National Park Service
U.S. Department of the Interior

Natural Resource Stewardship and Science

Pipestone National Monument

Natural Resource Condition Assessment

Natural Resource Report NPS/PIPE/NRR—2016/1106

ON THE COVER
Active pipestone quarry surrounded by prairie, Pipestone National Monument
Photograph by Dave Jones, Colorado State University

Pipestone National Monument

Natural Resource Condition Assessment

Natural Resource Report NPS/PIPE/NRR—2016/1106

David S. Jones[1], Roy Cook[1], John Sovell[2], Christopher Herron[1], Jay Benner[1], Karin Decker[2], Steven Sherman[1], Andrew Beavers[1], Johannes Beebee[3], and David Weinzimmer[1]

[1]Colorado State University
CEMML – Department 1490
Warner College of Natural Resources
Fort Collins, CO 80523-1490

[2] Colorado State University
Colorado Natural Heritage Program
Department of Fish, Wildlife and Conservation Biology
Warner College of Natural Resources
Fort Collins, CO 80523

[3] Colorado State University
Department of Civil and Environmental Engineering,
College of Engineering
Fort Collins, CO 80523

January 2016

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

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

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

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

This report received formal peer review by subject-matter experts who were not directly involved in the collection, analysis, or reporting of the data, and whose background and expertise put them on par technically and scientifically with the authors of the information.

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

This report is available from the Heartland Inventory and Monitoring Network website (http://science.nature.nps.gov/im/units/htln/) and the Natural Resource Publications Management website (http://www.nature.nps.gov/publications/nrpm/). To receive this report in a format optimized for screen readers, please email irma@nps.gov.

Please cite this publication as:

Jones, D. S., R. Cook, J. Sovell, C. Herron, J. Benner, K. Decker, S. Sherman, A. Beavers, J. Beebee and D. Weinzimmer. 2015. Pipestone National Monument natural resource condition assessment. Natural Resource Report NPS/PIPE/NRR—2016/1106. National Park Service, Fort Collins, Colorado.

NPS 372/131038, January 2016

Contents

Page

Contents (continued)

Contents (continued)

Page

Contents (continued)

Contents (continued)

Contents (continued)

Page

Contents (continued)

Figures

Figures (continued)

Page

Figures (continued)

Page

Figures (continued)

Page

Figures (continued)

Figures (continued)

Page

Figures (continued)

Page

Tables

Tables (continued)

Page

Tables (continued)

Page

Tables (continued)

Page

Tables (continued)

Page

Executive Summary

The National Park Service (NPS) Natural Resource Condition Assessment (NRCA) Program administered by the NPS Water Resources Division evaluates current conditions for important natural resources and resource indicators using primarily existing information and data. NRCAs also report on trends in resource condition when possible, identify critical data gaps, and characterize a general level of confidence for study findings. This NRCA complements historical resource assessments, is multi-disciplinary in scope, employs a hierarchical indicator framework, identifies and develops reference conditions/values for comparison against current conditions, and emphasizes spatial evaluation of conditions and GIS (map) products.

The NRCA for Pipestone National Monument, Minnesota began in 2012. This study employed a scoping process involving Colorado State University, monument and NPS staff to discuss the NRCA framework, identify important park resources, and gather existing information and data. Indicators and measures for each resource were then identified and evaluated. Data and information were analyzed and synthesized to provide summaries and address condition, trend and confidence using a standardized but flexible framework.

Pipestone National Monument was created in 2007 to: administer and protect the pipestone quarries, preserving the quarrying of pipestone for Indians of all tribes; to preserve, protect, and interpret the cultural and natural resources associated with the monument; and to provide for the enjoyment and benefit of all people. The monument has significance as a result of its important and unique natural and cultural features and ethnographic landscapes. These features combine to provide an unusual array of habitats supporting a diverse assortment of prairie plants and animals and rare habitats, federally listed threatened and endangered species, and globally rare remnant plant communities.

A total of 18 focal resources were examined: six addressing landscape context - system and human dimensions, three addressing chemical and physical attributes, eight addressing biological attributes, and one addressing an integrated natural-cultural topic. Landscape context - system and human dimensions included land cover and land use, night sky, soundscape, scenery, climate change and fire disturbance regime. Climate change and land cover/land use were not assigned a condition or trend – they provide important context to the park and many natural resources, and can be a source of stress and management concern. Landscape context components that were assigned a resource condition uniformly warranted moderate concern with a deteriorating trend. It is no accident that the trend is similar for scenery, night sky and soundscape. These three resources are all affected by land cover and land use occurring inside and outside the park, and are anticipated to deteriorate as changes continue to occur. The park is particularly susceptible to these stressors due to its relatively small size, which minimizes internal buffering. The fire regime warranted moderate concern with a downward trend, and might be significantly ameliorated via planning, programmatic and budgetary measures.

Chemical and physical resources included air quality, water quality and stream hydrology and geomorphology. Air and water quality warranted significant concern while stream hydrology and geomorphology warranted moderate concern. Conditions were estimated to be unchanging for two

out of three resources. All components are significantly impacted by factors and activities related to land uses outside the park boundary. The condition of these resources adversely affects human dimensions of the park such as visibility and scenery as well as biological components such as stream biota.

Biological resources included floristic components (prairie vegetation, western prairie fringed orchid, Sioux quartzite prairie community, invasive exotic plants) and faunal components (aquatic macroinvertebrates, bird community, fish community, and Topeka shiner). All faunal resources examined warranted moderate concern. Climate change vulnerability was integrated into the assessment of western prairie fringed orchid and Sioux quartzite prairie, and contributed to a deteriorating trend for the quartzite prairie. The park has some excellent examples of relatively rare species and communities. However, challenges related to invasive plant management and fire regime contribute to moderate ratings and some declining trends. With the exception of aquatic invertebrates, faunal resources were considered to be in good condition. Based on available information, trends in all resources were unchanging.

The pipestone quarries, an integrated natural/cultural resource, were considered to be in good condition with an unchanging trend. Management concerns for this resource consist of water management within the quarries and exposure to potentially contaminated water. Planning for the sustainable use of the catlinite quarries is critical to bridging the cultural and natural landscape elements and meeting the park's primary mission.

Ecosystem stressors impacting park resources and their management exist both inside and outside park boundaries. Altered disturbance regimes such as fire and flooding, conversion and fragmentation of natural habitats, spread of invasive exotic plants and animal species that threaten regional biological diversity, altered hydrology and channel degradation of streams, and water pollution appear to be significant stressors of biological resources. Other resources related to human dimensions (including cultural/ethnographic features) such as scenery, natural sounds and night sky are stressed or directly affected by changes in land uses and land cover, population and housing densities, traffic and wind energy development. Climate change was estimated to contribute to the vulnerability of sensitive resources such as Sioux quartzite prairie, Topeka shiner and western prairie fringed orchid. Many of the resources were found to have interrelated stressors, the most common stressors being invasive plants, increased development and altered watershed characteristics.

In some cases significant data gaps contributed to low confidence in the condition or trend assigned to a resource. Primary data gaps and uncertainties encountered were lack of recent survey data; uncertainties regarding reference conditions; availability of consistent, long-term data; and scientific understanding of the ecology of rare resources. Findings from the NRCA will help monument managers to develop near-term management priorities, engage in watershed or landscape-scale collaboration and education efforts, conduct park planning, and report program performance.

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.

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

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

---

[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.

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

Due to their modest funding, relatively quick 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.

> ***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*

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

However, it is important to note that NRCAs do not establish management targets for study indicators. That process must occur through park planning and management activities. What an 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.

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)

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://nature.nps.gov/water/nrca/index.cfm.

---

[6] An NRCA can be useful during the development of a park's Resource Stewardship Strategy (RSS) and can also be tailored to act as a post-RSS project.

[7] While accountability reporting measures are subject to change, the spatial and reference-based condition data provided by NRCAs will be useful for most forms of "resource condition status" reporting as may be required by the NPS, the Department of the Interior, or the Office of Management and Budget.

[8] The I&M program consists of 32 networks nationwide that are implementing "vital signs" monitoring in order to assess the condition of park ecosystems and develop a stronger scientific basis for stewardship and management of natural resources across the National Park System. "Vital signs" are a subset of physical, chemical, and biological elements and processes of park ecosystems that are selected to represent the overall health or condition of park resources, known or hypothesized effects of stressors, or elements that have important human values.

2. Introduction and Resource Setting

2.1. Introduction

2.1.1. Enabling Legislation/Presidential Proclamation[9]

The park purpose, mission goals, and legal and policy mandates guide the management of Pipestone National Monument. These mission and mandate statements define the parameters within which all management actions must fall. All alternatives to be considered in the general management planning effort must be consistent with and contribute to fulfilling these missions and mandates.

Legislation creating Pipestone National Monument was passed by Congress and signed by the President on August 25, 1937. The legislative purpose of the Monument is threefold:

1) to administer and protect the pipestone quarries, reserving the quarrying of pipestone for Indians of all tribes;
2) to preserve, protect, and interpret the cultural and natural resources associated with Pipestone National Monument; and
3) to provide for the enjoyment and benefit of all people.

Mission goals of the monument are to:

- continue to provide for American Indian use and access for the quarrying of the pipestone and cultural uses;
- preserve and protect cultural and natural resources; and
- provide for the public use, enjoyment, and understanding of Pipestone National Monument.

The original boundary encompassed approximately 116 acres. The Three Maidens tract was added to the monument in 1951. After closure of the Indian School in 1954, 164 acres were added to the monument in 1957 (Murray 1965, Rothman and Holder 1992). Today monument lands total approximately 282 acres owned in fee.

Pipestone National Monument is listed in the National Register of Historic Places. The memorandum of understanding (MOU) of 1983 between the National Park Service and the state placed Pipestone National Monument on the Minnesota Natural Heritage Register because it has features of Minnesota's natural diversity. According to the MOU, these lands are vital to the development and maintenance of a system of areas with scientific and/or natural values for the research and teaching of conservation and for the preservation of valuable plant and animal species and communities. Specific features of interest are the Sioux quartzite outcrops and associated Sioux quartzite prairie and eleven species designated endangered, threatened, or of special concern by the state. Nine federally-listed and/or state-listed species are now present in the national monument.

[9] Excerpted from NPS (2008a)

2.1.2. Geographic Setting

Pipestone National Monument (PIPE) is located in rural southwestern Minnesota in Pipestone County (Figure 2-1). The population of Pipestone County was 9,596 (according to 2010 Census records), a 3% decrease in populations since the 2000 Census. Three incorporated communities exist in Pipestone County: Edgerton, Jasper, and Pipestone. Pipestone, the county seat, is the most populous community (4,317 residents) and borders the national monument. The park is located within the Inner Coteau Subsection, which occupies the extreme southwest corner of Minnesota and includes parts of southeastern South Dakota and northwestern Iowa. This high plain lies west of Buffalo Ridge, which is the western boundary of the Coteau Moraines Subsection. This subsection contains several rivers but very few lakes. Agriculture is the predominant land use here, and few remnants of prairie and wetlands remain. Gravel and boulder mining occurs in this subsection, particularly on ridges of prairie and grasslands where large-scale wind-power production is expanding (MDNR 2006).

2.1.3. Monument Significance

Pipestone National Monument has significance as a result of its important and unique natural and cultural features and ethnographic landscapes. The following attributes contribute to the significance of the monument:

1) the monument is the only location where American Indians have quarried the red pipestone (catlinite) from very early times to the present;
2) the monument is significant as a sacred site associated with American Indian spiritual beliefs and cultural activities;
3) the monument is significant for its history of American Indian and European–American contact and exploration in the early 1800s, specific quarrying rights, and the Pipestone Indian School (1893–1953);
4) the monument protects a significant cultural/ethnographic landscape; and
5) the monument is significant for the landscape it protects, which consists of the tallgrass prairie that developed in association with the site’s distinct geologic and hydrologic features. Native, high quality prairie is exceedingly rare in the region.

These features combine to provide an unusual array of habitats supporting a diverse assortment of prairie plants and animals and rare habitats, federally listed threatened and endangered species, and globally rare remnant plant communities (NPS 2008a).

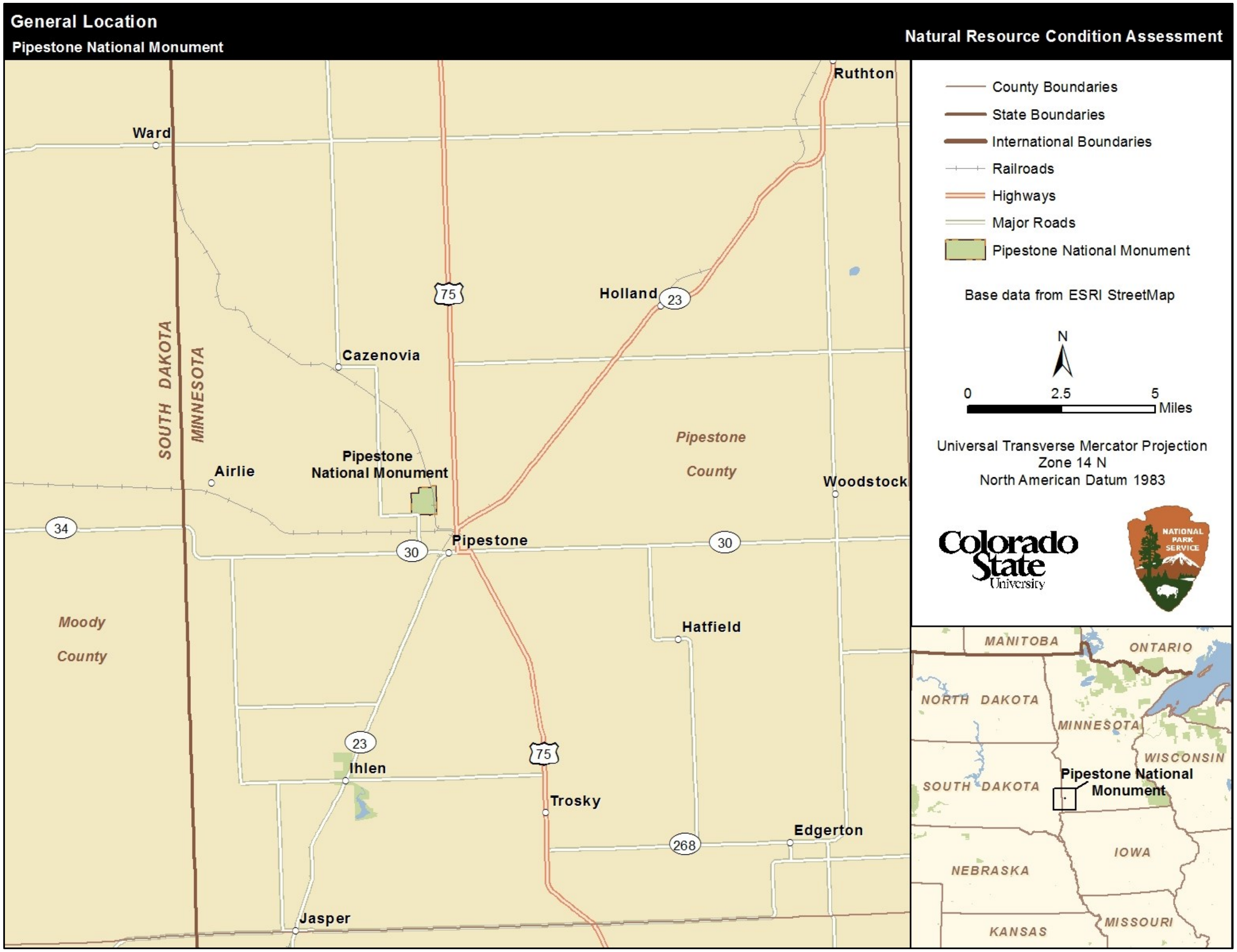


Figure 2-1. General location of Pipestone National Monument.

2.1.4. Ethnographic Resources and Cultural Use

The park is renowned as the location of catlinite quarries, but also contains other resources of cultural and ethnographic significance that are spatially and/or functionally associated with the quarries (Zedeno and Basaldu 2004, Hughes and Stewart 1997). The National Park Service defines ethnographic resources as "…landscapes, objects, plants and animals, or sites and structures that are important to a people's sense of purpose or way of life. In other words ethnographic resources are the kinds of resources managed by many other branches of the National Park Service, but understood from the viewpoint of peoples or groups for which they have a special importance different from that enjoyed by the public" (NPS 2013a).

The Three Maidens, with prairie restoration in foreground (CSU photo).

Pipestone National Monument houses a number of such resources that include quarries, the Three Maidens, Winnewissa Falls, Leaping Rock, Pipestone Creek, the Oracle and petroglyphs. Collectively, these resources form a cultural landscape originally focused on quarrying of the sacred pipestone. Traditionally the:

> "…Pipestone cultural landscape reflected systematic ceremonial uses by Indian people that were associated with quarrying pipestone. Upon arriving at the site, they would set up camp away from the quarries. Once greeted by thunder and lightning storms, the men would make ceremonial camps near the Three Maidens and begin to prepare themselves by cleansing in the creek, and giving prayers and tobacco offerings at the Three Maidens, the gateway into the sacred areas of Pipestone. If thunder and lightning greeted them, the place had heard their prayers and given them permission to enter the site. If thunder and lightning did not occur, the men may have returned to the ceremonial camp for more preparation or to the main camp to prepare for the return home. Having entered the quarry sites…the men who were not quarrying might continue with sweats and prayers until they were needed in the quarries. Upon entering a quarry, each man would make a tobacco offering to indicate their purity and to protect them while they worked. When they were done, they took the offerings with them so that they took all signs of themselves to show respect for the spirits of the sacred area." (Toupal et. al. 2004:122)

Traditional ceremonial uses of the area also contributed to the maintenance of vegetation used for domestic, medicinal and ceremonial purposes as collection was done in a manner that sustained the species of interest. Fire, natural and human caused, contributed to this maintenance cycle of vegetation as well. The creek was an integral part of the rite of passage for young men as well a place for ablutions prior entering the quarry areas. (Toupal et al. 2004, Mails 1998). Many of these


Leaping Rock (CSU photo).

traditional uses have been curtailed or eliminated as a result of changes introduced subsequent to Euro-American settlement. "In the contemporary Pipestone landscape… quarrying is the only traditional activity that remains, with the exception of occasional, minimal plant gathering for uses elsewhere. Vision quests, rites-of-passage, and curing ceremonies are not known to continue. The Sun Dance, a new religious use for this area, now occurs annually" (Toupal et al. 2004: 133). Selected ethnographic resources are briefly described below:

The pipestone quarries have been and remain the focus and reason for the cultural importance of the area (see Chapter 4).

The Three Maidens were traditionally the gateway to the quarries and a respectful distance was kept between them and those wishing to enter the area. Encroachment upon these sacred stones has reduced the privacy and seclusion required for ceremonial use of this location. It is conceivable, though unlikely, that this encroachment could be mediated through land acquisition and extension of the park boundaries. This seems unlikely in the foreseeable future. Keeping visitors further away from the stones and not allowing climbing up or defacement may help to improve the condition of this resource.

Winnewissa Falls forms where Pipestone Creek drops over a quartzite cliff feature. The falls were blasted and the creek channel lowered and straightened above the falls in the early 20th century in an effort to reduce flooding and improve agricultural drainage in adjacent lands. The result has been that the adjacent falls that once flowed during the rainy season no longer do so. Furthermore a bridge over Pipestone Creek is located only a short distance from the falls. These factors have changed the nature of the falls somewhat and also reduced the opportunity for privacy during ceremonies.

The Oracle/Old Stone Face/Leaping Rock quartzite features figure into Native American lore and history. The features are now obscured somewhat from view due to the growth of trees (as is the ridge in general) that were once kept at bay by natural and human-cause fires.

Pipestone Creek was historically used for ceremonial cleansing or submersion. The creek has been modified to such a degree by ditching and agricultural land uses that much of its upstream tributaries and mainstem no longer resemble natural streams.

Petroglyphs accumulated over time in the vicinity of the Three Maidens. Most of the petroglyphs were removed in 1888. Some of the panels are on display at the park visitor's center. The rock art sites of the monument, both those that occur in situ and that represented on the displaced slabs, are contributing elements of a multiple property National Register of Historic Places district based on the theme of American Indian rock art in the state of Minnesota (Scott 2006).

Sun Dance area showing shade arbor surrounding the Mystery Circle at center and sweat lodge at right (CSU photo).

The Sun Dance is a relatively recent cultural practice dating to the seventeenth or eighteenth century when the Sioux began to move onto the plains, however it likely has antecedents going back further in time (Mails 1998). The four day event is considered by many Native Americans to be the single most important religious event of the year and as Mails (1998) has put it "...the Sun Dance is a profound celebration of thanksgiving, growth, prayer and sacrifice." In the late nineteenth century the federal government attempted to eliminate the Sun Dance in part out disregard of its importance and meaning and also out of fear that it had the potential to cause an Indian revolt. The dance effectively went underground for decades until permission was granted for a public dance at the Rosebud reservation in 1928. Since then annual Sun Dances have occurred at many locations across the northern plains. Pipestone National Monument has hosted biannual Sun Dances for the past 24 years and semi-permanent facilities have been constructed to support these activities including a Mystery Circle, shade arbor and dedicated quarries and sweat lodge locations. The earlier dances at Pipestone attracted around 1,000 people, but more recent dances have seen declining attendance with approximately 50 to 100 people in attendance at the 2013 dances (pers. comm. Mark Calamia July 2013).

2.1.5. Park History

Pipestone National Monument and its environs represent a focal point of Native American social and ceremonial activity dating back generations and tied to the quarrying of the red pipestone known as catlinite and more recently to the Sun Dance ceremony. Natural and cultural resources are inextricably linked and must be evaluated and managed in an integrated fashion (pers. comm. Glen Livermont, December 2012). Prehistory and history of the park is described in a variety of documents (Corbett 1976, NPS 1996, Toupal et al 2004, NPS 2008a, NPS 2008b). The administrative history of the park is described by Rothman and Holder (1992).

European contact with Native American tribes brought cultural and natural changes to their landscapes and cultural traditions. In the first half of the 19th century, significant changes were occurring in the traditional cultural landscape. The traditions of the site were much the same but quarrying had taken precedence over medicine plants and rites-of-passage, and the landscape had become the domain of the Dakota Sioux to the exclusion of other traditionally associated tribes. In spite of the 1858 Treaty of Washington with the Yankton Sioux and 1860 survey to establish a reservation of 640 acres around the quarries that the Yankton would retain to ensure open and free access to the site, traders, settlers and a railroad encroached on the quarries and surrounding area throughout the 1860s, 1870s and 1880s (Toupal et al 2004). Commercial quarrying and settlement were a significant turning point for the biophysical landscape and cultural use of the area, and led to the suppression of fire, the displacement of wildlife by livestock, and the introduction of non-native plant species. As more traders and settlers came to the area, more and larger pipestone and building stone quarries developed (Toupal et al 2004).

Degradation of the reservation continued with the construction of an Indian school in 1893 in the northeast corner of the reservation, followed by blasting, channelization and lowering of Pipestone Creek by approximately 9 feet to remove obstructions at the Falls and to improve drainage to enable farming of the land north of the creek towards the school. Whereas seasonal flooding of Pipestone Creek historically spilled over the quartzite outcrop at multiple locations, after channelization flooding from the main channel became largely confined to Winnewissa Falls. The development of agriculture further changed the landscape and its hydrology, leading to degraded water quality and reduced acreage of wetlands.

Efforts to establish the area as some form of protected park land continued throughout the early 1900s. In 1928, the U.S. Government paid the Yankton Sioux for the Reservation land and guaranteed the tribe’s right to quarry pipestone, and Pipestone National Monument was established on a portion of the original acreage in 1937 (Toupal et al. 2004).

In the contemporary Pipestone landscape, quarrying is one of few traditional activities that take place at the monument, with the exception of occasional plant gathering for uses elsewhere. Encroachment from the town of Pipestone has forced the relocation of ceremonies and activities that once took place in the vicinity of the Three Maidens, and continues to impact the cultural experience related to sights (views and night skies) and soundscape. Vision quests, rites-of-passage, and curing ceremonies are now rare. While many of the significant historic cultural and natural elements are still present at the monument, its significance to Native Americans and cultural uses has greatly diminished (Toupal et al. 2004). Nonetheless, the monument has nurtured and promoted quarrying and pipestone craftsmanship over the years; a surge in quarrying and pipestone craft was noted in the 1960s (Corbett 1976). The park continues to provide a critical link to the past for Native Americans and a means to sustain cultural traditions related to both the place and quarrying activities.

2.1.6. Visitation Statistics

Park visitors are a mixture of recreation and non-recreation travelers and local residents. Annual park recreation visitation has decreased steadily since the mid 1970s and has stabilized over the past decade (Figure 2-2). Mean annual visitation for the five-year period ending 2012 was 73,144 recreation visitors. According to 2012 data, approximately 60% of visitors visit the trails and quarry sites and approximately 40% of visitors visit the Visitor’s Center. Other visitation includes Native American use of the Ceremonial Area. Monthly visitation is highest from May to October (Figure 2-3) (NPS 2013b).

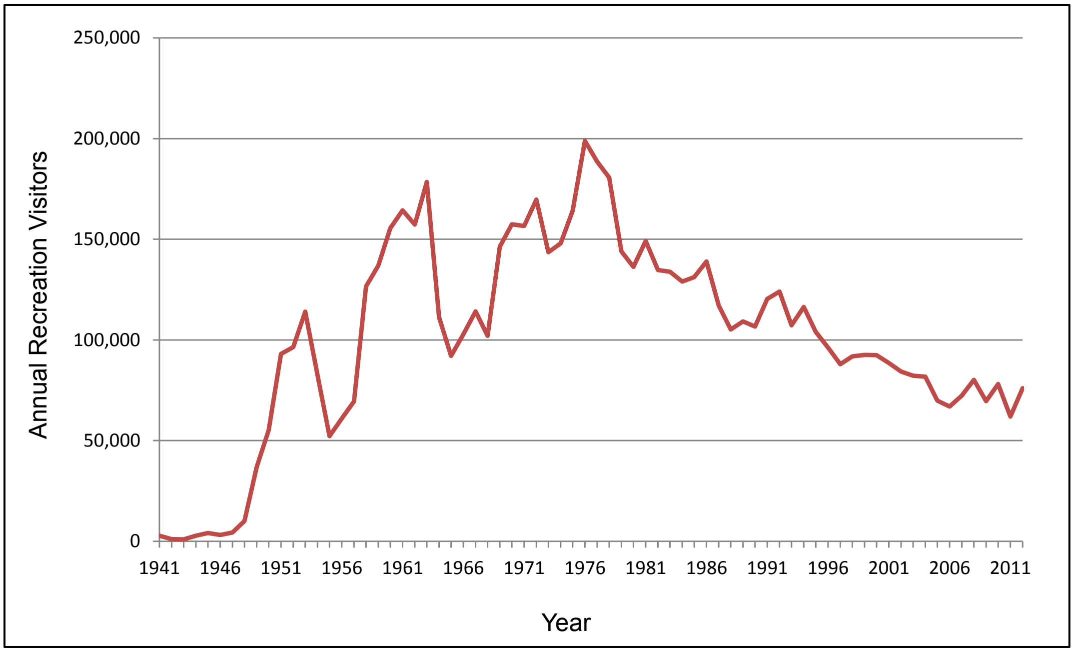


Figure 2-2. Annual PIPE recreation visitation for 1941-2012 (Data from NPS 2013b).

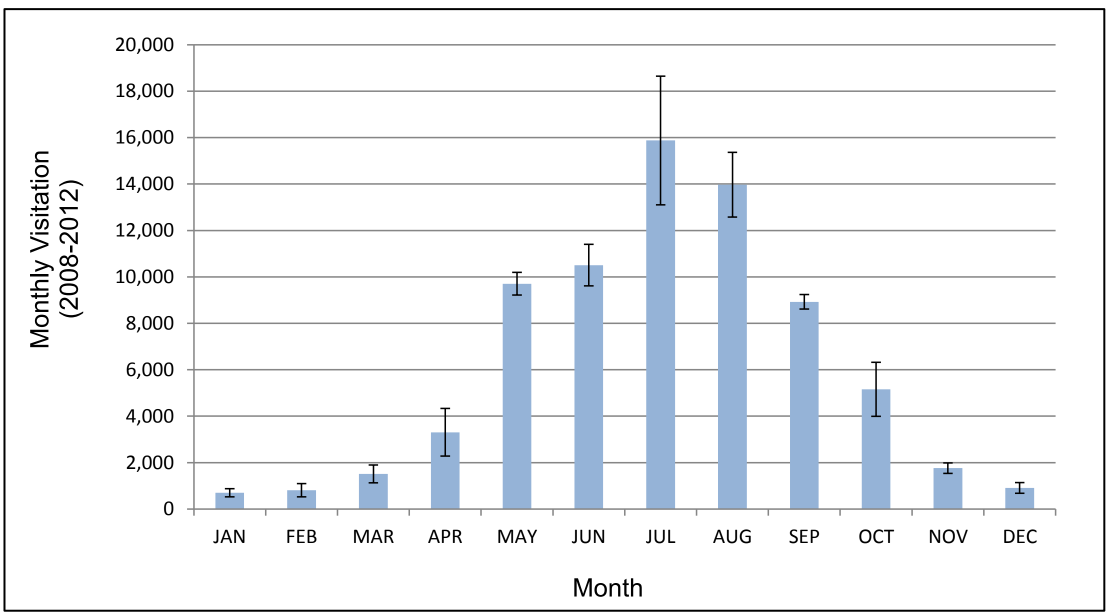
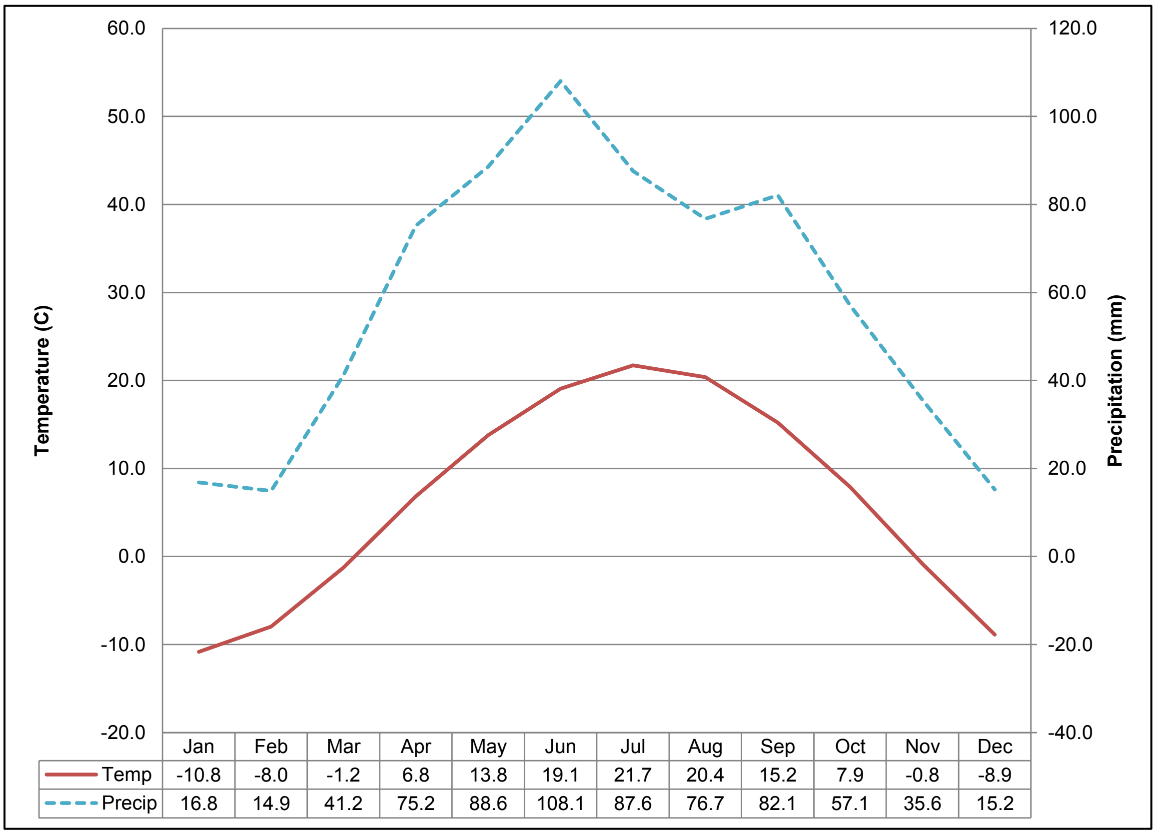


Figure 2-3. Mean monthly recreation visitation for PIPE for 2008-2012 (Data from NPS 2013b). Error bars represent 90% confidence intervals.

2.2. Natural Resources

2.2.1. *Climate*

The climate at PIPE is characterized by cool, moist summers and cold, dry winters. The average annual temperature at PIPE is 6.3° Celsius (C) (43.4° Fahrenheit (F)) (Figure 2-4). The coldest month is typically January with an average temperature of -10.8° C (12.5° F), a max of -3.2° C (26.3° F), and a min of -17.3 C (0.9° F). The hottest month is typically July with an average temperature of 21.7° C (71.1° F), an average high of 24.3° C (75.7° F), and an average low of 17.1° C (62.8° F) (NCDC 2013). The median growing season length at PIPE is 134 days with a last spring frost occurring around May 13 and a first fall frost around September 21 (MRCC 2013). Climate is examined in detail in Chapter 4.



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Temp	-10.8	-8.0	-1.2	6.8	13.8	19.1	21.7	20.4	15.2	7.9	-0.8	-8.9
Precip	16.8	14.9	41.2	75.2	88.6	108.1	87.6	76.7	82.1	57.1	35.6	15.2

Figure 2.4. Walter climate diagram of Pipestone National Monument 30-year temperature and precipitation averages (198-2011) (data source: NCDC 2013).

2.2.2. *Geology and Soils*

Pipestone lies on an eastern edge of the Coteau des Prairies, or Highlands of the Grasslands. As a geological unit, the area is a conspicuous iron-shaped landform running southeast to northwest for approximately 200 miles (320 km) through Iowa, Minnesota, and South Dakota (Toupal et al. 2004). It is a low plateau of thick glacial deposits covering a small ridge of Cretaceous shale that forms a significant drainage divide between the Big Sioux River to the southwest and the Des Moines and Minnesota Rivers to the northeast (USGS 2003). Elevations range from 980 to 1640 feet (300 to 500 meters) across level to rolling topography that is interspersed with many depressions and poorly-defined drainages. The soils are mostly deep, loamy, and silty with mixed mineralology and a frigid temperature regime. Soils in the depressions are poorly drained. Substantial outcrops of red Upper Precambrian quartzite layered with the softer red pipestone, or catlinite, occur in a few areas including Pipestone County (Wright 1972).

2.2.3. Hydrology

The major physical hydrologic features of PIPE are Pipestone Creek and Winnewissa Falls. Pipestone Creek enters the monument from the east and cascades in dramatic fashion over the escarpment formed from the Sioux quartzite, known as Winnewissa Falls. Downstream, Pipestone Creek drains into an impoundment in the middle of the monument, called Lake Hiawatha. The creek continues to flow to the northwest, exits the park, and ultimately drains into the Lower Big Sioux River. Pipestone Creek, while small, drains approximately 30,000 acres of land in the outlying agricultural region (NPS 2008a). Pipestone Creek has been designated critical habitat for the federally endangered Topeka shiner (Notropis topeka).

Pipestone Creek and its associated habitats, including the riparian corridor, ponds, intermittent drainageways, and marsh, provide critical wetland areas within the national monument (NPS 2008a), and these areas are mapped and described in the monument's Prairie Management Plan (Becker et al.1986). Wetland areas comprise approximately 8 percent of the monument's area. Some of the small wetland areas in the southeastern part of the monument still contain many native wetland plant species (NPS 2008a).

Heavy rains or rapidly melting snow can rapidly overwhelm the typical drainage of Pipestone Creek, and floodwaters can overtop the creek bed and flood the adjacent landscape. The underlying bedrock slows infiltration of rain or snowmelt and can promote surface flow during heavy events.

2.2.4. Air Quality

Pipestone National Monument is designated as a Class II airshed by the Clean Air Act of 1977, and as such allows a certain amount of air quality degradation under the law. In general, NPS (2008a) reports that, other than odor and dust from nearby agricultural activities in this rural corner of Minnesota, there have been few air quality issues at PIPE. The park does not contain any air quality monitoring equipment, but regional networks for air quality monitoring may provide some indication of the current condition of air resource quality for PIPE. Specific resource issues addressed later in the document include ozone concentrations, wet and dry pollution deposition, and particulate matter, all of which have consequences for the health and condition of natural communities and the quality of the visitor experience.

2.2.5. Land Use

The lands adjacent to Pipestone National Monument range from the small town of Pipestone and its 4,700 residents to the south and east, to the cultivated farmlands to the west, to the managed wildlife lands to the north. The monument protects remnant tallgrass prairie, restored prairie, and woodland areas along the creek bottom and escarpment in the face of a changing landscape.

The area around PIPE still maintains a rural character for the most part, and although the park is surrounded by agricultural land uses, the monument has not faced dramatic development pressures that have affected some other parks. Concerns about exotic invasive weeds have led to management activities to stem the movement of invasive grasses into the park. Pipestone Creek, critical habitat for the endangered Topeka shiner, drains 30,000 acres of nearby farmland. The creek reflects the activities on and changes to the landscape and transports pollutants and contaminants into and through the monument. Wind energy development in the region and within view of the park exists and is anticipated to increase.

2.2.6. Wildlife

The animal fauna in and around the national monument reflects both the unique resource values of PIPE as well as the historical changes in the fauna across the American landscape. Birds are abundant within the national monument, with over 100 species documented in a two-year survey that occurred nearly 30 years ago. More recently, Heartland Inventory and Monitoring Network inventories have documented nearly 70 bird species at PIPE, with plots in the eastern part of the monument near the creek and ponds showing higher than expected richness of breeding birds, while areas on the western side of the monument showing lower than expected richness. Fish communities have been impacted by land uses. Amphibians and reptiles are common around the park, but diversity is unexceptional. Regional extirpations mean that today's mammal fauna at PIPE reflects only a portion of its historic mammal fauna. Gone from this region are the bison, wolf, and elk (NPS 2008a); remaining in PIPE and its surrounding landscape are white-tailed deer, pocket gophers, badgers, red foxes, and many small mammals. White-tailed deer (*Odocoileus virginianus*) in particular show strong adaptability to changing landscapes and are abundant at the monument. There is a population of Richardson's ground squirrel to the northeast of the park, but not on park lands (personal comment Seth Hendricks, August 2015).

2.2.7. Vegetation

The presettlement vegetation of the region is characterized as true prairie dominated by more than 800 species of grasses and forbs with woody plants and trees occurring in larger valleys and along perennial streams. The prairie character was maintained through cycles of fires and drought (MDNR 2006). One of the earliest descriptions of the Pipestone landscape comes from the artist George Catlin from a visit to the Pipestone quarries in the 1830s. His view from the quartzite ridge encompassed "…the thousand treeless, bushless, weedless hills of grass and vivid green which all around me vanish into an infinity of blue and azure…" (Catlin 1844). The quartzite ridge, so distinct in the early account from the 1800s, is now largely hidden by oaks, ashes, elms and other trees once controlled by prairie fires.

The current landscape at the monument is dominated by remnant and restored tallgrass prairie vegetation, which exists on approximately 1 percent of its original range in Minnesota. Predominant native grasses include big bluestem (*Andropogon gerardii*), blue grama (*Bouteloua gracilis*), buffalograss (*Buchloe dactyloides*), blue joint grass (*Calamagrostis canadensis*), Canada wild rye (*Elymus canadensis*), green needlegrass (*Nassella viridula, syn. Stipa viridula*), Indian grass (*Sorghastrum nutans*), June grass (*Koeleria macrantha*), little bluestem (*Schizachyrium scoparium*), needle-and-thread (*Hesperostipa comata*), porcupine-grass (*Hesperostipa spartea*), prairie dropseed (*Sporobolus heterolepis*), sideoats grama (*Bouteloua curtipendula*), sweetgrass (*Hierochloe odorata*), switchgrass (*Panicum virgatum*), and western wheatgrass (*Agropyron smithii*) with prairie cordgrass (*Spartina pectinata*) found in the wet areas. Examples of native forbs include dotted gayfeather (*Liatris punctata*), fringed sagebrush (*Artemisia frigida*), leadplant (*Amorpha canescens*), Missouri goldenrod (*Solidago missouriensis*), prairie smoke (*Geum triflorum*), purple prairie clover (*Petalostemum purpureum*), western yarrow (*Achillea millefolium*), white sage (*Artemisia ludoviciana*) and wild bergamot (*Monarda fistulosa*).

Other communities include oak and riparian woodlands, the rare Sioux quartzite prairie, and wetlands associated with depressions and Pipestone Creek. State-listed plants are all associated with the Sioux quartzite prairie and ephemeral pools that occur on outcrops and shallow soils associated with quartzite outcrops. A combination of prescribed fire, mechanical control and herbicides are used to promote native vegetation and help manage nonnative vegetation at the park.

2.3. Resource Stewardship

2.3.1. Management Directives and Planning Guidance

Each unit in the National Park System is required by the National Park Service Organic Act of 1916 to "conserve the scenery and natural and historic objects and the wildlife therein and to provide for the enjoyment of the same in such a manner and by such means as will leave them unimpaired for the enjoyment of future generations." The General Authorities Act in 1970 (as amended) reiterated the provisions of the Organic Act and emphasized that "these areas, though distinct in character, are united through their inter-related purposes and resources into one national park system as cumulative expressions of a single national heritage." It also re-emphasized the importance of "unimpaired" NPS resources for future generations. The enabling legislation establishes park purposes and legislatively authorized uses within a context of cultural and natural resources. The *National Park Service Management Policies* (NPS 2006) provides Service-wide guidance for Park System planning, land protection, natural and cultural resources management, wilderness preservation and management, interpretation and education, use of the parks, park facilities and commercial visitor services. All management and planning documents developed for the park must adhere to these overarching documents and other laws, Executive Orders and Director's Orders.

In addition to these NPS-level documents, a number of important documents guide the management of natural resources in the monument. The *General Management Plan and Environmental Impact Statement* (GMP) (NPS 2008a) identifies specific management issues, sets forth management objectives and provides alternatives for addressing issues. According to the GMP, the current implemented management alternative re-emphasizes the interdependency of natural and cultural resources and focuses on reducing development in the heart of the monument. Emphasis is placed on preserving the setting, the site history, and the spiritual significance of the national monument as the source of pipestone. Implementation of this alternative involves continuation of most management activities and practices, modest land acquisition, partnership with other agencies and restoration of additional lands to tallgrass prairie. The existing visitor center and parking may be removed and the entry road shortened to end in a small parking area at the south quarry entrance. This, along with ongoing prairie restoration, would enable visitors to see the site much as it appeared prehistorically and to sense the significance of the site to American Indians. A new entrance may be created on the east side of the national monument just north of Pipestone Creek, and the maintenance operation may be moved out of current monument boundary. A visitor center for the national monument may be created outside the boundaries, and new visitor trails will be developed to reach the existing trail system (NPS 2008).

Other important resource management guidance at PIPE includes the *Resource Management Plan* (NPS 1996), *Fire Management Plan* (DeCoster et al. 2004), *Prairie Management Plan* (Becker et al. 1986), *Long-Range Interpretive Plan* (NPS 2008b), and the *Integrated Pest Management Plan* (NPS 2009).

Management Zones

Management zones were developed to facilitate planning and management of different areas and resources within the Historic Site, and are described in the *Pipestone National Monument General Management Plan* (NPS 2008a).

Administrative Zone

This zone includes administrative, residential, maintenance, storage and parking facilities necessary to the operation of the monument but not generally used by visitors. This zone contains previously disturbed and developed areas, and is typically landscaped with native plants to be as unobtrusive as possible. Maintaining the scenic quality of the surrounding area is important. Noise levels can be higher than elsewhere during maintenance activities. The administrative and visitor services zones currently are partly co-located at the Visitor Center.

Visitor Services Zone

This zone includes the Visitor Center, restrooms, picnic facilities, parking areas and trails/walkways. The monument is currently evaluating sites for the location of a new Visitor Center. Under the current plan, the existing Visitor Center would be moved or demolished. This zone is harmonized with the natural environment, natural processes, and scenic quality of the adjacent zones. Tolerance for any resource degradation is higher than in most other zones. Visitor services are highly accessible and convenient. Visitors are heavily concentrated in this area; the presence of vehicles and high levels of visitor use somewhat compromise the natural sounds in this zone.

Prairie Preservation Zone

The majority of the monument falls within this zone. The emphasis in the prairie preservation zone is on restoring and perpetuating natural systems and processes. It is intensively managed for the restoration of native vegetation, notably tallgrass prairie. The integrity of the prairie in this zone is paramount. The prairie preservation zone is a low density visitation area, with use restricted to existing trails. Natural quiet and scenic qualities are important in this zone. Intact native prairie creates a sense of the historic environment in which quarrying took place and facilitates immersion in the natural landscape. The probability of encountering other visitors and NPS staff is low to moderate.

Quarry Zone
The focus of the quarry zone is the quarries and associated activities. The tolerance for the disruption of natural processes associated with quarrying is high. Parts of the quarry zone associated with developed trails are a high visitor-use area that focuses on NPS interpretation. The other quarries (mostly the northern quarries) are closed to visitor access. Scenic quality and natural sounds can be somewhat compromised because of the visitor use and quarry drainage pumps. At times associated ceremonial activities are carried out in this zone.

Ceremonial Use Zone
This zone is located north of the Visitor Center. American Indians occasionally use the zone for ceremonies such as the Sun Dance and sweat lodges. When used only for sweat lodges, American Indians can experience solitude and natural sounds in a prairie environment. When not being used for American Indian ceremonies, the ceremonial use zone is managed in a way similar to the prairie preservation zone; native vegetation is encouraged and nonnative species are controlled. Portions of the zone are highly maintained, mostly through mowing. Sounds associated with ceremonial activities such as a Sun Dance are moderate. Semi-permanent or temporary facilities include sweat lodges and facilities associated with the Sun Dances, such as the arbor and kitchen facilities. Access trails and roads are unpaved.

Three Maidens Zone
The emphasis in this zone is on maintaining and enhancing the natural and spiritual qualities of the immediate area around the Three Maidens rock formation. The surrounding area is in the process of being restored to prairie vegetation. The tolerance for resource degradation is low. Visitation is moderate to high.

These broad and park-specific documents and management directives provide important information for identifying and characterizing focal resources and articulating resource reference conditions in this natural resource condition assessment.

2.3.2. Overview of Resource Management Concerns
Regional Great Plains ecosystem stressors that can impact park resources and their management include altered disturbance regimes such as fire and flooding, conversion and fragmentation of natural habitats, spread of invasive exotic plants and animal species that threaten regional biological diversity, loss of native pollinators, excess deer browsing, altered hydrology and channel degradation of streams, sedimentation and pollution of streams, and poorly-sited utility-scale wind turbines (Schneider et al. 2011).

Park management concerns highlighted in the *General Management Plan* (NPS 2008a) and by Park staff during the scoping process consist of often integrated natural and cultural resource issues as well as stressors from outside the park. The importance of interrelationships between ethnographic resources, the cultural context, pipestone quarries and craftsmanship and the prairie setting was repeatedly emphasized by the superintendent and the cultural resource manager. Primary resource management concerns within the park and beyond park boundaries are briefly described below.

