductance was marginally inversely related with discharge (as measured at the Hardin gauge; r = -0.59, p = 0.09, N = 12), with maximum conductance during low-flow conditions. Similar models for data from the nearby Tongue River watershed (US EPA 2007) suggest that the relationship between flow and SC varies depending on the magnitude of the flow with a positive relationship at low flow and a negative relationship at high flows. This may be due to groundwater forming a larger component of streamflow during low-flow conditions. Ground water often has higher concentrations of dissolved solids (and hence higher conductance) than surface water due to longer rock-water interaction time. While instantaneous maximum SC at the Monument was fairly high, it did not exceed the maximum criteria.

Dissolved oxygen was above the standard (where above the threshold in this case is a good thing) other than a late summer reading in 2010 which was below the 1 day minima for early life stages. It is unlikely that this was a biologically important exceedance that resulted in any fish kills (we know of none). In general, DO concentrations were greater during winter and spring and decreased in late summer (although our sample size by season is very small) when water temperatures and biological respiration in the river is increased.

Finally, although it was not meaningfully outside of the range set by MT DEQ, pH was somewhat basic.

Major Constituents

Major dissolved anions and cations were dominated by calcium, bicarbonate and sulfate. Alkalinity ranged from 189 to 239 mg/L, indicating that the Little Bighorn was well buffered. There are few established MT DEQ criteria for anions and cations and no SEI data from the Monument approached the threshold (for Fluoride) that does exist. Sulfate and chloride are both important indicators of possible anthropogenic disturbance (i.e., Biggs et al 2004), but there are likely not meaningful concentrations of sulfate or chloride at the Monument.

Using data from the late 1990s, Mast (2007) suggested that concentrations of most major constituents were lowest during high flow when there were large contributions of dilute snowmelt to the river. We see similar patterns across season in the 2007 – 2010 SEI data, although both studies had small sample sizes.

Nutrients

Nutrients collected included several forms of nitrogen (ammonium, nitrite + nitrate, total nitrogen, etc.) phosphorous (total and biologically available orthophosphate) and organic carbon. In general, concentrations were low and near detection limits, with little to no indication of eutrophication. The maximum values for nitrite + nitrate did exceed the chronic aquatic-life criteria once, but we feel this likely had few ecological implications and in general the near oligotrophic conditions for the river were somewhat of a surprise.

Metals in Water

Metals rarely occurred in detectable amounts in SEI samples during 2007 - 2010. Low trace-element concentrations may reflect a lack of urban and mining areas upstream or a more basic stream-water pH that can reduce the measurable metals in the water column. However, total aluminum, dissolved and total barium, total iron and dissolved and total manganese were detected in most samples and total iron and manganese were above their aquatic life criteria. We suspect that this reflects natural geology in the watershed.

Metals in Sediment

Although there were detectable amounts of nearly all measured metals in SEI samples from the surficial sediments of the Little Bighorn they were all below criteria TEC and PEC concentrations. Of note, the total mercury was not detected in any sample. Because the primary toxic form of mercury is methylmercury, total mercury-based toxicity estimates are not expected to be highly accurate.

Several factors suggest caution when interpreting the metals in sediment data. Most importantly, we have a very small sample size and our samples are episodic and not connected to events like storms that might mobilize metals. SEI sediment samples are composited across multiple depositional areas along the sample reach (where fine grained sediments collect) but concentrations of trace elements in fine grained sediments vary considerably in space and time due to patterns in streambed/streambank erosion and deposition of streambed material. Samples from riffles (where we generally cannot collect sediments) have concentrations of metals often 30 to 40 percent lower than in depositional areas (MacDonald et al 2000). Riffles are often key habitat for benthos, diatoms and fish. Finally, patterns among sediment metal concentrations, discharge and season were difficult to resolve in SEI data given very small sample sizes and these patterns will have to be examined with more data in the future.

Stream Productivity

Finally, neither chlorophyll-a or AFDM (both derived from benthic periphyton samples) were suggestive of any nutrient issues, with no values approaching the MT DEQ criteria (Suplee et al 2008; MT DEQ 2011). As with nutrients, MT DEQ criteria are only applicable during base flow (low temperatures in winter and high flow events during spring runoff tend to mute the local effects of eutrophication). The 2007 sample may have been after the time period for peak algal biomass (when it is an indicator of nutrient problems; Biggs 1996; Stevenson 1996) so our interpretation of these data should be viewed with caution. Moreover, we use nutrient assessment support criteria from MT DEQ (2011) for two level 4 ecoregions within the Northwestern Great Plains Ecoregion that do not include the Monument.

Overall Water/Sediment Physiochemistry Condition and Trend Summary

The status of water and sediment physiochemistry at the Monument in 2007 – 2010 was generally good, with few exceedances of MT DEQ criteria or meaningfully elevated concentrations of the sampled constituents. Dissolved oxygen did have an instantaneous minimum below warm water criteria but we saw no evidence of any ecological consequences from this and more detailed data are required to confirm this issue. Nutrient (nitrite + nitrate) concentrations only once and very marginally exceed criteria. While this suggests that there are no or few nutrient issues at the Monument, following MT DEQ (2011) more robust data may be needed to confirm this. Metal concentrations in water and in sediment were generally low and often non-detectable. Two constituents (iron and manganese) did have values above MT DEQ criteria but we suspect the source of this is natural. Sulfate, often used as general indicator of anthropogenic disturbance, was higher at the Monument than the median value across sites in the Northwestern Great Plains ecoregion (from data collected in 2000 – 2004 as part of the EMAP program; Stoddard et al 2005). While there are no MT DEQ criteria for this constituent, this may suggest that land use activities in the watershed of the Little Bighorn may have had a minor impact on the water quality at the Monument in 2007 - 2010.

The results from the trend models indicate that there are complex patterns in water quality over the last two or three decades at Hardin (and likely the Monument). In particular, an increasing trend in stream water temperature (while a small slope) reflects a possible increase of 2 or 3 degrees C over three decades that likely has or will have real biological consequences. Similarly, the decrease in conductivity from 1970 to 2010 is fairly large, suggesting it likely reflects real a meaningful (and improving) trend in water physiochemistry. Several species of nitrogen showed small but significant increasing trends

– but these data have not been collected since 1999. This may reflect increasing agricultural land uses in the 1990s.

Hydrology: Stream Flow

Given the distance between the Monument and USGS Hardin gauge (more than 30 river miles) we first compared stream flow at the two locations using USGS and NPS data from the WRD gauge at the Monument (we do not use these data to describe hydrology at the Monument as NPS WRD considers them provisional, but they are adequate for this comparison). Figure 4.6.4-1 shows a simple linear model between the two time series using daily mean discharge on days the gauges ran concurrently. The fit between the two data sets is strong, with a Pearson correlation of 0.95 (non-parametric models were similar) and an R^2 of 0.9. Interestingly, discharge diverges more as flow increases - perhaps reflecting more localized effects of debris jams or the tendency for high flows to be estimated. We interpret these results as suggesting it is generally acceptable to use the Hardin gauge for long term trend analyses of discharge on the Little Bighorn River at the Monument.

In terms of total discharge, 2008 was a wet water year, while 2009 and 2010 were slightly dryer than average. However, median stream flow across all years we analyzed was similar to the 30 year normal. Seasonal patterns were fairly typical for larger rivers on the eastern plains of Montana with a discharge peak in May to June driven by snowmelt and spring rains. Streamflow decreased rapidly through July and was lowest in August and September due to low precipitation rates and high rates of evapotranspiration. During summer months, water also is diverted from the river for irrigation. The 2008 water year was more variable than the historic average with higher peak flows and more variation in flow. During the 2009 and 2010 water years, maximum flow occurred later in the year and the midpoint of flows also shifted to later in the year. Minimum flows were higher in these three years perhaps due to apparent dewatering periods in the early 1960s and 2000s that lowered the historic mean minimum flow.

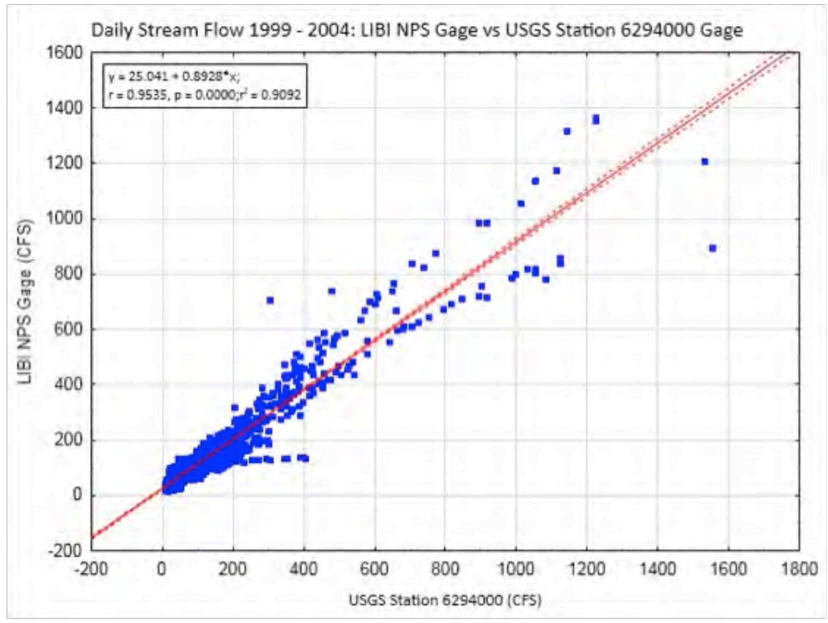

Figure 4.6.4-1 Linear model comparing daily mean stream discharge at the NPS WRD gauge in the Monument with the USGS gauge in Hardin, MT from 1999-2004.

When discharge data from the Hardin gauge were adjusted for seasonal patterns and tested for longer term trends there was a marginal ($p = 0.10$) negative trend of -0.71 cfs/year. The slightly dryer years (in terms of total streamflow and/or median flows) of 2008 – 2010 fit this pattern.

Montana is in the process of developing numeric stream flow criteria. Given the current lack of state criteria and the complexity of streamflow (and the amount of data analysis required to understand it) it is difficult to make any firm conclusions about stream flow during the SEI pilot.

Biological Communities

Due to high flow and unsafe conditions, biological samples (macroinvertebrates and periphyton) were collected in 2007 using an ad hoc arrangement of 11 subsample locations, spread across a variety of macrohabitats within the SEI sample reach at the Monument. Because many of the same methods (net mesh size, time of each sample, periphyton collection details, etc.) were used in these sample events we feel that the samples are sufficiently similar and treat the two data sets equivalently in most interpretation. No biological data was collected in 2008.

Table 4.6.4-2. Summary of core macroinvertebrate metrics for LIBI sentinel site on the Little Bighorn River in Little Bighorn National Battlefield Monument, 2007 – 2010. Bold values indicate metrics that exceed an impairment criteria or threshold and are not within a reference condition.

Metric	Base flow summer, 2007	Base flow summer, 2009	EMAP S:N
Plains Multimetric Index	46[1]	58	2.95
RIVPACS O:E (P > 0.5, P > 0.0)	**0.27,**1.0	**0.68,**1.2	1.44
RIVPACS BC (P > 0.5, P > 0.0)	0.68, 0.78	0.35,1.0	--
Plains Multimetric Index (classic)	70	90	--
Karr Benthic Index of Biotic Integrity	40	60	--
Hilsenhoff Biotic Index (Nutrients)	5.0	5.0	1.3
Fine Sediment Biotic Index	**2.8**	4.1	--
Temperature Index	18.2	18.0	--
Metal Tolerance Index	4.71	4.09	--
EPT Taxa Richness	8	15	2.02
Percent Tanypodinae	0	1.7	--
Percent Orthocladiinae of Chironomidae	0	41	--
Predator Taxa Richness	6	8	0.83
Percent Filterers and Collectors	96	82	0.51

[1] Midges in the 2007 LIBI sample were mistakenly not identified past family. Because the two component metrics of the overall MMI that depend upon midges being identified to at least subfamily (genus is preferred) respond in opposite ways to increased stress we elected to retain the current MMI in 2007 but results should be treated with caution;

Macroinvertebrates

In general, the macroinvertebrate bioassessment metrics currently used by MT DEQ suggest that the Little Bighorn in the Monument may have had reduced ecological integrity in 2007 and 2009 (Table 4.6.4-2). Results did vary across metric and years, indicating there was a meaningful amount of variation in the response or potential shortcomings in the data or application of the models.

The current MMI model used by MT DEQ indicated that macroinvertebrate communities were in a reference state in both years. This suggests that the suite of attributes of the macroinvertebrate assemblage summarized in the Monument's MMI was more characteristic of a reference condition system. However, the ratio of observed to expected taxa (O:E) from the RIVPACS model was well below MT DEQ criteria in 2007. In 2009 the value was higher and closer to the criteria value, but still not in a reference range. This suggests that the taxa list observed in the Little Bighorn differs from taxa expected in a reference site, or that there are "missing" species. The BC metric (again using only common species) mirrored this pattern.

MT DEQ guidance for resolving these sorts of mismatched results leads to the general conclusion that the benthos assemblage was not in a reference state. This is supported by the scoring of all macroinvertebrate metrics in a non-reference category when compared to ecoregion reference thresholds. However, most classic metrics scored the assemblage as reference and the RIVPACS results switch when all (or rare) species are used which may suggest that there are rare taxa in the Monument assemblage that are more typical of reference conditions. There is also some concern by MT DEQ and other partners that the current bioassessment metrics for the eastern plains of Montana are not entirely useful and there is ongoing research to improve these. We therefore have low confidence in this conclusion.

The S:N of the MMI metric was acceptable within the EMAP program, with relatively high values suggesting that the metric may be estimating conditions in the Little Bighorn at the Monument with acceptable precision. The S:N value for the O:E metric; however, was not as high.

The Plains Multimetric Index (Bukantis 1998; MT DEQ 2005) in 2009 and 2007 was within the reference region or near the upper end of the intermediate class (respectively) suggesting full or partial support of designated uses and no or moderate impairment. The component metrics in the classic Plains Multimetric Index differ from those in the current model, with the more recent model likely providing a more reliable index to condition (Jessup et al 2006). Similarly, the Karr Benthic Index of Biotic Integrity (Karr 1998) in 2009 and 2007 was within the "excellent" or "good" class (respectively). The Karr metric was originally calibrated for the Pacific Northwest and so it may not be well suited for the disturbance regime and river type at the Monument. Nevertheless, it has been successfully used across the west and we include it here for comparative purposes. These results are similar to the patterns seen with the current MMI, but not the RIVPACS metrics (O:E and BC) when only common species are used.

Hilsenhoff Biotic Index (HBI) (Hilsenhoff 1987) is an index of stream nutrient concentration based on tolerance values of a large number of macroinvertebrate taxa to organic pollution (Barbour et al. 1999). HBI is calculated as a weighted average tolerance value of all individuals in a sample. Higher index values indicate increasing tolerance to nutrient concentration. MT DEQ and EPA recently carried out an analysis using Montana data to examine the relationship between stream nutrient concentrations and benthic macroinvertebrate metrics (Zheng 2009); however, criteria developed from these models are not likely relevant for rivers like the Little Bighorn. Therefore, we use other thresholds from Hilsenhoff (1987). These suggest nutrient impairment was in the "Good, some organic pollution" class in both years at the Monument, suggesting that there were not excessively high nutrient concentrations in the Little Bighorn River. This matches water chemistry and diatom data. Nutrient pollution can be a widespread and significant stressor in rivers and watersheds like the Little Bighorn. However, impacts attributable to nutrients have declined over the past 16 years at most monitoring sites (McGuire 2010). Interestingly, there appears to be a complex interaction between metals and nutrients. Often, when the impacts of metal concentrations on the benthic community are reduced, a pulse of nutrient impairment is seen. Future monitoring will keep this in mind.

The Fine Sediment Biotic Index (FSBI) metric is another tolerance based index that describes the response within the benthic community to fine sediment (Relyea et al 2000). Lower scores indicate a community with more taxa capable of persisting in systems with higher levels of fines. It was developed for the north western US from 561 streams. While potentially more relevant to smaller mountain streams the model does include rivers from ecoregions similar to the Monument and many taxa included in the effort occur in Monument samples. FSBI results for both years at the Monument were in the lowest or second class (out of four) indicating that the benthos assemblage consisted of taxa that were moderately to very tolerant of fine sediment. However, at least in 2007, this does not match SEI habitat data for small sediment (see above), indicating that either the FSBI is not well suited to the Monument or that there was perhaps a temporal (habitat data are from 2009) or spatial (2007 benthos data came from an ad hoc set of subsample locations) disconnect in the two types of data. The response of the macroinvertebrate community to fine sediment is generally similar to diatom metrics for sediment (see below).

The Temperature Index results are slightly below the mean August temperature at the Monument of around 22 degrees C from SEI and USGS temperature data). There are no thresholds for the Temperature Index and MT DEQ does not use it in any formal way. Previous monitoring in and near the Little Bighorn (Bollman and Teply 2006) has used this metric as evidence of possible dewatering and/or thermal stress (metric values were above measured or expected temperatures). There are periods of dewatering on the Little

Table 4.6.4-3. Summary of core periphyton metrics for the sentinel site on the Little Bighorn River in Little Bighorn Battlefield NM, 2007 – 2010. Bold values indicate metrics that exceed the most impaired level of a criteria or threshold.

Metric	Base flow summer, 2007	Base flow summer, 2009
Sediment Increasers, Warm Water (PRA, prob.)	**25.6, 65.6**	**56.8, 95**
Nutrient Increasers, Warm Water (PRA, prob.)	3.9, 28.2	**13.8, 57.1**
Shannon Diversity	4.5	4.4
Siltation Index	36.7	29.7
Pollution Index	2.27	2.51
Montana Diatom Multimetric Index	4	4

Bighorn in the long term hydrology data set, but no evidence of this in the last decade or so.

Finally, the Metals Tolerance Index (MTI) indicated little to no moderate metal impairment in 2007 and 2009. The thresholds for this metric were developed for the Clark Fork River (McGuire 2009) and should be applied with caution to the Little Bighorn, When coupled with the lack of metal signal in SEI sediment chemistry data, we are confident that there are few if any metal issues at the Monument. Moreover, the MTI generally matches the results from diatom metal metrics (see below).

A few midge and mayfly taxa that filter food from the water column were fairly common in 2007 and 2009. Generalists, such as collectors and filterers, have a broader range of acceptable food materials than specialists and thus are more tolerant to pollution that might alter availability of certain foods. The richness of EPT taxa is generally sensitive to pollution. In 2007, EPT richness was very low and somewhat low in 2009 Moreover, there were no Plecoptera (stoneflies) in either collection. Notably, the sediment metric was in the non-reference or second to lowest category, suggesting that there may be some sediment issues within the Little Bighorn at the Monument.

We report S:N values from data sampled during 2000 - 2004 by EMAP at 1524 sites across the western US states and 90 repeat visits. We do this for select SEI biological responses collected at the Monument where we use the same methods as EMAP. Because this approach assumes that SEI crews perform identical to EMAP crews and that there is no systemic difference in the years used (2000-2004 vs. 2008-2010) we only use the EMAP S:N as rough guides (Note that there are EMAP sites in this data set near the Monument).

Periphyton

Diatom assemblages also suggest that there were some non-reference conditions in the Little Bighorn at the Monument during 2007 and 2009, with several departures from current reference criteria (Table 4.6.4-3). Diatoms (along with input from the surrounding floodplain) are the base of the food chain in rivers like the Little Bighorn and the impacted diatom community may be one of the reasons why we also see lower quality macroinvertebrate assemblage in the river (many of which graze on the diatoms).

Northwestern Great Plains Ecoregion Warm Water Sediment and Nutrient Increasers (Current)

Diatom samples were evaluated to determine the probability of sediment or nutrient impairment based on current MT DEQ models of the abundance of sediment and nutrient increaser taxa. We found 6 and 8 (2007 and 2009, respectively) sediment increaser taxa, representing a percent relative abundance in these two samples of around 26 and 57%. There were 4 and 7 species on the nutrient increaser list in the two samples. Research by Teply (2010a, b) suggests these diatom species have autecological affinities that make them suitable indicators of sediment or nutrients in the ecoregion. For sediment, the abundances suggest that the Little Bighorn had about a 66 and 95 percent probability of being impaired due to sediment in 2007 and 2009, respectively. For nutrients, the abundance of increasers suggests that there was about a 28 and 57 percent probability of being impaired due to nutrients in the two sample periods.

These impairment probabilities are based on evidence of taxa associated with sediment or nutrient-impaired streams and rivers in the Northwestern Great Plains ecoregion. For sediment, both relative abundances and impairment probabilities exceeded MT DEQ thresholds suggesting a consistent and strong sediment response in the diatom community at the Monument. This generally matches the sediment response in macroinvertebrates. For nutrients, the 2007 sample did not indicate a strong response but in 2009 the relative abundance and impairment probability marginally exceeded MT DEQ thresholds suggesting a variable and somewhat minor nutrient response in the diatom community. Both of these general match the strong sediment and minor nutrient signal seen in the macroinvertebrate community (Table 4.6.4-2) and, for nutrients, in the water chemistry data (Table 4.6.4-1). The sediment response also is similar to diatom metric data presented by Bahls (2006) for the Bighorn River near Hardin where there was also a high probability of sediment impairment.

Interestingly, we did not see a marked sediment issue within our habitat data (not included in this NRCA section). We believe this reflects a methodological challenge or incongruence in how habitat and periphyton data are collected and analyzed. Periphyton data are only collected from the littoral areas of the river as it is unsafe (or impossible) to sample deep water habitat. In contrast to other treatments of habitat data (i.e., Stoddard et al 2005), we elected to include substrate data from the thalweg in our habitat metrics. This is appropriate for rives like the Little Bighorn where there can be a meaningful amount of larger substrates in the middle of the channel. Had we constructed sediment metrics using only littoral data we would have seen higher cover of fine sediments (providing a better fit to the sediment increaser metric). So, at the whole river scale, there are more large sediments in the system, but when restricted to the shoreline, there are possible excessive fines as seen in the diatom increaser response.

Note that sediment increaser taxa do not discriminate other causes of impairment and this result does not indicate whether the Little Bighorn may or may not be impaired due to other causes. Moreover, NPS cannot make any statement as to whether this indicates the river meets designated uses. However, given the lack of numeric State standards for sediment impairment, these results offer an important piece of evidence in the assessment of SEI data from the Little Bighorn. Sediment is a serious issue in Montana with about half of the impaired streams in Montana impacted by sediment – either solely or in combination with other causes (Teply 2010a, b).

Classic and Disturbance Specific Metrics

Bahls (1993) develops diatom metrics that were used by the state in support of monitoring and assessment for nearly a decade. However, Teply and Bahls (2005) show that these metrics have relatively low capacity to discriminate impairment. Therefore, following MT DEQ guidance, we use these results only in a general way to help interpret the composition and condition of the diatom community at the Monument and as possible confirmation (or not) of the increaser metric results given above.

There were no exceedances of the criteria for any of these metrics during either sample event at the Monument. While some metrics scores fell within intermediate classes of impairment, most were actually well within the highest quality range (Table 4.6.4-3). Shannon's diversity was well above the reference threshold of 2.5, suggesting that the diatom community included a large number of species with generally equitable distributions. This implies that the species replacement seen in the increaser metrics (i.e., more sediment tolerant species) may not have adversely affected overall diversity. The siltation index was above the impairment criteria but did indicate partial support. Likewise, the pollution index (organic enrichment) was above the reference criteria. MT DEQ (2005) presented methods (based on Bahls (1993)) that combined these three metrics into a MMI-like synthetic index of stream condition. Applying this to the Monument's data suggested that diatom communities were intact with good biological integrity and no overall impairment.

Interpretation of Taxonomic Composition

In the next section we discuss select specific taxa within the samples (i.e. Bollman and Bowman 2007; Teply 2006). Using the autecology of the dominant species in the samples allows additional interpretation and may help resolve the cause of any impairment.

A complete taxa list with counts and relative abundance values is given in Appendix D in the full report (Schweiger et al. 2012). We collected 108 unique taxa (largely identified to species) over the two sample events. Community composition in the two periphyton samples fwas fairly typical for the recent Little Bighorn River (L. Bahls, pers. comm.).

Non-Diatom Algae

The periphyton community at the Monument consisted of diatoms, cyanobacteria, green and red algae. The cyanophytes (blue-green algae) *Homoeothrix janthina, Anabaena* and *Leptolyngbya* were the most abundant soft bodied taxa, ranging in relative abundance from 11 to 47%. Potapova (2005) presents water chemistry optima for several species of soft bodied algae including *Homoeothrix janthina*. This species tends to occur at sites with relatively good water quality with larger substrates but moderately high total nitrogen perhaps due to the absence of heterocytes in this organism, and therefore to its inability to fix free nitrogen. However, the red algae genus *Phormidium*, which contains several pollution-tolerant species, was also common at 12% relative abundance. Diatoms ranked first in biovolume for both sample events at over 50% and coupled with the less well resolved tolerances for soft bodied algae in Montana streams we focus on diatoms in SEI monitoring.

Diatoms

The taxa with highest total count and relative abundance across both samples was *Epithemia sorex* at 25% relative abundance. It is on the Teply and Bahls (2005) sediment and nutrient increaser lists for the Montana plains and on the current Teply (2010b) warm water ecoregions sediment increaser list. *E. sorex* is eutraphentic (prefers nutrient-enriched, eutrophic waters) and requires fairly high levels of dissolved oxygen. Its presence can suggest impairment by inorganic nutrients but probably little or no impairment by organic nutrients. It is frequently very abundant as an epiphyte on *Cladophora* and other coarse filamentous algae in western rivers that are nitrogen limited. *Diatoma moniliformis* was also common in both years, with a relative abundance of 16 to 20%. *D. moniliformis* is a fairly common species across the west. It is on the Teply and Bahls 2005 sediment and nutrient increaser lists for the for the Montana plains and on the current Teply (2010b) warm water ecoregions sediment increaser list. It tends to occur in systems with mid to high levels of fine sediment (as measured by percent embeddedness; data from Stoddard et al (2005) as analyzed and presented in Spaulding (2010)). The high abundances of these species (especially *E. sorex* and *D. moniliformis*) are the primary reason why the sediment increaser metric was so high, especially in 2009.

Nitzschia dissipata was relatively common in 2007. It is on the Teply and Bahls 2005 sediment and nutrient increaser lists for the Montana plains. However, it was removed from the increaser lists by the more reliable Teply (2010) models and data from Stoddard et al (2005) analyzed and presented on Spaulding (2010) suggest a fairly strong preference for systems with less overall anthropogenic disturbance. This species is motile and can deal with mobile sand grains and increased fines. It favors slower current velocities where sediments are prone to accumulate.

Finally, *Cocconeis pediculus* was relatively abundant in 2009. Like *E. sorex*, this species is primarily an epiphyte on *Cladophora* sp. (a filamentous green algae), which prospers mainly in nutrient-rich waters with slow to moderate current velocities where sedimentation is an issue.

Aquatic Invasive Species

There were no known zebra/quagga mussel or rusty crayfish occurrences in or near the Little Bighorn watershed (the mussels have been found outside Rocky Mountain National Park and the crayfish on the western slope of Colorado). There are no known current New Zealand mudsnail populations at the Monument, but mudsnails have been documented on the Bighorn mainstem below the Monument's sister park, Bighorn Canyon National Recreation Area. As of 2011 there were no known current populations of didymo (*Didymosphenia geminata)* on the Little Bighorn. *Didymo* is a diatom native to mountain habitats of North America and Europe (Blanco and Ector 2009). In recent years didymo has expanded into lower elevations, latitudes, and new regions of the globe (Kumar et al. 2009).

In general, patterns across bioassessment metrics were complex but the weight of evidence from all of the models used suggests that the Little Bighorn had somewhat reduced ecological integrity in 2007 and 2009, especially with regards to sediment impairment. However, there were no occurrences of any aquatic invasive species.

Trends in Biology

With sufficient data over time, we will be better able to estimate trends in our biological responses and relate these to relevant drivers, especially climate. Given the frequency at which we are able to afford SEI monitoring in the Monument this may take several more years.

Key Uncertainties

Physiochemistry Caveats:

There are two important caveats on SEI physiochemistry results:

- First, water physiochemistry is naturally variable seasonally or even daily and may be best measured more frequently than we can afford within SEI monitoring. It is possible that there are meaningful short term pulses in nutrients or major ions or diel fluctuations in field parameters like dissolved oxygen that we are not capturing using the SEI protocol. Similarly, while short term status is important it may not be as relevant as trends in these responses. A time series of SEI physiochemistry results will also allow more meaningful models of why a given parameter responds as it does (e.g., we may be able to determine key covariates or relate changes in chemistry to climate drivers or improvement/ degradation from the Superfund restoration process).
- Second, physiochemistry may be best interpreted as a stressor or driver of biological condition and may not be the most informative way to assess the overall condition of the Little Bighorn at the Monument.

Bioassessment Caveats

There are a few important caveats on the SEI bioassessment results.

- First, it is sometimes difficult using biological metrics to be diagnostic or to ascribe a causal relationship between a biological response and a stressor. While not necessarily needed from a strict long term monitoring perspective focused on ecological integrity, knowing, at least in a correlative sense, what might be causing a lower quality biological status is useful for park management and interpretation for visitors. As we accrue more data and our understanding and modeling of the biological response in the Little Bighorn improves, we may be able to make more definitive statements about why a particular response is seen at the Monument.
- Second, while one of the primary strengths of biological data is integration of condition across time, it is possible that our data contains spurious results due to short term fluctuations in community structure (especially for diatoms). Similarly, we will need several more years to construct true trend models for these responses. Longer time series of SEI biological data will also allow more meaningful models of why a

given aspect of the community responds as it does.

- Third, the bioassessment models we use are imperfect. As with any model, there is error and uncertainty associated with data sampling and processing, model calibration, validation, and model use. The current MT DEQ Plains MMI had a discrimination efficiency of 77 percent, indicating that the MMI was unable to distinguish between reference and degraded sites in approximately 23 percent of the samples – this is a bit low. Yet the Montana RIVPACS model is comparable to or better than most RIVPACS models in use in the USA and elsewhere. Good models typically have standard deviations in O:E less than 0.18. The Montana model was 0.17. Moreover, the model accounted for ~ 88% of the explainable variability in taxonomic composition among samples.

Threats

Streams are among the most significantly altered ecosystems in North America and face numerous and varied threats, including impacts from climate change, atmospheric deposition, altered hydrology, acid mine drainage, agriculture, pollution from boats, non-native species, erosion, improper sewage plant or drain field operations, and storm water runoff. Some of the day to day and long term management decisions at the Monument are least partially connected to the Little Bighorn River. It will be through the efforts of this long-term monitoring program that we will be able to continue to identify those threats to the quality of the Little Bighorn River.

Level of Confidence/

The level of confidence varied among indicators and even among different measures for the same indicator. For example, some measures for the same indicator have divergent patterns (i.e., one may be in a reference state and another is not). We qualitatively 'average out' this variance using our best professional judgment to derive an overall assessment for each category.

4.6.5. Sources of Expertise

The National Park Service Rocky Mountain Inventory and Monitoring Network's (ROMN) purpose is to develop and provide scientifically sound information on the current status and long-term trends in the composition, structure, and function of park ecosystems. As part of the NPS's effort to "improve park management through greater reliance on scientific knowledge," a primary role of the I&M Program is to collect, organize, and make available natural resource data and to contribute to the Service's institutional knowledge by facilitating the transformation of data into information through analysis, synthesis, and modeling of specific key "vital signs. The SEI protocol was developed by ROMN's Ecologist, William Schweiger (Schweiger et al. 2012b).

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4.7. Groundwater

Indicators/Measures

- Change in Groundwater Level

Condition - Trend - Confidence Level

Insufficient Data - Insufficient Data - Low

4.7.1. Background and Importance

Groundwater accounts for 1.7% of Earth's total water and 30.1% of Earth's freshwater (USGS 2012a). The overall trend in the United States is that as population increases, the amount of groundwater withdrawn also increases (Figure 4.7.1-1).

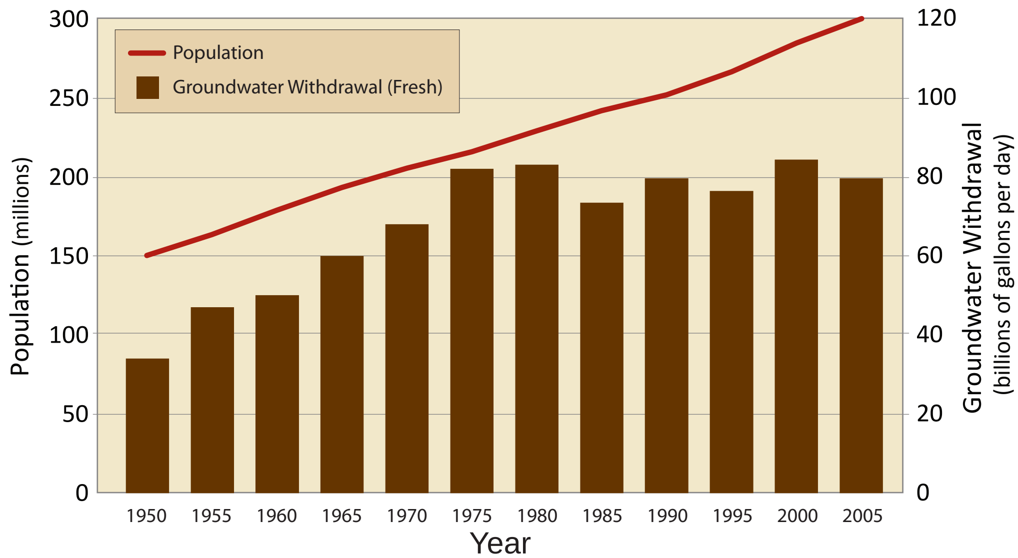
Long-term water-level declines caused by sustained groundwater pumping are a key issue associated with groundwater use, and many areas of the United States are experiencing groundwater depletion. More than half of Montana residents depend on groundwater for their primary water supply (Montana Watercourse 2012). Groundwater provides 94% of Montana's rural domestic-water supply and 39% of the public-water supply (Montana Natural Resource Information System 2012).

One environmental consequence to groundwater depletion is land subsidence, which is the settling or sinking of the Earth's surface. The increasing development of land and water resources threatens to exacerbate existing land-subsidence problems and initiate new ones throughout the United States (USGS 2012b).

NPS Management Policy 4.6.1 states that the NPS will perpetuate surface waters and groundwaters as integral components of park aquatic and terrestrial ecosystems (NPS 2006). It is the policy of the NPS to determine the quality of park surface and groundwater resources and avoid, whenever possible, the pollution of park waters by human activities occurring within and outside of parks.

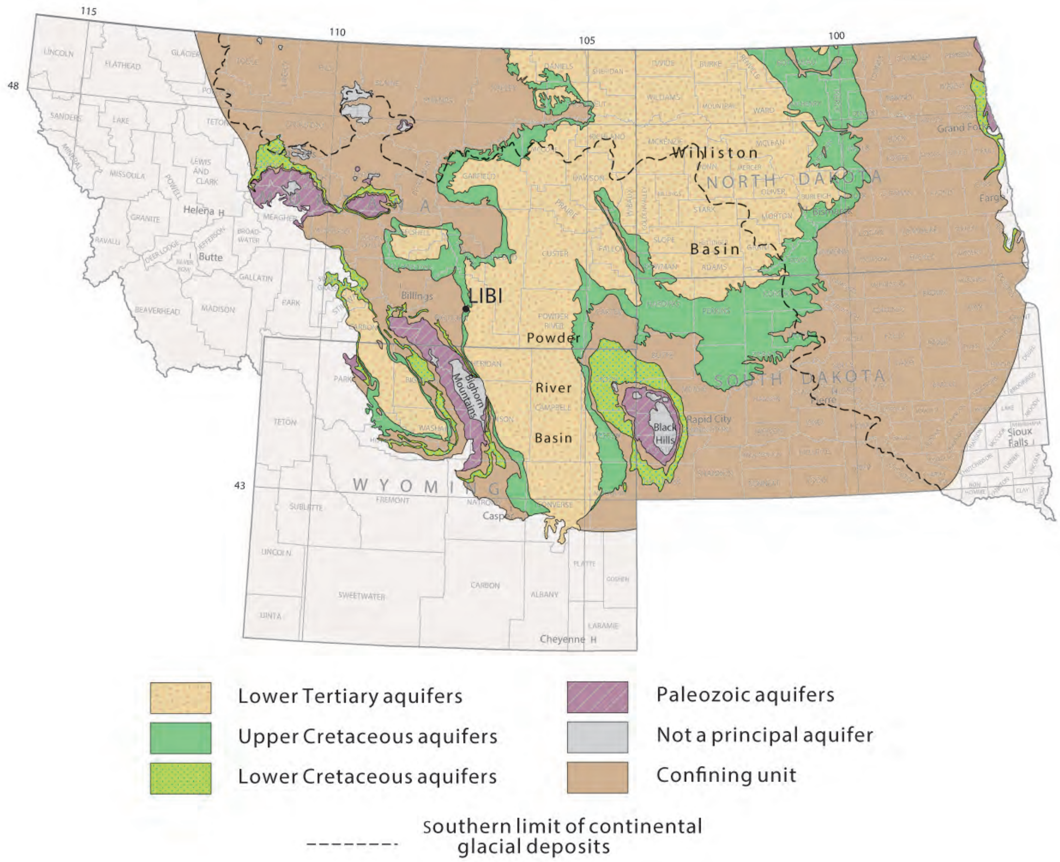
Aquifer Characteristics

The Northern Great Plains Aquifer System is comprised of five major aquifers and covers approximately 300,000 square miles in the United States alone, including eastern Montana (Figure 4.7.1-2) (USGS 2005a). The aquifer system lies mostly within two large basins-Williston and Powder River Basin, with Little Bighorn Battlefield National



Source: http://ga.water.usgs.gov/edu/wugw.html

Figure 4.7-1-1. Groundwater withdrawals for the United States, 1950–2005.



MAP SOURCE: HTTP://CAPP.WATER.USGS.GOV/GWA/CH_I/I-TEXT2.HTML#ETMON.CFM.

Figure 4.7.1-2. Northern Great Plains Aquifer System is a major aquifer that includes the region surrounding Little Bighorn Battlefield NM.

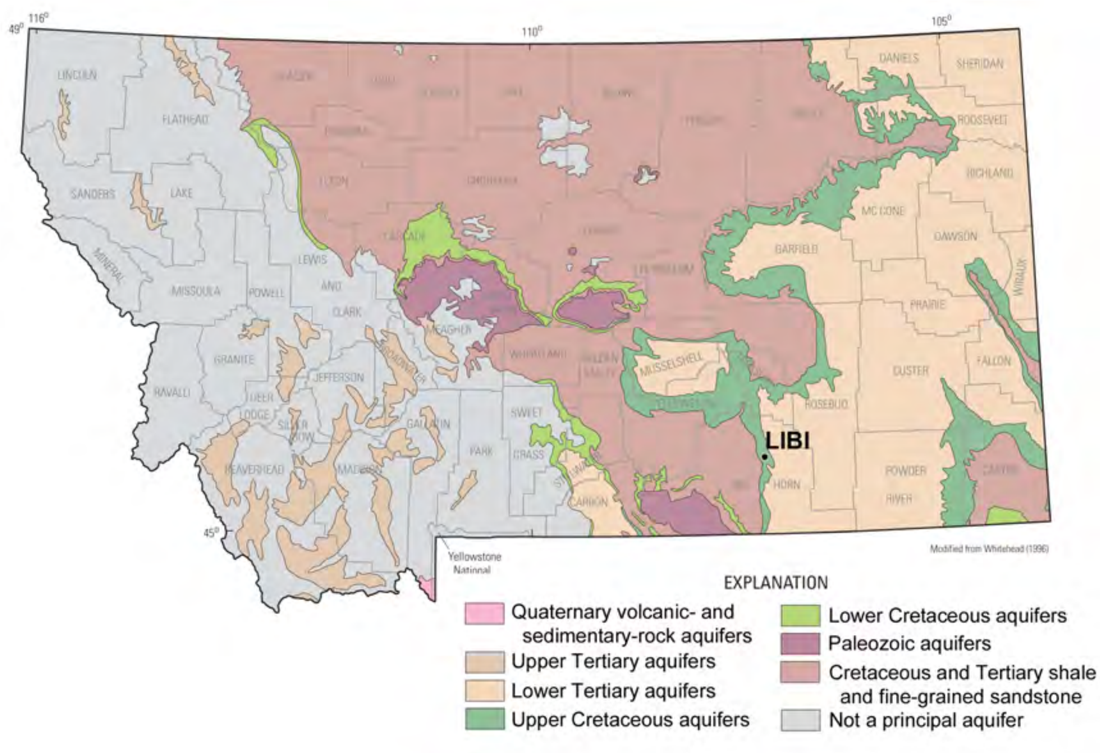
Monument situated within the Powder River Basin (USGS 2012c).

The major aquifers of the Northern Great Plains Aquifer System are comprised of sandstones of Tertiary and Cretaceous age and carbonate rocks of Paleozoic age (USGS 2005a). These five aquifers along with regional confining units throughout the System form one of the largest confined aquifer systems in the United States (USGS 2005a).

Unconsolidated glacial and alluvial deposits of Quaternary age, some of which are highly permeable, locally overlie the Northern Great Plains Aquifer System, but are not included in the major aquifer because the shallow groundwater flow in these deposits is very different from the deep, confined flow of the Northern Great Plains Aquifer System (USGS 2005a). It is this Quaternary alluvium, composed of unconsolidated sand, gravel, silt, and clay, along with Upper Cretaceous Judith River Formation, composed of sandstone and shale, that underlie an area of approximately 94 square miles, primarily located along the Little Bighorn River, including the area comprising the Monument (Figure 4.7.1-3) (Tuck 2003).

The thickness of the probable water-bearing zone within the Quaternary alluvium ranges from 2 to 39 feet, with a median thickness of 9 feet (Tuck 2003) and underlies the floodplains and adjacent terraces of the Little Bighorn River. Recharge to the alluvium is primarily through percolation of precipitation, excess water from irrigation, bank storage, subsurface inflow from Little Bighorn valley tributaries, and inflow from the underlying Judith River Formation (Tuck 2003). Discharge is primarily through evapotranspiration, well withdrawals, flow to irrigation drains, and subsurface outflow to the Little Bighorn River (Tuck 2003). Groundwater was estimated to contribute between 15-18% of the annual daily mean streamflow in water year 1995 of the Little Bighorn River near Hardin, MT (USGS 2005b)

The Judith River Formation is composed of an upper and lower sandstone member of 700



MAP SOURCE: USGS 2004.

Figure 4.7.1-3. General extent of near surface aquifers in Montana.

feet and 300 feet thicknesses, respectively and outcrops along or west of the Little Bighorn River, underlying most of the Quaternary alluvium throughout the valley (Tuck 2003). Similar to the alluvium deposit, recharge to the Judith River Formation is through percolation of precipitation, streamflow across outcrops, bank storage, canal leakage, and subsurface inflow from Quaternary high-terrace deposits. Discharge is primarily through upward subsurface outflow to the Quaternary alluvium and to the Little Bighorn River as well as from well withdrawals and evapotranspiration (Tuck 2003).

The groundwater from both the Quaternary alluvium and Judith River Formation is quite shallow (less than 100 feet below land surface) and is the primary water source for domestic and stock supplies throughout the area (Tuck 2003).

4.7.2. Data and Methods

Tuck (2003) collected hydrogeologic data between 1994-1995 by inventorying 192 existing wells and one spring along the Little Bighorn River within the Crow Indian Reservation (Figure 4.7.2-1). Several types of data were collected for each well, but the static water level is the attribute we are most interested in to assess the Monument's groundwater condition.

Tuck's (2003) groundwater level data included U.S. Geological Survey (USGS) National Water Information System data (http://nwis.waterdata.usgs.gov/usa/nwis/gwlevels/) (USGS 2012d), a national water database maintained to help determine if there has been any change in groundwater levels throughout the monitored wells.

Indicators/Measures

Change in Groundwater Level

Since groundwater storage is determined by aquifer characteristics and water levels within the aquifer, changes in storage are directly associated with changes in water levels. Rising water levels indicate increased storage, resulting from greater inflow than outflow, while declining water levels indicate that outflow exceeds inflow. Thus, change in groundwater level was used as the primary indicator for groundwater condition.

<u>USGS Groundwater Wells in the Monument</u>

One USGS monitored well, which is the Monument's only active well (D. Swanke,

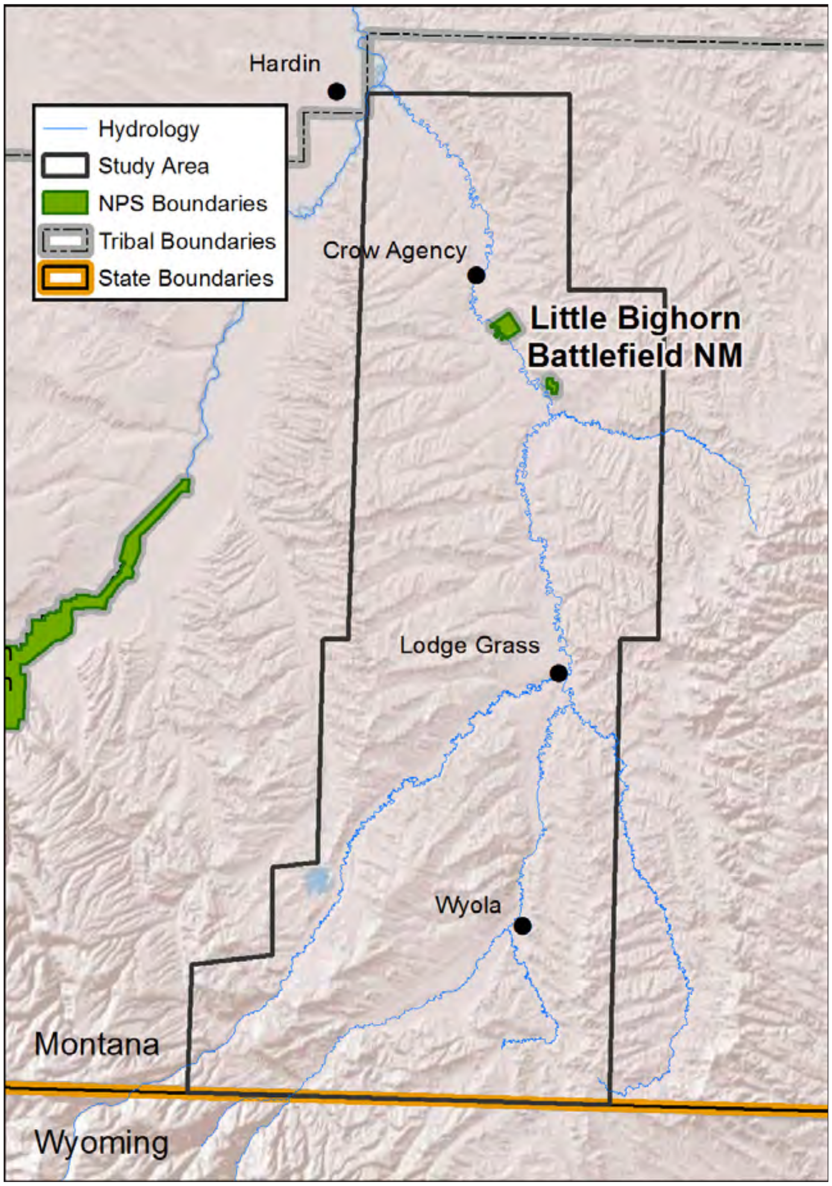


Figure 4.7.2-1. Tuck (2003) hydrogeologic study area (approximate boundary)

Superintendent, email comm.) is located in the Monument (Figure 4.7.2-2). The water level elevations and depths to water levels have been monitored at this for only two years -1953 and 1994.

Information pertaining to the well is listed in Table 4.7.2-1. The active well data were not graphed since only two years of data were collected. The two records include 3.31 m (10.87 ft) collected on 9/7/1953 and 2.59 m (8.51 ft) collected on 6/23/1994.

Tuck (2003) Hydrogeologic Data

Tuck (2003) gathered data from 193 groundwater and 27 surface water sites along the Little Bighorn River and its tributaries to describe the general geology and water resources of the Quaternary alluvium and the Upper Cretaceous Judith River Formation. Two of the groundwater sites were located in the Monument, with one being the current active well and the other site being an inactive well located by the cemetery. Tuck (2003) collected data on these wells during 1994 only and reported a static water level of 2.59 m (8.51 ft) for the Monument's active well and 44.60 m (146.33 ft) for the inactive well.

4.7.3. Reference Conditions

The reference condition we used for change in groundwater level is one of sustainability; where on average, supply meets demand. When supply meets demand, we expect variability that reflects annual variation in environmental conditions (e.g., rainfall, evapotranspiration, pumping), but lacks an overall long-term declining water level trend.

4.7.4. Condition and Trend

The thickness and extent of both the Judith River Formation and the alluvium varied throughout Tuck's 2003 study site, with water availability from these aquifers depending upon their thicknesses, extent of interstitial silt and clay, and amount of recharge (Tuck 2003). Since the Monument's active well is located in the Judith River Formation, most of the subsequent discussion will focus on the dynamics of that particular aquifer.

Table 4.7.2-1. USGS and active groundwater well located within Little Bighorn Battlefield NM's boundary.

Well	US Geological Survey ID	Years of Record	Depth of Well (ft)	Local Aquifer Description
Active Well	453358107262401	1953 & 1994 only	120	Parkman Sandstone of Montana Group, local aquifer

Judith River Formation

The majority of the Judith River Formation crops out to the west of the Little Bighorn River and dips to the southeast, east, and northeast due to structural deformation during the Bighorn Mountain uplift (Tuck 2003). The formation is comprised of two sandstone members: unnamed upper member that is approximately 700 feet of sandstone interbedded with sandy shale and shale and the lower, Parkman Sandstone Member, which is approximately 350 feet thick and also contains sandy shale (Tuck 2003). Groundwater in the Judith Formation can either be confined, unconfined, or leaky-confined depending upon the well location. Low well yields are typical within the formation due to laterally discontinuous materials and alternating layers of sedimentary materials within the formation (Richards 1955).