Invasive Nonnative Plants

Nonnative invasive plants have been introduced and have spread throughout the region via agriculture and other human disturbances and practices. Invasive exotic plants are of concern at PIPE because of their potentially detrimental effects on the native and restored tallgrass prairie and the rare Sioux quartzite prairie plant communities. A number of highly invasive exotic plants have become established on PIPE, including common buckthorn (*Rhamnus cathartica)*, crownvetch (*Securigera varia*), leafy spurge (*Euphorbia esula*), reed canarygrass (*Phalaris arundinacea*), smooth brome (*Bromus inermis*), sweetclover (*Melilotus officinalis*), Canada thistle (*Cirsium arvense*), and Tatarian honeysuckle (*Lonicera tatarica*). Wetlands in the core of the park are particularly affected by reed canary grass. An aggressive program to control invasive exotic plants is in place at PIPE. Fire is used as a management tool to control some invasives and promote healthy and diverse prairie.

Threatened and Endangered Species

The federally endangered Topeka shiner (*Notropis Topeka*) and the threatened western prairie fringed orchid (*Platanthera praeclara*) are found within the monument. Topeka shiner conservation is problematic due to the notable alterations within Pipestone Creek watershed and the relatively short section of stream within the park. Orchid populations appear to be favored by conservation measures that promote healthy tallgrass prairie communities, but the response of the species to various stressors and management strategies is poorly understood. Both species have populations that oscillate considerably over time and are somewhat difficult to monitor. In addition, a number of rare plants are found within the rare Sioux quartzite prairie.

Prairie Quality and Natural Processes

The monument has a wide variety of prairie types, including native (i.e., unplowed) tallgrass prairie, disturbed/restored tallgrass prairie, Sioux quartzite prairie, areas dominated or co-dominated by invasive plants, and prairie degraded by woody plant invasion. Woody plant encroachment along the Sioux quartzite outcrops competes with native prairie vegetation and has altered the visibility of geological features and the character of the cultural landscape. There are many plants found in the prairie that have important cultural uses to Native Americans. The primary tools used to manage the prairie are active restoration, weed management and prescribed fire. Prairie conservation is challenging and in recent years some gains may be partially offset by reduced frequency of prescribed burning.

Scenic Resources

Views from the park have changed significantly since the park's creation in 1937. The views are variable, consisting of urban and industrial elements, energy and power structures, communication lines and structures, exurban and urban development, agriculture, and natural settings such as the U.S. Fish and Wildlife parcel to the north managed by Minnesota Department of Natural Resources. The view of the prairie landscape is interrupted on the southwestern vista by large powerline towers and a 200-foot wind turbine as well as a number of large wind turbines to the west. When Pipestone National Monument was created, the surrounding lands were agricultural, and there were few obstructions to views from the national monument all the way to the horizon. Now, as the city of Pipestone has grown closer to the national monument, and as developments have appeared within view, the sense of open, endless prairie that was the setting for the quarries is being compromised. Some agricultural elements and most other development are inconsistent with the scenic values of these cultural landscapes. The cultural and ethnographic landscape of the national monument and the aesthetic values of the prairie are becoming more difficult for visitors to picture and for interpreters to explain (NPS 2008a).

Other Impacts of Land Uses on Visitor/Cultural Experience
The sights, sounds and landscape associated with the park environs have changed over time as human population has increased and uses of the area have become more intensive or changed. Land-use changes and development outside the monument impact the experience of visitors and Native Americans with regard to altered scenery, excessive and unnatural noise, light pollution and solitude. Moreover, important elements of the landscape including much native fauna such as bison are missing. The juxtaposition of development inside and outside the park with cultural features and landscapes diminishes the value of the resources.

Water Quality and Altered Hydrologic Regime
Pipestone Creek water quality and its watershed are highly degraded due to overwhelming upstream alterations including urbanization, little buffering of riparian corridors, farming, drain tiling and ditching, channelization of stream courses, and pollution from agricultural pesticides, fertilizers and application of dairy manure slurry to agricultural fields. Due to drainage within the watershed, the stream has a more perennial character than under pre-park conditions. Historic blasting and lowering of the stream channel above Winnewissa Falls has altered seasonal flooding patterns within the park. Pipestone Creek is currently listed as an impaired water body due to high concentrations of fecal coliforms.

Cultural Landscape Integrity
Conservation and protection of ethnographic and traditional cultural elements and settings is one of the primary purposes of the park. The park is renowned as the location of catlinite quarries, but also contains other resources of cultural and ethnographic significance that are spatially and/or functionally associated with the. Pipestone National Monument houses a number of such resources that include quarries, the Three Maidens, Winnewissa Falls, Leaping Rock, Pipestone Creek, the Oracle and petroglyphs. Collectively, these resources form a cultural landscape originally focused on quarrying of the sacred pipestone. While many of the significant historic cultural and natural elements are still present at the monument, its significance to Native Americans and cultural uses has greatly diminished over time by damage or alteration, overuse and encroachment by incompatible uses as well as poorly-planned park facilities.

2.3.3. Status of Supporting Science
Available data and reports varied significantly depending upon the resource topic. Much of the supporting baseline survey and monitoring data was collected through the Heartland Inventory and Monitoring (I&M) Network initiated in the early 2000s. The Heartland Network also supported requests for geospatial data. Landscape context information and aspects of human dimensions were greatly supported by program staff such as the Natural Sounds and Night Skies Division (NSNSD), the national NPS Air Resources Division, and the NPScape Project within the I&M Program.

Additional information and data were provided by the park, published and unpublished reports and articles, and other outside experts noted in the individual resource sections.

2.4. Literature Cited

Becker, D.A., T. Bragg and D. Sutherland. 1986. Pipestone National Monument prairie management plan. USDI National Park Service.

Catlin, George. 1844. Letters and notes on the manners, customs, and condition of the North American Indians (1832-1839). Letter No. 54: red pipestone quarry, Coteau Des Prairies. Available at the Library of Western Fur Trade Historical Source Documents web site, http://user.xmission.com/~drudy/mtman/html/catlin/ (Accessed 11 December 2013)

Corbett, William P. 1976. A history of the Red Pipestone Quarry and Pipestone National Monument. M.A. Thesis, Department of History, University of South Dakota, Vermillion.

Davis, John Wayne. 1934. A History of the Pipestone Reservation and quarry in Minnesota. M.A. thesis, Department of History, University of Colorado, Boulder.

DeCoster, J., K. Legg, R. O'Sullivan, D. Soliem and G. Wagner. Pipestone National Monument fire management plan. 2004. USDI National Park Service.

Hughes, D.T. and A.J. Stewart. 1997. Traditional use of the Pipestone National Monument: ethnographic resources of Pipestone National Monument. 79 pp. Wichita, Kansas: National Park Service.

Mails, Thomas E. 1998. Sundancing: the great Sioux piercing ritual. Tulsa, OK: Council Oak Books.

Midwest Regional Climate Center (MRCC). 2013. Historical climate data – growing season summary. (http://mrcc.isws.illinois.edu/climate_midwest/historical/grow/mn/216565_gsum.html). (Accessed 29 October 2013).Minnesota Department of Natural Resources. 2003. Prairie Parkland Province: Coteau Moraines and Inner Coteau, Vol. 2003: MDNR Ecological Services.

Minnesota Department of Natural Resources (MDNR). 2006. Tomorrow's habitat for the wild and rare: an action plan for Minnesota wildlife, comprehensive wildlife conservation strategy. Division of Ecological Services, Minnesota Department of Natural Resources.

Murray, Robert A. 1965. A history of Pipestone National Monument, Minnesota. Pipestone Indian Shrine Association.

National Climatic Data Center (NCDC). 2013. Climate data online. http://www.ncdc.noaa.gov/cdo-web/ (Accessed 5 November 2013).

National Park Service (NPS). 1996. Pipestone National Monument resource management plan. USDI National Park Service.

National Park Service (NPS). 2006. National Park Service management policies. USDI National Park Service.

National Park Service (NPS). 2008a. Final general management plan and environmental impact statement, Pipestone National Monument. USDI National Park Service.

National Park Service (NPS). 2008b. Pipestone National Monument long-range interpretive plan. Prepared by National Park Service Harpers Ferry Center Interpretive Planning Office and the staff of Pipestone National Monument. USDI National Park Service.

National Park Service (NPS). 2009. Pipestone National Monument integrated pest management plan. USDI National Park Service.

National Park Service. 2013a. U.S. Department of the Interior. Park ethnography program. http://www.nps.gov/ethnography/parks/resources. (accessed November 2013).

National Park Service (NPS). 2013b. National Park Service visitor use statistics Web Page. https://irma.nps.gov/Stats/ (Accessed 16 April 2013).

Rothman, H.K. and D.K. Holder. 1992. Managing the sacred and the secular: an administrative history of Pipestone National Monument. Report prepared for the National Park Service Midwest Region Office.

Schneider R., K. Stoner, G. Steinauer, M. Panella and M. Humpert (Eds.). 2011. Nebraska Natural Legacy Project, state wildlife action plan, 2nd edition. The Nebraska Game and Parks Commission, Lincoln Nebraska.

Scott, D.D. 2006. An archeological inventory and overview of Pipestone National Monument, Minnesota. United States Department of the Interior, National Park Service, Midwest Archeological Center.

Toupal, R.S., R.W. Stoffle, N. O'Meara and J. Dumbauld. 2004. *Takuśkaŋśkaŋ Ćaŋnomoḳe*: The everchanging pipestone quarries – Sioux cultural landscapes and ethnobotany of Pipestone National Monument, Minnesota. Prepared for the NPS Midwest Region Office by the Bureau of Applied Research in Anthropology, University of Arizona, Tucson, AZ.

U.S. Geological Survey (USGS). 2003. A tapestry of time and terrain: the union of two maps - geology and topography. The Coteau des Prairies, Vol. 2003: DOI USGS.

Wright, H.E., Jr. 1972. Physiography of Minnesota. *In* Sims, P.K. and G.B. Morey (eds.). 1972. Geology of Minnesota. St. Paul, MN: Minnesota Geological Survey: 515-560.

Zedeno, M.N. and R.C.Basaldu. 2004. Native American cultural affiliation and traditional association study – Pipestone National Monument, Minnesota. Prepared for the NPS Midwest Region Office by the Bureau of Applied Research in Anthropology, University of Arizona.

3. Study Scoping and Design

3.1. Preliminary Scoping

The initial phase of the study consisted of a series of meetings, conversations and collaborations between Colorado State University and NPS staff, including the Midwest Regional NPS Office, the Heartland I&M Network, park staff, Water Resources Division (NRCA proponent), and National I&M programs. Initial scoping consisted of reviewing the Heartland Inventory and Monitoring Network and Prairie Cluster Prototype Monitoring Program Vital Signs Monitoring Plan (DeBacker et al. 2005) in order to begin to understand the management and resource context for the park. Vital signs previous identified and prioritized for the park were the basis for a preliminary list of focal resources to support initial NRCA discussions with park and other NPS staff. A site visit and initial meetings took place December 6-7, 2012 at PIPE Headquarters. The purpose of the preliminary scoping meetings was to:

- establish contact and begin dialogue with key staff members;
- identify points of contact;
- provide an overview of NRCA purpose and process (for park staff);
- provide an overview of park context, administrative history and management concerns (for cooperators);
- discuss analysis framework, reporting scales/units, and rating system;
- identify and discuss priority/focal resources in support of framework development –
    - traditional natural resources (e.g., bison, water quality, rare plant),
    - ecological processes or patterns (e.g., fire regime),
    - specific natural or cultural/ethnographic features inextricably linked to natural resources, or
    - values linked to biophysical resources and landscape context (e.g., dark night skies, soundscape, viewscape);
- discuss key NRCA concepts including indicators and measures, threats and stressors, and reference conditions;
- identify and gather available data and information;
- identify sources of expertise inside and outside the NPS;
- define project expectations, constraints, and the need to balance depth vs. breadth; and
- review the assessment timeline.

Key constraints placed on the scope of NRCA development included the following:

- the assessment will provide a snapshot of a subset of park resources, as determined through the scoping process;
- some lower priority resources or those having little supporting data may not be fully examined to allow a more comprehensive analysis of higher-priority resources;

- the assessment will use existing information/data and not modeled or projected data, although limited analysis and data development may be undertaken where feasible (e.g., data to support views/scenery analysis) - future modeled data are only used in the climate change section; and
- assignment of condition ratings may be constrained by insufficient information or inadequately defined reference conditions.

3.2. Study Design

3.2.1. Indicator Framework, Focal Resources and Indicators

The NRCA uses a framework adapted from The Heinz Center (2008) to examine condition and trends in key natural resources at the park (Table 3-1). The Heinz structure was identified in the NRCA guidance documents as a relevant framework that organizes indicators under each focal resource within broad groupings of ecosystem attributes related to: landscape context including system and human dimensions; chemical and physical components; and biological components. Although threats and stressors are described for each focal resource, the *Land Cover and Land Use*, *Fire Regime* and *Climate Change* sections were added to address broad ecosystem-level processes and stressors affecting multiple resources. A small subset of the resources identified as important to the park and desirable to include in the NRCA during the scoping phase were either not included as focal resources or were addressed in a brief fashion due to lack of information or data, poor understanding of their ecological role and significance in the landscape, their absence at the park, or lack of justification to include them as a focal resource. The latter case for eliminating resources considered to have a lower priority for inclusion also reflected realities related to balancing cooperator budget, breadth of the assessment across many resources and depth of analysis. A total of 18 resources were examined and included here: six addressing landscape context - system and human dimensions, three addressing chemical and physical attributes, eight addressing biological attributes, and one addressing an integrated natural-cultural topic.

3.2.2. Reporting Areas

The reporting area for all resources is generally the entire area within the park boundary. In some cases indicators were analyzed using subsets based on geographic or ecological strata within the park, e.g., grassland birds and woodland birds. The results for those subsets were then combined into single park-wide condition and trend ratings for the resource. For several resources such as those capturing landscape context (e.g., land cover and land use, dark night skies, soundscape and viewscape), the extent of the analysis varies by resource, often extends outside park boundaries in a fixed or variable way and is in some cases influenced by the locations selected for analysis (e.g., location of key view points for scenery analysis). Because of the relatively small size of the park, some landscape context resources are affected largely by elements outside park boundaries.

Table 3-1. Pipestone National Monument natural resource condition assessment framework.

Ecosystem Attributes	Focal resources	Indicators and Measures of Condition
Landscape Context - System and Human Dimensions	Land Cover and Land Use	Land cover/land use Population and housing Conservation/protection status
	Night Sky	Artificial night sky brightness
	Soundscape	Ambient noise levels
		Anthropogenic sources of noise
		Traffic volumes on nearby and park roads
	Views and Scenery	Scenic quality from key view points
		Housing densities surrounding the park
		Potential visibility of new wind energy structures
		Air quality - visibility
	Climate Change	Modeled temperature and precipitation vs. historical baseline
		Aridity - Palmer index (historical) and moisture deficit (modeled)
		Plant phenology
	Fire Disturbance Regime	Fire frequency (return interval)
		Seasonality
		Severity
Chemical and Physical	Air Quality	Level of ozone
		Atmospheric wet deposition of total N and total S
		Visibility haze index
	Stream Hydrology and Geomorphology	Proper functioning condition (PFC) rating
		Channel evolution model (CEM) stage
	Water Quality	Total dissolved solids
		Chloride
		Sulfate
		Dissolved oxygen
		Coliform bacteria
		Temperature
Biological - Plants	Prairie Vegetation	Extent of vegetation community types
		Plant richness and diversity

		Vegetation structure and woody encroachment
		Invasive plant abundance/index
	Western Prairie Fringed Orchid	Population size
		Plant vigor (mean height and number of flowers per plant)
		Fire regime considerations
		Vulnerability to climate change
	Sioux Quartzite Prairie	Index of floristic quality (Mean C)

Table 3-1 (continued). Pipestone National Monument natural resource condition assessment framework.

Ecosystem Attributes	Focal resources	Indicators and Measures of Condition
Biological – Plants (continued)	Prairie Vegetation (continued)	Vegetation structure and woody encroachment
		Invasive plant abundance/index
	Western Prairie Fringed Orchid	Population size
		Plant vigor (mean height and number of flowers per plant)
		Fire regime considerations
		Vulnerability to climate change
	Sioux Quartzite Prairie	Index of floristic quality (Mean C)
		Relative cover of native plant species
		Structure and composition
		Status of state plants of concern
		Vulnerability to climate change
	Invasive Exotic Plants	Frequency
		Abundance and distribution
		Presence and abundance of state noxious plants
Biological - Animals	Aquatic Macroinvertebrates	Richness and diversity metrics
		Hilsenhoff Biotic Index
	Bird Community	Native species richness (S)
		Bird index of biotic integrity (IBI)
		Status of bird species of conservation concern
	Fish Community	Native species richness
		Fish index of biotic integrity (IBI)
	Topeka Shiner - at-risk biota	Topeka shiner abundance
		Relative abundance of predators
		Vulnerability to climate change
Integrated Natural/Cultural	Pipestone Quarries	Quarriable catlinite resource
		Quarrier health and safety

3.2.3. General Approach and Methods

General Approach

This study employed a scoping process involving Colorado State University, Park and NPS staff to discuss the NRCA framework, identify important Park resources, and gather existing literature and data for each of the focal resources. Indicators and measures to be used for each resource were then identified and evaluated. All available data and information was analyzed and synthesized to provide summaries and address condition, trend and confidence. Condition ratings compared the current condition(s) at the park to the reference condition(s) when possible. In some cases, due to interrelationships, a focal resource was used to help determine condition and/or trend for another focal resource. For example, changes and landcover/landuse and impervious surfaces within the watershed are used to support trend determination for stream hydrology.

Sources of Information and Data

Non-spatial data, published literature, unpublished reports and other grey literature related to conditions both inside and outside the park were obtained from myriad sources. The primary sources for park-specific resource data were park staff, Heartland I&M Network staff, and the public access side of the IRMA (Integrated Resource Management Applications) web portal, Park and HTLN staffs were an invaluable source of knowledge regarding resources, stressors and management history and activities. State and federal agency reports and data were downloaded using the web or obtained from the park or other agency staff. Spatial data were provided by the park, the Heartland Network, the NPS Midwest Region Office and other sources. The NPS Inventory and Monitoring (I&M) program and Night Skies and Natural Sounds Division (NSNSD) provided valuable data to support the assessment. Primary data sources are described in each focal resource section. In some cases existing data were reworked in order to make them more useful for analysis. In the case of stream geomorphology and views/scenery, we collected data in the field to support those resources due to a lack of existing information and data.

Subject Matter Experts

A number of subject matter experts were consulted while developing this assessment. Expert involvement included in-person and telephone meetings, correspondence, and reviews of preliminary resource drafts. The experts consulted for each focal resource are listed in the resource sections in Chapter 4.

Data Analyses and NRCA Development

Data analysis and development of technical sections followed NRCA guidance and recommendations provided by the NPS. Data analyses were tailored to individual resources, and methods for individual analyses are described within each section of chapter four. As one of the tenets of the NRCA framework, geospatial analysis and presentation of results is used where possible throughout the assessment. Periodic contact between the authors, park and other NPS staff and subject matter experts took place as needed to obtain additional data and information or collaborate on an analysis framework or approach or on the interpretation of results.

Final Assessments

Final drafts followed a process of preliminary draft review and comment by subject matter experts, reviewers, and park staff. Reviewer comments were incorporate and addressed to improve the analysis within the limits of the NRCA scope, schedule and budget. The final assessments attempt to provide the most up-to-date representation of existing data and information.

Rating Condition, Trend and Confidence

For each focal resource, a reference condition for each indicator is established and a condition rating framework presented, forming the basis for assigning a current condition to each indicator. In some cases current condition and trend may be based on data or information that is several or more years old. Condition may be based on qualitative, semi-quantitative or quantitative data. Trend is assigned where data exists for at least two time periods separated by an ecologically significant span or may be based on qualitative assessments using historical information, photographs, anecdotal evidence or professional opinion. It is not uncommon for there to be some correlation among indicators for a particular focal resource. In a few cases, the trend assigned to an indicator may be influenced by the data for a correlated indicator. For example, traffic trend data may influence the trend rating for anthropogenic noise levels or projected housing densities from the Land Cover and Land Use section may be used to infer trend for Scenery.

The level of confidence assigned to each indicator assessed integrates the comfort level associated with the condition and/or trend rating assigned. A lower confidence (i.e., higher uncertainty) may be assigned where modeled data has considerable uncertainty or numerous assumptions, where changes may be small and no quantitative data are available, where statistical inference is poor (e.g., as is often the case where sample sizes are inadequate), where interannual or seasonal variability is very high or unknown, where detectability is difficult when monitoring (e.g., some plants and birds), where only several closely spaced data points are available for trend determination (e.g., invasive exotic plant sampling only several years apart and only 2 periods available), or where a very small proportion of the reference frame or population of interest is sampled (in time or space), which influences influencing the representativeness of the sample (e.g., the timing and length of attended listening data for natural sounds analysis). Lack of information/data may result in an unknown condition rating, which is often associated with unknown trend and low confidence.

Where vulnerability to climate was examined for the western prairie fringed orchid, Topeka shiner, and Sioux quartzite prairie community, the climate change condition was not factored into the condition rating. The climate change indicators were assigned an *insufficient data* status and low level of confidence. However, the estimated vulnerability for a particular resource was used as a trend indicator along with other indicators. We included climate change vulnerability only as an indicator of trend for focal species and communities of interest. Climate change exposure information is crucial contextual information, but is not included in the condition rating for each resource. Including climate change vulnerability in the trend rating raises a flag where vulnerability may be high and leading to deteriorating conditions for the resource.

Symbology and Scoring[10]

This NRCA uses a standardized set of symbols to represent condition status, trend and confidence in the status and trend assessment (Table 3-2, Table 3-3). This standardized symbology provides some

[10] Adapted from NPS-NRCA Guidance Update dated January 14, 2014.

consistency with other NPS initiatives such as State of the Parks and Resource Stewardship Strategies.

The overall assessment of the condition for a focal resource may be based on a combination of the status and trend of multiple indicators and specific measures of condition. A set of rules was developed for summarizing the overall status and trend of a particular resource when ratings are assigned for two or more indicators or measures of condition. To determine the combined condition, each red symbol is assigned zero points, each yellow symbol is assigned 50 points, and each green symbol is assigned 100 points. Open (uncolored) circles are omitted from the calculation. Average scores of 0 to 33 warrant significant concern, average scores of 34 to 66 warrant moderate concern and average scores of 67 to 100 indicate the resource is in good condition. In some cases certain indicators may be assigned larger weights than others when combining multiple metrics into a condition score. In those cases the authors provide an explanation for the weights applied.

Table 3-2. Standardized condition status, trend and confidence symbology used in this NRCA.

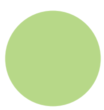
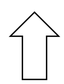
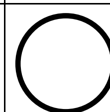
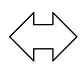
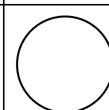
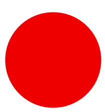
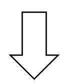
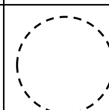
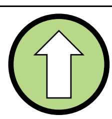
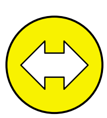
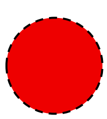
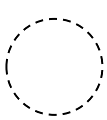
Condition Status		**Trend in Condition**		**Confidence in Assessment**	
	Resource is in Good Condition		Condition is Improving		High
	Warrants Moderate Concern		Condition is Unchanging		Medium
	Warrants Significant Concern		Condition is Deteriorating		Low

Table 3-3. Examples of how condition symbols should be interpreted.

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

To determine the overall trend, the total number of down arrows is subtracted from the total number of up arrows. If the result is 3 or greater, the overall trend is improving. If the result is -3 or lower, the overall trend is deteriorating. If the result is between 2 and -2, the overall trend is unchanged. Sideways trend arrows and cases where trend is unknown are omitted from this calculation.

Organization of Focal Resource Assessments

Background and Importance

This section provides information regarding the relevance of the resource to the park and the broader ecological or geographic context. This section explains the characteristics of the resource to help the reader understand subsequent sections of the document. Relevant stressors of the resource and the indicators/measures selected are listed or discussed.

Data and Methods

This section describes the source and type of data used for evaluating the indicators/measures, data management and analysis (including qualitative) methods used for processing or evaluating the data, and outputs supporting the assessment

Reference Conditions

This section describes the reference conditions applied to each indicator and how the reference conditions are cross walked to a condition status rating for each indicator. NRCAs must use logical and clearly documented forms of reference conditions and values. Reference condition concepts and guidance are briefly described in Chapter 1. A reference condition is "a quantifiable or otherwise objective value or range of values for an indicator or specific measure of condition that is intended to provide context for comparison with the current condition values. The reference condition is intended to represent an acceptable resource condition, with appropriate information and scientific or scholarly consensus" (NPS 2014). An important characteristic of a reference condition is that it may be revisited and refined over time. The nature of the reference condition prescribed for a particular resource can vary with the status of the resource relative to historical conditions and anticipated future conditions (Figure 3-1).

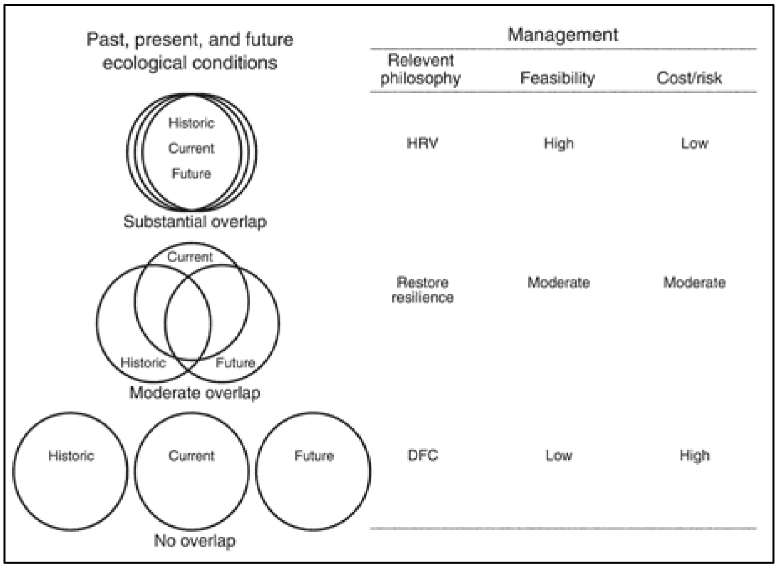


Figure 3-1. Illustration of three possible cases of the extent to which current ecosystem conditions in a place differ from historical conditions and from projected future conditions. Circles denote the range of variability for each time period. Also shown are the expected management criteria for each case. Abbreviations are HRV (historical range of variability) and DFC (desired future conditions) (Hansen et al. 2014).

For example, substantial overlap may exist for prairie vegetation, moderate overlap may exist for birds and little or no overlap may exist for nonnative invasive plants. Reference conditions can be particularly difficult to define where presettlement conditions or range of variability are unknown, and/or where little inventory and monitoring data exist.

Condition and Trend

This section provides a summary of the condition for each indicator/measure based on available literature, data, and expert opinions. A condition status, trend and confidence designation for each indicator/measure is assigned and accompanying rationale is provided. Where multiple indicators or metrics are used, a single rating is consolidated for each resource using the condition rating scoring framework described earlier in this chapter.

Uncertainty and Data Gaps

This section briefly highlights information and data gaps and uncertainties related to assessment of the resource. Low confidence can be associated with a combination of data that is not current, insufficient data, unrepresentative data, poorly documented data, or data having poor precision and/or accuracy.

Sources of Expertise

Individuals who were consulted or provided preliminary reviews for the focal resource are listed in this section.

3.3. Literature Cited

DeBacker, M.D., C.C. Young (editor), P. Adams, L. Morrison, D. Peitz, G.A. Rowell, M. Williams, and D. Bowles. 2005. Heartland Inventory and Monitoring Network and Prairie Cluster Prototype monitoring program vital signs monitoring plan. National Park Service Heartland I&M Network and Prairie Cluster Prototype Monitoring Program, Wilson's Creek National Battlefield. Available at http://science.nature.nps.gov/im/monitor/MonitoringPlans.cfm

Hansen, A.J., N. Piekielek, C. Davis, J. Hass, D.M. Theobald, J.E. Gross, W.B. Monahan, T. Olliff and S. W. Running. 2014. Exposure of U.S. National Parks to land use and climate change 1900–2100. Ecological Applications, 24(3), 2014, pp. 484–502

National Park Service (NPS). 2014. Natural resource condition assessment guidance documents and useful resources. NPS Water Resources Division. Available at: http://www.nature.nps.gov/water/nrca/guidance.cfm

The H. John Heinz III Center for Science, Economics and the Environment (The Heinz Center). 2008. The state of the nation's ecosystems 2008: measuring the lands, waters, and living resources of the United States. Washington, D.C.

4. Natural Resource Conditions

4.1. Chapter 4 Contents

Page

4.2. Land Cover and Land Use

4.2.1. Background and Importance

This section places park resources and management concerns within a local and regional context of land cover and land use, as well as implications related to population and resource conservation. Using several metrics, it characterizes conditions and dynamics of the surrounding areas, highlights the potential effects of related landscape-scale stressors on park resources, and underscores the conservation value of the park to the surrounding region. The synthesis of national data uses a series of straightforward spatial analyses for areas within and surrounding the park. Condition and trend ratings are not assigned to these landscape context metrics. In some cases long-term data are not available and for the most part the park has little influence over activities occurring outside park boundaries. Longer-term data are available for some population and housing metrics. A summary of the landscape metrics is provided to highlight conditions potentially influencing park natural resources.

Indicators of landscape context applied here include a variety of metrics for land cover and land use, population and housing, and land conservation status. Due to the relatively small size of the park, the overwhelmingly non-natural status of surrounding lands, and the lack of significant regional migration by fauna of concern, road densities and habitat fragmentation and connectivity both within the park and outside the park are not examined here.

Threats and Stressors

Land use is intensifying around many protected areas including parks and monuments (Wittemyer et al. 2008, Wade and Theobald 2010, Davis and Hansen 2011, Hansen et al. 2014). Many parks in the Heartland region are concerned with the ecological consequences of habitat loss associated with urbanization outside park boundaries, conversion of surrounding areas to non-natural uses, as well as the effects of runoff from impermeable surfaces on hydrologic flows through the parks (Hansen and Gryskiewicz 2003). The growth of housing adjacent to protected areas can create a patchwork of land use that degrades the conservation impact of high-value protected areas on adjacent parcels and within the region (Radeloff et al. 2010). Protected areas are most effective when they conserve habitat within their boundaries and are connected with other protected areas via intact corridors (Radeloff et al. 2010). According to the Radeloff et al. study, the main threat to protected areas in the U.S. is housing density, which is highly correlated with population density. Trends in the conversion of grasslands to corn and soybean cropping in recent years within the Corn Belt (portions of Minnesota, Iowa, Nebraska, South Dakota and North Dakota) may further degrade the conservation value of agricultural lands (Wright and Wimberly (2013). The adverse effects of development also impact the quality of the natural environment and visitor experience related to dark night skies, natural soundscapes and viewscapes/scenery.

Indicators and Measures

- Land cover and Use
    - Extent of Anderson Level I classes
    - Extent of natural vs. converted land cover

- Extent of impervious surface area
- Human population and housing
  - Housing density
  - Historical population: total and density
  - Population: current and projected total and density
- Conservation status
  - Protected area (ownership) extent
  - Biodiversity conservation status (level of protection)

4.2.2. Data and Methods

Spatial data for land cover, population, and housing used for condition and trend analysis were provided by the NPS NPScape Program and follow protocols described in Monahan et al. (2012). Sources of other data are noted below.

<u>Defining Areas of Interest</u>

Landscape context elements within and adjacent to the park were compared to resource conditions in the broader region surrounding the park. Landscape attributes important to park resources often vary with scale or spatial extent. Relevant scales or areas of analysis (AOAs) include the landscape within the park itself (i.e., the reporting unit used for many focal resources in this report), the 'boundary' area immediately adjacent to the park (e.g., 3 km buffer), the local area surrounding a park (e.g., within 30 km of the park boundary), the watershed area(s) upstream from the park influencing park streams, nearby counties, and the broader ecoregion. Areas of analysis used for the different landscape context indicators and metrics are based on recommendations from Monahan et al. (2012) (Table 4-1), and serve to capture a variety of scales to facilitate examination of the integrated effects of human activities. Contributing upstream watershed is included because it significantly influences water quality and watershed/hydrologic characteristics (Monahan and Gross 2012). The park is relatively small, regional topography is very gentle, and climate is fairly uniform throughout the areas of interest.

<u>Land Cover</u>

USGS National Land Cover Dataset (NLCD) data for 2006 was used to characterize current/recent conditions. NLCD data products are derived from Landsat Thematic Mapper (TM) imagery with a 30m pixel resolution. NLCD change detection is a very powerful tool because it follows a well-documented, consistent procedure that is highly repeatable over time. Although NLCD data date back to 1992, differences in classification and analysis methods do not favor comparison of the 1992 data with 2006 data (Monahan et al. 2012). We present the 2006 NLCD data. Procedures for the summarization of data for the following indicators are from NPS (2014a).

Anderson land cover/land use classes: NLCD data were interpreted and classified using Anderson Level I land cover classes (Table 4-1) for the areas of analysis listed in Table 4-2.

Table 4-1 Anderson land cover/land use classes (Anderson et al. 1976) and rules for reclassifying Anderson land cover as natural vs. converted land cover.

Anderson Level I	Anderson Level II	Natural/Converted
Open Water		Natural
Developed		Converted
Barren/Quarries/Transitional		Natural
Forest		Natural
Shrub/Scrub		Natural
Grassland/Herbaceous		Natural
Agriculture	pasture/hay vs. cultivated agriculture	Converted
Wetlands		Natural

Table 4-2. Areas of analysis used for landscape context measures.

	Areas of Analysis				
Indicators and Measures	**3 km Buffer Around Park**	**Park + 30 km Buffer**	**Contributing Upstream Watershed**	**Counties Overlapping With Park + 30 km Buffer**	**Tallgrass Prairie Region**
Land cover and use					
Anderson Level I	X	X	X		
natural vs. converted land cover	X	X	X		X
impervious surfaces			X		
Human Population and Housing					
population total and density by census block group (historical and projected)		X			
historical population totals by county				X	
housing density 1970-2010		X	X		
Conservation status					
Protected areas (ownership) and biodiversity conservation status	X	X			X

Acreage of natural vs. converted land cover: The NLCD Anderson Level I "developed" and "agriculture" classes were reclassified as "converted" (Table 4-1) and analyzed using the areas of analysis listed in 4.1-1. Other classes were classified as "natural".

Impervious surface area: The NLCD Anderson Level I "developed" classes are reclassified as "impervious" and all other land cover classes were classified as "pervious" and analyzed using the areas of analysis listed in Table 4-2. Areas that are more impervious reduce the amount of water infiltration into the soil and local water tables, and contribute to altered hydrographs and flashier runoff characteristics.

Historical land cover and land use changes at PIPE were examined by Narumalani et al. (2004). Aerial photography spanning a period of six decades, IKONOS pan-sharpened (1 meter pixel) data, and input from the National Park Service were used to develop land cover classification maps for the late 1930s, l960s and l990s. A post-classification algorithm was applied to derive land cover changes, and landscape metrics were used to analyze specific habitat classes. Specific imagery for the project included aerial photography from 1938 and 1968, digital USGS orthophoto quadrangles from 1991-1997 (1:12,000 black and white), and 1m pixel Ikonos color imagery from 2001. A total of 15 land cover/land use categories were identified for PIPE comprising a combination of the USNVC Formation Class (Grossman et al. 1998) and Anderson land use classes (Anderson et al. 1976). A one hectare minimum mapping unit was applied to classify and delineate land cover/land use polygons, in conjunction with site visits and collaboration with park staff. Land cover classes included upland forests/woodlands, cropland, degraded prairie/pasture, tallgrass prairie, native prairie plantings, other croplands (mainly smooth brome and reed canary grass strips), pasture, Sioux quartzite prairie, farm ponds, rivers and streams, commercial, farmsteads and agriculture buildings, urban, roads and railroads, and residential. The 2004 analysis examined the area extending approximately 5 km out from the monument boundary, including the City of Pipestone. The Narumalani et al. analysis focused on temporal changes in class-level metrics expressed as the total acreage or change of a given class integrated across all patches. Change detection for class-level metrics was used to highlight and evaluate ramifications of human (or human-induced activities) on the "natural" vegetation cover within and around the monument. Map products illustrate where changes occurred (Narumalani et al. 2004).

<u>Human Population and Housing</u>

Housing Density

Change from 1970 to 2010 and projected changes to 2050 were examined. The NPScape housing density metrics used here are based on the Spatially Explicit Regional Growth Model (SERGoM v3) (Theobald 2005). Housing density data are categorized into 11 non-uniform development classes described by Theobald (2005): rural (0-0.0618 units/ha), exurban (0.0618- 1.47 units/ha), suburban (1.47-10.0 unit/ha), and urban (> 10.0 units/ha). The non-uniform ranges permit a much finer delineation of areas of low-density housing than is common for non-ecological studies (Monahan et al. 2012).

Total Population and Population Density

Historical data was derived from county-level population totals for all counties overlapping with the 30 km park buffer and, and U.S Census Bureau block data from 1990, 2000 and 2010 for population density. Population density (number of people per square kilometer) classes follow NPScape guidance (NPS 2014b).

Conservation Status

For our region of interest, the two primary sources of protected areas data were the Protected Areas Database-US (PAD-US) Version 2 (Conservation Biology Institute 2013) and the National Conservation Easement Database (NCED). The two databases are designed to be used together to show comprehensive protection status for areas of interest while using compatible database attributes such as ownership type and agency.

Ownership

Land ownership greatly influences the level of conservation protection. The PAD-US (CBI Edition) Version 2 is a national database of protected fee lands in the United States. It portrays the United States protected fee lands with a standardized spatial geometry with valuable attribution on land ownership, management designations, and conservation status (using national GAP coding systems). The National Conservation Easement Database (NCED) Version III (July 2013) is a voluntary national geospatial database of conservation easement information that compiles records from land trusts and public agencies throughout the United States. It is a collaborative partnership by the Conservation Biology Institute, Defenders of Wildlife, Ducks Unlimited, NatureServe, and Trust for Public Land (National Conservation Easement Database 2013). As of May 2013, the acreage of publicly-held easements is considered to be 90% complete for Minnesota; the accounting of the acreage of NGO-held easements in Minnesota is currently estimated at approximately one percent complete. The low percentage of completeness for NGO-held easements is because: 1) they have not been digitized, 2) they were withheld from NCED, or 3) the NCED team is still working with the easement holders to collect the information (http://www.conservationeasement.us/about/completeness).

Level of Protection

The United States Geological Survey Gap Analysis Program (GAP) uses a scale of 1 to 4 to categorize the degree of biodiversity protection for each distinct land unit (Scott et al. 1993). A status of "1" denotes the highest, most permanent level of maintenance, and "4" represents no biodiversity protection or areas of unknown status. The PAD-US (CBI Version 2) database includes the coded GAP biodiversity protection status of each parcel. The NECD database is designed to accommodate the GAP protection status field but most parcels have not been assigned a GAP conservation value. The four status categories are described below.

> **Status 1:** These areas have permanent protection from conversion of natural land cover and a mandated management plan in operation to maintain a natural state within which disturbance events (of natural type, frequency, and intensity) are allowed to proceed without interference or are mimicked through management. Most national parks, Nature Conservancy preserves, some

wilderness areas, Audubon Society preserves, some USFWS National Wildlife Refuges and Research Natural Areas are included in this class.

Status 2: These areas have permanent protection from conversion of natural land cover and a mandated management plan in operation to maintain a primarily natural state, but which may receive use or management practices that degrade the quality of existing natural communities. Some national parks, most wilderness areas, USFWS Refuges managed for recreational uses, and BLM Areas of Critical Environmental Concern are included in this class.

Status 3: These areas have permanent protection from conversion of natural land cover for the majority of the area, but may be subject to extractive uses of either a broad, low-intensity type or localized intense type. This class also confers protection to federally-listed endangered and threatened species throughout the area. Most non-designated public lands, including USFS, BLM and state park land are included in this class.

Status 4: These areas lack irrevocable easement or mandate to prevent conversion of natural habitat types to anthropogenic habitat types. This class allows for intensive use throughout the tract, and includes those tracts for which the existence of such restrictions or sufficient information to establish a higher status is unknown. Most private lands fall into this category by default.

Protected areas data from the two databases was examined by owner type and by easement protection status within a 30 km buffer of the park boundary. GAP biodiversity protection values were summarized for NCED and PAD-US parcels by ownership type within the 30 km buffer areas of interest. Protected areas data was also examined within the entire range of the tallgrass prairie ecoregion. There is some spatial overlap between the PAD-US and NCED databases due to the existence of easements on some lands owned by federal, state and local agencies. Where easements existed on these public (i.e., protected) lands, the acreages were reported by owner only to avoid double counting in the number of protected acres.

4.2.3. Condition and Trend

Land Cover and Use

Extent of Anderson Level I Classes: Park Creation to 2000

The most notable change at PIPE for the period 1940s-1960s was the loss of pasture to cropland and urbanization (Figure 4-1, Figure 4-2). The three largest types of land-use conversions during the period for the area of analysis were pasture to cropland (406 ha), cropland to commercial (173 ha), and cropland to urban (149 ha). The reclassification of some areas of degraded prairie/pasture to Sioux quartzite prairie over time contributed to a loss in the total area of pasture area over time. The 1938 classification showed no forested acreage. During the 1960s-1990s period 60% of the savanna woodlands matured into deciduous forest. At the same time pasture areas continued to lose ground mainly through conversion to cropland and/or degraded prairie/pasture. The period from the 1940s to 1990 saw a significant increase in urbanization through infrastructure development (e.g., roads and railroads) as well as commercial (e.g., agricultural buildings) and residential development.

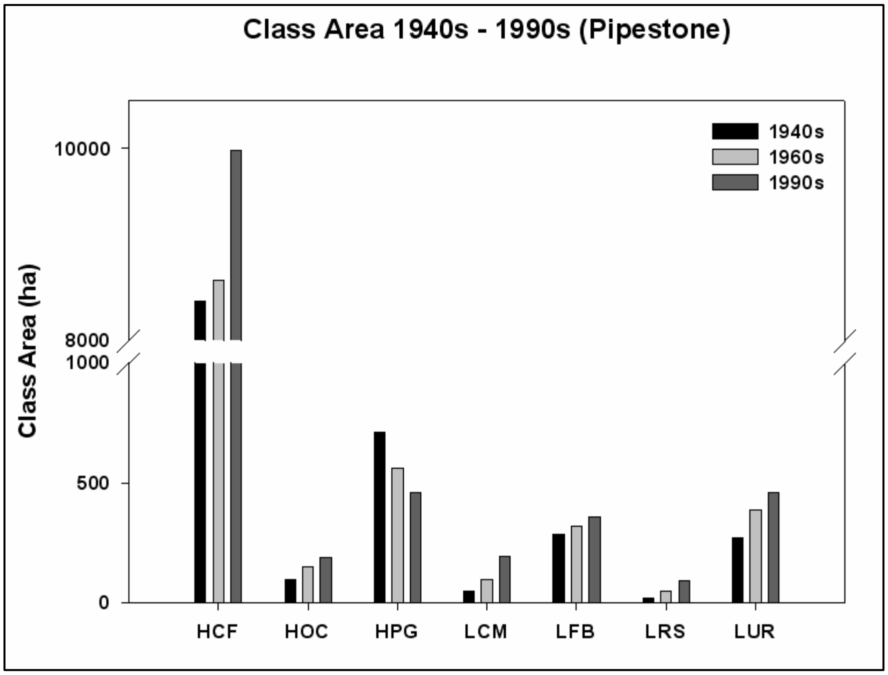


Figure 4-1. Changes in total area of land cover classes at Pipestone National Monument and the surrounding area for the 1940s, 1960s and 1990s derived from image interpretation (Narumalani et al. 2004). HCF=croplands, HOC=other croplands, HPG=pasture, LCM=commercial, LFB=farmsteads and agriculture buildings, LRS=residential, and LUR=urban.

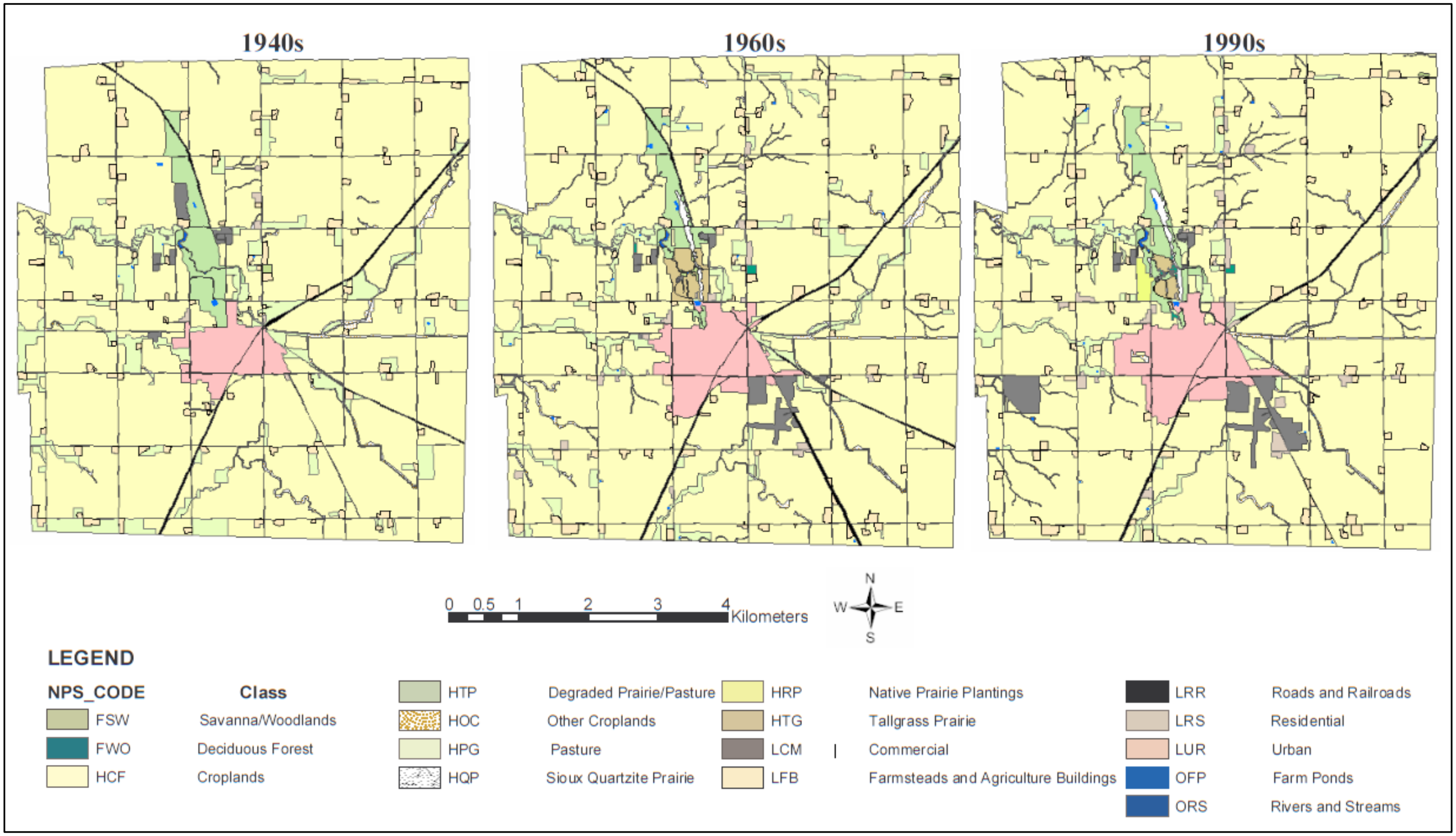


Figure 4-2. Land use/land cover classification maps of Pipestone National Monument and the surrounding area for the 1940s, 1960s, and 1990s derived from image interpretation (Narumalani et al. 2004).

The general decline in pasture areas and patch size and accompanying increases in cropland indicate changes in agricultural practices in the region. Shifts in the proportions of pasture vs. cropland may be influenced by soil conservation goals, changes in economic subsidies for grain crops, changes in profit margins, and changing demand for crops such as corn.

Extent of Anderson Level I Classes 2006

In the immediate vicinity of PIPE (3 km buffer) over 66% of land acreage is used for agriculture, and nearly 20% is developed (Table 4-3, Figure 4-3, Figure 4-4), reflecting the proximity of the park to the City of Pipestone. Within the 30 km buffer, over 32% of the acreage is agricultural and 5% is developed. The area within 3 km of the park boundary is more developed compared to the surrounding 30 km area. Land cover of the contributing upstream watershed of Pipestone Creek is over 83% agriculture, partially explaining the impaired condition of water quality in Pipestone Creek. The interaction between agricultural acreage and housing development, which is an important aspect of land cover and land use surrounding PIPE, is discussed in the *Population and Housing* section. The next most prevalent land cover class for all AOA's is grassland/herbaceous. These grassland areas are small and very fragmented, and likely have lost most of their ecological function (Figure 4-3).

Table 4-3. Anderson Level 1 land cover classes within 3 km and 30 km of the park boundary, and within the contributing upstream watershed of the park.

	3 km Buffer		Park + 30 km Buffer		Contributing Upstream Watershed	
Anderson Level I Classes	**Acres**	**% of Area**	**Acres**	**% of Area**	**Acres**	**% of Area**
Open Water	27	0.26%	2,423	0.33%	3	0.01%
Developed	2,075	19.87%	39,002	5.34%	2,146	10.02%
Barren/Quarries/Transitional	0	0.00%	296	0.04%	<1	0.00%
Forest	93	0.89%	4,522	0.62%	149	0.69%
Scrub/Shrub	<1	0.01%	762	0.10%	5	0.02%
Grassland/Herbaceous	1,187	11.37%	74,048	10.14%	1,129	5.27%
Agriculture	6,978	66.82%	601,152	82.34%	17,945	83.76%
Wetlands	83	0.80%	7,850	1.08%	48	0.22%
Total	**10,443**		**730,086**		**21,425**	

Within the Western Corn Belt Region, which encompasses portions of Minnesota, Iowa, Nebraska, South Dakota and North Dakota an accelerated rate of conversion of grasslands (including native and anthropogenically modified grassland types) to croplands such as corn and soybeans was documented between 2006 and 2011 (Wright and Wimberly 2013). Results indicated a net decline in grass-dominated land cover totaling nearly 530,000 ha (>1.3 million acres) over the five-year time period, with annual conversion rates varying from 1.0-5.4%. In Minnesota and eastern South Dakota, the net loss of grassland to corn and soybeans was estimated at 262,000 ha (647,400 acres). This trend will reduce the amount of native prairie and other pasture and hay fields, reduce connectivity among grassland patches, and reduce wildlife habitat value while further altering watershed characteristics and water quality.

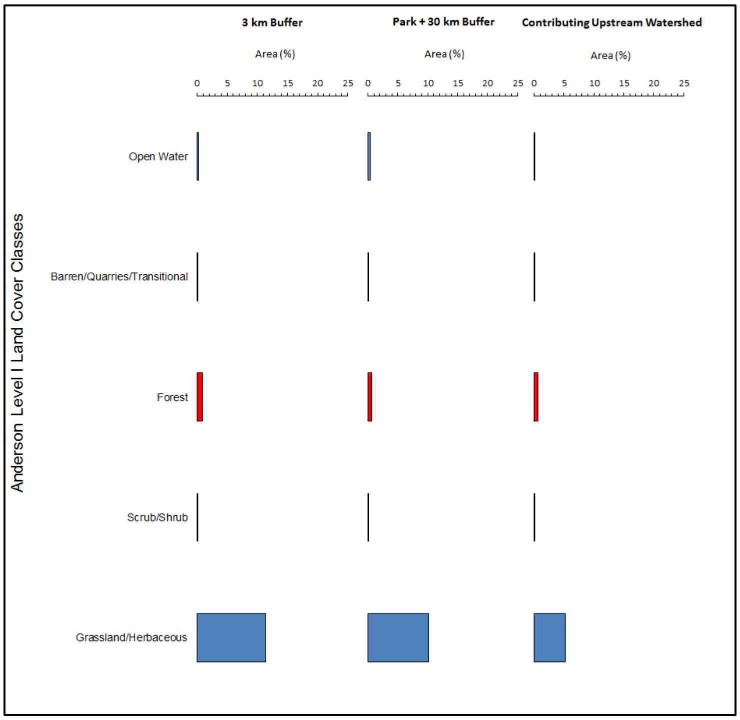


Figure 4-3. Anderson Level 1 land cover class proportions within 3 km and 30 km of the park boundary, and within the contributing upstream watershed of the park. Developed and agriculture land cover classes are omitted here to improve the scale of the graphic.

Natural vs. Converted Land Cover

Change in natural land cover is possibly the most basic indication of habitat condition (O'Neill et al. 1997). Knowing the proportion of natural land cover to converted land area provides a general indication of overall landscape condition, offering insight into potential threats and opportunities for future conservation.

The proportion of converted acreage surrounding PIPE is high in relation to the Tallgrass Prairie ecoregion as a whole (Table 4-4). Within 30 km of the park boundary, only 12.3% of the area is classified as natural, and only 6.2% of the contributing upstream watershed is classified as natural (Figure 4.1-5). Within the 30 km neighborhood, much of the area classified as natural is located on state conservation lands. The low proportion of natural acreage is largely attributed to the heavy agricultural use of the surrounding area, both for pasture and crops (Figure 4-4).

Table 4-4. Natural vs. converted acreage within 3 km and 30 km of the park boundary, within the contributing upstream watershed of the park, and within the Tallgrass Prairie Ecoregion.

	Natural		Converted	
AOA	**Acres**	**% of Area**	**Acres**	**% of Area**
3 km	1,390	13.31%	9,053	86.69%
Park + 30 km Buffer	89,900	12.31%	640,186	87.69%
Contributing Upstream Watershed	1,334	6.22%	20,091	93.78%
Tallgrass Prairie Ecoregion	63,104,955	32.73%	129,810,610	67.27%

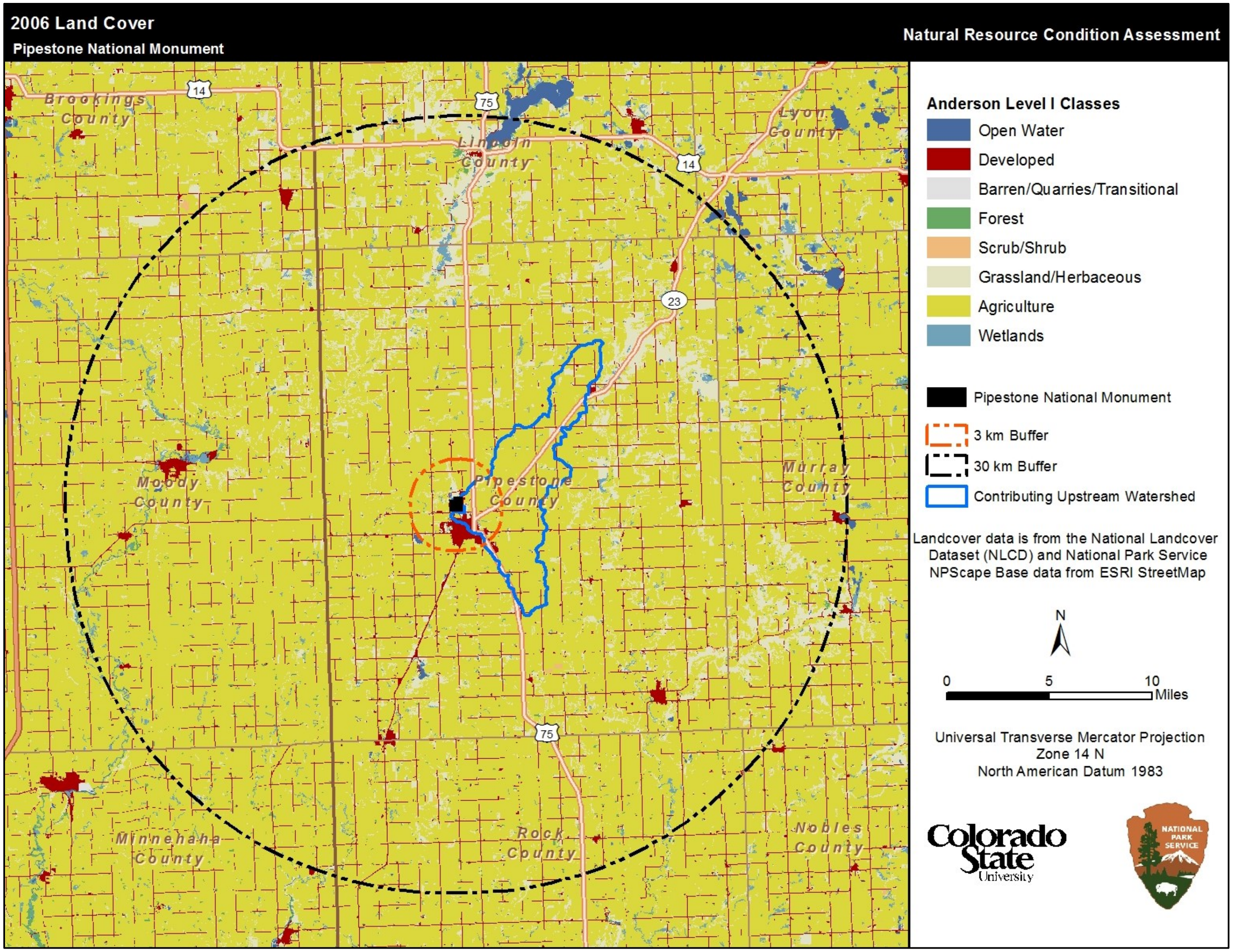


Figure 4-4. Anderson Level 1 land cover classes within 3 km and 30 km of the park boundary, and within the contributing upstream watershed of the park. National Land Cover Dataset data provided by NPS NPScape Program.

Impervious Surface Area

Impervious surfaces include bare rock, paved roads, and areas covered with concrete/cement. These surfaces prevent infiltration of precipitation into the ground. This reduced infiltration can cause significant hydrological effects including quicker runoff into streams and rivers resulting in flooding, more rapid rising and dropping of streamflow after precipitation events, reduced local evapotranspiration, and reduced recharge of local aquifers. Imperviousness can also increase aquatic pollution as contaminant transport is increased by water flowing directly to a stream or other water body without the opportunity for uptake or decomposition by plants and soil organisms. The effects of imperviousness on hydrology are especially pronounced in smaller watersheds, such as the contributing watershed upstream of the monument's Pipestone Creek (21,425 acres).

Most of PIPE's contributing upstream watershed is in the lowest imperviousness class (0-2% impervious surfaces) (Table 4-5, Figure 4-5). There is a low degree of imperviousness in relation to other parks in the region. This is most likely attributable to the fact that although the area is highly converted, most of the converted acreage is agricultural land, which retains a significant amount of its permeability. As a benchmark for future analysis, approximately 2.6% of the contributing upstream watershed of the park was classified as having >25% impervious surfaces (Table 4-5), the vast majority of which is concentrated near the town of Pipestone (Figure 4-6).

Table 4-5. Percent impervious surfaces acreage based on Anderson land cover classes within the contributing upstream watershed of the park.

Percent Impervious Surface	Acres	% of Area
0% - 2%	19,543	91.22%
2% - 4%	431	2.01%
4% - 6%	246	4.15%
6% - 8%	155	0.72%
8% - 10%	115	0.54%
10% - 15%	172	0.80%
15% - 25%	198	0.92%
25% - 50%	301	1.40%
50% - 100%	264	1.23%
Total	**21,425**	

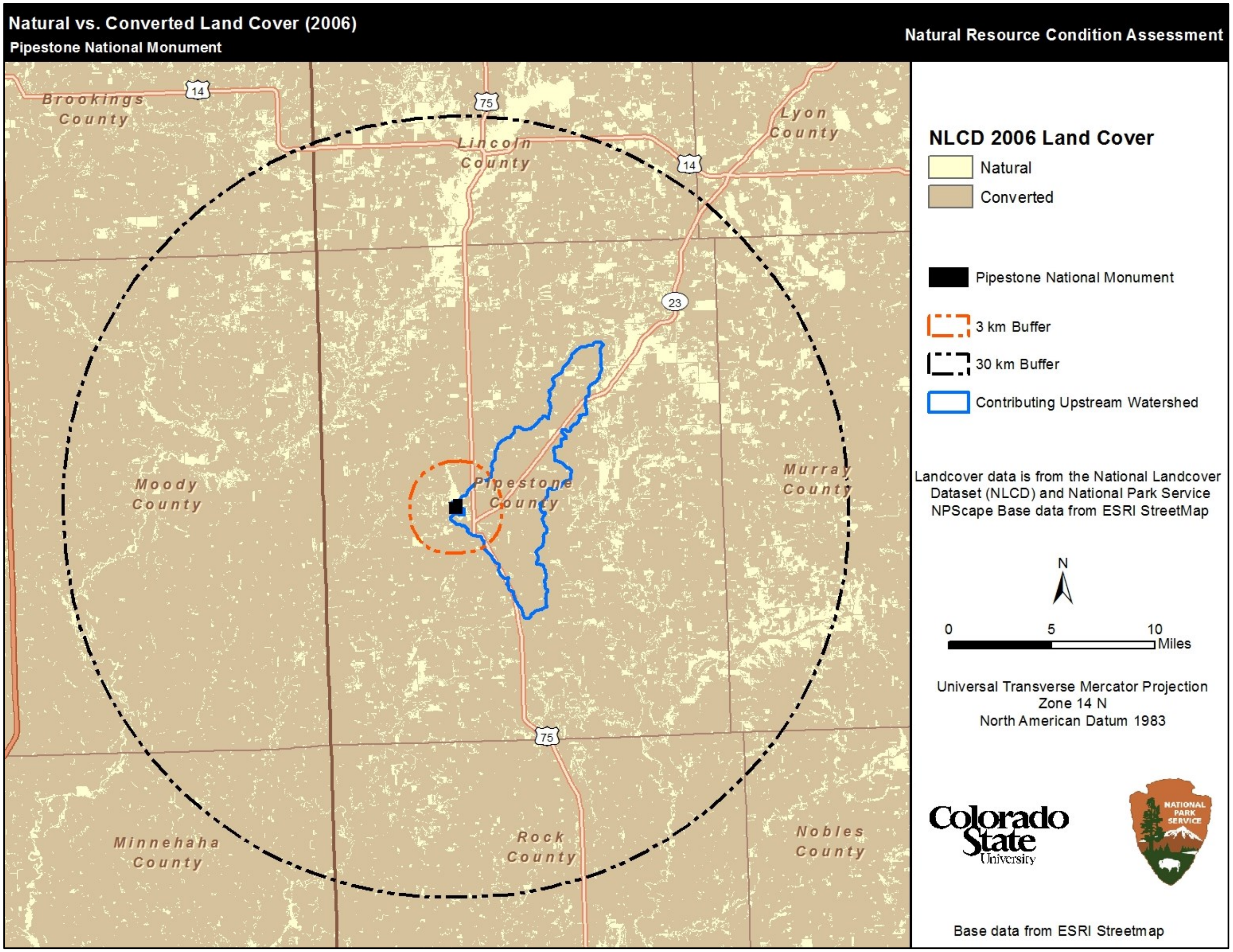


Figure 4-5. Natural vs. converted land cover classes within 3 km and 30 km of the park boundary, and within the contributing upstream watershed of the park. 2006 National Land Cover Dataset data provided by NPS NPScape Program.

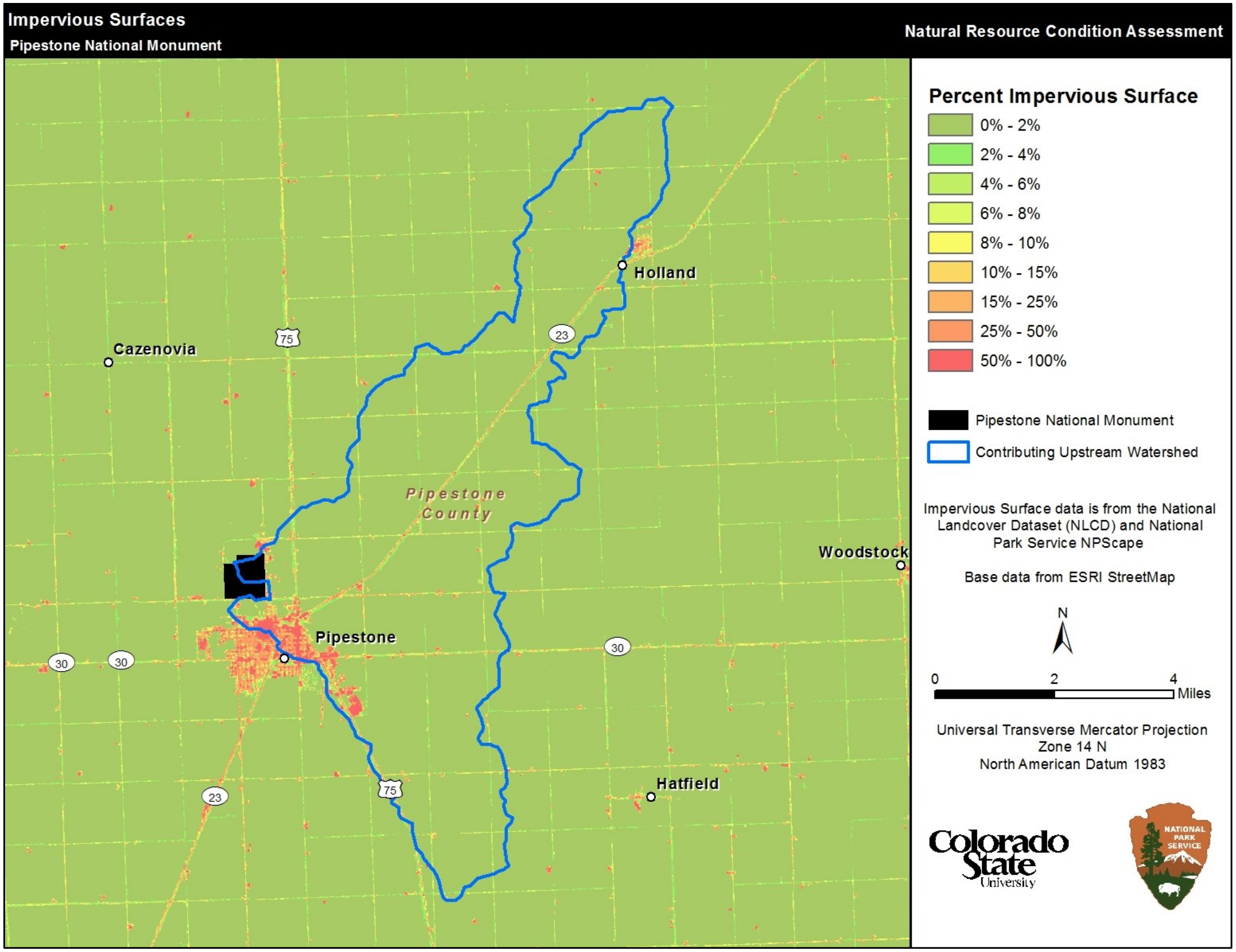


Figure 4-6. Percent impervious surfaces based on Anderson land cover classes within 3 km and 30 km of the park boundary, and within the contributing upstream watershed of the park. National Land Cover Dataset data provided by NPS NPScape Program.

Population and Housing

Historical and Projected Population

High human population density has been shown to adversely affect the persistence of habitats and species (Kerr & Currie 1995, Woodroffe 2000, Parks and Harcourt 2002, Luck 2007). Conversion of natural landscapes to agriculture, suburban, and urban landscapes is generally permanent, and this loss of habitat is a primary cause of biodiversity declines (Wilcove et al. 1998). Human conversion of landscapes can alter ecosystems and reduce biodiversity by replacing habitat with non-habitable cover types and structures, fragmenting habitat, reducing availability of food and water, increase disturbance by people and their animals, alter vegetation communities, and increase light, noise, and pollution.

Population density within 30 km of the monument's boundary is low, with most of the area within this 30 km radius having a density of 1-20 people/km^2 (Table 4-6, Figure 4-7) and consisting of agricultural fields. Historically, population has been relatively constant with the exception of Minnehaha County, South Dakota (Figure 4-8), which contains the City of Sioux Falls.

There appears to be a trend in conversion of rural (agricultural) land to exurban housing developments. In addition, a large portion of the acreage surrounding PIPE is private agricultural land, which is more readily converted to housing than other types of land coverage (Hansen and Gryskiewicz 2003).

Table 4-6. Population density classes and acreage for 1990, 2000, and 2010 by census block group for the park and surrounding 30 km buffer.

	Census Year					
	1990		2000		2010	
Population Density (#/km^2)	**Acres**	**% of Area**	**Acres**	**% of Area**	**Acres**	**% of Area**
1 - 20	1,202,295	97.37%	1,352,210	98.15%	1,269,671	98.75%
21 – 75	23,965	1.94%	15,078	1.09%	7,957	0.62%
76 – 150	7,127	0.58%	7,203	0.52%	5,003	0.39%
151 – 300	713	0.06%	2,461	0.18%	1,864	0.14%
301 – 750	379	0.03%	616	0.04%	1,217	0.09%
751 – 1200	340	0.03%	117	0.01%	0	0.00%
1201 – 1500	0	0.00%	0	0.00%	0	0.00%
1501 – 2000	0	0.00%	0	0.00%	0	0.00%
2001 – 3000	7,170	0.58%	0	0.00%	0	0.00%
>3000	27,163	2.20%	0	0.00%	0	0.00%

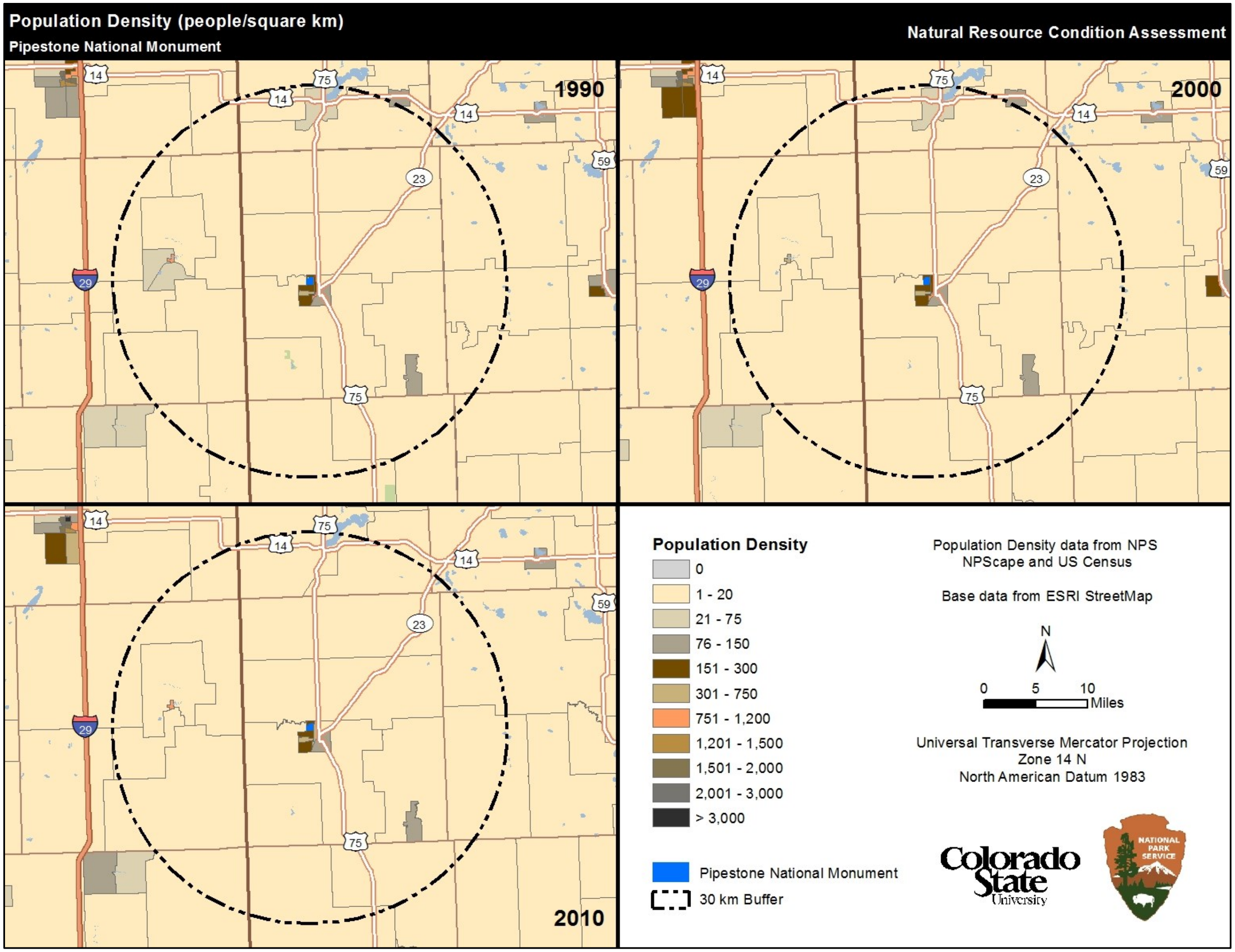


Figure 4.7. Population density for 1990, 2000, and 2010 by census block group for the park and surrounding 30 km buffer. The vertical brown line left of center represents the Minnesota-South Dakota state line. U.S. Census data provided by NPS NPScape Program.

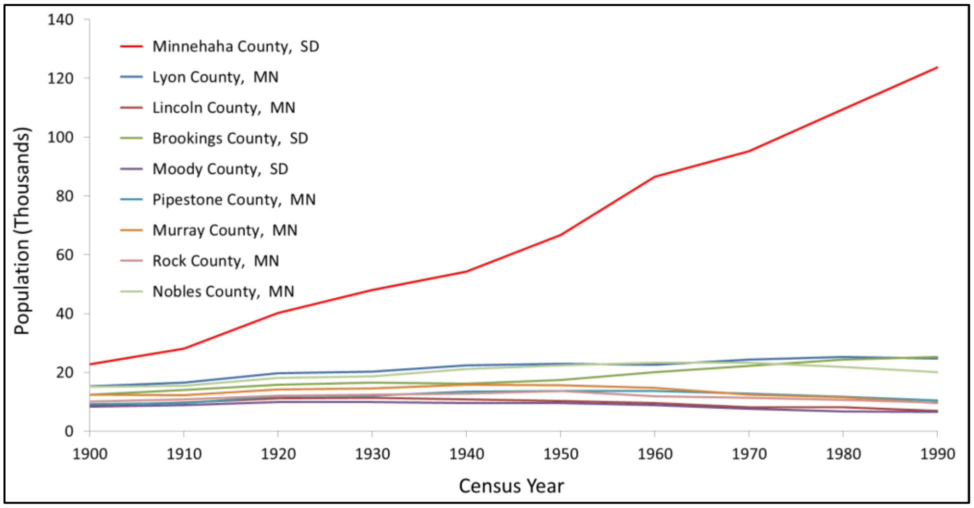


Figure 4-8. Historical population by decade for counties within 30 km of PIPE.

Housing Density

Housing density in the region surrounding the park shows marked patterns of change between 1970 and 2010 (Table 4-7, Figure 4-9). Areas shown in white in Figure 4-9 are primarily State Wildlife Management Areas and open water. Within a 30 km radius of the park, the most notable trend is an increase in exurban areas and a corresponding decrease in rural acreage. There is an increase in the acreage of suburban areas but the major change in housing density is associated with existing urban centers such as Flandreau and Pipestone. However, there is also a pattern of increasing exurban housing density in unincorporated areas, including areas close to towns and major roads. Acreage for urban, commercial/industrial, and urban regional park classes for 2010 were 40 (0.06%), 74 (0.11%, and 36 (0.06%), respectively. These acreages are not forecasted to significantly change by 2050. Beyond the 30 km area of interest, the largest changes in housing density are associated with the corridors of Interstates 90 and 29 and the cities of Brookings, Dell Rapids, Sioux Falls, Luvern, Worthington and Marshall. These general patterns of change are projected to continue to 2030 and beyond.

Table 4-7. Historical and projected housing density by decade for 1970-2050 for the park and surrounding 30 km buffer.

	Housing Density Classes					
	Rural (0 – 0.0618 units/ha)		Exurban (0.0618 – 1.47 units/ha)		Suburban (1.47 – 10.0 units/ha)	
Census Year	Acres	% of Area	Acres	% of Area	Acres	% of Area
1970	60,352	93.15%	4,155	6.41%	143	0.22%
1980	58,789	90.74%	5,703	8.80%	150	0.23%
1990	57,358	88.53%	7,127	11.00%	155	0.24%
2000	54,606	84.28%	9,876	15.24%	171	0.27%

Table 4-7 (continued). Historical and projected housing density by decade for 1970-2050 for the park and surrounding 30 km buffer.

	Housing Density Classes					
	Rural (0 – 0.0618 units/ha)		Exurban (0.0618 – 1.47 units/ha)		Suburban (1.47 – 10.0 units/ha)	
Census Year	Acres	% of Area	Acres	% of Area	Acres	% of Area
2010	54,549	84.20%	9,934	15.33%	167	0.26%
2020	54,439	84.03%	10,043	15.50%	168	0.26%
2030	54,354	83.90%	10,129	15.63%	168	0.26%
2040	54,310	83.83%	10,173	15.70%	168	0.26%
2050	54,268	83.76%	10,215	15.77%	168	0.26%

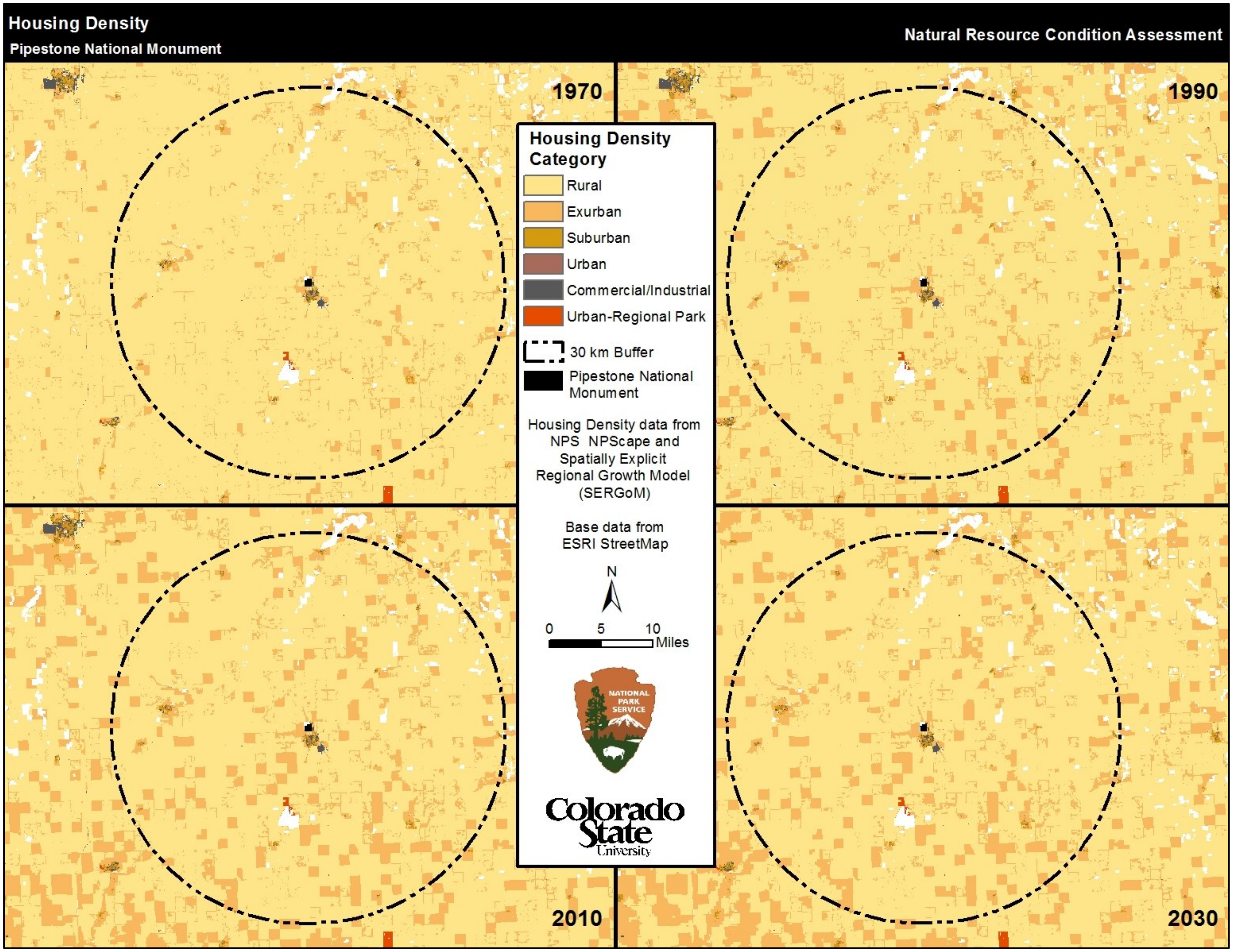


Figure 4-9. Historical and projected housing density for 1970, 1990, 2010 and 2030 for the park and surrounding 30 km buffer. SERGOM data provided by NPS NPScape Program.

Conservation Status

Spatial data from the Protected Areas Database-US (PAD-US) Version 2 (Conservation Biology Institute 2013) and the National Conservation Easement Database (NCED) were consolidated to show comprehensive protection status for areas of interest while using compatible database attributes such as ownership type and agency (Figure 4-10). The analysis illustrates the paucity of protected areas near the park and in the larger region.

Ownership

Across the tallgrass prairie region, over 95% of lands is privately held and has no formal conservation protection status (Table 4-8). Within the 30 km park buffer, contributing upstream watershed, and the Tallgrass Prairie ecoregion, most protected land is owned by the Federal and state governments. The 30 km park buffer and contributing upstream watershed areas of analysis (AOAs) each have less than half as much protected area as the Tallgrass Prairie ecoregion as a percentage of the total AOA.

Table 4-8. Acreage of lands within 30 km of the boundary of Pipestone National Monument, within the contributing upstream watershed of the park, and within the Tallgrass Prairie ecoregion having some level of conservation protection. Percentages are the proportion of total AOA area.

	Park + 30 km Buffer		Contributing Upstream Watershed		Tallgrass Prairie Ecoregion	
Ownership	**Acres**	**% of Area**	**Acres**	**% of Area**	**Acres**	**% of Area**
Federal	420	0.06%	420	1.96%	2,697,850	1.40%
Native American	0	0.00%	0	0.00%	1,342,495	0.70%
State	8331	1.14%	14	0.07%	2,642,484	1.37%
City and County	0	0.00%	0	0.00%	253,233	0.13%
Private Conservation	1348	0.18%	0	0.00%	202,828	0.11%
Joint Ownership/Unknown	0	0.00%	0	0.00%	148,056	0.08%
Other Conservation Easement	1794	0.25%	0	0.00%	874,316	0.45%
Total	**11,892**	**1.63%**	**434**	**2.03%**	**8,161,263**	**4.23%**

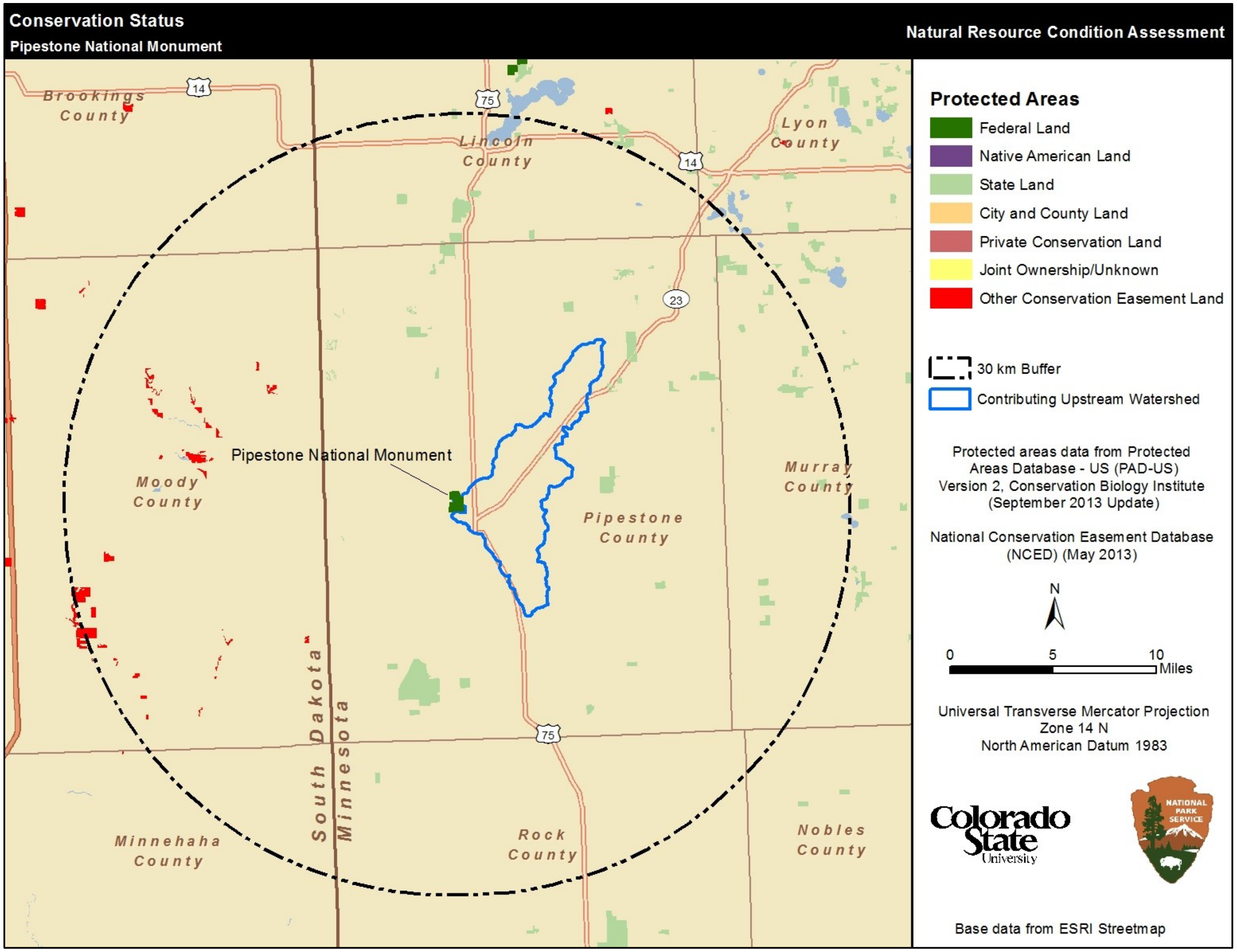


Figure 4-10. Conservation status of lands within 30 km of the boundary of Pipestone National Monument. Map classes combine ownership from the NCED database and biodiversity conservation status from the PAD-US protected areas database.

Level of Protection

There are differences in the inferred protection status of lands within each of the AOA's. Within 30 km of the monument, there is substantial land area within each biodiversity protection status level (Table 4-9). Approximately 0.5% of the land area is classified as having Level I or Level II protection. Most of the protected acreage in the contributing upstream watershed is Level II. For comparison, more than half of the protected acreage in the Tallgrass Prairie ecoregion is Level IV, the default, low-level protections status for private lands or those with unknown conservation status. More than 95% of land area in each of the AOA's is not protected, which highlights the importance of the monument and other occasional parcels that do provide biodiversity protection in the region. Moreover, in protected areas such as Pipestone National Monument natural processes and disturbance regimes are more likely to occur and support a greater degree of biodiversity, as well as provide critical linkages to the surrounding natural landscape.

Table 4-9. Biodiversity protection status of lands within 30 km of the park boundary, within the contributing upstream watershed of the park, and within the Tallgrass Prairie ecoregion (PAD-US and NCED data). Percentages are the proportion of total AOA area.

	Park + 30 km Buffer		Contributing Upstream Watershed		Tallgrass Prairie Ecoregion	
Protection Level	**Acres**	**% of Area**	**Acres**	**% of Area**	**Acres**	**% of Area**
I (highest)	1,767	0.24%	0	0.00%	241,924	0.13%
II	2,567	0.35%	304	1.42%	1,069,131	0.55%
III	4,434	0.61%	130	0.61%	2,359,903	1.22%
IV (lowest/status unknown)	3,124	0.43%	0	0.00%	4,490,304	2.33%
Total	**11,893**	**1.63%**	**434**	**2.03%**	**8,161,263**	**4.23%**

Land Cover and Land Use Summary

Overall, the monument has similar threats and stressors to other parks in the Tallgrass Prairie ecoregion. Most of these land cover and land use-related stressors at PIPE and in the larger region are related to the development of rural agricultural land and increases in population/housing over time. Conversion of hay and pasture lands to cropland is also a concern, as the former class has much higher conservation value. This trend in land development, coupled with the lack of significantly-sized and linked protected areas, is of significant concern to the conservation of natural resources of Pipestone National Monument to also include dark night skies, natural sounds and scenery. This summary of land cover and land use metrics provides a useful context of known stressors, supports resource planning and management within the park, and provides a foundation for collaborative conservation with other landowners in the surrounding area.

4.2.4. Uncertainty and Data Gaps

There are several sources of uncertainty associated with our analysis. The first is related to the single point in time (2006) that was examined for in land cover and land use using NLCD data. The inclusion of 2011and other data in the future will provide a more robust assessment of trends and rates of change in land cover and land use. Another source of uncertainty is associated with assumptions regarding the relationships between land ownership and conservation status. Although information about ownership and protection status can be useful, the degree to which biodiversity is represented within the existing network of protected areas is largely unknown (Pressey at al. 2002). Protection status and extent must be combined with assessments of conservation effectiveness (e.g., location, design, and progress toward conservation objectives) to achieve more meaningful results (Chape et al. 2005).

Table 4-10. Summary for landcover and land use indicators, Pipestone National Monument.

Indicator	Summary Notes Integrating Results for 3 km, Contributing Upstream Watershed and 30 km Areas of Interest
Land cover	
Extent of Anderson Level I and II classes	Most of the acreage surrounding PIPE is agricultural land. The next most prevalent land use is developed, most of which is housing developments.
Extent of impervious surface area	Highly impervious areas are concentrated in and around the city of Pipestone. Although the watershed is highly converted, most of the converted acreage is agricultural land, which retains a significant amount of its permeability.
Extent of natural vs. converted land cover	The proportion of converted acreage surrounding PIPE is high in relation to the Tallgrass Prairie Ecoregion as a whole. This can be attributed to the heavy agricultural use of the surrounding area, both for pasture and crops.
Population and Housing	
Historical and projected population total and density	Population density within 30 km of the monument's boundary is low, with most of the area having a density of 1-20 people/km^2. The low population density is attributable to the prevalence of agriculture surrounding the park. Historically, county populations in the surrounding area have been relatively stable with the exception of Minnehaha County, SD.
Housing density	Within a 30 km radius of the park, the most notable trend is an increase in exurban areas and a corresponding decrease in rural acreage. There is an increase in the acreage of suburban areas but the major change in housing density is associated with existing urban centers such as Flandreau and Pipestone. However, there is also a pattern of increasing exurban housing density in unincorporated areas, including areas close to towns and major roads.
Conservation Status	
Protected area extent and biodiversity protection status	Only a small portion of the acreage in the region surrounding the park is protected through ownership or conservation easements. The vast majority of land surrounding PIPE is private agricultural land, which generally has a low biodiversity protection level, limited conservation value, and is more readily developed than some other types of land. The rarity of protected lands within the region underscores the critical value of the park as a conservation island within a highly altered predominantly agricultural landscape.

4.2.5. Sources of Expertise

Bill Monahan, Ph.D., NPS Inventory and Monitoring Division, Fort Collins, Colorado. Dr. Monahan provided NPScape data summaries, consulted on the selection and use of various metrics, and provided helpful manuscript reviews.

4.2.6. Literature Cited

Anderson, J.R., E.E. Hardy, J.T. Roach and R.E. Witmer. 1976. A land use and land cover classification system for use with remote sensor data. USDI Geological Survey Professional Paper 964. A revision of the land use classification system as presented in U.S. Geological Survey Circular 671, United States Department of the Interior, Washington, D.C.

Conservation Biology Institute (CBI). 2013. Conservation Biology Institute protected areas database – US (PAD-US) Version 2 download website. http://consbio.org/products/projects/pad-us-cbi-edition (accessed 23 September 2013)

Chape, S., J. Harrison, M. Spalding and I. Lysenko. 2005. Measuring the extent and effectiveness of protected areas as an indicator for meeting global biodiversity targets. Philosophical Transactions of the Royal Society Biological Sciences 360:443–455

Davis, C. R., and A. J. Hansen. 2011. Trajectories in land-use change around U.S. National Parks and their challenges and opportunities for management. Ecological Applications 21:3299–3316.

Grossman, D.H., D. Faber-Langendoen, A.S. Weakley, M. Anderson, P. Bourgeron, R. Crawford, K. Goodin, S. Landaal, K. Metzler, K. D. Patterson, M. Pyne, M. Reid, & L. Sneddon 1998. International classification of ecological communities: terrestrial vegetation of the United States. Volume I. The National Vegetation Classification System: development, status, and applications. The Nature Conservancy, Arlington, Virginia

Hansen, A.J. and D. Gryskiewicz. 2003. Interactions between Heartland National Parks and surrounding land use change: development of conceptual models and indicators for monitoring. Prepared for the National Park Service Heartland Network by Montana State University.

Hansen, A.J., N. Piekielek, C. Davis, J. Hass, D.M. Theobald, J.E. Gross, W.B. Monahan, T. Olliff and S. W. Running. 2014. Exposure of U.S. National Parks to land use and climate change 1900–2100. Ecological Applications, 24(3), 2014, pp. 484–502

Kerr, J. T. and D. J. Currie. 1995. Effects of human activity on global extinction risk. Conservation Biology 9:1528–1538.

Luck, G.W. 2007. A review of the relationships between human population density and biodiversity. Biological Reviews 82:607-645.

Monahan, W. B., J. E. Gross. 2012. Upstream landscape dynamics of US national parks with implications for water quality and watershed management, in Sustainable Natural Resources Management, Dr. Abiud Kaswamila (Ed.), Available from: http://www.intechopen.com/books/sustainable-natural-resources-management/upstream-landscape-dynamicsof-us-national-parks-with-implications-for-water-quality-and-watershed-management.pdf

Monahan, W. B., J. E. Gross, L. K. Svancara, and T. Philippi. 2012. A guide to interpreting NPScape data and analyses. Natural Resource Technical Report NPS/NRSS/NRTR—2012/578. National Park Service, Fort Collins, Colorado.

Narumalani, S., D. Mishra, and R. Rothwell. 2004. Final report: land use/land cover interpretation and analysis for three national monuments. Calmit/University of Nebraska at Lincoln, Unpublished Report-2173388.