Infiltration and percolation recharge the formation primarily during the fall and winter before the ground freezes and during the early spring when evapotranspiration is minimal (Tuck 2003). In general, recharge from precipitation is most likely less than the annual amounts reported due to evaporation, transpiration, and soil retention.

Throughout some of the monitored wells, located in the formation (other than those within the Monument), water levels rose during the fall, winter, and spring, which may have been a result of above normal precipitation versus lack of use. However, according to Moulder et al. (1960), between the months of May-September, precipitation most likely doesn't substantially recharge the formation since evapotranspiration by crops and native vegetation usually exceeds precipitation during the growing season. The amount of recharge due to canal leakage or bank storage is unknown, however, Moulder et al. (1960) determined that the Monument's active well is affected by the Little Bighorn River stage. They further speculated that the Judith River Formation is hydraulically connected to the river where it crops out near the river and to the Quaternary alluvium near the Monument (Tuck 2003). Short-term water level changes in wells between Garryowen and the Monument also provide indirect evidence of the hydraulic connection between the two aquifers (Tuck 2003).

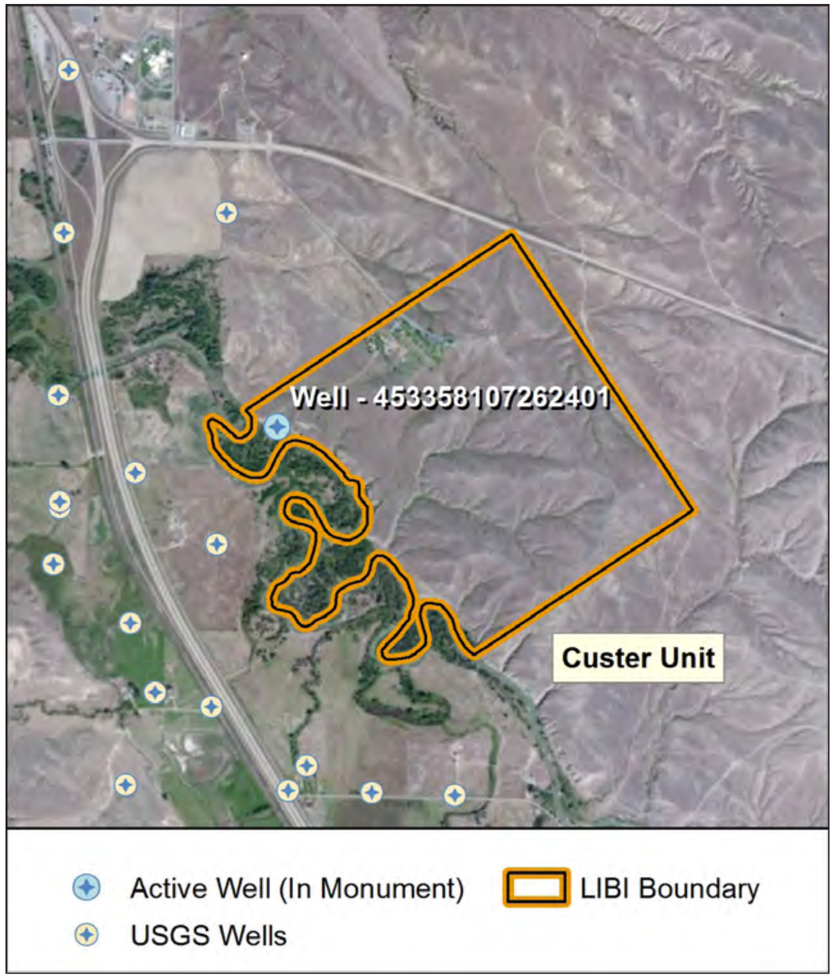


Figure 4.7.2-2. Active well location in the Monument. (Tuck 2003, USGS 2012d).

Discharge from the Judith River Formation occurs primarily through upward subsurface outflow to Quaternary alluvium and the Little Bighorn River, well withdrawals, and evapotranspiration (Tuck 2003). Where the formation crops out, and the depth of water is less than 15 feet, water most likely is discharged by evapotranspiration (Tuck 2003).

In 1995, above normal precipitation from March-October caused some well water levels to rise that were located in the Judith River Formation, making recharge greater than discharge during the 1995 growing season (Tuck 2003).

Overall, USGS groundwater data collected from the Monument's active and inactive well indicate a decrease in water levels (increasing depths to water) since 1977 and 1953, respectively.

Quaternary Alluvium
Many of the drillers' well logs for the thickness of the Quaternary alluvium aquifer ranged between 5 to 13 feet. In general, water levels rose in some wells during the fall, winter, and spring months and decreased from June-September, 1995 (Tuck 2003). Daily water-level fluctuations within the allluvium are common during the growing season due to evapotranspiration (Moulder 1960). Groundwater in the Quaternary alluvium is primarily used for domestic or stock watering purposes and believed to be hydraulically connected to the Judith River Formation near the Monument (Tuck 2003).

Water Use in Bighorn County Montana
According to the USGS (2000), Montana water use is higher from surface water withdrawals (5,000-10,000 million gallons/day) compared to groundwater withdrawals (0-2,000 million gallons/day). Irrigation accounts for Montana's largest withdrawal and consumptive use of water but is the lowest within the hydrologic unit (10080016) where the Monument is located at 252.65 million gallons/day (Figure 4.7.4-1) (USGS 2004). The largest groundwater withdrawal in Bighorn Bounty is for irrigation, which accounts for 2.58 million gallons/day or 1% of the total water withdrawal. However, this does not impact the Monument's groundwater since water from the Judith River Formation is not used for irrigation purposes (Tuck 2003). The next highest category of groundwater use in the county is for livestock at 1.05 million gallons/day. Even though less water is used for livestock operations compared to irrigation in Bighorn County, it is one of the highest withdrawal amounts for livestock in the state of Montana (Figure 4.7.4-2) (USGS 2004). The remaining categories and amounts of groundwater use in Bighorn County are shown in Figure (4.7.4-3).

Overall Condition/Trend
For assessing the condition of groundwater, we used one indicator/measure, which is summarized in Table 4.7.4-1. Based on the limited Monument-specific data available, we do not make a determination regarding groundwater condition or trend.

Key Uncertainties
A key uncertainty is the unknown extent of the Judith River Formation and the Quaternary alluvium aquifers. Many areas of the aquifers are discontinuous, but there is speculation that the Judith River Formation is hydrologically connected to the Little Bighorn River.

Threats
Even though groundwater withdrawals in Bighorn County may be significantly less than surface water withdrawals, excessive surface water use has the potential to decrease the amount of groundwater supply. We do not know the current supply and demand for groundwater in this area and cannot predict future development throughout the area.

In addition, groundwater levels typically react to climate depending upon precipitation or lack of (Patton 2006), and with climate change, groundwater levels most likely will also change.

4.7.5. Sources of Expertise
No groundwater experts were available for consultation.

4.7.6. Literature Cited
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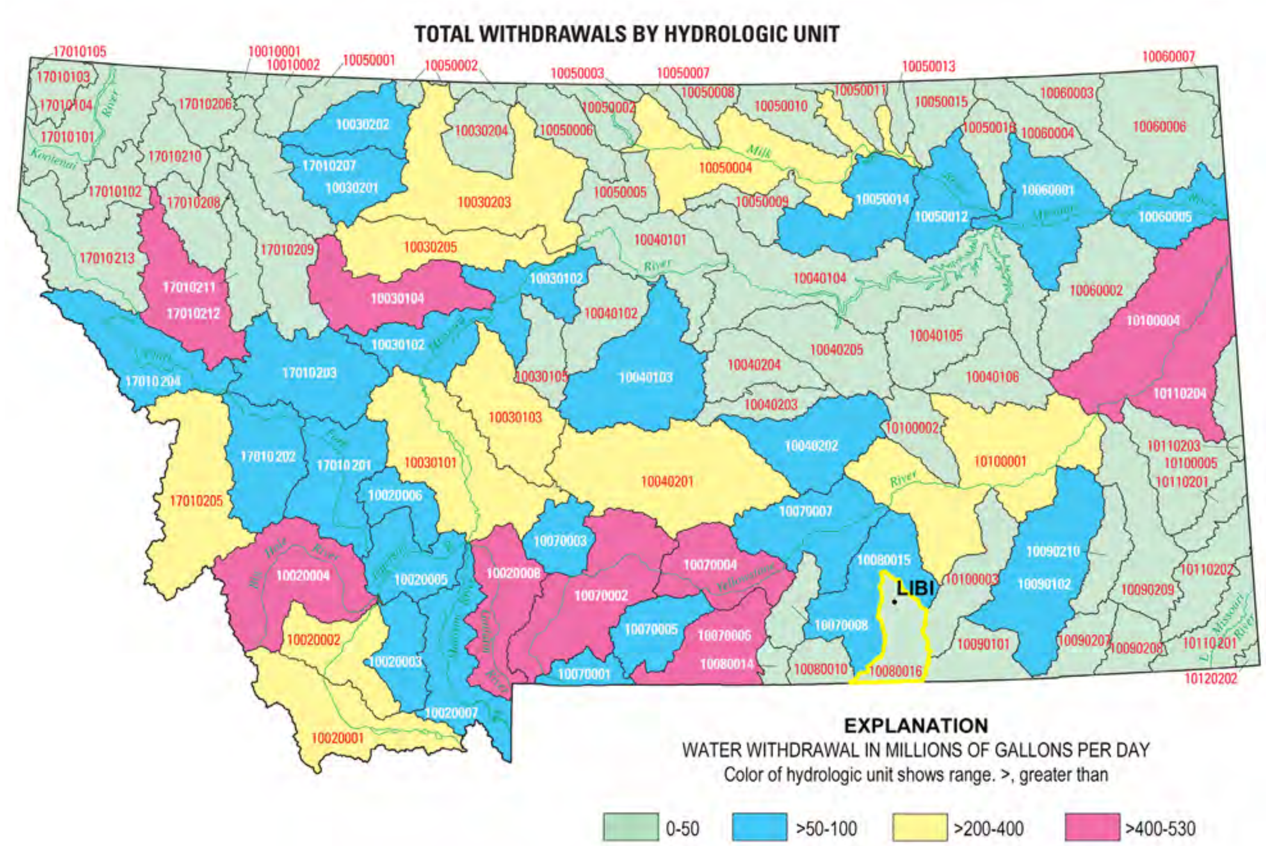

Figure 4.7.4-1. Montana water use by hydrologic unit. The Monument is located in the highlighted unit (USGS 2004).

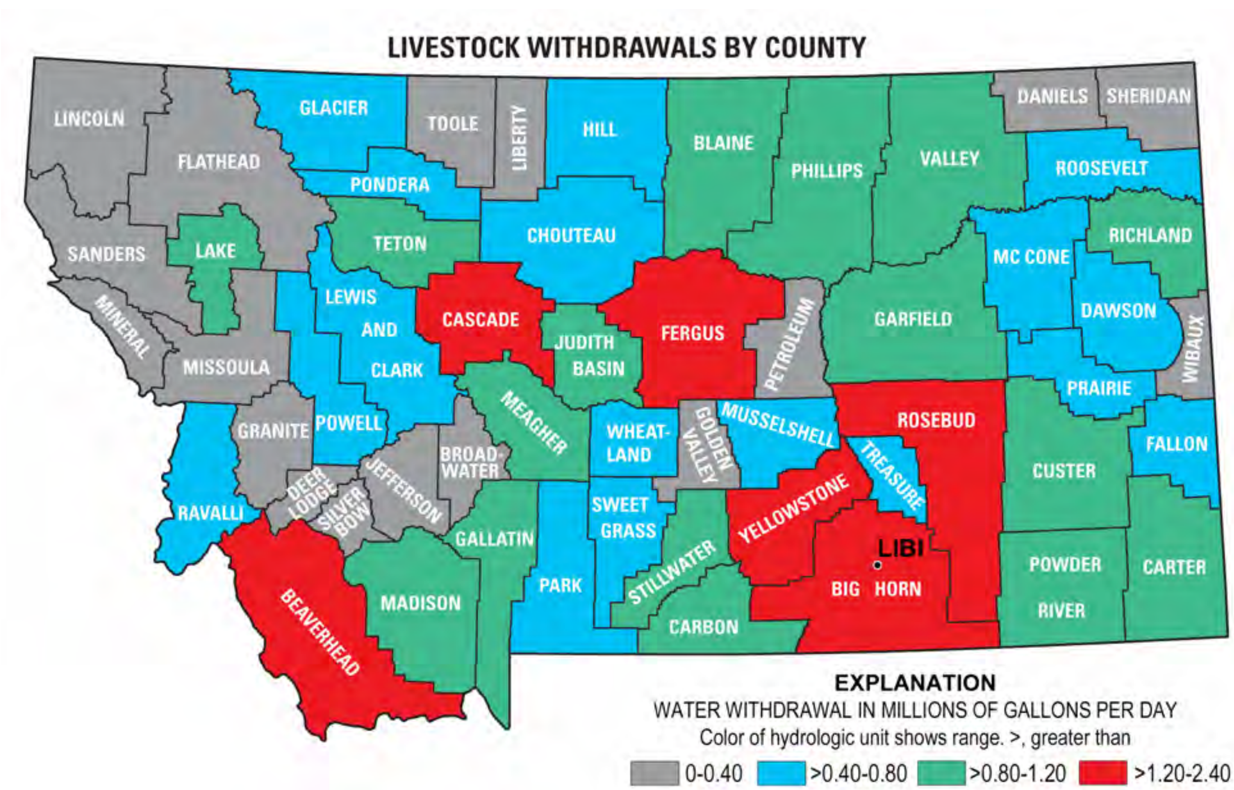

Figure 4.7.4-2. Water use for livestock by county (USGS 2004).

Table 4.7.4-1. Summary of the groundwater indicator/measure and its contribution to the overall groundwater Natural Resource Condition Assessment.

Indicator/Measure	Description of How the Indicator(s) Contributes to the Overall Resource Condition	General Contribution of this Indicator or Measure to the Overall Resource Condition.
Change in groundwater level	Water level can indicate depletion of an aquifer if the level continues to lower. This can be a result of supply exceeding demand and/or from a recharge rate that cannot maintain a degree of sustainability for the aquifer. On the other hand, if water level increase occurs that may be a result of retired wells and/or from recharge rates exceeding extraction.	The monument's well water level readings within the Judith River Formation aquifer indicate a slight decline in water level, but condition cannot be determined with the limited data.

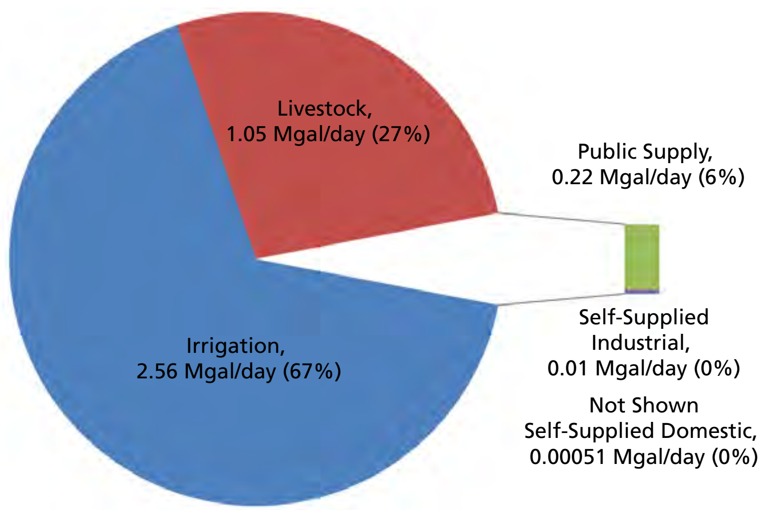

Figure 4.7.4-3. Total groundwater withdrawals by category of use in Bighorn County, MT.

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4.8. Riparian Habitat

Indicators/Measures

- Hydrology (5 measures)
- Vegetation (7 measures)
- Erosion/Deposition (5 measures)

Condition – Trend – Confidence Level

Good - Unchanging- High

4.8.1. Background and Importance

Riparian wetlands are a type of non-tidal wetland formed along river and stream floodplains. These habitats serve many functions including water purification, flood control, buffering riverbank erosion, provide habitat for numerous wildlife, fish, shellfish, and plant species, and also provide many recreational opportunities.

In the arid west, riparian habitat is often in marked contrast with the surrounding terrestrial vegetation and is strongly influenced by the presence or absence of water (NPS-WRD 2012).

The National Park Service (NPS) has several wetland protection procedures and policies (Director's Order #77-1: Wetland Protection (2002), Director's Order #77-2: Floodplain Management and Procedural Manual (2003); Procedural Manual #77-1 (2012), and NPS Management Policies (2006)) to ensure a "no net loss" of wetlands throughout the NPS. Little Bighorn Battlefield National Monument contains two ecological and topographic zones of the Northern Great Plains: dry uplands and the Little Bighorn River floodplain (NPS 2010, Rice et al. 2012), as such, Monument staff have identified the riparian habitat and its associated hydrology along the Little Bighorn River as one of its most important habitats (Britten et al. 2007).

The Little Bighorn River and surrounding area are characterized by broadly terraced river valleys with irregularly eroded uplands, comprised of alluvial soils (Smoak 2012). This landscape originated from repeated surges of glacial melt water and sediment deposition associated with the Pinedale Glaciation and post glacial period (Vuke et al. 2007). The primary landforms include expansive floodplains, fluvial terrace levels, and meandering river channels exhibiting point bar/cutbank morphology (Martin et al. 2012).

One of these meandering rivers is the Little Bighorn-a free flowing, perennial river and a tributary of the larger Bighorn River. The Little Bighorn originates in the Wolf Mountains in Wyoming and flows into Montana. It is dominated by snowmelt discharge with some influence from summer thunderstorms (Martin et al. 2012). It stretches approximately 222 km (138 miles) and is part of the Big Horn watershed (Figure 4.8.1-1).

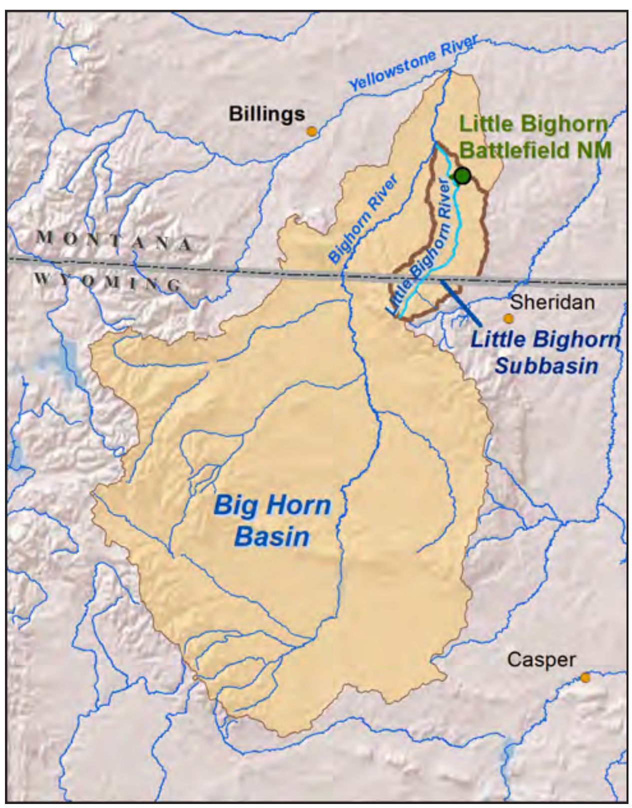

Figure 4.8.1-1. Little Bighorn River is a tributary of the Bighorn River and part of the Big Horn watershed.

Figure 4.8.1-2. Monument riparian habitat located along the Little Bighorn River.

Monument land, specifically the Custer Unit, is adjacent to 5.6 km (3.5 miles) of the Little Bighorn River's eastern bank. The river demarcates the essentially undeveloped upland/grassland habitat to the east where 310 hectares (765 acres) comprise the Monument, and the river valley bottom to the west, where several developments including transportation corridors (i.e., interstate and railroad), and agricultural and farmland have been established (NPS 2010).

The Monument's riparian habitat is comprised of complex mix of woody and herbaceous riparian vegetation, occupying approximately 25.7 hectares (Rice et al. 2012) (Figure 4.8.1-2).

A properly functioning riparian habitat is influenced by several factors and interactions between geologic formations, soil, water, vegetation, and local as well as regional (watershed) land use activities/practices. A river system and associated riparian habitat strives to maintain a dynamic equilibrium between streamflow forces and channel processes. A naturally functioning system is able to respond to larger waterflow events without excessive change to the riparian habitat plant communities and river channel characteristics. In fact, these larger flow events are a necessary process in the evolution of a river and riparian system, and as a result, aquatic and riparian habitat is maintained and water quality is enhanced. It is when ongoing impacts to the natural river processes occur that riparian habitats can no longer maintain resiliency and their proper functioning.

4.8.2. Data and Methods

Monitoring of the Monument's riparian habitat is conducted annually by Rocky

Mountain Inventory and Monitoring staff as part of their long-term stream ecological integrity monitoring strategy (Schweiger et al. 2012). Their current monitoring report spans 4 years (2007-2010). By the inherent nature of a long-term quantitative monitoring effort, it is difficult to derive a trend with a dataset of 4 years, so we wanted to augment the monitoring data with the perspectives from a team of scientists working in riparian systems. Thus, through a technical assistance request, an interdisciplinary team of experts from the NPS' Water Resources Division and Rocky Mountain Inventory and Monitoring Network conducted a qualitative riparian habitat rapid assessment at the Monument (Martin et al. 2012). The team used "A User Guide to Assessing the Proper Functioning Condition and the Supporting Science for Lotic Areas" developed by Prichard et al. (1998) for the assessment. Their methodology was based upon a "Proper Functioning Condition (PFC)", which describes both the condition assessment process as well as a reference condition (Prichard et al. 1998). The team examined aerial photos of the Little Bighorn River and conducted an on-site evaluation in June 2012. They agreed that the entire length of river bordering the Monument's boundary shared a common set of attributes and processes, therefore, decided not to separate the 5.6 km (3.5 miles) of the Little Bighorn River that runs along the Monument's boundary into separate reaches and instead assessed it as one unit (Martin et al. 2012) (Figure 4.8.2-1). This assessment is essentially derived from Martin et al. (2012) findings; readers seeking additional detail are encouraged to read the full report, which can be found at https://irma.nps.gov.

Both terrestrial and aquatic attributes and processes are important to riparian habitat areas and are used to assess the condition of a given area. This assessment included three main categories including hydrology, vegetation, and erosion/deposition. A total of 17 common attributes and processes within each of these three categories was assessed by the interdisciplinary team (Figure 4.8.2-2) using a standardized checklist/datasheet developed by Prichard et al (1998). It is the culmination of these indicators, listed below, that determined the overall condition of the Monument's riparian habitat.

Indicators/Measures

Hydrology

Streamflow forces and channel processes are characteristics of a riparian habitat's hydrologic function, and five attributes/processes were assessed for this category of measure.

Indicator: Floodplain inundated frequently

A floodplain is topographically flat, a landform of unconsolidated sediments originating from the stream, and subject to periodic flooding, with usually a recurrence interval between 1 and 3 years (Prichard et al. 1998). The floodplain's role is to handle a basin's discharge and sediment load by

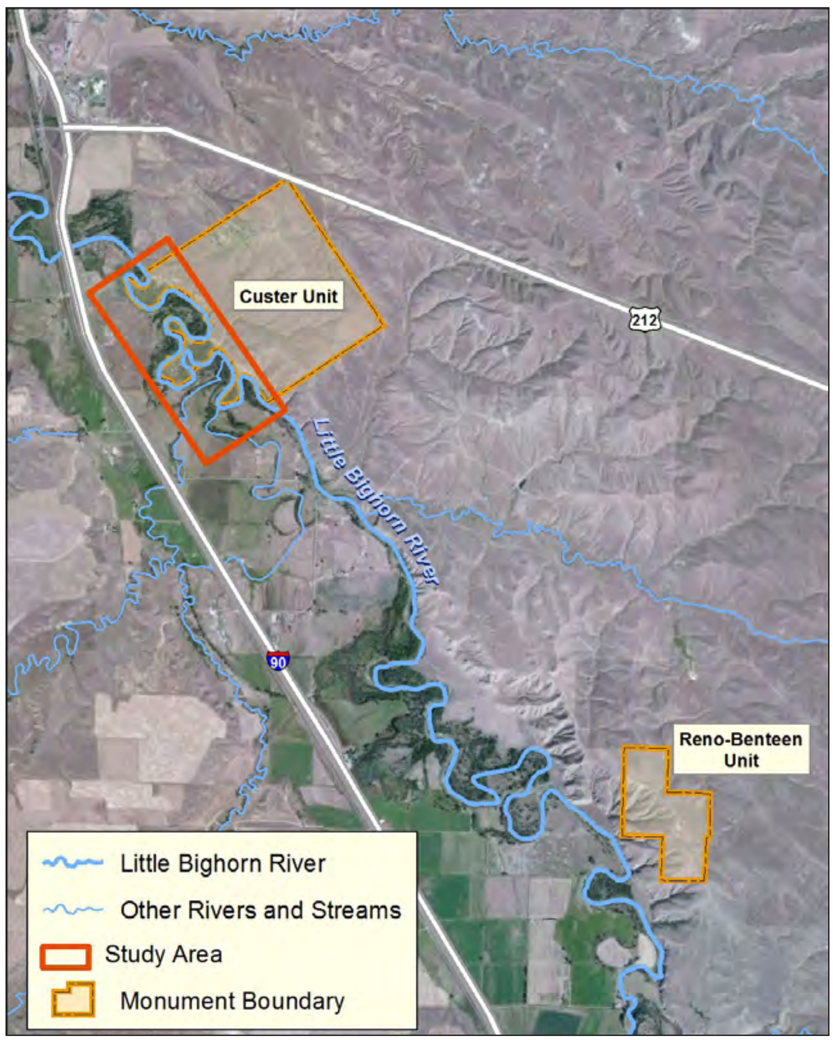

Figure 4.8.2-1. The Little Bighorn River shares approximately 5.6 km with the Monument's Custer unit southwestern boundary.

Figure 4.8.2-2. NPS scientists conducting the riparian habitat condition assessment along the Little Bighorn River reach adjacent to the Monument.

spreading out the water and sediment onto a low area adjacent to the stream. This hydrologic function dissipates energy, which keeps a riparian habitat in functioning condition. Periodic flooding also promotes vegetation growth, contributing to a properly functioning riparian area as well.

Indicator: Beaver dams are active and stable

Beaver dams modify the hydrology of the area where constructed, and in some areas are responsible for the creation of floodplains (Gebhardt et al. 1998). However, sometimes when dams are not maintained, they can breach and instantaneously release a massive amount water potentially causing degradation to the riparian system.

Indicator: Sinuousity, width/depth ratio, and gradient are in balance

Stream channel characteristics play an important role in how well the river system can dissipate energy. A higher stream gradient or a decrease in sinuosity will increase velocity resulting in accelerated erosion. To achieve balance, the size and shape of a stream should be near what would be expected within the setting it occupies.

Indicator: Riparian habitat area is widening or has achieved potential extent

Sediment capture develops floodplains, which in turn, aids functionality of a riparian habitat area. In addition, as sediment is deposited, vegetation can "take root", increasing certain types of vegetation such as sedges, willows, and rushes.

Indicator: Upland watershed is not contributing to riparian habitat degradation

Assessing changes in water and/or sediment supply from uplands can help determine functionality of the riparian habitat area affected. Changes in upland conditions can affect the discharge, timing, and duration of streamflow events in lower areas, possibly degrading a riparian habitat's condition.

Indicators/Measures

Vegetation

Most riparian habitats require some amount of vegetation to achieve functionality (Prichard et al. 1998). Different factors such as type, amount, and proportion of vegetation contribute to a riparian habitat's condition. In order to accommodate periodic flooding, lateral distribution of vegetation is necessary.

In addition, plants must be vigorous and able to maintain or recruit into the plant community to serve their various functions.

Indicator: There is a diverse age-class distribution of riparian habitat vegetation

Age class distribution is often associated with vigor of a system, and multiple age classes of vegetation provide recruitment and replacement. Not all age classes need to be present for a system to maintain or recover from a severe event, and the older age classes can usually persist even with degraded conditions.

Indicator: There is diverse composition of riparian habitat vegetation

Not all plants need to be present within a riparian habitat for the system to maintain itself, but there needs to be enough variety for a riparian habitat to recover and maintain its vegetative component. Limited number of species makes an area more vulnerable to extreme climatic changes or disease, although areas that contain unique water regimes or soils may naturally only support a limited number of plant species.

Indicator: Species present indicate maintenance of riparian habitat soil moisture characteristics

Plants that grow in riparian habitats are hydrophytes and must be in contact with the water table in order to survive. Different types of plants require different wetness regimes and different plants vary in root depths. The root depths sometimes suggest that a water table may not be close to the surface if the plants growing are ones that usually have deeper root systems. Wetland plants are divided into different categories, indicating their preference for growing in wetlands or uplands and degree of wetness required.

Indicator: Streambank vegetation is comprised of those plants or plant communities that have root masses capable of withstanding high streamflow events

Plants that have adapted to riparian habitat conditions, such as cottonwood, aspen, alder, willow, sedge, rush, and some grasses, develop root masses that help stabilize riverbanks, especially during high-flow events. If banks are undercut during storm or high runoff events, many changes can occur to the channel's width/depth ratio, gradient, and sinuosity, which in turn, may decrease the system's ability to dissipate energy. The presence of obligate and facultative wetland plants is usually a good indication that the streambank will remain stabilized.

Indicator: Riparian wetland plants exhibit high vigor

If plants are weakened or stressed, they are less able to withstand stressors making the riparian habitat more susceptible to degradation. On the other hand, plants that exhibit vigor are usually more equipped to maintain or recover from stressors.

Indicator: Adequate riparian habitat vegetation cover is present to protect banks and dissipate energy during high flows

The amount of vegetation present indicates a riparian habitat's ability to dissipate energy, protect riverbanks from collapse, filter sediment, and aid floodplain development, which also dissipates energy during storms or high runoff. Some bank erosion is a natural part of river channel evolution, but excessive erosion usually indicates some failure in the system.

Indicator: Plant communities are an adequate source of coarse and/or large woody material

Not all areas support large woody vegetation and many rangeland and meadow riparian habitat areas do not require woody species to maintain channel stability. However, if this type of vegetation is a natural part of the system, it serves as a hydrologic modifier. Usually, during high-flow events, coarse or woody vegetation must be present to withstand the high energy and to recover the system back to a proper functioning condition.

Indicators/Measures

Erosion/Deposition

Erosion and depositional processes are naturally occurring within a stream or river system, however, excessive amounts of either indicate an imbalance. Five indicators were used to assess the erosion/deposition processes for this assessment.

Indicator: Floodplain and channel characteristics are adequate to dissipate energy

Energy dissipation results from the presence of a floodplain, which distributes the water over a larger area, and channel characteristics such as sinuosity, which reduces the velocity of waterflow. In addition, objects such as rocks or large woody debris can also aid in energy dissipation.

Indicator: Point bars are revegetating

In some channels, point bars form as part of the natural depositional process and subsequent vegetation colonization aids in erosion control when high runoff events occur. The vegetative type has to be capable of forming root masses that can withstand high flow occurrences.

Indicator: Lateral stream movement is associated with natural sinuosity

Streams naturally adjust their channel by moving side to side without degrading the overall riparian habitat environment. The movement is affected by many factors such as the type of stream, the type of materials that form the streambanks, and the types and amounts of vegetation growing along the banks. For example, streambanks composed of sandy materials will more easily erode than materials such as clay or silt, which provide more cohesiveness. Excessive movement can negatively impact a river/riparian area by diminishing the system's ability to dissipate energy.

Indicator: System is vertically stable

This measure is used to determine whether a channel is lowering at a natural versus an accelerated rate. Naturally occurring channel lowering usually occurs over hundreds or more years, whereas, some accelerated lowering can occur over a decade or less. The channel lowering reduces the landscape's overall elevation including the valley bottom through erosion.

Indicator: Stream is in balance with the water and sediment being supplied by the watershed

Stream channels adjust to water and sediment loads and are classified as either single thread or braided channels. Most braided channels indicate unnaturally high sediment loads, whereas, excessive erosion indicates an imbalance in water flow.

4.8.3. Reference Conditions

A riparian habitat area needs to be in dynamic equilibrium with its streamflow forces and channel processes to be considered in proper functioning condition. This requires the system to maintain itself and/or recover after large runoff events without significant changes to the stream channel characteristics or to the riparian habitat vegetative communities (Martin et al. 2012). However, some change is expected and even necessary to maintain resiliency. In contrast, systems that are functional but susceptible to degradation due to failure in one or more of the attributes associated with either the hydrology, vegetation, or erosion/depositional processes are considered to be in moderate condition. Those systems that are not providing adequate functioning and subsequent protection are considered nonfunctional. These three states: proper function, functional-at risk, and nonfunctional, comprise the reference conditions against which the Monument's riparian habitat was assessed and is based on the condition definitions developed by Prichard et al. (1998) (Table 4.8.3-1). Prichard et al. (1998) also included a fourth condition class-Unknown- when sufficient information was unavailable to make a condition determination, however, this class was not applicable to the Monument's assessment therefore was excluded.

4.8.4. Condition and Trend

The results for the Monument's riparian habitat condition assessment revealed that all indicators present during the 2012 assessment were in proper functioning (good) condition. These results are listed in Table 4.8.4-1. In addition, the overall trend for the riparian habitat at the Monument is unchanging,

Table 4.8.3-1. The reference conditions used to determine whether the condition of the riparian habitat at Little Bighorn Battlefield NM were good, moderate, or of significant concern as adapted from Prichard et al. 1998.

Good	Moderate	Significant Concern
A good condition is referred to as a Proper Functioning Condition or PFC. PFC is a state of resiliency that allows a riparian habitat area to hold together during high flow events with a high degree of reliability. The resiliency allows an area to establish vegetative communities that create the structure necessary for fish and waterfowl habitat, to establish floodplains that help dissipate energy, and channel characteristics such as sinuosity and lower gradients, which help prevent streambank erosion.	A moderate concern condition is considered to be "Functional-At Risk" , which means that the riparian habitat area is in fundamental condition, but an existing soil, water, or vegetation indicator(s) is compromised making it susceptible to degradation. However, the majority of the riparian habitat indicators do not need to be compromised to receive a moderate condition rating.	A significant concern condition is considered to be "Nonfunctional". The riparian habitat area is not providing adequate vegetation, landform, or large woody debris to dissipate stream energy associated with high flows, therefore, erosion is not reduced and water quality degradation is occurring. In addition, channel characteristics are such that high flow events either deposit an inordinate amount of sediment or water flow results in excessive erosion.

although some land use practices along the river's west bank have impacted the riparian vegetation, which may eventually degrade and compromise the riparian habitat and river system.

Hydrology Condition

The river's channel morphology and evolution is strongly influenced by the silty sandstone bedrock formation (i.e., Judith River Formation) that is found along its northeastern valley margin (Martin et al. 2012) where the alluvial valley ranges between 1,524-1,829 meters (5,000-6,000 feet) wide. Along the reach adjacent to the Monument's boundary, as well as along several different reaches throughout the Little Bighorn, the river persistently erodes the northeastern margin suggesting a topographic or tectonic influence (Martin et al. 2012). This influence may have allowed the river to maintain a well-developed meander pattern despite losing a portion of the valley's width to developments (KellerLynn 2011).

Comparison between an 1891 hand drawn map of the river channel and current aerial imagery suggests the lateral stream movement has occurred within nearly the same area at least since the time of the Custer Battle (Figure 4.8.4-1). The meanders have shifted substantially maintaining sinuosity over the past 100 years (Martin et al. 2012). This well developed sinuosity has helped maintain a channel gradient to less than one percent.

USGS has installed seven water gages over the past 100 years along the Little Bighorn River and two are still operating: State Line

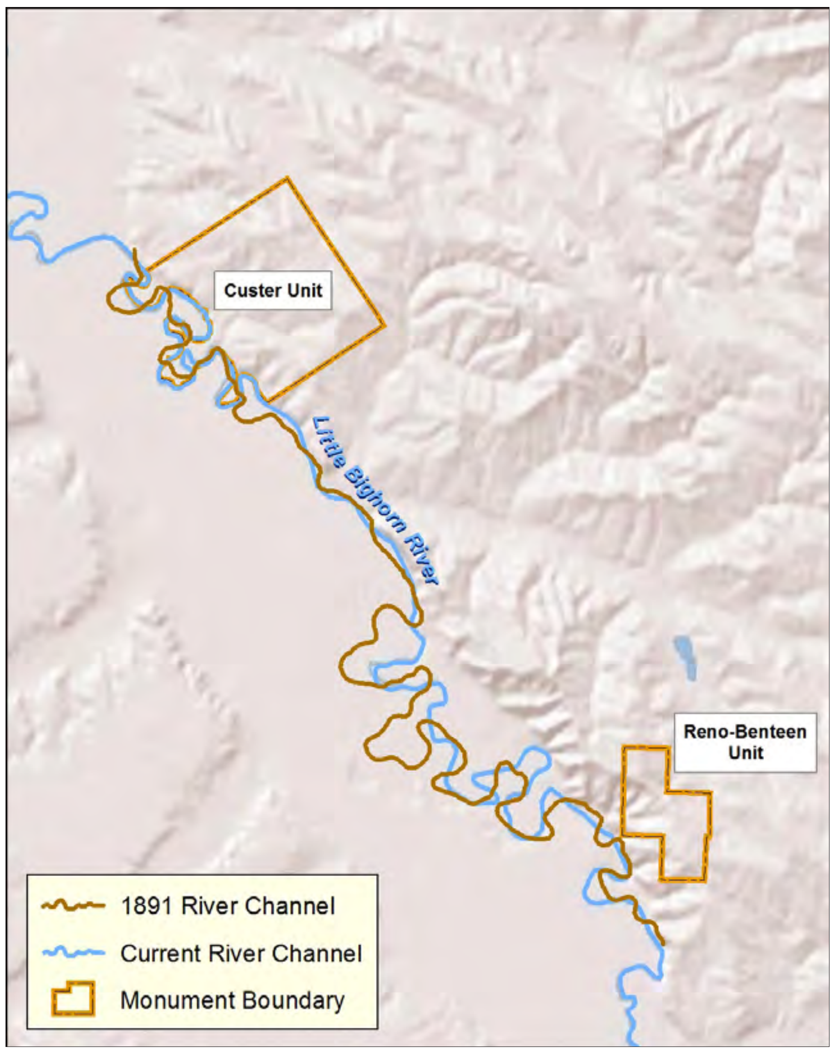

Figure 4.8.4-1. A comparison between the 1891 and current Little Bighorn River channels.

Table 4.8.4-1. Results for the riparian wetland condition assessment at Little Bighorn Battlefield NM (Martin et al. 2012).

Indicator/Measure	Definition
Hydrology	
Floodplain	Good-No channel incision in the river was observed. There were recent sediment deposits on the floodplain, and multiple active point bars indicated relatively frequent flooding, sediment deposition, and sustaining riparian vegetation.
Beaver dams	N/A-This indicator could not be assessed since no dams were found on or above this area of the river. However, signs of recent beaver activity (this year and last) were evidenced by chewed vegetation.
Sinuosity, width/depth ratio, and gradient	Good-The overall sinuosity, gradient, width/depth ratio, and channel/floodplain form were in balance with landscape setting. Three cutbanks were identified with minimal riparian vegetation present but not to the extent where the entire reach is at risk of failing.
Riparian habitat area	Good-The area is approaching or at potential extent for the majority of the reach except where agricultural and ranching practices have removed riparian vegetation along the western bank. These specific areas were experiencing some channel widening.
Upland watershed	Good-There is some minor, localized sediment inputs from uplands where agriculture/ranch practices have removed the vegetation.
Vegetation	
Age class distribution of riparian habitat vegetation	Good-Multiple age classes of sand bar and peach-leaf willows and green ash were present. Cottonwood seedlings were growing on the point bars and channel bars, and mature trees were common on the floodplain. It appeared as if recruitment age cottonwoods were establishing as well.
Diverse vegetation composition	Good-A wide range of herbaceous and woody plants were present, especially ones capable of forming root masses that are able to withstand frequent to moderately frequent flooding.
Soil moisture characteristics	Good-The presence of wetland obligate species, including water sedge and Chair-maker's bulrush, and of facultative wetland species, including willows and horsetail species indicates that the plants are growing in water, therefore, soil conditions appeared to be moist.
Plants have root masses capable of withstanding high streamflow events	Good-Several types of plant species present were capable of growing root systems that dissipate excessive energy, thereby, stabilizing streambanks.
Vigorous plants	Good-Most plants appeared vigorous, although some yellowing of cottonwood leaves was observed. In addition, Tamarisk and Russian olive plants were scattered along the river implying a potential future threat.
Vegetation cover	Good-With exception of a few locations where grazing and/or agricultural practices have removed riparian vegetation, enough plant cover was present to protect streambanks and dissipate excessive energy from high flow events.
Plant communities are source of large woody material (for maintenance/ recovery)	N/A-This river showed no sign of utilizing large woody material for channel maintenance (M. Martin, NPS, pers. comm.).
Erosion/Deposition	
Floodplain and channel characteristics	Good-No evidence of channel instability was observed even after a >100-year flow and 500 year flood event in 2011: one year prior to assessment.
Point bars	Good-Depositional processes appeared to be properly functioning based upon the presence of point bars as well as the presence of vegetation establishment on the bars.
Lateral stream movement	Good-Based upon the aerial imagery and 1891 hand drawn map comparison, the primary meander belt appears to be in nearly the same location for over 100 years, suggesting functioning lateral movement.
Vertical stability	Good-The comparison between an 1891 hand drawn map and 2005 aerial imagery of the river's channel alignment show substantially shifting meanders but marked sinuosity suggesting vertical stability.
Balance of water and sediment	Good-No evidence of braiding or excessive erosion was observed during on-site evaluation.

gage (#06289000) and Hardin, MT gage (#06294000).

These stream gages record data that describe stream levels, streamflow (discharge rates), and even water quality (USGS 2012a). The gage near Hardin, MT has been active since 1953 and the State Line water gage has been active since 1939 (Figures 4.8.4-2 and 4.8.4-3).

Floods occurred at the Hardin, MT gage in May of 1978 and May 2011, a year prior to this assessment. The 2011 water flow peak was a result of melting snowpack and runoff that occurred for over a month. This same flow resulted in the June 2011 flood recorded at the State Line gage (Martin et al. 2012).

One of the most noteworthy points is that the 2011 peak flow at the Hardin gage was in excess of the calculated 500-year flood average for this area, which according to FEMA has a 0.2 percent annual chance of flooding (FEMA 2012). The interdisciplinary team of scientists witnessed flood debris deposited on many of the overbank areas as a result of the 2011 flooding. However, results from the 2012 on-site riparian habitat assessment indicated no adverse impact to the channel (i.e., excessive eroding or deposition) or to the floodplain from such an extreme water event. According to Martin et al. (2012) on-site observations along the Little Bighorn River reach adjacent to the Monument appeared to be near bankfull level, indicating that the lower terraces are frequently inundated (i.e., frequent flooding occurs)(Martin et al. 2012).

Overall, this reach of the Little Bighorn River contained abandoned meanders, cutoff channels, and a variety of terrace levels indicating that the channel sinuosity, width/depth ratio, and gradient were in proper functioning condition (Martin et al. 2012). Also, as evidenced by the relatively constant river channel width, the team believed the riparian system associated with this reach of the river had reached its potential width, except for the developed areas along the western bank, which are outside the Monument's jurisdiction (Martin et al. 2012). The team also concluded that activities from

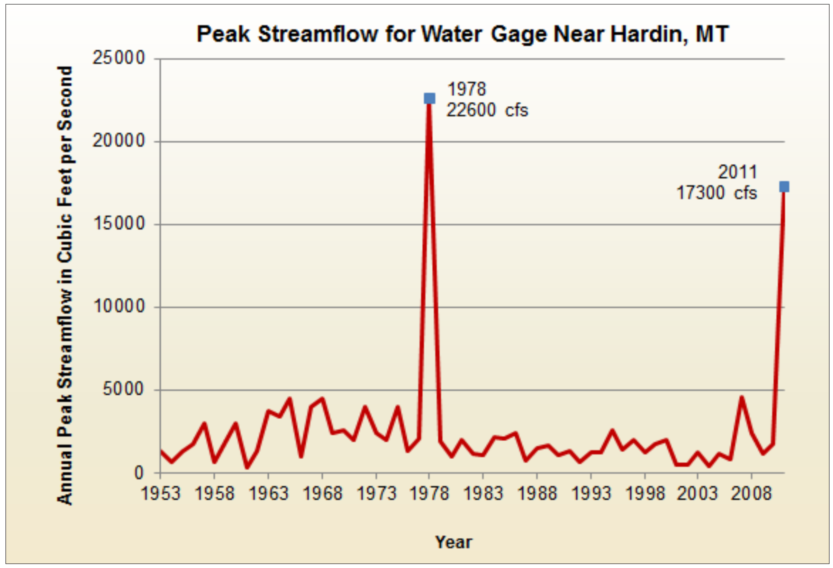

Figure 4.8.4-2 Peak streamflow at USGS water gage near Hardin, MT along the Little Bighorn River (USGS 2012b).

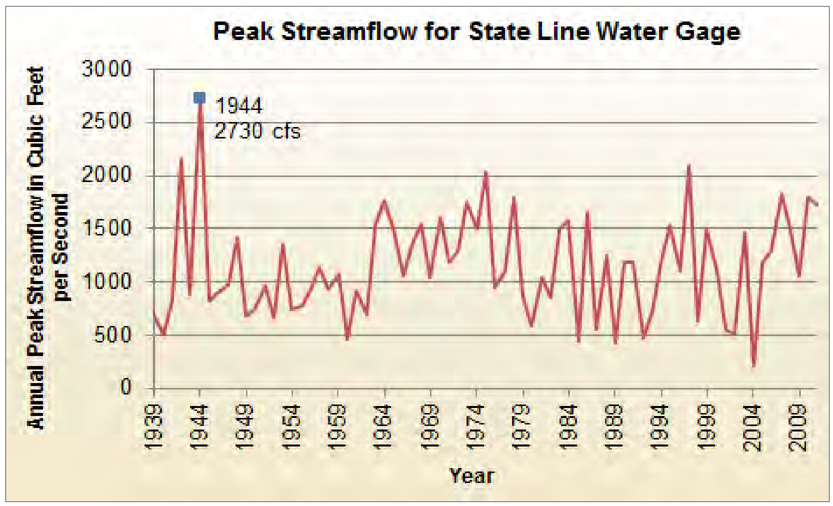

Figure 4.8.4-3. Peak streamflow at USGS State Line water gage along the Little Bighorn River (USGS 2012c).

within the watershed is not degrading the riparian habitat adjacent to the Monument.

Riparian Vegetation Condition

Riparian habitat vegetation serves a variety of functions in a river system including sediment capture, sources for woody debris, which in turn assists with energy dissipation, and creates habitat structure and food sources for several species. There were differences in the types of vegetation growing depending upon location throughout the riparian habitat area. For example, the riparian woody vegetation growing on the active floodplain, which included the lowest terraces and point bars, primarily consisted of sand bar willow (*Salix exigua*), peachleaf willow (*Salix amygdaloides*), green ash (*Franxinus pennsylvanica*), and woods' rose (*Rosa woods*i). The herbaceaous species growing within the active floodplain consisted of water sedge (*Carex aquatilis*), wild licorice (*Glycyrrhiza lepidota*), Chair-maker's bullrush (*Schoenoplectus americanus*), and horsetail *(Equisetum spp.*). In addition, as a result of the 2011 flooding, thousands of cottonwood seedlings were growing throughout the active floodplain and lower terraces (Martin et al. 2012). It is expected that those seedlings growing in the lower energy sites will survive and diversify the plains cottonwood age classes. All of these species growing within the active floodplain and lower terraces have root systems that help stabilize the banks from excessive erosion.

On the higher terrace levels, growing above the active floodplain, mature plains cottonwood (*Populus deltoides*) is the dominant species, however, medium aged trees are mostly absent from the area assessed (Martin et al. 2012). Pederson et al. (2012) conducted a dendroecological analysis of the riparian area cottonwoods and concluded that the current stands of cottonwoods can be grouped into two cohorts: a major establishment pulse c. 1880-1900, with minimal recruitment occurring c. 1900-1925. Pederson et al (2012) did not find any evidence of cottonwoods establishing since the 1930s and suggest the riparian system has changed significantly since the battle, with far fewer trees in present day.

The age class distribution, with the exception of mid-sized plains cottonwood (~10-40 cm dbh), was well represented for species present and plant vigor appeared good with the exception of some yellowing on cottonwood seedling leaves. Both Russian olive (*Elaeagnus angustifolia*) (30-40 plants) and Tamarisk (*Tamarix chinensis*) (10-20 plants) were scattered throughout the reach assessed and were growing close to the river. But overall, the team of scientists considered the riparian vegetation to be contributing to the river's stability and proper functioning condition.

<u>Erosion/Deposition Condition</u>

Meandering rivers like the Little Bighorn, typically migrate through their floodplain, eroding the older terraces and floodplain alluvium along the cutbanks and depositing the sediment onto point bars where they slowly aggrade (Martin at al. 2012). All evidence of erosion and deposition that was observed during this assessment implied properly functioning processes. This is especially significant given the fact that the area experienced a 500-year flood event in 2011 (one year prior to this assessment) and no excessive erosion was observed (Martin et al. 2012).

<u>Overall Condition and Trend</u>

In summary, the condition of the Monument's riparian habitat is a combination of vegetation, hydrology, and erosion and deposition factors and processes. These factors and processes are interconnected, and when evaluated as a whole, provide a comprehensive assessment of the Monument's riparian habitat. Table 4.8.4-2 summarizes the riparian habitat indicator categories and how they contributed overall to the assessment of good condition.