National Conservation Easement Database (NCED). 2013. National Conservation Easement Database website. http://nced.conservationregistry.org/ (Database download of September 2013 Update, accessed September 26 2013)

National Park Service (NPS). 2014a. NPScape standard operating procedure: land cover measure – area per category, impervious surface, change index, and natural vs. converted. Version [2014-05-01]. National Park Service, Natural Resource Stewardship and Science. Fort Collins, Colorado.

National Park Service (NPS). 2014b. NPScape standard operating procedure: population measure – current density and total. Version [2014-05-01]. National Park Service, Natural Resource Stewardship and Science. Fort Collins, Colorado.

O'Neill, R.V., C. T. Hunsaker, K. B. Jones, K. H. Riitters, J. D. Wickham, P. M. Schwartz, I. A. Goodman, B. L. Jackson, and W. S. Baillargeon. 1997. Monitoring environmental quality at the landscape scale. BioScience 47:513–519.

Parks, S.A. and A. H. Harcourt. 2002. Reserve size, local human density, and mammalian extinctions in US protected areas. Conservation Biology 16:800-808.

Pressey, R. L., G. L. Whish, T. W. Barrett and M. E. Watts. 2002 Effectiveness of protected areas in north-eastern New South Wales: recent trends in six measures. Biological Conservation 106:57–69.

Radeloff, V.C., S.I. Stewart, T.J. Hawbaker, U. Gimmi, A.M. Pidgeon, C.H. Flather, R.B. Hammer, and D.P. Helmers. 2010. Housing growth in and near United States protected areas limits their conservation value. Proceedings of the National Academy of Sciences of the United States of America. 107:940-945

Scott, J. M., F. Davis, B. Csuti, R. Noss, B. Butterfield, C. Groves, H. Anderson, S. Caicco, F. D'Erchia, T.C. Edwards, Jr., J. Ulliman, and R. G. Wright. 1993. Gap analysis: a geographic approach to protection of biological diversity. Wildlife Monographs 123:3-41.

Theobald, D.M. 2005. Landscape patterns of exurban growth in the USA from 1980 to 2020. Ecology and Society, 10(32)

Wade, A., and D. Theobald. 2010. Residential development encroachment on U.S. protected areas. Conservation Biology 24:151–161.

Wilcove, D.S., D. Rothstein, J. Dubow, A. Phillips, & E. Losos. 1998. Quantifying threats to imperiled species in the United States. BioScience 48:607-615.

Wittemyer, G., P.Elsen, W.T. Bean, A. Coleman, O. Burton and J.S. Brashares. 2008. Accelerated human population growth at protected area edges. Science 321:123–126.

Woodroffe, R. 2000. Predators and people: using human densities to interpret declines of large carnivores. Animal Conservation 3:165-173.

Wright, C.K. and M.C. Wimberly. 2013. Recent land use change in the Western Corn Belt threatens grasslands and wetlands. Proceedings of the National Academy of Sciences of the United States of America. March 5, 2013. Vol 110(10):4134–4139

4.3. Night Sky

4.3.1. Background and Importance

National parks serve as refuges for the endangered resource of natural darkness and starry night skies. Existing studies from the NPS Midwest Region since 2000 found that dark night skies are rated as "extremely" or "very" important by 57% of visitor groups (Kulesza 2013). The National Park Service recognizes the significance of naturally dark night skies to humans and many wildlife species and aims to protect the night skies of parks just like other important natural resources. With nearly half of all species being nocturnal and requiring naturally dark habitat, the presence of excessive artificial light may cause significant impacts to these species (Rich & Longcore 2006). For humans, there is cultural, scientific, economic, and recreational value associated with high-quality night skies. NPS Management Policies state that the NPS "will preserve, to the greatest extent possible, the natural lightscapes of parks, which are natural resources and values that exist in the absence of human-caused light" (NPS 2006). The Management Policies also provide specific actions that the NPS will take to prevent the loss of dark conditions and natural night skies: restricting the use of artificial lighting where safety and resource requirements allow, utilizing minimal-impact lighting techniques, and providing shielding for artificial lighting (NPS 2006).

The National Park Service defines a natural lightscape as the resources and values that exist in the absence of human-caused light at night time. Natural lightscapes are critical for night time scenery and nocturnal habitat. There are many species that depend on natural patterns of light and dark for navigation, predation and other natural processes. Light pollution can have a negative effect on the organisms within a park and can also reduce the enjoyment of park visitors. Light pollution is the introduction of artificial light either directly or indirectly into the natural environment. Light pollution degrades the view of the night sky by reducing the contrast between faint extraterrestrial objects and the background of the luminous atmosphere. An example of light pollution is sky glow, sometimes referred to as artificial sky glow, light domes or fugitive light; which is the brightening of the night sky from human caused light scattered into the atmosphere. Another form of light pollution is glare, which is the direct shining of light. Both of these forms of light pollution impact the human perception of nighttime, natural landscapes and features of the night sky (NPS 2014).

Excessive artificial light pollution in NPS units threatens to adversely impact natural and cultural resources and the quality of visitor experiences. It is important to document existing baseline conditions of the lightscapes in national park units so that monitoring of long-term changes can be implemented and management actions taken to restore natural conditions, where necessary (NPS undated). Poor air quality in combination with light pollution can dim the stars and other celestial objects and lead to reduced ability to see starry skies. Poor air quality also 'scatters' artificial light, resulting in parks near cities and other significant light sources having a greater 'sky glow' than if pollution was not present (Kulesza 2013). The NPS has clearly declared its commitment to protecting dark night skies for the benefit of natural ecosystems and the enjoyment of current and future generations of park visitors.

The monument's *Final General Management Plan and Environmental Assessment* (GMP) (NPS 2008) affirms the importance of the night sky in contributing to quality visitor experiences. The GMP lists the actions that the monument will take to assure that desired night sky conditions are attained. These management actions include working with neighboring community and agency partners to encourage protection of the night sky and evaluating impacts to the monument's lightscape from facilities within the monument (NPS 2008, p. 36). The GMP acknowledges the environmental impacts of continued visitor use under the Preferred Alternative: "Noise, artificial lighting, and human activities associated with ongoing visitor use of the national monument would prevent natural prairie ecosystems and wildlife populations from reaching their full potential in size and population density" (NPS 2008).

<u>Threats and Stressors</u>

The primary threat to dark night skies at Pipestone NM is anthropogenic light sources from development near the park boundaries and the adjacent City of Pipestone. These artificial light sources are a distinct threat to the natural and historical lightscape of the monument, as well as the quality of visitor experiences that can be offered to the public. As the city of Pipestone has encroached on the monument's borders, it becomes more difficult for the monument to provide a setting that maintains the historical and aesthetic values for which it was created. Some artificial light is generated at the Visitor Center and parking lot in the core of the park. Under the current GMP, the park Headquarters/Visitor Center and maintenance facilities would be removed from the center of the monument to improve scenery and restore ethnographic landscapes. This would also remove some light sources from the main core of the monument and marginally improve dark night skies conditions.

A comprehensive examination of landscape context related to landcover/landuse, population and housing, all of which are correlated with light pollution, was performed for the area surrounding the monument and is presented in the Landscape Context section within this chapter. These parameters can be highly correlated with ambient light levels. Therefore changes in these factors can have significant impacts on the night sky of the monument.

<u>Indicators and Measures</u>

- Artificial night sky brightness

4.3.2. Data and Methods

Artificial night sky brightness was examined using existing data. Cinzano et al. (2001) created an atlas that displays artificial night sky brightness worldwide. It is possible to locate Pipestone NM and the surrounding region on the image for North America from the atlas. The image was inspected for the quality of the night sky and major sources of light pollution in proximity to the monument. The NPS Natural Sounds and Night Skies Division (NSNSD) is developing a national model of ambient light levels and anthropogenic light sources. Modeling was applied to all NPS units, including the entire area of Pipestone National Monument and the surrounding region. This spatial database will permit estimation of the impact of anthropogenic light pollution on the darkness of night skies in the monument. However, model results were not available to include in this assessment.

4.3.3. Reference Conditions

The reference condition for the night sky in PIPE is one in which the intrusion of artificial light into the night scene is minimized. Natural sources of light (such as moonlight, starlight, and the Milky Way) will be more visible from the monument than anthropogenic sources. As little outdoor lighting as is necessary to maintain a safe environment for visitors and employees will be utilized. To help the monument achieve its cultural mission, it is important that the night sky retains its historic character.

4.3.4. Condition and Trend

The image from the Cinzano et al. (2001) atlas of artificial night sky brightness for North America is shown in Figure 4-11, including a magnified image centered on the monument. From the zoomed image, it is apparent that the monument is close to pockets of darker night skies, especially to the north and east. However, there are also several nearby sources of significant light pollution, such as the cities of Sioux Falls, South Dakota to the southwest and Minneapolis, Minnesota to the northeast. Other towns in the region (for example, Watertown and Brookings, South Dakota and Marshall, Minnesota) produce noticeable levels of light pollution, but their effects are more localized. The town of Pipestone, Minnesota and residential and commercial light sources near the park significantly affect to the quality of the night sky in the monument. Observations of the night sky at the park are significantly affected by light sources within a mile of the park, as well as light domes from distant sources.

Based on the available data, the condition of the night sky at the monument warrants moderate concern. Because of trends in population, housing and development in the region, there is a deteriorating trend in the condition of the night sky. Confidence in the assessment is medium.

Table 4-11. Condition and trend summary for dark night skies at Pipestone National Monument.

Indicator	Condition Status/Trend	Rationale
Dark Night Skies (overall)		**The condition warrants moderate concern with a deteriorating trend. Confidence in the assessment is medium.**
Artificial Night Sky Brightness		Light pollution from the town of Pipestone, nearby urban areas, and more distant urban centers degrades the quality of the monument's night skies.

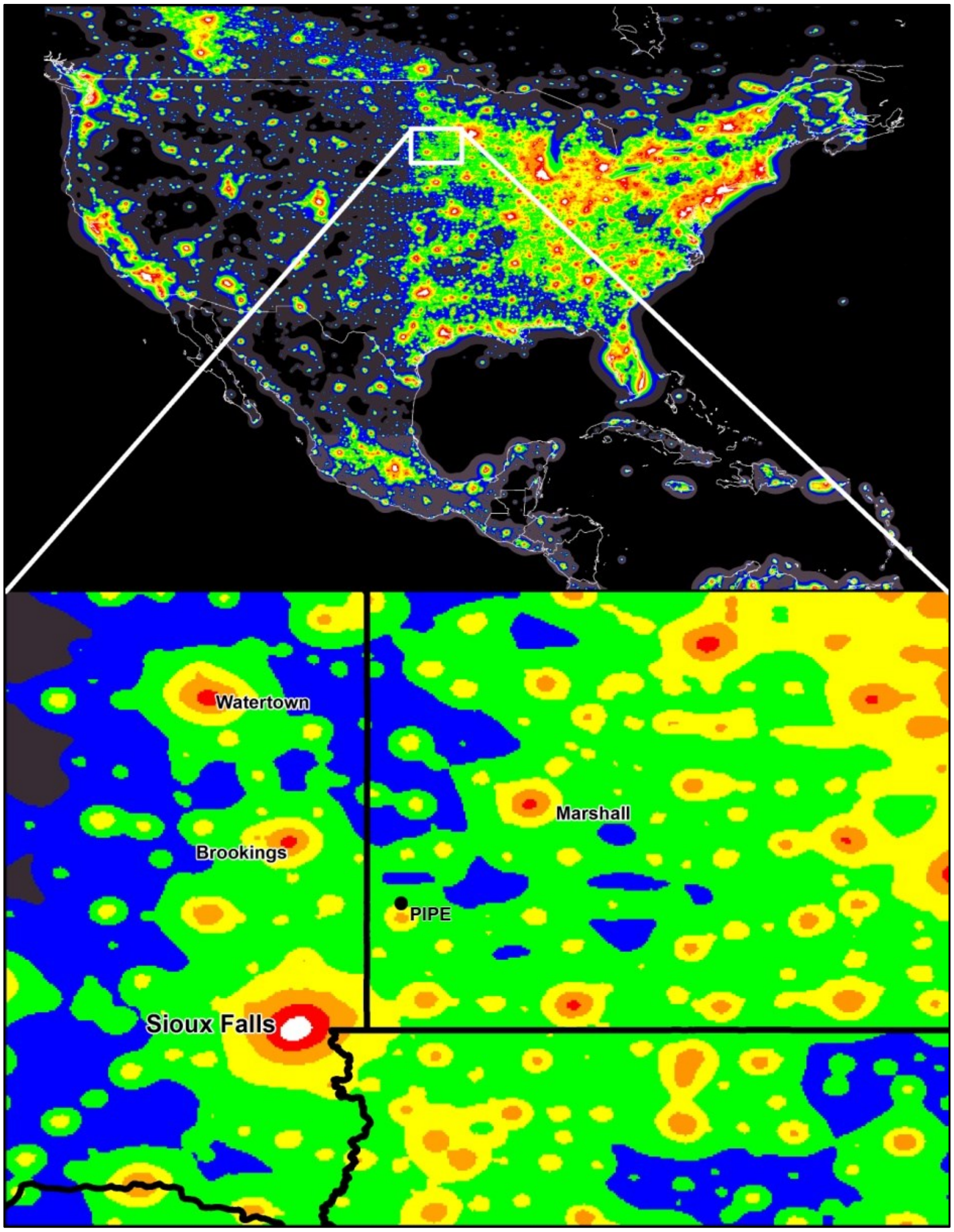


Figure 4-11. Artificial night sky brightness in the contiguous U.S. (top) and the region surrounding Pipestone National Monument (bottom) (Cinzano et al. 2001). Black represents darker conditions and white areas represent the brightest night sky conditions.

4.3.5. Uncertainty and Data Gaps

No night sky monitoring studies have been conducted by the NPS at Pipestone NM. The modeled ambient light level data are appropriate for NRCA condition rating, and may be assigned a medium confidence level (pers. comm., Chad Moore). The NSNSD national model of ambient light levels and anthropogenic sources of light were not available during preparation of this assessment but will provide a more quantitative indicator in the future.

4.3.6. Sources of Expertise

Chad Moore, Night Skies Program Manager, NPS Natural Sounds and Night Skies Division

4.3.7. Literature Cited

Cinzano P., F. Falchi, & C. D. Elvidge. 2001. The first world atlas of the artificial night sky brightness, Monthly Notices of the Royal Astronomical Society 328:689–707.

Kulesza, C., Y. Le, & S. J. Hollenhorst. 2013. National Park Service visitor perceptions & values of clean air, scenic views, & dark night skies; 1988–2011. Natural Resource Report NPS/NRSS/ARD/NRR–2013/632. National Park Service, Ft. Collins, Colorado.

National Park Service (NPS). 2006. National Park Service management policies. U.S. Government Printing Office. ISBN 0-16-076874-8.

National Park Service (NPS). 2008. Final general management plan/environmental impact statement, Pipestone National Monument, Minnesota. USDI National Park Service.

National Park Service (NPS). Undated. Measuring lightscapes. Retrieved from http://www.nature.nps.gov/night/measure.cfm. Accessed 17 July 2013.

National Park Service (NPS). 2014. Night skies at Homestead National Monument. http://www.nps.gov/home/naturescience/night-skies-at-homestead-national-monument.htm (Accessed 17 January 2014).

Rich, C., & T. Longcore. 2006. Ecological consequences of artificial night lighting, Island Press.

4.4. Soundscape

4.4.1. Background and Importance

Park natural soundscape resources encompass all the natural sounds that occur in parks, including the physical capacity for transmitting those natural sounds and the interrelationships among park natural sounds of different frequencies and volumes (NPS 2006). Previous research shows that visitors to national parks are often highly motivated to experience natural quiet and the sounds of nature (McDonald et al. 1995). Most visitors prefer to hear sounds that are intrinsic to the natural and cultural settings of the parks they are visiting. A growing body of research also documents the biological and behavioral impacts of unnatural and unusual noise on a variety of wildlife (Barber et al. 2010). Many species depend on natural soundscape conditions – free from anthropogenic noise intrusions – to successfully reproduce and survive (Habib et al. 2007; Rabin et al. 2006). In 2000 the NPS issued *Director's Order #47: Soundscape Preservation and Noise Management* "to articulate National Park Service operational policies that will require, to the fullest extent practicable, the protection, maintenance, or restoration of the natural soundscape resource in a condition unimpaired by inappropriate or excessive noise sources" (NPS 2000). The order established guidelines for monitoring and planning to preserve park soundscapes. New NPS management policies introduced in 2006 included several directives related to soundscapes, including the affirmation that "The Service will preserve, to the greatest extent possible, the natural soundscapes of parks. The Service will restore to the natural condition wherever possible those park soundscapes that have become degraded by unnatural sounds (noise), and will protect natural soundscapes from unacceptable impacts" (NPS 2006). Excessive anthropogenic noise in NPS units threatens to adversely impact natural and cultural resources and the quality of visitor experiences. The NPS has clearly declared its commitment to protecting intrinsic soundscapes for the enjoyment of current and future generations of park visitors.

PIPE's *2008 Final General Management Plan/Environmental Assessment* (FGMP/EA) describes the legal mandates of the NPS to protect natural soundscapes like other natural resources. "Actions will be taken to prevent or minimize unnatural sounds adversely affecting national monument resources or values or visitors' enjoyment of them" (NPS 2008, p. 36). The FGMP/EA highlights specific management actions that the monument will follow to mitigate noise intrusions, including encouraging aircraft to avoid flying over the monument, requiring tour bus companies to follow regulations to reduce noise levels, and minimizing noise produced by motorized equipment used by PIPE staff (NPS 2008, p. 36). The significance of providing opportunities for quiet and peacefulness is emphasized in the FGMP/EA. In the Plan's *Management Zones/Management Prescriptions* section, expected soundscape conditions are detailed. In the Visitor Services Zone, the Plan states that "Natural sounds might be compromised because of the presence of vehicles and high levels of use" (NPS 2008, p. 50). In the Prairie Preservation Zone, a low density visitor use area of the monument, "Natural quiet and scenic quality would be important" (NPS 2008, p. 51). In the Quarry Zone, "Scenic quality and natural sounds would be somewhat compromised because of the visitor use and quarry drainage pumps" (NPS 2008, p. 51). And in the Ceremonial Use Zone, an area occasionally used for American Indian ceremonies, the Plan states that "American Indians might experience solitude and natural sounds in a prairie environment. Sounds associated with ceremonial activities such as a Sun Dance would be moderate" (NPS 2008, p. 52).

The FGMP/EA acknowledges the environmental impacts of continued visitor use under the Preferred Alternative: “Noise, artificial lighting, and human activities associated with ongoing visitor use of the national monument would prevent natural prairie ecosystems and wildlife populations from reaching their full potential in size and population density” (NPS 2008, p. 186). Thus, noise originating from modern transportation, visitor activities, facilities, and development within and beyond the monument’s boundaries and from motorized management actions represents a distinct threat to the natural and historic soundscape of PIPE, as well as the quality of visitor experiences that can be offered to the public. As the city of Pipestone has encroached on the monument’s borders, it becomes more difficult for the monument to provide a setting that maintains the historical and aesthetic values for which it was created (pers. comm. S. Hendriks, July 8, 2013).

Threats and Stressors

Primary threats to the natural soundscape include noise originating from modern transportation within and beyond the monument’s boundaries; from motorized monument management activities; and from commercial, industrial, urban and exurban development. Transportation and development noise sources are a distinct threat to the natural and historical soundscape of PIPE, as well as the quality of visitor experiences. Park management activities have been minimized over time through the use of best management practices, including the use of electric utility vehicles for park management and maintenance. Aircraft noise is typically one of the most pervasive threats to natural sounds in NPS units. Aircraft noise at PIPE is a notable source of anthropogenic noise. Major nearly airports include Sioux Falls, South Dakota; Omaha, Nebraska; Des Moines, Iowa; Minneapolis, Minnesota; and Sioux City, Iowa (Sioux Gateway Airport and Iowa Air National Guard Base). A majority of the high elevation air traffic is from Minneapolis to points west (FlightAware 2014). There is little regional propeller airplane traffic feeding larger airport hubs (University of Nebraska Omaha 2014). Government reports indicate that air and vehicle traffic are projected to significantly increase at regional and national scales (U.S. Department of Transportation 2010; U.S. Department of Transportation 2013).

A comprehensive examination of landscape context related to landcover/landuse, population and housing, all of which are correlated with degradation of natural and historical soundscapes, was performed for the area surrounding the monument and is presented in the Landscape Context section within this chapter. These parameters can be highly correlated with ambient sound levels. Therefore changes in these factors can have significant impacts on the soundscape of the monument.

Indicators and Measures

- Anthropogenic sources of noise – presence/absence and relative noise level
- Traffic volume on US-75 and other local roads – vehicle counts
- Percent time above specified levels –35, 45, 52, and 60 dBA
- Exceedence levels – L_{90}, L_{50}, L_{10}
- Sounds levels by frequency
- Attended listening sessions – percent time audible natural/anthropogenic sound sources

- Anthropogenic sound level impacts (modeled) – minimum, 1st quartile, median, 3rd quartile, maximum

4.4.2. *Data and Methods*

The condition of the soundscape at PIPE was evaluated based on data provided by the NPS Natural Sounds and Night Skies Division (NSNSD). The NSNSD conducted acoustical monitoring at a single site in PIPE for 37 days in 2013 (NPS 2013). Various metrics of soundscape condition were collected during this monitoring period and are described below. The NSNSD provided results from nation-wide modeling of ambient sound levels (Mennitt et al. 2013). Modeling was applied to all NPS units, including the entire area of PIPE and the surrounding region. This analysis permitted estimation of the impact of anthropogenic noise on natural sound levels in the monument. Traffic volume data for adjacent roads and highways are summarized in order to provide some context for the analysis of external sources of noise affecting the monument. The NSNSD conducted four hours of attended listening over the course of a single day at PIPE in May, 2013 to identify all sound sources that are audible from a specific site in the monument during a fixed time interval (M. Nelson, personal communication, July 15, 2013). Results from the 2013 data collection are presented in Nelson (2014) and summarized here. Qualitative data from PIPE staff are also presented in this assessment. Staff members were asked to identify natural and human-caused (extrinsic or intrinsic to the monument's values) sounds present at PIPE. Staff members were also asked to describe the desired soundscape conditions for PIPE, including anthropogenic cultural sounds that could potentially be considered appropriate for the monument's mission and purpose.

Decibel Scale

Sound pressure levels are often represented in the logarithmic decibel (dB) scale. In this scale, 0 dB is equivalent to the lower threshold of human hearing at a frequency of 1 kHz. This scale can be adjusted to account for human sensitivity to different frequencies of sound, a correction known as A-weighting. A-weighted sound pressure levels are represented in the dBA scale. Examples of common sound sources (both within and outside of park environments) and their approximate dBA values are presented in (Table 4-12) (Lynch 2009).

Table 4-12. Sound pressure level examples from NPS and other settings (Lynch 2009).

Park Sound Sources	Common Sound Sources	dBA
Volcano crater (Haleakala National Park)	Human breathing at 3m	10
Leaves rustling (Canyonlands National Park)	Whispering	20
Crickets at 5m (Zion National Park)	Residential area at night	40
Conversation at 5m (Whitman Mission National Historic Site)	Busy restaurant	60
Snowcoach at 30m (Yellowstone National Park)	Curbside of busy street	80
Thunder (Arches National Park)	Jackhammer at 2m	100
Military jet at 100m AGL (Yukon-Charley Rivers National Preserve)	Train horn at 1m	120

4.4.3. Reference Conditions

The reference condition for the soundscape in PIPE is one dominated by natural sounds that are intrinsic to the monument, such as the sounds of wind, running water, birds, amphibians, deer, and insects. Cultural sounds specific to traditional quarrying activities and American Indian ceremonies are also an important component of the monument's desired soundscape conditions. Opportunities to experience solitude and the sounds of a natural prairie environment are essential to many of the traditional ceremonies (pers. comm. S. Hendriks, July 29, 2013).

Monument managers have identified natural sound sources that are no longer present in PIPE, such as the extirpated wildlife species American bison and greater prairie chicken (pers. comm. S. Hendriks, September 10, 2013). A reference condition rating system for the six soundscape indicators is presented in Table 4-13.

Table 4-13. Reference condition ratings framework for soundscape indicators at PIPE.

Indicator	Good Condition	Warrants Moderate Concern	Warrants Significant Concern
Anthropogenic Sources of Noise	Infrequent, low, or inaudible levels of anthropogenic noise. Annoyance level of visitors low. Recognizes historical sounds from quarrying/traditional ceremonies.	Moderately frequent and audible anthropogenic noise. Annoyance level of visitors moderate.	Frequent and highly audible anthropogenic noise. Annoyance level of visitors high.
Road Traffic Volume	No increase (<5%) in daily traffic volumes of approximately 2,750 vehicles and 345 heavy commercial vehicles (US-75); no increase in the proportion of heavy commercial trucks. Based on 2010 data.	5-10% increase in total traffic volume from 2010 baseline; higher proportion of heavy commercial trucks.	>10% increase in total traffic volume from 2010 baseline; higher proportion of heavy commercial trucks.
Percent Time Above Specified Levels	Percent time above 52 dBA (level of speech interference for interpretive programs) ≤10%.	Percent time above 52 dBA (level of speech interference for interpretive programs) is >10% to <25%.	Percent time above 52 dBA (level of speech interference for interpretive programs) ≥25%.
Exceedence Levels	L_{50} ≤ 35 dBA (sound level exceeded 50% of the time is less than or equal to 35 dBA)	5 dBA < L_{50} < 45 dBA (sound level exceeded 50% of the time is between 35 and 45 dBA)	L_{50} ≥ 45 dBA (sound level exceeded 50% of the time is greater than or equal to 45 dBA)
Attended Listening	Natural sounds heard continuously; anthropogenic (except appropriate cultural) sounds heard rarely.	Natural sounds heard some of the time; anthropogenic sounds heard frequently but not continuously.	Natural sounds heard rarely; anthropogenic sounds heard continuously.
Anthropogenic Sound Level Impacts	Median impact ≤ 3 dBA Maximum impact ≤ 7.5 dBA	3 dBA < Median impact < 5 dBA 7.5 dBA < Maximum impact < 10 dBA	Median impact ≥ 5 dBA Maximum impact ≥ 10 dBA

4.4.4. Condition and Trend

Anthropogenic Sources of Noise

The following common sources of anthropogenic noise were identified by staff members at PIPE (pers. comm. S. Hendriks, July 8, 2013): vehicle traffic on adjacent roads outside the park and on the park road; trains from the nearby railroad; park administrative noise (including utility vehicles, lawn mowers, and weed-trimmers); sounds produced by the pipestone quarrying process (including seasonal water pumps in the quarries); heavy equipment in a nearby gravel pit; and noise from the city of Pipestone. Development and population changes in the area surrounding the park was examined in the *Land Cover and Land Use* section of this chapter. Within a 30 km radius of the park, the most notable trend is an increase in exurban areas and a corresponding decrease in rural acreage. There is an increase in the acreage of suburban areas but the major change in housing density is associated with existing urban centers such as Flandreau and Pipestone. However, there is also a pattern of increasing exurban housing density in unincorporated areas, including areas close to towns and major roads. Notable increases in population and increases in housing density occurred between 1970 and 2010, but significant increases are not forecast through 2030. The condition of this indicator warrants moderate concern with an unchanging trend and medium confidence level.

Traffic Volume: US-75 and Other Local Roads

According to the Minnesota Department of Transportation, US-75 near the junction of 4th Street and State Road 23 in the town of Pipestone had an annual average daily traffic volume of 2,750 vehicles in 2010, including 345 heavy commercial vehicles (Minnesota Department of Transportation 2011). The Minnesota DOT also records trends in vehicle miles of travel on state road segments, which can be influenced by changes in population, employment, and gas prices. In Pipestone County, vehicle miles of travel increased 20-29% on all road types between 1992 and 2011 (Minnesota Department of Transportation 2012). Employment growth in the county was 50-59% during that same period. Table 4-14 summarizes how heavy commercial traffic was distributed across different types of roads in Minnesota in both 1992 and 2011 (Minnesota Department of Transportation 2012). There is a trend towards higher use of the interstate highway, relative to U.S. and Minnesota state highways, for heavy commercial traffic in 2011 compared to 1992. This indicator is in good condition with a deteriorating trend and a medium confidence level.

Table 4-14. Percentage of total annual heavy commercial traffic by road type (Minnesota Department of Transportation 2012)

	Percentage of heavy commercial traffic	
Road Type	**1992**	**2011**
Interstate	39.4	43.6
U.S. Highways	30.6	28.6
Minnesota State Highways	30.0	27.8

Percent Time Above Specified levels

The NSNSD collected acoustical monitoring data for 37 days at one site (Sundance Grounds) in the spring of 2013 (NPS 2013). Percent time above specific sound pressure (decibel) levels was determined for 2 frequency ranges: 20 – 1250 Hz (low frequency range) and 12.5 – 20,000 Hz (full frequency range). The low frequency range includes common transportation noise but excludes higher frequency sounds, such as those produced by birds and insects. Sound pressure levels measured in the monument were compared to levels that are known to produce functional effects in humans, including blood pressure and heart rate increases in sleeping humans at 35 dBA (Haralabidis et al. 2008), the World Health Organization's recommended maximum noise level inside bedrooms at 45 dBA (Berglund et al. 1999), speech interference for interpretive programs at 52 dBA (EPA 1974), and speech interruption for normal conversation at 60 dBA (EPA 1974). For the low frequency range during daytime hours (0700 to 1900), measured sound pressure levels were above 35 dBA 35.9% of the time, above 45 dBA 2.0% of the time, above 52 dBA 0.6% of the time, and above 60 dBA 0.1% of the time. For the full frequency range during daytime hours, measured sound pressure levels were above 35 dBA 73.5% of the time, above 45 dBA 7.8% of the time, above 52 dBA 2.1% of the time, and above 60 dBA 0.3% of the time. For the low frequency range during nighttime hours (1900 to 0700), measured sound pressure levels were above 35 dBA 26.6% of the time, above 45 dBA 1.8% of the time, above 52 dBA 0.6% of the time, and above 60 dBA 0.1% of the time. For the full frequency range during nighttime hours, measured sound pressure levels were above 35 dBA 48.4% of the time, above 45 dBA 3.8% of the time, above 52 dBA 1.2% of the time, and above 60 dBA 0.2% of the time. These results indicate a good condition, with an unknown trend and a high confidence level.

Exceedence Levels

The NSNSD also calculated the sound pressure levels that were exceeded a certain percentage of the time during the monitoring period (i.e., L_{50} is the dBA value that is exceeded 50% of the stated time period), (NPS 2013). For the low frequency range during daytime hours, L_{90} was 30.1 dBA, L_{50} was 33.4 dBA, and L_{10} was 38.2 dBA. For the full frequency range during daytime hours, L_{90} was 33.2 dBA, L_{50} was 36.7 dBA, and L_{10} was 43.4 dBA. For the low frequency range during nighttime hours, L_{90} was 30.0 dBA, L_{50} was 32.5 dBA, and L_{10} was 37.5 dBA. For the full frequency range during nighttime hours, L_{90} was 32.7 dBA, L_{50} was 35.4 dBA, and L_{10} was 40.3 dBA. Table 4-15 summarizes the percent time above and exceedence level metrics. Mean L_{50} exceedence levels are above the 35 dBA threshold for the full frequency range during both day and night. The condition of this indicator warrants moderate concern with a high confidence level. No trend data are available.

Table 4-15. Percent time above various sound pressure levels and exceedence levels for various percentages of time.

Time of Day	Frequency Range (Hz)	Percent Time Above (%)				Exceedence Levels (dBA)		
		35 dBA	*45 dBA*	*52 dBA*	*60 dBA*	L_{90}	L_{50}	L_{10}
Day (0700-1900)	20-1250	35.9	2.0	0.6	0.1	30.1	33.4	38.2
	12.5-20,000	73.5	7.8	2.1	0.3	33.2	36.7	43.4
Night (1900-0700)	20-1250	26.6	1.8	0.6	0.1	30.0	32.5	37.5
	12.5-20,000	48.4	3.8	1.2	0.2	32.7	35.4	40.3

<u>One-third Octave Bands</u>

The full frequency spectrum derived from acoustic monitoring can be divided into 33 smaller frequency bands (each representing a single one-third octave range). The NSNSD created plots of the daytime and nighttime sound pressure levels for each frequency band in order to demonstrate the distribution of lower- and higher-frequency sounds occurring in PIPE throughout the day (NPS 2013). The octave band plots are displayed in Figure 4-12. Although these plots can be informative when combined with other metrics, they are not useful indicators of soundscape quality on their own. Furthermore, it is challenging to select a reference condition for this indicator. Sound levels by frequency are included here for reference and may be used in future assessments; a condition rating is not assigned.

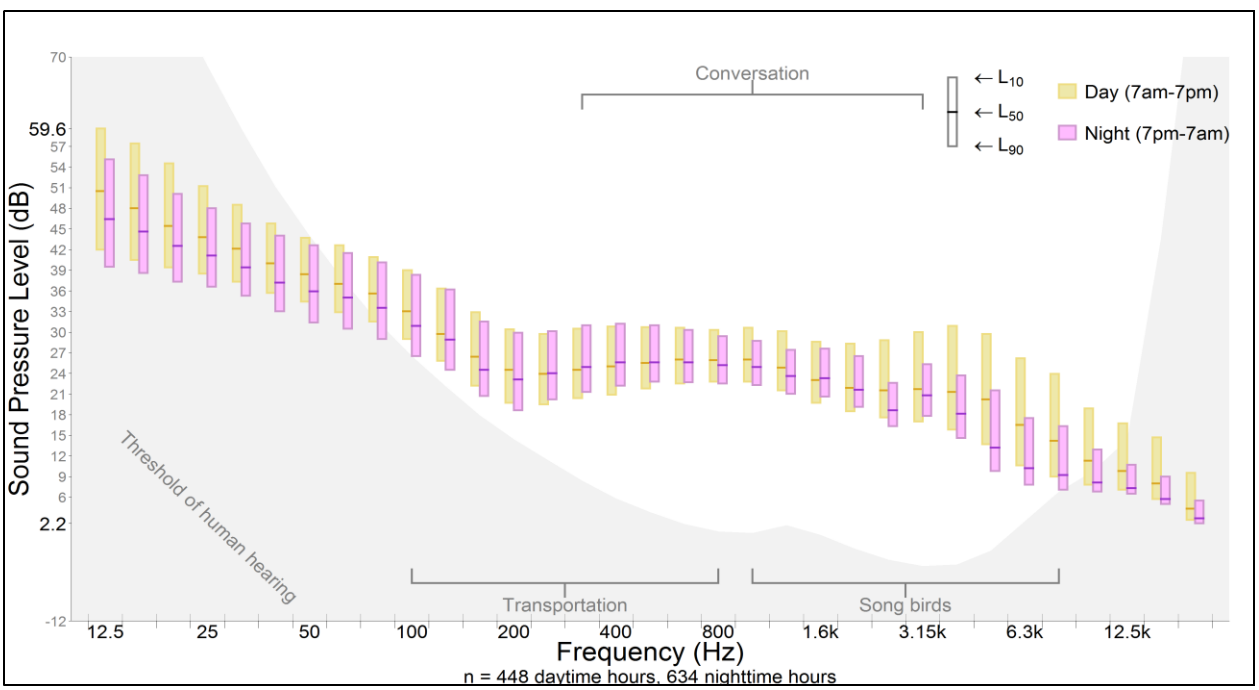


Figure 4-12. Daytime and nighttime sound pressure levels for 33 one-third octave frequency bands. Graphic provided by NSNSD (July 2013).

Attended Listening

The NSNSD conducted four hours of attended listening over the course of a single day at PIPE in May, 2013 (M. Nelson, personal communication, July 15, 2013). Attended listening consists of a trained observer recording all sounds – natural and anthropogenic – that are audible from a specific site during a fixed time interval. In this case, four 1-hour listening sessions were performed at the Sundance Grounds site where the acoustical monitoring stations were set up. These sessions are summarized below to provide an estimate of how often different sound sources are audible in the monument.

Although the individual listening sessions only represent a small snapshot in time and place, the results are potentially informative in determining the balance between natural, cultural, and other anthropogenic sounds that may typically be audible to PIPE visitors. For example, in all 4 sessions, vehicles were audible for at least 98% of the listening hour. Aircraft were audible 5% to 20% of the time, and people could be heard from 3% to 13% of the time. The sound of a train was audible during 20% of one session. An unknown non-natural sound (a distant low hum) was heard by the listener at least 98% of the time in 3 of the 4 sessions. Sounds associated with quarrying in the monument were heard 11% of the time in the first session but 1% of the time or less in the 3 other sessions. In terms of natural sounds, birds, amphibians, and wind could be heard nearly constantly during all sessions. Deer and insects were also audible at times. Full results are included in Table 4-16. The condition of this indicator warrants significant concern with a medium confidence level. No trend data are available.

Table 4-16. Time audible percentages for various sound sources in PIPE from attended listening sessions (NPS 2013).

	Time Audible (%)			
Sound Source	***Session1*** **(2013-05-07 13:15-14:15)**	***Session 2*** **(2013-05-07 14:30-15:30)**	***Session 3*** **(2013-05-07 16:15-17:15)**	***Session 4*** **(2013-05-07 17:30-18:30)**
Bird	99.9	99.9	99.6	99.9
Vehicle	99.0	98.4	99.3	100.0
Wind	95.2	94.8	98.2	99.7
Amphibian	93.3	97.4	99.9	99.5
Aircraft	20.4	12.2	6.4	4.7
Insect	15.4	5.8	3.5	0.2
Quarrying	10.6	0.2	0.4	1.1
Dog	3.6	3.8	0.9	0.9
People	2.9	11.9	12.5	13.1
Non-natural unknown	2.6	98.3	98.6	99.7
Deer	0.8	---	---	8.9
Train	---	---	19.5	---

Anthropogenic Impacts on Ambient Sound Level

The NSNSD has used acoustic modeling to estimate the anthropogenic impact to the ambient sound level in PIPE, which is the existing sound level minus the estimated natural sound level (Mennitt et al. 2013). Mean impact thus provides a measure of how much anthropogenic noise is increasing the existing sound level above the natural sound level, on average, in the monument. In PIPE, the mean impact was 10.8 dBA. Additional metrics describing a range of impacts across the landscape of the monument were also obtained. Minimum impact (minimum sound level impact in the monument) was 8.8 dBA, 1st quartile impact (25% of points in the monument have this level or impact or less) was 9.9 dBA, median impact (50% of the monument has this impact or less) was 11.0 dBA, 3rd quartile impact (75% of the monument has this impact or less) was 11.7 dBA, and maximum impact (maximum impact value inside monument boundaries) was 12.1 dBA. Modeled mean impacts in the area immediately surrounding PIPE as well as the larger region are shown in Figure 4-13. Estimated sound level impacts in the southern end of the monument are slightly higher compared to modeled impacts in the northern end of the monument.

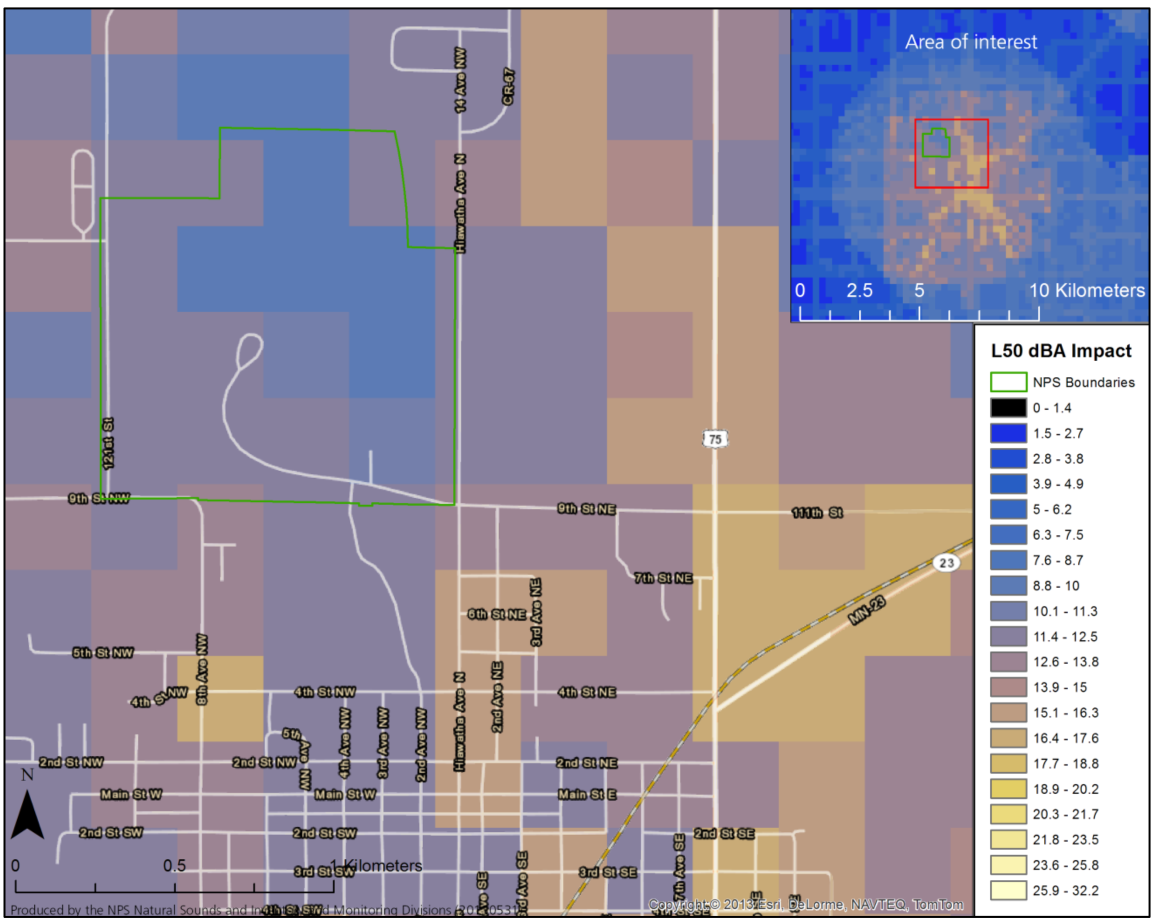


Figure 4-13. Modeled mean sound level impacts in the area immediately surrounding PIPE and in the larger region (inset). Graphic provided by NSNSD (May 2013).

For reference in translating sound level impacts into functional effects (for human visitors and resident wildlife), an increase in background sound level of 3 dB produces an approximate decrease in listening area of 50%. In other words, by raising the sound level in PIPE by just 3 dB, the ability of listeners to hear the sounds around them is effectively cut in half. Furthermore, an increase of 7 dB leads to an approximate decrease in listening area of 80%, and an increase of 10 dB decreases listening area approximately 90%. The condition of this indicator warrants significant concern with a medium confidence level. No trend data are available.

Overall Condition

The data presented above suggest that the condition of the soundscape in PIPE warrants moderate concern, and there is a deteriorating trend in the condition of the soundscape. Confidence in the assessment is high due to the number of indicators and the inclusion of several quantitative indicators. The sound pressure level associated with physiological changes in humans (35 dBA) was exceeded 74% of the time in the monument during the day and 48% of the time during the night (36% and 27% for the low frequency range, respectively). Sound pressure levels exceeded 45 dBA only 2% to 8% of the time, depending on the time of day and frequency range measured. Sound pressure levels also exceeded 52 dBA (the level at which speech interference occurs for interpretive programs) only 2% of the time most. The mean exceedence levels in the park (L_{50} for the full frequency range) were 36.7 dBA during the day and 35.4 dBA at night, which are moderate values. Additionally, the attended listening sessions found that vehicle noise was audible at least 98% of the time in the monument. An unknown non-natural sound (a distant low hum) was audible at least 98% of the time in 3 of the 4 listening sessions. The nationwide modeling of anthropogenic sound level impacts indicates that modern noise intrusions are substantially increasing the existing ambient sound level above the natural ambient sound level of the monument (mean impact = 10.8 dBA). As long as noise from the encroaching city of Pipestone and its associated development, vehicles within and beyond PIPE's boundaries, and park management activities remains pervasive in the monument, the condition of the soundscape will likely continue to deteriorate. Regional projections for aircraft and traffic volumes indicate deteriorating conditions as noise originating outside of the park increases over time. Table 4-17 summarizes the status and trend for each of the soundscape and natural sounds indicators.

Table 4-17. Condition and trend summary for the soundscape at Pipestone National Monument.

Indicator	Condition Status/Trend	Rationale
Soundscape and Natural Sounds (overall)		Resource condition warrants moderate concern with a deteriorating trend. Confidence in the assessment is high.
Anthropogenic Sources of Noise		Noise from anthropogenic sources is pervasive, especially encroachment from the city of Pipestone and its associated development. Transportation noise is frequently audible and ground and air transportation volumes are projected to increase.
US-75 Traffic Volume		Vehicle miles of travel increased 20-29% on all road types in Pipestone County between 1992 and 2011. If those trends continue, then the monument's soundscape will be negatively impacted by increasing traffic noise.
Percent Time Above Specified Levels		Sound pressure levels exceed 52 dBA ≤10% of the time. Sound pressure levels exceed 45 dBA ≤10% of the time, as well.
Exceedence Levels		Measured L_{50} is between 35 and 45 dBA.
Attended Listening		Although natural sounds like birds, wind, and amphibians were heard nearly continuously, vehicles were also audible at least 98% of the time.
Ambient Sound Level		Anthropogenic noise is significantly increasing the existing ambient sound level above the natural ambient sound level of the monument (median impact > 5.0 dBA and maximum impact > 10.0 dBA).

4.4.5. Uncertainty and Data Gaps

The NPS NSNSD has conducted acoustical monitoring studies at a single site in PIPE to measure ambient sound levels and the audibility of different intrinsic and extrinsic sound sources in the monument. A full acoustical monitoring report is forthcoming. However, evaluative research has not been collected to determine the social impacts of existing soundscape conditions on visitor experiences in PIPE.

4.4.6. Sources of Expertise

Emma Lynch, Acoustical Resource Specialist, NPS Night Skies and Natural Sounds Division

Misty Nelson, Acoustical Technician, NPS Night Skies and Natural Sounds Division

4.4.7. Literature Cited

Barber, J. R., K. F. Fristrup, C. L. Brown, A. R. Hardy, L. M. Angeloni, and K. R. Crooks. 2010. Conserving the wild life therein: protecting park fauna from anthropogenic noise. Park Science, 26(3):26–31.

Berglund, B., T. Lindvall, and D. H. Schwela, editors. 1999. Guidelines for community noise. World Health Organization, Geneva.

FlightAware. 2014. FlightAware live flight tracking by airport. http://flightaware.com/live/ (accessed 10 January 2014).

Habib, L., E. M. Bayne, and S. Boutin. 2007. Chronic industrial noise affects pairing success and age structure of ovenbirds (*Seiurus aurocapilla*). Journal of Applied Ecology 44:176-184.

Haralabidis, A., K. Dimakopoulou, F. Vigna-Taglianti, M. Giampaolo, A. Borgini, M. Dudley. and L. Jarup. 2008. Acute effects of night-time noise exposure on blood pressure in populations living near airports. European Heart Journal 29:658-664.

Lynch, E. 2009. San Antonio Missions National Historical Park acoustical monitoring report. Natural Resource Report NPS/NRPC/NRTR 2009. National Park Service. Fort Collins, CO. Published Report-2174172.

McDonald, C. D., R. M. Baumgartner, and R. Iachan. 1995. National Park Service aircraft management studies. National Park Service, USDI, Report No. 94-2, Denver, CO.