<u>Historical Context</u>

In spite of the fact that the Little Bighorn River area became known to the wider public due to the famous 1876 Custer Battle, the river and its riparian plants, represented something far greater to the Native People living off the land and water resources. Rivers (fresh waters) supported life and aided survival. Within the riparian habitat along the Little Bighorn River, shelter could be found, firewood from cottonwoods could be collected, and food and water could be hunted and gathered, ensuring survival, especially during harsh winter months (Figure 4.8.4-4) (Smoak 2012).

In 1868, the area surrounding the Little Bighorn River legally became part of the Crow Reservation but remained contested ground among the Plains Tribes: in part, due to the fact that the river and its plants provided sustenance. The plants were used for food, medicine, and construction materials, and also had significant spiritual and cultural meaning (Smoak 2012). According to Smoak

Table 4.8.4-2. Summary of the riparian habitat indicators/measures categories and their contributions to the overall riparian habitat Natural Resource Condition Assessment.

Indicator/Measure	Description of How the Indicator(s) Contributes to the Overall Resource Condition	General Contribution of this Indicator or Measure to the Overall Resource Condition.
Hydrology (5 indicators)	The hydrology of a riparian habitat affects how well water flow energy can be dissipated, including erosion and sediment depositional processes. These hydrologic characteristics are also affected by upland watershed activities in addition to on-site activities/changes.	As evidenced by the river channel's sinuosity, gradient, and width to depth ration, the hydrology component of the Monument's riparian habitat is properly functioning and in good condition.
Riparian Vegetation (7 indicators)	Riparian vegetation is specialized and controlled by how much water a plant's root system can withstand. Some species are obligate wetland, indicating the need for standing water in order to survive. Several different classes of wetland species also exist, and collectively, provide the necessary cover, debris, and root systems to maintain resiliency during high flow events.	Several different types of species were present and growing where expected based upon their individualized water needs. Age classes were well represented implying the riparian habitat's ability to recruit and maintain vegetation populations. A limited number of invasive species were present. Overall the condition of the riparian vegetation was good.
Erosion/Deposition (5 indicators)	Erosion and sediment deposition is a natural and necessary process for a river and its riparian habitat to maintain dynamic equilibrium. Properly functioning conditions manifest as channel and floodplain "intactness", lack of channel braiding, or streambank failure. Lateral movement also implies erosion and depositional balance.	No evidence of channel instability or excessive deposition was observed. This is especially significant given the fact that a 500-year flood occurred in 2011, and the river system appeared to be in functioning condition even after such a recent extreme event.

(2012), "Whenever possible, Plains Indian peoples situated their villages in or adjacent to riparian areas where water and ample floral resources were in close proximity."

Perhaps Chief Eelapuash (Arapooish in some older literature) sums up the Little Bighorn River area the best by stating,

"The Crow Country is exactly in the right place. …In the autumn, when your horses are fat and strong from the mountain pastures, you can go down into the plains and hunt the buffalo, or trap beaver on the streams. And when winter comes on, you can take shelter in the woody bottoms along the rivers; there you will find buffalo meat for yourselves, and

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Figure 4.8.4-4. 1911 view of Crow tepees along Little Bighorn River.

> cottonwood bark for your horses. … Everything good is to be found there. There is no country like the Crow Country." (Graetz and Graetz 2000).

Cottonwoods were one of the most important plant species to the Native way of life. This species was used to provide shelter and firewood, and its inner bark served as a food source. It was also a sacred plant with the trunk of a tree serving as the center pole for the sundance (Smoak 2012). A recent study conducted by Pederson et al. (2012) provided a dendroecological analysis of riparian area cottonwoods along the Little Bighorn River. None of the trees definitively dated back to the year of the battle, and they suggest that a high number of trees were probably seedlings or saplings during the time of the 1876 battle (Pederson et al. 2012).

Several additional riparian plant species were commonly used as building materials, meat drying racks, baskets, medicines and food sources. Both peachleaf willow (*Salix amygdaloides*) and sandbar willow (*S. exigua*) were most likely present during the time of the battle and were used by the tribes (Bock and Bock 2006). Beavers were also plentiful and trapped for their furs, which were sold by the Crows (Smoak 2012).

The ecological conditions of the Little Bighorn Valley provided fertile grounds for horses, bison, and antelope to graze, which in turn, drew Native groups to the area for hunting. In many ways, this area became a "borderland", which was a dangerously contested area that hunters entered only when thoroughly prepared or for war (Smoak 2012). As a result, much of the Crow homeland became contested as Lakotas and Cheyennes fought the Mountain Crows for control.

The Little Bighorn Valley became a place where Lakotas and Cheyennes arrived in early summer due to the bison herds and other game species. Eventually, the security of the riparian shelter was traded for mobility of following the herds, but in 1876, the Lakota-Cheyenne encampment proved to be an anomaly. Word traveled throughout villages of Plains people of a planned United States Army attack. This led to a mass exodus of Native peoples leaving the military agencies and joining the already established Indian encampment of Sitting Bull. Eventually, a smaller Indian camp was established along the western shore of the Little Bighorn River, and some have speculated that the placement of the camp, with the topography, steep eastern banks, and deep holes in the river due to the beavers, was the result of Sitting Bull's strategic genius. It was these natural features, including the river bends that made the Army attack more difficult and problematic than anticipated (Smoak 2012; NPS 2010), but these same natural features (i.e., brush, timber, and old riverbank) provided cover for Reno's troops (Collins 1955).

Now, over a century later, the area across the Little Bighorn River where the 1876 Indian encampment was located is part of the Little Bighorn Battlefield National Monument. The resources and ecological processes that provided sustenance to Native peoples over thousands of years along the Little Bighorn River are the same resources that we are assessing as part of this Natural Resource Condition Assessment, in hopes of maintaining or improving for thousands of more years to come.

Level of Confidence/Key Uncertainties

NPS' Water Resources Division conducted the riparian assessment through a technical assistance request to evaluate the functional condition of the Monument's riparian habitat area. Based on the expertise of the scientists, we're confident that the findings accurately reflected the condition of the Monument's riparian habitat at the time of the assessment.

Threats

According to Prichard et al. (1998), a state of resiliency within a riparian habitat area needs to be maintained to respond to a high-flow event. Different land use practices such as agriculture and ranching, located along Little Big Horn River's western bank, may threaten the riparian habitat's ability to maintain this resiliency. By the early 1960s, 53% of the Little Bighorn River had been modified (Beschta 1998 as cited in KellerLynn 2011). Several segments along the river's left bank (across


MIKE BRITTEN

Figure 4.8.4-5. River cutbank along the Little Bighorn River's western bank where agricultural practices have removed all vegetation.

from the reach adjacent to the Monument's boundary) is used for agriculture (Figure 4.8.4-5). As a result, the riparian vegetation, including the woody species, has been completely removed. According to Martin et al. (2012), meandering rivers that have lost significant riparian vegetation may undergo channel widening and could eventually experience instability. Some channel widening was observed at isolated locations during the onsite assessment but no dramatic changes to the channel were observed. Scattered non-native plants, including Tamarisk (*Tamarix chinensis*) and Russian olive (*Elaegnus angustifolia*) were observed along the banks. In 2006, Bock and Bock also noted the presence of honeysuckle (*Lonicera tatarica*) and Russian olive, stating they had the potential to crowd out native species.

The land use practices along the river's western bank may also impact the historical integrity of the 1876 Lakota-Cheyenne encampment. All land comprising the Monument is located to the east of the river and along the eastern river bank, but the historic Indian encampment area, which was situated along the river's western bank, is located outside NPS jurisdiction (Figure 4.8.4-6). Moreover, another uncertainty to the resource from a cultural perspective is that the natural progression of a river is to erode and deposit materials eventually creating U-shaped bends in the river called oxbows. The erosion process may remove artifacts by scouring the soil, which is a concern for a site containing significant historical artifacts.

In August 2010, an interdisciplinary team of natural resource specialists, an archaeologist, and a hydrologist from Little Bighorn Battlefield, Bighorn Canyon National Recreation Area, and the NPS Water Resources Division evaluated ongoing channel migration, the presence of cultural material in the eroding alluvial deposit, and the feasibility of various stabilization treatments (Martin 2010). The team concluded that, overall, the river displays the elements of a properly functioning meandering stream. The observed erosion and channel migration is predominantly a natural process consistent with meandering river evolution. Furthermore, a cursory reconnaissance of the site failed to detect any cultural material on the surface or in the eroding bank. Consequently, investigators saw no compelling reason to undertake bank stabilization treatments (Martin 2010).

In addition, Scott (2010) investigated three Little Bighorn River oxbows, located along the Monument's boundary, for artifacts using a metal detector. No archeological materials

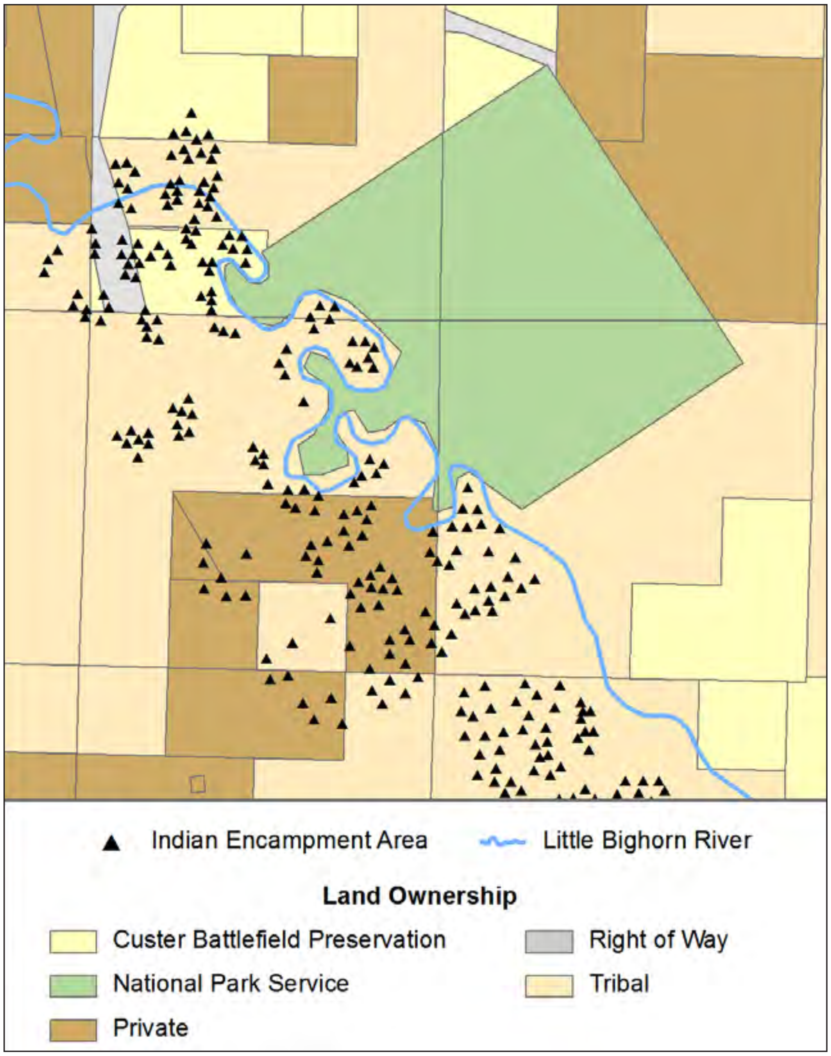

Figure 4.8.4-6. The area along Little Bighorn River's western bank, across from the Monument's Custer Unit, is where the historic 1876 Lakota-Cheyenne Indian encampment was located, which is outside NPS jurisdiction.

predating the late nineteenth century were found. The riverbank was also visually examined and no culturally deposited soil strata were observed. This suggested that modern flooding had either removed the 1876 surface period or sedimentation had buried the period artifacts deep enough beyond the detection capacity of the metal detectors used (Scott 2010).

Finally, developments of the I-90 and the Burlington Northern Railroad grade have excluded a portion of the river's meander belt from fluvial processes, however, the southwestern margins of the river valley may not be adversely affected. Evidence indicates that the Little Bighorn River has been situated along the northern and eastern margins of the valley for an extended period of time, which may be due to topographic or tectonic influence (Martin et al. 2012).

4.8.5. Sources of Expertise

The National Park Service's Water Resources Division scientists, Mike Martin, Joel Wagner, and Jalyn Cummings, provide leadership for the preservation, protection, and management of the water and aquatic resources in the NPS. Mike Britten, Program Manager for the Rocky Mountain Inventory and Monitoring Network, which includes Little Bighorn Battlefield NM, also assisted with the riparian assessment.

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4.9. Grasslands

Indicators/Measures

- Hydrology Soil/Site Stability and Hydrologic Function (6 measures)
- Biotic Integrity (5 measures)

Condition – Trend - Confidence Level

Moderate – Unchanging - High

Grasslands as a whole are essentially the dominant vegetation type of Little Bighorn Battlefield NM. Even vegetation types that may be formally classified as a shrubland (e.g., Western Snowberry (*Symphoricarpos occidentalis*) or woodland (e.g., Rocky Mountain Juniper (*Juniperus scopulorum*) communities, have a pronounced grassland component.

4.9.1. Background and Importance

The central grassland region of North America is one of the largest contiguous grassland environments on earth (Lauenroth et al. 2008), and depending on which classification is used, there are at least three distinct grassland types: tallgrass prairie, mixed grass prairie, and shortgrass steppe (prairie). Little Bighorn Battlefield NM is located within the region generally classified as mixed grass prairie (Figure 4.9.1-1). Mixed grass prairie is composed of both tall and short grasses and is found on uplands, slopes, and creek bottoms throughout the northwestern Great Plains, including most of eastern Montana. In the southeastern portion of the state where mixed grass prairie borders sagebrush steppe, the big sagebrush-western wheatgrass (*Artemisia tridentata*; ssp *wyomingensis* / *Pascopyrum smithii*) association becomes more common. Primary drivers in this system are fire and grazing. In drought conditions, the shorter grasses are favored. Forb diversity is also high in mixed grass prairies. Wildlife such as mule deer, sage grouse, pheasants, and antelope are common on uncultivated grasslands. (Great Plains Mixedgrass Prairie, Mt Field Guide 2013).

An influential wildlife species of western U.S. grasslands is the black-tailed prairie dog (*Cynomys ludovicianus*). Prairie dogs are an important component of the ecosystems they inhabit and are considered by some to be a keystone species, because they directly and indirectly influence grasslands through

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Figure 4.9.1-1 . Grassland at Little Bighorn Battlefield NM

their grazing and burrowing, as prey, and by providing shelter and nesting habitat for a variety of animals (Kotliar et al. 2006). Because of this pronounced effect on the ecosystem, their management may be complex. Prairie dogs do not occur within Little Bighorn Battlefield NM boundaries, but they occur directly adjacent to the northwestern boundary of the Custer Battlefield unit, where they occupy approximately 17 acres of land (NPS Intermountain Support Office, GIS Program).

Climate is typical of mid-continental regions with long severe winters, hot summers, low humidity, and lots of sunshine. Winds move freely across the northern Great Plains and contribute to rapid swings in temperature. Plant growth can be limited by seasonal precipitation and species composition and production vary by annual fluctuations in timing and amount of rainfall. Daytime temps average in the 80s (°F) in the summer (infrequently reaching over 100°F, with days in the 90s not uncommon). Winter temps average mid-teens to mid-20s. Temperatures below 0°F are not uncommon (NRCS, 2003).

Annual precipitation ranges from 250 to 460 millimeters (10 to 16 inches). Typical rainfall ranges between 11 and 13 inches with approximately 75% falling between April and September (primary growing season months). Snowfall averages 28 inches with snow cover typically not exceeding 3 inches except from infrequent heavy snowfall, which may occur in late winter/early spring. The frost-free season averages 105-145 days per year (NRCS, 2003).

<u>Grasslands at Little Bighorn Battlefield NM</u>

While the Monument is situated within the broad category of mixed grass prairie, there is also considerable variation in grasslands throughout the Monument. The Rocky Mountain I&M Network (ROMN) coordinated vegetation classification and mapping of the Monument among cooperators from University of Montana and the NPS Vegetation Inventory Program (VIP) (Rice et al. 2012). The project was completed using guidance from the NPS-USGS VIP, a national effort to classify, describe, and map vegetation communities in more than 280 national park units across the US. This program uses a hierarchical classification scheme, the National Vegetation Classification Standard (http://biology.usgs.gov/npsveg/nvcs.html), as a basis for classifying vegetation. The principal investigators identified 19 different National Vegetation Classification (NVC) associations, within 13 mapping units. The 19 plant associations consisted of one juniper-dominated woodland, two green ash forest types, six shrubland associations, three of which are silver buffaloberry dominated, and ten herbaceous associations, all of which are dominated by grasses (Rice et al, 2012) (Figure 4.9.1-2) (Table 4.9.1-1).

<u>Historic Context</u>

Grassland and shrubland habitat types are of great importance to the Monument; they not only characterize the monument ecologically, but they are also key components of the cultural landscape the park was established to protect (Figure 4.9.1-3). The Monument is a small park unit (765 acres) in southeast Montana dedicated to telling the story of Custer's Last Stand and preserving the battlefield on which this historic battle that pitted the US Army and the Sioux against the Lakota and Cheyenne tribes took place. Historically, upland vegetation at the Monument was predominantly northern mixed grass prairie with sections of sagebrush-dominated shrub steppe (Bock et al, 1987); modern fires have since diminished sagebrush numbers, and the park is currently characterized by rolling grasslands with scattered silver sage (*Artemisia cana*) and mesic shrub-lined ravines. As per the monument's General Management Plan that calls for providing visitors with a visual representation of the historic battlefield, park managers aim to restore sagebrush to represent historic populations.

<u>Conditions During Assessment</u>

During the period of data collection at the Monument, it is important to recognize that conditions have been quite variable. We used the Palmer Drought Index (Palmer 1965) as modified by Heddinghaus and Sabol (1991) (NOAA 2013) to provide an indication of drought conditions in June (the time of sampling) of each year. During 2009 and 2010

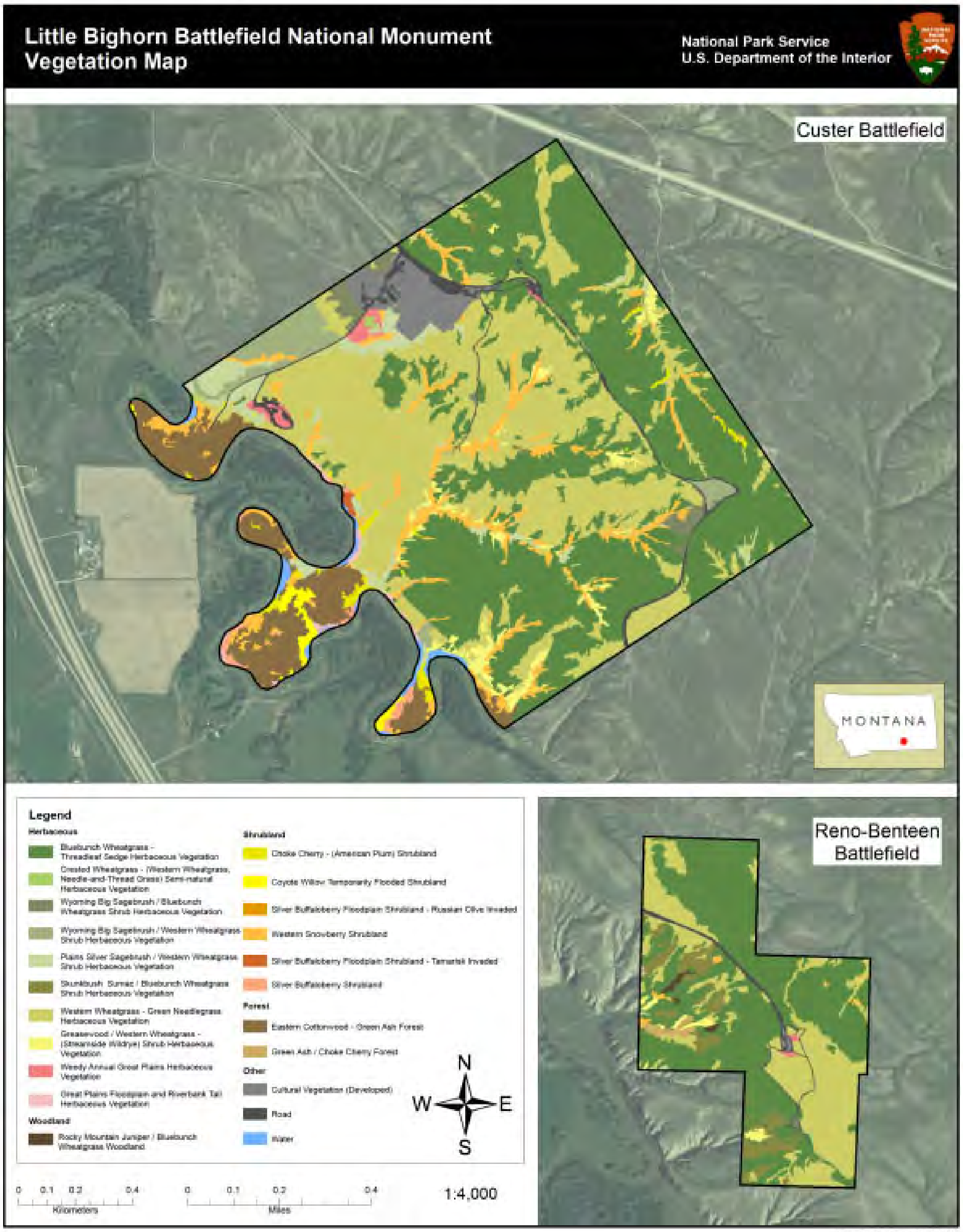


Figure 4.9.1-2. The map classes identified by The Colorado Natural Heritage Program Rice et al. (2012) including the plant alliances used by the National Vegetation Classification (NVC) system.

the monument was experiencing conditions that were in the midrange of variability (Figure 4.9.1-4). However, in 2011 the site was experiencing very moist conditions followed by severe drought in 2012. We have tried to take these conditions into account in our interpretations, but the reader should be aware that such conditions may have an impact on our assessment.

4.9.2. Data and Methods

We considered three categories of measures/indicators for the assessment of grassland condition at the Monument based on the approach presented by Pellant et al. (2005): soil/site stability, hydrologic functioning, and biological integrity. These categories are defined by Pellant et al. (2005) as follows:

Table 4.9.1-1. The 19 National Vegetation Classification (NVC) plant associations identified by the Colorado Natural Heritage Program and their corresponding area occupied.

NVC Plant Association	Primary Class	Area (hectares / acres)
Bluebunch Wheatgrass - Threadleaf Sedge	Grassland	137.2 ha / 339.0 ac
Choke Cherry - (American Plum)	Shrubland[1]	1.9 ha/ 4.6 ac
Coyote Willow Temporarily Flooded	Shrubland	1.6 ha / 4.0 ac
Crested Wheatgrass - (Western Wheatgrass, Needle-and-Thread Grass)	Grassland	0.2 ha / 0.4 ac
Eastern Cottonwood - Green Ash	Forest	16.5 ha / 40.7 ac
Greasewood / Western Wheatgrass - (Streamside Wildrye)	Grassland	5.4 ha / 13.3 ac
Great Plains Floodplain and Riverbank Tall	Grassland	0.9 ha / 2.3 ac
Green Ash / Choke Cherry	Forest	0.6 ha / 1.4 ac
Plains Silver Sagebrush / Western Wheatgrass	Grassland	7.5 ha / 18.5 ac
Rocky Mountain Juniper / Bluebunch Wheatgrass	Woodland[1]	0.3 ha/ 0.9 ac
Silver Buffaloberry Floodplain - Russian Olive Invaded	Shrubland	0.02 ha / 0.05 ac
Silver Buffaloberry Floodplain - Tamarisk Invaded	Shrubland	0.2 ha / 0.6 ac
Silver Buffaloberry	Shrubland	1.2 ha / 3.1 ac
Skunkbush Sumac / Bluebunch Wheatgrass	Grassland	5.3 ha / 13.2 ac
Weedy Annual Great Plains (Provisional)	Grass/Forb	1.3 ha / 3.3 ac
Western Snowberry	Shrubland[1]	13.9 ha / 34.3 ac
Western Wheatgrass - Green Needlegrass	Grassland	99.1 ha / 244.8 ac
Wyoming Big Sagebrush / Bluebunch Wheatgrass	Grassland	2.9 ha / 7.2 ac
Wyoming Big Sagebrush / Western Wheatgrass	Grassland	6.2 ha / 15.3 ac

[1]Can include a prominent grass component

Figure 4.9.1-3. One of the values of grasslands, is the importance that they played in the historic context. The ability for visitors to imagine the historic setting can dramatically add to their sense of place in that historic context.

Soil/Site Stability - The capacity of an area to limit redistribution and loss of soil resources (including nutrients and organic matter) by wind and water.

Hydrologic Function - The capacity of an area to capture, store, and safely release water from rainfall, run-on, and snowmelt (where relevant), to resist a reduction in this capacity, and to recover this capacity when a reduction does occur.

Biotic Integrity -The capacity of the biotic community to support ecological processes within the normal range of variability expected for the site, to resist a loss in the capacity to support these processes, and to recover this capacity when losses do occur. The biotic community includes plants, animals, and microorganisms occurring both above and below ground.

In combination, the measures/indicators from each of these categories provide the basis for this assessment. We have summarized the indicators for each of these groups below.

Indicators/Measures

Soil/Site Stability and Hydrologic Function

The soil/ site stability/hydrologic function indicators were assessed primarily through site visits by the ROMN crews to the 32 long-term vegetation and soil monitoring plots installed at the monument. Locations of these sites can be found Figure 4.9.2-1– Map of Monitoring Sites.

The methodology used for these assessments used an approach based on those described in the qualitative assessment protocol "Interpreting Indicators of Rangeland Health (Version 4.0) (http://usda-ars.nmsu.edu/monit_assess/index.html), in which Soil/Site Stability qualitative indicators (Table 4.9.2-1) were used to assess the ability of an area to limit redistribution and loss of soil resources by wind and water. These indicators are a subset of the indicators outlined in this assessment protocol. Additionally, the ROMN does not measure compaction in the field. Rather, bulk density as determined in the Colorado State

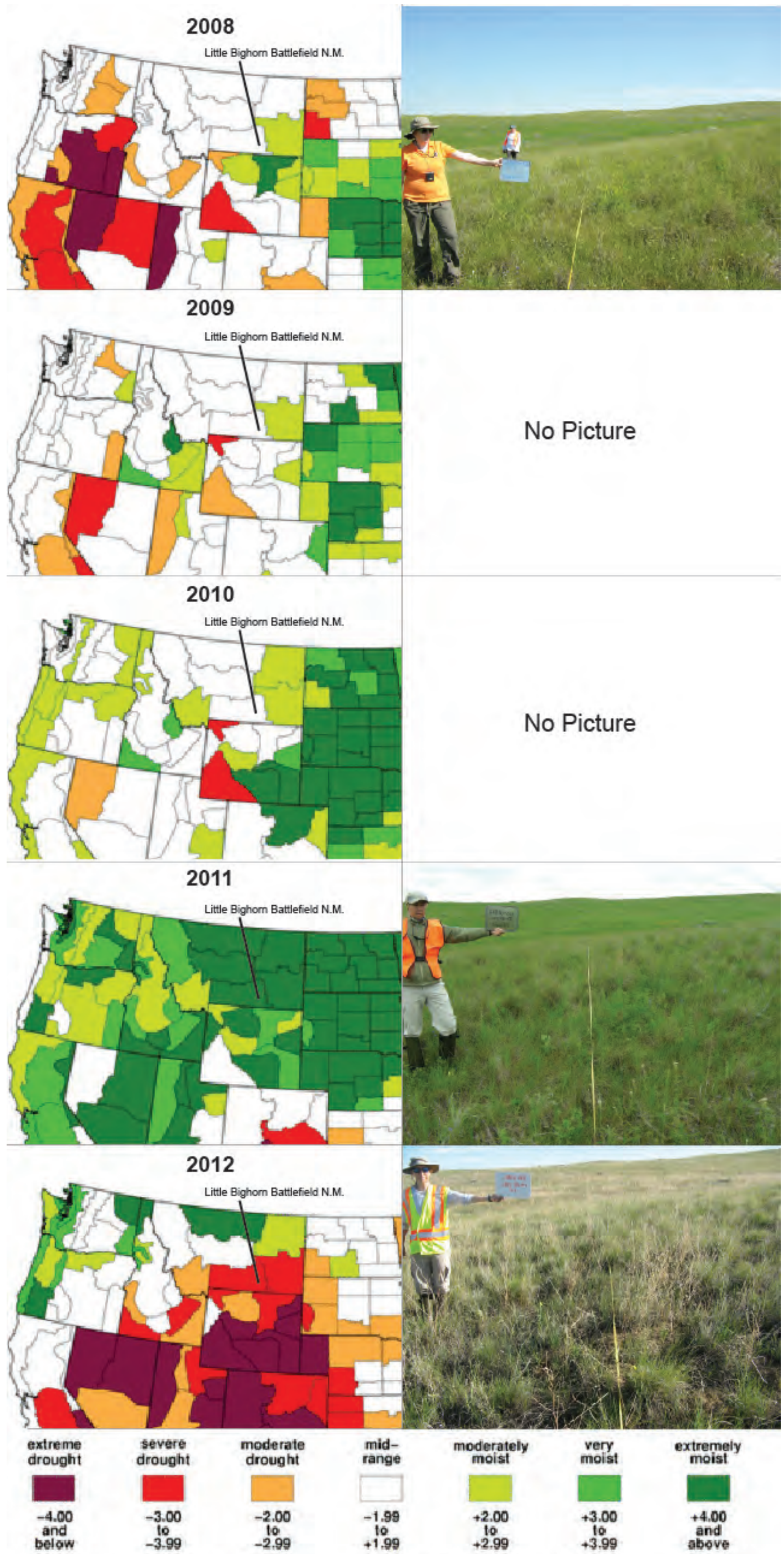


Figure 4.9.1-4. The Modified Palmer Drought Index (NOAA 2013) for June 2008 - 2012. Also shown to the right of each map are photos taken from monitoring transect (LIBI-G001_Tr1) for the corresponding time period. 2008 is shown for reference, although data were collected only from 2009 through 2012.

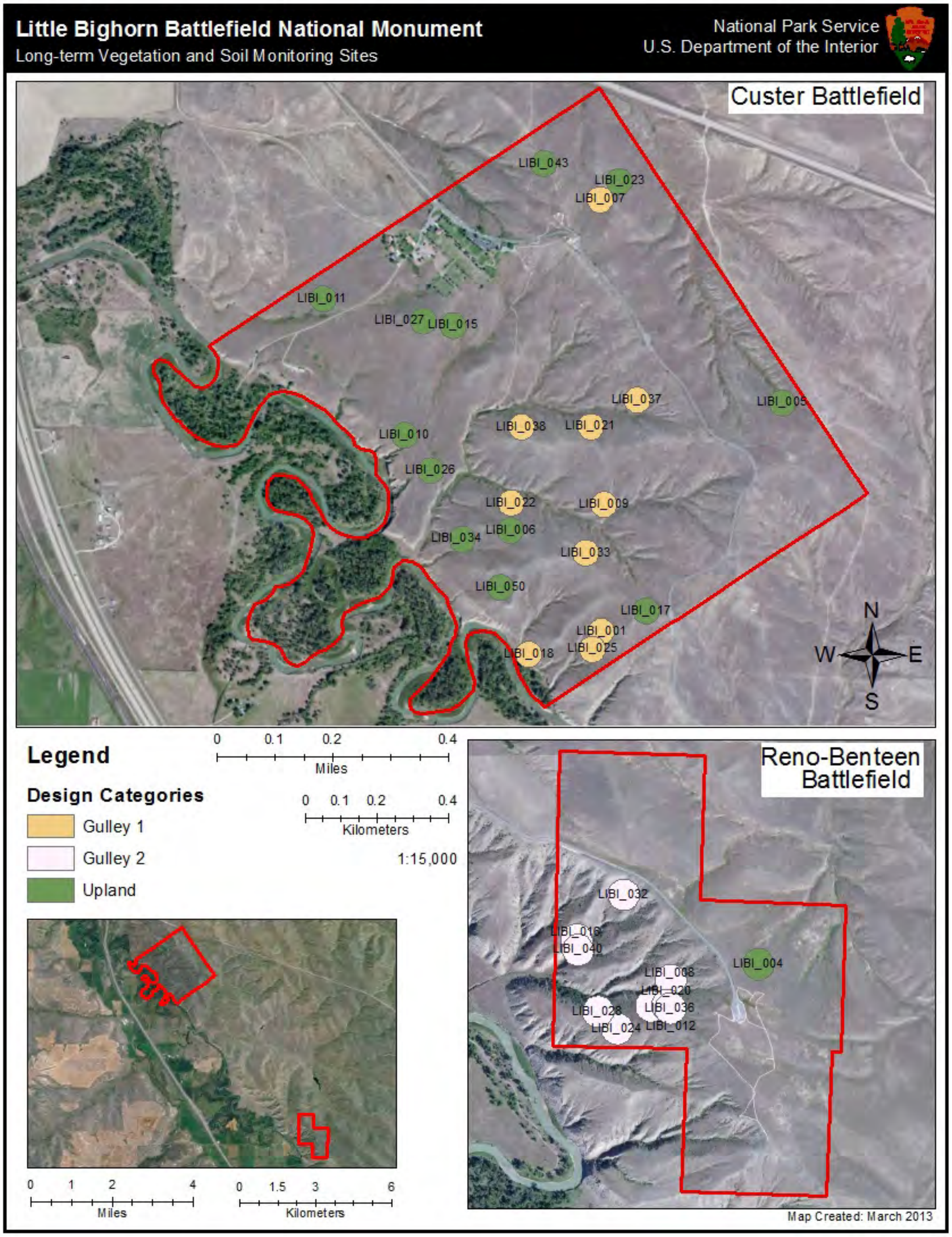


Figure 4.9.2-1. Location of grassland vegetation and soil monitoring plots at Little Bighorn Battlefield NM

University soils lab serves as proxy for soil compaction.

Qualitative indicators can provide land managers and technical assistance specialists with a good communication tool, and when used in conjunction with quantitative monitoring and inventory information, they can be used to provide early warnings of resource problems on upland rangelands.

These indicators were used in conjunction with soil survey information and ecological site descriptions for the 32 monitoring sites, each of which were approximately ½ hectare in size. The Soil/Site Stability qualitative indicators observed and documented were used to perform the rapid soil assessments. The rapid soil assessment, along with bulk density, were used to determine the departure from the expected soil/site stability attributes.

Table 4.9.2-1. Indicators/measures used to assess the soil/site stability and hydrologic function of grasslands at Little Bighorn Battlefield NM.

Rills/Gullies	Rills: A small, intermittent water course with steep sides, usually only several centimeters deep (SSSA 1997) Gullies: A furrow, channel, or miniature valley, usually with steep sides through which water during and immediately after rains or snowmelt commonly flows (SRM 1999). Small channels eroded by concentrated water flow.
Bare Ground	All land surface not covered by vegetation, rock, or litter (SRM 1999). As used in this document, visible biological crusts and standing dead vegetation are included in cover estimates or measurements and therefore are not bare ground (e.g., mineral soil).
Soil surface loss or degradation	The removal or decline of part or all of the soil surface layer.
Bulk Density	"Bulk density is an indicator of soil compaction. It is calculated as the dry weight of soil divided by its volume." (NRCS 2008)

Table 4.9.2-2. Indicators of grassland biotic integrity developed for this assessment.

Indicator	Description
Species Composition, Landscape-scale Diversity	The extent to which landscape-scale diversity reflects spatial pattern of soils and disturbance.
Species Composition, Local scale	The extent to which species composition within a site (e.g., ecological site) deviates substantially from the expected native species compliment either from exotics or native species.
Response of Annual Species to Disturbance	The extent to which annual species persist in sites not recently disturbed, compared to undisturbed and recently disturbed sites.
Relative proportion of functional groups (e.g., graminoid, forbs, shrubs, etc.)	The relative proportions of functional groups relative to what would be expected based on site characteristics (e.g., lack of forbs, excessive shrub density, etc.)
Relative proportion of C3 and C4 species.	The relative proportions of f C3 and C4 plants relative to what would be expected based on site characteristics

The assessment for the biotic integrity of grasslands was made via a combination of a field assessment by grassland experts Alan Knapp (Colorado State University) and Tim Seastedt (University of Colorado at Boulder) and data collected as part of the ROMN's ongoing upland and soils monitoring. The first task was to determine appropriate indicators of grassland biotic integrity. Using the qualitative indicators of rangeland health presented in Pellant et al. (2005) as a starting point, the grassland experts, in collaboration with network and park staff, developed a suite of five indicators of grassland biotic integrity that was deemed appropriate for this assessment. These indicators are summarized in Table 4.9.2-2 and described in greater detail below.

Based on these indicators, a rapid field assessment was conducted based on visits to multiple sites at the Monument. Each site was qualitatively evaluated by the experts based on the indicators developed. Monitoring data collected by the ROMN during the past four years following Manier et al. (2011) augmented expert opinion to provide a more quantitative baseline for future assessment.

Grassland monitoring data were collected between 2009-2012 in 32 circular plots, each comprised of three 36.6m long transects plus ten 1 m^2 plots as part of this monitoring effort(Figure 4.9.2-1). At each 1 m^2 quadrat and along each transect, the percent cover was estimated for each species.

Indicators/Measures

Biotic Integrity

Species Composition, Landscape-scale Diversity

The local species composition generally reflects local conditions of soils, moisture, disturbance, etc. As such, we would expect the diversity across a broader region to generally reflect the variation in these site characteristics. However, it is not reasonable to expect a one to one correspondence between local communities and their corresponding sites because a multitude of factors can influence the local expression of vegetation communities at a given site. Rather, we are trying to determine that some reasonable level of landscape diversity exists and that it generally corresponds to changes in ecological conditions.

Local Scale Species Composition

The intent behind this indicator is to see if the species composition is generally consistent with what might be expected for the site, given the local conditions (soils, disturbance, moisture, etc). We considered this using two measures. First, was the degree to which the local species consisted of native vs exotic species? Details about which exotic species are present and their effect on the site are presented in greater detail in Chapter 4.13. Here we just provide an initial indicator of the extent of invasion by exotic species by looking at the proportion of native and exotic species. Second, we looked at the species composition of the native species relative to what might be expected for that site. This was based on a combination of NRCS Ecological Site Descriptions and expert opinion. As we have done for other indicators, this assessment is based primarily on percentage cover, rather than the number of individual species because most species are quite rare and cover provides a more realistic assessment of the impact of exotic invasion. However, we do present the proportion of individual species as well merely as an ancillary reference.

Response of Annual Species to Disturbance

It is generally expected that the number of annual species at a given site would be higher immediately following a disturbance, and would shift toward an increasing number of perennials as time passes since a disturbance. The persistence of annuals after a disturbance could indicate some basis for concern. For example roadside areas that are frequently and unnaturally disturbed might be expected to have a greater persistence of annual species compared to interior sites.

Relative Proportion of Functional Groups

The composition of functional groups can have a dramatic effect of grassland ecosystems and their associated processes (Tilman et al. 1997, Pellant et al. 2005). Tilman et al. (1997) found that functional composition and functional diversity were principal factors explaining plant productivity, plant percent nitrogen, plant total nitrogen, and light penetration. They further concluded that habitat modifications and management practices that change functional diversity and functional composition would likely have a dramatic effect on ecosystem processes.

Relative Proportion of C3 and C4 Species -

Mixed grass prairies in Montana are typically dominated by perennial C3 (cool season) grasses interspersed with perennial C4 (warm season) grasses. The proportion of C3 and C4 grasses can dramatically influence how these grassland communities respond to climate change and levels of CO_2, although the nature of such response has been much debated (Wand et al. 1999).

Because C3 plants are most productive under cool, moist conditions, grasses with this photosynthetic pathway are known as “cool season grasses.” C3 grasses are typically less drought and heat tolerant than C4 or “warm season grasses” and require higher levels of carbon dioxide to photosynthesize (Anderson 2012).

Seasonal separation of C3 and C4 grasses — in Anderson (2012), he writes, "the temporal and geographical distribution C4 and C3 grasses are linked to mean summer temperature gradients (Terri and Stowe 1976 as cited in Anderson 2012). C3 grasses thrive in regions where mean daytime growing season temperatures fall below 22° C; dominance shifts to C4 grasses where mean growing season temperatures occur above 30° C (Ehleringer et al. 1997 as cited in Anderson 2012). Latitudinally, in North American prairies, this shift occurs close to 45° (Ehleringer 1978 as cited in Anderson 2012)." The Monument sits at approximately 45.6° latitude. Daytime temperatures during growing season at the Monument average in the upper 20s and it is not unusual for them to surpass 30° C. Anderson continues, "where the two groups of grasses grow together, C3 grasses, e.g., Western wheatgrass (*Pascopyrum smithii*), green needlegrass (*Nassella viridula*), and prairie Junegrass (*Koeleria macrantha)*, grow in the spring and early summer, whereas the C4 grasses begin growth later than the C3 grasses and maximize growth in mid-summer. Utilizing early season moisture prior to the emergence of C4 grasses is the primary strategy that enables the typically less drought tolerant C3 grasses to persist."

4.9.3. Reference Conditions

Soil/Site Stability and Hydrologic Function

Pellant et al. (2005) described general reference conditions they considered to be an optimal functional state (their none to slight category) under natural disturbance regimes (Table 4.9.3 1). They then described general descriptions for departures from that optimal state into four other categories of condition. These categories ranged from their optimal state to an extreme or total state of degradation.

We considered the condition of grasslands as "good" if the current condition fell either within Pellant et al.'s (2005) "none to slight", or "slight to moderate" categories. The "moderate" ranking was assigned if the departure from optimal fell within Pellant et al's (2005) "moderate" class. And finally, we considered the condition of grasslands as a "significant concern" if the departure from optimal fell within Pellant et al's (2005) "moderate to extreme" or "extreme to total" classes.

Biotic Integrity

Determining definitive quantitative reference conditions for grassland communities at the Monument is somewhat problematic given the dynamic nature of these resources. Part of our consideration in choosing the indicators we have used for biotic integrity is that are moderately robust to the potentially substantial seasonal and annual variation that plant communities often exhibit. We began with a conceptual framework for assigning condition based on what might be expected for the site conditions at the Monument (Table 4.9.3-2). We recognize, however, that seasonal and annual variation in such things as rainfall and disturbance can results in dramatic shifts in specific measurement that are still within an acceptable range of natural variation.

Our indicator of Landscape-scale diversity focuses on whether or not the diversity of plant communities reflects to a reasonable extent the diversity in site characteristics. As such, we used the spatial pattern of soil types (NRCS 2012) and ecological sites (NRCS 2007) as a general reference for the extent and pattern of landscape diversity that might be expected.

For the remaining indicators, we used the Natural Resources Conservation Service's ecological site descriptions (NRCS 2007) as a very general reference for plant community characteristics that might be expected given the soil types and ecological sites that occur at the Monument. It is important to note however, the values in the site descriptions are typically only provided for what are considered the historic climax plant communities (HCPCs), and variations in the dynamics of those communities are presented only through qualitative descriptions and/or generalized state and transition models. Consequently we do not strictly adhere to the HCPCs as a reference condition in the sense that departures from that reference necessarily represent a degraded quality; rather as a general guide to be used in conjunction with

Table 4.9.3-1. Reference conditions used to assess the current condition for soil/site stability/hydrologic function indicators.

Indicator	Significant Concern		Moderate Concern	Good	
	Extreme to Total	Moderate to Extreme	Moderate	Slight to Moderate	None to Slight
Rills	Rill formation is severe and well defined throughout most of the site.	Rill formation is moderately active and well defined throughout most of the site.	Active rill formation is slight at infrequent intervals; mostly in exposed areas	No recent formation of rills; old rills have blunted or muted features.	Current or past formation of rills as expected for the site.
Gullies	Common with indications of active erosion and downcutting; vegetation is infrequent on slopes and/or bed. Nickpoints and headcuts are numerous and active.	Moderate in number to common with indications of active erosion; vegetation is intermittent on slopes and/or bed. Headcuts are active; downcutting is not apparent.	Moderate in number with indications of active erosion; vegetation is intermittent on slopes and/or bed. Occasional headcuts may be present.	Uncommon, vegetation is stabilizing the bed and slopes; no signs of active headcuts, nickpoints, or bed erosion.	Match what is expected for the site; drainages are represented as natural stable channels; vegetation common and no signs of erosion.
Pedestals and/or terracettes	Abundant active pedestalling and numerous terracettes. Many rocks and plants are pedestaled; exposed plant roots are common.	Moderate active pedestalling; terracettes common. Some rocks and plants are pedestaled with occasional exposed plant roots.	Slight active pedestalling; Most pedestals are in flow paths and interspaces and/or on exposed slopes. Occasional terracettes present.	Active pedestalling or terracette formation is rare; some evidence of past pedestal formation, especially in flow patterns on exposed slopes.	Current or past evidence of pedestaled plants or rocks as expected for the site. Terracettes uncommon or absent.
Bare ground	Much higher than expected for the site. Bare areas are large and generally connected.	Moderate to much higher than expected for the site. Bare areas are large and occasionally connected.	Moderately higher than expected for the site. Bare areas are of moderate size and sporadically connected.	Slightly to moderately higher than expected for the site. Bare areas are small and rarely connected.	Amount and size of bare areas match that expected for the site.
Water flow patterns	Water flow patterns extensive and numerous; unstable with active erosion; usually connected.	Water flow patterns more numerous and extensive than expected; deposition and cut areas common; occasionally connected.	Number and length of water flow patterns nearby match what is expected for the site; erosion is minor with some instability and deposition.	Number and length of water flow patterns match what is expected for the site; some evidence of minor erosion. Flow patterns are stable and short.	Matches what is expected for the site; minimal evidence of past or current soil deposition or erosion.
Soil surface resistance to erosion	Extremely reduced throughout the site. Biological stabilization agents including organic matter and biological crusts virtually absent.	Significantly reduced in most plant canopy interspaces and moderately reduced beneath plant canopies. Stabilizing agents present only in isolated patches.	Significantly reduced in at least half of the plant canopy interspaces or moderately reduced throughout the site.	Some reduction in soil surface stability in plant interspaces or slight reduction throughout the site. Stabilizing agents reduced below expected	Matches that expected for the site. Surface soil is stabilized by organic matter decomposition products and/or a biological crust.
Soil surface loss and degradation	Soil surface horizon absent. Soil structure near surface is similar to, or more degraded, than that in subsurface horizons. No distinguishable difference in subsurface organic matter content.	Soil loss or degradation severe throughout site. Minimal differences in soil organic matter content and structure of surface and subsurface layers.	Moderate soil loss or degradation in plant interspaces with some degradation beneath plant canopies. Soil structure is degraded and soil organic matter content is significantly reduced.	Some soil loss has occurred and/or soil structure shows signs of degradation, especially in plant interspaces.	Soil surface horizon intact. Soil structure and organic matter content match that expected for site.
Bulk Density	Extensive; severely restricts water movement and root penetration	Widespread; greatly restricts water movement and root penetration.	Moderately widespread, moderately restricts movement and root penetration.	Rarely present or is thin and weakly restrictive to water movement and root penetration.	Matches that expected for the site; none to minimal, not restrictive to water movement and root penetration.

Table 4.9.3-2. Reference conditions used to assess the current condition for grassland biotic integrity indicators.

Indicator	Significant Concern	Moderate Concern	Good
Landscape- scale diversity	Significant lack of spatial landscape heterogeneity that does not reflect the expected diversity for the soil types and sites	Moderate lack of spatial landscape heterogeneity that does not fully reflect the spatial pattern of soils and disturbance	Landscape-scale diversity reflects spatial pattern of soils and disturbance
Local scale species composition	Species composition deviates substantially from the native species compliment that would typically occur at such sites. Such a deviation could also be either from exotics or native species.	Species composition moderately deviates from the expected native species compliment either from exotics or native species in such a way that does reflect typical types of natural disturbance (e.g., fire or prairie dogs).	Species composition reflects expected native species compliment consistent with the site characteristics (e.g., from ESDs). Species composition need not reflect expected climax communities if their current state reflects typical types of natural disturbance (e.g., fire or prairie dogs).
Annual, biennial and perennial species relative to Disturbance	Substantially higher proportion of annual species than expected in sites not recently disturbed.	Proportion of perennial species is moderately lower that what might be expected given the site and time since disturbance.	Proportion of perennial species is approximately what would be expected given the site and time since disturbance.
Relative proportion of functional groups (e.g., graminoids, forbs, shrubs, etc.)	Proportions of functional groups differ substantially from what might be expected based on- site characteristics (e.g., lack of forbs, excessive shrub density, etc.)	Proportions of functional groups exhibit moderately departure from what might be expected given the site and disturbance history.	Proportions of functional groups (e.g., grasses, forbs, and shrubs) are consistent with what might be expected given the site characteristics.
Relative proportion of C3 and C4 species.	Sites dominated by C3 grasses at shortgrass sites traditionally dominated by C4 grasses.	Higher than expected proportion of C3 grasses given the ecological site and disturbance history.	Appropriate mix and natural variability of C4 (warm season) and C3 (cool season) grasses for the site (to maximize resilience)

the state and transition models, descriptions of the alternative communities represented by the site dynamics, as well as other ecological considerations from the literature or grassland experts.

4.9.4. Condition and Trend

Soil/Site Stability / Hydrologic Function

The results from the ROMN crew's soil assessments indicated that the overall current condition of the soil/site stability/hydrologic at the Monument was good, with departures from expected generally being slight to moderate (Table 4.9.4-1). In the instances where departures were more severe, the sites were situated on steep, erodible slopes and/or in areas of modern fire.

Biotic Integrity

Species Composition, Landscape-scale Diversity

The patterns of plant community distribution generally match that of the ecological sites and soils (Figure 4.9.4-1); although there is less detail in the breakdown of communities, particularly relative to soil types. This lack of fine scale diversity may merely reflect the classification process of plant communities rather than an absence of any expected diversity. Further, during the rapid assessment, our grassland experts did not express any concern over a lack of landscape diversity and felt that this aspect was in very good condition. Thus, we consider landscape scale diversity as being in good condition with no evidence for any degrading trend.

Local Scale Species Composition

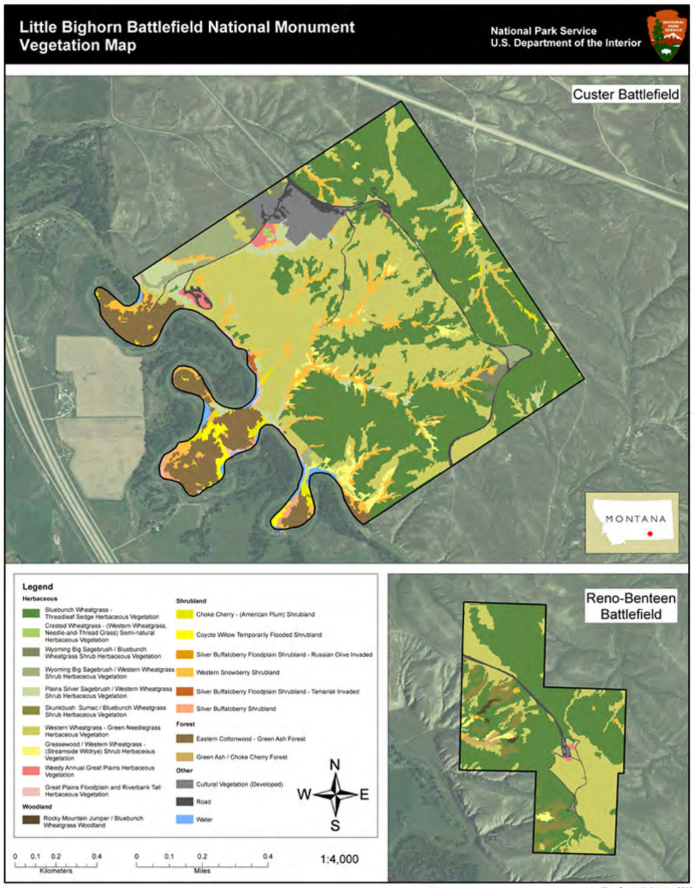
As previously indicated, we do not have an expectation for species composition to exactly match the species list for historic climax plant communities (NRCS 2007). In part, this is because of local variability of micro sites as well as temporal variability such as seasonal or annual variation in rainfall, etc. In addition, not all sites at the monument are in a climax state given their history of disturbance. However, the ecological site descriptions do provide a crude indication of what species might be expected. Appendix D provides a list of species observed at monitoring sites

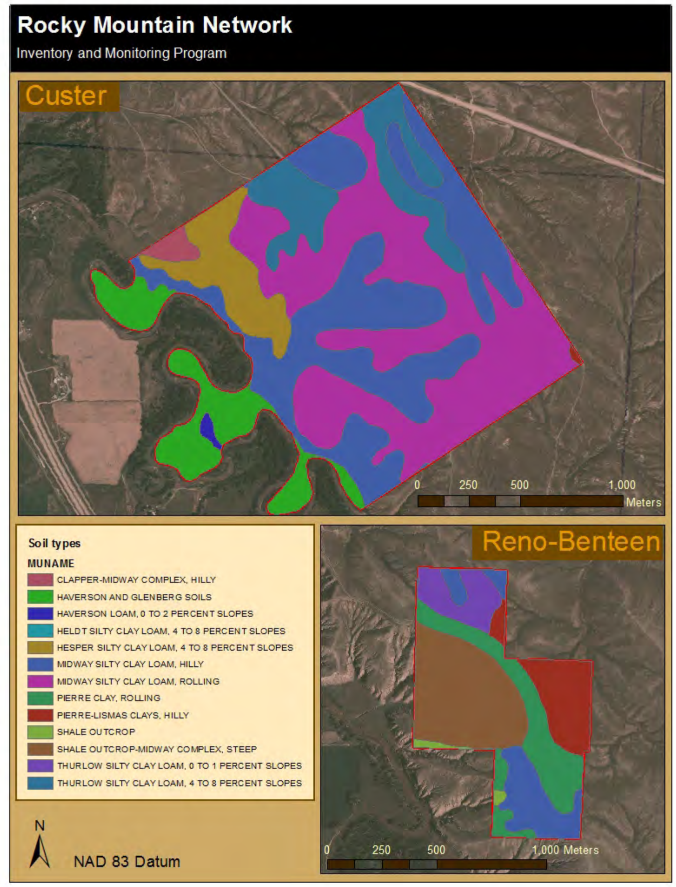
Table 4.9.4-1. Condition of soil site stability and hydrologic function of sites sampled relative to reference conditions. Also shown are the ecological sites documented for each sample location.

Site ID	Rills/ Gullies	Pedestals	Bare Ground	Water flow patterns	Sol Surface Resistance	Soil surface loss	Bulk Density	Ecological Site Documented at the Site
LIBI_001	N/S	N/S	N/S	N/S	S/M	N/S	N/S	Shallow Clay (R058AE199MT)
LIBI_004	N/S	N/S	N/S	N/S	S/M	S/M	N/S	Clayey (R058AE002MT)
LIBI_005	N/S	N/S	N/S	N/S	S/M	N/S	N/S	Clayey (R058AE002MT)
LIBI_006	N/S	N/S	N/S	N/S	S/M	S/M	N/S	Clayey (R058AE002MT)
LIBI_007	S/M	N/S	N/S	N/S	S/M	S/M	N/S	Shallow Clay (R058AE199MT)
LIBI_008	N/S	N/S	S/M	M	M	S/M	N/S	Clayey (R058AE002MT)
LIBI_009	N/S	N/S	N/S	N/S	S/M	S/M	N/S	Shallow Clay (R058AE199MT)
LIBI_010	S/M	N/S	N/S	N/S	N/S	N/S	N/S	Clayey (R058AE002MT)
LIBI_011	N/S	N/S	N/S	N/S	S/M	N/S	N/S	Clayey (R058AE002MT)
LIBI_012	M	N/S	N/S	M	M	S/M	N/S	Clayey (R058AE002MT)
LIBI_015	N/S	N/S	N/S	N/S	S/M	N/S	N/S	Clayey (R058AE002MT)
LIBI_016	M/X	M	S/M	M/X	M	S/M	N/S	Clayey (R058AE002MT)
LIBI_017	S/M	N/S	N/S	S/M	N/S	N/S	N/S	Clayey (R058AE002MT)
LIBI_018	S/M	M	N/S	S/M	S/M	N/S	N/S	Shallow Clay (R058AE199MT)
LIBI_020	S/M	N/S	N/S	M	S/M	S/M	N/S	Clayey (R058AE002MT)
LIBI_021	N/S	N/S	N/S	N/S	N/S	N/S	N/S	Shallow Clay (R058AE199MT)
LIBI_022	N/S	N/S	N/S	N/S	S/M	S/M	N/S	Shallow Clay (R058AE199MT)
LIBI_023	N/S	N/S	N/S	N/S	N/S	N/S	N/S	Clayey (R058AE002MT)
LIBI_024	N/S	N/S	N/S	N/S	N/S	N/S	N/S	Clayey (R058AE002MT)
LIBI_025	N/S	N/S	N/S	N/S	N/S	N/S	N/S	Shallow Clay (R058AE199MT)
LIBI_026	N/S	N/S	N/S	N/S	N/S	N/S	N/S	Clayey (R058AE002MT)
LIBI_027	N/S	N/S	N/S	N/S	M/X	S/M	N/S	Clayey (R058AE002MT)
LIBI_028	N/S	N/S	S/M	N/S	N/S	M	N/S	Clayey (R058AE002MT)
LIBI_032	S/M	S/M	M	S/M	S/M	M	N/S	Clayey (R058AE002MT)
LIBI_033	N/S	N/S	N/S	N/S	S/M	N/S	N/S	Shallow Clay (R058AE199MT)
LIBI_034	N/S	N/S	N/S	N/S	S/M	N/S	N/S	Clayey (R058AE002MT)
LIBI_036	N/S	N/S	N/S	N/S	S/M	N/S	N/S	Clayey (R058AE002MT)
LIBI_037	N/S	N/S	N/S	N/S	N/S	N/S	N/S	Shallow Clay (R058AE199MT)
LIBI_038	N/S	N/S	N/S	N/S	S/M	N/S	N/S	Shallow Clay (R058AE199MT)
LIBI_040	M	N/S	S/M	M/X	M	N/S	N/S	Clayey (R058AE002MT)
LIBI_043	N/S	N/S	S/M	N/S	N/S	N/S	N/S	Clayey (R058AE002MT)
LIBI_050	N/S	N/S	N/S	N/S	M	N/S	N/S	Clayey (R058AE002MT)

N/S = None to Slight S/M = Slight to Moderate M = Moderate M/X = Moderate to Extreme X = Extreme

along with an indication of which taxa are also described in the Ecological Site Descriptions' climax communities. Lists of species that we observed as well as the lists of species reported for historic climax plant communities from those site descriptions are located at (http://esis.sc.egov.usda.gov/Welcome/pgReportLocation.aspx?type=ESD). When considering the condition of the monument's grasslands, we tried to take into account not only the ecological site, but also the other factors discussed above that influence species composition. Not surprisingly, species composition at several sites did not closely match the HCPCs, but on a whole, 55- 67% of climax species were represented in the monitoring sites (Appendix D.) Therefore, we believe the Local Scale Species Composition status is good but we don't have enough data over time to estimate trends.





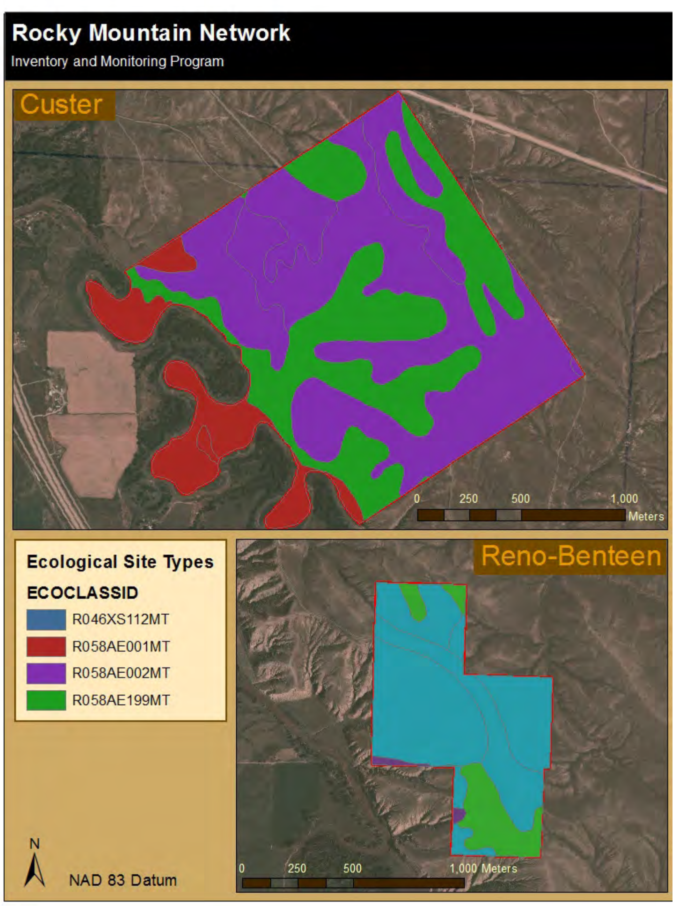


Figure 4.9.4-1. The distribution of soil types based on plant communities from Rice et al. (2012) (upper left), ecological sites based on NRCS (2007) (upper right) and soil types based on NRCS (2012) (bottom).

Table 4.9.4-2. The number and percentage of native and exotic species of each life form found on Little Bighorn Battlefield NM during Rocky Mountain Network's the 2009-2012 grassland monitoring sampling.

Life Form	Native	Exotic	Total	Percent Native
Graminoid	17	9	26	65%
Forb	91	25	116	78%
Shrub	12	0	12	100%
Tree	4	0	4	100%
Vine	3	1	4	75%

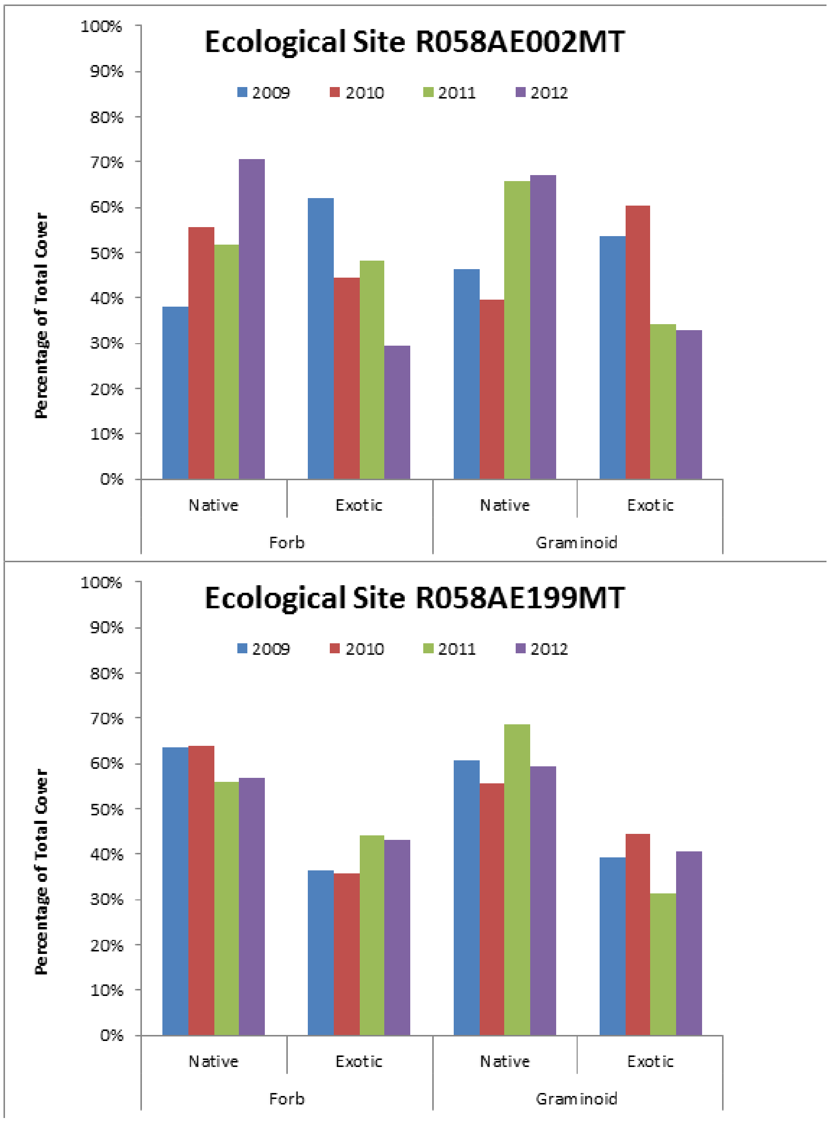


Figure 4.9.4-2. The percentage of native and exotic grasses and forbs for each ecological site samples in 2009-2012 at LIttle Bighorn Battlefield NM.

Exotic vs Native Species -- One of the major threats to grasslands and other plant communities is exotic species. Invasive 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), and changes in water availability (D'Antonio and Mahall 1991).

Based on four years (2009-2012) of grassland sampling in 32 monitoring plots, which are located throughout the park unit, 127 of 162 (78%) of the species observed were native (Table 4.9.4-2). However, the number of species does not take into account how prevalent those species are on the landscape. Based on the percentage of cover, grasses on are sample plots were almost 70% native in both ecological site types; forbs were 50-60% native species averaged across all four years of monitoring (Figure 4.9.4-2). Exotics don't appear in the Ecological Site Description state and transition models until a fairly degraded state. Active exotic species monitoring should continue to be an active management concern; it was of moderate concern to our subject matter experts in light of possible future changes in environmental characteristics due to shifts in climate and/or catastrophic events and exotics seem poised to increase significantly. While exotic plant taxa are not seemingly increasing over the four year monitoring period, a substantial percentage of the Monument's vegetation is non-native. As a result, we consider this to be of moderate concern, and the overall ranking assigned to the grasslands since the exotics that are currently present have the potential to completely shift the entire grassland system.

<u>Response of Annual Species to Disturbance</u>

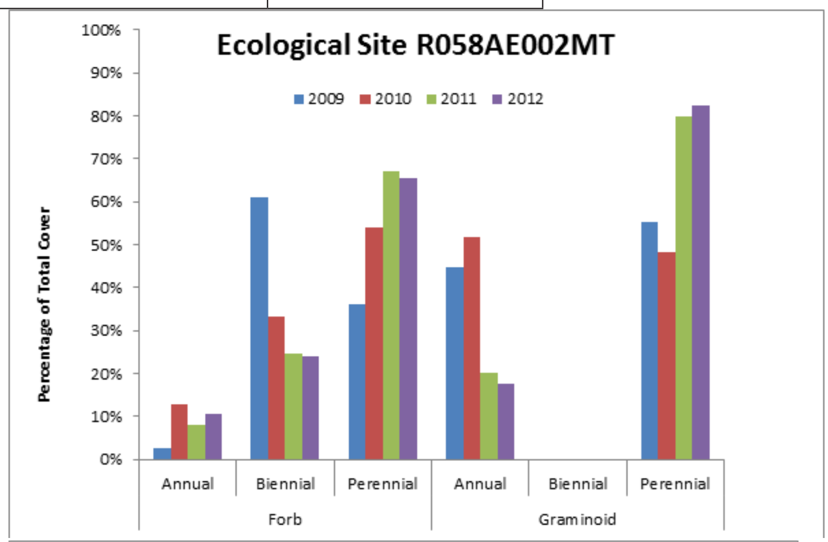
The proportion of annual, biennial and perennial species provides an indication

Table 4.9.4-3. The number and percentage of perennial grass and forb species observed at each ecological site on Little Bighorn Battlefield NM during the 2009-2012 grassland monitoring sampling. Also shown are the percentages reported for historic climax plant communities in the ecological site descriptions for that site based on NRCS (2007).

Ecological Site Number	Life Form	Percent Perennials Observed (2009 - 2012)	Percentage of Perennials Expected for Ecological Site Description Climax Community
R058AE002MT	Graminoid	65% (11% of which are exotic)	100%
	Forb	45% (2.7% of which are exotic)	100%
R058AE199MT	Graminoid	70% (8.6% of which are exotic)	100%
	Forb	57% (3.7% of which are exotic)	100%

of the stability of the site, and it is generally expected that the proportion of annual species at a given site would be higher immediately following a disturbance, but would shift toward an increased proportion of perennials as time passes since a disturbance. Data from grassland monitoring samples indicated that grasses were predominantly perennial in all years except 2010, when annual graminoid cover exceeded perennial cover in the R058AE002MT ecological sites (Figure 4.9.4-3). Forbs tended to have a higher proportion of perennial species based on canopy, except in 2009, when biennial forb cover surpassed perennial forb cover in the same ecological site as the perennial graminoids in 2010.

Based on what is considered the historic climax plant communities (NRCS 2007), the proportion of perennial species was generally higher for grasses than for forbs (Table 4.9.4-3), but the proportion of both perennial life forms were lower than expected. As previously discussed, we did not have any expectation for the proportion of annuals, biennials, and perennials, to coincide exactly with historic climax plant communities, in part because of local site variability and not all sites are at a climax stage. However, monitoring the proportion of annuals in the upcoming years is warranted, especially for forbs. If perennial numbers do not increase, then causes other than recent disturbance due to fire should be considered, followed by possible management actions.



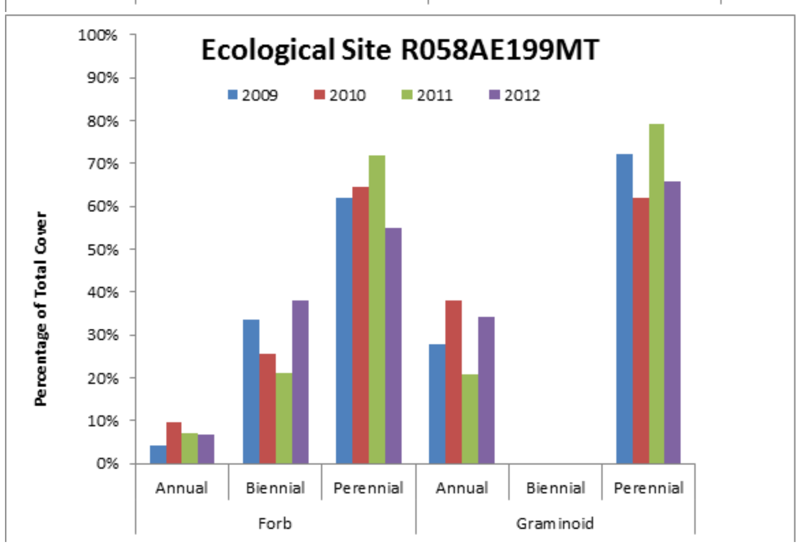


Figure 4.9.4-3. The percentage of annual, biennial, and perennial grasses and forbs for each ecological site and each years sampled at Little Bighorn Battlefield NM.

Relative Proportion of Functional Groups -
The proportions of functional groups observed in our grassland monitoring did not

Table 4.9.4-4. The percentage cover of each life form observed at each ecological site on Little Bighorn Battlefield NM during the 2009-2012 grassland monitoring sampling. Also shown is the potential range of percentages reported for historic climax plant communities in the ecological site descriptions for that site based on NRCS (2007).

Ecological Site Number	Life Form	Percent Observed (2009 - 2012)	Expected ranges of cover based upon Ecological Site Descriptions
R058AE002MT	Grass/Grasslike	41%	55 - 85%
R058AE002MT	Forb	16%	5 - 10%
R058AE002MT	Shrub/Vine	7%	1 - 5%
R058AE002MT	Tree	0%	0%
R058AE199MT	Grass/Grasslike	44%	20 - 40%
R058AE199MT	Forb	15%	1 - 5%
R058AE199MT	Shrub/Vine	8%	10 - 15%
R058AE199MT	Tree	0%	0%

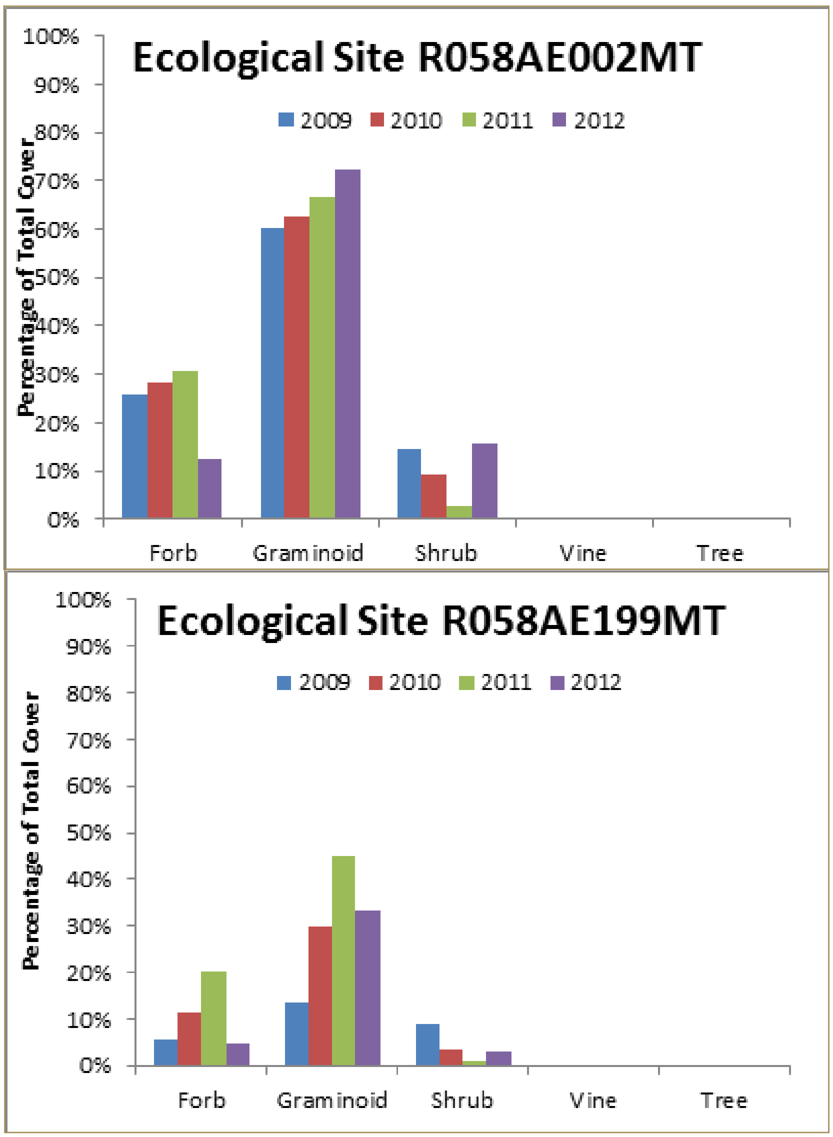


Figure 4.9.4-4. The percentage of life forms for each ecological site samples in 2009-2012 at Little Bighorn Battlefield NM.

the ecological site descriptions (Table 4.9.4 4) and showed some annual variability among years, especially in the R058AE199MT ecological site (Figure 4.9.4-4). However, for reasons previously discussed, this did not cause any particular concern. Deviations were not great and canopy cover for all or many life forms often exceeded expected percentages across the board.

The iconic shrub of the Monument, big sagebrush, is common in the general area and in places within the Monument (e.g., north of the administration road down to the river in the Custer unit). The 83 and 91 fires likely killed many sagebrush (*Artemisia tridentata*) plants but not all –large sagebrush plants are scattered in the Custer unit (along Deep Ravine and in the "island" of prairie surrounded by the park road south of Last Stand Hill, for example) that likely survived the fire. Sagebrush likely has waxed and waned at the site, declining due to fire and increasing over time, especially with grazing by native ungulates and non-native horses. The current lower density of sagebrush in the Monument now is not of ecological concern.

Relative Proportion of C3 and C4 Species –
During the rapid assessment, the subject experts found no major concern about the proportion of C3 and C4 Grasses. As is typical for mixed grass prairie, grassland sites at Little Bighorn are dominated by C3 grasses. Our

Table 4.9.4-5. The percentage of C4 vs C3 grasses observed at each ecological site at Little Bighorn Battlefield NM during the 2009-2012 grassland monitoring sampling. Also shown are the expected percentages derived from ecological site descriptions for that site based on the species reported for historic climax plant communities.

Ecological Site Number	Percentage of C3 (vs C4) Grasses Observed (2009 - 2012)	Expected Percentage of C3 grasses derived from Ecological Site Description
R058AE002MT	96%	69%
R058AE199MT	99%	71%

monitoring data indicated that overall, C3 grasses comprised 96-99% of the total grass cover, and therefor C4 grasses comprised 1-4%. As expected, there is some variation of this among the ecological sites (Figure 4.9.4-5) (Table 4.9.4-5). This is certainly a reasonable expectation for mixed grass prairie in this region.

Predicted, generalized climate change impacts for this region are drier, hotter, and more severe storms (and more frequent, severe fires). Should these predictions be correct, it may favor shrub invasion and alter C4 and C3 species composition toward an increase in the proportion of C4 taxa which in turn will affect the plants and animals native to the mixed grass ecosystem.

<u>The Role of Fire in Grassland Condition at Little Bighorn Battlefield NM</u>
Note: The discussion of the role of fire at Little Bighorn Battlefield NM was provided by Tim Seastedt, Professor at Colorado State University, Department of Biology, who served as one of the grasslands subject matter experts.

Decisions about using fire as a management tool at this site require periodic re-visitation. Chances are very good the upland grasslands had a fairly high (10-20 yr?) fire return interval during the 19th century, and in this case, using fire as a management tool to maintain the upland grasslands is appropriate. Opportunistic plans to use wildfires as a management tool need to be discussed (e.g., not if but when a wildfire occurs, where will be the logical defense/suppression boundaries?).

If the Monument was a common summer gathering area for Native Americans then the area would likely have experienced

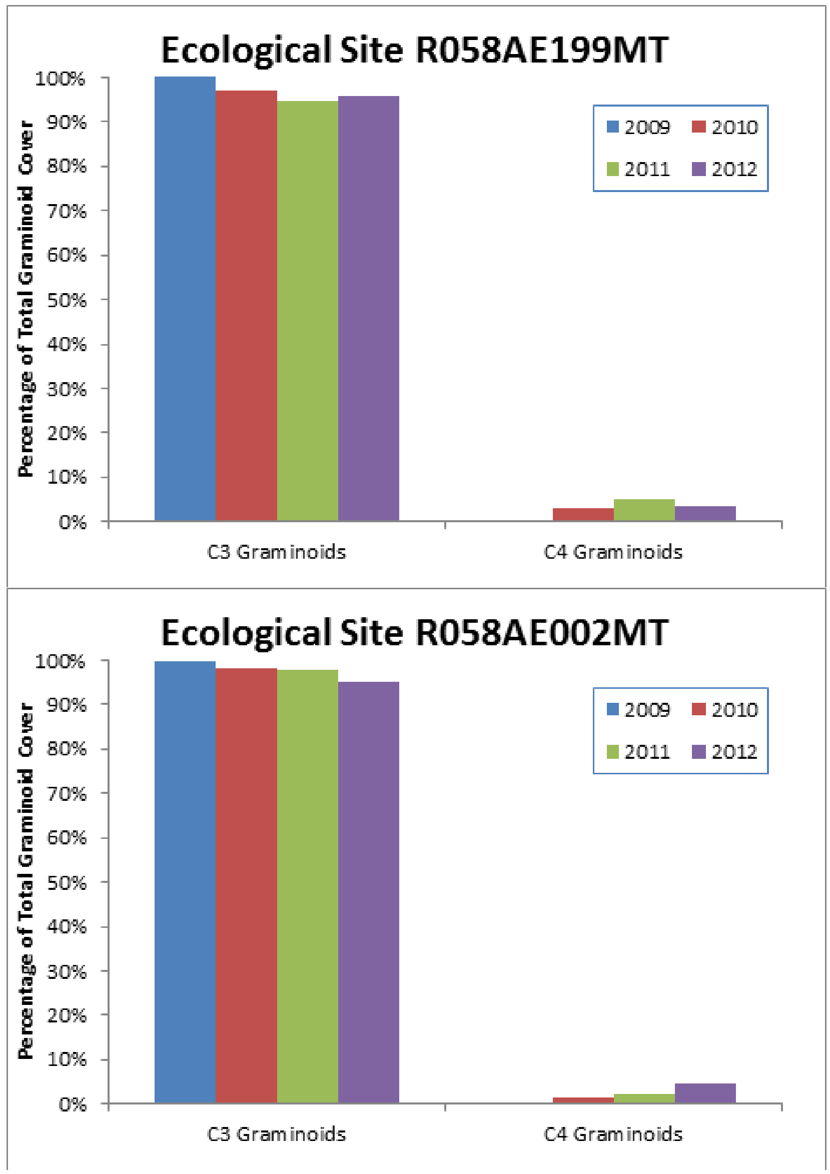


Figure 4.9.4-5. The percentage of C3 and C4 grasses for each ecological site samples in 2009-2012 at Little Bighorn Battlefield NM.

substantial grazing pressure from horse herds. Such activity would suppress the extent and intensity of many fires, and support a bottomland that contained ample shrublands. The fact that a small group of Reno's men

Table 4.9.4-6. Summary of the grassland indicators/measures categories and their contributions to the overall assessment of grassland condition.

Indicator/Measure	Description of How the Indicator(s) Contributes to the Overall Resource Condition	General Contribution of this Indicator or Measure to the Overall Resource Condition.
Soil/Site Stability and Hydrologic Function (6 measures)	Soil/Site Stability and Hydrologic Function addresses capacity of an area to limit excessive loss and/or redistribution of soil resources by wind and water.	Cumulative departures from expected conditions for most measures of Soil/ Site Stability and Hydrologic Function general ranged from none to slight, with only a few sites having some measures with moderate departures, and these sites were situated on steep, erodible slopes and/or in areas of modern fire.
Biotic Integrity (5 measures)	The biotic integrity addresses the capacity for the composition and functioning of the grassland communities to remain within normal range of variability expected for the site and to resist a loss in this capacity and/ or to recover this capacity when losses do occur.	Most measures of biotic integrity showed little departure from the range of variability that would be expected for those sites. Cover was generally dominated by perennial C3 grasses, which is what would be expected in a health mixed grass prairie. The biggest concern is from exotic plants. Exotic species were of moderate concern to our subject matter experts in light of possible future changes in environmental characteristics due to shifts in climate and/or catastrophic events.

successfully hid for the evening following the Battle before joining Reno's group, and the comments found in "Black Elk Speaks" regarding the discovery of infantry hiding in shrubs, argues that the bottomlands and lower hillslopes probably did contain substantial woody vegetation. This leads one to believe that there should be no strong reason to reduce shrub cover at lower elevation areas at the Monument but should be maintained in at least its current abundance.

Overall Condition

For assessing the condition of grasslands, we used a variety of indicators/measures that were not mutually exclusive but were intended to be different ways of capturing the essence of what we thought represented the condition of the Monument's grasslands. Grassland condition can be assessed from many different angles, but we chose two main categories, Soil/Site Stability and Hydrologic Function and Biotic Integrity, for this resource. A summary of how they contributed to the overall grassland condition is summarized in Table 4.9.4-6. Based on the indicators, data, and expert opinion, we consider the overall condition of the grasslands at Little Bighorn Battlefield NM to be in good condition. The only real concern raised about the Monument grasslands is exotic plant taxa. Half of the top 10 species with highest cover are exotic at the ROMN monitoring sites and are worth closely monitoring, especially with respect to observing changes related to climate conditions (for example, how do invasives appear to respond after drought conditions or wet springs?). The exotic annual bromes appear to be coexisting now (not displacing native vegetation) and there may not be a problem. However, if the system is shifted by some event, there is concern that the bromes may become dominant and lead to a significant shift in community structure and composition, and therefore transition to a lower functioning ecosystem. Conversely, the small stature of these disturbance/interstitial space occupiers (including the annual brome and alyssum) may preclude invasion by larger, more undesirable invasives.

In general, the Custer unit appears more disturbed (and greater occurrence of invasives) than the Reno-Benteen unit (although the area west of the road in the Reno-Benteen unit had a lot of soil disturbance from gophers and a high cover of cheatgrass (*Bromus tectorum*) and Japanese brome (*B. japonicus*).

The grasslands appear to have the appropriate species composition: C3 species dominate (as expected), the proportions of grasses:forbs:shrubs appears appropriate and healthy and consistent with accounts of the vegetation in 1876. However, the abundance and cover of bromes should be carefully monitored as well as the cover of the natives bunchgrasses to make sure their relative proportions are not shifting. Overall the park grasslands are in moderate condition, primarily due to the presence of highly invasive exotic plants.

Level of Confidence/Key Uncertainties

Overall, our confidence in this assessment is high, although as is generally the case, there are uncertainties. Some of the key uncertainties for the grassland assessment include annual variability, the effect of drought conditions, and the effect of recovery from disturbance.

Annual variability in rainfall, temperatures, diseases, etc., can have a dramatic effect on some indicators (e.g., plant species composition), which in turn, affects our interpretation of grassland condition. The Palmer Drought Index showed conditions during the four year assessment period ranged from cooler and wetter than normal to severe drought in 2012. It is possible that the typical range of variability was captured during this time, but the duration is too short (especially the lag time following the hotter and drier conditions in 2012) to state positively how these fluctuating conditions affected vegetation response.

Another uncertainty is that parts of the site are changing in response to time since disturbance. A number of monitoring sites were burned (1983 and 1991) and are slowly recovering from that period. However, it will likely take decades before we fully understand the degree to which these areas might recover to their pre-disturbed state.

4.9.5. Sources of Expertise

During the course of this assessment, we consulted with the following individuals who provided subject matter expertise as well as an on-site rapid assessment.

Dr. Alan K. Knapp is a Professor at Colorado State University, Department of Biology. Dr. Knapp has an extensive background of research and publications related to the ecology of grasslands.

Dr. Timothy Seastedt is a Professor at University of Colorado, Boulder, Department of Ecology and Evolutionary Biology. He also has an extensive background of research and publications related to the ecology of grasslands.

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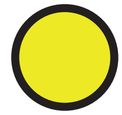
4.10. Exotic Plants

Indicators/Measures

- NatureServe Invasive Species Impact Rank
- Invasiveness Score-Colorado Natural Heritage Program
- Proportion of Interior Sites Infested With High Priority Species
- Proportion of Monument and Battlefield Tour Road Infested With High Priority Species

Condition – Trend – Confidence Level



Moderate – Insufficient Data – High

4.10.1. Background and Importance

Globalization of commerce, transportation, human migration, and recreation in recent history has introduced invasive exotic species to new areas at an unprecedented rate. Biogeographical barriers that once restricted the location and expansion of species have been circumvented, culminating in the homogenization of Earth's biota. Although only 10% of introduced species become established and only 1% become problematic (Williamson 1993; Williamson and Fitter 1996) or invasive, nonnative species have profound impacts worldwide on the environment, economies, and human health.

Exotic 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 these species to natural resources is often irreparable, and our understanding of the consequences incomplete. Exotic 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 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." (Figure 4.10.1-1). National parks, like land managed by other

MIKE BRITTEN

Figure 4.10.1-1. Smooth brome (*Bromus inermis*) patch in Reno-Benteen unit at Little Bighorn Battlefield NM.

organizations, are deluged by new exotic 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 4,600 acres of public land each year in the United States (Asher and Harmon 1995), significantly altering local flora. For example, exotic plants comprise an estimated 43% and 36% of the flora of the states of Hawaii and New York, respectively (Rejmanek and Randall 1994). Exotic plants infest an estimated 2.6 million acres of the 83 million acres managed by the NPS. Prevention and early detection are the principal strategies for successful invasive exotic plant management. While there is a need for long-term suppression programs to address high-impact species, eradication efforts are most successful for infestations of less than one hectare in size (Rejmanek and Pitcairn 2002).

4.10.2. Data and Methods

Several reports have documented exotic plant presence at Little Bighorn Battlefield NM (Bock and Bock 1987, 2006; Simonson 2001; Wood and Rew 2005; Shorrock et al. 2010; Lehnhoff and Lawrence 2010; Rice et al. 2012; Martin et al., 2012; Schweiger et al. 2012; and Waldhart 2012). A comprehensive list of every identified exotic plant species from the previously mentioned reports, in addition to files from Monument staff containing lists of exotic species that are present in the park, was created and is in Appendix E. Exotic plants identified as high priority species, either by Monument resource management staff based upon their best professional judgement, or identified as noxious by the State of Montana (2010) have been extracted from the comprehensive list (Appendix E) for a total of 32 species and are shown in Table 4.10.2-1. These plants are the ones evaluated to assess current exotic plant condition at the Monument.

In evaluating current condition and trend for exotic plants at Little Bighorn Battlefield NM, a total of four indicators/measures were used to assess the condition of exotic plant species.

Indicators/Measures

NatureServe Invasive Species Impact Rank (I-Rank)

Invasiveness Score-Colorado Natural Heritage Program

The first two indicators we used determined which exotic plant species posed the greatest risk to the Monument. The NatureServe database, which is based on the Invasive Species Assessment Protocol developed by Randall et al. (2008) is a ranking system that categorizes and lists nonnative plants for large areas such as regions (e.g. Great Plains) or states (e.g. Colorado) according to their overall impact on native biodiversity. The invasiveness ranking protocol assesses four major categories for each plant (ecological impact, current distribution and abundance, trend in distribution and abundance, and management difficulty) for a total of 20 questions. 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 (Randall et al. 2008).

The second ranking system we used was developed by Rocchio et al. (2007) for the Colorado Natural Heritage Program (CNHP). They developed a Floristic Quality Assessment (FQA) for Colorado, which is a vegetative community index designed to assess the degree of "naturalness" of an area based on the presence of conservative plant species. Conservative plants are those that show strong affinity to high-quality natural areas (areas representing "pre-settlement conditions"). One component of the assessment is assigning an invasiveness score to exotic plants. The relative invasiveness of each exotic and the variations of impact are based on the definitions outlined in Richardson et al. (2000) and those used in the Kansas FQA (J. Rocchio,Vegetation Ecologist Washington Dept. of Natural Resources, Natural Heritage Program, pers. comm. 2/4/13).

Table 4.10.2-1. List of high priority exotic plant species found within Little Bighorn Battlefield National Monument.

Scientific Name	Common Name	MT Noxious Weed List 2010[1]	Nature Serve Invasive Species Impact Rank (I-RANK) (Randall et al. 2008)	Invasiveness Ranking Unpublished Database (Rocchio 2007)
Acroptilon repens (Centaurea repens)	Russian knapweed	2B	High/Medium	4
Agropyron cristatum (desertorum)	Crested wheatgrass		Medium/Low	4
Berteroa incana	Hoary alyssum	2A	Low/Insignificant	2
Bromus inermis	Smooth brome		High/Medium	4
Bromus tectorum	Cheatgrass	3	High	4
Cardaria draba	Hoary cress/Whitetop	2B	NYA[2]	4
Centaurea stoebe (biebersteinii)	Spotted knapweed	2B	High/Medium	4
Cirsium arvense	Canada thistle	2B	High/Medium	4
Cirsium vulgare	Bull thistle		Medium/Low	4
Convolvulus arvensis	Field Bindweed	2B	Medium/Low	4
Cynoglossum officinale	Houndstongue	2B	Medium/Low	4
Descurainia sophia	Herb sophia		Medium/Low	3
Elaeagnus angustifolia	Russian olive	3	High	4
Eragrostis cilianensis	Stinkgrass		Medium/ Insignificant	2
Euphorbia esula	Leafy spurge	2B	High/Medium	4
Hypericum perforatum	St. Johnswort	2B	High/Medium	4
Kochia scoparia	Kochia		Low	4
Lepidium perfoliatum	Clasping pepperweed		Low/Insignificant	4
Linaria dalmatica	Dalmatian toadflax	2B	NYA	4
Lonicera tatarica	Tatarian honeysuckle		High/Medium	2
Medicago sativa	Alfalfa		Insignificant	3
Melilotus officinalis	Yellow Sweetclover		Medium/Low	3
Poa bulbosa	Bulbous bluegrass		NYA	3
Potentilla recta	Sulphur cinquefoil	2B	High/Medium	4
Rheum rhabarbarum	Garden rhubarb		NYA	1
Rumex crispus	Curly dock		Low/Insignificant	3
Salsola tragus (kali, iberica)	Prickly Russian thistle		NYA	4
Sisymbrium altissimum	Tall tumblemustard		NYA	4
Solanum nigrum	Black nightshade		NYA	N/A
Tamarix chinensis/ramosissima	Saltcedar	2B	High	4
Taraxacum officinale	Dandelion		NYA	3
Thlaspi arvense	Fanweed		Low/Insignificant	3

[1]Noxious: N = Listed on Montana's noxious weed list (September 2010); 2A: These weeds are common in isolated areas of Montana. Management criteria will require eradication or containment where less abundant. 2B: These weeds are abundant in Montana and widespread in many counties. Management criteria will require eradication or containment where less abundant. 3: Regulated Plants: (NOT MONTANA LISTED NOXIOUS WEEDS). These regulated plants have the potential to have significant negative impacts. The plant may not be intentionally spread or sold other than as a contaminant in agricultural products. The state recommends research, education and prevention to minimize the spread of the regulated plant.

[2]NYA indicates that the plant has yet to be assessed for invasiveness.

Montana Natural Heritage Program (MNHP) has also developed a system for assessing floristic quality (Jones 2005) that includes exotics in the assessment index. MNHP did not, however, explicitly assign invasiveness scores to individual, exotic taxa. Therefore, we used our best professional judgement in evaluating whether or not to use the CNHP ranking system for the same taxa occurring in Montana. Because CNHP's criteria used for classification were quite general, we decided it was appropriate to use the Rocchio (2007) system at the regional scale.

Rocchio et al's. (2007) ranking system is broken into four categories, ranging from invasiveness scores of 1-4 with the following definitions:

1 = Casual exotic species (e.g. waifs) which may reproduce occasionally but do not form self-replacing populations and therefore require repeated introductions for their persistence;

2 = Naturalized exotic plants are those which reproduce consistently and sustain populations over many life-cycles but do not necessarily invade natural, semi-natural or human-made ecosystems.

3 = Invasive, non-transformers; invasive exotic species which produce reproductive offspring, often in large numbers, at considerable distances from parent plants, and thus have the potential to spread over a considerable area. However, their ability to alter ecosystem form, function, and composition is minimal or less than that of transforming invasive species (see below ranking of 4).

4 = Invasive-transformers; invasive, exotic species which are capable of forming monotypic stands or with high ability to alter ecosystem function. These species are capable of transforming compositional and functional characteristics of natural plant communities. These are species which (a) use excessive amounts of resources (e.g water - *Tamarix* sp.), (b) donors of limiting resources (e.g. nitrogen), (c) fire promoters (e.g. *Bromus tectorum*), (d) salt accumulators (e.g. *Tamarix*), etc.

The Colorado Noxious Weed Act (http://www.ag.state.co.us/DPI/weeds/statutes/weedlaw.PDF) defines a noxious weed as "an alien plant or parts of an alien plant that have been designated by rule as being noxious or has been declared a noxious weed by a local advisory board, and meets one or more of the following criteria:

(a) Aggressively invades or is detrimental to economic crops or native plant communities;

(b) Is poisonous to livestock;

(c) Is a carrier of detrimental insects, diseases, or parasites;

(d) The direct or indirect effect of the presence of this plant is detrimental to the environmentally sound management of natural or agricultural ecosystems."

Criteria (a) and (d) meet the definition for an invasiveness score of 4.

In addition, A noxious weed is defined by Montana Law (MCA 7-22-2101) (http://www.gallatin.mt.gov/Public_Documents/gallatincomt_weed/MT_LocalCountyWeedAct.pdf) as, "any exotic plant species established or that may be introduced in the state that may render land unfit for agriculture, forestry, livestock, wildlife, or other beneficial uses or that may harm native plant communities."

It's important to note that the invasiveness values in the Colorado's FQA are incomplete and based upon minimal panel ranking input (J. Rocchio, pers. comm.); however, Joanna Lemly, Wetland Ecologist with the CNHP, stated that the rankings are extremely useful despite the lack of completeness.

Indicators/Measures

Proportion of Interior Sites Containing High Priority Exotic Species

The Rocky Mountain Inventory and Monitoring Network (ROMN) identified vegetation composition, structure, and soils (VCSS) as a vital sign to assess park upland

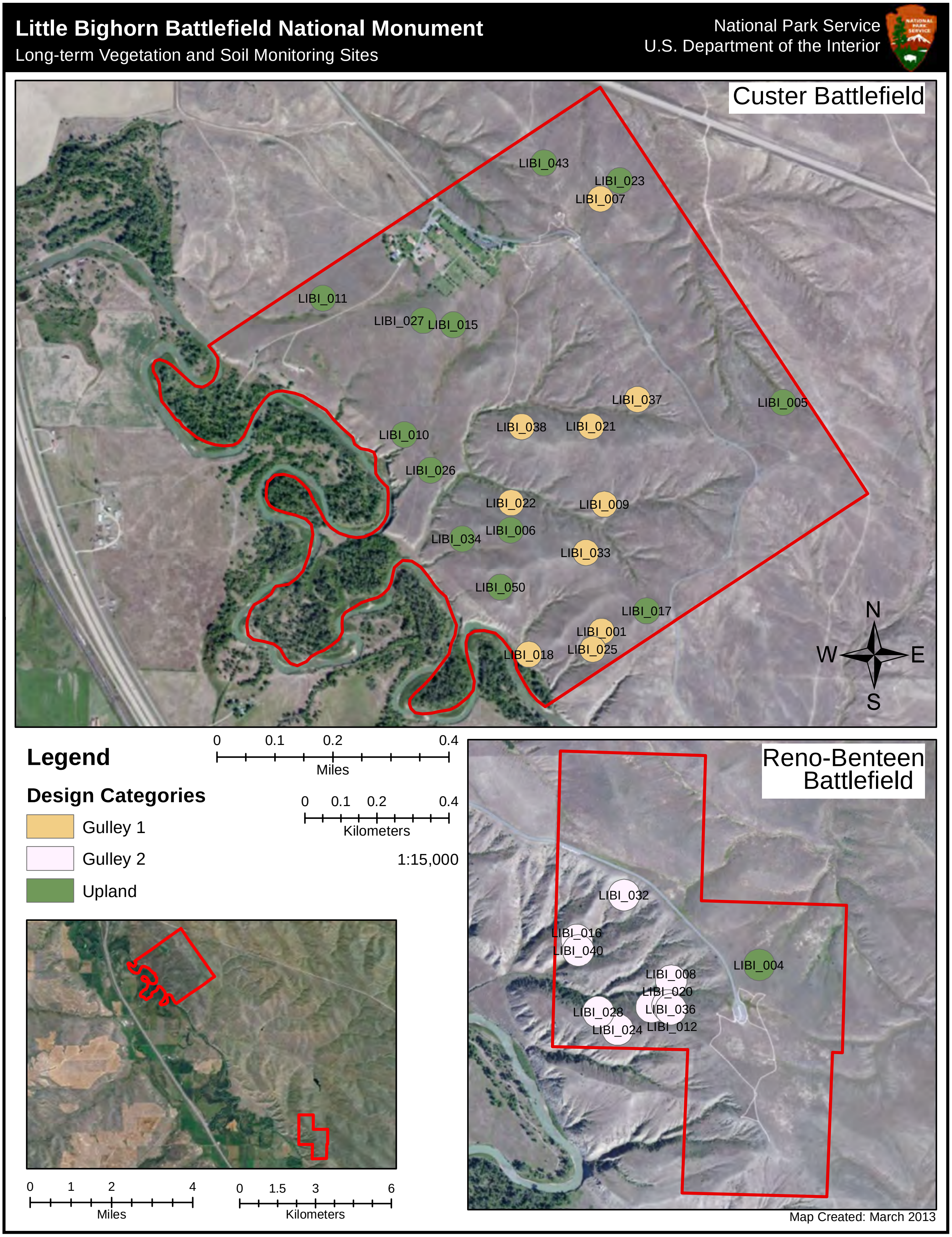


Figure 4.10.2.1. ROMN Vegetation Composition Structuture and Soils (VCSS) Monitoring Sites

vegetation ecosystems (Britten et al. 2007), with one of the objectives to determine status and trends in abundance of invasive/exotic plant taxa in the Monument based on park-specific lists of likely and ecologically significant invaders (Shorrock et al. 2010). Data collection began in the summer of 2009, following the VCSS protocol developed by Manier et al. (2011), which was under development in 2009 (Shorrock et al. 2010).