Mennitt, D., K. Fristrup, K. Sherrill, and L. Nelson. 2013. Mapping sound pressure levels on continental scales using a geospatial sound model. 43rd International Congress and Exposition on Noise Control Engineering, Innsbruck, Austria, Sept 15-18:1–11.

Minnesota Department of Transportation. 2011. Traffic volume (AADT/HCAADT) table. Available from http://www.dot.state.mn.us/traffic/data/data-products.html#volume (accessed 8 September 2013).

Minnesota Department of Transportation. 2012. Vehicle miles of travel: trends in Minnesota 1992-2011. Office of Transportation Data and Analysis.

National Park Service (NPS). 2000. Director's order #47: Soundscape preservation and noise management. Available from http://www.nps.gov/policy/DOrders/DOrder47.html (accessed 24 November 2011).

National Park Service (NPS). 2006. National Park Service management policies. U.S. Government Printing Office. ISBN 0-16-076874-8.

National Park Service (NPS). 2008. Final general management plan and environmental impact statement, Pipestone National Monument, Minnesota.

National Park Service (NPS). 2013. Acoustical monitoring snapshot, Pipestone National Monument.

Nelson, M.D. 2014. Pipestone National Monument: Acoustic monitoring report. Natural Resource Technical Report NPS/NRSS/NRTR— 2014/879. National Park Service, Fort Collins, Colorado.

Rabin, L. A., R. G. Coss, and D. H. Owings. 2006. The effects of wind turbines on antipredator behavior in California ground squirrels (*Spermophilus beecheyi*). Biological Conservation 131:410-420.

University of Nebraska Omaha. 2014. Animated atlas: air traffic over North America (March 2003 to September of 2007 Data). http://maps.unomaha.edu/animatedflightatlas/Overview.html (accessed 10 January 2014).

U.S. Department of Transportation. 2010. FAA Aerospace forecast fiscal years 2010-2030, Federal Aviation Administration (FAA), aviation policy and plans. 2010.

U.S. Department of Transportation. 2013. Traffic volume trends. Federal Highway Administration, Office of Policy Information. May 2013.

U.S. Environmental Protection Agency (EPA). 1974. Information on levels of environmental noise requisite to protect public health and welfare with an adequate margin of safety. EPA, Washington, D.C.

4.5. Scenery and Views

4.5.1. Background and Importance

Visual resources or scenery has important value in terms of historical and cultural context, aesthetics, and tourism and health. Scenery encompasses the visible physical features on a landscape including the land, water, vegetation, structures, animals and other features, and is linked to air quality-related values and dark night skies. The National Park Service Organic Act of 1916 specifies that the NPS shall "conserve the scenery and the natural and historical objects and the wild life therein and to provide for the enjoyment of the same in such manner and by such means as will leave them unimpaired for the enjoyment of future generations." Protection and conservation of scenic resources is also required under other legislation and policies such as the National Environmental Policy Act, Federal Land Policy and Management Act, National Historic Preservation Act, the Clean Air Act and NPS guidance. Current *NPS Management Policies* (NPS 2006) do not provide guidance regarding service-wide policies or practices for scenery conservation.

Figure 4-14. View to the west from near the Oracle feature (CSU photo).

Scenery is consistently rated as a top priority by park visitors, and is increasingly addressed in General Management Plans, Resource Management Plans and Cultural Landscape Plans/Reports. Park units generally address visual resource management on a case-by-case basis (Mark Meyer, personal comment August 2013), and effort is increasingly applied to conservation of visual resources as forces and development external to parks increasingly impact visual landscapes supporting natural and historical views.

Within the NPS Midwest Region, scenic views were ranked as the 1st or 2nd most important criteria for visit quality 33% of the time, and rated *extremely* or *very important* by 89% of respondents (Kulesza et al. 2013). Although, scenery at the monument is not specifically addressed in the park management and planning documents, the importance of scenery here can be linked to important and unique natural and cultural features and ethnographic landscapes. The National Park Service defines ethnographic resources as "…landscapes, objects, plants and animals, or sites and structures that are important to a people's sense of purpose or way of life.

The prairie ecosystem that once covered the tallgrass prairie region is one of horizontal character. Fields of grass extend outward towards the horizon, with only a few trees or other vertical features extending above prairie grasslands and the horizon. Even as settlers converted the prairie to agricultural fields, the horizontal nature of the landscape remained intact. Horizontal manmade elements constitute the greatest inconsistencies in the landscape views from the park.

Views from the park have changed significantly since the park's creation in 1937. When Pipestone National Monument was created, the surrounding lands were agricultural, and there were few obstructions to views from the national monument all the way to the horizon. Construction of wind power turbines, power transmission lines and communications towers within the past 20 years, and other development have impacted the scenery experienced by park visitors (personal comment Glen Livermont December 2012). Views from key points within the park are variable, consisting of urban and industrial elements, energy and power structures, communication lines and structures, exurban and urban development, agriculture, and natural settings such as the U.S. Fish and Wildlife parcel to the north managed by Minnesota Department of Natural Resources. As the city of Pipestone has grown closer to the national monument and developments have appeared within view, the sense of open, endless prairie that was the setting for the quarries is being compromised. Some agricultural elements and most other development are inconsistent with the scenic values of these cultural landscapes. The cultural and ethnographic landscape of the national monument and the aesthetic values of the prairie are becoming more difficult for visitors to picture and for interpreters to explain (NPS 2008). Impacts to park views are anticipated to increase over time.

There are NPS initiatives that collectively support park scenery and viewshed conservation, including support for NPS renewable energy and visual resources staff and development of a Scenery Conservation Program within the NPS Air Resources Division. Other federal agencies such as the Bureau of Land Management, Forest Service and Fish and Wildlife Service also have established or are developing programs to promote scenery conservation. Important components of these initiatives include scenery inventory, evaluation and conservation, with consideration to renewable energy visual impacts and viewshed impacts extending beyond park boundaries.

Threats and Stressors

The vast majority of threats and stressors to the park viewscape are related to development and incompatible land uses outside the park boundary.

- Air pollution/haze affects visitors' ability to see features, color and detail in distant views.
- Suburban/exurban development.
- Industrial development – large/tall structures are more important than acreage occupied. Industrial development is also related to other incompatible elements such as transmission lines, visible smoke/steam/dust, roads, increased traffic and noise.
- Other-made structures, including farms that have larger structures (e.g., outbuildings, silos) and more mechanized equipment relative to the homesteading era.
- Roads and traffic.
- Energy development and infrastructure (e.g., wind turbines and power transmission structures).
- Communications structures.

Indicators and Measures

- Scenic quality of landscape views
- Housing densities in the surrounding 30km area

- Potential visibility of new wind turbines
- Air quality - visibility

4.5.2. Data and Methods

Scenery has not been previously evaluated at PIPE. Measures supporting this assessment include both quantitative and qualitative assessments. The assessment framework integrates ground-based measures of scenic quality from key viewpoints with two GIS –based measures: housing density and potential visibility of wind structures. In this assessment we use the terms scenery, views, and scenic resources interchangeably. The viewshed is the total landscape that can be seen from a particular location, which could be a point, such as a scenic overlook; a line, such a travel route; or an area, such as a lake. Several factors limit the spatial extent of the viewshed from a given viewpoint either in the real world or when using geospatial modeling. These factors include topography, vegetation, manmade structures, target height, viewer height, the curvature of the earth, and atmospheric refraction. The actual visibility of an object would depend on the viewer's eyesight, and on the object's size, shape, color, reflectivity, and orientation to the viewer; the lighting that falls on the object; the presence of haze and other factors (USDI 2013).

<u>Scenic Quality</u>

Key Viewpoints and Views

A viewpoint is the designated location from which a viewed landscape is evaluated. The viewed landscape or view is the scene the observer is looking at from the viewpoint. Some viewpoints may have several different and distinct views. In some cases a single view may encompass all directions from a viewpoint.

Important viewpoints and associated views were discussed and identified as part of the NRCA scoping process and data gathering. Nine primary viewpoints and associated views considered important and/or having high levels of visitation were evaluated (Figure 4-15). An additional five viewpoints of secondary interest to the park were visited and photographed but are not included in the assessment. Secondary viewpoints are either in areas not frequented by the public or in areas that may relevant to changes in park facilities or infrastructure.

Panoramic photos for the primary points were taken by CSU staff in August 2013 with a Canon G10 camera using a 50mm focal length and an image resolution of 14.6 megapixels. Each high-resolution panorama consisted of five to six overlapping photos in a single row that were combined using Gigapan Stitch software. Resulting photos had a field of view approximately 80-140 degrees wide and 20-25 degrees tall. Panoramas with a size of approximately 16,000 x 35,000 pixels and were exported as .tiff graphics ranging from 60-100 megabytes in size. Original and stitched panoramic photographs and associated location data will be delivered to the park with the NRCA.

Figure 4-15. Location of primary viewpoints (green circles) and other viewpoints (red triangles) at Pipestone National Monument. Park boundary is the orange and black dashed line.

Each view was evaluated by CSU staff in August 2013 using methodology developed by the NPS Scenery Conservation Program (SCP), Air Resources Division and presented at a workshop at Homestead National Monument in August 2013. Using the SCP methodology, a landscape character type was assigned to each view. Possible types include natural/natural appearing, pastoral, agricultural, rural, suburban, urban and industrial. Primary landscape types present at PIPE are natural/natural-appearing, rural and agricultural landscapes. Landscape character types are described in NPS Scenery Conservation Program (2014a). For each view, landscape character elements and landscape design elements were characterized and evaluated within the foreground, middle-ground and background using a streamlined version of the SCP methods.

The distance zones are based on visibility of features rather than specific, fixed distances from the observer. For the foreground, human scale is most important and the viewer may feel that they are "part of the landscape". Surface features are often visible, colors are distinct and details of human and wildlife activities are most easily observed. For the middle-ground, viewers may feel more like they are looking "at the landscape" rather than "being in it". Patterns and landforms define the view, rather than individual elements. Objects such as trees, shrubs, rock outcrops and houses form a texture or pattern. Details are lost and the outlines of objects are less distinct. Colors become more muted and less distinct at the farther reaches of the middle-ground. The background is characterized by elements being very far away. Texture and patterns have largely disappeared. The horizon and landforms such as mountains dominate the backdrop. In some areas of rolling or mountainous terrain, in heavily vegetated landscapes, or urban settings the background may not be seen at all or it may not have a discernable limit (NPS Scenery Conservation Program 2014a).

Figure 4-16. Example of approximate distance zones used in characterizing and evaluating landscape views in the Great Plains (CSU photo).

The scenic quality of each viewed landscape was evaluated based on the assigned landscape character and the assessment of the viewed landscape, and incorporates both natural and cultural considerations. Scenic quality scores were assigned to landscape character integrity, which is based on an evaluation of landscape elements present (landform, landcover, land use and human structures), the quality and condition of those elements, and the presence and type of inconsistent elements in the view. Dominant and secondary elements visible in each distance zone are the main drivers of the scenic quality rating. The conspicuousness of manmade features affects their impact as inconsistent elements within a view (Table 4-18).

Table 4-18. Characteristics affecting the conspicuousness of human-made features (Struthers et al. 2014).

Characteristic	Less Conspicuous	More Conspicuous
Distance	Distant from the vantage point	Close to the vantage point
Size (height, length, volume)	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

Housing Densities in the Surrounding Area

Houses and their associated utilities and roads commonly degrade the quality of landscape views comprised of natural and/or cultural elements. Housing density data derived from U.S. Census Bureau Data and summarized by the NPS NPScape program were used to examine the distribution and extent of housing density classes within a 30km area surrounding the park. A comprehensive examination of land cover, landuse, population and housing density is presented in Section 4.1 of this assessment. The results for housing densities in the region surrounding the park are used here as an indicator of condition and changes in one of the threats to park views. The extent and percentage of housing density classes between 1970 and 2050 were examined using development classes described by Theobald (2005): rural (0-0.0618 units/ha), exurban (0.0618- 1.47 units/ha), suburban (1.47-10.0 unit/ha), and urban (> 10.0 units/ha).

Potential Visibility of New Wind Turbines

A spatial analysis of visibility of wind turbines from the interpretive deck adjacent to the Visitor's Center was completed by the NPS Midwest Geospatial Support Center in support of this assessment. Viewshed analysis produced several data layers used here: areas where an 80m tall windmill hub would be visible, areas where a 130m tall windmill blade would be visible and the percent vertical visibility of the 80m structure where it would be visible. The analysis used a 10 m digital elevation model, considered earth curvature, and was performed on bare earth (i.e., did not consider the effects of vegetation or other non-terrain obstructions). Following guidance in Sullivan et al. (2013), a conservative interpretation suggests that an appropriate radius for visual impact analyses with respect to wind turbines would be 48 km (30 mi); the facilities would be unlikely to be missed by casual observers at up to 32 km (20 mi) and could be major sources of visual contrast at up to 16 km (10 mi).

Harnessing the power of the wind has a long history across America's landscape. Factory-made windmills have been used for pumping water on farms since the 1850s (Oklahoma Historical Society 2012). Settlers in the westward expansion used windmills to pump water for use on farms and ranches, and windmills were later an integral part of electrifying rural America (DOE 2014). This continues today, with small to industrial scale wind farms dotting the landscape in areas of favorable wind characteristics. The American Wind Energy Association, a national trade group, reports that as of the end of 2012 (the last year for which there are tabulated data), there was over 60,000 MW installed production capacity in the United States, generating enough power to supply 15 million American homes (AWEA 2014). The installation of wind energy capacity in 2012 outstripped all other energy production installations in America (AWEA 2014) and is anticipated to expand, prompted by both environmental and economic forces. The analysis used here uses a turbine hub height of 80m and a rotor diameter of 100 m to represent a windmill that would produce 2.2-3.0 megawatts.

The prairie ecosystem that once covered the Midwestern United States is one of horizontal character: fields of grass extend outward towards the horizon, with only a few trees or other vertical features jutting above grass level. Even as settlers converted the prairie to agricultural fields, the horizontal nature of the landscape remained intact. When Pipestone NM was created, the surrounding agricultural lands did not interfere with the distant views and the "sense of open, endless prairie that was the setting of the quarries" (NPS 2008). This viewshed (the total visible area from a particular fixed vantage point) is an important resource value for Pipestone, as it is for many parks, monuments, and historic sites. Protecting these views from modern intrusion is an important management goal of the NPS (NPS 2006). Pipestone NM management highlighted the potential threat of wind turbines and energy development in the *General Management Plan* (NPS 2008): "the development of wind farms and wind turbines within the viewsheds of the national monument would be inconsistent with the scenic values of these landscapes."

Wind turbines (and other associated tall structures, including transmission and meteorological towers) introduce strong vertical elements into what was once primarily a horizontal landscape. These visible structures produce visual contrasts due to the form, color, lines, and movement of turbines and associated infrastructure, including impacts from blinking or static lights (DOI 2013). Moreover, the turbines are so large that the scale is often unbalanced relative to other landscape elements. Distance can attenuate some of the scenic impacts. However, nearby viewers might be unable to ignore the disruption to the viewshed, from the sweep of the rotors, the reflectivity of the surface, or even the shadows cast by the structures as the sun moves across the sky (DOI 2013). The visibility of a wind energy facility or individual turbines is influenced by the distance and orientation of affected location with respect to turbines; rotor size and height of turbines; blade orientation, pitch, and speed (dependent on wind speed and direction); geographic location and sun angle; local topography; presence of screening vegetation; weather/cloud cover; presence of airborne particles/haze and other factors (DOE 2013, USDI 2013). The magnitude of the visual impacts associated with a given wind energy facility would depend on site- and project-specific factors (DOE 2013), including:

- distance of the proposed wind energy facility from viewers;
- weather and lighting conditions;
- size of the facility (i.e., number of turbines) and turbine spacing;
- size (including height and rotor span) of the wind turbines;
- surface treatment of wind turbines, the control building, and other structures (primarily color);
- the presence and arrangements of lights on the turbines and other structures;
- viewer characteristics, such as the number and type of viewers (e.g., hosting landowners, residents, tourists, motorists, and workers) and their attitudes toward renewable energy and wind power;
- the visual quality and sensitivity of the landscape, including the presence of sensitive visual and cultural resources including historic properties;
- the existing level of development and activities in the wind energy facility area and nearby areas, and the landscape's capacity to withstand human alteration without loss of landscape character; and
- the presence of workers and vehicles for maintenance activities.

Because the visual impact can be highly variable with structure characteristics, site and environmental conditions as well as viewer dependent factors, the assessment of some impacts on visual resources is complex and somewhat uncertain. Nonetheless, for nearby viewers, the very large sizes and strong geometric lines of both the individual turbines and a collective array of turbines could dominate views, and the large sweep of moving rotors would tend to focus attention (DOE 2013).

The *Upper Great Plains Programmatic Environmental Impact Statement* (UGP PEIS) is an attempt by the Western Area Power Administration and the US Fish and Wildlife Service to create a comprehensive strategy for addressing emerging wind development projects in six states in the upper Midwest (DOE 2013). The draft PEIS addresses the impacts of wind development on visual resources similarly to USDI (2013). Pipestone National Monument lies within an area of Minnesota with high potential for wind development, suggesting that the pressure on the park's scenic resources will continue to grow (DOE 2013, NREL 2013).

<u>Air Quality – Visibility</u>
Visibility can affect view condition by limiting the distance and clarity of the observed views. Poor visibility due to air quality degradation can reduce the quality and integrity of landscape views over time. Condition and trends in air quality attributes are examined in Section 4.7 of this report. Visibility is measured using the Haze Index in deciviews (dv). Visibility conditions are the difference between average current visibility and estimated average natural visibility, where the average natural visibility is the mean between the 40^{th} and 60^{th} percentiles (NPS ARD 2013a). Five-year interpolated averages are used in the contiguous US.

4.5.3. Reference Conditions

The scenic and historical integrity at the park overlap somewhat, and are integrated within the scenic quality evaluation. The reference state is based on a range of natural conditions and historical/cultural elements that would have existed in the period referenced by the park's mission or that support current management initiatives (e.g., Sundance grounds). In accordance with the park mission and purpose, the reference condition for park views combines a natural prairie, the pipestone quarries and ethnographic features. When the park was created in 1937, the surrounding area was predominantly natural/natural appearing (pasture) and agricultural, with some rural elements including homes near the town of Pipestone. The landscape would have been characterized by open vistas dominated by farm fields and pastures with some remnant tallgrass prairie vegetation consisting of diverse grasses, forbs and occasional patches of shrubs with woodland corridors along perennial streams. There would have been occasional farmsteads having one or more small buildings and livestock. Occasional fences, fencerows, and occasional dirt roads would have been present. The homesteaded landscape may have also included wooden and metal windmills, and beginning in the 1870s, barbed wire fencing would have been used in some areas. By the 1930s, some electrical or communication wires may have been present.

Inconsistent landscape elements within views can be inside or outside the park. Examples of inconsistent landscape elements include:

- paved roads and high density of dirt roads and/or high traffic volumes;
- urban, suburban and exurban development;
- rural homes that are not farms;
- industrial-era farm structures such as large silos;
- energy and communication infrastructure, including wind turbines, electrical and phone transmission lines, and communication towers such as cell phone towers;
- fencing;
- commercial and industrial structures;
- irrigation structures;
- commercial advertisement elements such as billboards and excessive signage;
- vegetation that is inconsistent with the reference condition and landscape character type; and
- park structures and infrastructure.

A summary of reference conditions and condition class rating for scenic quality, housing density, and visibility indicators is shown in Table 4-19, Table 4-20, and Table 4-21, respectively. Due to the uncertainties in viewshed modelling and the lack of previous research on the effects of wind turbine development on the perceived viewshed quality of a landscape, an objective condition rating system was not created for visibility of wind turbines.

Table 4-19. Condition rating framework for scenic quality at Pipestone National Monument (modified from NPS Scenery Conservation Program 2014b).

Component	Significant Concern	Moderate Concern	Good Condition
Landscape character elements	Few important character elements are plainly visible and/or many important elements are missing.	Some important landscape features are present, but some important elements are missing.	Most or all important elements of the designated landscape character are plainly visible (e.g., natural features, land use types, structures, etc.).
Quality and condition of elements	Most elements are of poor quality and/or in poor condition. Many or most natural-appearing elements are poor examples of the idealized features. Built elements appear to be of poor quality, or are not well cared for.	Most elements are of fair quality and/or in fair condition. Some natural-appearing elements such as vegetation may not all appear to be healthy or vigorous or may be outside of the natural range of variability expected; lakes and rivers may appear polluted or littered with debris. Some built elements may be of lower quality, are of unfinished construction, or not well cared for.	Most elements are of high quality and in good condition, such as a robust, healthy forest, or a lake with clean water and a natural-looking shoreline, but natural cycles and stress agents within the natural range of variability are acceptable. Built elements use appropriate materials, designs, and finishes and appear to be well cared for.

Table 4-19 (continued). Condition rating framework for scenic quality at Pipestone National Monument (modified from NPS Scenery Conservation Program 2014b).

Component	Significant Concern	Moderate Concern	Good Condition
Inconsistent elements	Many or major inconsistent elements are plainly visible and may be dominant features in the view.	Some inconsistent landscape character elements are plainly visible.	Only a few minor inconsistent landscape character elements such as industrial facilities in a natural landscape or suburban housing developments in an agricultural landscape are plainly visible.

Table 4-20. Condition class descriptions for housing densities (modified from Struthers et al. 2014).

Condition Class	Description
Good	Undeveloped or rural, agricultural (farm and ranch) housing. Housing densities are primarily < 0.07 units /ha. Small concentrated areas of higher densities may exist, but usually not in proximity to the observation point and are relatively inconspicuous.
Moderate Concern	Housing densities are more prominent in the landscape and are generally exurban in character with densities between 0.07 and 1.5 units/ha, but the scenic and historic values are largely maintained.
Significant Concern	Higher density housing generally falls within the suburban class (>1.5 to 10 units/ha) or more dense classes, such that the scenic and historic value is either lost or close to being lost.

Table 4-21. Condition rating framework for visibility (NPS ARD 2013b).

Condition Class	Visibility
Good	<2 dv
Moderate Concern	2-8 dv
Significant Concern	>8 dv

4.5.4. Condition and Trend

Scenery and views from the park are variable, consisting of urban and industrial elements, energy and power structures, communication lines and structures, exurban and urban development, agriculture, and natural settings. Some views are dominated by within-park landscapes and elements, while others are influenced by midground and background elements and landscapes outside park boundaries. View directions typically represent a field of view of about 100 degrees. For example a view to the north might include scenery from the northwest, north and northeast (i.e., 310 degrees to 50 degrees).

Scenic Quality from Primary Viewpoints

Scenic quality was evaluated for the 9 primary viewpoints and views. Most views were classified as having more than one viewed landscape character type, often with a natural/natural appearing character in the foreground and rural and agricultural character types dominating the middle ground and background. A description of each view is presented below. Scenic quality scores figure most heavily in the overall quality rating for each point (Table 4-22).

Viewpoint 1:"First view northwest"

This is the first view of the park just inside the entrance at the crest of the road looking to the northwest (Figure 4-17). Native prairie is in the foreground; the middle ground includes park houses, trees and prairie vegetation; the background is dominated by rural and agriculture landscapes, with power lines in the middle ground and several wind turbines on the horizon. There are many trees on the north side of the road, in the valley and adjacent to the homes. The number of homes and lack of farms gives this view a decidedly rural vs. agricultural character.

Viewpoint 2:"Demo quarry east"

View from just east of quarry line by trail intersection near demonstration quarry (Figure 4-18). This is part of the Circle Trail often walked as part of a loop to see the quarries, cultural features at the outcrop, Winnewissa Falls and Pipestone Creek. The view is to the east across prairie vegetation and open woodlands toward the quartzite outcrop. The overall character is natural/natural appearing, although there is much nonnative grass present. The foreground is native and nonnative vegetation. The middle ground is dominated by deciduous woodlands, and there is no discernible background beyond the tops of the trees, with the exception of one communications tower. Much of the quartzite outcrop that would have been plainly visible in the 1800s through park creation is obscured by trees. The straight path is a highly visible and inconsistent element.

Viewpoint 3:"Lake Hiawatha to east"

View from the northwest corner of Lake Hiawatha. This viewpoint is on the West Trail loop. The view is to the east across the lake, wetland/prairie vegetation, and open woodlands toward the quartzite outcrop (Figure 4-19). The overall character is natural/natural appearing, although there is much nonnative grass and many deciduous trees such as elms and burr oak. The trees change the overall setting to an open savanna with a wood line along the quartzite outcrop. Lake Hiawatha is an impoundment but this is not obvious to the casual viewer. The foreground is native and nonnative vegetation. The middle ground is dominated by deciduous woodlands, and there is no discernible background beyond the tops of the trees. The quartzite outcrop is seen at one location in the middle ground where trees have been removed. Much of the quartzite outcrop that would have been plainly visible in the 1800s through park creation is obscured by trees. Other than the vegetation, there are no inconsistent elements visible. The path is a combination of asphalt, concrete and flagstone.

Viewpoint 4:"Winnewissa Falls approach"

View to the east from the clockwise approach to the falls along the West Trail loop (Figure 4-20). The overall character is natural/natural appearing, although there is much nonnative vegetation and an overabundance of deciduous trees. The foreground is dominated by Pipestone Creek, riparian vegetation and the path. The treed area to the left (north side of the creek) is dominated by burr oak (*Quercus macrocarpa*) whereas the south side of the creek includes a mixture of cottonwood, elm, ash, willow and maples. The herbaceous diversity along the stream appears to be low. The trees change the overall setting to an enclosed view. Visibility of the quartzite outcrop and features such as

Table 4-22. Summary of primary view scenic quality condition ratings at Pipestone National Monument.

Viewpoint/View	Landscape character elements	Quality and condition of elements	Inconsistent elements	Scenic quality rating
Viewpoint 1 : first view northwest	moderate concern	moderate concern	moderate concern	moderate concern
Viewpoint 2: demo quarry east	moderate concern	moderate concern	moderate concern	moderate concern
Viewpoint 3: Lake Hiawatha to east	good	moderate concern	good	good
Viewpoint 4: Winnewissa Falls approach	moderate concern	moderate concern	moderate concern	moderate concern
Viewpoint 5: The Oracle to west	moderate concern	moderate concern	significant concern	moderate concern
Viewpoint 6: Visitor Center deck west and north	good	good	moderate concern	good
Viewpoint 7: Three Maidens to north	moderate concern	moderate concern	significant concern	moderate concern
Viewpoint 10: Sun Dance arbor 360 degrees	good	good	moderate concern	good
Viewpoint 11: Sun Dance camp 360 degrees	good	good	moderate concern	good

Figure 4-17. Panoramic photo showing the initial view of the park from the entrance road (viewpoint 1, view “first view northwest”). CSU Photo August 2013.

Figure 4-18. Panoramic photo looking east along Circle Trail from near the demonstration quarry (viewpoint 2, view “demo quarry east”). CSU Photo August 2013.

Figure 4-19. Panoramic photo looking east from the northwest corner of Lake Hiawatha (viewpoint 3, view “Lake Hiawatha east”). CSU Photo August 2013.

Figure 4-20. Panoramic photo looking east from the clockwise Circle Trail approach to Winnewissa Falls (viewpoint 4, view “Winnewissa Falls approach). CSU Photo August 2013.

Leaping Rock and Winnewissa Falls are obscured by the dense tree and shrub vegetation. Winnewissa Falls and the stone-faced concrete bridge and walkway below the falls are partially visible in the middle ground. There is no discernible background. Much of the quartzite outcrop that would have been plainly visible in the 1800s through park creation is obscured by trees. Inconsistent elements include the predominance of trees, the stone and concrete bridge and walkway below the falls, and the asphalt path.

Viewpoint 5:"The Oracle to west"
View from on top of the Sioux quartzite bluff on Circle Trail spur near the Oracle cultural feature (Figure 4-21). The view is to the west across Lake Hiawatha, open prairie patches, woodland, and agricultural lands. The dominant landscape character is natural/natural appearing. The foreground is dominated by the quartzite outcrop, park trail and mix of prairie and woodland patches. The paved trail and abundance of trees are inconsistent elements in the foreground. The middle ground is dominated by a prairie patch and deciduous trees. The abundance of trees is an inconsistent element in the middle ground. The background is dominated by open agricultural fields and woodlands. Residential development, transmission lines and wind turbines are plainly visible inconsistent elements in far middle ground and background. Power transmission lines include H-type wooden structures, lattice tower structures and the horizontal lines themselves. Wind turbines include the Pipestone Schools turbine approximately 1 mile distant and four wind turbine structures approximately 5 miles to the west.

Viewpoint 6:"Visitor Center deck west and north"
View to the west and north from the interpretive deck on the west side of the Visitor Center (Figure 4-22, 44-23). The foreground is restored prairie, middle ground and background is rural residential and agricultural with a few farm buildings visible. This is one of the best prairie views within the park. Wooden H-type power line support towers and lines are dominant elements in the middle ground and background. Other inconsistent elements include rural residential development and treed areas associated primarily with residential development, the State Wildlife Area to the north, farms and the two cemeteries on the west side of the park. The Pipestone Schools wind turbine is moderately conspicuous on the southwest horizon. The wind turbines near Airlie are visible but are small and inconspicuous.

Viewpoint 7:"Three Maidens to north"
View from directly in front of Three Maidens boulders, looking north across the monument (Figure 4-24). This is a very flat landscape which limits the features visible. Nonetheless, this is a highly visited area and often the first stop by park visitors. The immediate foreground is an active prairie restoration project. The foreground and middle ground are dominated by prairie with scattered clumps of shrubs and trees. Developed inconsistent elements include the parking lot, road, park buildings, a communications tower, and signage by the road. Trees are dominant features in all distance zones, and obscure the vastness of the prairie landscape from this low elevation viewpoint. They block views of the prairie, the quarry areas, and the quartzite outcrop/bluffs. A treed horizon and farmed fields are seen in the background. Power transmission support structures and lines are visible in the middle and background but are moderately inconspicuous.

Figure 4-21. Panoramic photo looking west the quartzite outcrop near the Oracle feature (viewpoint 5, view “Oracle to west”). CSU Photo August 2013.

Figure 4-22. Panoramic photo looking west from the Visitor Center interpretive deck (viewpoint 6, view “Visitor Center deck west and north”). CSU Photo August 2013.

Figure 4-23. Panoramic photo looking north from the Visitor Center interpretive deck (viewpoint 6, view “Visitor Center deck west and north”). CSU Photo August 2013.

Figure 4-24. Panoramic photo looking north from the Three Maidens picnic area (viewpoint 7, view “Three Maidens to north”). CSU Photo August 2013.

Viewpoint 10:"Sun Dance arbor 360 degrees"
View from the Sun Dance arbor in the center of the Sun Dance ceremonial grounds (Figures 4-25 to 4-28). This view is considered a single view encompassing all directions. The view point is in a relatively low landscape position. This is a relatively flat landscape which limits the features visible. To the east, the terrain rises and there is no discernible background. In all directions, the foreground consists of mowed grass and pole structures used to shelter the participants. The ceremonial area is in a maintained (i.e., landscaped) condition and built structures supporting ceremonial use of the area appear to be in good condition. Beyond the pole structures there is prairie, solitary and clumped trees, several quarries and the camping area to the west, and some Sioux quartzite outcrops to the east. The middle ground is dominated by natural and natural-appearing prairie. There are many deciduous trees present that obscure prairie views and limit the viewing distance. The far middle ground and background have a mixture of rural and agricultural landscape characters. Several farms are visible in the background. Inconsistent elements in the middle ground and background include numerous rural residences, the Pipestone Schools wind turbine to the southwest, extensive areas where trees dominate the view, and power line support towers and power lines.

Viewpoint 11:"Sun Dance camp 360 degrees"
View from the camping area on the west side of the Sun Dance ceremonial grounds (Figures 4-29 to 4-32). This area provides camping associated with Sun Dance ceremonies. It consists of a field dominated by native and nonnative prairie grasses, access via a dirt road from the north, and several wooden structures used for cooking and eating. When in use, the area might have up to several hundred people. This view is considered a single view encompassing all directions. The view point is in a relatively low landscape position. This is a relatively flat landscape which limits the features visible. To the east and southeast, the foreground and middle ground are dominated by scattered trees and areas used for quarrying and camp kitchen and eating structures; there is no discernible background. In other directions, view is somewhat similar to other views in the park looking south, west and north and not obscured by trees in the foreground. The foreground is dominated by natural/natural-looking prairie vegetation. The middle ground is dominated by natural and natural-appearing prairie, scattered trees and groups of trees within the monument, the State Wildlife Area, residences, farms and other development. The far middle ground and background have a mixture of rural and agricultural landscape characters. Several modern farm structures are visible in the background. Inconsistent elements in the middle ground and background include numerous rural residences, the Pipestone Schools wind turbine to the southwest, areas where trees dominate the view, and H-style and lattice power line support towers and power lines.

Key views were evaluated and assigned a scenic quality rating (Table 4-23) using the criteria in Table 4-19.

Figure 4-25. Panoramic photo looking north from the Sun Dance arbor (viewpoint 10, view “Sun Dance arbor 360 degrees”). CSU Photo August 2013.

Figure 4-26. Panoramic photo looking east from the Sun Dance arbor (viewpoint 10, view “Sun Dance arbor 360 degrees”). CSU Photo August 2013.

Figure 4-27. Panoramic photo looking south from the Sun Dance arbor (viewpoint 10, view “Sun Dance arbor 360 degrees”). CSU Photo August 2013.

Figure 4-28. Panoramic photo looking west from the Sun Dance arbor (viewpoint 10, view “Sun Dance arbor 360 degrees”). CSU Photo August 2013.

Figure 4-29. Panoramic photo looking north from the Sun Dance camp area (viewpoint 11, view “Sun Dance camp 360 degrees”). CSU Photo August 2013.

Figure 4-30. Panoramic photo looking east from the Sun Dance camp (viewpoint 10, view “Sun Dance camp 360 degrees”). CSU Photo August 2013.

Figure 4-31. Panoramic photo looking south from the Sun Dance camp (viewpoint 10, view “Sun Dance camp 360 degrees”). CSU Photo August 2013.

Figure 4-32. Panoramic photo looking west from the Sun Dance camp (viewpoint 10, view “Sun Dance camp 360 degrees”). CSU Photo August 2013.

Table 4-23. Housing densities within 30 km of Pipestone National Monument in 2010 (data provided by NPS NPScape Program).

Density Class	Area (hectares)	Percent of 30Km buffer area
Rural (0 – 0.0618 units/ha)	54,549	84.20%
Exurban (0.0618 – 1.47 units/ha)	9,934	115.30%
Suburban (1.47 – 10.0 units/ha)	167	0. 30%
Urban (>10.0 units/ha)	40	0.06%
Commercial/Industrial	74	0.11%

Housing Densities

Housing density in the region surrounding the park shows marked patterns of change between 1970 and 2010 (Table 4-23). Within a 30 km radius of the park, the most notable trend is an increase in exurban areas and a corresponding decrease in rural acreage. There is an increase in the acreage of suburban areas but the major change in housing density is associated with existing urban centers such as Flandreau and Pipestone. However, there is also a pattern of increasing exurban housing density in unincorporated areas, including areas close to towns and major roads. However, acreages of rural, exurban, suburban and urban areas are not forecast to significantly change by 2050. Additional details are presented in the Land Cover and Land Use chapter of this assessment. Locally, the State Wildlife Area to the north is protected from development by virtue of its ownership, but most other lands are privately held. Although the housing density is predominantly rural, small concentrated areas of higher densities exist close to the park, are visible from some key view points and are relatively conspicuous. Based on this information, this indicator warrants moderate concern for views, with an unchanging trend and high level of confidence.

Potential Visibility of New Wind Turbines

Wind power generating facilities in the counties surrounding PIPE range from single turbine generating less than one megawatt (e.g., Pipestone Schools) to farms of over 100 turbines generating over 200 megawatts of power (Figure 4-33). Most recently, the Prairie Rose II project designed to produce up to 100 MW was constructed in Pipestone and Rock counties less than ten miles from the monument, southeast of Jasper and west of Hardwick. Fortunately, despite the proximity to the monument, the 80 meter hubs of these turbines are not visible from the monument due to regional topography. The most visible wind turbines from important park view points are the solitary Pipestone Schools turbine southwest of the park and a group of four turbines at the town of Airlie approximately six miles west of the park near the South Dakota border.

With average annual wind speeds between 7.5 and 9.0 m/s, the vicinity of the park is considered to have suitable and attractive wind resources for electricity production (DOE 2014). With assistance from the NPS Midwest Geospatial Support Center, the potential visibility of 80 m tall and 130 m tall wind turbine structures from view points within the park was examined relative to the NREL wind suitability data layer (Figure 4-34). The analysis addresses the following questions: 1) Where would construction of wind turbines potentially affect views from the park?, and 2) How much of the area falls within suitable wind energy production areas?

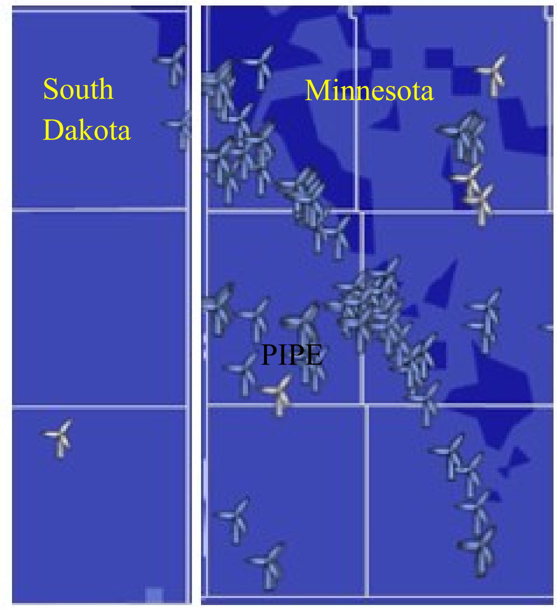


Figure 4-33. Distribution of wind turbine projects within the counties surrounding Pipestone National Monument (NRDC 2014). The Monument is roughly centered on the graphic within Pipestone County. Darker turbine icons represent existing facilities and lighter icons represent proposed facilities. The Prairie Rose II project south of the park has been constructed.

Results show that 80 m turbine hubs could potentially be seen on a total of about 171,000 acres; 130 m tall rotor blades could potentially be seen on a total of about 311,300 acres. Eighty-meter tall turbines would be visible approximately two miles to the east, five miles to the south, 10 miles to the west, and over 20 miles to the northwest, while rotor blades (130 m) would be visible for approximately 2-5 additional miles in any direction (Figure 4-34). The degree of visibility of an 80 m tall turbine is show in Figure 4-35. For example, the four turbines located approximately 5 miles west of the park are approximately 50% visible.

The viewshed area to the south east and north of the park is generally classified as having good wind power potential. Most of the visible area to the west and northwest is generally classified as having fair wind power potential (Figure 4-34). The degree of visibility for structures built to the west and northwest would also be high, generally in the 50-100% visible range (Figure 4-35). Over 90% of the area where 80m and 130m blade rotors turbines would be visible falls in the fair or good wind suitability class (Table 4-24). This indicates that there is an enormous potential for future wind farm development to affect key park views to the south and west. Results for this indicator warrant moderate concern for park views with a deteriorating trend. Confidence is low due to the assumptions associated with viewshed modeling applied here and uncertainties regarding actual future development of wind farms in the region.

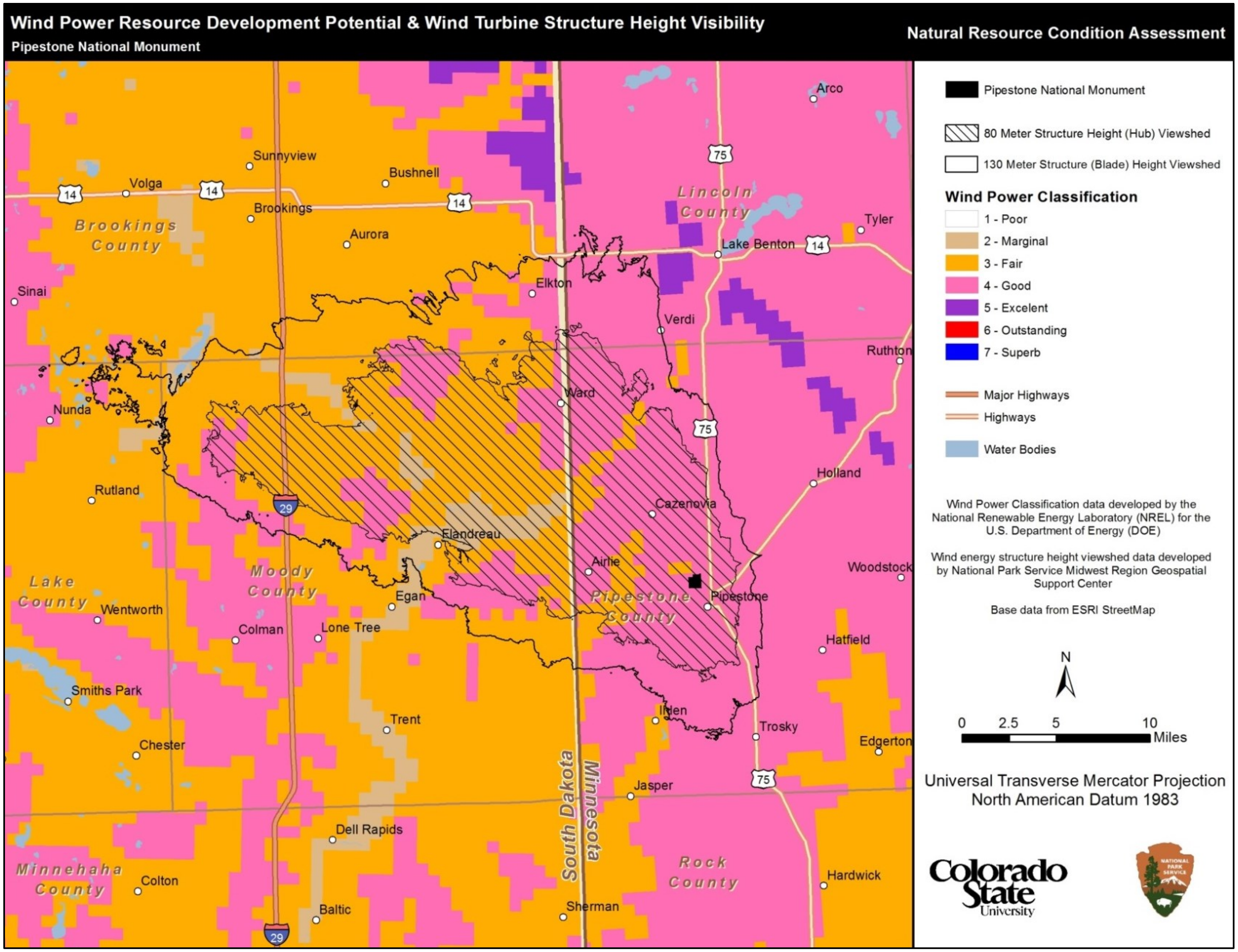


Figure 4-34.. Areas potentially visible within the viewshed of key viewpoints within Pipestone National Monument for 80 m (turbine hub) and 130 m (rotor blade) wind energy structure heights.

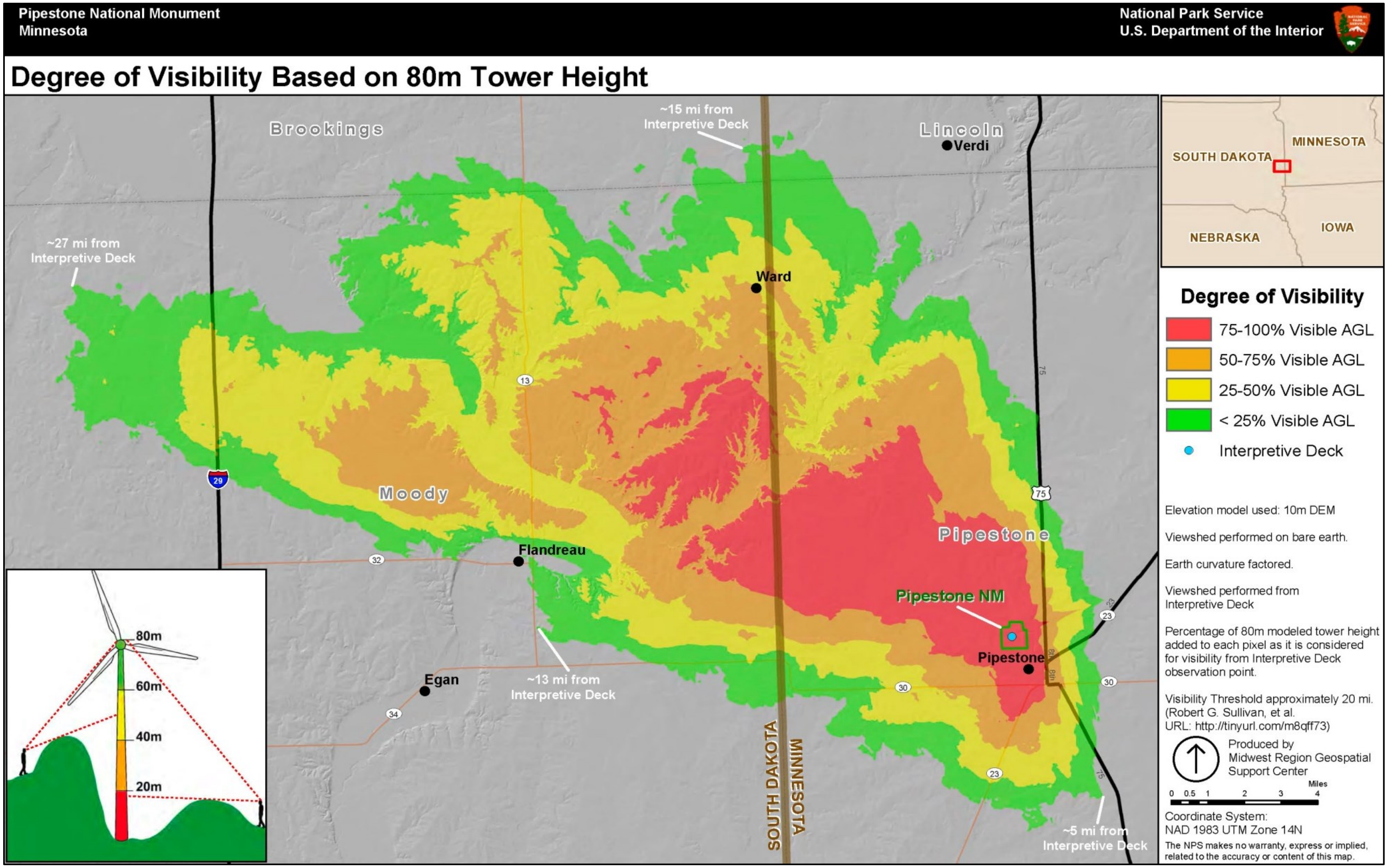


Figure 4-35. Degree of visibility from the Pipestone National Monument interpretive deck, based on 80 m turbine height (data and graphic provided by NPS Midwest Geospatial Support Center November 2013).

Table 4-24. Area and percentage of viewshed within each National Renewable Energy Lab wind power suitability class for 80 m and 130 m structure heights for Pipestone National Monument.

Wind Energy Structure Height	Acres (% of viewshed) Poor wind power class	Marginal wind power class	Fair wind power class	Good wind power class	Excellent or better wind power class	Total acres all classes within viewshed
80m turbine hub	0.0 (0%)	9,753 (5.6%)	77,302 (44.4%)	83,992 (48.2%)	0.0 (0%)	171,046[1]
130m structure	0.0 (0%)	15,023 (4.8%)	147,614 (46.8%)	148,683 (47.1%)	0.0 (0%)	311,320[2]

[1] "No Data" acreage of 3,128 acres not counted in above total.