A total of 32 sites throughout the Monument's upland vegetation only are sampled over 4 years, with each site containing ten 1 m^2 plot and three associated transects (Shorrock et al. 2010). The monitoring sites are located at least 50 meters from any disturbance, including roads, trails, developed areas, buildings, fences, gates, pullouts, and parking lots (L. O'Gan, ROMN Data Manager, pers. comm. 3/4/13) (Figure 4.10.2-1).

The number of interior sites containing a high priority exotic species will be assessed to determine the proportion of sites infested using the VCSS monitoring data collected from 2009-2012 (Shorrock et al. 2010; unpublished monitoring data 2010-2012).

Indicators/Measures

Proportion of Monument and Battlefield Tour Road Containing High Priority Exotic Species

Wood and Rew (2005) and Lehnhoff and Lawrence (2010), both with Montana State University, mapped the distribution of exotic plants throughout the Monument. Wood and Rew (2005) did not map the riparian habitat and mapped exotic plant infestations by standing in the center of a patch, recording the infestation as a point. While we can calculate the 2005 area infested, we do not have distribution information to compare to Lehnhoff and Lawrence's 2010 exotic plant distribution data. Instead, we use the 2010 survey data, pertaining to the high priority exotic species, to determine percent of total Monument acreage infested. Lehnhoff and Lawrence's 2010 survey included the entire Monument -765 acres- and the Battlefield Tour Road (37 acres) for a total of 802 acres. We also created distribution maps for each high priority species mapped but excluded *Bromus tectorum* since its area was modeled instead of directly mapped.

4.10.3. Reference Conditions

The most desirable reference condition for a park is the complete absence of exotic species. However, such a reference condition is probably not a realistic standard to which exotic plant species should be compared. We consider a more realistic reference condition to be the capability for the integrity of the primary communities (e.g., riparian habitat, shrublands, and Great Plains prairie) to be maintained. By this, we mean that the ecological attributes (e.g., species composition, structure, etc.) and natural processes remain within the natural variation for the community type. Therefore, the reference condition of "good" is that species are known to occur regionally or on adjacent lands, but have not yet been confirmed within the Monument, or if species have been confirmed, distribution is sparse, limited in extent, and may vary from sparse individuals to dense patches. A "moderate" condition is when species have been found in the Monument in small, localized patches. Finding and controlling patches might prevent large-scale invasion, and distribution is somewhat limited in extent and may vary in intensity from sparse individuals to dense patches. A condition of significant concern is warranted when exotic plants threaten to alter these primary communities to the point where they no longer maintain their attributes or processes. For example, when exotic species dominate a community where key native species are expected for that community type, then the area would be considered as severely degraded. However, significant concern is also warranted when the trend for a community is clearly toward such a degraded outcome rather than it actually having been realized.

4.10.4. Condition and Trend

<u>Invasiveness Rankings</u>

As expected, several of the high priority exotic species listed in Table 4.10.2-1 also ranked high in invasiveness. Three species, including *Bromus tectorum*, *Elaeagnus angustifolia*,

Table 4.10.4-1. High priority exotic species with the highest invasiveness rankings from NatureServe (Randall et al. 2008) and Colorado Natural Heritage Program (Rocchio 2007).

Exotic Species	Species Treated by EPMT in 2012
Nature Serve Ranking of High and Rocchio (2007) Ranking of 4	
Bromus tectorum	X
Elaeagnus angustifolia	
Tamarix chinensis/ramosissima	
Nature Serve Ranking of High/Medium and Rocchio (2007) Ranking of 4	
Acroptilon repens	X
Bromus inermis	
Centaurea stoebe (biebersteinii)	X
Cirsium arvense	X
Euphorbia esula	
Hypericum perforatum	
Potentilla recta	X
Not Yet Ranked by NatureServe but Rocchio (2007) Ranks as 4, and these plants are listed on Montana's 2010 Noxious Weed List.	
Cardaria draba	X
Linaria dalmatica	X

and *Tamarix chinensis/ramosissima* were ranked the highest in both ranking systems. An additional seven species were ranked as high using Rocchio (2007) invasiveness scores and ranked as High/medium using Randall et al. (2008) scores. Two additional species were added, *Cardaria draba* and *Linaria dalmatica*, based upon the high ranking assigned by Rocchio (2007) and their status as noxious weeds in Montana even though they have yet to be ranked by NatureServe. Seven of these twelve species were targeted for control by the Monument's 2012 Exotic Plant Management Team (Waldhart 2012) (Table 4.10.4-1).

Several remaining species were ranked as highly invasive by Rocchio (2007) (i.e., ranking of 4), which only considers invasiveness, whereas these same plants are not ranked as high by Randall et al. (2008) which considers ease or difficulty of control, current extent of

Table 4.10.4-2. Number and percentage of high priority exotic plant species detected in interior sites sampled in 2009 -2012 at Little Bighorn Battlefield NM.

High Priority Exotic Species	Number of Sites	% (N=32)
Agropyron cristatum	4	12.5
Bromus inermis	10	31.25
Bromus tectorum	30	93.75
Cirsium arvense	6	18.75
Convolvulus arvensis	4	12.50
Descurainia sophia	3	9.38
Lepidium perfoliatum	1	3.12
Medicago sativa	1	3.12
Melilotus officinalis	22	68.75
Sisymbrium altissimum	7	21.88
Taraxacum officinale	28	87.50

Species in highlighted cells were ranked the highest by Randall (2008) and Rocchio (2007).

populations (state or regional level), as well as invasiveness.

Comparing the two ranking systems revealed the following:

- The two rankings differed in approximately 1/3 of the species.
- NatureServe rankings were typically lower, with the exception of *Lonicera tatarica*, which was ranked lower by Rocchio (2007).
- The higher the NatureServe score, the more likely to match Rocchio (2007) invasiveness ranking.
- Rocchio (2007) only considers a plant's ability to invade and excludes management considerations so is typically ranked higher.

<u>Proportion of Interior Sites</u>

The proportion of VCSS interior sites containing at least one high priority exotic species is listed in Table 4.10.4-2. Eleven of the high priority exotic plants were found in at least one VCSS monitoring site. One of the three highest ranked species for invasiveness, *Bromus tectorum*, was found in almost 94% of the interior sites. Exotic bromes are well known to dramatically change the character of an ecosystem, including such changes as major shifts in community composition and structure (Knapp 1996) as well as substantially alter fire regimes (Whisenant 1990). In many cases these changes have become, for all practical purposes, irreversible (Knapp 1996). Thus, from a standpoint of significance of impact to the Monument's upland vegetation ecosystem, we would consider the exotic brome to be a significant concern.

No additional highly invasive species based upon the invasiveness ranking was found within the VCSS monitoring sites, but both *Melilotus officinalis* and *Taraxacum officinale* were found in more than half (68.75% and 87.50%, respectively) of the interior sites, suggesting they are well established. In addition, both *Alyssum alyssoides* and *Lactuca serriola* were found in 100% of the VCSS sites, and *Melilotus officinalis* was found in 68.75% of the sites, which also indicates that these plants have begun to establish themselves through the interior of the Monument.

Since the VCSS interior sites are located only in the upland vegetation habitat, presence of exotic plant species within the Monument's riparian habitat is documented annually during ROMN's stream ecological integrity monitoring (Schweiger et al. 2012). During 2009, the following three high priority exotics were found: Canada thistle (*Cirsium arvense*), Russian olive (*Elaeagnus angustifolia*), and Salt Cedar (*Tamarisk* ssp.). Eleven riparian plots were surveyed and values ranging from 0 to 1, with 1 describing a species that occurred at all 11 riparian plots were recorded. Canada thistle was found in the highest number of plots with a frequency of 0.73, followed by Russian olive at 0.55 then Tamarisk at 0.27 (Schweiger et al. 2012).

Proportion of Monument Acreage Infested

Lehnhoff and Lawrence (2010) mapped 14 exotic plant species, 9 of which are considered high priority species at the Monument and 9 were rated as the most highly invasive by both Randall et al. (2008) and Rocchio (2007). As mentioned previously, the distribution for *Bromus tectorum* was modeled because it was so widespread during the 2010 survey versus mapped and will not be included. Table 4.10.4-3 shows the mapped acreage and percent of Monument and Battlefield Tour Road containing the high priority exotic species.

Table 4.10.4-3. Number of acres and percentage of total area occupied by high priority exotic species mapped by Lehnhoff and Lawrence (2010) at Little Bighorn Battlefield NM and along Battlefield Tour Road.

High Priority Exotic Species	Number of Acres	% of Monument and Battlefield Road Occupied by Species(802 acres)
Acroptilon repens	0.064	0.008
Bromus inermis	24.69	3.08
Cardaria draba	0.143	1.78
Centaurea biebersteinii	0.06	.007
Cirsium arvense	25.7	3.20
Cirsium vulgare	0.003	0.0004
Convolvulus arvensis	19.31	2.41
Cynoglossum officinale	0.435	0.054
Elaeagnus angustifolia	0.0012	0.0001
Hypericum perforatum	4.1	0.51
Linaria dalmatica	0.0069	0.0009
Poa bulbosa	10.745	1.34
Salsola tragus	0.027	0.003
Total Acres	85.2851	10.63

Species in highlighted cells were rated the highest by Randall (2008) and Rocchio (2007) invasiveness ranking.

Of the species mapped, *Cirsium arvense* and *Bromus inermis* occupied the most acreage, 25.7 acres and 24.69 acres, respectively, followed by *Convolvulus arvensis*, 19.31 acres, and *Poa bulbosa*, 10.745 acres. The distribution of the species listed in Table 4.10.4-3, as mapped by Lehnhoff and Lawrence (2010), are shown in Figures 4.10.4-1, -2, -3, -4, -5, -6, -7, -8, -9. The distribution maps for the remaining mapped species are in Appendix F.

Overall Condition

For assessing the condition of exotic plants, we used 4 indicators/measures that were

Table 4.10.4-4. Summary of the exotic plants indicators/measures and their contributions to the overall exotic plants condition assessment.

Indicator/Measure	Description of How the Indicator(s) Contributes to the Overall Resource Condition	General Contribution of this Indicator or Measure to the Overall Resource Condition.
NatureServe Invasiveness Ranking	Not all exotics are the same and as such need to be assessed individually from the perspective of which ones pose the greatest risk to a given ecosystem. NatureServe considers the invasiveness of a species by considering ecological impact, current distribution and abundance, trend in distribution and abundance, and management difficulty.	The highest ranked species included cheatgrass, Russian olive, and Salt Cedar. Seven additional species were ranked as high/medium for their invasiveness. Both Russian olive and Salt cedar are located within the riparian habitat, whereas, cheatgrass is widespread throughout the upland vegetation.
Rocchio (2007)Invasiveness Ranking	Rocchio (2207) invasiveness ranking considers invasiveness of a plant only. This ranking is based on a scale of 1 to 4, with 4 representing the most invasive.	Since Rocchio's (2007) ranking considers invasiveness only, several species were considered as highly invasive. 62.5% of the high priority species were ranked the most invasive with the ability to form monotypic stands and alter the ecosystem.
Proportion of interior Sites Infested	Interior sites were established by ROMN as their vegetation composition, structure, and soils monitoring sites. These sites are located at least 50 m. from any development such as roads, trails, structures, etc.	At least one high priority species was found in at every VCSS site. Cheatgrass, one of the most invasive plants at the Monument, was found in almost 94% of the sites. An additional 10 high priority species were found at the upland vegetation monitoring sites.
Proportion of Monument and Battlefield Road Infested	Lehnhoff and Lawrence (2010) conducted a Monument-wide invasive plant survey and mapped the distribution of 13 high priority invasive plant species. *Bromus tectorum* was so widespread that they modeled the population distribution instead of mapping.	The proportion of Monument and Battlefield Tour Road infested with a high priority exotic species varied. Canada thistle and smooth brome each occupied a little over three acres. Cheatgrass was not mapped dues to its widespread distribution but represents the highest proportion of acreage infested.

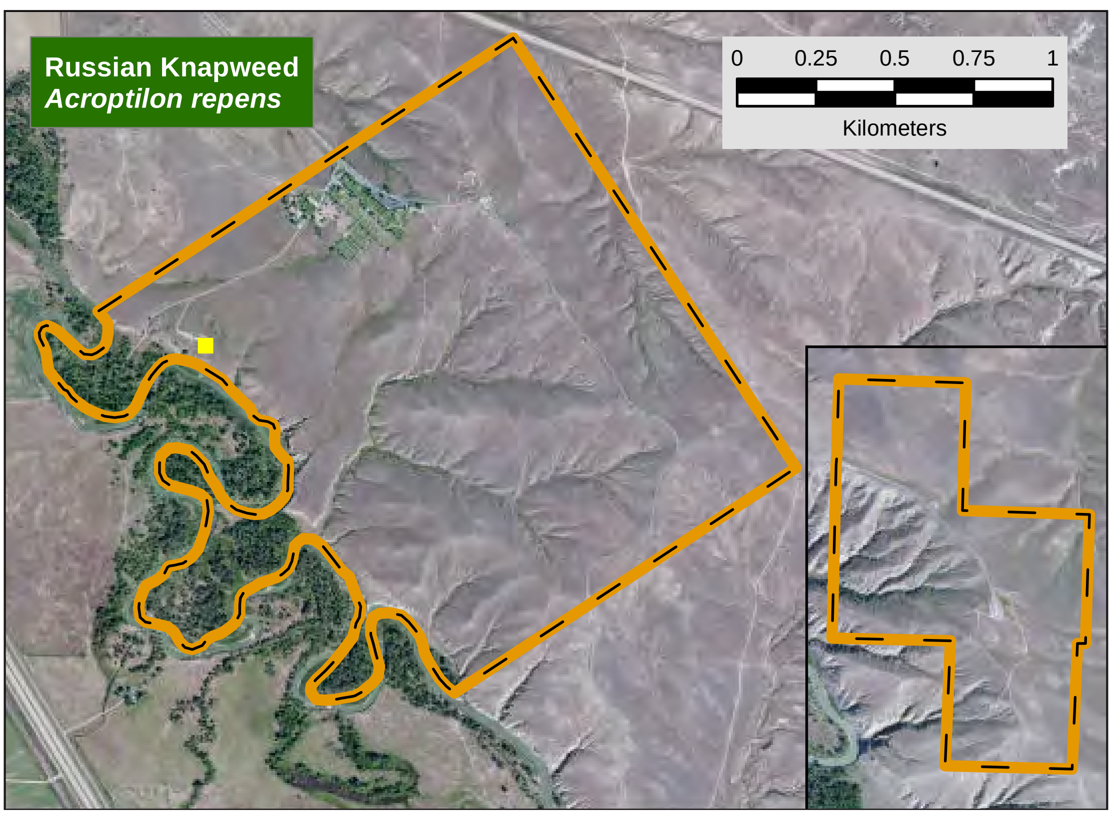


Figure 4.10.4-1. Known distribution of *Acroptilon repens* based on survey conducted by Lehnhoff and Lawrence (2010).

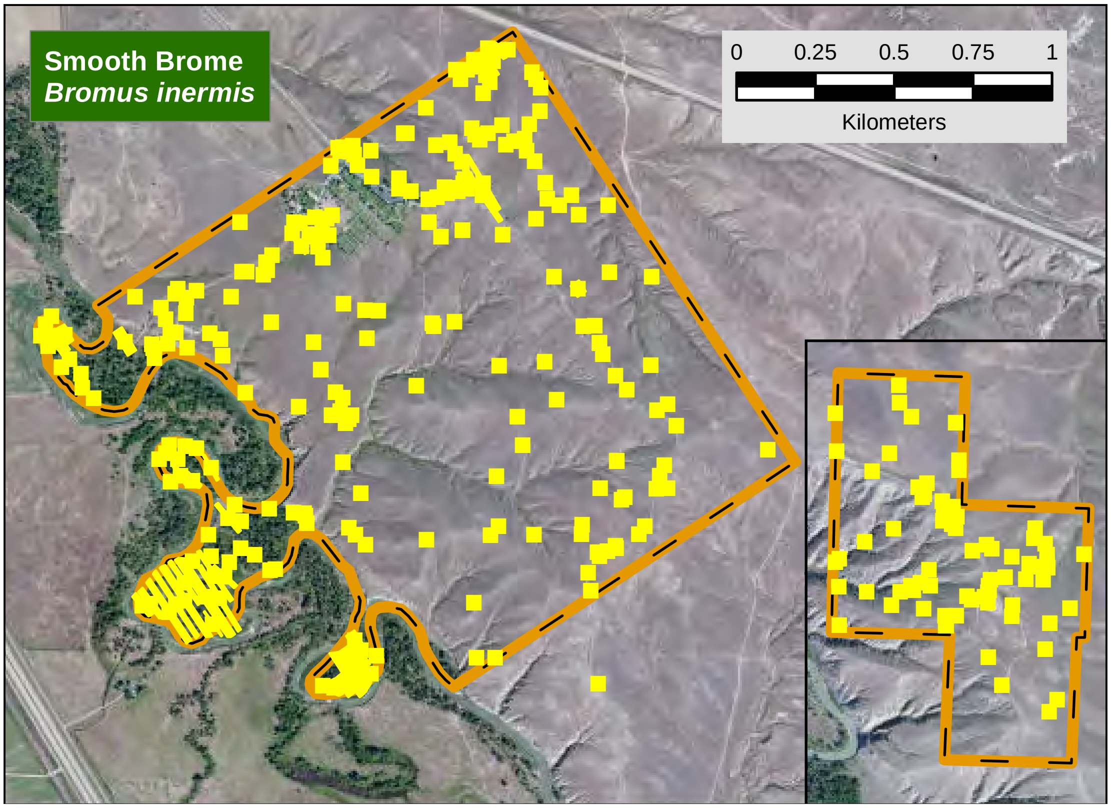


Figure 4.10.4-2. Known distribution of *Bromus inermis* based on survey conducted by Lehnhoff and Lawrence (2010).

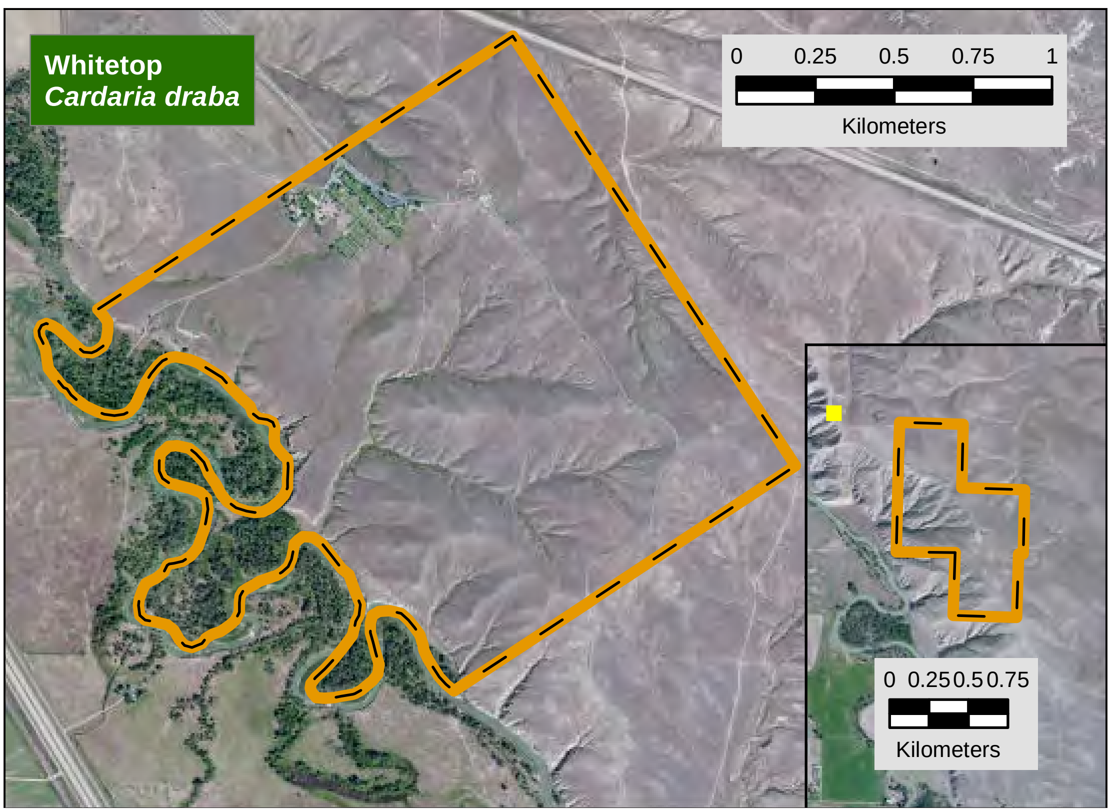


Figure 4.10.4-3. Known distribution of *Cardaria draba* based on survey conducted by Lehnhoff and Lawrence (2010).

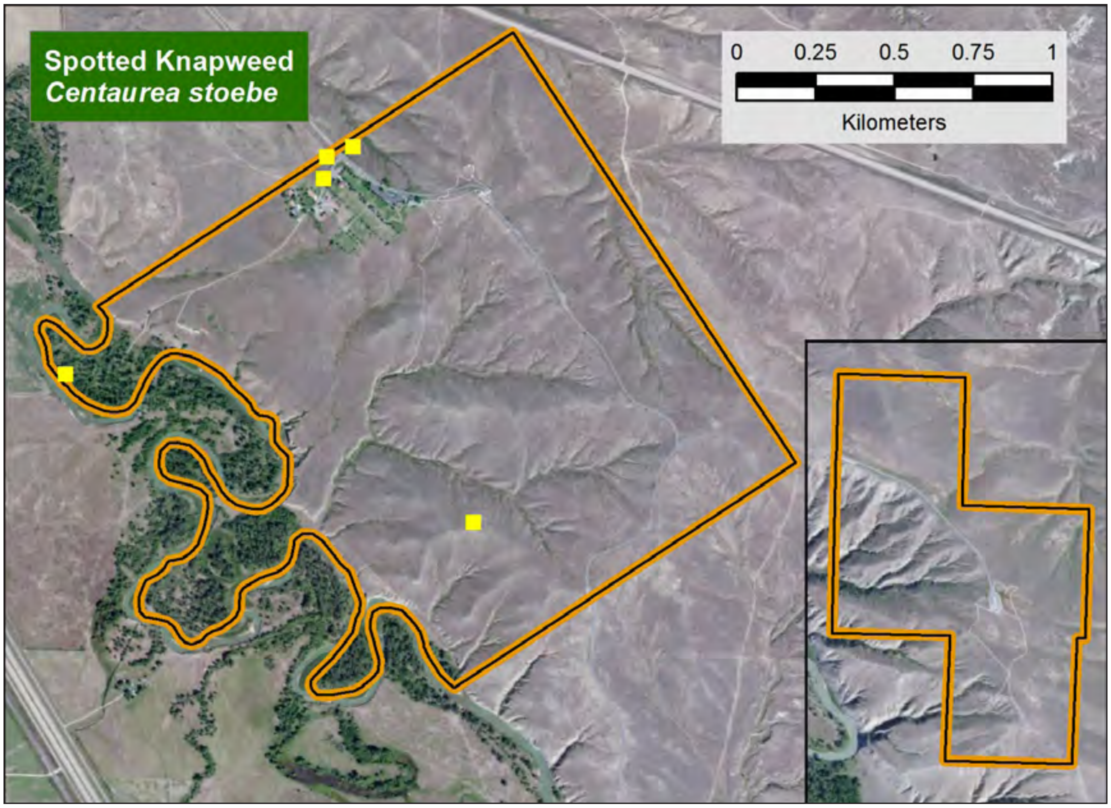


Figure 4.10.4-4. Known distribution of *Centaurea stoebe* based on survey conducted by Lehnhoff and Lawrence (2010).

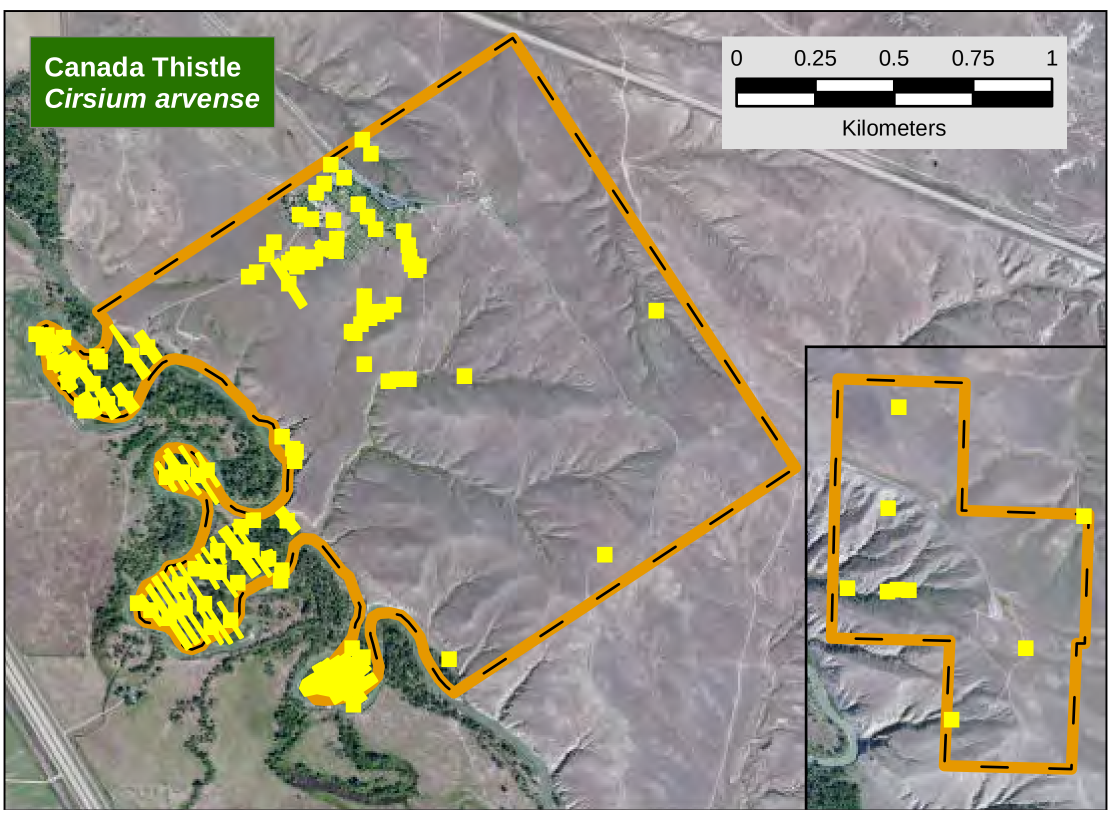


Figure 4.10.4-5. Known distribution of *Cirsium arvense* based on survey conducted by Lehnhoff and Lawrence (2010).

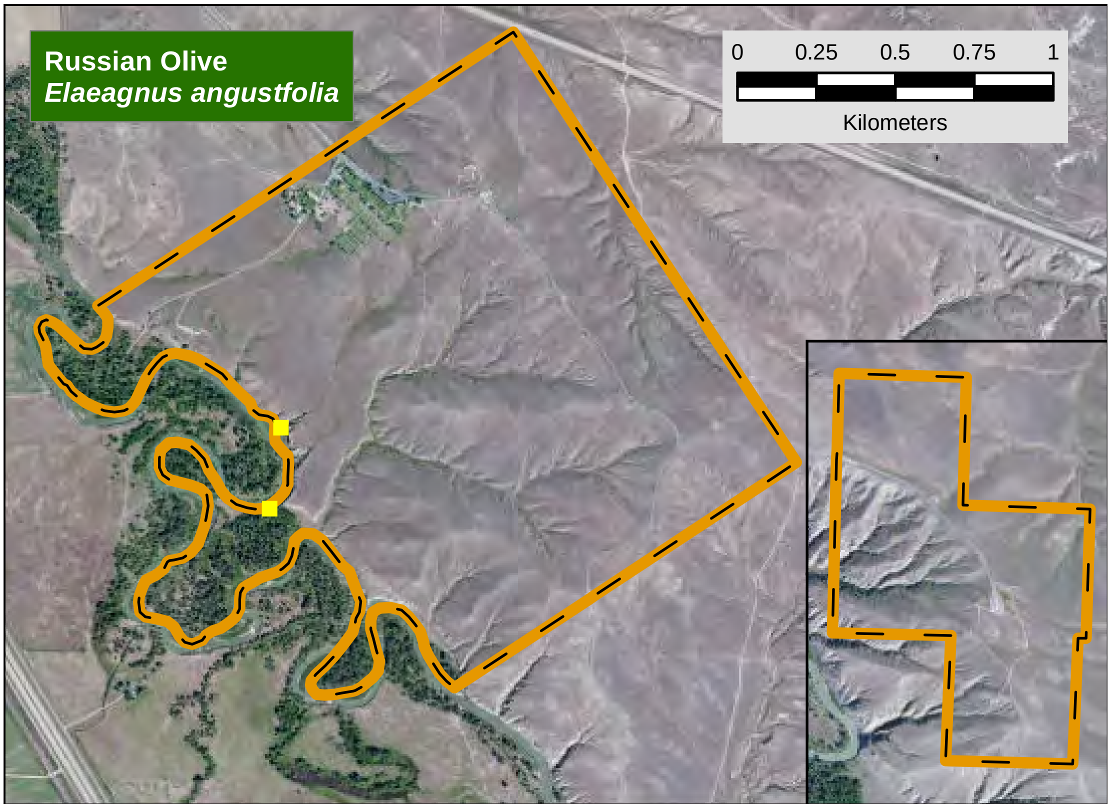


Figure 4.10.4-6. Known distribution of *Elaeagnus angustifolia* based on survey conducted by Lehnhoff and Lawrence (2010).

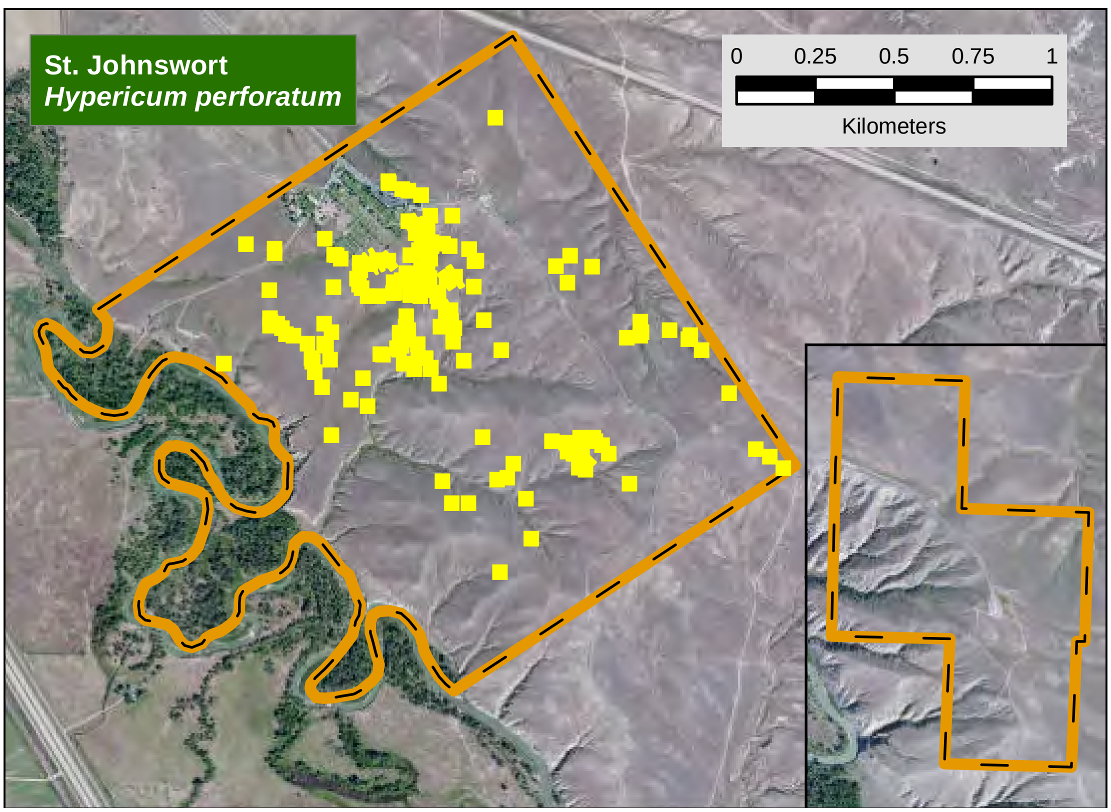


Figure 4.10.4-7. Known distribution of *Hypericum perforatum* based on survey conducted by Lehnhoff and Lawrence (2010).

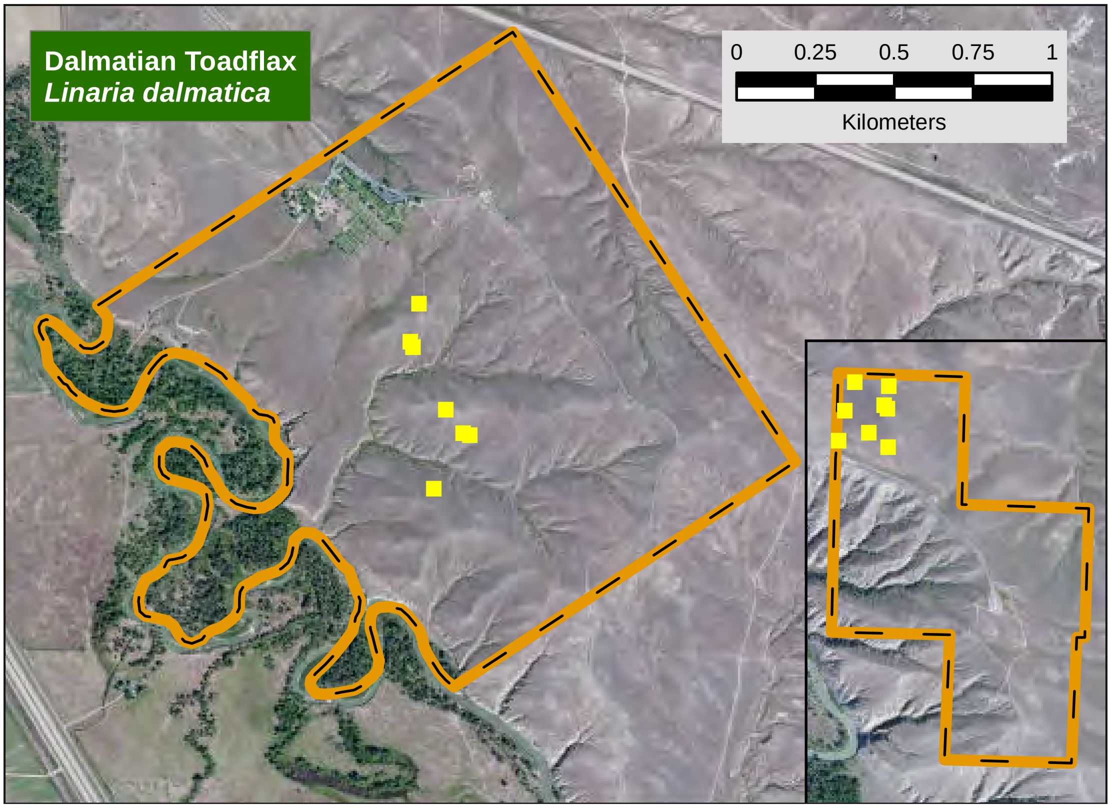


Figure 4.10.4-8. Known distribution of *Linaria dalmatica* based on survey conducted by Lehnhoff and Lawrence (2010).

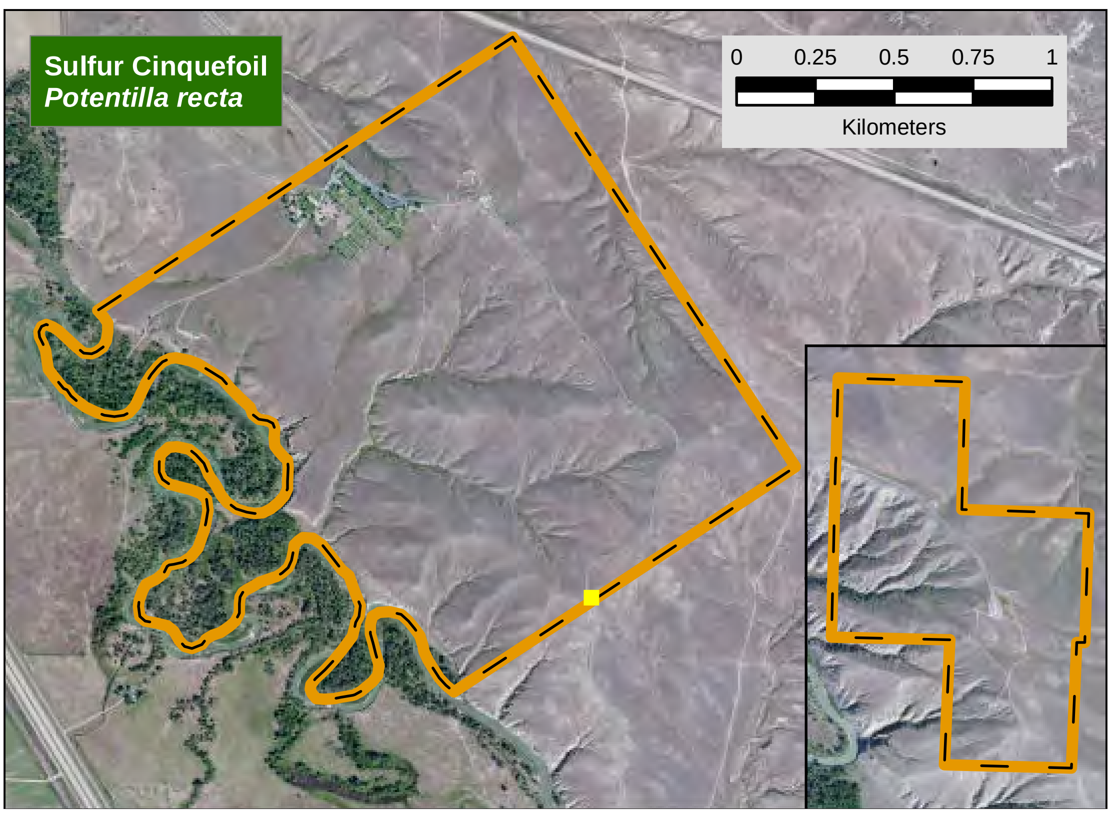


Figure 4.10.4-9. Known distribution of *Potentilla recta* based on survey conducted by Lehnhoff and Lawrence (2010).

not mutually exclusive but were intended to be different ways of capturing the essence of what we thought represented the current condition of the Monument's exotic plants. A summary of these indicators and measures are listed in Table 4.10.4-4. Overall, we are moderately concerned about the condition of exotic plants at the Monument due to the invasiveness of several of the exotic species found, the widespread distribution of highly invasive exotic plants like *Bromus tectorum* and *Bromus inermis*, and the high relative cover of the invasive bromes. We cannot determine trend at this time based upon the limited data. According to grassland researchers Knapp and Seastedt, who conducted a rapid assessment of the upland grasslands in 2012 for the purposes of this condition assessment, the Custer unit contains more exotics than the Reno-Benteen unit. They considered the grasslands to be in good condition but had concern regarding the abundance and cover of exotic bromes increasing in relative proportion to the native plants (Knapp and Seastedt 2012). Despite of their concern, they believed the exotic grasses were coexisting with the native plants and not displacing the native vegetation. ROMN vegetation crew believe the "exotic bromes have been persisting in the Monument grasslands for several years (~ a decade or more) and that the interannual dynamics/trends are unclear at this point, but the likelihood of expansion/dominance due to fire and/or drought is likely higher than it has been in the past (hard to quantify – but this would be due to an established seed-bank as well as time for "thorough" distribution by the annuals)" (D. Shorrock, pers. comm.) and may be a larger threat than currently realized.

Level of Confidence/Key Uncertainties/ Threats

We have high confidence that ROMN staff and crews correctly identify exotic species located within the VCSS sites and riparian plots; however, those sites occupy a relatively small area of the Monument. One of the biggest uncertainties of this assessment is the status of unsurveyed areas relative to exotic plant presence and/or under-representation of exotic plant presence in previous studies. The Monument's Resource Management Plan (NPS 2007) identifies the need to expand the exotic plants baseline survey to include a broader range of species and include the riparian area of the Monument.

One of the biggest threats to the Monument's upland grasslands is the introduction of new exotic species. Monument staff have implemented an Early Detection Rapid Response strategy where they have identified highly invasive exotic species and enlisted the help of visitors and neighbors to identify and report the presence of these targeted species.

Another potential threat is not treating an existing widespread exotic species because it's not perceived as highly invasive. For example, the exotic, annual field brome (*Bromus arvensis)* is not considered a high priority exotic species but was found in 100% of VCSS sites (Shorrock et al. 2010; unpublished 2010-2012 data). It also had the highest percent relative cover of (31%) of all exotic species within the VCSS sites. It received the highest invasiveness ranking of 4 by Rocchio (2007) but has yet to be ranked by NatureServe (D. Shorrock, IMR NRCA Coordinator, pers. comm.). The Monument's wet deposition total nitrogen monitoring resulted in a moderate concern for air quality, and increases in nitrogen have been found to promote invasions of fast-growing annual grasses like bromes (e.g., cheatgrass) and exotic species (e.g., Russian thistle) at the expense of native species (Brooks 2003, Allen et al. 2009, Schwinning et al. 2005). These increased grasses can increase fire risk (Rao et al. 2010). Nitrogen may also increase water use in plants like big sagebrush (Inouye 2006).

4.10.5. Sources of Expertise

Surveys for exotic plants at Little Bighorn Battlefield NM were conducted by teams well trained in species identification and methods. These included (1) the VCSS monitoring and stream ecological integrity monitoring teams of the ROMN, (2) the Monument's Exotic Plant Management Team, (3) researchers from several universities, and (4) Monument staff.

Donna Shorrock was an ecologist with the ROMN and is now the Intermountain

Regional Office NRCA coordinator and holds an M.S. in Plant Biology. She has worked as a botanist and plant ecologist with the NPS and non-profit organizations for the past 13 years.

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4.11. Breeding Landbirds

Indicators/Measures

- Species Occurrence (3 measures)

Condition – Trend – Confidence Level

Good - Insufficient Data - High

4.11.1. Introduction

To assess the condition of breeding landbirds at Little Bighorn Battlefield NM, we used one indicator/measure of condition, species occurrence. We evaluated species occurrence in three contexts: 1) a temporal context (i.e., changes over time), 2) a spatial context (i.e., comparisons with the surrounding region), and 3) a conservation context (i.e., the occurrence and status of species of conservation concern). We focused on breeding landbirds only because there is virtually no information on migrating or non-breeding season landbird use of the Monument.

The first two components of the assessment were conducted using a 2012 survey and report by the Rocky Mountain Bird Observatory (RMBO)-- *Avian Area Searches on Little Bighorn National Battlefield: 2012 Report* (Van Lanen and Hanni 2012). To avoid unnecessary duplication of effort, we present the RMBO report in its entirety in sections 4.11.2 through 4.11.5 of this chapter. We made no changes to the RMBO report, except, in some cases, to section headings, figure numbers, and table formatting. Because of our use of the RMBO report in this way, the breeding landbirds section of the NRCA uses a different numbering format than the rest of the NRCA. The final component of this assessment for landbirds, the conservation context of species occurrence, was conducted by us. The methods and results of this third component are presented in sections 4.11.6 and 4.11.7 of this chapter. Note that there is one Literature Cited section in this chapter, as we have combined the references from the RMBO report with ours.

The following sections are from *Avian Area Searches on Little Bighorn National Battlefield: 2012 Report* (Van Lanen and Hanni 2012).

4.11.2. Background and Importance

Birds can be excellent indicators of biological integrity and ecosystem health (Morrison

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Figure 4.11.1-1. Western Meadowlark.

1986, Hutto 1998, O'Connell et al. 2000, Rich 2002, U.S. EPA 2002, Birdlife International 2003). Birds comprise a diverse group of niche specialists, occupy a broad range of habitats, are relatively easy to monitor and are sensitive to both physical and chemical impacts on the environment. They are useful barometers for environmental change and measuring the sustainability of ecosystems impacted by human activities.

Monitoring is an essential component of wildlife management and conservation science (Witmer 2005, Marsh and Trenham 2008). Common goals of population monitoring are to estimate the population status of target species and to detect changes in populations over time (Thompson et al. 1998, Sauer and Knutson 2008). Effective monitoring programs can identify species that are at-risk due to small or declining populations (Dreitz et al. 2006), provide an understanding of how management actions affect populations (Alexander et al. 2008, Lyons et al. 2008), and evaluate population responses to landscape alteration and climate change (Baron et al. 2008, Lindenmayer and Likens 2009), as well as provide basic information on species distributions.

The last known avian monitoring that occurred on Little Bighorn Battlefield NM was conducted in 2006 (Bock and Bock 2006). Although the Monument is unique from other areas in eastern Montana in that it is not subject to cattle grazing and is largely free of human-related disturbance (visitor access is restricted to paved portions of the Monument and along one short trail), changes to the vegetative and bird community are nevertheless expected to occur over time. The spread of exotic plant species, alterations in the vegetation community resulting from climate change, changing hydrologic patterns, disease, natural disturbance (e.g., fire and flooding), and succession all are likely to influence the bird community of the Monument. Also, Little Bighorn Battlefield NM is a small national park and, even though it is protected, land cover and land use changes around the park and in the region would be expected to influence bird populations in the Monument. As such, periodic avian monitoring to assess the impacts of landscape changes on the bird community can be particularly instructive. To better inform the managers at the Monument on avian response to these changes, an RMBO staff member conducted avian area searches over five days from 30 May to 3 June, 2012 to inventory the breeding bird community within the Monument. Raw count data from the area searches were then compared to data collected under the Integrated Monitoring of Bird Conservation Regions (IMBCR) (White et al. 2012) program within the Montana portion of Bird Conservation Region 17 (BCR17) (Badlands and Prairies BCR) in 2012.

4.11.3. Methods

<u>Study Area</u>

The area searches were conducted over the entire extent of the Little Bighorn Battlefield NM. The Monument is made up of two parcels separated by approximately three miles, the Custer Battlefield and the Reno-Benteen Battlefield. The Custer Battlefield represents the larger parcel spanning approximately 600 acres. The Reno-Benteen Battlefield is considerably smaller and encompasses approximately 165 acres. Together these parcels span 765 acres (Land Resource Division, National Park Service 2012) located within BCR17 in southeastern Montana (Figure 4.11.3-1). The landscape is characterized by gently rolling hills with the upland portions of the Monument dominated by northern mixed grass prairie. Swales and ravines throughout the Custer Battlefield are inhabited by shrub species including Western Snowberry (*Symphoricarpos occidentalis*), Prairie Rose (*Rosa arkansana*), Chokecherry (*Prunus virginiana*), and Silver Sagebrush (*Artemisia cana*) (Bock and Bock 2006). The southern extent of the Custer Battlefield borders the Little Bighorn River and represents riparian habitat with mature Eastern Cottonwood (*Populus deltoides*), willow trees (*Salix amygdaloides* and *S. exigua*), Green Ash (*Fraxinus pennsylvanica*), Box Elder (*Acer negundo*), and a few Russian Olives (*Elaeagnus angustifolia*). The only other area with substantial tree cover is located around the Custer National Cemetery and the visitor center, with cottonwood

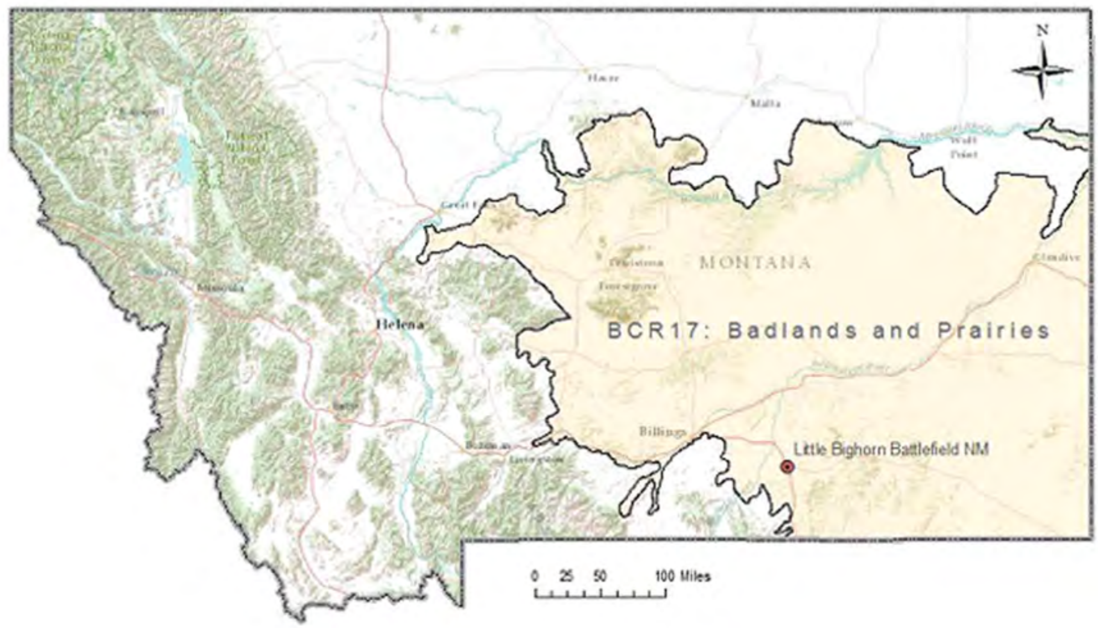

Figure 4.11.3-1. Little Bighorn Battlefield National Monument located within Bird Conservation Region 17 (Badlands and Prairies) in southeastern Montana.

species (*Populus* spp.), Blue Spruce (*Picea pungens*), Rocky Mountain Juniper (*Juniperus scopulorum*), and Green Ash representing the most abundant overstory species.