[2] "No Data" acreage of 4,235 acres not counted in above total.

Air Quality - Visibility

The five-year averages for visibility consistently fall in the "Poor Condition" category. The visibility levels have been between 8.0 dv and 10.1 dv throughout the 2001-2010 periods. The condition of this indicator warrants significant concern, with an unchanging trend and medium confidence due to the regional and modeled nature of the data. Although the gently rolling topography and lack of high vantage points at PIPE somewhat limit the observation of distant objects due to visual obstruction by trees, other objects and the curvature of the earth, the poor visibility rating is notable. Condition of this indicator warrants significant concern with an unchanging trend. This indicator is described in more detail in the *Air Quality* section of this report.

Overall Condition and Trend

Overall condition of views warrants moderate concern with a deteriorating trend. Confidence in the assessment is medium (Table 4-25). Some scenic views are relatively high quality but some have been affected by development or other activities that can detract from the visitor experience. Power line support structures, power lines and rural residential housing significantly degrade many of the key park views. Some views are significantly impacted by overabundant trees that are incongruent with the desired prairie landscape character. Condition of scenery is weighted most heavily toward the scenic quality ratings, which are based on actual views and human observations from defined vantage points. Less weight is given to the examination of housing densities and landcover, which illuminate larger landscape issues that may affect the park into the future and also impact secondary views in and around the park. The evaluation of potential visibility of new wind turbine developments highlights an issue that is of great concern to park managers, and illustrates geographically the park views that may be impacted. Although wind energy results are assigned a lesser weight relative to the quality of on-the-ground views, the high likelihood of wind farm construction affecting views in the future is considered in the trend rating.

Orientation of visitor views toward the east and north will provide the best natural or natural/appearing views and minimize dominance of inconsistent landscape character elements such as power transmission lines, wind turbines and residential development.

Table 4-25. Condition and trend summary for scenery at Pipestone National Monument.

Indicator	Condition Status/Trend	Rationale
Scenery and Views (overall)		**Condition warrants moderate concern with a deteriorating (anticipated) trend. Confidence in the assessment is high.**
Scenic quality		The majority of key views received ratings of moderate concern for landscape character elements, quality and condition of elements and inconsistent elements. Nearly all views were significantly impacted by the presence of inconsistent elements, the most common elements being trees on the prairie, rural housing, power line support structures and lines and wind turbines.
Housing densities in the surrounding 30 km area		Within a 30 km radius of the park, the most notable trend is an increase in exurban areas since 1970 and a corresponding decrease in rural acreage. There is also an increase in the acreage of suburban areas but the major change in housing density is associated with existing urban centers such as Flandreau and Pipestone. Acreages of rural, exurban, suburban and urban areas are not forecast to significantly change by 2050. Additional details are presented in the Land Cover/Land Use chapter of this assessment. Relative to the rating framework, the condition falls between the moderate concern and good condition criteria.
Potential visibility of wind turbines		Extensive areas where wind turbine structures would be visible spread out from the monument on all sides, especially to the west and northwest. The key views from the park to the south, west and north contain an extremely high proportion of acreage in the "fair" and "good" mapped wind energy potential classes. Park views are already impacted by several projects and there is considerable potential for future wind farm development within the park's viewshed. Confidence is low due to the assumptions associated with viewshed modeling applied here and uncertainties regarding actual future development of wind farms in the region.
Air Quality - Visibility		The five-year averages for visibility consistently fall in the NPS Air Resources Division "poor condition" category. See the *Air Quality* section of the NRCA for more details.

4.5.5. Uncertainty and Data Gaps

Further examination of key park views by monument staff is recommended incorporating the scenic quality protocols being developed by the NPS Scenery Conservation Program.

4.5.6. Sources of Expertise

Rob Bennets, Network Coordinator, Southern Plains I&M Network, NPS Inventory and Monitoring Division

Doug Wilder and Matt Colwin, NPS Midwest Geospatial Support Center

Mark Meyer, Renewable Energy Visual Resource Specialist, NPS Natural Resources Stewardship/Science, Air Resources Division

4.5.7. Literature Cited

American Wind Energy Association (AWEA). 2014. Wind energy facts at a glance. http://www.awea.org/Resources (accessed 2/16/2014).

Department of Energy (DOE). 2013. Upper Great Plains wind energy programmatic environmental impact statement. DOE/EIS-0408.

Department of Energy (DOE). 2014. History of wind energy. http://energy.gov/eere/history-wind-energy, accessed 2/16/2014.

Kulesza, C., Y. Le, and S.J. Hollenhorst. 2013. National Park Service visitor perceptions & values of clean air, scenic views, & dark night skies; 1988–2011. Natural Resource Report NPS/NRSS/ARD/NRR–2013/632. National Park Service, Ft. Collins, Colorado.

National Park Service (NPS). 2006. Management policies. U.S. Department of Interior, National Park Service, Washington, D.C. ISBN 0-16-076874-8.

National Park Service (NPS). 2008. General management plan, Pipestone National Park. USDI National Park Service.

National Park Service Air Resources Division (NPS ARD). 2013a. Methods for determining air quality conditions and trends for park planning and assessments. http://www.nature.nps.gov/air/planning/docs/AQ_ConditionsTrends_Methods_2013.pdf. (Accessed 23 August 2013).

National Park Service Air Resources Division (NPS ARD). 2013b. Air quality in national parks: trends (2000-2009) and conditions (2005-2009). Natural Resources Report NPS/NRSS/ARD/NRR – 2013/683. National Park Service, Denver, Colorado.

National Park Service Scenery Conservation Program. 2014a. Landscape character type descriptions. July 2014 version.

National Park Service Scenery Conservation Program. 2014b. Scenic quality individual rating form. July 2014 version. Information provided by Mark Meyer.

National Renewable Energy Lab (NREL). 2013. Wind research web site. http://www.nrel.gov/wind/resource_assessment.html (accessed September 2013).

Natural Resources Defense Council (NRDC). 2014. Renewable energy for America website, energy map. http://www.nrdc.org/energy/renewables/default.asp (accessed June 2014)

Oklahoma Historical Society. 2012. Online encyclopedia of Oklahoma history and culture: windmills. http://digital.library.okstate.edu/encyclopedia/entries/w/wi028.html (accessed 7 July 2012).

Struthers, K., R.E. Bennetts, K. P. Valentine-Darby, H. Sosinski, N. Chambers, and T. Folts. 2014. Washita Battlefield National Historic Site natural resource condition assessment. Natural Resource Report NPS/SOPN/NRR-2014/748. National Park Service, Fort Collins, Colorado.

Sullivan, R. L. Kirchler, T. Lahti, S. Roché, K. Beckman, B. Cantwell and P. Richmond. 2013. Draft Manuscript - wind turbine visibility and visual impact threshold distances in western landscapes. Argonne National Laboratory, Argonne, Illinois

Theobald, D.M. 2005. Landscape patterns of exurban growth in the USA from 1980 to 2020. Ecology and Society, 10(32)

United States Department of the Interior (USDI). 2013. Best management practices for reducing visual impacts of renewable energy facilities on BLM-administered lands. Bureau of Land Management. Cheyenne, Wyoming. 342 pp.

4.6. Climate Change

4.6.1. Background and Importance

Climate change is increasingly recognized as a major stressor of biological taxa, communities and ecological systems. Understanding the magnitude and effects of changing climate is essential within the NPS to "manage for change while confronting uncertainty" while developing new management and adaptation strategies (National Park System Advisory Board Science Committee 2012) and a significant scientific component of the NPS *Climate Change Response Strategy* (NPS 2010). Resources vulnerable to climate change at PIPE may include the federally endangered Topeka shiner (*Notropis Topeka*), the Western prairie fringed orchid (*Platanthera praeclara*), and the Sioux quartzite prairie community, a rare feature that includes ephemeral pools supporting many wetland species.

The climate suitable for Great Plains grasslands is expected to remain relatively stable with some expansion to the north in Canada, but the range of tallgrass prairie along the eastern boundary is expected to contract (Rehfeldt et al. 2012). This contraction would potentially affect tallgrass prairie primarily in Illinois, southwestern Minnesota, Iowa, northern Missouri, and the eastern portions of South Dakota, Nebraska, Kansas, Oklahoma and Texas. Increasing CO_2 tends to increase plant growth and water use efficiency, but may be limited by water and nutrient availability. Transpiration rates usually decline as CO_2 increases, while, in many plants, photosynthesis and growth increase. Growth response to CO_2 is usually highest in rapidly-growing plants and in plants with the C3 photosynthetic pathway (most woody plants and 'cool-season' grasses) versus the C4 pathway (most 'warm-season' grasses) (Polley 1997).

Changes in grassland composition due to the interaction of temperature, moisture, nutrient availability and CO_2 are very difficult to predict (Polley 1997, Morgan et al. 2008), but evidence increasingly suggests that rising CO_2 and temperature plus increased winter precipitation can favor herbaceous forbs, legumes, and woody plants in many Great Plains rangelands, with uncertain changes in the balance between cool-season and warm-season perennial grasses (Morgan et al. 2008). Changes in species composition will likely vary by region and by year and will depend on depth and timing of available soil water as well as disturbance factors such as grazing, fire, and disease, which can have strong influence on plant communities (Bagne et al. 2013). Long-term research at the Konza Prairie found that primary productivity NPP in tallgrass prairie is a product of spatial and temporal variability in light, water, and nutrients, driven by a combination of topography, fire history, and climate, and is not driven strongly by precipitation alone (Briggs and Knapp 1995). Dynamics shaping plant community composition will also be influenced by increasingly severe and frequent droughts, floods and fires (Bagne et al. 2013).

The synopsis of potential changes to the park climate presented here characterizes the "exposure" component of resource vulnerability, the other components being resource sensitivity and adaptive capacity. Overall climate change vulnerability for a particular resource is estimated using a combination of exposure, sensitivity and adaptive capacity (Glick et al. 2011).Climate change is examined here using modeled future climate scenarios, but potential resource vulnerability and management implications are based on the relative amounts and directions of changes rather than specific magnitudes or thresholds of change. Although the Park can do its part to mitigate greenhouse gas emissions and optimize the efficiency of park operations vis a vis greenhouse gases, climate change and its associated effects on park resources are largely out of the control of park managers. It is happening and will require an evaluation of the vulnerability of park resources. Moreover, specific and diverse adaptation measures for some park resources may be necessary to mitigate effects of climate change and transition to future climatic conditions.

Threats and Stressors

Increases in atmospheric greenhouse gases are resulting in changes in global, regional and local climates. Changes in the amounts and patterns of temperature and precipitation have numerous direct and indirect effects on environmental conditions and biota. An increase in the frequency of extreme weather is also anticipated under climate change.

Indicators and Measures

- Temperature changes from baseline – minimum, mean, and maximum temperatures (monthly)
- Precipitation changes from baseline – annual and seasonal; very heavy events
- Indices of aridity/drought – historical period of record and future vs. baseline period
- Plant phenology (baseline only) and growing season – enhanced vegetation index values for onset of spring greenup, maximum greenness (peak vegetation) and onset of minimum greenness; projected changes in frost-free period.

4.6.2. Data and Methods

A variety of data and analysis approaches are used to characterize the climate during the historical period of record and examine possible changes in climate for the park. A combination of site-specific and regional results is presented. Historical climate and modeled future climate change were examined for the area extending approximately 30km from the park boundary. Because the park is relatively small, geographic variation within the park is minimal and monthly values were averaged across the area of interest.

Two families of scenarios are generally used for future climate projections: the 2000 Special Report on Emission Scenarios (SRES) and the 2010 Representative Concentration Pathways (RCP). Results for both of these families are presented here. The SRES scenarios are named by family (A1, A2, B1, and B2) and the RCP scenarios are numbered according to the change in radiative forcing (from +2.6 to +8.5 watts per square meter) anticipated by 2100. Comparing carbon dioxide concentrations and global temperature change between the SRES and RCP scenarios, SRES A1fI is similar to RCP 8.5, SRES A1B is similar to RCP 6.0 and SRES B1 is similar to RCP 4.5 (Walsh et al. 2014b).

Consolidation of future modeled climates and comparisons with historical baseline and graphic representation of results was supported by the USGS North Central Climate Science Center (NCCSC) hosted by Colorado State University (http://revampclimate.colostate.edu/). Future climate projections for the NCCSC products are presented for several scenarios of future greenhouse gas concentrations (i.e., emission scenarios); representative concentration pathway (RCP) 8.5 represents the high emissions scenario and RCP 4.5 represents a moderate emissions scenario. Examination of historical climate data used PRISM (4km) data downloaded from http://cida.usgs.gov (Prism Climate Group 2014). Climate projections for non-spatial graphics use CMIP5 downscaled data downloaded from the Green Data Oasis website (http://gdo-dcp.ucllnl.org/downscaled_cmip_projections/dcpInterface.html) (CMIP5 Modeling Groups 2014). CMIP5 downscaling procedures are described in Maurer et al. (2002). Approximately 35 general circulation models (GCMs) that use quantitative methods to simulate the interactions of the atmosphere, oceans, land surface, and ice were used for the NCCSC summaries. Because the variability in results among models makes interpreting results problematic, ensemble summaries were used to combine the simulations of multiple GCMs and quantify the range of possibilities for future climates under the different emission scenarios. Using ensemble median values based on the results from many GCMs provides a more robust climate simulation versus using results of individual models (Girvetz et al. 2009). Seasonal summaries use the following groupings: winter = December, January, and February, spring = March, April, and May, summer = June, July, and August, and autumn = September, October, and November

The Palmer Drought Severity Index (PDSI) uses temperature and precipitation data to calculate water supply and demand, incorporates soil moisture, and is considered most effective for unirrigated cropland (Palmer 1965, USDA 2014). Long-term drought is cumulative, so the intensity of drought during a point in time is dependent on the current weather patterns plus the cumulative patterns of the previous period. The Index is used widely by the U.S. Department of Agriculture and other agencies. PSDI values range between -4.00 or less (extreme drought) and +4.00 or greater (extreme moisture). The index uses a value of 0 as “normal”. The Palmer Index is most effective in determining long term drought (i.e., at least several months). Monthly PSDI values were obtained from the National Climatic Data Center (NCDC 2013a). Assumptions of the PSDI regarding the relationship between temperature and evaporation may give biased (i.e., overestimated evaporation) results in the context of climate change (Sheffield et al. 2012). However, examination of historical PSDI does appear to corroborate known drought periods and the PSDI approach is not used to model future drought.

Moisture deficit was modeled using the web-based Climate Wizard Custom tools applying 12 km downscaled climate projections for more than 15 different GCMs (The Nature Conservancy, University of Washington and University of Southern Mississippi 2014; Maurer et al. 2007). Two greenhouse gas emissions scenarios - High (A2) and Medium (A1B) were used for the Climate Wizard results. The balance between precipitation and the amount of water that an ecosystem could potentially use though evaporation and transpiration (i.e., potential evapotranspiration or PET) is the basis for the climatic moisture deficit. PET is higher with warmer temperatures and more daylight hours. PET was calculated based on monthly temperature and monthly average number of daylight hours using a modified version of the Thornethwaite equation and procedures described by Wolock and McCabe (1999). Climatic moisture deficit quantitatively estimates moisture stress in a system; a higher moisture deficit reflects higher moisture stress. A deficit (in mm) occurs only when precipitation (i.e., supply) is less than PET (i.e., demand) in a given month. If precipitation decreases or temperature increases (increasing PET) moisture deficit increases. Deficit is calculated as monthly PET minus precipitation (in mm), and is set to zero if precipitation is greater than PET. Monthly results are summed to provide seasonal or annual values (The Nature Conservancy, University of Washington and University of Southern Mississippi 2014).

Plant phenology was examined using existing and freely available remote sensing data, specifically the NASA-funded 250 meter spatial resolution land-surface phenology product for North America. This product is calculated from an annual record of vegetation health observed by NASA's Moderate Resolution Imaging Spectroradiometer (MODIS) instrument. The land surface phenology product summarizes all the observations throughout a year into a few, key, ecologically relevant biophysical parameters or metrics. MODIS land products include two Vegetation Indexes (VI) derived from the remotely sensed fraction of photosynthetically active radiation detected every one to two days by the MODIS sensors (Gao et al. 2007). Normalized difference vegetation index (NDVI) and enhanced vegetation index (EVI) datasets represent 8 day composites of MODIS data at the 250 meter spatial resolution scale (Tan et al, 2010). The revisit interval for any geographic point is approximately 1-2 days. The resulting land surface phenology metrics are produced from these composites using an enhanced algorithm within the TIMESAT software program (Tan et al. 2010). Phenology data for pixels within the park boundary were gathered and summarized by Kevin James of the Heartland I&M Network using procedures and tools described in James et al. (2013). It was important to keep the pixels examined within the park, since most areas outside the park are not prairie or other forms of native vegetation.

4.6.3. Reference Conditions

For most indices, the reference condition for this assessment is an 85-year period from about 1895, when meteorological data was first collected, to 1980, when a significant change in many climate indices roughly began. Although there may be some changes occurring during this period, the long reference period avoids bias associated with wet, dry, warm and cold periods or extreme events such as prolonged or severe drought. Some analyses of historical data use a 1950-1980 baseline because of limited dates associated with downscaled CMIP5 data. For the climatic moisture deficit projections, future values were compared to a baseline period of 1961-1980. For frost-free season length, the baseline period was 1901-1960.

4.6.4. Historical Conditions, Range of Variability and Modeled Changes

<u>Temperature</u>

Historical Trends

A linear regression model was fit to average minimum and average maximum monthly temperature for 1895-1980 and 1980 to 2012 in the vicinity of Pipestone National Monument (Figure 4-36). The earlier period corresponds to the period that is associated with no change in climate or a slower rate of change compared to 1980 or later. At PIPE, mean minimum monthly temperatures increased significantly over time during 1895-1980 ($p<0.01$ but did not increase significantly from 1980-2012 ($p=0.57$)). The model results for mean monthly maximum temperature over time were not statistically significant for either period.

Trends in monthly minimum temperatures over time are further illustrated in a graphical representation of the data for the period of record (Figure 4-37), which normalizes differences between a baseline period of 1895 to 1980 with individual monthly values. For example, cooler temperatures across most months are evident in the period before 1940 compared to more recent years. High temperatures associated with severe droughts that occurred in the 1930s, late 1950s, late 1980s are clearly shown in Figure 4-37 (bottom). An anomaly plot showing annual mean temperatures over time further illustrates significant changes in this variable during the recent past, with minimum temperatures for most years since 1920 being 0.5-1.5 deg. C above the long term average (Figure 4-38). Monthly data was also grouped by season into model quartiles for minimum temperature (Figure 4-39).

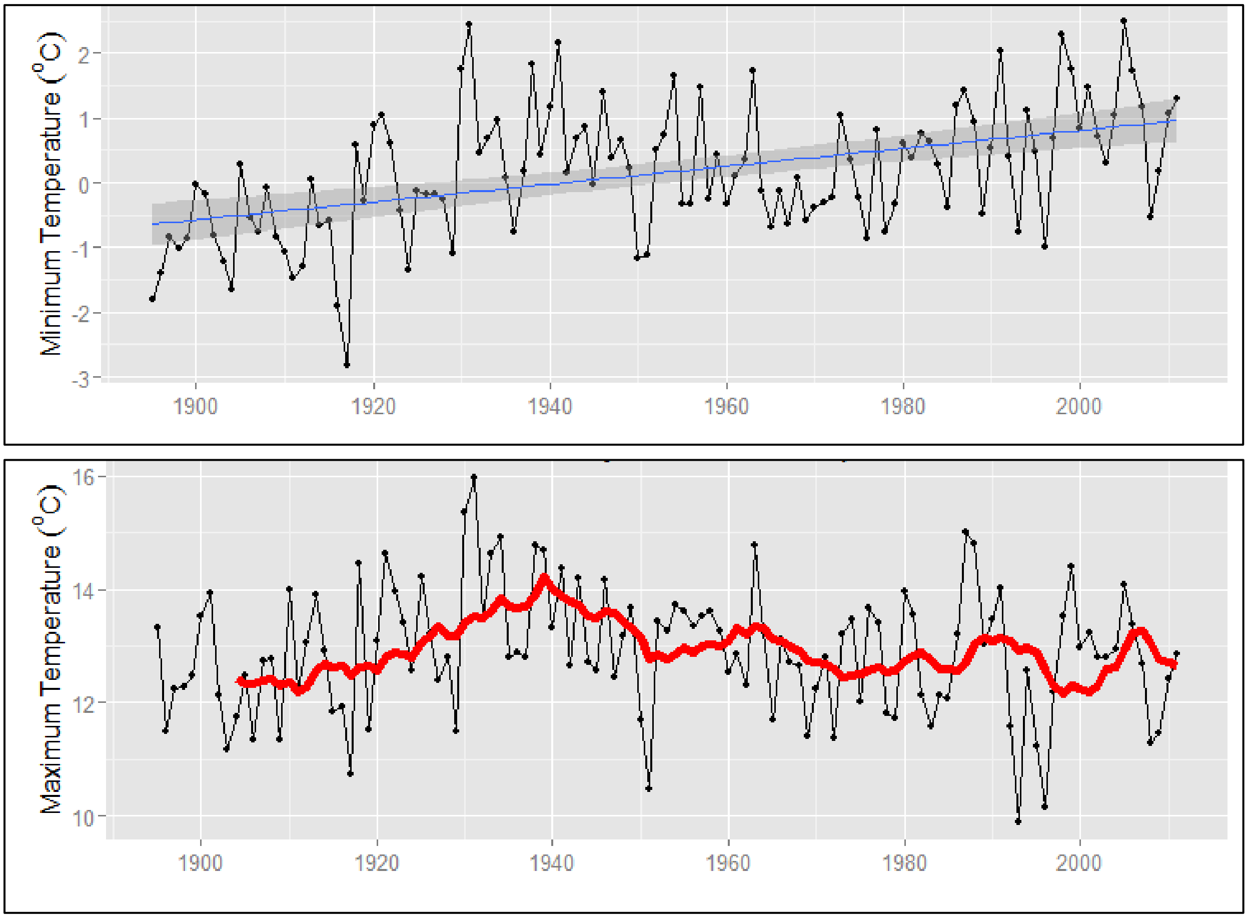


Figure 4-36. Historical PRISM data for minimum temperature showing significant linear model fit (top) and maximum temperature with a five year lag running mean (bottom). (Data and graphic prepared by NCCSC)

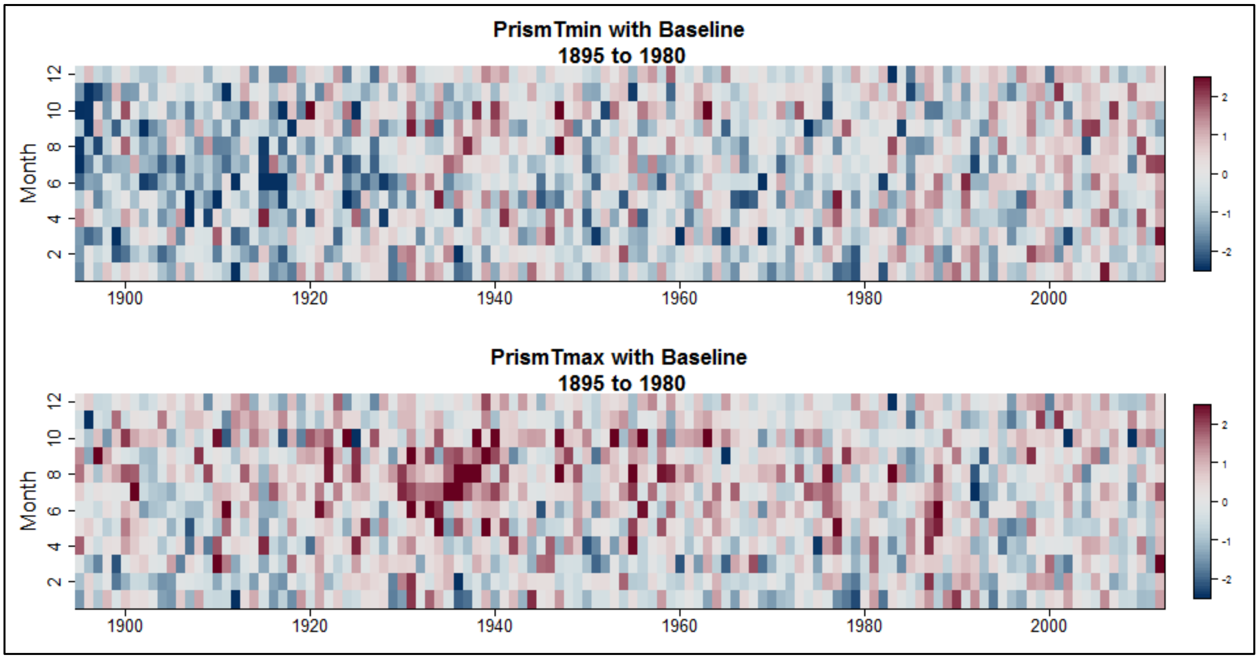


Figure 4-37. Mean monthly minimum temperature (top) and monthly maximum temperature (bottom) showing the normalized difference from a baseline (1895-1980) period for each month and year for Pipestone National Monument. The baseline is calculated monthly within the specified year range. They pixels are normalized by month and colors range from +/- 2.5 standard deviations from the mean of the baseline period. (Data and graphic prepared by NCCSC)

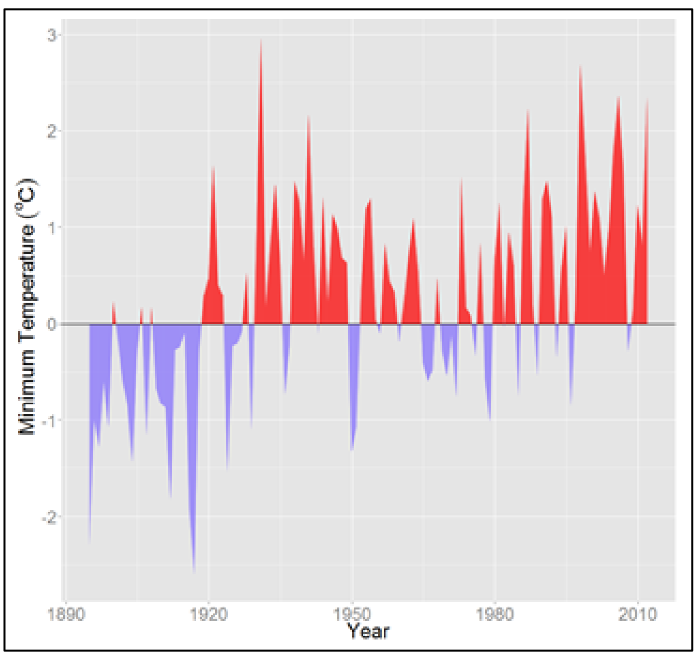


Figure 4-38. Anomaly plot for mean minimum temperature showing the difference between individual years from 1895 to 2012 and a baseline (1895 to 1980 average) for Pipestone National Monument. (Data and graphic prepared by NCCSC)

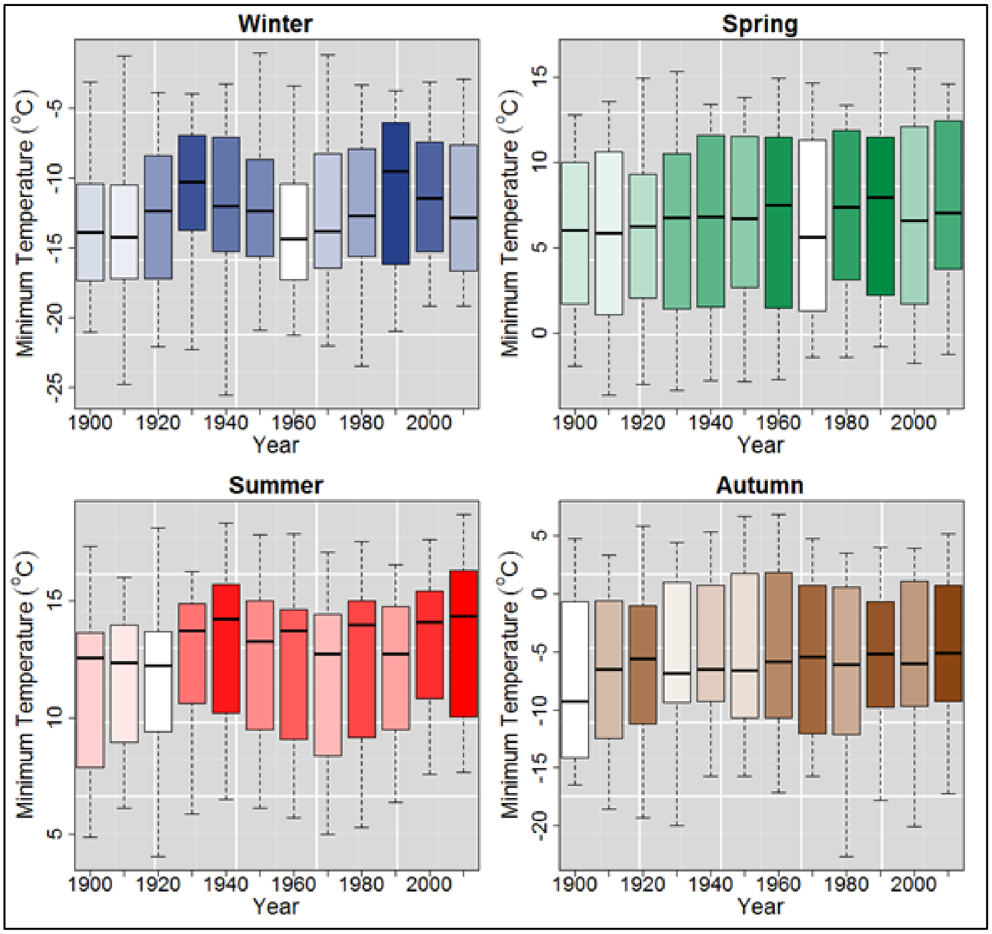


Figure 4-39. Seasonal historical mean minimum temperature quartiles using PRISM data. Within a season, darker colors represent higher temperatures. (Data and graphic prepared by NCCSC)

Modeled Future Changes

Models indicate that temperatures at the park will rise significantly under climate change (Figure 4-40). According to median ensemble estimates, both minimum and maximum temperature are expected to increase by approximately 2-3 °C by 2050, and by approximately 3.0-6.5 °C by 2100, depending on the scenario (Figure 4-40).

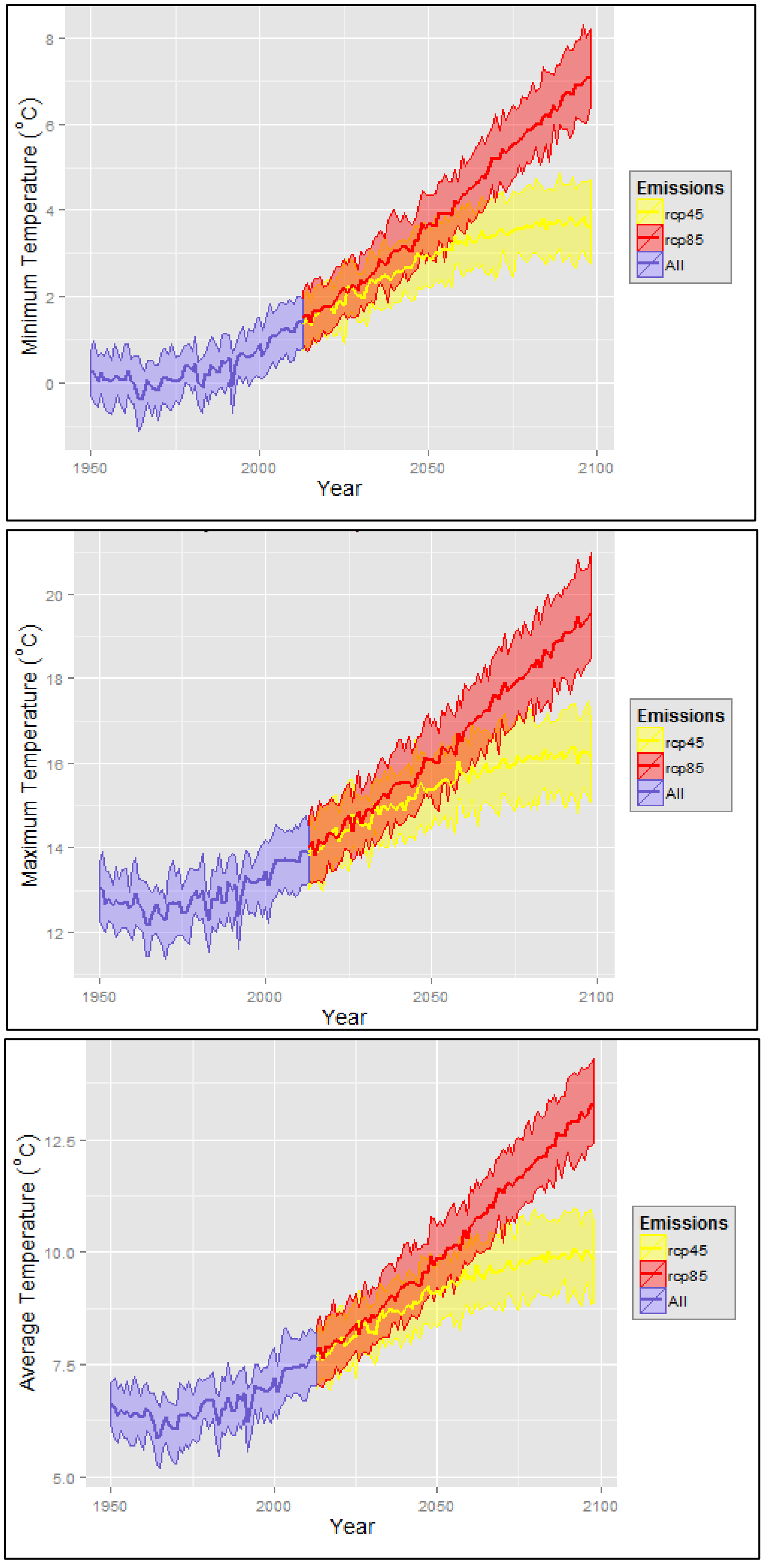


Figure 4-40. Projections for annual minimum, maximum and mean temperature with median, 25 and 75% quantiles grouped by emissions scenario for Pipestone National Monument. (Data and graphic prepared by NCCSC)

Precipitation

Historical Trends

Historical trends in monthly and annual precipitation for 1895-2010 were examined to understand patterns and variability. Mean monthly precipitation appears to be increasing for some months in the latter half of the period of record, but patterns of seasonality are not clear (Figure 4-41). Linear regression of mean monthly precipitation with time were not significant for the 1895-1970 period ($p>0.20$) or the 1970-2012 period ($p>0.15$) (Figure 4-42). Variability in seasonal and annual precipitation is relatively high.

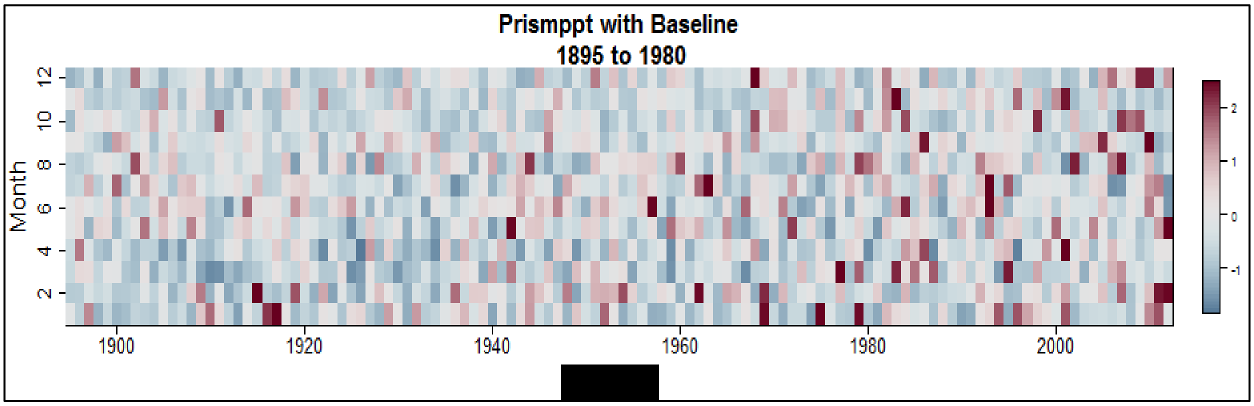


Figure 4-41. Mean monthly precipitation showing the normalized difference from a baseline (1895-1980) period for each month and year for Pipestone National Monument. The baseline is calculated monthly within the specified year range. They pixels are normalized by month and colors range from +/- 2.5 standard deviations from the mean of the baseline period. (Data and graphic prepared by NCCSC)

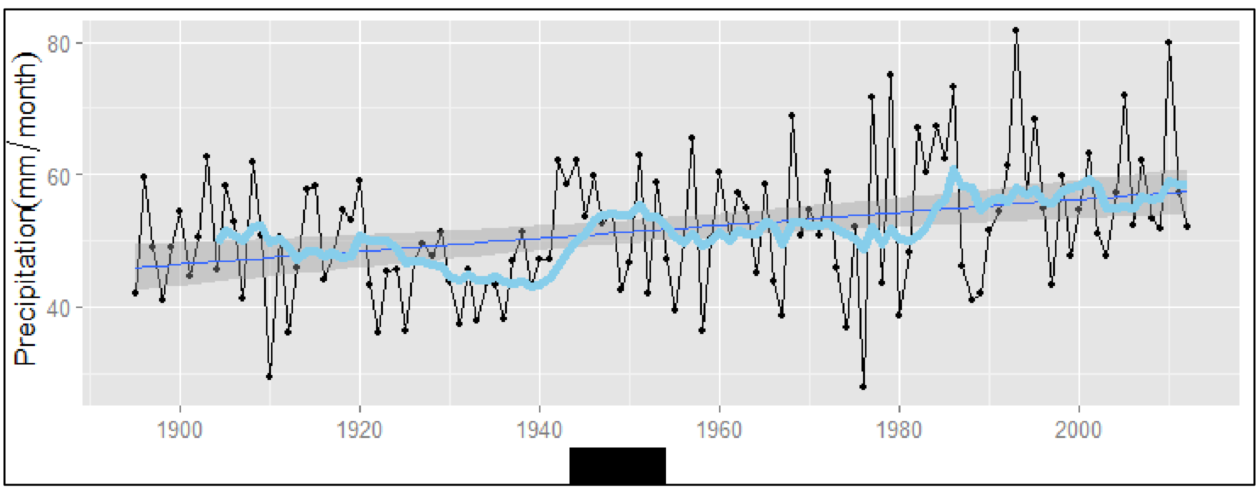


Figure 4-42. Historical PRISM data for precipitation at Pipestone National Monument showing linear model fit and a five year lag running mean. (Data and graphic prepared by NCCSC)

In recent decades there have been increases nationally in the annual amount of precipitation falling in very heavy events, defined as the heaviest 1% of all daily events from 1901 to 2012. The largest regional increases have been in the Northeast, Great Plains, Midwest and Southeast regions when compared to the 1901-1960 average (Walsh et al. 2014a). Regional results for the Midwest region including Pipestone National Monument indicate 20 to 30% or more increases in the annual amount of precipitation falling in very heavy events over the past few decades (Figure 4-43).

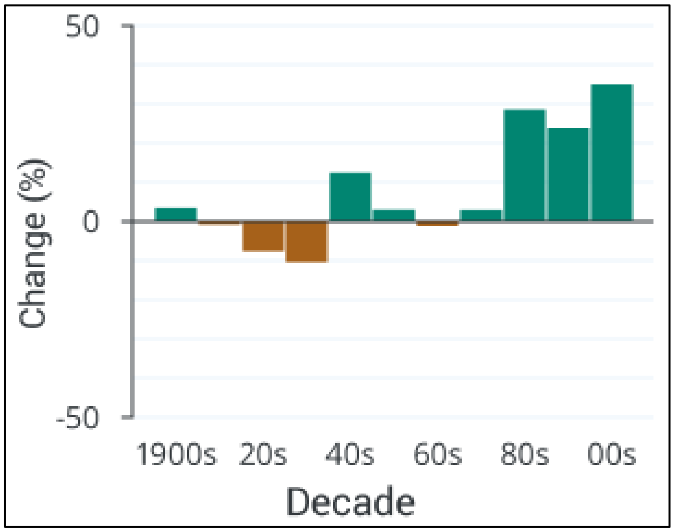


Figure 4-43. Percent changes in the annual amount of precipitation falling in very heavy events compared to the 1901-1960 average for the Midwest region including Iowa and Minnesota. A very heavy event is defined as the heaviest 1% of all daily events from 1901 to 2012. The far right bar is for 2001-2012 (Kunkel et al. 2013 as presented in Walsh et al. (2014a).

Modeled Future Changes

Modeled climate through the year 2100 shows an increase in mean monthly precipitation under both moderate (RCP4.5) and high (RCP8.5) emission scenarios (Figure 4-44). Both the medium and high emission scenarios produce increasing mean monthly precipitation, with an increase of approximately 3-5 mm per month or 35-60 mm (1.3 – 2.3 inches) per year by 2050.

<u>Aridity</u>

Aridity and moisture availability is examined using the Palmer Drought Severity Index (Palmer 1965) for the historical 1940-2012 period. A climatic deficit index (The Nature Conservancy, University of Washington and University of Southern Mississippi 2014) is used to compare the 1961-1980 baseline with mid-century (2050) and end-century (2095) modeled values for medium (A1B) and high (A2) emission scenarios.

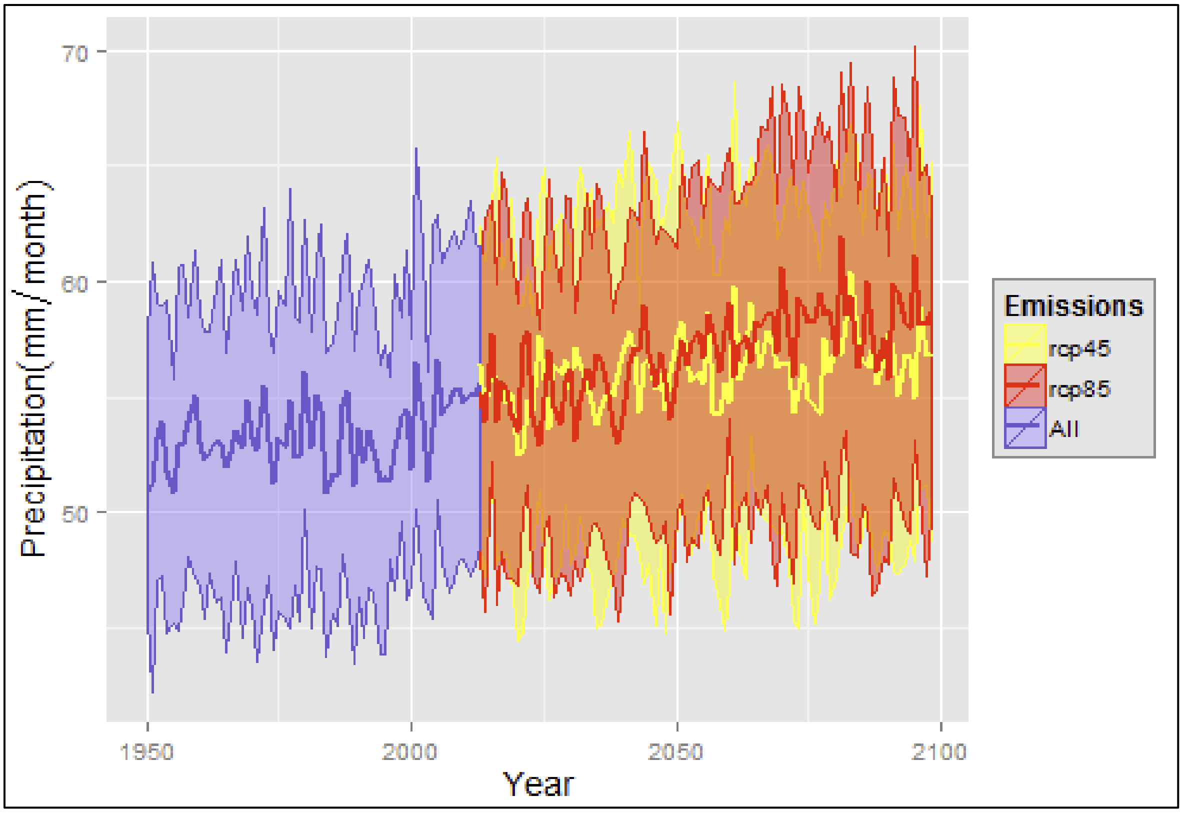


Figure 4-44. Projections for precipitation/month with mean, 25% and 75% quantiles grouped by emissions scenario for Pipestone National Monument. (Data and graphic prepared by NCCSC)

Historical Trends

Palmer Drought Severity Index (PDSI) values were calculated for the period from 1940 to 2012 (Figure 4-45). The Palmer Index is most effective in determining long term drought (i.e., at least several months). Long-term drought is cumulative, so the intensity of drought during a point in time is dependent on the current weather patterns plus the cumulative patterns of the previous period. PSDI values range between -4.00 or less (extreme drought) and +4.00 or greater (extreme moisture). The index uses a value of 0 as "normal", and value of -1.5 is considered drought. While drought is sometimes described as cyclic, the frequency and duration of cycles is highly unpredictable. For the period of record, PIPE PDSI data shows periodic moderate to severe drought lasting 2-4 years occurring every 5 to 15+ years since 1940.

Modeled Future Changes

Moisture deficit results for Pipestone National Monument were modeled using the Climate Wizard Custom Tools (http://climatewizardcustom.org/). Modeled results varied by emissions scenario and season were highly variable across global circulation models. Under the moderate and high emissions scenarios, annual moisture deficit is projected to be approximately 35-65 mm per year by 2050 and 90-120 mm per year by 2095 (Figure 4-46). Seasonal changes were most evident for summer and fall periods. Annual summer season moisture deficits ranging from 80-90 mm (3.3 inches) are forecast for medium and high-emission scenarios by 2095.

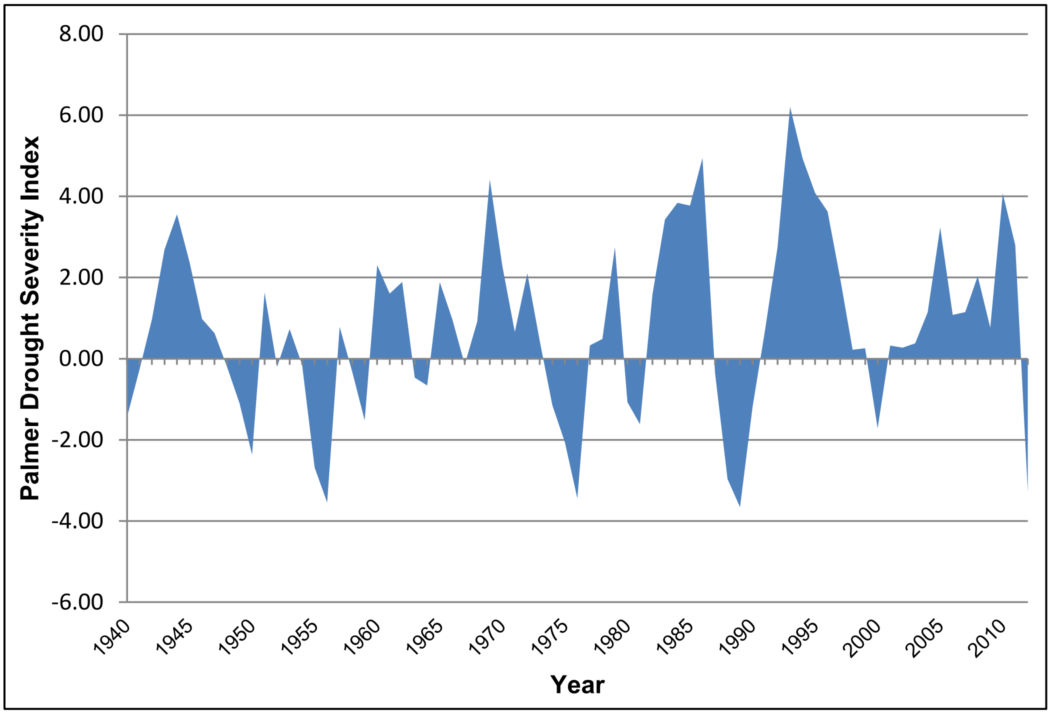


Figure 4-45. Palmer Drought Severity Index from 1940 – 2012 for Pipestone National Monument. Negative values represent drought conditions and positive values represent moist conditions (NCDC 2013a).

Plant Phenology and Frost-Free Period

Plant Phenology

Plant phenology serves as an excellent global warming indicator because it is one of the most readily observable ecosystem reactions to climate change (McEwan et al. 2011). Increases in temperature are responsible for plants flowering earlier in the spring and the delayed onset of dormancy in autumn. This affects not only synchrony among plants, pollinators and complex evolutionary adaptation, but can shorten (or lengthen) a plant's growing season. Phenology also plays an important role in the amount of water released to the atmosphere via evapotranspiration, sequestration of carbon in new growth, and the amount of nitrogen utilized from the soil (Ibanez et al. 2010).

Plant phenology in the park and surrounding area is primarily governed by a combination of plant genetics and the effects of weather and day length. If plant communities change due to management, disturbance, changing climate, or other drivers, then plant phenology may also change due to those compositional changes. For example, cool-season grasses such as smooth brome (*Bromus inermis*) tend to start growing earlier in the spring, reach maximum production and flower earlier compared to warm season grasses such as little bluestem (*Schizachyrium scoparium*) and indiangrass (*Sorghastrum nutans*).

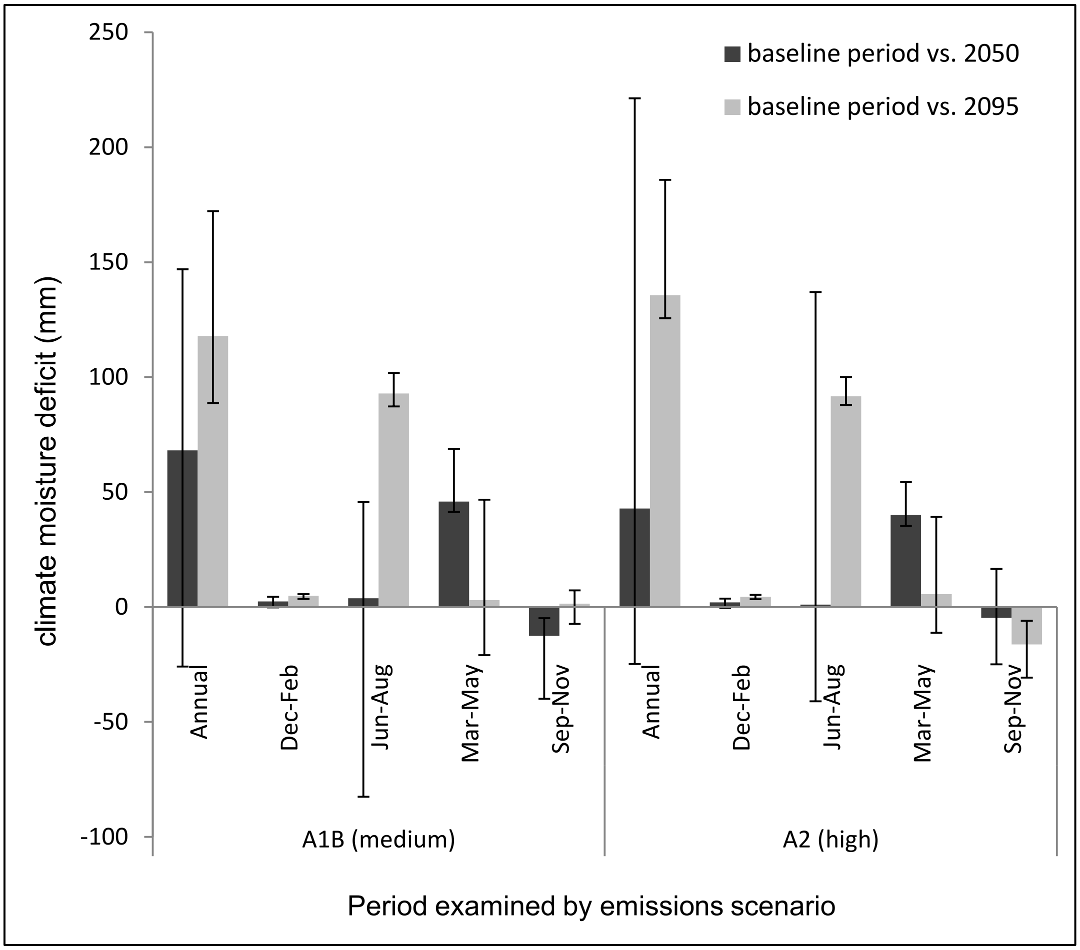


Figure 4-46. Annual and seasonal climatic moisture deficit for 2040-2060 and 2090-2099 compared to the baseline 1961-1980 period under two emission scenarios for a 30 X 30km area surrounding Pipestone National Monument. Higher positive values indicate increasing aridity. Median values with 25% and 75% quartile limits. Analysis was done using the Climate Wizard Custom tools (The Nature Conservancy, University of Washington and University of Southern Mississippi 2014). High positive values reflect drier conditions.

In a study of temperature changes and plant phenology in the northern Great Plains, Dunnell and Travers (2011) found that 5% to 17% of the species observed have significantly shifted their first flowering time either earlier or later relative to the previous century. Overall, they found that as spring temperatures in the northern Great Plains have increased and the growing season has lengthened, some spring flowering species have advanced their first flowering time, some fall species have delayed their first flowering, and some species have not changed (Dunnell and Travers 2011).

Despite a plethora of collaborative scientific endeavors including the USA National Phenology Network, high resolution spatial and temporal phenology data are generally unavailable for most locations. Approaches used to investigate the influence of global change on terrestrial plant and ecosystem phenology include species-level observation networks such as the USA National Phenology Network, remote sensing such as MODIS analysis used here, Eddy-covariance monitoring of carbon fluxes using recording stations, phenology modeling and plot-scale global change experiments. A review of the utility, limitations and temporal and spatial resolution of various methods is presented by Cleland et al. (2007).

Here we use a greenness index derived from MODIS imagery to characterize plant phenology. For the 11-year baseline period of record, the mean greenup date was April 18 (90% confidence interval of +/- 5.0 days), mean vegetation greenness peaked on July 20 (90% confidence interval of +/- 2.6 days) and mean onset of minimum greenness was November 15 (90% confidence interval of +/- 11.8 days) (Figure 4-47). The onset of greenup appears to be the most consistent. Dates for maximum greenness were most consistent from year to year (i.e., had the lowest variance), followed by greenup dates and onset of minimum greenness. The distribution of annual values for the three metrics over the baseline period is show in Figure 4-48.

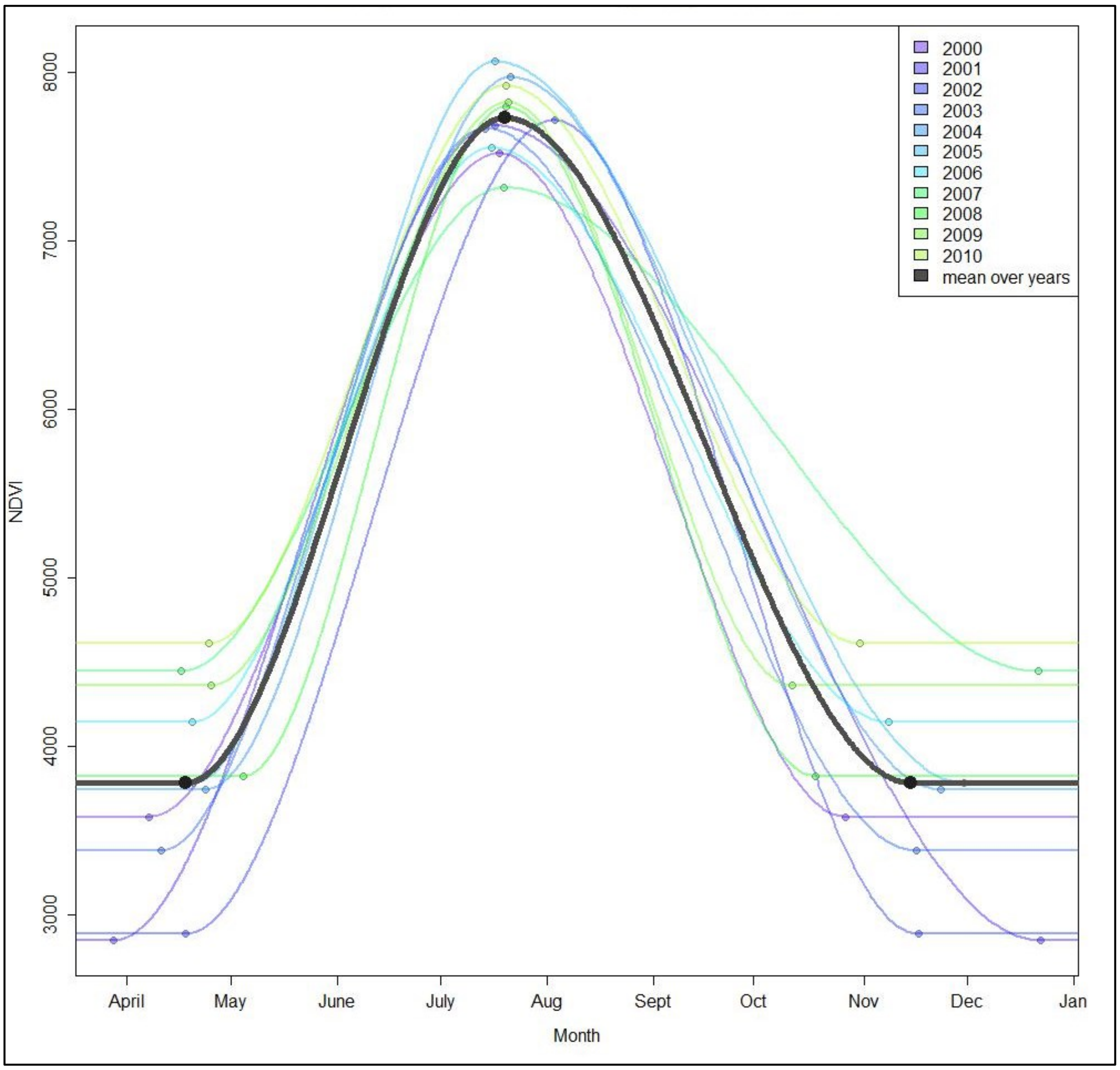


Figure 4-47. Phenology curves for Pipestone National Monument based on MODIS imagery vegetation indices. The graph shows dates for greenup initiation (left), maximum greenness (center), and the end of vegetation senescence or onset of minimum greenness (browndown end) (right) for the period of record. Data visualization provided by Heartland I&M Network.

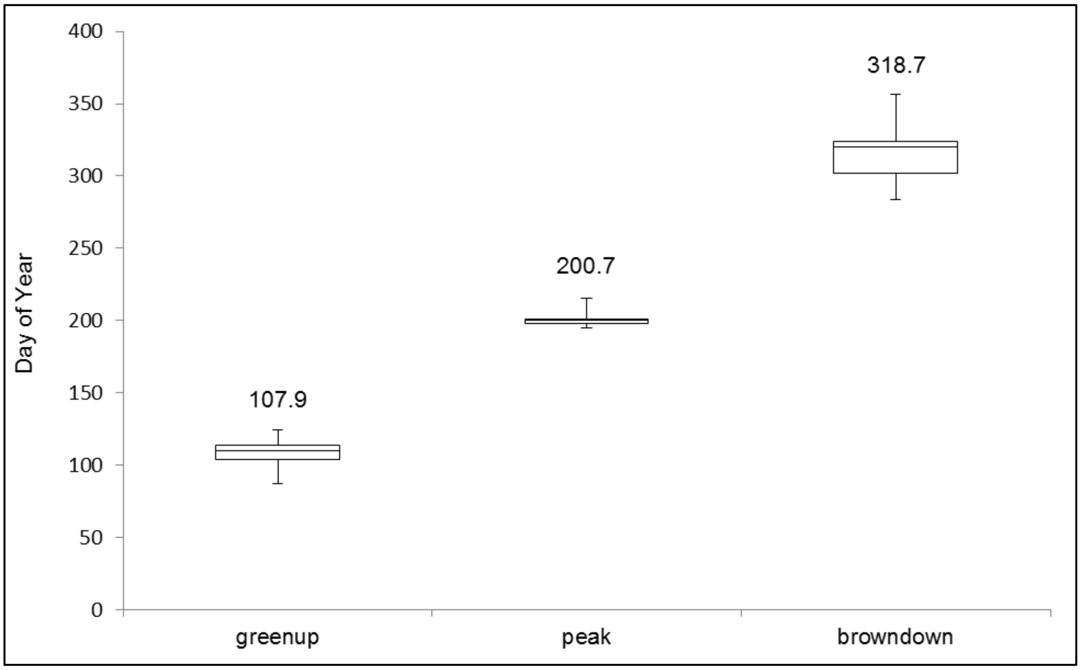


Figure 4-48. Box plots for the base period for dates associated with onset of vegetation greenup, maximum greenness and onset of minimum greenness, based on MODIS EVI data. Lines represent median values, boxes represent the limits of 25th and 75th percentile values and whiskers represent remaining values. Numbers above box plots are means for each phenological period.

Frost-Free Period

The length of the frost-free season is a major determinant of the types of plants and crops that do well in a particular region. These observed climate changes are correlated with increases in satellite-derived estimates of the length of the growing season (Jeong et al. 2011). The frost-free season length, defined as the period between the last occurrence of 32°F in the spring and the first occurrence of 32°F in the fall, has been gradually increasing since the 1980s (USEPA 2012). The last frost in the spring has been occurring earlier in the year, and the first frost in the fall has been happening later. In the eastern Great Plains region, the average frost-free season for 1991-2011 was about 9-10 days longer than during 1901-1960 (Walsh et al. 2014a). A longer growing season can increase carbon sequestration in plants (Peñuelas et al. 2009) and increase the growth of both desirable and undesirable plants. In some cases where moisture is limited, greater evaporation and plant transpiration associated with the longer growing season can mean less productivity due to increased drying (Melillo et al. 2014).

By the 2070-2099 period, the frost-free season for the eastern Great Plains is projected to rise significantly as heat-trapping gas emissions continue to grow, increasing by 10-20 days under the lower emissions (B1) scenario and 30-40 days under the higher (A2) emissions scenario compared to the 1901-1976 baseline period (Melillo et al. 2014).

Overall Assessment

All indications are that the climate in this park region is already becoming drier (despite increasing precipitation), hotter, and is more prone to more frequent and extreme weather events and drought. Trends in the indicators are projected to continue or accelerate by the end of the century. Because these changes in the environment are beyond the control of park managers and climate is not a conventional resource to be managed, climate change is not evaluated using the condition status and trend framework applied in this condition assessment. Research and monitoring related to climate change, the anticipated vulnerability of specific resources vis-a-vis climate change, and its associated effects on resources and interaction with other ecological processes can be informed by this broad overview of the magnitude of climate change in the park region.

4.6.5. Sources of Expertise

Jeffrey Morisette, Director, DOI North Central Climate Science Center

Marian Talbert, Biostatistician, DOI North Central Climate Science Center

John Gross, Climate Change Ecologist, NPS Inventory and Monitoring Program National Office

Kevin James, Plant Ecologist, Heartland I&M Program

4.6.6. Uncertainty and Data Gaps

Climate change projections have inherently high uncertainty. Confidence is higher in modeled temperature dynamics and lower for modeled precipitation totals and seasonal patterns. The largest uncertainty in projecting climate change beyond the next few decades is the level of heat-trapping gas emissions (Walsh et al. 2014b). Information gaps to help manage resources and understand the repercussions of climate change to the park include the need for: 1) more specific, applied examples of adaptation principles that are consistent with uncertainty about the future; 2) a practical adaptation planning process to guide selection and integration of recommendations into existing policies and programs; and 3) greater integration of social science and extension of adaptation approaches beyond park boundaries (Heller and Zavaleta 2009).

4.6.7. Management and Ecological Implications

Changing climate is anticipated to impact Great Plains grasslands in a number of ways, and is likely to compound the effects of existing stressors to potentially increase the vulnerability of grasslands to pests, invasive species and loss of native species (NFWPCAP 2012). Species ranges and ecological dynamics are already responding to recent climate shifts, and current reserves including NPS units will be unable to support all species, communities and ecosystems (Heller and Zavaleta 2009), some of which form the core of their park mission. Some of the key anticipated ecological impacts and management implications of climate change in the tallgrass prairie region and PIPE include:

- Contraction of tallgrass prairie extent along the eastern boundary (Rehfeldt et al. 2008);
- Increased plant production in northern latitude and high altitude Great Plains rangelands and decreased plant productivity in the southern Great Plains (Morgan et al. 2008);
- Increases in invasive exotic plants (Morgan et al. 2008);

- Reduced water availability – projected annual and seasonal moisture deficits indicate that any increases in precipitation in the region are unlikely to be sufficient to offset overall decreases in soil moisture and water availability due to increase temperatures, increase water utilization and aquifer depletion (Karl et al. 2009). Water dependent habitats are especially at risk due to increased evaporation resulting in altered aquifer and surface water dynamics (Bagne et al. 2013).
- More frequent extreme events such as heat waves, droughts and heavy rains (Karl et al. 2009), with heavier rainfall events likely in the northern and central areas (Kunkel et al. 2013) and increasing likelihood of flooding in the wetter, northern portions of the Great Plains (USEPA 2013);
- Limited ability for species and communities to adapt; the relatively flat terrain characterizing these grasslands increases vulnerability to climate change because species and habitats may be obliged to migrate long distances to compensate for temperature shifts. This challenge is exacerbated by the highly fragmented and altered agricultural landscape in the region (Bagne et al. 2013).
- A decrease in rainfall may lead to a net carbon loss in the system (IPCC 2007). Trees and shrubs show higher CO_2 responsiveness than do herbaceous plants, which may lead to increases in woody plants as atmospheric CO_2 rises (IPCC 2007).
- Climate change is likely to exacerbate existing stressors related to anthropogenic disturbances at landscape scales including energy development and agriculture that fragment the landscape and hinder species adaptation (Bagne et al. 2013, Shaeffer et al. 2014).

It is increasingly clear that given significant shifts in climatic variables, adaptation efforts will need to emphasize managing for inevitable ecological changes and concurrently adjusting some management objectives or targets (Stein et al. 2013). In a review of articles examining biodiversity conservation recommendations in response to climate change, Heller and Zavaleta (2009) synthesized conservation recommendations with regard to regional planning, site-scale management, and modification of existing conservation plans. They found that most recommendations offer general principles for climate change adaptation but lack specificity needed for implementation. Specific adaptation tools and approaches will undoubtedly help park managers with these challenges. Adaptation approaches need to be intentional, context-specific and based on a deliberative process, rather than selecting from a generic menu of options (Stein et al. 2014).

While climate change cannot be controlled by the park, managers can take steps to minimize the severity of exposure to these changes and help conserve sensitive resources as the transition continues. Although an in-depth analysis of the effects of climate change on park natural resources goes beyond the scope of this NRCA, a preliminary evaluation of the vulnerability of targeted park resources is being prepared to help understand how climate change vulnerability might be integrated in future assessments. Existing condition analyses and data sets developed by this NRCA will be useful for subsequent park-level climate change studies and planning efforts.

4.6.8. Literature Cited

Bagne, K., P. Ford, and M. Reeves. 2012. Grasslands. USDA Forest Service, Climate Change Resource Center. http://www.fs.fed.us/ccrc/topics/grasslands/index.shtml. Accessed October 21, 2013.

Briggs, J.M. and A.K. Knapp. 1995. Interannual variability in primary production in tallgrass prairie: Climate, soil moisture, topographic position, and fire as determinants of aboveground biomass. American Journal of Botany 82(8): 1024-1030.

Cleland, E.E., I. Chuine, A. Menzel, H.A. Mooney and M.D. Schwartz. 2007. Shifting plant phenology in response to global change. Trends in Ecology and Evolution 22(7):357-365.

CMIP5 Modeling Groups. 2014. CMIP5 multi-model dataset, 2014. http://gdo-dcp.ucllnl.org/downscaled_cmip_projections/.

Davey, C.A., K.T. Redmond, and D.B. Simeral. 2007. Weather and climate inventory, National Park Service, Heartland Network. Natural Resource Technical Report NPS/HTLN/NRTR – 2007/043. National Park Service, Fort Collins, Colorado.

Dunnell K.L. and S.E. Travers. 2011. Shifts in the flowering phenology of the northern Great Plains: patterns over 100 years. American Journal of Botany 98(6):935–945.

Girvetz, E.H., C. Zganjar, G. Raber, E. Maurer, P. Kareiva and J. Lawler. 2009. Applied climate-change analysis: The Climate Wizard Tool. PLoS ONE 4(12): e8320.

Glick, P., B.A. Stein, and N.A. Edelson (eds.). 2011. Scanning the conservation horizon: a guide to climate change vulnerability assessment. National Wildlife Federation, Washington, D.C.

Environmental Protection Agency (USEPA). 2012. Climate change indicators in the United States, 2nd Edition. 84 pp., U.S. Environmental Protection Agency, Washington, D.C.

Ibanez, I, R.B. Primack, A.J. Miller-Rushing, E. Ellwood, H. Higuchi H, S.D. Lee, H. Kobori and J.A. Silander. 2010. Forecasting phenology under global warming. Philosophical transactions of the Royal Society B - biological sciences 365:3247–3260.

James, K.M., C. Talbert and J.T. Morisette. 2013. NPScape standard operating procedure: Land Surface Phenology Toolset. Version 2014-07-24. National Park Service, Natural Resource Stewardship and Science. Fort Collins, Colorado.

Jeong, S. J., C.H. Ho, H.J. Gim, and M.E. Brown. 2011. Phenology shifts at start vs. end of growing season in temperate vegetation over the Northern Hemisphere for the period 1982-2008. Global Change Biology 17:2385-2399.

Heller, N.E and E.S.Zavaleta. 2009. Biodiversity management in the face of climate change: a review of 22 years of recommendations. Biological Conservation 142: 14-32.

Karl, T.R., J.M. Melillo, and T.C. Peterson (eds.). 2009. Global climate change impacts in the United States. United States Global Change Research Program (USGCRP). Cambridge University Press.

Kunkel, K.E, L.E. Stevens, S.E. Stevens, L. Sun, E. Janssen, D. Wuebbles, M.C. Kruk, D.P. Thomas, M. Shulski, N. Umphlett, K. Hubbard, K. Robbins, L. Romolo, A. Akyuz, T. Pathak, T. Bergantino, and J.G. Dobson. 2013. Regional climate trends and scenarios for the U.S. national climate assessment, Part 4 - climate of the U.S. Great Plains. U.S. Department of Commerce, National Oceanic and Atmospheric Administration (NOAA) Technical Report NESDIS 142-4, 82 pp.

Maurer, E.P., L. Brekke, T. Pruitt, and P.B. Duffy. 2007. Fine-resolution climate projections enhance regional climate change impact studies, Eos Trans. AGU, 88(47), 504.

Maurer, E.P., A.W. Wood, J.C. Adam, D.P. Lettenmaier, and B. Nijssen. 2002. A long-term hydrologically-based data set of land surface fluxes and states for the conterminous United States. Journal of Climate 15(22): 3237-3251.

McEwan, R.W., R. J. Brecha, D.R. Geiger and G.P. John. 2011. Flowering phenology change and climate warming in Southwestern Ohio. Plant Ecology 212.1 (2011): 55-61.

McKee, T.B., N.J. Doeskin and J. Kleist. 1993. The relationship of drought frequency and duration to time scales. In: Proceedings of the eighth conference on applied climatology, Anaheim, CA, January 17-23, 1993. American Meteorological Society. Boston, MA. pp. 179-184.

Melillo, J. M., Terese (T.C.) Richmond, and G. W. Yohe, eds. 2014. The third national climate assessment, U.S. Global Change Research Program

Milchunas, D.G., A.R. Mosier, J.A. Morgan, D.R. LeCain, J.Y King and J.A. Nelson. 2005. Elevated CO_2 and defoliation effects on a shortgrass steppe: forage quality versus quantity for ruminants. Agriculture, Ecosystems and Environment 111:166-184.

Morgan, J.A., J.D. Derner, D.G. Milchunas, and E. Pendall. 2008. Management implications of global change for Great Plains rangelands. Rangelands 30(3):18-22.

National Climatic Data Center (NCDC). 2013a. Archive of monthly PDSI estimates. http://www1.ncdc.noaa.gov/pub/data/cirs/drd964x.pdsi.txt (accessed November 5, 2013).

National Climatic Data Center (NCDC). 2013b. Climate data online. http://www.ncdc.noaa.gov/cdo-web/ (accessed 5 November 2013).

National Fish, Wildlife and Plants Climate Adaptation Partnership (NFWPCAP). 2012. Grassland ecosystems background paper. Developed in support of the national fish, wildlife and plants climate adaptation strategy. Association of Fish and Wildlife Agencies, Council on Environmental Quality, Great Lakes Indian Fish and Wildlife Commission, National Oceanic and Atmospheric Administration, and U.S. Fish and Wildlife Service. Washington, DC.

National Park Service (NPS). 2010. Climate change response strategy. USDI NPS.

National Park System Advisory Board Science Committee. 2012. Revisiting Leopold: resource stewardship in the National Parks. National Park Foundation.

Oak Ridge National Laboratory Distributed Active Archive Center (ORNL DAAC). 2012. MODIS subsetted land products, Collection 5. http://daac.ornl.gov/MODIS/modis.html (accessed 28 October 2013).

Palmer, W.C. 1965. Meteorological drought. Research Paper No. 45. U.S. Weather Bureau.

Peñuelas, J., T. Rutishauser and I. Filella. 2009. Phenology feedbacks on climate change. Science, 324, 887-888

Polley, H. W. 1997. Implications of rising atmospheric carbon dioxide concentration for rangelands. Journal of Range Management. 50:562-577.

PRISM Climate Group. 2014. Prism 4km climate data. Oregon State University. Available from http://prism.oregonstate.edu/.

Rehfeldt, G.E., N.L. Crookston, C. Sáenz-Romero and E.M. Campbell. 2012. North American vegetation model for land-use planning in a changing climate: a solution to large classification problems. Ecological Applications 22:119–141.

Shafer, M., D. Ojima, J. M. Antle, D. Kluck, R. A. McPherson, S. Petersen, B. Scanlon, and K. Sherman. 2014. Ch. 19: Great Plains. Climate change impacts in the United States: the third national climate assessment, J. M. Melillo, Terese (T.C.) Richmond, and G. W. Yohe, eds., U.S. Global Change Research Program, pp.441-461.

Sheffield, J., E.F. Wood and M.L. Roderick. 2012. Little change in global drought over the past 60 years. Nature 491:435-438.

Stein, B.A., P. Glick, N. Edelson, and A. Staudt (eds.). 2014. Climate-smart conservation: putting adaptation principles into practice. National Wildlife Federation, Washington, D.C.

Stein, B.A., A. Staudt, M.S. Cross, N.S. Dobson, C. Enquist, R. Griffis, L.J. Hansen, J.J. Hellman, J.J. Lawler, E.J. Nelson and A. Pairis. 2013. Preparing for and managing change: climate adaptation for biodiversity and ecosystems. Frontiers in Ecology and the Environment 11(9):502-510.

The Nature Conservancy, University of Washington and University of Southern Mississippi. 2014. Climate Wizard. Online tool available at http://www.climatewizard.org/index.html (accessed December 1, 2013).

United States Environmental Protection Agency (USEPA). 2013. EPA Climate change web site: impacts and adaptation: Great Plains impacts. Available at:

http://www.epa.gov/climatechange/impacts-adaptation/greatplains.html (accessed September 2013)

U.S. Department of Agriculture (USDA). 2014. U.S. Drought Portal, National Integrated Drought Information System. http://www.drought.gov/drought/content/products-current-drought-and-monitoring-drought-indicators/palmer-drought-severity-index (accessed March 2014).

Van-Rooy, M.P. 1965. A rainfall anomaly index (RAI) independent of time and space. Notos 14: 43

Walsh, J., D. Wuebbles, K. Hayhoe, J. Kossin, K. Kunkel, G. Stephens, P. Thorne, R. Vose, M. Wehner, J. Willis, D. Anderson, V. Kharin, T. Knutson, F. Landerer, T. Lenton, J. Kennedy, and R. Somerville. 2014a. Chapter 2: Our changing climate *in* Climate change impacts in the United States: The third national climate assessment, J. M. Melillo, Terese (T.C.) Richmond, and G. W. Yohe, Eds., U.S. Global Change Research Program, pp. 19-67.

Walsh, J., D. Wuebbles, K. Hayhoe, J. Kossin, K. Kunkel, G. Stephens, P. Thorne, R. Vose, M. Wehner, J. Willis, D. Anderson, V. Kharin, T. Knutson, F. Landerer, T. Lenton, J. Kennedy, and R. Somerville. 2014b. Appendix 3: Climate science supplement *in* Climate change impacts in the United States: The third national climate assessment, J. M. Melillo, Terese (T.C.) Richmond, and G. W. Yohe, Eds., U.S. Global Change Research Program, 790-820.

Wolock, D.M. and G. J. McCabe. 1999. Explaining spatial variability in mean annual runoff in the conterminous United States. Climate Research 11:149-159.

4.7. Fire Disturbance Regime

4.7.1. Background and Importance

According to *NPS Management Policies* (NPS 2006), natural resources in NPS units will be managed to preserve fundamental physical and biological processes, as well as individual species, features, and plant and animal communities. The 2006 *NPS Management Policies* specifically mentions the importance of restoring natural processes such as fire to areas that have been disturbed by fire suppression, as well as the importance of maintaining open areas in situations where they were formerly maintained by natural processes. Further principles and strategic guidelines governing the management of wildland fire on NPS parks are presented in *Director's Order #18: Wildland Fire Management* (NPS 2008). At PIPE, fire is a critical natural process that is being used in conjunction with other tools and techniques to restore the natural landscape and ethnographic character of the area, restore the tallgrass prairie ecosystem and manage introduced exotic plants and woody species.

Fire is one of the principal disturbances on the landscape at Pipestone National Monument, both historically and currently. From a fire and fuels perspective, grazing by livestock and bison influenced the fire regime by reducing fuel accumulation and standing fuels. Currently there is no managed grazing at PIPE by bison or livestock, although grazing by native ungulates, other mammals and insects does occur. The role of fire and its importance to a healthy prairie ecosystem is well documented throughout the ecological literature (Anderson et al. 1970, Bragg and Hulbert 1976, Buell and Facey 1960, Hartnett et al. 1996, Wright and Bailey 1982). The tallgrass prairie system contains plant and animal communities that are characterized as fire-adapted or fire-dependent, requiring periodic episodes of fire to retain their ecological integrity. Under anthropogenic fire suppression, these communities can experience undesirable impacts such as successional trends towards shrubland or woodland communities, loss of habitat for fire-adapted plant and animal species, and vulnerability to severe wildland fire as a result of increased fuel loads (NPS 2006).

In recent years, scientists and land managers have recognized the importance of creating heterogeneity on the landscape to promote diversity, sustain species adapted to natural disturbance regimes, and foster a variety of faunal habitat structures (Wiens 1997, Fuhlendorf and Engle 2001, Reinking 2005). In tallgrass prairie, the primary disturbance agents of fire and grazing interact with other biotic and abiotic factors to maximize heterogeneity and species diversity on the landscape (Fuhlendorf et al. 2006, Hamilton 2007, Knapp et al. 1999). While ecosystem traits such as increased heterogeneity and mean species richness may benefit from synergistic effects of fire and grazing (by cattle or bison), even without grazing the ecosystem benefits from fire, and especially frequent fire, are clear (Hartnett et al. 1996, Bowles and Jones 2013). The strategy of creating a diverse and shifting mosaic of seral stages is healthy for the ecosystem and tends to benefit native flora and fauna (Gaetani et al. 2010).

Under the current Fire Management Plan (DeCoster et al. 2004) the monument uses prescribed fires to favor native prairie vegetation. In conjunction with mechanical and chemical exotic vegetation control, fire helps to control the abundance of woody and invasive plants. The monument's six prairie management units are organized into four burn units (Figure 4-49). An additional burn unit on the old school property on the northwest side of the park was added recently but is not included in

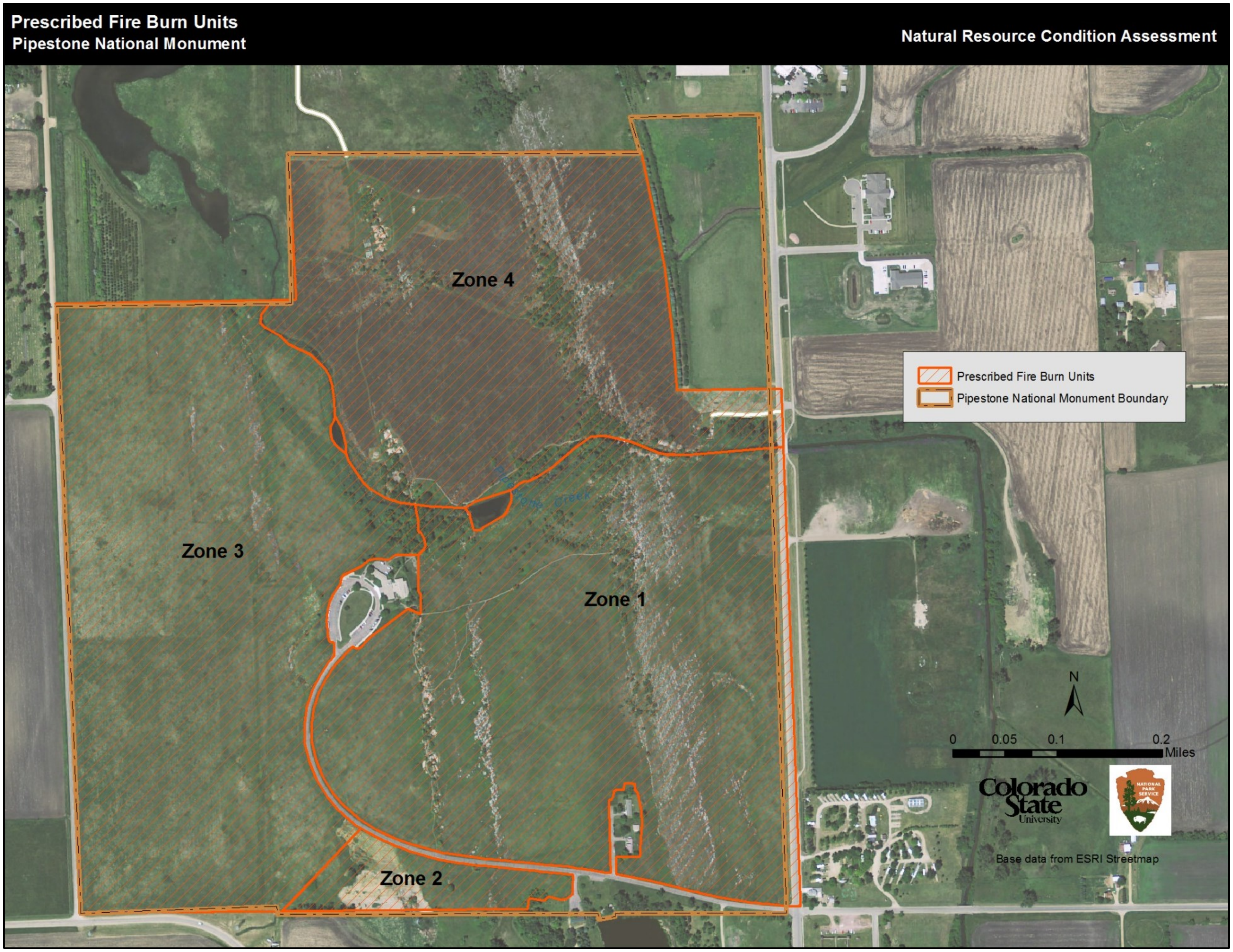


Figure 4-49. Pipestone National Monument burn unit schematic.

this analysis. The two fire seasons at the monument are spring (April through early June) and fall (September through late October). The burn units are typically burned on a 3-5 year rotation intended to include spring and fall burns. Managed fire frequency aims to be shorter than the historical average (Wright and Bailey 1982), as frequent fire is recommended by the *Prairie Management Plan* (Becker et al. 1986) and the scientific literature to prevent and reduce exotic and woody vegetation during prairie restoration. Once the desired future conditions are met for species composition, introduced exotics, and woody plants the monument plans to burn on a more historical burn frequency of every 5 to 10 years to maintain the prairie. Mowed lines are established as firebreaks prior to each burn to prevent accidental ignition of non-target areas. Individual burn plans are prepared and approved for the implementation of each prescribed fire. All wildland (i.e., unplanned) fires are immediately suppressed.

Commercial quarrying of catlinite and settlement by European emigrants in the mid 1800s led to fire suppression in the region (NPS 2008). The presettlement vegetation of the region is characterized as true prairie dominated by more than 800 species of grasses and forbs with woody plants and trees occurring in larger valleys and along perennial streams. The prairie character was maintained through cycles of fires and drought (MDNR 2003). One of the earliest descriptions of the Pipestone landscape comes from the artist George Catlin from a visit to the Pipestone quarries in the 1830s. His view from the quartzite ridge encompassed "…the thousand treeless, bushless, weedless hills of grass and vivid green which all around me vanish into an infinity of blue and azure…" (Catlin 1844). The quartzite ridge, so distinct in the early account from the 1800s, is now largely hidden by oaks, ashes, elms and other trees once controlled by prairie fires.

<u>Fire Regime Components</u>
As a natural process and disturbance agent, fire directly or indirectly influences a number of the focal resources addressed in this assessment, including prairie vegetation, the endangered western prairie fringed orchid, invasive exotic plants, Sioux quartzite prairie community, faunal resources, views and scenery, and cultural use and resources. Fire is perhaps the most influential ecological driver currently shaping the monument. The fire regime is characterized by fire frequency, seasonality, extent and severity.

Fire Frequency
Before the arrival of European agriculture, fires on the Great Plains often covered vast areas with much of the burned area far from the ignition source due to the long distances that a fire could burn uninterrupted through the ample and unbroken fuels. The frequency of lightning-caused fires in the region is relatively low and most presettlement and post-settlement fires are thought to be of anthropogenic origin (Schroeder and Buck 1970). Historical fire frequency was high, with average return intervals estimated to be less than 10 years (Guyette et al. 2011, Wright and Bailey 1982). Landscape fragmentation resulting from modern agricultural practices and urban development have virtually eliminated landscape-level fire spread and thus vastly reduced the fire frequency on remaining prairie remnants. Prescribed fire is often used by land managers to introduce the ecological benefits of fire.

Lack of frequent fire in tallgrass prairie usually results in increased woody encroachment (Bragg and Hulbert 1976, Briggs et al. 2002, Bowles and Jones 2013). Conversely, high frequency fire with return intervals of two years or less over the course of a decade or more may decrease species richness (Davison and Kindscher 1999, Collins et al. 2002, Collins et al. 1995), though it should be noted that some species richness arises from undesirable species. High frequency fire may also help control some invasive species (Smith and Knapp 1999). The relationship between fire and undesirable species has led many land managers to use a fire frequency of less than 5 years in the northern Great Plains to control woodies and minimize their encroachment into the prairie.

Fire Seasonality

The timing of burns plays a role in determining vegetation responses (Towne and Owensby 1984, Engle and Bidwell 2001, Towne and Kemp 2003). The timing of the burn in relation to plant growth stage may influence the abundance or expression of plant guilds. In general, species that are actively growing, flowering, or setting seed at the time of fire tend to decline over repeated applications during this point in their phenology. Species that benefit most from fire are usually those that are just beginning to grow (Davison and Kindscher 1999). The response of woody plants to season of burning is unclear. Burning during drought or during seed set may result in slow post-fire recovery (Pyne et al 1996). Some literature suggests that late summer burns promote subdominant species such as some forbs without compromising the vigor of dominant warm-season grasses (Copeland et al. 2002) and may favor early flowering species that would otherwise be eliminated by competition from large, late flowering C-4 grasses (Howe 1994, Howe 1995, Howe 2000).

Prior to European settlement, fire generally escalated during drought years (Anderson et al. 1970). The fire season covered many months (Anderson et al. 1970, Knapp and Seastedt 1998) and fires on the Great Plains were possible for much of the year due to both anthropogenic and natural causes (Bragg and Hulbert 1976, TPNPERC 2005). Large fires, which accounted for most of the acreage burned, were restricted to those periods when fuels were dry across vast acreages allowing fires to spread unimpeded (Wright and Bailey 1982).

Seasonality of prescribed burn programs is often determined by containment considerations and often differs from presettlement seasonality of burns. Spring fires are often easier to conduct successfully than other seasons due to high soil moisture and frequent rains. However, the traditional burn season of February to April has some of the fewest hours per day available to conduct prescribed burns (Weir undated). Managers consider a host of factors when determining burn timing such as target plant phenology, prescription weather, local events, acceptance of fire, and availability of operational crews.

Fire Severity

Fire severity during prescribed grassland fires is usually low due to moderate weather conditions, limited fuel and the relatively short residence time of the fire as it passes over any given point on the landscape. However, energy output from a fire at the high end of this range may be as much as four times that of a fire at the low end (Engle et al. 1993, Ewing and Engle 1988). In prairie ecosystems, fire severity will increase as fuel loads increase with time since burn and where shrubs encroach.

Fire Extent
The extent of historical fires on the prairie landscape varied widely. Almost all fire regimes exhibit a power law probability distribution of fire size versus number of fires, meaning the vast majority of fires are very small and only a handful are very large (Cui and Perera 2008). However, the acreage accounted for by the few large fires accounts for the vast majority of all acres burned and therefore these few large fires are of outsized important to the overall fire regime.

Burn size is important in part because of its effect on encroachment, particularly of woody species. Prairie remnants with stands of woody species close by will experience higher rates of seeding from undesirable species. The park's size is sufficient to allow managers to burn most of it, reducing unburned pockets available to woody species. This will help to prevent seeding and subsequent encroachment, easing the burden of woody species control.

In terms of present day fire management, bigger fires are not always better, and fires of the extent of 200 years ago no longer occur. The park is an island of prairie surrounded for miles by agricultural land or degraded prairie. Therefore, the needs of prairie species must be met to the greatest extent possible using habitat within the park boundaries, necessitating management of a mosaic of communities and seral/structural stages on a much smaller geographic scale than would have occurred in pre-settlement times. For these reasons, fire extent is not considered further in this assessment as an indicator.

Burn Considerations Related to Western Prairie Fringed Orchid Management
The federally endangered western prairie fringed orchid (*Platanthera praeclara*) occurs on Pipestone National Monument. To better manage the timing of prescribed fires in relation to the western prairie fringed orchid life cycle, a burn sub-unit was created within the existing Fire Management Unit 1. The timing and frequency of prescribed fires can be based on monitoring, research and weather variables. Burning in drought years is not recommended (Pleasants 1998). The invasion of introduced cool season exotic grasses may be controlled along the perimeter of the orchid population by conducting burns later in the spring (DeCoster et al. 2004). For smooth brome (*Bromus inermis*) control, Willson and Stubbendiek (1997) recommend burning when the node or five leaves are present on the grass. This typically would occur in later spring and most often when new orchid plants are above the ground surface. Therefore, prescribed fires at this time could cause negative impacts to the orchids. The US Fish and Wildlife recovery plan (1996) recommends that the best management for this species is that which best maintains the quality of the grassland and prairie habitats. Further discussion of western fringed prairie orchid condition, trend and management is presented in the *western fringed prairie orchid* section of this chapter.

Implications of Climate Change on Fire Regime
The effects of changing climate on the fire regime and fire-related ecological effects at the park have not been modeled or examined in detail. A comprehensive summary of historical climate variation and climate change projections for the park and surrounding area is presented in Section 4.5. Results for precipitation, temperature, aridity, and growing season vary by emissions scenario, future time period and sometimes by season. In general, the climate at PIPE is forecast to become hotter and wetter compared to the current climate, but increased temperatures are anticipated to more than offset

the increase in precipitation. Both minimum and maximum temperatures are expected to increase by approximately 2-3 ^{o}C by 2050, and by approximately 3.0-6.5 ^{o}C by 2100, depending on the emissions scenario. Precipitation is projected to increase by approximately 3-5 mm per month or 35-60 mm (1.3 – 2.3 inches) per year by 2050. Very heavy rainfall events are projected to become more frequent. As an index of drought, annual summer season moisture deficits ranging from 80-90 mm (3.3 inches) compared to historical baseline conditions are forecast for medium and high-emission scenarios by 2095. It is getting significantly warmer earlier in the spring and the growing season is projected to lengthen by 10-40 days per year depending on the emissions scenario.

Specific implications of climate change on the park's fire regime and fire management cannot be predicted with a high level of confidence, but some generalizations and likely scenarios merit discussion. Wildland fire in the region surrounding the park is virtually non-existent. Small-scale prescribed burning outside the park occurs occasionally on private and public lands. The fire regime at the park is highly managed and driven by prescribed fire events planned for specific dates within burn units of a defined size and location. Therefore, it seems unlikely that the fire return interval would be affected by climate change. Prescribed burns in the park are currently conducted only during fuels and weather conditions meeting a burn prescription window (i.e., acceptable range of temperature, humidity, wind and fuel conditions) to minimize the chance of fires getting out of control or producing unwanted smoke. Similar prescription windows would be applied in the future. Therefore, future fire intensity and severity would likely be similar to current fire intensity and severity. Severity of later summer burns may increase since severity is affected by soil moisture. The most significant management implication of climate change may be that prescribed burning prescription windows may become smaller and/or fewer in number as minimum and maximum temperatures rise and relative humidity declines. These changing factors would make it more difficult for the park to reach prescribed burn acreage/frequency objectives, especially when the park is scheduling burns supported by non-resident crews well ahead of the scheduled burn. Summer and late summer/fall burns may also be more difficult to schedule with smaller prescription windows, or periods meeting prescription may occur earlier or later in the year.

Threats and Stressors

- Virtual elimination of fire outside of the Monument as this reduces the possibility of fire spread into the monument.
- Continued alteration of the natural fire regime within the Monument, which now emphasizes low fire frequency and severity with little temporal and spatial variation.
- Encroachment of development outside the monument boundary that may place additional constraints on burning due to fire risk and smoke.

Indicators and Measures

- Fire frequency
- Fire seasonality
- Fire severity

4.7.2. Data and Methods

The park has a long history of prescribed fire dating to 1971. Fire history from park records is used to examine fire regime indicators and determine the overall fire regime within the period of record. No empirical data are available prior to the start of park records, however there are voluminous anecdotal descriptions of the pre-settlement fire regime of the Great Plains and other grassland ecosystems from historical journals, newspaper articles, and other sources that have since been compiled and corroborated by current research.