Data for the Monument were compared to data collected under the IMBCR design within the BCR17 portion of Montana (see Figure 4.11.3-1) at point count stations where the primary habitat was classified as either "grassland" or "riparian" (Hanni et al. 2012). BCR17 is an ecoregion characterized by rolling plains and mixed grass prairie that contains large tracts of intact dry grassland (White et al. 2012). BCR17 includes the Little Bighorn basin and was considered representative of habitat found within the Monument. As such, the Montana portion of BCR17 was expected to have a similar bird community as the Monument and was therefore considered an appropriate region for comparisons.

Avian Surveys

A RMBO staff member, skilled in both ocular and aural identification of avian species, visited the Monument for five days from 30 May to 3 June in 2012 to catalogue avian diversity and raw counts of species. The first day was spent traversing the boundaries of both battlefields and recording spatial data via GPS in order to facilitate complete coverage of the Monument during the formal area searches. Area searches were then conducted over four consecutive days from 31 May to 3 June, during which the observer walked transect lines spaced roughly 250 m apart. Surveys were conducted in the morning (beginning at roughly 5 AM and concluding no later than 10:30 AM) in order to collect data when the birds were most active and detectable. Three mornings were spent searching the larger Custer Battlefield, and a single morning was spent searching the Reno-Benteen Battlefield.

Data Recording and Analysis

Each individual bird detected was recorded along with behavioral data including if the individual was a member of a flock, paired up with another individual, copulating, engaging in courtship or territorial displays, carrying food or a fecal sack, carrying nesting material, observed on or visiting a nest, or if a juvenile bird was detected. The detection method for each avian observation was also classified as either song, call, or a visual observation. Individuals or flocks of birds were not recorded if the observer had reason to believe they had already been detected (e.g., flocks of European Starlings which were repeatedly making trips from the riparian area towards the visitor center). The observer only recorded birds that were located within, or passed over, the boundary of the park. Birds were not recorded if they were detected from within the Monument but were only observed outside of the Monument boundary.

Raw counts of individuals by species were totaled for each battlefield and for the Monument as a whole. Additionally, raw count data collected in 2012 under the IMBCR program at point count stations classified as being in "grassland" or "riparian" habitat (Hanni et al. 2012) within the Montana portion of BCR17 (hereafter known as MT BCR17) were used as a regional comparison. In total, the MT BCR17 data represented avian detections recorded during 6-minute point counts at 145 point count stations on 30 different 1km^2 grid cells selected for sampling (White et al. 2012). The numbers for the Monument and the MT BCR17 reflect relative abundance and do not account for individuals that were present but went undetected.

4.11.4. Results

On the Custer Battlefield 464 individual birds of 43 species were detected during 3 days of area searches, compared to 113 individual birds of 25 species on the Reno-Benteen Battlefield during a single morning of surveying. In total, 577 individual birds of 47 species were detected during the 4 days of avian area searches on the Monument (Table 4.11.4-1.), for an average of 0.754 individuals detected per acre. The five most common species detected on the Monument were Western Meadowlark, Canada Goose, Lark Bunting, Common Grackle, and European Starling, a non-indigenous avian species (NIS).

Of the 47 species documented on Little Bighorn Battlefield NM, 4 species were confirmed to be nesting (either juveniles or a nest were observed), strong evidence of breeding was confirmed for 8 species (individuals were observed copulating, engaging in breeding/territorial displays, and/or birds were observed carrying food or nesting material), and moderate evidence of breeding was recorded for 8 species (a pair of birds were observed together) (Table 4.11.4-2).

In comparison, 2,421 individual birds were detected of 108 species during the 145 point counts conducted in grassland and riparian habitats under the IMBCR program in the Montana portion of BCR17 (Table 4.11.4-3).

Table 4.11.4-1. Number of individual birds detected by species at the Reno-Benteen Battlefield and Custer Battlefield, and the total number of individuals detected on Little Bighorn Battlefield National Monument (Total LIBI Count) during area searches in 2012. ***Note that for the NRCA we alphabetized the list by common name.***

Common Name	Family	Scientific Name	Reno-Benteen Battlefield	Custer Battlefield	Total LIBI Count
American Crow	Corvidae	*Corvus brachyrhynchos*	1	2	3
American Goldfinch	Fringillidae	*Carduelis tristis*	5	0	5
American Kestrel	Falconidae	*Falco sparverius*	0	2	2
American Robin	Turdidae	*Turdus migratorius*	5	25	30
Barn Swallow	Hirundinidae	*Hirundo rustica*	0	5	5
Black-billed Magpie	Corvidae	*Pica hudsonia*	1	0	1
Brown Thrasher	Mimidae	*Toxostoma rufum*	0	2	2
Brown-headed Cowbird	Icteridae	*Molothrus ater*	7	22	29
Bullock's Oriole	Icteridae	*Icterus bullockii*	1	13	14
Canada Goose	Anatidae	*Branta canadensis*	0	63	63
Cedar Waxwing	Bombycillidae	*Bombycilla cedrorum*	3	9	12
Chipping Sparrow	Emerizidae	*Spizella passerina*	0	9	9

Notes: Bolded species are designated as species of continental concern, continental stewardship, or regional concern by Partner's in Flight for Bird Conservation Region 17.
* Non-indigenous species

Table 4.11.4-1. Number of individual birds detected by species at the Reno-Benteen Battlefield and Custer Battlefield, and the total number of individuals detected on Little Bighorn Battlefield National Monument (Total LIBI Count) during area searches in 2012 (continued).

Common Name	Family	Scientific Name	Reno-Benteen Battlefield	Custer Battlefield	Total LIBI Count
Cliff Swallow	Hirundinidae	*Petrochelidon pyrrhonota*	3	2	5
Common Grackle	Icteridae	*Quiscalus quiscula*	0	32	32
Common Nighthawk	Caprimulgidae	*Chordeiles minor*	0	1	1
Common Raven	Corvidae	*Corvus corax*	0	1	1
Eastern Kingbird	Tyrannidae	*Tyrannus tyrannus*	0	8	8
Eurasian Collared-Dove*	Columbidae	*Streptopelia decaocto*	0	5	5
European Starling*	Sturnidae	*Sturnus vulgaris*	12	48	60
Grasshopper Sparrow	Emerizidae	*Ammodramus savannarum*	9	9	18
Gray Catbird	Mimidae	*Dumetella carolinensis*	0	1	1
Great Blue Heron	Ardeidae	*Ardea herodias*	0	1	1
Great Horned Owl	Strigidae	*Bubo virginianus*	0	1	1
House Finch	Fringillidae	*Carpodacus mexicanus*	0	1	1
House Wren	Troglodytidae	*Troglodytes aedon*	1	3	4
Lark Bunting	Emerizidae	*Calamospiza melanocorys*	2	28	30
Lark Sparrow	Emerizidae	*Chondestes grammacus*	10	18	28
Lazuli Bunting	Cardinalidae	*Passerina amoena*	2	3	5
Mourning Dove	Columbidae	*Zenaida macroura*	4	11	15
Northern Flicker	Picidae	*Colaptes auratus*	0	2	2
Northern Harrier	Accipitridae	*Circus cyaneus*	1	1	2
Northern Rough-winged Swallow	Hirundinidae	*Stelgidopteryx serripennis*	1	2	3
Red-tailed Hawk	Accipitridae	*Buteo jamaicensis*	2	2	4
Ring-necked Pheasant*	Phasianidae	*Phasianus colchicus*	1	9	10
Say's Phoebe	Tyrannidae	*Sayornis saya*	0	4	4
Sharp-tailed Grouse	Phasianidae	*Tympanuchus phasianellus*	1	5	6
Short-eared Owl	Strigidae	*Asio flammeus*	0	2	2
Spotted Towhee	Emerizidae	*Pipilo maculatus*	9	13	22
Tree Swallow	Hirundinidae	*Tachycineta bicolor*	0	1	1
Vesper Sparrow	Emerizidae	*Pooecetes gramineus*	6	0	6
Warbling Vireo	Vireonidae	*Vireo gilvus*	0	1	1
Western Kingbird	Tyrannidae	*Tyrannus verticalis*	0	13	13
Western Meadowlark	Icteridae	*Sturnella neglecta*	22	69	91
Western Tanager	Thraupidae	*Piranga ludoviciana*	0	1	1
Western Wood-Pewee	Tyrannidae	*Contopus sordidulus*	1	0	1
Yellow Warbler	Parulidae	*Dendroica petechia*	3	10	13
Yellow-breasted Chat	Parulidae	*Icteria virens*	0	4	4
Total Number of Individuals			**113**	**464**	**577**

Notes: Bolded species are designated as species of continental concern, continental stewardship, or regional concern by Partner's in Flight for Bird Conservation Region 17.
* Non-indigenous species

Table 4.11.4-2. Indications of breeding status for avian species detected during RMBO surveys on Little Bighorn Battlefield National Monument in 2012.

Species	Behavior	Breeding Status
Cedar Waxwing	For, Flk, **Fdg**	Confirmed Nesting
Great Horned Owl	**Fdg**	Confirmed Nesting
Lark Sparrow	Cop, **Nst**, Pr	Confirmed Nesting
Western Kingbird	Dsp, Pr, **Nst**	Confirmed Nesting
American Goldfinch	Flk, Pr, **Mat**	Strong Evidence
American Robin	For, Pr, **Fd**	Strong Evidence
Common Grackle	For, Flk, Pr, **Fd**	Strong Evidence
Eastern Kingbird	**Dsp**, Pr	Strong Evidence
European Starling	For, Flk, **Fd**	Strong Evidence
Lark Bunting	**Dsp**, Pr	Strong Evidence
Red-tailed Hawk	Pr, **Dsp**	Strong Evidence
Western Meadowlark	For, **Dsp**, Pr, **Fd**	Strong Evidence
Brown-headed Cowbird	Flk, **Pr**	Moderate Evidence
Bullock's Oriole	**Pr**	Moderate Evidence
Canada Goose	Flk, **Pr**	Moderate Evidence
Grasshopper Sparrow	**Pr**	Moderate Evidence
Lazuli Bunting	**Pr**	Moderate Evidence
Mourning Dove	**Pr**	Moderate Evidence
Ring-necked Pheasant	**Pr**	Moderate Evidence
Spotted Towhee	For, **Pr**	Moderate Evidence

Behavior Codes:

Cop = Copulation; Dsp = Territorial/Breeding display; Fdg = Fledgling observed; Flk = Flock; Fd = Carrying food; For = Foraging; Mat = Carrying material; Nst = Active nest observed; Pr = Pair.

Behaviors leading to the determination of the breeding status are bolded.

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Figure 4.11.4-1. Lark Sparrow nest found near the cemetery on the Custer Battlefield in 2012.

Table 4.11.4-3. Number of individual birds detected by species at points in grassland and riparian habitat in the Montana portion of Bird Conservation Region 17 (Badlands and Prairies) under the Integrated Monitoring of Bird Conservation Regions program. The numbers of individuals were obtained from 145 point counts conducted within 30 1 km² grid cells in 2012. *Note that we alphabetized (by common name) the list from Van Lanen and Hanni (2012).*

Common Name	Family	Scientific Name	2012 Count
American Avocet	Recurvirostridae	*Recurvirostra americana*	1
American Crow	Corvidae	*Corvus brachyrhynchos*	13
American Goldfinch	Fringillidae	*Carduelis tristis*	14
American Kestrel	Falconidae	*Falco sparverius*	7
American Robin	Turdidae	*Turdus migratorius*	47
American Wigeon	Anatidae	*Anas americana*	15
Baird's Sparrow	Emberizidae	*Ammodramus bairdii*	13
Bald Eagle	Accipitridae	*Haliaeetus leucocephalus*	1
Bank Swallow	Hirundinidae	*Riparia riparia*	2
Barn Swallow	Hirundinidae	*Hirundo rustica*	7
Belted Kingfisher	Alcedinidae	*Ceryle alcyon*	2
Black-billed Cuckoo	Cuculidae	*Coccyzus erythropthalmus*	1
Black-billed Magpie	Corvidae	*Pica hudsonia*	6
Black-capped Chickadee	Paridae	*Poecile atricapillus*	11
Black-headed Grosbeak	Cardinalidae	*Pheucticus melanocephalus*	7
Blue Jay	Corvidae	*Cyanocitta cristata*	2
Blue-winged Teal	Anatidae	*Anas discors*	1
Bobolink	Icteridae	*Dolichonyx oryzivorus*	20
Brewer's Blackbird	Icteridae	*Euphagus cyanocephalus*	21
Brewer's Sparrow	Emberizidae	*Spizella breweri*	24
Brown Thrasher	Mimidae	*Toxostoma rufum*	2
Brown-headed Cowbird	Icteridae	*Molothrus ater*	136
Bullock's Oriole	Icteridae	*Icterus bullockii*	14
California Gull	Laridae	*Larus californicus*	10
Canada Goose	Anatidae	*Branta canadensis*	53
Cedar Waxwing	Bombycillidae	*Bombycilla cedrorum*	20
Chestnut-collared Longspur	Emberizidae	*Calcarius ornatus*	28
Chimney Swift	Apodidae	*Chaetura pelagica*	9
Chipping Sparrow	Emberizidae	*Spizella passerina*	32
Clay-colored Sparrow	Emberizidae	*Spizella pallida*	14

Bolded species are designated as species of continental concern, continental stewardship, or regional concern by Partner's in Flight for Bird Conservation Region 17.

Table 4.11.4-3. Number of individual birds detected by species at points in grassland and riparian habitat in the Montana portion of Bird Conservation Region 17 (Badlands and Prairies) under the Integrated Monitoring of Bird Conservation Regions program. (Continued).

Common Name	Family	Scientific Name	2012 Count
Cliff Swallow	Hirundinidae	*Petrochelidon pyrrhonota*	9
Common Grackle	Icteridae	*Quiscalus quiscula*	20
Common Merganser	Anatidae	*Mergus merganser*	3
Common Nighthawk	Caprimulgidae	*Chordeiles minor*	3
Common Yellowthroat	Parulidae	*Geothlypis trichas*	10
Dark-eyed Junco	Emberizidae	*Junco hyemalis*	1
Downy Woodpecker	Picidae	*Picoides pubescens*	3
Dusky Flycatcher	Tyrannidae	*Empidonax oberholseri*	4
Eastern Kingbird	Tyrannidae	*Tyrannus tyrannus*	35
Eurasian Collared-Dove	Columbidae	*Streptopelia decaocto*	1
European Starling	Sturnidae	*Sturnus vulgaris*	33
Field Sparrow	Emberizidae	*Spizella pusilla*	8
Gadwall	Anatidae	*Anas strepera*	7
Grasshopper Sparrow	Emberizidae	*Ammodramus savannarum*	134
Gray Catbird	Mimidae	*Dumetella carolinensis*	4
Great Blue Heron	Ardeidae	*Ardea herodias*	21
Great Horned Owl	Strigidae	*Bubo virginianus*	1
Greater Sage-Grouse	Phasianidae	*Centrocercus urophasianus*	1
Hairy Woodpecker	Picidae	*Picoides villosus*	1
Horned Lark	Alaudidae	*Eremophila alpestris*	46
House Wren	Troglodytidae	*Troglodytes aedon*	85
Killdeer	Charadriidae	*Charadrius vociferus*	34
Lark Bunting	Emberizidae	*Calamospiza melanocorys*	91
Lark Sparrow	Emberizidae	*Chondestes grammacus*	25
Lazuli Bunting	Cardinalidae	*Passerina amoena*	8
Least Flycatcher	Tyrannidae	*Empidonax minimus*	31
Loggerhead Shrike	Laniidae	*Lanius ludovicianus*	1
Long-billed Curlew	Scolopacidae	*Numenius americanus*	7
Mallard	Anatidae	*Anas platyrhynchos*	12
Marbled Godwit	Scolopacidae	*Limosa fedoa*	1
Mountain Bluebird	Turdidae	*Sialia currucoides*	3
Mountain Chickadee	Paridae	*Poecile gambeli*	1
Mourning Dove	Columbidae	*Zenaida macroura*	96

Bolded species are designated as species of continental concern, continental stewardship, or regional concern by Partner's in Flight for Bird Conservation Region 17.

Table 4.11.4-3. Number of individual birds detected by species at points in grassland and riparian habitat in the Montana portion of Bird Conservation Region 17 (Badlands and Prairies) under the Integrated Monitoring of Bird Conservation Regions program. (Continued).

Common Name	Family	Scientific Name	2012 Count
Northern Flicker	Picidae	*Colaptes auratus*	39
Northern Harrier	Accipitridae	*Circus cyaneus*	3
Northern Rough-winged Swallow	Hirundinidae	*Stelgidopteryx serripennis*	7
Orchard Oriole	Icteridae	*Icterus spurius*	2
Osprey	Accipitridae	*Pandion haliaetus*	1
Pine Siskin	Fringillidae	*Carduelis pinus*	4
Prairie Falcon	Falconidae	*Falco mexicanus*	1
Red Crossbill	Fringillidae	*Loxia curvirostra*	30
Red-breasted Nuthatch	Sittidae	*Sitta canadensis*	4
Red-headed Woodpecker	Picidae	*Melanerpes erythrocephalus*	10
Red-tailed Hawk	Accipitridae	*Buteo jamaicensis*	12
Red-winged Blackbird	Icteridae	*Agelaius phoeniceus*	53
Ring-billed Gull	Laridae	*Larus delawarensis*	1
Ring-necked Pheasant	Phasianidae	*Phasianus colchicus*	32
Rock Wren	Troglodytidae	*Salpinctes obsoletus*	15
Sage Thrasher	Mimidae	*Oreoscoptes montanus*	1
Sandhill Crane	Gruidae	*Grus canadensis*	7
Savannah Sparrow	Emberizidae	*Passerculus sandwichensis*	17
Say's Phoebe	Tyrannidae	*Sayornis saya*	3
Sharp-tailed Grouse	Phasianidae	*Tympanuchus phasianellus*	25
Short-eared Owl	Strigidae	*Asio flammeus*	1
Song Sparrow	Emberizidae	*Melospiza melodia*	7
Sora	Rallidae	*Porzana carolina*	2
Spotted Sandpiper	Scolopacidae	*Actitis macularia*	7
Spotted Towhee	Emberizidae	*Pipilo maculatus*	20
Sprague's Pipit	Motacillidae	*Anthus spragueii*	1
Townsend's Solitaire	Turdidae	*Myadestes townsendi*	1
Tree Swallow	Hirundinidae	*Tachycineta bicolor*	26
Turkey Vulture	Cathartidae	*Cathartes aura*	5
Upland Sandpiper	Scolopacidae	*Bartramia longicauda*	15
Vesper Sparrow	Emberizidae	*Pooecetes gramineus*	120
Violet-green Swallow	Hirundinidae	*Tachycineta thalassina*	1

Bolded species are designated as species of continental concern, continental stewardship, or regional concern by Partner's in Flight for Bird Conservation Region 17.

Table 4.11.4-3. Number of individual birds detected by species at points in grassland and riparian habitat in the Montana portion of Bird Conservation Region 17 (Badlands and Prairies) under the Integrated Monitoring of Bird Conservation Regions program. (Continued).

Common Name	Family	Scientific Name	2012 Count
Warbling Vireo	Vireonidae	*Vireo gilvus*	15
Western Kingbird	Tyrannidae	*Tyrannus verticalis*	29
Western Meadowlark	Icteridae	*Sturnella neglecta*	442
Western Wood-Pewee	Tyrannidae	*Contopus sordidulus*	33
White-breasted Nuthatch	Sittidae	*Sitta carolinensis*	1
Willet	Scolopacidae	*Catoptrophorus semipalmatus*	3
Wilson's Phalarope	Scolopacidae	*Phalaropus tricolor*	1
Wilson's Snipe	Scolopacidae	*Gallinago delicata*	10
Wood Duck	Anatidae	*Aix sponsa*	8
Yellow Warbler	Parulidae	*Dendroica petechia*	95
Yellow-breasted Chat	Parulidae	*Icteria virens*	12
Yellow-rumped Warbler	Parulidae	*Dendroica coronata*	5
Unidentified Individuals			20
Total Number of Individuals			2,420

Bolded species are designated as species of continental concern, continental stewardship, or regional concern by Partner's in Flight for Bird Conservation Region 17.

NPS

Figure 4.11.4-2. Fledgling Great Horned Owl near the natural resource office on the Custer Battlefield. (photo taken by NPS staff and cited in Van Lanen and Hanni 2012, p.3)

Approximately 2,238 acres were surveyed during these counts resulting in an average bird density of 1.08 individuals per acre. The five most common species detected within the Montana portion of BCR17 were Western Meadowlark, Brown-headed Cowbird, Grasshopper Sparrow, Vesper Sparrow, and Mourning Dove.

4.11.5. Discussion

Bird species detected during the 2012 area searches differed from those found by Bock and Bock (2006) considerably. In total, 10 species were detected during the 2012 area searches that were not previously detected by Bock and Bock (2006): Common Nighthawk, Common Raven, Great Horned Owl, Lazuli Bunting, Say's Phoebe, Short-eared Owl, Tree Swallow, Warbling Vireo, Western Tanager, and Yellow-breasted Chat. Each of these species were detected in low numbers indicating that they may not have been present during the Bock and Bock (2006) surveys or could have been missed due to the low densities. In contrast, Bock and Bock recorded 23 species that were not detected during the 2012 area searches: Belted Kingfisher, Black-capped Chickadee, Black-headed Grosbeak, Brewer's Blackbird, Brewer's Sparrow, Common Merganser, Downy Woodpecker, Ferruginous Hawk, Hairy Woodpecker, Horned Lark, Killdeer, Loggerhead Shrike, Mallard, Rock Pigeon, Song Sparrow, Spotted Sandpiper, Swainson's Hawk, Turkey Vulture, Upland Sandpiper, Veery, White-breasted Nuthatch, White-crowned Sparrow, and Wilsons' Warbler. One reason some of these species may have been detected during the Bock and Bock (2006) study is that their surveys were conducted during a much broader seasonal window (surveys were conducted between 11 May and 21 October) which included portions of the migratory season. Species such as Brewer's Sparrow, Brewer's Blackbird, Ferruginous Hawk, Turkey Vulture, and White-crowned Sparrow are likely to pass through the Monument during migration but are unlikely to be found in late May and early June when the 2012 area searches were conducted. Additionally, some of the Bock and Bock (2006) surveys occurred prior to two extensive fires that burned both battlefields (Custer Battlefield burned in 1983 and the Reno-Benteen Battlefield burned in 1991). These fires killed a considerable amount of *Artemisia tridentate* (big sagebrush) and removed other shrub cover that likely contributed to Brewer's Sparrow occupancy in the area. Also, these fires likely reduced the amount of ground cover, making the habitat more suitable for species that are affiliated with bare ground (such as Horned Lark). Another reason for the discrepancy in species observed is that a number of the species detected by Bock and Bock that were not detected in 2012 are birds associated with water (i.e., Belted Kingfisher, Common Merganser, Mallard, and Spotted Sandpiper). These species were detected in 2012 but were not witnessed within the Monument boundary and therefore not recorded. Bock and Bock may have recorded birds that were detected from within the Monument even if they were outside of the Monument boundary, or those species may have flown over the Monument boundary during their surveys. Finally, given the brief survey effort (five days) by RMBO in 2012, several species were likely present but went undetected. Shortly after the RMBO surveys, Mike Britten of the National Park Service observed six additional species: Killdeer, Red-winged Blackbird, House Sparrow, Wood Duck, Swainson's Hawk, and Red Crossbill, and witnessed an American Kestrel carrying food (personal communication). Increased sampling intensity by RMBO throughout the breeding season would likely have increased the number of species observed in 2012 and confirmed breeding for additional species.

The ten most frequently detected bird species at Little Bighorn Battlefield NM during the 2012 area searches were also some of the most common species detected during the 2012 IMBCR surveys within the Montana portion of BCR17. Five of the ten most commonly detected species at the Monument are also in the top ten most commonly detected species on the IMBCR surveys. Only one of the top ten most commonly detected species within the Montana portion of BCR17 was not detected on the park during the RMBO surveys: Red-winged Blackbird. This is not surprising as there is not a substantial wetland component, with which Red-winged Blackbirds show a strong association, within the park. The relatively similar density of individual birds in the Monument (0.754 individuals/acre) and other portions of Montana BCR17 (1.08 individuals/acre) indicates that park habitat quality is fairly representative of adjacent lands within the ecoregion. The slightly higher number of individual birds per acre in the Montana portion of BCR17 may be a result of a more heterogeneous environment across the BCR than is found within the Monument, or because the IMBCR surveys occurred on a larger proportion of riparian habitat which typically supports a higher density of birds than mixed grass prairie.

In total, ten species designated as species of continental concern, continental stewardship, or regional concern by Partner's in Flight for Bird Conservation Region 17 were detected on Little Bighorn Battlefield NM, indicating that the Monument represents some important habitat for potentially vulnerable avian species. Given that the Monument is currently dominated by mixed-grass prairie, the ten special designation species detected represent nearly the full suite expected to inhabit the park. In the event that a substantial sagebrush component returns to the Monument, additional species such as Greater Sage-Grouse, Brewer's Sparrow, and Sage Thrasher would be more likely to inhabit the park. However, an increase in sagebrush cover on the park would likely be detrimental to several grassland species of special designation such as Grasshopper Sparrow, Short-eared Owl, and Lark Bunting. Since the Monument represents a rather small geographic area, it is unlikely that managers can take action to provide ample acreage of both habitat types simultaneously. We therefore recommend that managers allow natural succession to occur and do not actively manage for either the sagebrush or grassland suite of species.

Given that birds are easy to study, act as excellent indicators of habitat quality, and readily respond to changes in habitat condition, we recommend that avian monitoring continue on the Monument to better inform managers on the impacts of succession, disturbance, and the introduction of exotic species on the wildlife community. Future monitoring efforts would benefit from an adoption of procedures that allow for distance estimation and account for incomplete detection. If IMBCR procedures are utilized, then results could be directly compared to data collected within the MT portion of BCR17, and detection data from approximately 1,000 sampled grids could be used to increase precision of occupancy and density estimates.

4.11.6. Conservation Context Component- The Occurrence and Status of Species of Conservation Concern

Note that Van Lanen and Hanni (2012) provided some conservation context (i.e., the bolded species in Table 4.11.4-1, text on the previous page), but we provide a more in-depth analysis here. We began the analysis by creating a comprehensive list of species that have been reported to occur at the Monument; the list consists of 1) the species list from Bock and Bock (2006), which is identical to and is the source of the certified bird list for the Monument (dated September 2006, and available from NPSpecies), 2) the species detected in the 2012 RMBO survey, and 3) species observed by Mike Britten (NPS) during the riparian and grassland rapid assessment field work for the NRCA (see Appendix H).

Our intent for this context was: to determine which species that occur at Little Bighorn Battlefield NM are considered species of conservation concern at either national or local scales; to assess the current status (occurrence) of those species at the Monument; and to evaluate the potential for the Monument to play a role in the conservation of those species. For the latter, we assigned each species of conservation concern to a class representing the potential for the Monument to play a role in its conservation during the breeding season (Table 4.11.6-1). This was based primarily on whether or not the Monument was within the normal breeding range of the species and the availability of breeding habitat at the Monument (Table 4.11.6-2). Because the assessments are based on the breeding season,

Table 4.11.6-1. Classes assigned to species of concern regarding the potential for Little Bighorn Battlefield National Monument to play a role in their conservation.

Potential for Conservation	Conservation Class Description
High	These are species for which the Monument is within the normal breeding range or in proximity to the edge of that range. They are also species for which we considered the Monument to have good breeding habitat. We assigned species to this class if we believed, based on the evidence, that the potential for breeding was good, regardless of whether they currently occur at the Monument in substantial numbers.
Moderate	These are the species for which the Monument is within the normal breeding range or in proximity to the edge of that range, and for which there is some habitat at the Monument that might support occurrence or even some breeding in limited numbers.
Low to None	These are the species that are either outside of their normal breeding range and/or for which the habitat at the Monument is unlikely to support breeding. This does not preclude limited occurrences of the species, but the potential for the Monument to play any significant role in the conservation of that species is very limited.

Table 4.11.6-2. Breeding habitat classes assigned to each species of conservation concern that has been reported to occur at Little Bighorn Battlefield National Monument and is within or near its normal breeding range.

Breeding Habitat Class	Class Description
Exists	This class was assigned when the habitat at the Monument is characteristic of habitats where a given species might be expected to breed.
Possibly Exists	This class was assigned when it was unlikely that the habitat at the Monument would support consistent or widespread breeding, but does not preclude some breeding in limited numbers.
Limited to None	This class was assigned when it is unlikely that the habitat at Little Bighorn Battlefield NM would support breeding by that species. This does not imply that the species would not occur at the Monument in limited numbers or during other seasons, but rather that it would be unlikely to breed there.

we assigned each species to one of the three breeding habitat classes shown in the table based on the Birds of North America (BNA) species accounts (Cornell Lab of Ornithology 2013) in combination with local knowledge. Whether or not species were within their normal breeding range at the Monument was also determined using the BNA accounts and local knowledge.

To develop a list of species of conservation concern for Little Bighorn Battlefield NM, we used the lists developed by several organizations. There have been a large 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), which 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 confusion, and perhaps frustration, for managers that 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 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

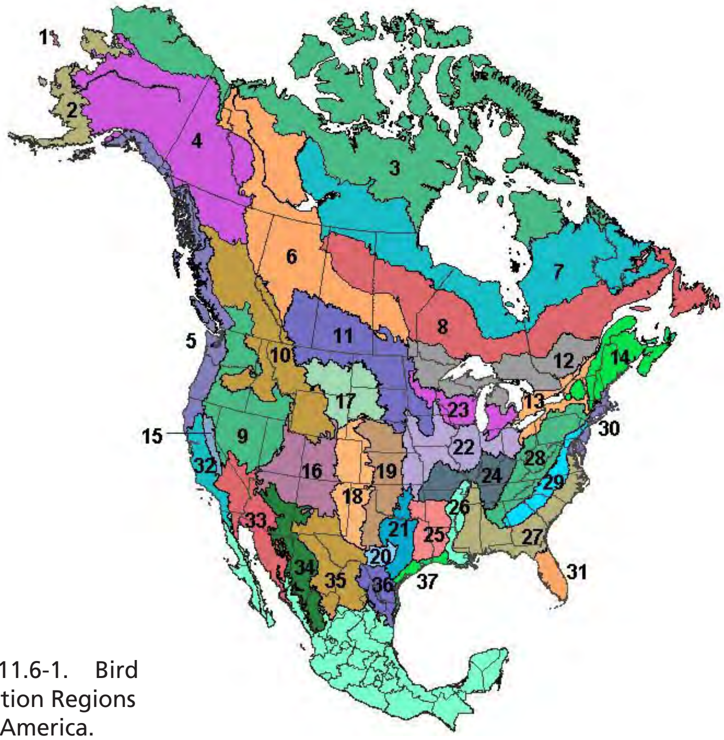

Figure 4.11.6-1. Bird Conservation Regions in North America.

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) (U.S. North American Bird Conservation Initiative 2013). Bird Conservation Regions (BCRs) are ecologically distinct regions in North America with similar bird communities, habitats, and resource management issues (Figure 4.11.6-1). As mentioned previously, Little Bighorn Battlefield NM lies within the Badlands and Prairies Unit (BCR-17) (see Figure 4.11.3-1).

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 the condition assessment. Appendix G presents additional details on each of the organizations/efforts.

- U.S. Fish & Wildlife Service: Under the Endangered Species Act, the U.S. Fish and Wildlife Service (USFWS) lists species as threatened, endangered, or candidates for listing.
- State of Montana: The State maintains lists of threatened and endangered (and proposed and candidate) species based on USFWS threatened and endangered species lists. The State also maintains a list of "species of concern," which are native animals that breed in Montana and are "at risk" due to declining populations, threats to their habitats, and/or restricted distribution (http://fwp.mt.gov/fishAndWildlife/species/speciesOfConcern/).
- USFWS: This agency also developed lists of birds of conservation concern according to: the Nation, USFWS Region, and BCR.
- The National Audubon Society (NAS) and American Bird Conservancy (ABC): These groups combined efforts to produce a "Watch List," based on, but not identical to, the Partners in Flight approach to species assessment (see below). The 2007 WatchList has two primary levels of concern: a "Red Watchlist," which identifies what these organizations consider as species of highest national concern; and a "Yellow WatchList," which is made up of species that are somewhat less critical (Butcher et al. 2007).
- 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 (Continental Concern [CC] and Continental Stewardship [CS]) and Regional Importance (Regional Concern [RC] and Regional Stewardship [RS]) (Panjabi et al. 2005).

Reference Condition for Species of Concern

This component of the assessment is somewhat different than the other two (temporal and spatial contexts) in that the focus is on the avian species for which the Monument can play a role in their conservation. From the combined list of species reported for the Monument (Appendix H), we identified the species that occurred on one or more of

Table 4.11.6-3. Summary of species on the certified species list and detected during the 2012 RMBO survey at Little Bighorn Battlefield National Monument that are of conservation concern, as listed by government agencies and non-governmental organizations.

Common Name	Listed Species		Species of Conservation Concern Lists							
	Federal [1]	State [2]	US Fish & Wildlife Service			NAS/ ABC [3]	Partners in Flight National Conservation Strategy [4]			
							BCR 17			
	USFWS	MT	National	Region 6	BCR 17	2007 Watch List	CC	RC	CS	RS
Black-billed Magpie [A,B]								●		
Brewer's Sparrow [A]		SC	●		●	●		●	●	
Brown Thrasher [A,B]									●	
Common Nighthawk [B]								●		
Ferruginous Hawk [A]		SC		●	●			●		●
Grasshopper Sparrow [A,B]				●	●			●	●	●
Great Blue Heron [A,B]		SC								
Lark Bunting [A,B]						●		●	●	●
Lark Sparrow [A,B]								●		
Lazuli Bunting [B]										●
Loggerhead Shrike [A]		SC	●	●	●					
Northern Harrier [A,B]								●		●
Sharp-tailed Grouse [A,B]									●	●
Short-eared Owl [B]			●	●	●	●		●		
Swainson's Hawk [A]			●			●				
Upland Sandpiper [A]			●	●	●					
Veery [A]		SC								
Vesper Sparrow [A,B]								●		●

[1] Federal Listed Species Codes
T = Threatened C= Candidate
E = Endangered

[2] MT Species Codes
T = Threatened
E = Endangered
SC = Species of Concern

[3] NAS/ABC - 2007 Watchlist
● = Red List
● = Declining or Rare

[4] PIF NCS Categories
CC = Continental Concern RC = Regional Concern
CS = Continental Stewardship RS = Regional Stewardship

A= Species on Little Bighorn Battlefield NM certified bird list B= Species detected during 2012 RMBO survey

the lists of species of conservation concern. Those considered as having the greatest potential for conservation at the Monument are those within their breeding range and for which breeding habitat exists at the park.

<u>Condition and Trend for Species of Conservation Concern</u>

There are 18 species that have been reported at Little Bighorn Battlefield NM that are listed as species of conservation concern on one or more of the lists described above and in Appendix G (Table 4.11.6-3). There are no species listed as endangered or threatened that are known to occur at the Monument. However, five species are listed by the State as species of concern. There are seven species that have been detected at the Monument that have been identified by the USFWS as having the greatest conservation need at a National, USFWS Regional, or BCR geographic scale (U.S. Fish and Wildlife Service 2008). Four species appear on the NAS/ABC 2007 WatchList, all in the declining or rare categories (Yellow WatchList). Thirteen of the 18 species in the table are listed by PIF

Table 4.11.6-4. Species on the certified bird list (and in Bock and Bock 2006) and those detected during the 2012 RMBO survey at Little Bighorn Battlefield NM that are species of concern on one or more watch list. Species are organized by whether they have high, moderate, or low potential for the Monument to contribute to their conservation.

Common Name	On Certified Bird List	2012 RMBO Survey	Range Status	Breeding Habitat Class
High Potential				
Black-billed Magpie	•	•	Year-round	Exists
Common Nighthawk		•	Breeding	Exists
Grasshopper Sparrow	•	•	Breeding	Exists
Great Blue Heron	•	•	Breeding	Exists
Lark Bunting	•	•	Breeding	Exists
Lark Sparrow	•	•	Breeding	Exists
Lazuli Bunting		•	Breeding	Exists
Loggerhead Shrike	•		Breeding	Exists
Sharp-tailed Grouse	•	•	Year-round	Exists
Veery	•		Breeding	Exists
Vesper Sparrow	•	•	Breeding	Exists
Moderate Potential				
Brewer's Sparrow	•		Breeding	Probably Exists
Brown Thrasher	•	•	Breeding	Probably Exists
Upland Sandpiper	•		Breeding	Probably Exists
Low to No Potential				
Ferruginous Hawk	•		Breeding	Limited (foraging, but limited nesting)
Northern Harrier	•	•	Breeding	Limited (foraging, but limited nesting)
Swainson's Hawk	•		Breeding	Limited (foraging, but limited nesting)
Short-eared Owl		•	Year-round	Limited to None

in one or more of its categories (i.e., CC, RC, CS, RS), although none are listed in the Continental Concern category.

Summary of Species Listed as Birds of Conservation Concern

For this summary, we emphasize species for which Little Bighorn Battlefield NM has the greatest potential to positively impact their conservation during the breeding season, based on their habitat and range. We do not mean to imply that other seasons are not important for the conservation of birds, they are. Rather, we have limited this assessment to the breeding season because that is the only season for which we have current information. We also recognize that there is uncertainty and subjectivity in our assessment. Thus, we do not mean to imply that the classes we assigned are the only "correct" categories. Rather, this represents our interpretation from the available evidence, but we fully expect that other interpretations might be appropriate. Of the 18 species listed by one or more organization as being of conservation concern, we believe that eleven have sufficient habitat at the Monument to be considered as having high conservation potential (Table 4.11.6-4). These are the species that are within or on the edge of their normal breeding range and sufficient habitat exists at the Monument to support breeding. All but two of the species (Loggerhead Shrike, Veery) were detected during the 2012 RMBO survey. All but two of the species (Common Nighthawk, Lazuli Bunting) were on the park species list (and reported in Bock and Bock 2006).

Table 4.11.6-5. The number of individuals of species with highest conservation potential detected at Little Bighorn Battlefield National Monument during the 2012 RMBO survey, and the description of the species according to the certified bird list.

Species	2012 Survey	Certified Bird List
Black-billed Magpie	1	Resident, common
Common Nighthawk	1	------
Grasshopper Sparrow	18	Resident, common
Great Blue Heron	1	Resident, common
Lark Bunting	30	Resident, common
Lark Sparrow	28	Resident, common
Lazuli Bunting	5	------
Loggerhead Shrike	0	Resident, uncommon
Sharp-tailed Grouse	6	Resident, uncommon
Veery	0	Resident, rare
Vesper Sparrow	6	Resident, common

Little Bighorn Battlefield NM has been protected from most development and livestock grazing since soon after the Battle of Little Bighorn in 1876, and it is in relatively pristine condition compared to the surrounding landscape. Several of these eleven "high conservation potential" species use agricultural and more developed habitats as well as native prairie and shrublands. The Monument likely provides the highest conservation potential for Grasshopper Sparrow and Sharp-tailed Grouse, which are more reliant on native prairie and shrubland (and riparian habitat in the winter for the Grouse) than the other species.

Table 4.11.6-5 reports the number of individuals of each species that were detected during the 2012 survey, as well as the resident class and abundance descriptors used on the

Table 4.11.7-1. Summary of the landbird indicators/measures and their contributions to the overall landbirds natural resource condition assessment.

Indicator/Measure	Description of How the Indicator(s) Contributes to the Overall Resource Condition	General Contribution of this Indicator / Measure to the Overall Resource Condition.
Species Occurrence • Temporal context • Spatial context • Conservation context	Although other measures that are currently not available (i.e., data for density, occupancy, etc.) may be more appropriate for this measure, we simply used occurrence for this assessment. We considered three different facets of occurrence to provide a greater perspective to this measure.	A total of 74 bird species have been reported to occur at the Monument (Appendix H), with most of them occurring within their normal breeding ranges. Ten species were detected during the 2012 RMBO survey that were not previously detected by Bock and Bock (2006)/on the certified park bird list. Twenty-three species recorded by Bock and Bock (2006) were not detected during the five-day 2012 RMBO survey, but some of the birds may have been detected if the survey had been longer. The ten most frequently detected species at the Monument during the 2012 survey were among the most common species detected during 2012 regional surveys. The Monument has a high potential to influence 11 species that have been identified as species of concern by various bird conservation organizations.

park bird species list. Based on the available information, we consider the condition of species of conservation concern to be good.

4.11.7. Overall Condition & Trend

For assessing the condition of landbirds, we used one indicator/measure that assessed landbird occurrence. This indicator is summarized in Table 4.11.7-1. Although our assessment is based on limited data, we found no justification to warrant concern for breeding landbird occurrence at Little Bighorn Battlefield NM at this time.

Although there were differences in bird species detected during the 2012 RMBO survey compared to those found by Bock and Bock (2006; the same as the park certified bird list), we do not have any particular concerns for species occurrence. The temporal comparison found 23 species that had been recorded by Bock and Bock (2006) that were not detected during the 2012 RMBO survey. On the other hand, 10 species were detected during the 2012 survey that were not previously detected by Bock and Bock (2006) (Van Lanen and Hanni 2012). As described earlier, RMBO suggested the reasons for this may be: 1) that the Bock and Bock surveys were conducted during a broader seasonal window (May-October), which included parts of the migratory season (compared to late May and early June for the 2012 survey). 2) Extensive fires that occurred after some of the Bock and Bock surveys killed and removed shrub cover that may have affected the occupancy of some species in the area. 3) Some of the species are associated with water (e.g., Belted Kingfisher), and while they were not observed within the Monument in 2012 they were observed nearby outside the boundaries. 4) Some of the species may not have been detected in 2012 merely due to the brief (5 days) survey effort; they may have been present but went undetected. According to Van Lanen and Hanni (2012) increased sampling intensity throughout the breeding season would likely have increased the number of species observed in 2012.

Similarly, there was nothing particularly surprising or alarming when comparing species observed during the 2012 RMBO survey to the species observed during 2012 IMBCR surveys within the Montana portion of BCR 17. The ten most frequently detected bird species at the Monument during the 2012 RMBO survey were among the most common species detected during the 2012 regional surveys (Van Lanen and Hanni 2012). Half of the ten most commonly detected species at the Monument were also among the top ten species in the regional surveys.

We found eleven species of conservation concern that we believe have high conservation potential at Little Bighorn Battlefield NM. All but two of the species were detected during the 2012 RMBO survey, and the two species with probably the highest conservation potential at the Monument, Grasshopper Sparrow and Sharp-tailed Grouse, had multiple detections by RMBO (18 and 6, respectively). We have no particular concern that two of the species were not detected during the five-day survey.

Based on the temporal and spatial comparisons conducted by RMBO in their 2012 report, and our assessment of species of conservation concern, we consider the overall condition of breeding landbirds at Little Bighorn Battlefield NM to be good. Unfortunately, we do not have sufficient data to justify a trend in the condition at this time.

<u>Level of Confidence/Key Uncertainties</u>

The key uncertainties related to this assessment are the overall lack of data and subjectivity with respect to assigning individual species to range, habitat, or conservation classes. Although the Bock and Bock surveys and the RMBO survey conducted as part of this NRCA provided quantitatively rigorous data, we relied primarily on qualitative indicators to assess the condition of landbirds. This is because the two survey methods were different and covered different periods of the breeding season (Bock and Bock surveyed over several months of the breeding season while RMBO surveyed over a 5-day period in late May/early June). Quantitative comparisons of these two data sets are therefore not justified. If future comparable surveys are conducted, there would be a firm basis for quantitative analysis and comparisons.

We determined the breeding ranges primarily from the BNA species accounts and had to judge from online and hard copies whether or not the Monument was within those ranges. Similarly, there is considerable subjectivity in our assignment of habitat classes. We based this assessment on a combination of the BNA accounts, as well as our own and local knowledge of the species in question.

Finally, as pointed out by Van Lanen and Hanni (2012), the work of Bock and Bock (2006) (that is the basis for the park bird species list) was used for the temporal comparison of species occurrence. The list of species compiled includes species observed outside of the breeding season. However, we believe that this has been adequately accounted for in the discussion provided by Van Lanen and Hanni (2012), which appears in section 4.11.5 of the report.

4.11.8. Sources of Expertise

The first two components (of three) of the breeding landbirds analysis came from the 2012 survey and report by RMBO-- *Avian Area Searches on Little Bighorn National Battlefield: 2012 Report* (Van Lanen and Hanni 2012). Additional input on all components of the analysis was provided by Mike Britten, the program manager for ROMN, who has expertise in avian ecology.

4.11.9. Literature Cited

Note that this section consists of the literature cited section of the RMBO report, as well as references from Sections 4.11.1, 4.11.6, and 4.11.7.

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MIKE BRITTEN

Fritillary on *Apocynum* at Little Bighorn Battlefield National Monument.

Chapter 5: NRCA Discussion and Connection to *State of the Park* Reporting

5.1. Introduction

The purpose of this chapter is to provide a summary of the natural resource topics assessed for Little Bighorn Battlefield National Monument's NRCA. The format will be closely aligned to the *State of the Park* report to aid the integration of natural resource condition information derived from this NRCA into the park's *State of the Park* report.

State of the Park

As part of the stewardship of national parks for the American people, the NPS has begun to develop *State of the Park* reports to assess the overall status of each park's resources. The NPS will use the *State of the Park* report information to improve park priority setting and to synthesize and communicate complex park condition information to the public in a clear and simple way (NPS 2011a,b).

The key purposes of each *State of the Park* report is to:

- Provide to visitors and the American public a snapshot of the status and trend in the condition of a park's priority resources and values.
- Summarize and communicate complex scientific, scholarly, and park operations factual information and expert opinion using non-technical language and a visual format.
- Highlight park stewardship activities and accomplishments to maintain or improve the *State of the Park*.
- Identify key issues and challenges facing the park to help inform park management planning.

In this chapter, we will address three of the four *State of the Park* purposes by providing an overall natural resource summary table showing the resource topic condition findings, which is based on the hierarchical framework discussed in Chapter 3. The Status and Trend symbols used in the resource summary table, and throughout this report, can also be found in Chapter 3, Table 3.2.3-1.

The background color, in green, yellow, or red, represents the current condition, the direction of the arrow summarizes the condition's trend, if any, and the thickness of the outside line represents the degree of confidence in the assessment of the resource. If the condition of a resource is transitioning from one condition level into another it is shown as two colors within the circle. (e.g., half green indicating good condition and half yellow for moderate condition). Circles with no color indicate an unknown condition.

The Monument's *State of the Park* natural resource summary is shown in Table 5.1-1. The rationale provides an explanation for the overall condition of each resource topic assessed for the Monument's NRCA. The internet version of this NRCA report is available at http://www.nature.nps.gov/water/nrca/reports.cfm.

In section 5.2, we summarize each natural resource topic by individual indicators and assign condition status, along with a brief review explaining the rationale for the resource condition. We also include a resource brief, summarizing key information pertaining to each natural resource topic. Sections 5.3 and 5.4 discuss noteworthy natural resource condition highlights and key issues and challenges for consideration in management planning, respectively. All of the sections in Chapter 5 are intended to be used as a stand-alone document to aid Monument staff in developing the natural resource component of their *State of the Park* report.

5.2. *State of the Park* – Natural Resources

Our NRCA assessment of each natural resource topic assessed for Little Bighorn Battlefield NM is based on a synthesis of the park's monitoring, evaluation, and management programs, as well as expert opinions and other credible scientific literature and/or programs. Copies of references and website links to sources used to assess each resource topic are provided on a DVD with the final NRCA report.

The overall assessment of the condition for a Priority Resource or Value may be based on a combination of the status and trend of multiple indicators and specific measures of condition shown in the tables below.

Table 5.1-1 *State of the Park* Natural Resource Summary Table

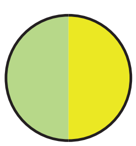
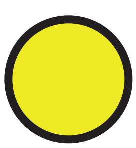
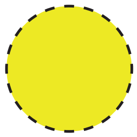
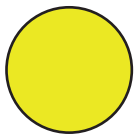
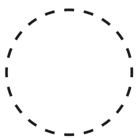
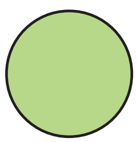
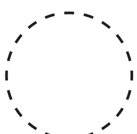
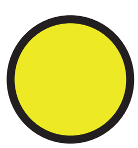
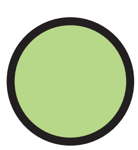
Priority Resource or Value	Condition Status/Trend	Rationale
Natural Resources		
Viewshed		To assess viewshed condition, four measures of scenic and historic integrity were used, two ground based using vantage points and panoramic images (intactness and conspicuousness of noncontributing features) and two aerial-perspective measures using GIS representation and analysis (road and housing density). Overall, the scenic and historic integrity of the viewsheds at Little Bighorn Battlefield National Monument is in good to moderate condition. The landscape surrounding Little Bighorn Battlefield National Monument remains largely rural and sparsely developed. The location of the Monument so near the intersection of two highways is somewhat problematic, however, because of the associated commercial development and infrastructure. Although the topography mitigates this impact in much of the Monument, there are some critical viewpoints where these noncontributing features are conspicuous.
Night Sky		All-sky Anthropogenic Light Ratio, zenith sky brightness, and Bortle Dark-Sky Scale measures were used to assess the night sky. Although the Bortle Dark-Sky Scale measures resulted in a "rural sky," some air glow was observed. The anthropogenic light measurement is the most accurate measure used, and indicates moderate condition. The sky brightness readings also indicated moderate condition.

Table 5.1-1 State of the Park Natural Resource Summary Table (continued)

Priority Resource or Value	Condition Status/Trend	Rationale
Soundscape		The Monument's soundscape is comprised of a variety of sounds, including natural and noise. Last Stand Hill receives high concentrations of vehicle and visitor activity where contemplation is desirable. However, this area is located in the Monument's development subzone, which allows for a higher degree of activity and associated noises. The Reno-Benteen Unit is likely quieter than at Last Stand Hill, but overall, we consider the Monument's soundscape to be in moderate condition.
Air Quality		Air quality monitoring is multifaceted and includes visibility, ozone, and wet deposition for total nitrogen and total sulfur. Three of the four air quality condition indicator values warranted moderate concern. Only wet deposition of sulfur was consideration to be within a level to warrant a good condition rating. Trends were derived for wet deposition and long-term data (1990-2009) indicate a deteriorating trend for NH_4, an improving trend from SO_4, and no trend for NO_3.
Geology		A geologic resource inventory was conducted in 2011 but no indicators or measures were developed for this topic.
Stream Ecological Integrity		The ecological integrity of a stream is the capacity to support and maintain a balanced, integrated and adaptive community of organisms, having a species composition, diversity, and functional organization comparable to minimally-disturbed natural streams in the ecoregion. There are three indicators and associated measures that were used to determine an overall good condition for the Monument's stream resource.
Groundwater		Tuck (2003) gathered data from 193 groundwater and 27 surface water sites along the Little Bighorn River and its tributaries to describe the general geology and water resources of the Quaternary alluvium and the Upper Cretaceous Judith River Formation. Two of the groundwater sites were located in the Monument, but only one well is currently active. Assessing groundwater condition is a complex process that includes the geology, geomorphology and landuse/land cover of the surrounding area as well as long-term data. Because of this complexity, and lack of site-specific data, we did not assign a condition to the groundwater resource.
Riparian Habitat		A proper functioning condition for riparian habitat requires integration between water flow and floodplain characteristics, vegetation types and amounts, and erosion and sediment deposition processes. All of these aspects are properly functioning throughout the Monument's riparian habitat area and supporting the system's resiliency.
Grasslands		Based on the indicators, data, and expert opinion, we consider the overall condition of the grasslands at Little Bighorn Battlefield NM to be in moderate condition. This is primarily due to the presence of highly invasive exotic plants, particularly the bromes.
Exotic Plants		We used three indicators, one with two measures, to assess exotic plant condition. Using two invasiveness ranking systems, the highest ranked species included cheatgrass, Russian olive, and Salt Cedar. Both Russian olive and Salt cedar are located within the riparian habitat, whereas, cheatgrass is widespread throughout the upland vegetation. At least one high priority exotic species was found in at every vegetation composition, structure, and soils monitoring site. Cheatgrass was found in almost 94% of the sites.
Landbirds		We used one indicator/measure, species occurrence, in three separate contexts (temporal, spatial, and conservation), to assess the condition of breeding landbirds. A total of 74 bird species have been reported at the NM, with 47 of them being observed in a 2012 RMBO survey. The NM is within the normal breeding range of most of the species. The ten species counted in the highest numbers at the NM during the 2012 survey were among the most common species detected during 2012 regional surveys. We consider the condition of landbirds at the NM to be good, but we do not have sufficient data to justify a trend in the condition at this time.

Viewshed			
Indicators of Condition	Specific Measures	Condition Status/Trend	Rationale
Scenic and Historic Integrity	Intactness		The Monument's landscape remains rural, although some features (highways, development, structures) encroach somewhat on the intactness. Overall, as measured by intactness, the Monument is in good to moderate condition.
	Conspicuousness of Noncontributing Features		Although the rural landscape is largely intact, some noncontributing features are relatively conspicuous (size and color of structures in developed areas, the movement and noise associated with the highway, for example). Since the topography of the Monument often hides these features, we assessed the condition as good to moderate.
	Housing Density		Housing density is relatively low surrounding the Monument indicated good condition.
	Road Density		Road density is relatively low surrounding the Monument indicating good condition.

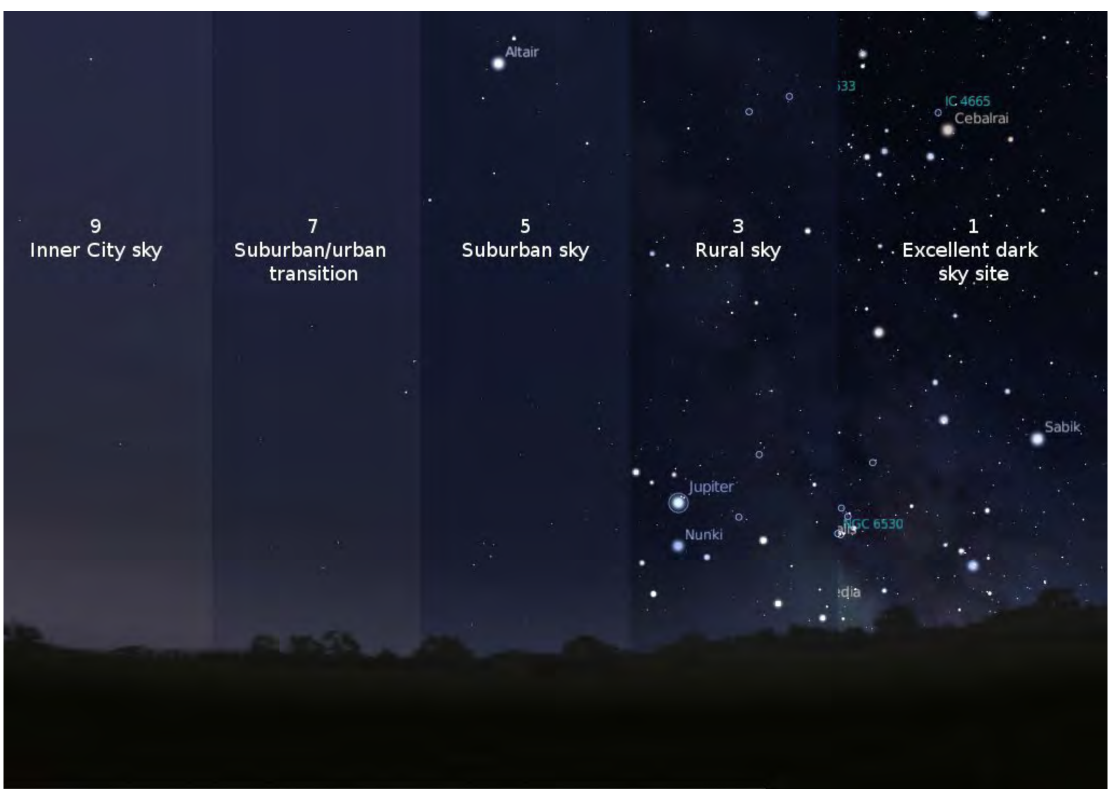
Resource Brief

The scenic and historic integrity of Little Bighorn Battlefield National Monument is imparted to visitors through the viewshed--what people see when they visit the site. Not only does the condition of the viewshed impact visitor experience and enjoyment, it is often times critical to their understanding the events that occurred on the site; key aspects of the battle can be envisioned playing out on the landscape, its topography and natural setting. Viewshed condition is impacted negatively by fragmentation (a lack of intactness on the landscape), the conspicuousness of noncontributing features--or those things on the landscape that look out of place, and the amount of development--roads and homes that may break up the landscape and be conspicuous eyesores. Some features contribute to scenic and historic integrity and impact viewsheds in a positive way--historic structures, features, or monuments, the natural topography and landscape features, and even a rural agricultural setting. At Little Bighorn NM, the surroundings are largely rural and the landscape is mainly intact. There are some significant noncontributing features that negatively impact the viewshed condition--highways, roadside development, and even park infrastructure. Although throughout most of the Monument the topography hides these features, there are still some vantage points where there are intrusions into the viewshed.

Night Sky			(moderate condition)
Indicators of Condition	Specific Measures	Condition Status/ Trend	Rationale
Zenith Sky Brightness	All-sky Anthropogenic Light Ratio	(moderate condition)	Ground-based measurement of ALR indicated the night sky condition to be moderate, on the edge between good and moderate.
	Zenith Sky Brightness	(moderate condition)	SQM reading indicated moderate condition.
Sky Quality	Bortle Dark-Sky Scale	(good condition)	The Monument's night sky was assessed to be consistent with its rural surroundings. This is considered good condition.

Resource Brief

Natural dark skies are a valued resource for many reasons; they are an important factor for maintaining healthy biological systems and have an aesthetic appeal for recreational value. Night skies, and the objects that can be seen, also have strong cultural connections. For thousands of years, people have watched the night sky and told stories connected to the stars, planets, and constellations that they observe. The night sky at Little Bighorn Battlefield NM is consistent with what one would expect to see in a rural area, away from the lights of the city. The Milky Way is clearly defined, and many star clusters, nebulae, and other celestial objects can be seen; although some ambient light pollution can be detected from the park buildings and infrastructure and the nearby cities and towns.



Composite image illustrating the range of night sky conditions based on the Bortle Dark Sky Scale.

Soundscape			
Indicators of Condition	Specific Measures	Condition Status/Trend	Rationale
Sound Sources	Types of Sounds Relative to Location		The loudest noises that likely occur in the Monument are from traffic and human conversations. The Monument is separated into two units: Custer and Reno-Benteen, with Last Stand Hill located in the Custer Unit adjacent to a concentrated area of noise-producing activities, which is inconsistent with providing a place for contemplation, therefore we consider this indicator to be in moderate condition.
Sound Characteristics (Reno-Benteen Unit only)	Loudness and Pitch		Sound levels and frequencies were recorded in 2013 at a location within the Reno-Benteen Unit. The majority of levels and frequencies appeared to be consistent with a quieter location, however, we expect that given the close proximity of developments adjacent to the popular visitor sites, within the Custer Unit, the decibel levels will likely be louder and the frequencies will most likely be higher pitched.

Resource Brief

Visitors to national parks often indicate that an important reason for visiting the parks is to enjoy the relative quiet. 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). Cultural activities are also considered to contribute to a good soundscape condition and are desirable at cultural parks. The soundscape at the Monument is comprised of natural and anthropogenic noises. High concentrations of noises are likely heard at Last Stand Hill- a place intended to evoke contemplation. Most of the noises heard are associated with activities surrounding the visitor center, including a parking area where high concentrations of vehicle and visitor activity can be heard. Vehicles also travel the Battlefield Tour Road that runs along Last Stand Hill and connects the Custer Unit to the Reno-BenteenUunit-another popular visitor location, which is likely quieter compared to Last Stand Hill.

ROBERT BENNETTS

Vehicles contribute to the noises heard at the Monument.

Air Quality			
Indicators of Condition	Specific Measures	Condition Status/Trend	Rationale
Air Quality	Visibility Haze Index		A five-year average of interpolated visibility values were derived to determine that the condition of visibility is of moderate concern at the Monument.
Air Chemistry	Level of Ozone		A five-year average of interpolated ozone values were derived to determine that the condition of ozone is of moderate concern at the Monument. In addition, six plants have been identified as ozone sensitive, four of which are bioindicators.
	Atmospheric Wet Deposition in Total N		A five-year average of interpolated atmospheric wet deposition values were derived to determine that the condition of total nitrogen is of moderate concern, with a trend from 1999-2009 of no trend for NO_3 and deteriorating trend for NH_4.
	Atmospheric Wet Deposition in Total S		A five-year average of interpolated atmospheric wet deposition values were derived to determine that the condition of total sulfur is good, with an improving trend from 1999-2009 at the Monument.

Resource Brief

Air quality doesn't just affect the air we breathe, it also affects many air quality related values such as visibility and cultural and natural resources. There are different facets to air quality monitoring including ozone levels, visibility conditions, and wet deposition levels. Based upon five-year interpolated values, visibility and ozone levels, warrant a significant concern. Atmospheric wet deposition has been monitored on-site at the Monument since 1984. The condition for atmospheric wet deposition in total nitrogen is of moderate concern with no trend for NO_3 and a deteriorating trend for NH_4. Atmospheric wet deposition for total sulfur is in good condition with an improving trend. The Monument contains six ozone-sensitive plant species, four of which serve as ozone bioindicators. Bioindicator species are more likely to exhibit ozone damage before other species are impacted by higher ozone levels. The Monument's air quality is largely influenced by activities and operations that occur outside its boundary, and the future condition of its air quality condition is ultimately dependent on local, regional, and national planning.

Wet deposition monitoring station at Little Bighorn Battlefield NM.

Geology

Indicators of Condition	Specific Measures	Condition Status/Trend	Rationale
None	None		None

Resource Brief

The bedrock that underlies Little Bighorn Battlefield National Monument (NM) is from the Upper Cretaceous Period (about 100 million to 65.5 million years ago) and represents sediments (mud and sand) originally deposited in a seaway that inundated west-central North America. Surficial units consist of alluvium (gravel, sand, silt, and clay) that streams deposited during the Quaternary Period (the past 2.6 million years). These rocks and unconsolidated deposits give rise to the landforms that influenced the actions taken during the Battle of the Little Bighorn.

The topography of Little Bighorn Battlefield NM is dominated by ridges that rise above the floodplain of the Little Bighorn River. Ravines and coulees dissect these ridges. During the Battle of the Little Bighorn, the ridges provided views across the broad valley and, also, provided defensible high ground for soldiers of the 7th Cavalry. Ravines and coulees, which cut into the ridges, allowed for the secluded advance of Indian attackers. The incised ravines and coulees also provided access routes to the higher ground for the retreating soldiers under Reno's command.

Geology, and associated soils, are the basis for vegetation communities, the hydrology, and the basic landforms and topography for an area, that then support the biotic communities. Soils, hydrology, and landform also influence human settlement patterns, and how people use the land--for farming, ranching, hunting, fishing, and other basic land uses.

The steep banks of the Little Bighorn River.

Stream Ecological Integrity			
Indicators of Condition	Specific Measures	Condition Status/Trend	Rationale
Water Chemistry	Water Physiochemistry		Nutrients, major ions and metals concentrations were all acceptable with few exceedances of MT DEQ aquatic life (or human health) criteria. Sulfate concentrations were higher than in ecoregion reference sites. While there is some mixed evidence (the reason behind our medium confidence, otherwise it is high), the long term trend in several parameters seems to be improving.
	Water in situ Chemistry		All of the core NPS parameters were in an acceptable reference range. Dissolved oxygen needs more careful monitoring. The long term trend in stream temperature suggests rising water temperature (but the period of record is short).
	Physiochemistry Sediment		Most metals were present in low concentrations and did not exceed consensus based criteria. Total iron and manganese did have values above MT DEQ aquatic criteria but we suspect the source of this is natural. We lack data to assess trends in metal concentrations.
Habitat	Streamflow		2009 and 2010 years were dry while 2008 was wet. There was a suggestion of a shift in timing of peak flows to later in the summer. Stream flow decreased over the long term (the period of record is short).
Biological Communities	Macroinvertebrates		Patterns across macroinvertebrate metrics were complex. The weight of evidence suggests that there was an out of reference community present, but there is some concern about the quality of models used in rivers like the Little Bighorn. Littoral fine sediment may be the primary cause behind a degraded condition. We lack data to assess trends.
	Diatoms		Like macroinvertebrates, most diatom metrics suggested some degraded conditions in the river, especially in response to sediment. Diatoms are the base of the food chain and the lack of an intact diatom community may be one of the reasons why we also see lower quality macroinvertebrate assemblages. Likewise, nutrient metrics were variable with some suggestion of issues. We lack data to assess trends.
	Aquatic Invasives		No aquatic invasive species were found although the New Zealand mudsnail is in the Bighorn River watershed and likely on the move. SEI monitoring will watch closely for these and other invasive species over the coming years.

Note: This table was extracted from Schweiger et al. 2012 and does not report the indicators/measures in exactly the same format as found in the Stream Ecological Integrity section of this NRCA.

Resource Brief

Ecological integrity of a stream is the capacity to support and maintain a balanced, integrated and adaptive community of organisms, having a species composition, diversity, and functional organization comparable to minimally-disturbed natural streams in the ecoregion. The following information presents key results from pilot monitoring of Stream Ecological Integrity (SEI) in the Little Bighorn River at Little Bighorn Battlefield National Monument from 2007 – 2010 by Rocky Mountain Inventory and Monitoring Network staff (Schweiger et al. 2012).

Overall, the ecological integrity of the Little Bighorn at the Monument appears to be mixed, with higher quality water physiochemistry but with some indication of non-reference biological condition.

Few nutrients, major ions or metals or exceeded human health, aquatic life or consensus-based criteria during 2007 – 2010, suggesting most water physiochemistry was reference, however, median concentrations of sulfate were higher at the Monument than across EPA monitoring sites in the Northwestern Great Plains ecoregion. While there are no state criteria for these parameters, this result may suggest that anthropogenic disturbances, particularly agriculture, may influence water quality in the Little Bighorn at the Monument..

Trends in most water physiochemistry parameters using data from the nearby USGS gauge in Hardin, MT were mixed. Stream water temperature has increased at slow rate since 1972 and streamflow has decreased at a somewhat higher rate since 1953. Many biological metrics were below MT DEQ thresholds (or suggest impairment) and most were also below reference conditions developed from sites in the Northwestern Great Plains ecoregion. The presence of a few indicator species of algae may suggest issues with sediment. No invasive exotic aquatic species of concern such as New Zealand mudsnails or didymo were found - although mudsnails are in the nearby Bighorn River drainage.

MIKE BRITTEN

The Little Bighorn River.

Groundwater			
Indicators of Condition	Specific Measures	Condition Status/Trend	Rationale for Resource Condition
Groundwater	Change in groundwater level		Condition is not asasessed at this time.

Resource Brief

Groundwater accounts for 1.7% of Earth's total water and 30.1% of Earth's freshwater (USGS 2012a). The overall trend in the United States is that as population increases, the amount of groundwater withdrawn also increases (Figure 4.7.1-1).

Long-term water-level declines caused by sustained groundwater pumping are a key issue associated with groundwater use, and many areas of the United States are experiencing groundwater depletion. More than half of Montana residents depend on groundwater for their primary water supply (Montana Watercourse 2012). Groundwater provides 94% of Montana's rural domestic-water supply and 39% of the public-water supply (Montana Natural Resource Information System 2012).

One environmental consequence to groundwater depletion is land subsidence, which is the settling or sinking of the Earth's surface. The increasing development of land and water resources threatens to exacerbate existing land-subsidence problems and initiate new ones throughout the United States (USGS 2012b).

Unconsolidated glacial and alluvial deposits of Quaternary age, some of which are highly permeable, locally overlie the Northern Great Plains Aquifer System, but are not included in the major aquifer because the shallow groundwater flow in these deposits is very different from the deep, confined flow of the Northern Great Plains Aquifer System (USGS 2005). It is this Quaternary alluvium, composed of unconsolidated sand, gravel, silt, and clay, along with Upper Cretaceous Judith River Formation, composed of sandstone and shale, that underlie an area of approximately 94 square miles, primarily located along the Little Bighorn River, including the area comprising the Monument (Tuck 2003).

Tuck (2003) collected hydrogeologic data between 1994-1995 by inventorying 192 existing wells and one spring along the Little Bighorn River within the Crow Indian Reservation. Tuck's (2003) groundwater level data included U.S. Geological Survey (USGS) National Water Information System data (http://nwis.waterdata.usgs.gov/usa/nwis/gwlevels/) (USGS 2012c), a national water database maintained to help determine if there has been any change in groundwater levels throughout the monitored wells. USGS groundwater data collected from wells located in the Monument indicate a decrease in water levels (increasing depths to water) since 1977 and 1953, respectively.

The condition of the groundwater resource at the Monument is an interplay of water levels recharge rate, well location, geology, geomorphology and landuse/land cover and cannot be determined at this time.

Riparian Habitat

Indicators of Condition	Specific Measures	Condition Status/Trend	Rationale
Hydrology	Floodplain		No channel incision in the river was observed. There were recent sediment deposits on the floodplain, and multiple active point bars indicated relatively frequent flooding, sediment deposition, and sustaining riparian vegetation.
	Beaver dams	N/A	This indicator could not be assessed since no dams were found on or above this area of the river. However, signs of recent beaver activity (this year and last) were evidenced by chewed vegetation.
	Sinuosity, width/depth ratio, and gradient		The overall sinuosity, gradient, width/depth ratio, and channel/floodplain form were in balance with landscape setting. Three cutbanks were identified with minimal riparian vegetation present but not to the extent where the entire reach is at risk of failing.
	Riparian wetland area		The area is approaching or at potential extent for the majority of the reach except where agricultural and ranching practices have removed riparian vegetation along the western bank. These specific areas were experiencing some channel widening.
	Upland watershed		There is some minor, localized sediment inputs from uplands where agriculture/ranch practices have removed the vegetation.
Vegetation	Age class distribution of riparian habitat vegetation		Multiple age classes of sand bar and peach-leaf willows were present. Cottonwood seedlings were growing on the point bars and channel bars, and mature trees were common on the floodplain. It appeared as if recruitment age cottonwoods were establishing as well.
	Diverse vegetation composition		A wide range of herbaceous and woody plants were present, especially ones capable of forming root masses that are able to withstand frequent to moderately frequent flooding.
	Soil moisture characteristics		The presence of wetland obligate species, including water sedge and Chair-maker's bulrush, and of facultative wetland species, including willows and horsetail species indicates that the plants are growing in water, therefore, soil conditions appeared to be moist.
	Plants have root masses capable of withstanding high streamflow events		Several types of plant species present were capable of growing root systems that dissipate excessive energy, thereby, stabilizing streambanks.
	Vigorous plants		Most plants appeared vigorous, although some yellowing of cottonwood leaves was observed. In addition, Tamarisk and Russian olive plants were scattered along the river implying a potential future threat.
	Vegetation cover		With exception of a few locations where grazing and/or agricultural practices have removed riparian vegetation, enough plant cover was present to protect streambanks and dissipate excessive energy from high flow events.
	Plant communities are source of large woody material	N/A	This indicator could not be assessed because the river did not show any sign of utilizing such material for channel maintenance.

Continued Next Page

Riparian Habitat			
Indicators of Condition	Specific Measures	Condition Status/Trend	Rationale
Erosion/Deposition	Floodplain and channel characteristics		No evidence of channel instability was observed even after a >100-year flow and 500 year flood event in 2011: one year prior to assessment.
	Point bars		Depositional processes appeared to be properly functioning based upon the presence of point bars as well as the presence of vegetation establishment on the bars.
	Lateral stream movement		Based upon the aerial imagery and 1891 hand drawn map comparison, the primary meander belt appears to be in nearly the same location for over 100 years, suggesting functioning lateral movement.
	Vertical stability		The comparison between an 1891 hand drawn map and 2005 aerial imagery of the river's channel alignment show substantially shifting meanders but marked sinuosity suggesting vertical stability.
	Balance of water and sediment		No evidence of braiding or excessive erosion was observed during on-site evaluation.

Resource Brief

Riparian wetlands are a type of non-tidal wetland formed along river and stream floodplains. These wetlands serve many functions including water purification, flood control, buffering riverbank erosion, habitat for numerous wildlife, fish, shellfish, and plant species, and also provide many recreational opportunities. In the arid west, riparian habitat is often in marked contrast with the surrounding terrestrial vegetation and is strongly influenced by the presence or absence of water (NPS-WRD 2011).

An interdisciplinary team of experts from NPS' Water Resources Division conducted a qualitative riparian habitat assessment at the Monument along the Little Bighorn River (Martin et al. 2012), using "A User Guide to Assessing the Proper Functioning Condition and the Supporting Science for Lotic Areas" developed by Prichard et al. (1998). This assessment included three main categories including hydrology, vegetation, and erosion/deposition. A total of 17 common attributes and processes within each of these three categories was assessed.

The entire length of river bordering the Monument's boundary shared a common set of attributes and processes so it was assessed as one unit. All of the indicators, except for the ones that were not present, were considered to be in good condition, with an overall improving trend.

Grasslands

Indicators of Condition	Specific Measures	Condition Status/Trend	Rationale
Soil/Site Stability and Hydrologic Function	Rills/Gullies		Condition did not deviate substantially from that which would be expected for the site.
	Water Flow Patterns		Condition did not deviate substantially from that which would be expected for the site.
	Pedestals and/or terracettes		Condition did not deviate substantially from that which would be expected for the site.
	Bare ground		Condition did not deviate substantially from that which would be expected for the site.
	Soil surface resistance to erosion		Condition did not deviate substantially from that which would be expected for the site.
	Soil surface loss or degradation		Condition did not deviate substantially from that which would be expected for the site.
	Bulk density		Condition did not deviate substantially from that which would be expected for the site.
Biotic Integrity	Landscape-scale Diversity		The patterns of plant community distribution generally match that which would be expected given the ecological sites and soils.
	Local-scale Species Composition		Native species are generally consistent with what would be expected given the ecological sites and soils; however, exotic species, particularly exotic bromes are of moderate concern. The highly invasive bromes have the potential to quickly and drastically alter the grasslands.
	Annual, biennial and perennial species relative to Disturbance		Both Grasses and forbs tended to have somewhat lower proportion of perennials, but this could be due to recent disturbances and are not of high concern unless this pattern persists.
	Relative proportion of functional groups (e.g., graminoid, forbs, shrubs, etc.)		The proportions of functional groups did not entirely match those reported in the ecological site descriptions, but these departures did not cause any particular concern.
	Relative proportion of C3 and C4 species.		Sites tended to be dominated by C3 grasses, which is generally expected for northern mixed grass prairies.

Continued Next Page

Resource Brief

Based on the indicators, data, and expert opinion, we consider the overall condition of the grasslands at Little Bighorn Battlefield NM to be in moderate condition. The real concern raised about these grasslands was exotic plants. Currently, the exotic annual bromes appear to be coexisting, rather than displacing native vegetation. However, if the system is shifted by some event, there is concern that the bromes may become dominant and lead to a significant shift in community structure and composition, and therefore transition to a lower functioning ecosystem.

MIKE BRITTEN

Grassland at Little Bighorn Battlefield NM.

Exotic Plants

Indicators of Condition	Specific Measures	Condition Status/Trend	Rationale
Exotic Plant Invasiveness Exotic Plant Ease of Control	NatureServe Invasiveness Rank (I-Rank)		The highest ranked species included cheatgrass, Russian olive, and Salt Cedar. Seven additional species were ranked as high/medium for their invasiveness. Both Russian olive and Salt cedar are located within the riparian habitat, whereas, cheatgrass is widespread throughout the upland vegetation.
	Invasiveness Score Colorado Natural Heritage Program		Since Rocchio's (2007) ranking considers invasiveness only, several species were considered as highly invasive. 62.5% of the high priority species were ranked the most invasive with the ability to form monotypic stands and alter the ecosystem.
Exotic Plant Locations Exotic Plant Distribution	Proportion of Interior Sites Infested with High Priority Exotics		At least one high priority species was found in at every VCSS site. Cheatgrass, one of the most invasive plants at the Monument, was found in almost 94% of the sites. An additional 10 high priority species were found at the upland vegetation monitoring sites.
	Proportion of Monument and Battlefield Tour Road Infested with High Priority Exotics		The proportion of Monument and Battlefield Tour Road infested with a high priority exotic species varied. Canada thistle and smooth brome each occupied a little over three acres. Cheatgrass was not mapped dues to its widespread distribution but represents the highest proportion of acreage infested.

Resource Brief

The negative impact exotic plants have on native ecosystems is well documented and most parks are faced with dire circumstances when it pertains to their ability to control and manage these pests.

NPS-ROMN

Long-tern monitoring of grasslands by ROMN helps to determine status and trends in abundance of exotic plant taxa in the Monument.

The Rocky Mountain Inventory and Monitoring Network (ROMN) identified vegetation composition, structure, and soils (VCSS) as a vital sign to assess park upland vegetation ecosystems, with one of the objectives to determine status and trends in abundance of invasive/exotic plant taxa in the Monument (Britten et al. 2007). ROMN monitoring data (Shorrock et al. 2010), Lehnhoff and Lawrence (2010) exotic plants survey data, and two invasiveness ranking systems were used to assess the condition of exotic plants at the Monument. Overall, we are moderately concerned about the condition of exotic plants at the Monument due to the invasiveness of several of the exotic species found, the widespread distribution of highly invasive exotic plants like *Bromus tectorum* and *Bromus inermis*, and the high relative cover of the invasive bromes found throughout the VCSS sites. We cannot determine trend at this time based upon the limited data.

Landbirds			
Indicators of Condition	Specific Measures	Condition Status/Trend	Rationale
Species Occurrence	Temporal Context		Of 60 bird species on the certified park list and reported in Bock and Bock (2006), 23 were not detected in the 2012 RMBO survey. However, 10 species that were not previously observed by Bock and Bock (2006) were observed by RMBO in 2012. Four additional species were observed by NPS personnel with bird expertise in 2012 after the RMBO survey. There are several reasons why more species may have been observed by Bock and Bock (2006), including the longer sampling period in the Bock and Bock surveys, and their sampling within and outside of the breeding season. Based on this temporal comparison, we have no particular concerns for landbirds at the NM at this time.
	Spatial Context		There was nothing particularly surprising or of concern when comparing species observed during the 2012 RMBO survey to the species observed during 2012 IMBCR surveys within the surrounding region. The ten most frequently detected bird species at the NM during the 2012 RMBO survey were among the most common species detected during the 2012 regional surveys. Half of the ten most commonly detected species at the NM were also among the top ten species in the regional surveys. Based on this spatial context comparison, we have no concerns for breeding landbirds at this time.
	Conservation Context		Eighteen species that have been reported to occur at the NM are listed by one or more organization as being of conservation concern. Of these, we consider eleven species to have high conservation potential at the park; these are species that are within their normal breeding range and have sufficient habitat at the NM to support their breeding. All but two of these species were observed during the 2012 RMBO survey, and the two species that probably have the highest conservation potential at the NM, Grasshopper Sparrow and Sharp-tailed Grouse, had multiple detections by RMBO. We consider the condition of species of conservation concern to be good.

Resource Brief

Landbirds are a conspicuous component of many ecosystems, and changes in landbird populations may be indicators of change in the biotic or abiotic components of the environment upon which they depend (Canterbury et al. 2000; Bryce et al. 2002). Landbirds are also highly detectable and can be efficiently surveyed with the use of numerous standardized methods (Bibby et al. 2000; Buckland et al. 2001). In addition to being good indicators of ecosystem change, landbird communities are inherently valuable. The condition of landbirds at the NM was assessed using one indicator/measure—species occurrence (presence/absence). We evaluated species occurrence in three contexts: a temporal context, a spatial context, and a conservation context. The primary sources of information for the assessment were 1) a 2012 survey and report by the Rocky Mountain Bird Observatory (RMBO)-- Avian Area Searches on Little Bighorn National Battlefield: 2012 Report (Van Lanen and Hanni 2012), and 2) a 2006 report (Bock and Bock 2006) that is the basis for the certified list of birds at the NM. The temporal and spatial species occurrence assessments were taken from the 2012 RMBO report, and the conservation context assessment was conducted by us. A total of 74 bird species have been reported to occur at the NM, with nearly all of the species occurring within their normal breeding ranges. The temporal species occurrence comparison found that, of 60 bird species recorded at the NM by Bock and Bock (2006), 37 were observed in the 2012 RMBO survey. Twenty-three species were not detected in recent surveys. However, 10 species that were detected during the 2012 survey were not previously detected by Bock and Bock (2006). RMBO (2012) suggested several reasons for the differences. The spatial species comparison, using all 2012 data, found that the ten most frequently detected bird species at the NM during the 2012 RMBO survey were among the most common species detected during 2012 regional surveys (IMBCR surveys within the Montana portion of BCR 17). Also, five of the ten most commonly detected species at the NM were among the top ten species in the regional surveys. Of 18 species of conservation concern that have been reported at the NM, we believe 11 have high conservation potential at the NM. These are species that are within their normal breeding range and have sufficient breeding habitat at the NM. All but two of the species were detected during the 2012 RMBO survey. The species that probably have the highest conservation potential at the NM, Grasshopper Sparrow and Sharp-tailed Grouse, had multiple detections by RMBO. Based on the temporal and spatial comparisons conducted by RMBO in their 2012 report, and our assessment of species of conservation concern, we consider the overall condition of birds at the NM to be good. Unfortunately, we do not have sufficient data to justify a trend in the condition.

The Grasshopper Sparrow is one of eleven species identified as species of conservation concern with the highest conservation potential at the Monument.

5.3. Noteworthy Resource Condition Highlights

The list below provides examples of noteworthy highlights that will help to maintain or improve the condition of the Monument's natural resources.

Landscape Level Resources

Viewshed

- Most of the Monument has viewsheds in good condition; the rural setting, rolling topography, and the trails, monuments, and markers within the site all contribute to a positive visitor experience. The placement of trails, interpretive signs, and the visitor flow through the park generally encourages a connection with the landscape and the historical events, through the viewsheds.

Night Sky

- Although the monument is relatively small, and located close to the highway, the night skies are quite good, from a qualitative standpoint.

Supporting Environment Resources

Air Quality

- Total sulfur wet deposition is in good condition, with an improving trend based on data from 1999-2009.

Stream Ecological Integrity

- An integrated approach to monitoring the stream ecological integrity of the Little Bighorn River along the Monument will provide condition and trend data to address long-term issues, not only related to the water resources, but also related to topics such as climate change, atmospheric deposition, altered hydrology, , non-native species, erosion, improper sewage plant or drain field operations, and storm water runoff.

Vegetation Resources

Grasslands

- The grasslands are in relatively good condition; however, the threat of invasive exotic plants, particularly the annual bromes, have the ability to quickly and drastically alter the current grassland condition.

Riparian Habitat

- All measures of hydrology, vegetation, and erosion/deposition indicate that the condition of the riparian habitat is good along the Little Bighorn River.

Exotic Plants

- Monument staff have implemented an Early Detection Rapid Response program to manage the introduction of new exotic and highly invasive plant species. This is the most effective management technique that can be employed to proactively manage new exotic plant infestations.

Wildlife Resources

Landbirds

- A total of 74 bird species have been reported to occur at the NM, with 37 of the species detected during a 2012 RMBO survey. Four additional species were observed (that are not on the certified park species list from 2006) by NPS personnel (Mike Britten) after for the 2012 survey. Twenty-four percent of the 74 species (or 18 species) are considered species of conservation concern by one or more organization. Eleven of these 18 species have high conservation potential at the NM, because they are within their normal breeding ranges and breeding habitat exists for them at the park.

5.4. Key Issues and Challenges for Consideration in Management Planning

Little Bighorn Battlefield NM continues to contribute to the successful preservation of natural resources that are representative of the mixed grass prairie ecosystem of North America. In collaboration with its many partnerships, the Monument continues working towards understanding, monitoring, and preserving these important resources. This section provides some interpretations of some key issues and challenges identified throughout the development of this NRCA are discussed below.

Viewshed

The viewpoint at Last Stand Hill in the Custer Unit is probably the most visited, and has the most impacted viewshed. From that vantage point (looking to the south) the highway development and the Monument infrastructure (visitor center, parking lot, roads, traffic, and administration buildings) all degrade the viewshed to a certain degree. To the extent decisions about infrastructure, the siting of new visitors' centers, and other management decisions can consider viewshed impacts, the higher quality visitor experience is likely to result.

Night Sky

Lighting in the park (on the outside of buildings and in parking lots) can impair night sky viewing and contribute to light pollution. The cultural significance of the monument, and the cultural significance of night sky, provides an opportunity to partner with the Crow Agency schools and Crow elders in educational programs.

Soundscape

Noises heard within the Monument are largely generated within the Last Stand Hill area due to the high visitation and high concentration of visitor services within this very popular area. The anthropogenic noises are not congruent with the concept of contemplation that Last Stand Hill and associated features evoke. The Monument is exploring various options for relocating the visitor center and services, which should improve the soundscape condition surrounding Last Stand Hill.

Air Quality

The Monument has a moderate condition rating for wet deposition in total nitrogen (N). Increases in N have been found to promote invasions of fast-growing annual grasses (e.g., cheatgrass) and exotic species (e.g., Russian thistle) at the expense of native species. These exotic plants, in turn, can increase the fire risk throughout an infested area. While management actions cannot necessarily impact the Monument's N levels, considering exotic plant management options, in light of increased N levels, may prove useful.

Geology and Riparian Habitat

Flooding is a concern regarding the potential loss of artifacts along the floodplain and riverbanks of the Little Bighorn River, and may require some type of stabilization. Channel migration is another potential threat to imbedded artifacts along the streambed. The Monument may want to consider an inventory of oxbows and other channel migration features. Such an inventory could provide more information about how the river morphology has changed following the 1876 battle, and perhaps even over a longer timescale (Pleistocene or Holocene). Remapping of the river channel, or comparison of aerial photographs following the 2011 flooding could provide information regarding the record flood's impact on river morphology.

Soil erosion is exacerbated by "social trails" or paths that cut across the landscape. Management actions that maintain trails and keep people on developed trails, and discourage the use of social trails, will help minimize erosion impacts.

The National Monument may want to consider field-based paleontological resource inventories to determine if additional fossil resources are present within exposed bedrock of the park.

Stream Ecological Integrity

Several issues affect streams, including impacts from climate change, atmospheric deposition, altered hydrology, acid mine drainage, agriculture, pollution from boats, non-native species, erosion, improper sewage plant or drain field operations, and storm water runoff. Continued long-term monitoring of this resource will help management and resource staff address local and regional concerns.

Grasslands

The only real concern raised about the Monument's grasslands is exotic plant taxa. Half of the top 10 species with highest cover are exotic at the ROMN monitoring sites and are worth closely monitoring, especially with respect to observing changes related to climate conditions (for example, how do invasives appear to respond after drought conditions or wet springs?). The exotic annual bromes appear to be coexisting now (not displacing native vegetation) and there may not be a problem. However, if the system is shifted by some event, there is concern that the bromes may become dominant and lead to a significant shift in community structure and composition, and therefore transition to a lower functioning ecosystem.

Exotic Plants

Highly invasive exotic plants, including the annual bromes are widely distributed throughout the park. Their widespread distribution and invasiveness add to the difficulty of management. Some exotic plants have not been targeted for control, such as *Bromus arvensis* and *B. hordeaceus* but are found throughout most of the vegetation composition, structure, and soils monitoring sites. Exotic annual grasses can increase fire risk, which may be especially relevant during the drought.

Landbirds

The breeding landbird assessment in the NRCA is qualitative because there are no rigorously comparable data on breeding landbird status over time. In the future, if information on breeding landbirds is important for National Monument management, repeating either the 2012 RMBO survey or the Bock and Bock (2006) methods would provide a means to begin to evaluate landbird trends.

Monitoring habitat at the National Monument, especially the upland and riparian areas, provides information on bird habitat. Shrub cover, including sagebrush (*Artemesia tridentata*), is important for several of the NM's species of high conservation potential, including Brewer's Sparrow, Lark Sparrow, Lark Bunting, Grasshopper Sparrow, and Sharp-tailed Grouse (Birds of North America species accounts). Understanding the status of sagebrush and other woody species, such as Skunkbrush (*Rhus trilobata*) and Snowberry (*Symphiocarpus occidentalis*), provides some indication of habitat quality for these bird species.

The 1983 fire at the National Monument killed virtually all of the big sagebrush and was the single most dramatic consequence of the fire. The effects of fire on big sagebrush and other woody vegetation should be considered in managing fire if landbirds are an important management consideration for the National Monument. Similarly, since the richest habitat in the park for landbirds is the riparian bottomland (Bock and Bock 2006), fire should be carefully managed in (and likely excluded from) the riparian areas of the park.

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Appendix A: Team Members and Subject Matter Experts

Table A.1. Little Bighorn Battlefield National Monument NRCA Project Team Members

Little Bighorn Battlefield NM NRCA Project Team
Jeff Albright, NPS Water Resources Division's Coordinator of the NRCA Series
Rob Bennetts, NPS Southern Plains Inventory and Monitoring Network Program Manager
Mike Britten, NPS Rocky Mountain Inventory and Monitoring Network Program Manager
Nina Chambers, Northern Rockies Conservation Cooperative, Writer/Editor
Tomye Folts-Zettner, NPS Southern Plains Inventory and Monitoring Network Biologist
Kate Hammond, NPS Little Bighorn Battlefield Superintendent (Former)
Donna Shorrock, NPS Rocky Mountain Inventory and Monitoring Network Ecologist (Former), now NPS Intermountain Region Natural Resource Condition Assessment Regional Coordinator
Heidi Sosinski, NPS Southern Plains Inventory and Monitoring Network Data Manager
Melena Stichman, NPS Little Bighorn Battlefield Biological Science Technician (Former)
Kim Struthers, Utah State University, Writer/Editor
Denice Swanke, NPS Little Bighorn Battlefield Superintendent
Patty Valentine-Darby, University of West Florida, Biologist and Writer/Editor
Christopher Ziegler, NPS Little Bighorn Battlefield Chief of Cultural and Natural Resources Management

Table A.2. Little Bighorn Battlefield NM NRCA Subject Matter Experts and Reviewers

Subject Matter Expert	Topic	Project Deliverables
Jeff Albright, National Park Service Water Resources Division, Natural Resource Condition Assessment Series Coordinator	All	Program level review
Donna Shorrock, National Park Service Intermountain Region Natural Resource Condition Assessment Regional Coordinator	All	Program level review
Crow Tribe	All	Tribal Consultation on October 15, 2014
Melanie Myers, Colorado State University GIS Analayst	Viewshed	Viewshed analyses
Jordan Hoaglund, National Park Service Denver Service Center Community Planner	Viewshed	Provided original viewshed analyses for the Monument
Mark Meyer, National Park Service Air Resources Division, Renewable Energy Visual Resource Specialist	Viewshed	Reviewed viewshed section
Chad Moore, National Park Service Night Sky Program Manager	Night Sky	Provided NPS guidance on night sky monitoring and review of night sky section
Lynn Powers, Southwest Montana Astronomical Society President	Night Sky	Assisted in the night sky rapid assessment at Little Bighorn Battlefield National Monument
Emma Lynch, National Park Service Natural Sounds and Night Skies Division, Acoustical Resource Specialist	Soundscape	Provided natural sounds NRCA template for parks who have not had on-site acoustical monitoring conducted
Ellen Porter, National Park Service Air Resources Division	Air Quality	Reviewed air quality section
Bruce Heise, National Park Service Geologic Resources Division Geologist and Program Administrator, Geologic Resources Inventory	Geology	Reviewed geology section

Table A.2. **Little Bighorn Battlefield NM *NRCA Subject Matter Experts (cont.)***

Subject Matter Expert	Topic	Project Deliverables
William Schweiger, National Park Service Rocky Mountain Inventory and Monitoring Network Ecologist	Stream Ecological Integrity	Reviewed stream ecological integrity section
Mike Martin, National Park Service Water Resources Division, Hydrologist	Riparian Habitat	Provided expert assessment and trip report for riparian habitat during June 2012 field visit. Reviewed riparian habitat section.
Joel Wagner, National Park Service Water Resources Division, Wetlands Program Leader	Riparian Habitat	Provided expert assessment for riparian habitat during June 2012 field visit
Jalyn Cummings, National Park Service Water Resources Division, Hydrologist	Riparian Habitat	Provided expert assessment for riparian habitat during June 2012 field visit
Alan Knapp, Colorado State University Department of Biology Professor	Grasslands	Provided expert assessment for grasslands during June 2012 field visit
Tim Seastedt, University of Colorado, Department of Ecology and Evolutionary Biology Professor	Grasslands	Provided expert assessment for grasslands during June 2012 field visit. Provided grasslands review.
Myron Chase, National Park Service Intermountain Region Integrated Pest Management Biologist	Exotic Plants	Provided exotic plants review
Mark Strum, National Park Service Intermountain Region Branch Chief of Biological Resources	Exotic Plants	Provided exotic plants review
Nick Van Lanen, Rocky Mountain Bird Observatory Wildlife Biologist	Breeding Landbirds	Conducted the 2012 field sampling/analysis and prepared the report on which much of the NRCA chapter is based
David Hanni, Rocky Mountain Bird Observatory Wildlife Biologist	Breeding Landbirds	Conducted the 2012 field sampling/analysis and prepared the report on which much of the NRCA chapter is based
Authors Who Served as Subject Matter Experts	Topic	Project Deliverables
Mike Britten, National Park Service Rocky Mountain Inventory and Monitoring Network Program Manager	Riparian Habitat, Grasslands, and Breeding Landbirds	Provided expert assessment for riparian habitat, grasslands, and breeding landbirds during June 2012 field visit
Donna Shorrock, National Park Service Rocky Mountain Inventory and Monitoring Network Ecologist (former)	Grasslands and Exotic Plants	Provided expert assessment for grasslands during June 2012 field visit and provided expert opinion for exotic plants
Heidi Sosinski, National Park Service Southern Plains Inventory and Monitoring Network Data Manager	Viewshed	Viewshed analyses

Appendix B: Viewshed Analysis Steps

The process Melanie Myers and Heidi Sosinski used to complete the Little Bighorn Battlefield NM's viewshed analyses is listed below.

Downloaded spatial data from Internet.

Downloaded 1/3 arc second national elevation dataset (NED) grid (roughly equivalent to a 30 m digital elevation model [DEM]) from The National Map Seamless Server (http://seamless.usgs.gov/). The x and y values for the NED are in arc seconds while the z data are in meters. Projected NED into NAD83 UTM 13 to get all data in meters.

Downloaded Little Bighorn Battlefield National Monument boundary, roads, and trails layers from NPS Integrated Resource Management Applications (IRMA) portal (https://irma.nps.gov).

Prepared Observation Point layers for Viewshed Analyses.

Created point layers for entrance and upper parking lot.

Used Edit > Create New Feature tool to create an observation points (the Overlook). Saved file as obs_point.shp

Added field named "OFFSETA" (type = double) to shapefile and set value to 1.68 for each record in the attribute table. The value of 1.68 in the field "OFFSETA" represents an observer height of 1.68m (~5'6").

Initial analysis showed that using the default observer value in OFFSETA underestimated the visible area when compared to actual visibility on site. To account for this, an additonal offset of 10m was added to all analysis.

Added field named "OFFSETB (type = double) and set the value to 10. The value of 10 in the field "OFFSETB" represents the addtional 10 meters needed to reflect actual visibility.

Ran Viewshed Analysis using ESRI Spatial Analyst Viewshed Tool.

Using the Viewshed Tool in ESRI's ArcGIS 10, Spatial Analyst Toolbox, ran viewsheds using the following inputs.

Input raster = 1/3 arc second NED.

Input point observer feature = obs_point.shp.

After the viewshed analyses were complete, housing and road density data were obtained and modified to depict past, present, and future densities around the Monument. These datasets were created by the NPS's Natural Resource Program Center by compiling and analyzing landscape-scale US Census Bureau data that linked measurable attributes of landscape (i.e., road density, population and housing density, etc.) to resources within natural resource based parks. This resulted in the creation of a dataset titled NPScape (Budde et al. 2009; Gross et al. 2009). The following modifications were made to NPScape data for purposes of this assessment:

Table B.1. The original classes from NPScape and new classes assigned to housing densities for this assessment of the viewshed at Little Bighorn Battlefield NM

<table>
<tr><th>Original Class</th><th>New Class</th></tr>
<tr><td>Private undeveloped</td><td>Private undeveloped</td></tr>
<tr><td><1.5 units/square km</td><td><1.5 units/square km</td></tr>
<tr><td>1.5–3 units/square km</td><td rowspan="2">1.5–6 units/square km</td></tr>
<tr><td>4–6 units/square km</td></tr>
<tr><td>7–12 units/square km</td><td rowspan="6">> 6 units / square km</td></tr>
<tr><td>13–24 units/square km</td></tr>
<tr><td>25–49 units/square km</td></tr>
<tr><td>50–145 units/square km</td></tr>
<tr><td>146–494 units/square km</td></tr>
<tr><td>495–1234 units/square km</td></tr>
<tr><td>Commercial / Industrial</td><td>Commercial / Industrial</td></tr>
</table>

Downloaded spatial data from Internet.

Downloaded Monument-specific NPScape data from the NPScape website (http://science.nature.nps.gov/im/monitor/npscape/index.cfm).

Simplified NPScape Housing Density Projections.

Converted Little Bighorn Battlefield NM 30 km housing density projection rasters to polygon shape files.

Combined classes to reduce number of original classes to five (Table B.1).

Appendix C: Bortle Dark-Sky Scale

Key for the Summer Sky— Latitudes 30° to 50° N

The Milky Way is not visible and sky glow extends above 35 degrees. Little to no dark adaptation is possible. Ground texture is easily seen, and artificial light dominates the landscape. Visible constellations are limited to the very brightest if any. The sky has a uniform washed out appearance.[1]

If this describes your nighttime environment, continue below

If the nighttime environment appears darker than this description, jump to the next section

Sky appears nearly completely washed out, and is luminous. Dark adaptation is not possible, ground is brightly illuminated and fewer than 200 stars are visible. Only the most major constellations are identifiable. For instance, the entire keystone of Hercules or the five stars of Delphinus are not completely visible.

this is accurate → **Bortle Class 9** — if darker—proceed below

Constellations are visible but may be missing key stars, sky background has a uniform washed out glow with light domes reaching 60 degrees above the horizon. Stars such as the tip of Sagitta or epsilon Lyrae are not visible. If clouds are present they are brilliantly lit.

this is accurate → **Bortle Class 8** — if darker—proceed below

Brighter constellations are easily seen in full, yet sky background has greyish or yellow background. Milky Way may be just barely seen near the zenith. The Scutum and Cygnus star clouds are not visible.If clouds are present they are brilliantly lit. Ground texture is still visible.

this is accurate → **Bortle Class 7**

The Milky Way is visible but discontinuous, and lost to light domes near the horizon. Fine details and structure are not easily visible, if at all. Ground texture is still visible, and shadows are cast from light pollution. Light domes are clearly visible along the horizon and appear brighter than any portion of the visible Milky Way.[2]

If this describes your nighttime environment, continue below

If the nighttime environment appears darker than this description, jump to the next section

The Milky Way is just visible overhead, but is not continuous and is diminished to obvious skyglow. Cygnus ,Scutum, and Sagittarius star fields just visible. If clouds present they are illuminated and reflecting light. Ground texture is seen with difficulty.

this is accurate → **Bortle Class 6** — if darker—proceed below

Milky Way is faintly present, but may have occasional gaps and is lost to skyglow near the horizon. Great rift in Cygnus is just visible. Any clouds present are brighter than the background sky and reflect light back. Zodiacal light may be glimpsed, but is difficult to see amidst the light pollution. Ground texture is not visible but forms are easily seen.

this is accurate → **Bortle Class 5** — if darker—proceed below

Milky Way is evident from horizon to horizon, but fine details are lost. Clouds are just brighter than background sky, but appear dark at zenith. Light domes are much brighter than brightest part of Milky Way and extend to up to 15 degrees above the horizon. Zodiacal light is evident in west after sunset or in east before dawn. Deep sky objects such as the M13 globular cluster and Northern Coal Sac are visible.

this is accurate ▶ **Bortle Class 4**

The Milky Way has a defined outline with visible structure and detail. Very few light domes are visible just along the horizon and do not cast shadows. You may see color in the Zodical light when compared to bluish-white color of the Milky Way. Scattered clouds appear dark against the night sky except those clouds just above light domes.[3]

If this describes your nighttime environment, continue below

Milky Way appears complex with visible outline, however some light pollution is still evident along the horizon. Light domes only slightly brighter than brightest part of the Milky Way. Zodiacal light easily seen, but band and gegenschein difficult or absent. Many summer globular clusters and emission nebulae are visible with the naked eye despite distracting light domes along the horizon. Venus casts an obvious shadow.

this is accurate ▶ **Bortle Class 3** — if darker—proceed below

Very few light domes are visible; with none extending above 5 degrees and fainter than the Milky Way. Airglow is often visible, and character in its brightness may be seen. Ground is mostly dark. The Zodiacal band (away from the Milky Way and at least 45 degrees above the horizon) and gegenschein are visible. The rift in the Cygnus star cloud is visible. The Prancing Horse in Sagittarius and Fingers of Ophiuchus dark nebulae are visible, extending to Antares. Jupiter and Milky Way cast barely visible shadows.

this is accurate ▶ **Bortle Class 2** — if darker—proceed below

The Milky Way is intricate, marbled, and veined with Sagittarius region of the Milky Way casting obvious shadows. Milky Way appears 40 degrees wide in some parts with a convoluted outline. The horizon completely free of light domes, though some distant light domes may be visible from mountain tops. Transparency and seeing are excellent (among the best of the year) with very low airglow. Many objects such as M81 or the Helix nebula are visible with the naked eye. Zodical light is striking as a complete band. Any clouds are very difficult to see.

this is accurate ▶ **Bortle Class 1**

The Bortle Dark-Sky Scale is a qualitative scale developed by John Bortle and published in Sky & Telescope Magaine in 2001. It provides a useful complement to quantitative measures. The National Park Service is testing this dichotomous key for use by professional and citizen scientists. Some knowledge of the night sky and visual observational techniques are required to properly implement this assessment.

note 1) At least 5 minutes of dark adaptation is required to properly differentiate Class 7,8 & 9 skies.

note 2) At least 10 minutes of dark adaptation is required to properly differentiate Class 4, 5 & 6 skies.

note 3) 20 to 120 minutes of dark adaptation is required to properly differentiate Class 1, 2 & 3 skies.

Developed by Jeremy White, Dan Duriscoe, and Chad Moore of the NPS Natural Sounds & Night Skies Division, www.nature.nps.gov/night

August 2, 2012

Appendix D: Local Scale Species Composition

Scientific Name	Common Name	Nativity	Growth Habit	Duration	Listed in Ecological Site Description
Achillea millefolium var. occidentalis	western yarrow	Native	Forb/herb	Perennial	
Achnatherum hymenoides	Indian ricegrass	Native	Graminoid	Perennial	● (red)
Agropyron cristatum	crested wheatgrass	Non-Native	Graminoid	Perennial	
Allium cernuum	nodding onion	Native	Forb/herb	Perennial	● (orange)
Allium textile	textile onion	Native	Forb/herb	Perennial	● (orange)
Alyssum alyssoides	pale madwort	Non-Native	Forb/herb	Annual, Biennial	
Amelanchier alnifolia	Saskatoon serviceberry	Native	Tree, Shrub	Perennial	
Anaphalis margaritacea	western pearly everlasting	Native	Forb/herb	Perennial	
Androsace occidentalis	western rockjasmine	Native	Forb/herb	Annual	
Androsace septentrionalis	pygmyflower rockjasmine	Native	Forb/herb	Annual, Perennial	
Antennaria corymbosa	flat-top pussytoes	Native	Forb/herb	Perennial	● (orange)
Antennaria parvifolia	small-leaf pussytoes	Native	Forb/herb	Perennial	● (orange)
Antennaria rosea	rosy pussytoes	Native	Forb/herb	Perennial	● (orange)
Arenaria capillaris	slender mountain sandwort	Native	Subshrub, Forb/herb	Perennial	
Arenaria serpyllifolia	thymeleaf sandwort	Non-Native	Forb/herb	Annual	
Arnica sororia	twin arnica	Native	Forb/herb	Perennial	
Artemisia campestris	field sagewort	Native	Forb/herb	Biennial, Perennial	
Artemisia cana	silver sagebrush	Native	Subshrub, Shrub	Perennial	● (blue)
Artemisia frigida	prairie sagewort	Native	Subshrub	Perennial	● (blue)
Artemisia ludoviciana	white sagebrush	Native	Subshrub, Forb/herb	Perennial	
Artemisia tridentata	big sagebrush	Native	Tree, Shrub	Perennial	● (blue)
Astragalus agrestis	purple milkvetch	Native	Forb/herb	Perennial	● (orange)
Astragalus atropubescens	hangingpod milkvetch	Native	Forb/herb	Perennial	● (orange)
Astragalus australis	Indian milkvetch	Native	Forb/herb	Perennial	● (orange)
Astragalus crassicarpus	groundplum milkvetch	Native	Forb/herb	Perennial	● (orange)
Astragalus drummondii	Drummond's milkvetch	Native	Forb/herb	Perennial	● (orange)
Astragalus falcatus	Russian milkvetch	Non-Native	Forb/herb	Perennial	● (orange)
Besseya wyomingensis	Wyoming besseya	Native	Forb/herb	Perennial	
Bouteloua curtipendula	sideoats grama	Native	Graminoid	Perennial	● (red)
Bouteloua gracilis	blue grama	Native	Graminoid	Perennial	● (orange)
Bromus arvensis	field brome	Non-Native	Graminoid	Annual	
Bromus hordeaceus	soft brome	Non-Native	Graminoid	Annual	
Bromus inermis	smooth brome	Non-Native	Graminoid	Perennial	
Bromus tectorum	cheatgrass	Non-Native	Graminoid	Annual	
Calamovilfa longifolia	prairie sandreed	Native	Graminoid	Perennial	
Calochortus nuttallii	sego lily	Native	Forb/herb	Perennial	
Camelina microcarpa	littlepod false flax	Non-Native	Forb/herb	Annual, Biennial	

● (red) = Listed in ESD R058E002MT ● (orange) = Listed in ESD R058E199MT ● (blue) = Listed in both ESD's

Scientific Name	Common Name	Nativity	Growth Habit	Duration	Listed in Ecological Site Description
Carex douglasii	Douglas' sedge	Native	Graminoid	Perennial	
Carex filifolia	threadleaf sedge	Native	Graminoid	Perennial	● (orange)
Castilleja sessiliflora	downy paintedcup	Native	Subshrub, Forb/herb	Perennial	
Cerastium arvense	field chickweed	Native	Forb/herb	Perennial	
Cerastium fontanum	common mouse-ear chickweed	Non-Native	Forb/herb	Biennial, Perennial	
Cerastium nutans	nodding chickweed	Native	Forb/herb	Annual, Perennial	
Chaenactis douglasii	Douglas' dustymaiden	Native	Forb/herb	Biennial, Perennial	
Cirsium arvense	Canada thistle	Non-Native	Forb/herb	Perennial	
Cirsium undulatum	wavyleaf thistle	Native	Forb/herb	Biennial, Perennial	
Clematis ligusticifolia	western white clematis	Native	Vine	Perennial	
Collomia linearis	tiny trumpet	Native	Forb/herb	Annual	
Comandra umbellata	bastard toadflax	Native	Subshrub, Forb/herb	Perennial	
Convolvulus arvensis	field bindweed	Non-Native	Vine, Forb/herb	Perennial	
Crepis acuminata	tapertip hawksbeard	Native	Forb/herb	Perennial	
Crepis occidentalis	largeflower hawksbeard	Native	Forb/herb	Annual, Perennial	
Cryptantha torreyana	Torrey's cryptantha	Native	Forb/herb	Annual	
Dalea candida	white prairie clover	Native	Subshrub, Forb/herb	Perennial	● (orange)
Dalea purpurea	purple prairie clover	Native	Subshrub, Forb/herb	Perennial	● (orange)
Descurainia sophia	herb sophia	Non-Native	Forb/herb	Annual, Biennial	
Dianthus armeria	Deptford pink	Non-Native	Forb/herb	Annual, Biennial	
Draba brachycarpa	shortpod draba	Native	Forb/herb	Annual	
Draba nemorosa	woodland draba	Non-Native	Forb/herb	Annual	
Draba reptans	Carolina draba	Native	Forb/herb	Annual	
Echinacea angustifolia	blacksamson echinacea	Native	Forb/herb	Perennial	● (orange)
Echinocereus viridiflorus	nylon hedgehog cactus	Native	Shrub	Perennial	
Eleocharis macrostachya	pale spikerush	Native	Graminoid	Perennial	
Elymus lanceolatus	thickspike wheatgrass	Native	Graminoid	Perennial	
Epilobium brachycarpum	tall annual willowherb	Native	Forb/herb	Annual	
Ericameria nauseosa	rubber rabbitbrush	Native	Shrub, Subshrub	Perennial	● (orange)
Erigeron caespitosus	tufted fleabane	Native	Forb/herb	Perennial	
Erigeron ochroleucus var. scribneri	buff fleabane	Native	Forb	Perennial	
Erigeron pumilus	shaggy fleabane	Native	Forb/herb	Perennial	
Eriogonum pauciflorum	fewflower buckwheat	Native	Subshrub, Forb/herb	Perennial	● (red)
Escobaria missouriensis	Missouri foxtail cactus	Native	Shrub	Perennial	
Euphorbia spathulata	warty spurge	Native	Forb/herb	Annual, Perennial	
Festuca idahoensis	Idaho fescue	Native	Graminoid	Perennial	
Galium aparine	stickywilly	Native	Vine, Forb/herb	Annual	

● (red) = Listed in ESD R058E002MT ● (orange) = Listed in ESD R058E199MT ● (blue) = Listed in both ESD's

Scientific Name	Common Name	Nativity	Growth Habit	Duration	Listed in Ecological Site Description
Gaura coccinea	scarlet beeblossom	Native	Subshrub, Forb/herb	Perennial	
Gayophytum humile	dwarf groundsmoke	Native	Forb/herb	Annual	
Geum triflorum	old man's whiskers	Native	Forb/herb	Perennial	
Gutierrezia sarothrae	broom snakeweed	Native	Subshrub, Shrub, Forb/herb	Perennial	● (orange)
Hedeoma hispida	rough false pennyroyal	Native	Forb/herb	Annual	
Helianthella quinquenervis	fivenerve helianthella	Native	Forb/herb	Perennial	
Hesperostipa comata	needle and thread	Native	Graminoid	Perennial	● (orange)
Heterotheca villosa	hairy false goldenaster	Native	Subshrub, Forb/herb	Perennial	● (red)
Holosteum umbellatum	jagged chickweed	Non-Native	Forb/herb	Annual	
Juniperus scopulorum	Rocky Mountain juniper	Native	Tree, Shrub	Perennial	
Koeleria macrantha	prairie Junegrass	Native	Graminoid	Perennial	● (orange)
Lactuca serriola	prickly lettuce	Non-Native	Forb/herb	Annual, Biennial	
Lactuca tatarica	blue lettuce	Native	Forb/herb	Biennial, Perennial	
Lappula occidentalis	flatspine stickseed	Native	Forb/herb	Annual, Biennial	
Lappula squarrosa	European stickseed	Non-Native	Forb/herb	Annual, Biennial	
Lepidium perfoliatum	clasping pepperweed	Non-Native	Forb/herb	Annual, Biennial	
Lesquerella alpina	alpine bladderpod	Native	Forb/herb	Perennial	
Lesquerella montana	mountain bladderpod	Native	Forb/herb	Perennial	
Leucocrinum montanum	common starlily	Native	Forb/herb	Perennial	
Linum lewisii	Lewis flax	Native	Subshrub, Forb/herb	Perennial	
Linum rigidum	stiffstem flax	Native	Forb/herb	Annual, Perennial	
Lithospermum incisum	narrowleaf stoneseed	Native	Forb/herb	Perennial	
Lithospermum ruderale	western stoneseed	Native	Forb/herb	Perennial	
Logfia arvensis	field cottonrose	Non-Native	Forb/herb	Annual	
Lomatium dissectum	fernleaf biscuitroot	Native	Forb/herb	Perennial	● (red)
Lomatium nuttallii	Nuttall's biscuitroot	Native	Forb/herb	Perennial	● (red)
Lupinus argenteus	silvery lupine	Native	Subshrub, Forb/herb	Perennial	
Lygodesmia juncea	rush skeletonplant	Native	Forb/herb	Perennial	
Maianthemum stellatum	starry false lily of the valley	Native	Forb/herb	Perennial	
Medicago lupulina	black medick	Non-Native	Forb/herb	Annual, Perennial	
Medicago sativa	alfalfa	Non-Native	Forb/herb	Annual, Perennial	
Melilotus officinalis	sweetclover	Non-Native	Forb/herb	Annual, Biennial, Perennial	
Mertensia longiflora	small bluebells	Native	Forb/herb	Perennial	
Mertensia oblongifolia	oblongleaf bluebells	Native	Forb/herb	Annual, Perennial	
Microseris nutans	nodding microseris	Native	Forb/herb	Perennial	
Musineon divaricatum	leafy wildparsley	Native	Forb/herb	Perennial	● (blue)
Myosotis stricta	strict forget-me-not	Non-Native	Forb/herb	Annual	
Nassella viridula	green needlegrass	Native	Graminoid	Perennial	● (orange)

● (red) = Listed in ESD R058E002MT ● (orange) = Listed in ESD R058E199MT ● (blue) = Listed in both ESD's

Scientific Name	Common Name	Nativity	Growth Habit	Duration	Listed in Ecological Site Description
Opuntia fragilis	brittle pricklypear	Native	Shrub	Perennial	
Opuntia polyacantha	plains pricklypear	Native	Shrub	Perennial	● (orange)
Parietaria pensylvanica	Pennsylvania pellitory	Native	Forb/herb	Annual	
Pascopyrum smithii	western wheatgrass	Native	Graminoid	Perennial	● (orange)
Pediomelum argophyllum	silverleaf Indian breadroot	Native	Forb/herb	Perennial	
Pediomelum esculentum	large Indian breadroot	Native	Forb/herb	Perennial	
Penstemon nitidus	waxleaf penstemon	Native	Subshrub, Forb/herb	Perennial	● (red)
Phacelia linearis	threadleaf phacelia	Native	Forb/herb	Annual	
Phlox hoodii	spiny phlox	Native	Forb/herb	Perennial	● (orange)
Plantago elongata	prairie plantain	Native	Forb/herb	Annual	
Plantago patagonica	woolly plantain	Native	Forb/herb	Annual	
Poa bulbosa	bulbous bluegrass	Non-Native	Graminoid	Perennial	
Poa compressa	Canada bluegrass	Non-Native	Graminoid	Perennial	
Poa palustris	fowl bluegrass	Native	Graminoid	Perennial	
Poa pratensis	Kentucky bluegrass	Non-Native	Graminoid	Perennial	
Poa secunda	Sandberg bluegrass	Native	Graminoid	Perennial	● (orange)
Prunella vulgaris	common selfheal	Native	Forb/herb	Perennial	
Prunus virginiana	chokecherry	Native	Tree, Shrub	Perennial	
Pseudoroegneria spicata	bluebunch wheatgrass	Native	Graminoid	Perennial	● (orange)
Psoralidium tenuiflorum	slimflower scurfpea	Native	Forb/herb	Perennial	● (orange)
Rhus trilobata	skunkbush sumac	Native	Shrub	Perennial	● (red)
Rosa arkansana	prairie rose	Native	Subshrub	Perennial	● (red)
Rosa woodsii	Woods' rose	Native	Subshrub	Perennial	
Sarcobatus vermiculatus	greasewood	Native	Shrub	Perennial	● (orange)
Silene antirrhina	sleepy silene	Native	Forb/herb	Annual	
Silene conoidea	weed silene	Non-Native	Forb/herb	Annual	
Silene menziesii	Menzies' campion	Native	Forb/herb	Perennial	
Silene oregana	Oregon silene	Native	Forb/herb	Perennial	
Sisymbrium altissimum	tall tumblemustard	Non-Native	Forb/herb	Annual, Biennial	
Sphaeralcea coccinea	scarlet globemallow	Native	Subshrub, Forb/herb	Biennial, Perennial	● (orange)
Sporobolus airoides	alkali sacaton	Native	Graminoid	Perennial	● (blue)
Symphoricarpos occidentalis	western snowberry	Native	Shrub	Perennial	
Symphyotrichum ericoides	white heath aster	Native	Forb/herb	Perennial	
Symphyotrichum falcatum	white prairie aster	Native	Forb/herb	Perennial	
Symphyotrichum subspicatum	Douglas aster	Native	Forb/herb	Perennial	
Taraxacum officinale	common dandelion	Non-Native	Forb/herb	Perennial	
Thermopsis rhombifolia	prairie thermopsis	Native	Forb/herb	Perennial	● (red)
Thinopyrum intermedium	intermediate wheatgrass	Non-Native	Graminoid	Perennial	
Thlaspi arvense	field pennycress	Non-Native	Forb/herb	Annual	

● (red) = Listed in ESD R058E002MT ● (orange) = Listed in ESD R058E199MT ● (blue) = Listed in both ESD's

Scientific Name	Common Name	Nativity	Growth Habit	Duration	Listed in Ecological Site Description
Toxicodendron rydbergii	western poison ivy	Native	Shrub, Forb/herb, Subshrub, Vine	Perennial	
Tradescantia bracteata	longbract spiderwort	Native	Forb/herb	Perennial	
Tragopogon dubius	yellow salsify	Non-Native	Forb/herb	Annual, Biennial	
Trifolium aureum	golden clover	Non-Native	Forb/herb	Annual, Biennial	
Veronica americana	American speedwell	Native	Forb/herb	Perennial	
Veronica arvensis	corn speedwell	Non-Native	Forb/herb	Annual	
Veronica peregrina	neckweed	Native	Forb/herb	Annual	
Vicia americana	American vetch	Native	Vine, Forb/herb	Perennial	●
Viola nuttallii	Nuttall's violet	Native	Forb/herb	Perennial	
Yucca glauca	soapweed yucca	Native	Subshrub, Shrub, Forb/herb	Perennial	
Zigadenus elegans	mountain deathcamas	Native	Forb/herb	Perennial	●
Zigadenus venenosus	meadow deathcamas	Native	Forb/herb	Perennial	●

● = Listed in ESD R058E002MT ● = Listed in ESD R058E199MT ● = Listed in both ESD's

Appendix E: Comprehensive List of Exotic Plant Species at Little Bighorn Battlefield NM

Scientific Name[1]	Common Name[1]	Simonson 2001	Wood and Rew 2005	Bock and Bock 2006	NPS 2007	Lehnhoff and Lawrence 2010	NPS 2010	Shorrock et al. 2010 and unpub. 2010-2012 Data	Rice et al. 2012	Waldhart 2012	Schweiger et al. 2012	Martin et al. 2012	Certified NPSpecies List 2013
Acroptilon repens/ Centaurea repens	Russian knapweed		•	•		•	•						•
Agropyron cristatum (desertorum)	Crested wheatgrass			•	•		•	•					•
Agrostis gigantea	Redtop				•								•
Agrostis hyemalis	Ticklegrass			•									
Alyssum alyssoides	Field pennycress	•		•	•			•	•				•
Alyssum desertorum	Desert madwort			•	•				•				•
Arenaria serpyllifolia	Thymeleaf sandwort							•					
Amaranthus retroflexus	Pigweed								•				
Asparagus officinalis	Asparagus												•
Astragalus falcatus	Russian milkvetch							•					
Berteroa incana	Hoary false madwort	•			•	•	•						•
Bromus arvensis (japonicus)	Field brome							•					
Bromus hordeaceus	Soft brome	•		•				•	•				•
Bromus inermis	Smooth brome	•		•	•	•	•	•	•				•
Bromus japonicus	Japanese brome	•		•	•	•			•				•
Bromus secalinus	Rye brome	•		•									
Bromus tectorum	Cheatgrass	•	•	•	•	•	•	•	•				•
Camelina microcarpa	Littlepod false flax							•	•				•
Cardaria draba	Hoary cress/Whitetop		•			•	•						•
Centaurea stoebe (biebersteinii)	Spotted knapweed		•			•	•						•
Cerastium fontanum	Common mouse-ear chickweed							•					
Chenopodium album	Lambsquarters			•	•				•				•
Cichorium intybus	Chicory	•		•	•								•
Cirsium arvense	Canada thistle	•	•	•	•	•	•	•	•		•		•
Cirsium vulgare	Bull thistle		•			•	•		•				•
Convolvulus arvensis	Field Bindweed	•	•	•		•	•	•	•				•
Cynoglossum officinale	Houndstongue		•			•	•						•
Descurainia sophia	Herb sophia	•		•	•		•	•	•				•
Dianthus armeria	Deptford pink							•					
Dipsacus	Teasel								•				
Draba nemorosa	Woodland draba							•					
Elaeagnus angustifolia	Russian olive		•	•	•	•	•				•	•	•
Elymus repens	Quackgrass				•								•
Eragrostis cilianensis	Stinkgrass						•						

Species listed in red text are the high priority species identified by Little Bighorn Battlefield NM and ROMN staff and listed in Table 4.10.2-1.

Scientific Name[1]	Common Name[1]	Simonson 2001	Wood and Rew 2005	Bock and Bock 2006	NPS 2007	Lehnhoff and Lawrence 2010	NPS 2010	Shorrock et al. 2010 and unpub. 2010-2012 Data	Rice et al. 2012	Waldhart 2012	Schweiger et al. 2012	Martin et al. 2012	Certified NPSpecies List 2013
Euphorbia esula	Leafy spurge	•		•	•								•
Festuca pratense	Meadown Fescue			•									
Fraxinus pennsylvanica	Green ash				•							•	
Halogeton glomeratus	Saltlover		•										•
Herperis matronalis	Dame's rocket									•			
Holosteum umbellatum	Jagged chickweed							•					
Hypericum perforatum	St. Johnswort		•	•	•	•	•						•
Kochia scoparia	Kochia						•						
Lactuca serriola	Prickly lettuce	•		•	•			•	•				•
Lactuca tatarica	Blue lettuce				•								
Lappula squarrosa	European stickseed							•					
Lepidium perfoliatum	Clasping pepperweed			•	•		•	•	•				•
Linaria dalmatica	Dalmatian toadflax		•	•	•	•	•						•
Logfia arvensis	Field cottonrose							•					
Lolium pratense	Meadow fescue												•
Lonicera tatarica	Tatarian honeysuckle			•			•						•
Medicago lupulina	Black medic clover	•			•			•					•
Medicago sativa	Alfalfa			•			•	•					•
Melilotus officinalis	Yellow Sweetclover	•	•	•	•	•		•	•				•
Mentha arvensis	Field mint				•								
Myosotis stricta	Strict forget-me-not							•					
Phleum pratense	Timothy	•			•								•
Poa bulbosa	Bulbous bluegrass			•	•	•	•	•					•
Poa compressa	Canada bluegrass				•			•					•
Poa juncifolia	Alkali Bluegrass			•									•
Poa pratensis	Kentucky bluegrass	•		•	•			•	•				
Potentilla recta	Sulphur cinquefoil					•							
Rheum rhabarbarum	Garden rhubarb	•		•	•		•						•
Rumex crispus	Curly dock			•	•		•		•				•
Salsola tragus (kali, iberica)	Prickly Russian thistle	•	•	•	•	•	•						•
Silene conoidea	Weed silene	•		•	•			•					•
Sisymbrium altissimum	Tall tumblemustard	•		•	•		•	•	•				•
Solanum nigrum	Black nightshade						•						•
Tamarix ramosissim a/ chinensis	Saltcedar						•				•	•	
Tanacetum vulgare	Tansy							•					
Taraxacum officinale	Dandelion	•		•	•		•	•	•				•
Thinopyrum intermedium	Intermediate wheatgrass							•					

Species listed in red text are the high priority species identified by Little Bighorn Battlefield NM and ROMN staff and listed in Table 4.10.2-1.

Scientific Name[1]	Common Name[1]	Simonson 2001	Wood and Rew 2005	Bock and Bock 2006	NPS 2007	Lehnhoff and Lawrence 2010	NPS 2010	Shorrock et al. 2010 and unpub. 2010-2012 Data	Rice et al. 2012	Waldhart 2012	Schweiger et al. 2012	Martin et al. 2012	Certified NPSpecies List 2013
Thlaspi arvense	Field pennycress	•		•	•				•				•
Tragopogon dubius	Western salsify	•		•	•	•		•	•				•
Trifolium aureum	Golden clover								•				
Triticum aestivum	Wheat			•	•								•
Veronica arvensis	Common speedwell							•	•				

Species listed in red text are the high priority species identified by Little Bighorn Battlefield NM and ROMN staff and listed in Table 4.10.2-1.

Note: Trifolium breweri is listed in the Monument's 2013 NPSpecies but has yet to be confirmed in Montana (Donna Shorrock, pers. comm., 4/12/13) so was not included in the comprehensive list of exotics.

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Appendix F: Maps of the Known Distribution of Exotic Plant Species

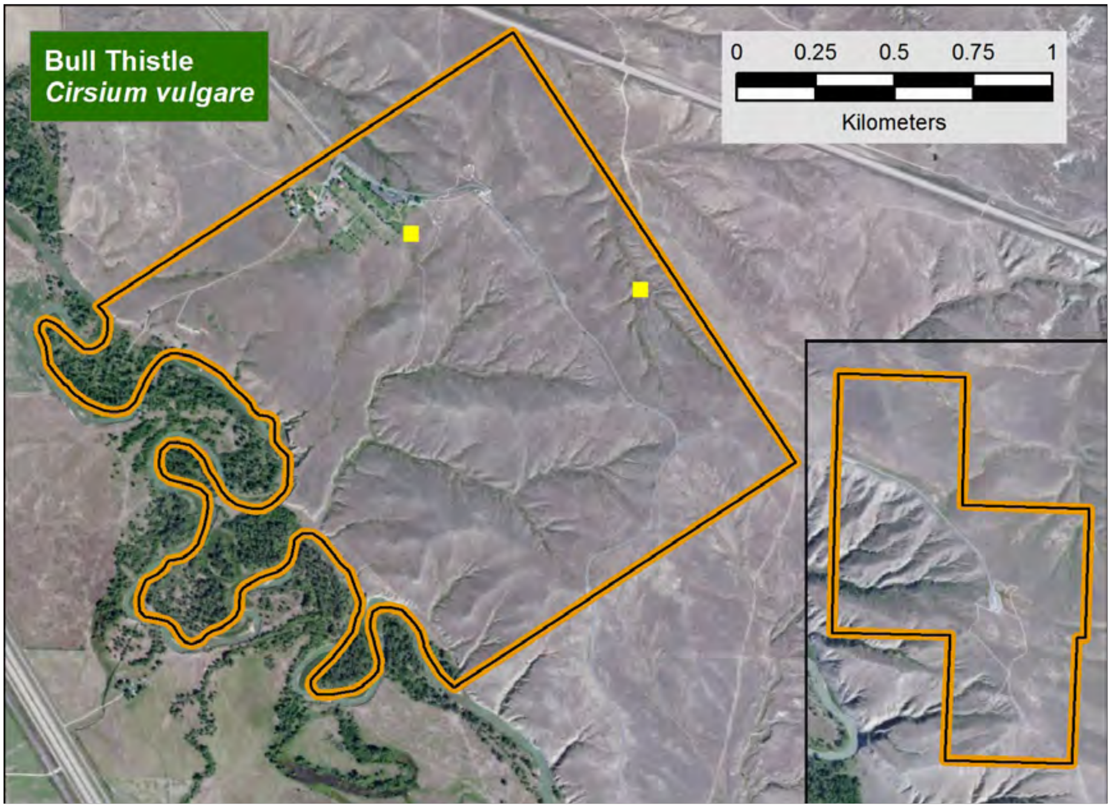

Figure F-1. Bull thistle (*Circium vulgare)*

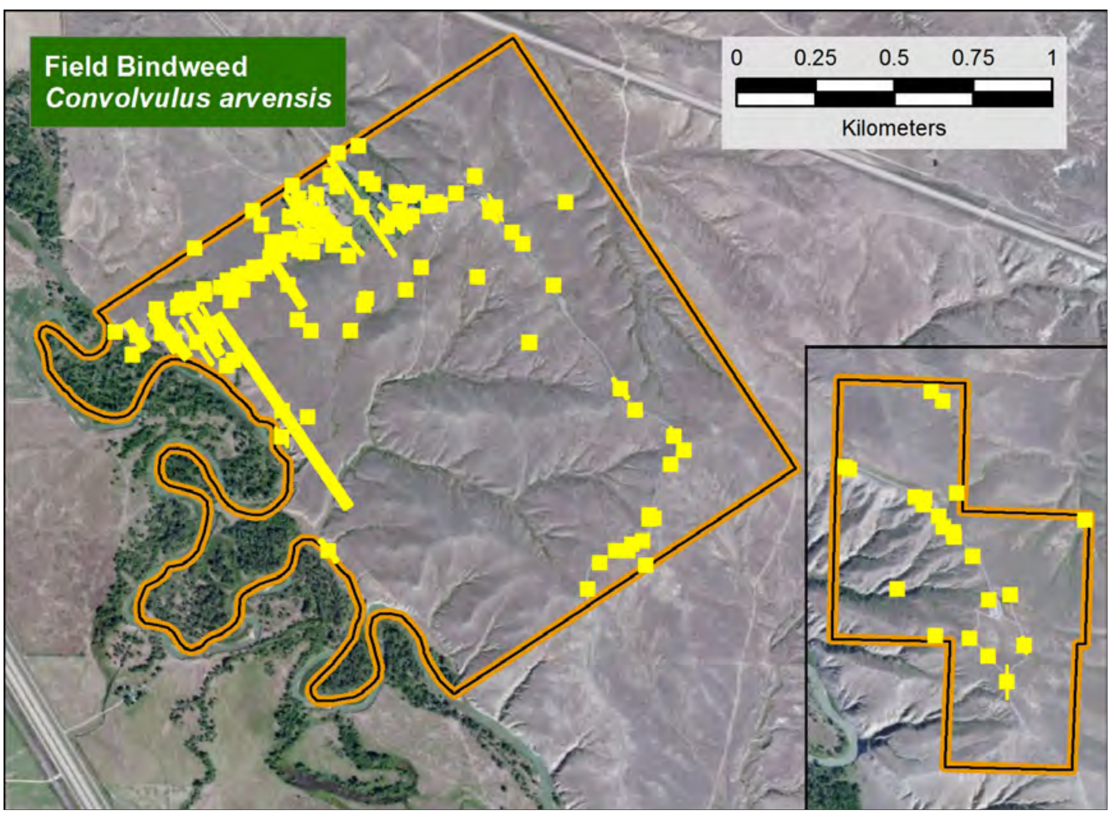

Figure F-2. Field bindweed (*Convolvulus arvensis)*

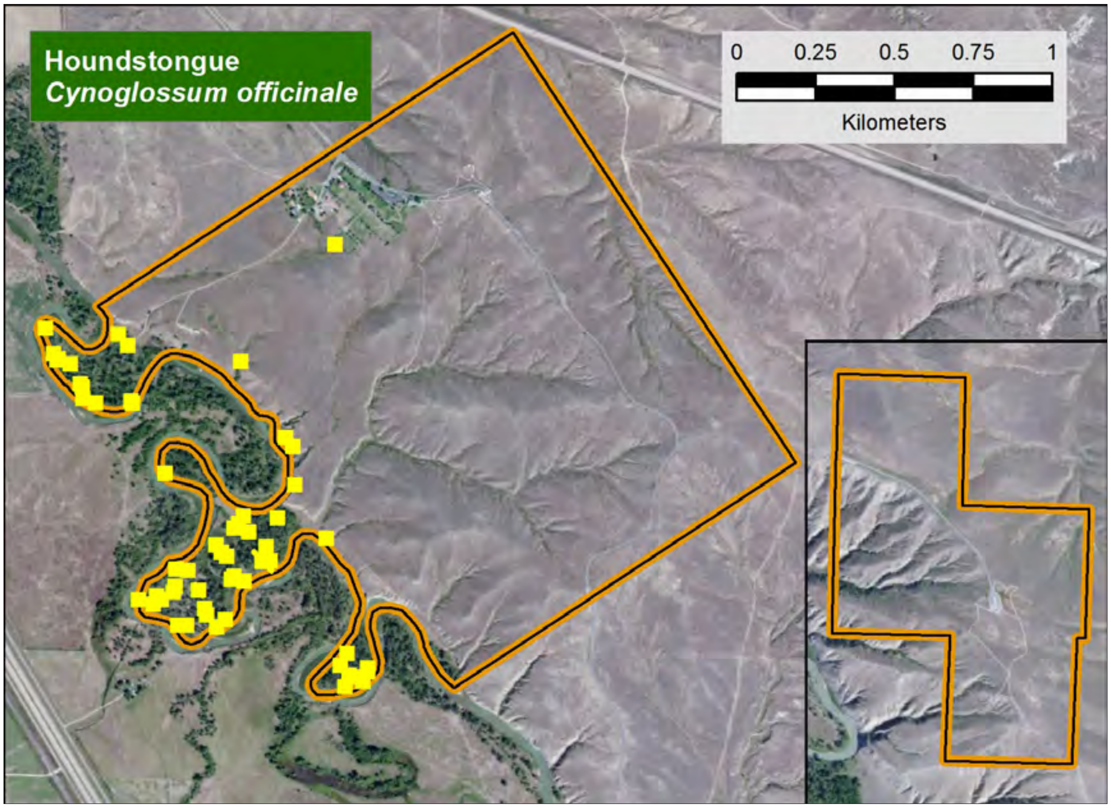

Figure F-3. Houndstongue (*Cynoglossum officinale*)

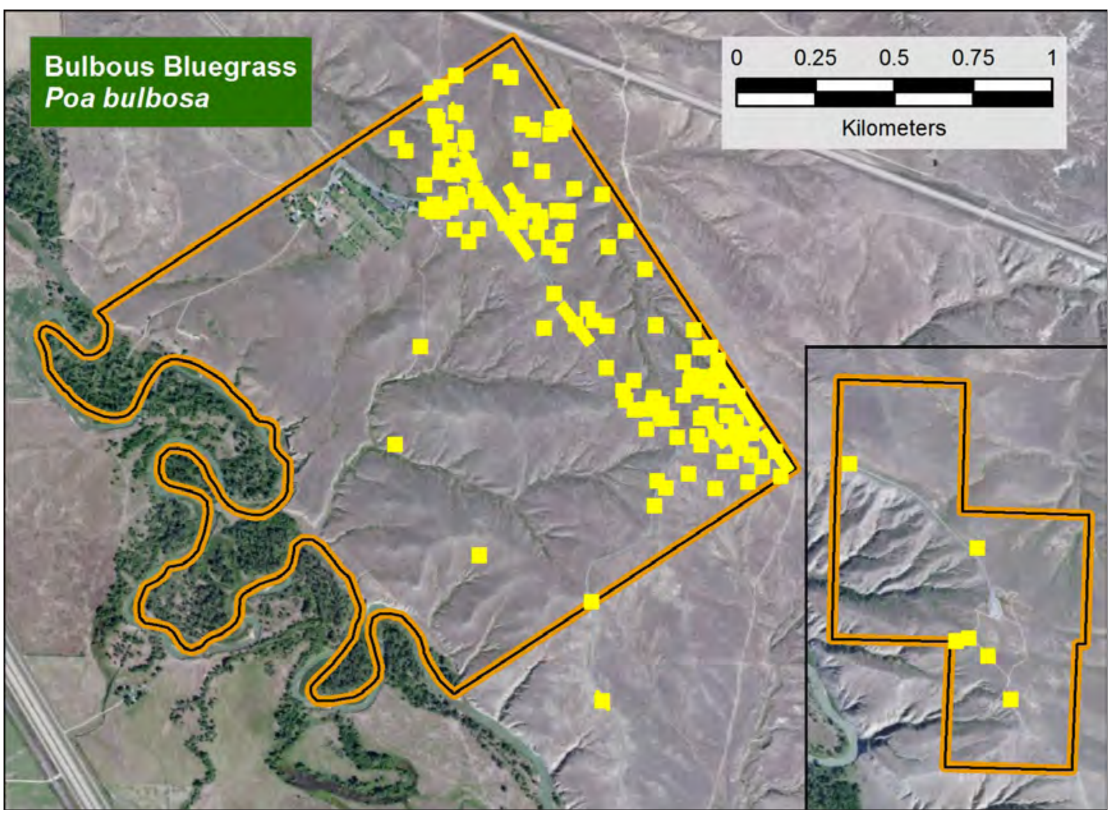

Figure F-4. Bulbous bluegrass (*Poa bulbosa*)

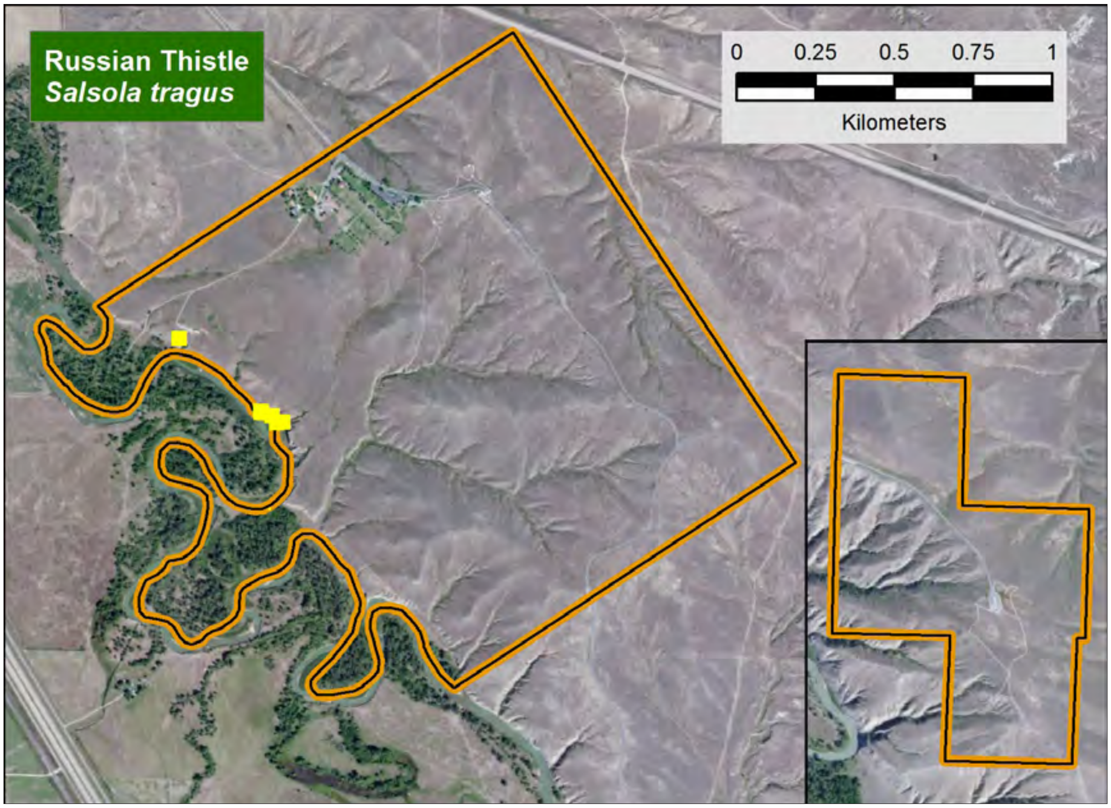

Figure F-5. Russian thistle (*Salsola tragus*)

Appendix G: 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 preseneted here supports Section 4.11 on breeding landbirds. This appendix contains some of the same, but additional, information as that section of the report.

One component of the landbird condition assessment was to assess species occurrence in a conservation context. We compared the list of species that occur at Little Bighorn Battlefield National Monument (NM) (i.e., those detected during a 2012 Rocky Mountain Bird Observatory [RMBO] survey [Van Lanen and Hanni 2012], and those on the certified park species list [same as those species reported in Bock and Bock 2006]) 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 confusion and perhaps frustration for managers that 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 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, 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) (U.S. North American Bird Conservation Initiative 2013). Bird Conservation Regions (BCRs) 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.

G.1. Conservation Organizations Listing Species of Conservation Concern

Below we present a snapshot 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.

State of Montana

The State of Montana (Montana Fish, Wildlife, and Parks) maintains listings of species considered as threatened or endangered within the state based on USFWS threatened and endangered species lists (http://fwp.mt.gov/fishAndWildlife/species). Also, Montana Fish, Wildlife, and Parks and the Montana Natural Heritage Program jointly maintain a "species of concern" list. These are native species that breed in the state and are "at risk" due to declining populations, habitat threats, and/or restricted distributions (http://fwp.mt.gov/fishAndWildlife/species/speciesOfConcern/).

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 conservtion 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 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.

National Audubon Society/American Bird Conservancy

The National Audubon Society and American Bird Conservancy each formerly published their own lists of bird species of concern, but have recently combined efforts into a single "Watch List". This collaborative effort was based on a concern by these organizations that there were too many lists with similar purposes (Butcher et al. 2007). Their 2007 WatchList is based on, but not identical to, the Partners in Flight (PIF) approach to species assessment (see below).

The 2007 WatchList has two primary levels of concern: a "Red Watchlist" and a "Yellow WatchList", although the latter is subdivided into two categories. The Red WatchList identifies what these organizations consider as species of highest national concern. This list overlaps considerably with the IUCNs "Red List" (not presented here), thus, can essentially be considered as a list of globally threatened birds that occur in the United States (Butcher et al. 2007). The Yellow WatchList is made up of species that are somewhat less critical, but serves as an early warning list of birds that have the potential of being elevated to the Red WatchList. Species on this list can be there either because their populations are declining or because they are considered rare.

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. 2005). 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. 2005).

Their assessments are conducted at multiple scales. At the broadest scale, the

North American Landbird Conservation Plan (Rich et al. 2004) 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. 2005). 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://www.rmbo.org/pif/pifdb.html) maintained by RMBO. 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. (2005), and a general summary is as follows:

Criteria for Species of Continental Importance

A. Continental Concern (CC)

- Species is listed on the Continental Watch List (Rich et al. 2004)
- Species occurs in significant numbers in the BCR
- Future conditions are not enhanced by human activities.

B. Continental Stewardship (CS)

- Species is listed as Continental Stewardship Species (Rich et al. 2004)
- Relatively high density (compared to highest density regions) and/or a high proportion of the species occurs in the BCR
- Future conditions are not enhanced by human activities.

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. 2005 for details). The criteria for each category are:

A. Regional Concern (RC)

- Regional Combined Score > 13 (see Panjabi et al. 2005 for details)
- High regional threats or moderate regional threat combined with significant population decline
- Occurs regularly in significant numbers in the BCR.

B. Regional Stewardship (RS)

- Regional Combined Score > 13 (see Panjabi et al. 2005 for details)
- High importance of the BCR to the species
- Future conditions are not enhanced by human activities.

G.2. Literature Cited

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Van Lanen, N.J., and D.J. Hanni. 2012. Avian Area Searches on Little Bighorn Battlefield National Monument: 2012 Report. Tech. Report # SC-LIBI-01. Rocky Mountain Bird Observatory, Brighton, Colorado.

Appendix H: Bird Species Recorded at Little Bighorn Battlefield NM

Listed below is the full list of bird species: 1) occuring on the park certified bird list and reported in Bock and Bock (2006); 2) detected during the 2012 Rocky Mountain Bird Observatory (RMBO) survey at the NM; and 3) observed by Mike Britten (NPS) during the riparian and grassland rapid assessment field work for the NRCA. The distribution status was determined using Birds of North America species accounts as a general reference.

Common Name	LIBI Certified Bird List (9-7-2006) [1]	2012 RMBO Area Search	NPS Observations in 2012 [2]	Distribution/Range Status
American Crow	Rc	X	----	Breeding and Wintering
American Goldfinch	Rc	X	----	Year-round
American Kestrel	Rc	X	X	Breeding
American Robin	Ra	X	----	Breeding and Wintering
Barn Swallow	Rc	X	----	Breeding
Belted Kingfisher	Ru	----	----	Breeding
Black-billed Magpie	Rc	X	----	Year-round
Black-capped Chickadee	Rc	----	----	Year-round
Black-headed Grosbeak	Ru	----	----	Breeding
Brewer's Blackbird	Ru	----	----	Breeding
Brewer's Sparrow	Rc	----	----	Breeding
Brown Thrasher	Rc	X	----	Breeding
Brown-headed Cowbird	Ru	X	----	Breeding
Bullock's Oriole	Ru	X	----	Breeding
Canada Goose	Ra	X	----	Breeding and Wintering
Cedar Waxwing	Rc	X	----	Year-round
Chipping Sparrow	Rc	X	----	Breeding
Cliff Swallow	Rc	X	----	Breeding
Common Grackle	Rc	X	----	Breeding
Common Merganser	Rc	----	----	Breeding and Wintering
Common Nighthawk	----	X	----	Breeding
Common Raven	----	X	----	Year-round
Downy Woodpecker	Rc	----	----	Year-round
Eastern Kingbird	Rc	X	----	Breeding
Eurasian Collared Dove	Ru	X	----	Outside Normal Breeding Range [3]
European Starling	Ra	X	----	Year-round
Ferruginous Hawk	Ru	----	----	Breeding
Grasshopper Sparrow	Rc	X	----	Breeding
Gray Catbird	Rc	X	----	Breeding

Residence Class: R = Resident; T = Transient; X = Not Provided

Abundance Class: a = abundant; c = Common; u= uncommon; r = rare

[1] Although the certified list is from 2006, no changes have been made to the list. The source of the list is Bock and Bock (2006); however, the
Bock and Bock report contains some different designations for residence class and/or abundance class.

[2] Observations by Mike Britten (NPS) during riparian and grassland rapid assessment field work for the NRCA.

[3] Outside normal breeding range, but within 100 miles of breeding range edge.

Common Name	LIBI Certified Bird List (9-7-2006) [1]	2012 RMBO Area Search	NPS Observations in 2012 [2]	Distribution/Range Status
Great Blue Heron	Rc	X	----	Breeding
Great Horned Owl	----	X	----	Year-round
Hairy Woodpecker	Rc	----	----	Year-round
Horned Lark	Rc	----	----	Year-round
House Finch	Ra	X	----	Year-round
House Sparrow	----	----	X	Year-round
House Wren	Ra	X	----	Breeding
Killdeer	Rc	----	X	Breeding
Lark Bunting	Ru	X	----	Breeding
Lark Sparrow	Rc	X	----	Breeding
Lazuli Bunting	----	X	----	Breeding
Loggerhead Shrike	Ru	----	----	Breeding
Mallard	Ra	----	----	Breeding and Wintering
Mourning Dove	Ra	X	----	Breeding
Northern Flicker	Rc	X	----	Year-round
Northern Harrier	Ru	X	----	Breeding
Northern Rough-winged Swallow	Rc	X	----	Breeding
Red Crossbill	----	----	X	Year-round
Red-tailed Hawk	Rc	X	----	Breeding
Red-winged Blackbird	----	----	X	Breeding
Ring-necked Pheasant	Ru	X	----	Year-round
Rock Pigeon	Rc	----	----	Year-round
Say's Phoebe	----	X	----	Breeding
Sharp-tailed Grouse	Ru	X	----	Year-round
Short-eared Owl	----	X	----	Year-round
Song Sparrow	Ru	----	----	Breeding
Spotted Sandpiper	Ru	----	----	Breeding
Spotted Towhee	Rc	X	----	Breeding
Swainson's Hawk	Ru	----	X	Breeding
Tree Swallow	----	X	----	Breeding
Turkey Vulture	Rc	----	----	Breeding
Upland Sandpiper	Ru	----	----	Breeding
Veery	Rr	----	----	Breeding
Vesper Sparrow	Rc	X	----	Breeding
Warbling Vireo	----	X	----	Breeding
Western Kingbird	Rc	X	----	Breeding
Western Meadowlark	Ra	X	----	Breeding
Western Tanager	----	X	----	Breeding

Residence Class: R = Resident; T = Transient; X = Not Provided

Abundance Class: a = abundant; c = Common; u= uncommon; r = rare

[1] Although the certified list is from 2006, no changes have been made to the list. The source of the list is Bock and Bock (2006); however, the
Bock and Bock report contains some different designations for residence class and/or abundance class.

[2] Observations by Mike Britten (NPS) during riparian and grassland rapid assessment field work for the NRCA.

[3] Outside normal breeding range, but within 100 miles of breeding range edge.

Common Name	LIBI Certified Bird List (9-7-2006) [1]	2012 RMBO Area Search	NPS Observations in 2012 [2]	Distribution/Range Status
Western Wood Pewee	Rc	X	----	Breeding
White-breasted Nuthatch	Rc	----	----	Year-round
White-crowned Sparrow	Tr	----	----	Outside Normal Breeding Range [3]
Wilson's Warbler	Ru	----	----	Outside Normal Breeding Range [3]
Wood Duck	----	----	X	Breeding
Yellow Warbler	Rc	X	----	Breeding
Yellow-breasted Chat	----	X	----	Within area of scattered breeding

Residence Class: R = Resident; T = Transient; X = Not Provided

Abundance Class: a = abundant; c = Common; u= uncommon; r = rare

[1] Although the certified list is from 2006, no changes have been made to the list. The source of the list is Bock and Bock (2006); however, the Bock and Bock report contains some different designations for residence class and/or abundance class.

[2] Observations by Mike Britten (NPS) during riparian and grassland rapid assessment field work for the NRCA.

[3] Outside normal breeding range, but within 100 miles of breeding range edge.

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