Data were obtained from the park and the Heartland I&M Network. Current fire data are limited to the year, size, and generalized season of the fire (winter, spring, summer, or fall). Thus, analysis of current fire management is limited to fire return interval (i.e., fire frequency), seasonality, and extent of burning within park boundaries and fire severity is extrapolated from these data.

4.7.3. Reference Conditions

The pre-settlement fire regime, based on published literature, is used as the reference condition for assessing condition status and trend of the fire regime. Achieving a "good condition" rating under present day land management pressures may not be feasible for a variety of reasons. These include challenges related to sensitive resources such as the Western prairie fringed orchid; park stakeholder needs, concerns and expectations; smoke management and fire containment needs; budgetary issues; and invasive species considerations. Nonetheless, the pre-settlement fire regime is documented to have been well-suited to maintaining the biotic and abiotic elements of a healthy and functional prairie ecosystem and no alternative regime has been demonstrated to achieve the same benefits. The condition rating framework for fire regime indicators at Pipestone National Monument is shown in Table 4-26.

Table 4-26. Condition rating framework for fire indicators at Pipestone National Monument.

Indicator	Good Condition	Warrants Moderate Concern	Warrants Significant Concern
Fire Frequency	mean fire return interval for all burn units<=5 years fire return interval regularly varies within and among burn units	mean fire return interval for all burn units 6-10 years fire return interval occasionally varies within and among burn units	mean fire return interval for all burn units >10 years little or no variation in fire frequency within and among burn units
Fire Seasonality	season of most burns executed within historical range (March through October) season of burns regularly varies within and among burn units	more than ¼ of burns executed outside of historical range seasonality of burns occasionally varies within and among burn units	more than ½ of burns executed outside of historical range little or no variation in seasonality of burns within and among burn units
Fire Severity	burns occasionally result in moderate to high burn severity	burns very rarely result in moderate to high burn severity	no burns result in moderate to high burn severity

4.7.4. Condition and Trend

Fire Frequency

Current management at Pipestone Monument includes an active prescribed burn program that aims to burn a portion of the monument every year. As of March 2014, 2010 was the last year in which a prescribed burn occurred. Within the period for which data are available, starting in 1971, the fire return interval was generally four years or less, which compares well with the reference condition (Figures 4-50 and 4-51). In the past 10 years for which data are available (through 2014) however, the return interval became substantially longer (Figure 4-52), though it still falls within the range of the reference condition in approximately half of the burn units. This analysis did not include prescribed burns conducted in fire management units 1 and 4 in 2014 and unit 3 in 2015.

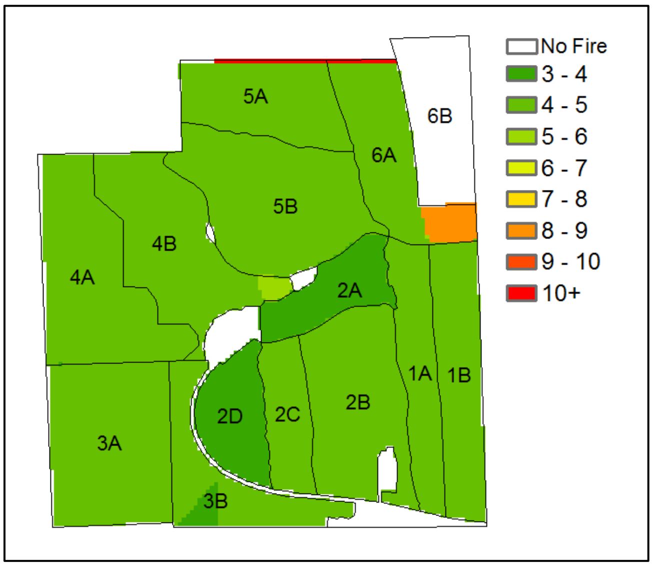


Figure 4-50. Average fire return interval, in years, from 1971 to 2014.

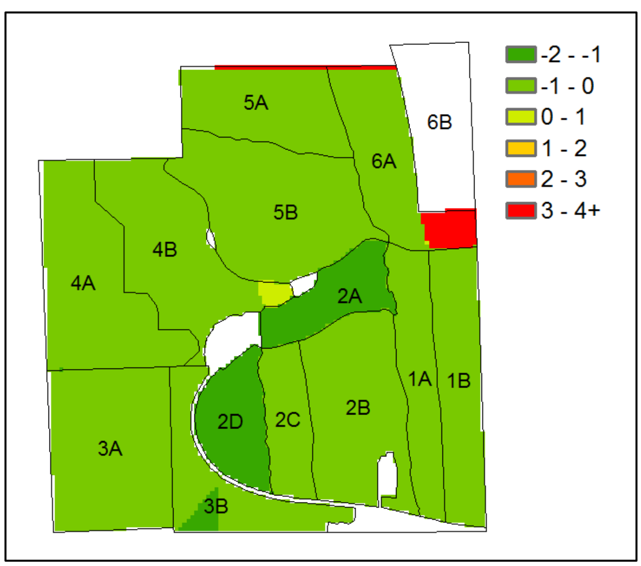


Figure 4-51. The historical return interval (5 years) subtracted from the average return interval.

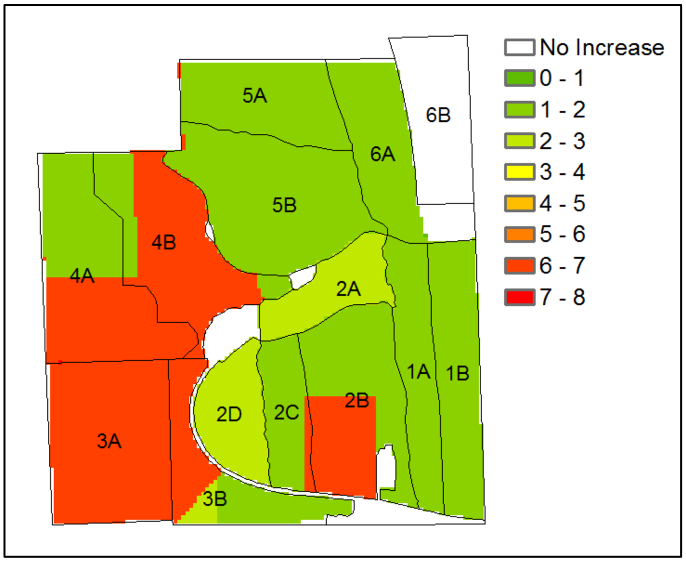


Figure 4-52. The average fire return interval of the last 10 years subtracted from the 1971 – 2014 average.

The fire return interval currently varies within and among burn units (Figure 4-53). Units 2B and 2C have the lowest variability while units 1A, 1B, and 2A have the highest variability. Overall, there is good variability spatially, with different burn units receiving differing fire return intervals. That may suffice for the short term in producing a variety of ecological conditions within the monument, but in the longer term, temporal variability will likely be required in most, if not all, burn units. In regard to temporal variability, there appears to be a tendency to burn at 2 or 3 year intervals as these two intervals account for 69% of all fire return intervals. Most of the longest intervals occurred during the span from the early 1970s to the early 1980s and most of the shortest intervals occurred from the early 1980s to the late 1990s, when the burn intervals were almost all either two or three years. Since that time, all of the burn units have experienced an interval of 6 to 10 years in length.

Fire Seasonality

At PIPE, virtually all burns occurred during the spring months with almost no variability in fire season. Aside from a period between 1994 and 1997 when four burns were executed in the fall, there are no records of prescribed fires being carried out in any other season of the year. This will tend to benefit warm season grasses at the expense of cool season grasses and spring forbs (Towne and Kemp 2003, Towne and Owensby 1984). The *Fire Management Plan and Environmental Assessment* (DeCoster et al. 2004) states that under the preferred alternative both spring and fall burns would be employed under the 3-5 year return interval. Nearly all burning has taken place in the spring season. Because there is little or no variation in seasonality of burns within and among burn units, the condition of this indicator warrants significant concern.

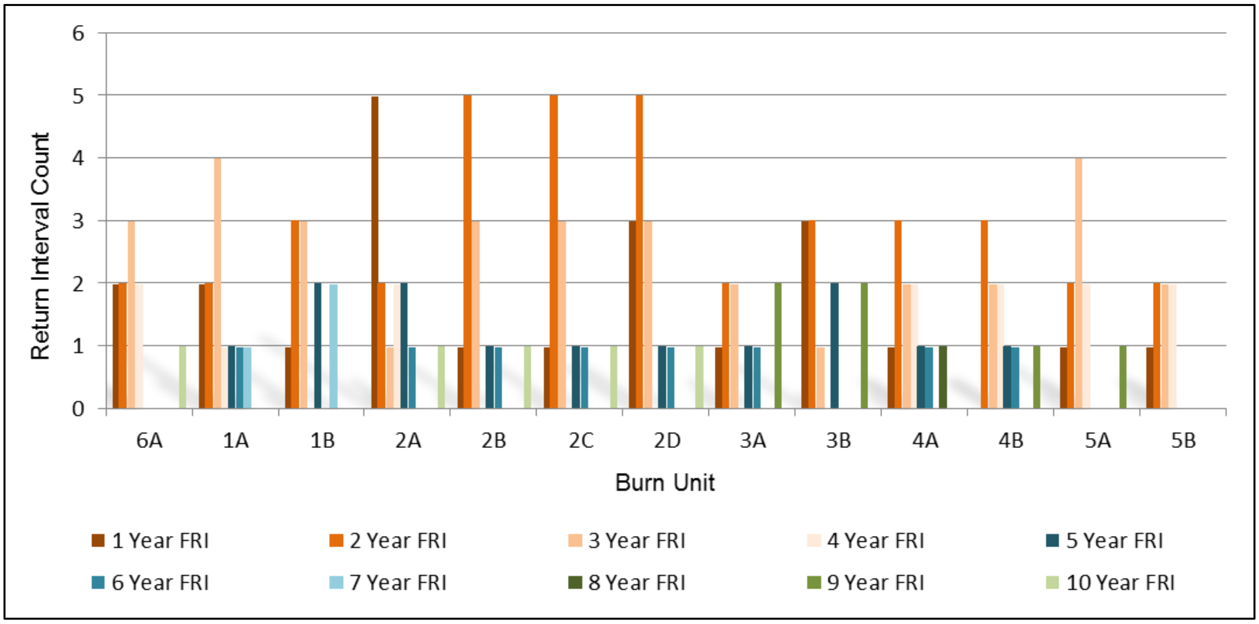


Figure 4-53. The count of return interval frequency in each burn unit of PIPE from 1971 to 1997. FRI = Fire Return Interval.

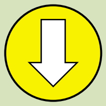
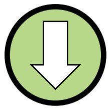
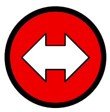
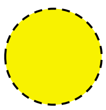
<u>Fire Severity</u>

There is no information with which to assess fire severity though it can be assumed that fire severity will increase with time since the last occurance of fire. Given that burn frequency generally falls within the range of the reference condition, it can be extrapolated that burn severity is probably consistent with the reference condition of mostly low to moderate burn severity. However, this also means that if fires were in prescription that they were planned to be of low intensity if the prescription was for low winds, moderate humidity and moderate temperature. The inferred lack of significant variability in fire severity warrants moderate concern for this indicator with an unknown trend due to lack of data.

<u>Overall Rating</u>

The condition of the fire regime warrants moderate concern with a deteriorating trend (Table 4-27). The trend is weighted more heavily toward fire frequency than the other indicators. Fire regime components vary in their ability to meet reference conditions for the monument. Although fire frequencies generally fall within the desired range, variability in the seasonality of fire may limit the restoration benefits and reduce heterogeneity within the prairie. Administrative uncertainties and inconsistent funding of prescribed burn management may adversely affect the condition of this resource over time.

Table 4-27. Condition and trend summary for fire regime at Pipestone National Monument.

Indicator	Condition Status/Trend	Rationale
Fire Regime (overall)		The condition of the fire regime warrants moderate concern with a deteriorating trend. Confidence in the assessment is medium due to variability in implementation of prescribed burns.
Fire Frequency		Results indicate the fire return interval over the past several decades has been within the range of the reference condition. The last ten years indicate a notable downward trend in fire frequency, though it is still within the range of the reference condition. There is moderate variability in the fire frequency within and among burn units.
Fire Seasonality		Data are complete but coarse. The timing within a season is important to post-fire responses. The current spring-only burning program probably conflicts with more variable burn timing in the reference condition. There is generally a lack of variability in the seasonality of burning.
Fire Severity		Data related to fire severity does not exist. Extrapolated data suggests that fire severity falls within the range of the reference conditions. However, conservative fire prescription windows to minimize the risk of fires escaping or endangering property and health are characterized by conditions that produce low to moderate severity. Therefore, high-severity fires are likely occurring less often than under presettlement conditions. Data are not available to assess the current trend.

4.7.5. Uncertainty and Data Gaps

Burn locations and data are documented by the Park and the Heartland I&M Network. There is no way to assess burn severity from the existing data.

4.7.6. Sources of Expertise

Sherry Leis, Fire Science Program Leader and Heartland Inventory and Monitoring Network Cooperator, Missouri State University Biology Department, Springfield, Missouri. Ms. Leis provided helpful reviews on the draft manuscript.

4.7.7. Literature Cited

Anderson, K. L., E.F. Smith, and C.E. Owensby. 1970. Burning bluestem range. Journal of Range Management 23:81-92.

Becker, D.A., T. Bragg and D. Sutherland. 1986. Prairie management plan, Pipestone National Monument. USDI National Park Service.

Bowles, M.L. and M. D. Jones. 2013. Repeated burning of eastern tallgrass prairie increases richness and diversity, stabilizing late successional vegetation. Ecological Applications, 23(2):464–478

Bragg, T. B., and L.C. Hulbert. . 1976. Woody plant invasion of unburned Kansas bluestem prairie. Journal of Range Management 29:19-24.

Briggs, J. M., A.K. Knapp, and B.L. Brock. 2002. Expansion of woody plants in tallgrass prairie: A 15 year study of fire and fire-grazing interactions. The American Midland Naturalist 147:287-294.

Buell, M. F. and V. Facey. 1960. Forest-prairie transition west of Itasca Park, Minnesota. Bulletin of the Torrey Botanical Club 87:46-58.

Catlin, George. 1844. Letters and notes on the manners, customs, and condition of the North American Indians (1832-1839). Letter No. 54: Red Pipestone Quarry, Coteau Des Prairies. Available at the Library of Western Fur Trade Historical Source Documents web site, http://user.xmission.com/~drudy/mtman/html/catlin/ (Accessed 11 December 2013).

Collins, S. L., S.M. Glenn, and D.J. Gibson. 1995. Experimental analysis of intermediate disturbance and initial floristic composition: Decoupling cause and effect. Ecology 76:486-492.

Collins, S. L., S.M. Glenn, and J.M. Briggs. 2002. Effect of local and regional processes on plant species richness in tallgrass prairie. Oikos 99:571-579.

Copeland, T. E., W. Sluis, and H.F. Howe. 2002. Fire season and dominance in an Illinois tallgrass prairie restoration. Restoration Ecology 10:315-323.

Cui, W. and A. H. Perera. 2008. What do we know about forest fire size distribution, and why is this knowledge useful for forest management? International Journal of Wildland Fire 17:234-244.

Davison, C., and K. Kindscher. 1999. Tools for diversity: Fire, grazing, and mowing on tallgrass prairies. . Ecological Restoration 17:136-143.

DeCoster, J., K. Legg, R. O'Sullivan, D. Soliem and G. Wagner. 2004. Pipestone National Monument fire management plan and environmental assessment. USDI National Park Service.

Engle, D. M., J.F. Stritzke, T.G. Bidwell, and P.L. Claypool. 1993. Late-summer fire and follow-up herbicide treatments in tallgrass prairie. Journal of Range Management 46:542-547.

Engle, D. M., and T.G. Bidwell. 2001. The response of central North American prairies to seasonal fire. Journal of Range Management 54:2-10.

Ewing, A. L., and D.M. Engle. 1988. Effects of late summer fire on tallgrass prairie microclimate and community composition. The American Midland Naturalist 120:212-223.

Fuhlendorf, S. D. and D. M. Engle. 2001. Restoring heterogeneity on rangelands: ecosystem management based on evolutionary grazing patterns. BioScience 51:625-632.

Fuhlendorf, S.D., W.C. Harrel, D.M. Engle, R.G. Hamilton, C.A. Davis, and D.M. Leslie Jr. 2006. Should heterogeneity be the basis for conservation? Grassland bird response to fire and grazing. Ecological Applications 16:1706–1716.

Gaetani, M. S., K. Cook, and S. A. Leis. 2010. Fire effects on wildlife in tallgrass prairie. Natural Resource Report NPS/HTLN/NRR—2010/193. National Park Service, Fort Collins, Colorado.

Guyette, R.P., M.C. Stambaugh, and J.M. Marschall. 2011. A quantitative analysis of fire history at national parks in the Great Plains. A report prepared for the Great Plains Cooperative Ecosystem Studies Unit and National Park Service. 78 pp.

Hamilton, R.G. 2007. Restoring heterogeneity on the Tallgrass Prairie Preserve: applying the fire-grazing interaction model. In Masters, R. E. and K. Galley (eds.). Proceedings of the 23rd Tall Timbers Fire Ecology Conference: Fire in Grassland & Shrubland Ecosystems. 261p.

Hartnett, D. C., K. R. Hickman, and L. E. F. Walter. 1996. Effects of bison grazing, fire, and topography on floristic diversity in tallgrass prairie. Journal of Range Management 49:413-420.

Howe, H. F. 1994. Response of early- and late-flowering plants to fire season in experimental prairies. Ecological Applications 4:121-133.

Howe, H. F. 1995. Succession and fire season in experimental prairie plantings. Ecology 76:1917-1925.

Howe, H. F. 2000. Grass response to seasonal burns in experimental plantings. Journal of Range Management 53:437-441.

Knapp, A.K., J.M. Briggs, S.L. Collins, D.C. Hartnett, L.C. Johnson, and E.G. Towne. 1999. The keystone role of bison in North American tallgrass prairie. BioScience 49:39–50.

Knapp, A. K. and T. R. Seastedt. 1998. Introduction: grasslands, Konza Prairie and long-term ecological research. Pages 3-15 *in* A. K. Knapp, J. M. Briggs, D. C. Hartnett, and S. L. Collins, editors. Grassland dynamics: long-term ecological research in tallgrass prairie. Oxford University Press, New York.

McMurphy, W. E., and K.L. Anderson. 1965. Burning Flint Hills range. Journal of Range Management 18:265-269.

Minnesota Department of Natural Resources. 2003. Prairie Parkland Province: Coteau Moraines and Inner Coteau. MDNR Ecological Services.

National Park Service (NPS). 2008. Final general management plan/environmental impact statement, Pipestone National Monument. USDI National Park Service.

National Park Service (NPS). 2006. NPS management policies. USDI National Park Service.

Owensby, C. E., and K.L. Anderson. 1967. Yield responses to time of burning in the Kansas Flint Hills. Journal of Range Management 20:12-16.

Pleasants, J.M. 1998. The effects of spring burns on the western prairie fringed orchid (*Platanthera praeclara*). Proceedings of the 14th Annual North American Prairie Conference.

Pyne, S. J., P. L. Andrews, and R. D. Laven. 1996. Introduction to wildland fire. Wiley, New York.

Reinking, D. L. 2005. Fire regimes and avian responses in the central tallgrass prairie. Studies in Avian Biology 30:116-126.

Schroeder, M.J., and C.C. Buck. 1970. Fire weather, USDA Forest Service, Agricultural Handbook 360. 288 pp.

Smith, M. D., and A.K. Knapp. 1999. Exotic plant species in a C4-dominated grassland: invasibility, disturbance, and community structure. Oecologia 120:605-612.

Towne, G. and K. E. Kemp. 2003. Vegetation dynamics from annually burning tallgrass prairie in different seasons. Journal of Range Management 56:185-192.

Towne, G. and C. Owensby. 1984. Long-term effects of annual burning at different dates in ungrazed Kansas tallgrass prairie. Journal of Range Management 37:392-397.

TPNPERC. 2005. Tallgrass Prairie National Preserve: park education resource center. National Park Trust, Rockville, MD.

U.S. Fish and Wildlife Service (USFWS). 1996. *Platanthera praeclara* (Western prairie fringed orchid) recovery plan. U.S. Department of the Interior, Fish and Wildlife Service, Ft. Snelling, Minnesota. 101 pp.

Weir, J.R. Undated. The best time of year to conduct prescribed burns - Oklahoma Cooperative Extension fact sheet. Division of Agricultural Sciences and Natural Resources, Oklahoma State University. Available at http://pods.dasnr.okstate.edu/docushare/dsweb/Get/Document-7504/NREM-2885web.pdf (accessed January 2014).

Wiens, J.A. 1997. The emerging role of patchiness in conservation biology. Pages 93–107 *in* S.T.A. Pickett, R.S. Ostfeld, M. Shachak, and G.E. Likens (eds.). The ecological basis for conservation: heterogeneity, ecosystems, and biodiversity. Chapman and Hall, New York.

Willson, G.D. and J. Stubbendieck. 1997. Fire effects on four growth stages of smooth brome (*Bromus inermis* Leyss.). Natural Areas Journal. 17:306-312.

Wright, H. A. and A. W. Bailey. 1982. Fire Ecology, United States and Southern Canada. John Wiley & Sons, New York.

4.8. Air Quality

4.8.1. Background and Importance

The NPS' Organic Act, Air Quality Management Policy 4.7.1, and the Clean Air Act (CAA) of 1977, and its subsequent amendments protect and regulate the air quality of the National Parks within the United States. The NPS is responsible for protecting air quality and related issues which may be impacted by air pollution. Many resources in parks can be affected by air pollution. For example, scenic vistas require good visibility and low haze. Human-made pollution can harm ecological resources, including water quality, plants and animals. Air pollution can also cause or intensify respiratory symptoms for visitors and employees at NPS areas. Because of these many links, poor and/or declining air quality can impact park visitation. A synthesis of seven visitor studies conducted in the NPS Midwest Region found that clean air was ranked as *extremely important* or *very important* by 88% of visitor groups (Kulesza et al. 2013). National Park Service properties fall under two different classifications for air quality protection. Class I airsheds are defined as national parks over 6,000 acres (2,428 ha), national wilderness areas, national memorial parks over 5,000 acres (2,023 ha), or international parks in existence as of August 7, 1977 (NPS ARD 2013b). Class II airsheds are areas of the country protected under the CAA, but identified for somewhat less stringent protection from air pollution damage than a Class I area, except in specified cases (NPS ARD 2013b). Based on these classifications of airsheds, PIPE falls under the Class II area of protection.

Air quality can have a significant impact on the vegetation and ecology of an area. The Agricultural Research Service (ARS) (2012) describes ground-level ozone as having a larger effect on plants than all other air pollutants combined. Nitrogen (ammonia - NH_4) and Sulfur (sulfate - SO_3) deposition can cause acidification of water bodies, while excess nitrate (NO_3) can lead to nutrient effects on biodiversity. Decreased visibility from haze does not affect the ecology of an area so much as it affects the human element through decreased viewing opportunities of the protected lands within NPS properties.

As of December 2012, the PIPE area was not listed by EPA as an area of nonattainment for any air quality indicators (EPA 2013). PIPE experiences "Very High" exposure to atmospheric Nitrogen (N) enrichment and has been described as being very highly at risk from N enrichment (Sullivan et al 2011a). PIPE also has "Moderate" exposure to acidic deposition from Sulfur (S) and N emissions and has been described as being moderately at risk from acidic deposition (Sullivan et al 2011b).

Threats and Stressors

The Minnesota Pollution Control Agency (MPCA) has listed (2013) a variety of non-point pollution sources that are becoming more of an issue for air quality than the standard point sources of pollution, such as factories. On a large scale, changing climate and weather patterns may be the biggest concern for the future of air quality in Minnesota. On a more local scale, non-point sources of air pollution that are becoming a larger factor for air pollution include: residential wood burning, residential garbage burning, stationary diesel generators, on- and off-road vehicles, and mercury emission sources (MPCA 2013).

Indicators and Measures

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

4.8.2. Data and Methods

The NPS' Air Resources Division (ARD) has produced an interactive Air Atlas that shows the 5-year interpolated values for ozone, atmospheric deposition, and visibility at each NPS property across the contiguous US. Interpolated values for ozone, wet deposition, and visibility were used to assess the air quality condition at PIPE. The NPS ARD's Air Atlas provides the best air quality information for PIPE.

The NPS ARD (2013c) published the trends and conditions of air quality at all NPS properties using data from 2000-2009 and 2005-2009, respectively. This publication used a non-parametric regression technique known as the Theil Method to determine ozone, deposition, and visibility trends using yearly data. Although the five-year averages may appear to have some trends, these are not always supported by the annual values. Currently, there are no monitoring stations for ozone, wet deposition, or visibility located within the monument. Monitoring data originates from regional monitoring stations and interpolated values. Ozone is monitored in Sioux Falls, SD about 35 miles southwest of PIPE. Wet deposition is monitored at two stations in the regions, Lamberton, MN is about 60 miles northeast of PIPE and Huron, South Dakota is about 100 miles northwest of PIPE. There is no Interagency Monitoring of Protected Visual Environments (IMPROVE) visibility monitoring stations within 100 miles of PIPE (NPS ARD 2001). Bennett and Banerjee (1995) assessed air pollution vulnerability of 22 Midwestern parks, which includes PIPE. At the time of the study they concluded that PIPE was at low risk of ozone, sulfur dioxide, and sulfur pollutants.

4.8.3. Reference Conditions

Reference conditions are based on USEPA standards or have been recommended by NPS ARD (2013a). A summary of reference conditions and condition class rating for air quality indicators is shown in Table 4-28.

Table 4-28. Reference condition framework for air quality indicators (NPS ARD 2012b).

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

Ozone

The EPA's standard benchmark for protecting human health is 75 parts per billion (ppb), averaged over an 8-hour period. The 3 year average of the annual 4^{th}-highest daily maximum 8-hour average ozone concentration must not exceed the 75 ppb mark to meet the EPA standard. The NPS ARD utilizes the five-year averages of 4th highest daily maximum 8 – hour ozone concentrations for parks within the contiguous United States (NPS ARD 2013a).

The NPS ARD ranks ozone conditions as “Good” if levels are less than or equal to 60 ppb, “Moderate” between 61-75 ppb, and “Poor” if levels are greater than or equal to 76 ppb (Table 4-28).

Wet Deposition

The NPS ARD (2013a) considers parks which receive less than 1 kg/ha/yr of nitrogen and sulfur as being in “Good Condition”. Parks receiving between 1 – 3 kg/ha/yr are ranked as “Moderate Condition”. Those parks that receive greater than 3 kg/ha/yr are ranked as “Poor Condition” (Table 4-28).

Visibility

Visibility is measured using the Haze Index in deciviews (dv). Visibility conditions are the difference between average current visibility and estimated average natural visibility, where the average natural visibility is the mean between the 40th and 60th percentiles (NPS ARD 2013a). Five-year interpolated averages are used in the contiguous US.

Visibility is considered to be in “Good Condition” if visibility is less than 2 dv, “Moderate Condition” if between 2-8 dv, and “Poor Condition” if greater than 8 dv (Table 4-28)(NPS ARD 2013a).

4.8.4. Condition and Trend

Condition status ratings for air quality indicators are summarized in Table 4-29 (NPS ARD 2012b).

Table 4-29. Condition status results for air quality indicators at Pipestone National Monument (NPS ARD 2012b).

Averaged 5-year Period	Ozone (ppb)	Total N (kg/ha/yr)	Total S (kg/ha/yr)	Visibility (dv)
2006-2010	60.5 (moderate)	4.8 (poor)	1.7 (moderate)	9.5 (poor)
2005-2009	63.7 (moderate)	5.0 (poor)	1.9 (moderate)	9.9 (poor)
2004-2008	63.0 (moderate)	5.1 (poor)	2.0 (moderate)	10.1 (poor)
2003-2007	65.3 (moderate)	5.3 (poor)	2.2 (moderate)	10.1 (poor)
2001-2005	66.1 (moderate)	5.6 (poor)	2.2 (moderate)	8.0 (moderate)

Ozone

Ozone is known to impact vegetation and human health and is a concern at many NPS properties. There are 5 plant species identified within PIPE that are sensitive to ozone (Table 4-30) and 4 species that are slightly sensitive to ozone. Ozone is able to enter leaves through stomata and causes chlorosis and necrosis of leaves (Figure 4-54), among other problems. Soil moisture plays a big role in the uptake of ambient ozone. Moist soils allow plants to transpire and increase stomatal conductance which, in turn, increases ozone uptake (Panek and Ustin 2004). Ozone causes problems for humans as well, including difficulty breathing, chest pain, coughing, inflamed airways, and making lungs more susceptible to infection (EPA 2012).

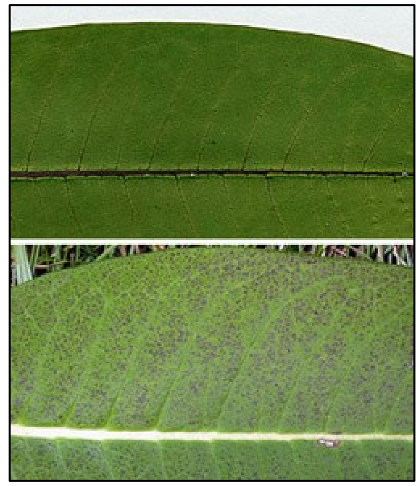


Figure 4-54. *Asclepias syriaca* normal leaf (top) and ozone-injured leaf (bottom). Photo: NPS ARD.

From 2006-2010 PIPE experienced a 4th highest 8-hr ozone average concentration of 60.5 parts per billion (ppb) (Table 4-29) (NPS 2012a). The ozone levels at PIPE improved slightly from the 2001-2005 period to the 2006-2010 period, but the trend is not statistically significant (NPS ARD 2013c). This indicator warrants moderate concern, with an unchanging trend and medium confidence due to the regional and modeled nature of the data.

Table 4-30. PIPE plant species sensitive to Ozone (NPS ARD 2003; NPS ARD 2004).

Scientific Name	Common Name
Asclepias syriaca	Common milkweed
Fraxinus pennsylvanica	Green ash
Parthenocissus quinquefolia	Virginia creeper
Philadelphus coronarius	Sweet mock-orange
Sambucus Canadensis	American elder

Wet Deposition

The five-year averages for total N consistently fall in the “Poor Condition” category and total S deposition consistently falls in the “Moderate Condition” category (Table 4-29). The deposition rates improved slightly from the 2001-2005 period to the 2006-2010 period but the trend is not statistically significant (NPS ARD 2013c). The condition of this indicator warrants significant concern, with an unchanging trend and medium confidence due to the regional and modeled nature of the data.

Visibility

The five-year averages for visibility consistently fall in the “Poor Condition” category. The visibility levels have been between 8.0 dv and 10.1 dv throughout the 2001-2010 period. The condition of this indicator warrants significant concern, with an unchanging trend and medium confidence due to the regional and modeled nature of the data.

Overall Condition

Based on the evaluation of air quality indicators, air quality condition warrants significant concern, with an unknown trend. Confidence in the assessment is medium (Table 4-31). Impacts to air quality appear to be largely from distant sources that are affecting regional air quality.

Table 4-31. Condition and trend summary for air quality at Pipestone National Monument.

Indicator	Condition Status/Trend	Rationale
Air Quality (overall)		**The condition of air quality indicators warrants significant concern, with an unchanging trend. Confidence in the assessment is medium.**
Ozone		Ozone levels have been improving since 2001, but the trend is not statistically significant. This indicator is in Moderate Condition.
Wet Deposition (total N and total S)		Wet deposition measurements are consistently high for PIPE. Wet deposition levels are in Poor Condition with no trend.
Visibility		Visibility measurements are consistently poor for PIPE. The analysis and reports indicate that the trend is unchanging and there is moderate confidence in the assessment.

4.8.5. Uncertainty and Data Gaps

Monitoring stations are needed within PIPE to better understand the specific air quality conditions at the property. The Air Atlas interpolations are adequate, but can misrepresent park conditions due to modeling errors. Monitoring of air quality conditions within PIPE or nearby would eliminate uncertainty from the interpolations.

4.8.6. Sources of Expertise

Tamara Blett, Ecological Effects Program Manager, NPS Air Resources Division

4.8.7. Literature Cited

Bennett, J.P and M. Banerjee. 1995. Air pollution vulnerability of 22 midwestern parks. Journal of Environmental Management 44: 339-360.

Environmental Protection Agency (EPA). 2012. Health Effects – Ground level ozone. http://www.epa.gov/airquality/ozonepollution/health.html. (Accessed 15 August 2013).

Environmental Protection Agency (EPA). 2013. The Green Book Nonattainment Areas for Criteria Pollutants. http://www.epa.gov/oaqps001/greenbk/. (Accessed 15 August 2013).

Kulesza, C., Y. Le, and S.J. Hollenhorst. 2013. National Park Service visitor perceptions & values of clean air, scenic views, & dark night skies; 1988–2011. Natural Resource Report NPS/NRSS/ARD/NRR–2013/632. National Park Service, Ft. Collins, Colorado.

Minnesota Pollution Control Agency (MPCA). 2013. Air quality in Minnesota: 2013 report to the legislature. http://www.pca.state.mn.us/index.php/view-document.html?gid=18909. (Accessed 2/23/2014).

National Park Service Air Resources Division (NPS ARD). 2001. Air quality monitoring considerations for the Heartland Network. http://www.nature.nps.gov/air/permits/aris/networks/docs/htlnAirQualitySummary.pdf. (Accessed 29 October 2013).

National Park Service Air Resources Division (NPS ARD) 2003. Ozone sensitive plant species on National Park Service and U.S. Fish and Wildlife Service lands: results of a June 24-25, 2003 workshop Baltimore, Maryland. http://www.nature.nps.gov/air/pubs/pdf/BaltFinalReport1.pdf. (Accessed 26 August 2013).

National Park Service Air Resources Division (NPS ARD). 2004. Heartland Network: assessing the risk of foliar injury from ozone on vegetation in parks in the Heartland Network. http://www.nature.nps.gov/air/pubs/pdf/03Risk/htlnO3RiskOct04.pdf. (Accessed 26 August 2013).

National Park Service Air Resources Division (NPS ARD). 2012a. 2006-2010 5-year average ozone estimates. NPS air quality estimates. National Park Service. Denver, CO. Available at http://www.nature.nps.gov/air/Maps/AirAtlas/IM_materials.cfm. (Accessed 14 August 2013).

National Park Service Air Resources Division (NPS ARD). 2012b. 2006-2010 5-year average wet deposition estimates. NPS air quality estimates. National Park Service. Denver, CO. Available at http://www.nature.nps.gov/air/Maps/AirAtlas/IM_materials.cfm. (Accessed 15 August 2013).

National Park Service Air Resources Division (NPS ARD). 2012c. 2006-2010 5-year average visibility estimates. NPS air quality estimates. National Park Service. Denver, CO. Available at http://www.nature.nps.gov/air/Maps/AirAtlas/IM_materials.cfm. (Accessed 15 August 2013).

National Park Service Air Resources Division (NPS ARD). 2013a. Methods for determining air quality conditions and trends for park planning and assessments. http://www.nature.nps.gov/air/planning/docs/AQ_ConditionsTrends_Methods_2013.pdf. (Accessed 23 August 2013).

National Park Service Air Resources Division (NPS ARD). 2013b. NPS air quality glossary. http://www.nature.nps.gov/air/aqbasics/glossary.cfm. (Accessed 15 August 2013).

National Park Service Air Resources Division (NPS ARD). 2013c. Air quality in national parks: trends (2000-2009) and conditions (2005-2009). Natural Resources Report NPS/NRSS/ARD/NRR – 2013/683. National Park Service, Denver, Colorado.

Panek, J.A., and S.L. Ustin. 2004. Ozone uptake in relation to water availability in ponderosa pine forests: measurements, modeling, and remote-sensing. PMIS #76735. King's Canyon and Yosemite National Parks. Accessed online: http://www.nature.nps.gov/air/pubs/pdf/toxics/PanekReport2004.pdf. 8/1/2013.

Sullivan, T.J., T.C. McDonnel, G.T. McPherson, S.D. Mackey, and D. Moore. 2011a. Evaluation of the sensitivity of inventory and monitoring national parks to nutrient enrichment effects from atmospheric nitrogen deposition: Heartland Network (HTLN). Natural Resource Report NPS/NRPC/ARD/NRR – 2011/311. National Park Service, Denver, Colorado.

Sullivan, T.J., G.T. McPherson, T.C. McDonnell, S.D. Mackey, and D. Moore. 2011b. Evaluation of the sensitivity of inventory and monitoring national parks to acidification effects from atmospheric sulfur and nitrogen deposition: Heartland Network (HTLN). Natural Resource Report NPS/NRPC/ARD/NRR – 2011/359. National Park Service, Denver, Colorado.

4.9. Stream Hydrology and Geomorphology

4.9.1. Background and Importance

NPS Management Policies (NPS 2006a) specify that the Service will manage watersheds as complete hydrologic systems and minimize human-caused disturbance to the natural upland processes that deliver water, sediment, and woody debris to streams. These processes include runoff, erosion, and disturbance to vegetation and soil caused by fire, insects, weather events and other stressors. The Service will manage streams to protect stream processes such as flooding, stream migration, and associated erosion and deposition that create habitat features. The Service will protect watershed and stream features primarily by avoiding impacts on watershed and riparian vegetation and by allowing natural fluvial processes to proceed unimpeded (NPS 2006a). These park and national NPS goals require an integrated perspective that includes upland vegetation and grazing management, wildlife management, management of springs and impoundments, and riparian zone management, all of which affect aquatic resources and surface water quality.

Pipestone Creek above Winnewissa Falls was channelized into bedrock in the early 1900s. (CSU Photo)

Surface waters at Pipestone National Monument (PIPE) include Pipestone Creek and Lake Hiawatha. Pipestone Creek is a significant natural and ethnographic resource for the monument. It has important cultural value, including its use for cleansing rituals associated with traditional quarrying. It also provides habitat for the federally endangered Topeka shiner and the aquatic macroinvertebrate community and provides landscape and habitat diversity for flora and fauna, including woodland riparian habitat. Pipestone Creek flows through the monument from east to west and fills Lake Hiawatha after flowing over Winnewissa falls (Figure 4-55) (NPS 2013a). It originates as a series of agricultural drainage ditches to the northeast, near the town of Holland. The creek is subject to flooding, rising by several meters over a 24hr period. Pipestone creek water quality and quantity is significantly affected by the agricultural watershed and drainage ditches fed by drain tile outlets providing flow to the creek (Harris et al 1991). The main stem of the stream reach immediately upstream from the monument boundary is a straightened ditch with smaller ditches and natural small streams feeding it.

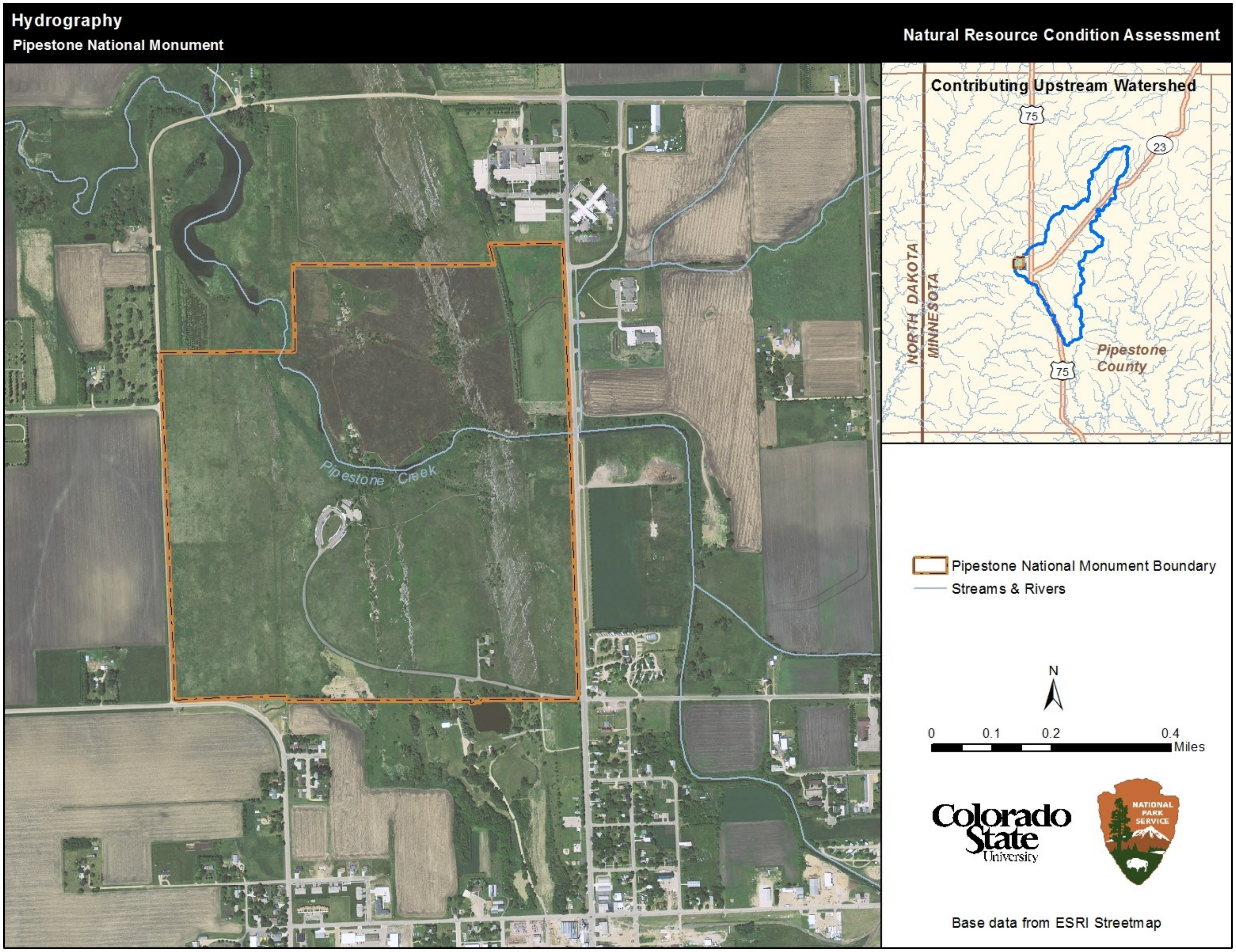


Figure 4-55. Surface hydrography in the vicinity of Pipestone National Monument, Minnesota

Approximately 91% of PIPE's contributing upstream watershed is classified as having 0-2% impervious surfaces. Approximately 2.6% of the contributing upstream catchment of the park was classified as having >25% impervious surfaces (Table 4-5), the vast majority of which is concentrated near the town of Pipestone. Landcover and landuse characteristics of PIPE's contributing upstream watershed are examined in detail in the *Land Cover and Land Use* section of this chapter.

Stream condition depends on interactions between inflowing supplies of water and sediment, valley setting, and external controls such as riparian vegetation. A stream is generally considered stable and in equilibrium when its sediment-transport capacity balances the sediment supply delivered from the watershed and upstream reaches such that the stream dynamically maintains its pattern, dimension, and profile over engineering time scales of about 50 years. If watershed changes alter the flow regime, sediment supply, vegetative reinforcement, or the channel directly, the stream may undergo a period of instability involving incision and/or widening in response. During this transition period, streams commonly exhibit increased erosion, bank failures, and aggradation which can negatively influence aquatic and riparian habitats which are major determinants of biotic composition.

The objective of this study was to assess the hydrology and geomorphology within Pipestone National Monument to determine current condition of Pipestone Creek relative to a defined reference condition.

Threats and Stressors

- Development and agricultural within the watershed affecting impervious surfaces, stream flows, and hydrologic response to precipitation events.
- Upstream ponds, sediment-control and flood-control structures that alter flow seasonality, amounts and sediment loads.
- Historical degradation of stream stability resulting in channel incision, headcutting and slumping resulting in continued channel and bank instability and accelerated erosion.
- Climate change may increase the incidence of extreme runoff events, which may impact stream condition and recovery.

Indicators and Measures

- Proper functioning condition (PFC) rating
- Channel evolution model (CEM) stage

4.9.2. Data and Methods

Pipestone Creek was visually assessed for Proper Functioning Condition (PFC) (BLM 1998) and Channel Evolution Model (CEM) stage (Schumm et al. 1984) along its course within the park. The assessment was conducted on June 21, 2013. PFC assessment consisted of evaluating seventeen hydrologic, vegetative, soil and geomorphological parameters ultimately leading to a PFC and CEM ratings for the stream reach. PFC condition characteristics are described below. The CEM rating was used to support the PFC determination as well as indicate the trend in condition, especially where Functional at Risk conditions exist.

Proper Functioning Condition: Streams and associated riparian areas are functioning properly when adequate vegetation, landform, or large woody debris is present to:

1) dissipate stream energy associated with high waterflows, thereby reducing erosion and improving water quality;
2) filter sediment, capture bedload, and aid floodplain development;
3) improve floodwater retention and groundwater recharge;
4) develop root masses that stabilize stream banks against cutting action;
5) develop diverse ponding and channel characteristics to provide habitat and the water depths, durations, temperature regimes, and substrates necessary for fish production, waterfowl breeding, and other uses; and
6) support greater biodiversity.

Functional – At Risk: These riparian areas are in functional condition, but an existing soil, water, vegetation, or related attribute makes them susceptible to degradation. For example, a stream reach may exhibit attributes of a properly-functioning riparian system, but it may be poised to suffer severe erosion during a large storm in the future due to likely migration of a headcut or increased runoff associated with recent urbanization in the watershed. When this rating is assigned to a stream reach, then its "trend" toward or away from PFC is assessed.

Nonfunctional: These are riparian areas clearly not providing adequate vegetation, landform, or large woody debris to dissipate stream energy associated with high flows, and thus are not reducing erosion, improving water quality, sustaining desirable channel and riparian habitat characteristics as described in the PFC definition. The absence of certain physical attributes such as a floodplain where one should exist is an indicator of nonfunctioning conditions.

Channel Evolution Model (CEM): Developed by Schumm *et al.* (1984), the CEM is designed to determine the stage of stream evolution in incising channels. The CEM rating was used to support the PFC determination as well as indicate the trend in condition, especially where Functional at Risk conditions exist. CEM scores of I, III, and V might not indicate trends but a CEM Type II channel usually indicates a deteriorating trend. CEM Type IV channel indicates an improving trend.

Determining the CEM stage is a useful tool for managers to not only help identify the current condition of the stream but also to indicate the possible future trend allowing for informed management decisions about stream protection and rehabilitation. There are many reasons why incision may occur within a stream, but it is generally due to a disparity between sediment-transport capacity and sediment supply (Watson *et al*., 2002). Incision sometimes manifests as a headcut that will progress upstream as long as the sediment-transport capacity is higher than the supply and no resistive strata are encountered. Eventually the channel will incise deep enough to where bank failures occur due to geotechnical instability. Failures are generally caused by bank heights greater than the critical bank height, which results in mass failures and widening in the channel. With the addition of new sediment to the channel from the failed banks, the ratio of sediment-transport capacity to supply may switch, resulting in aggradation and a decrease in bed slope. The decreased bed slope reduces the sediment-transport capacity of the stream eventually resulting in a new dynamic quasi-equilibrium slope and a newly-stable channel. This evolution takes place in five stages and can generally be seen in order from upstream to downstream (Figure 4-56).

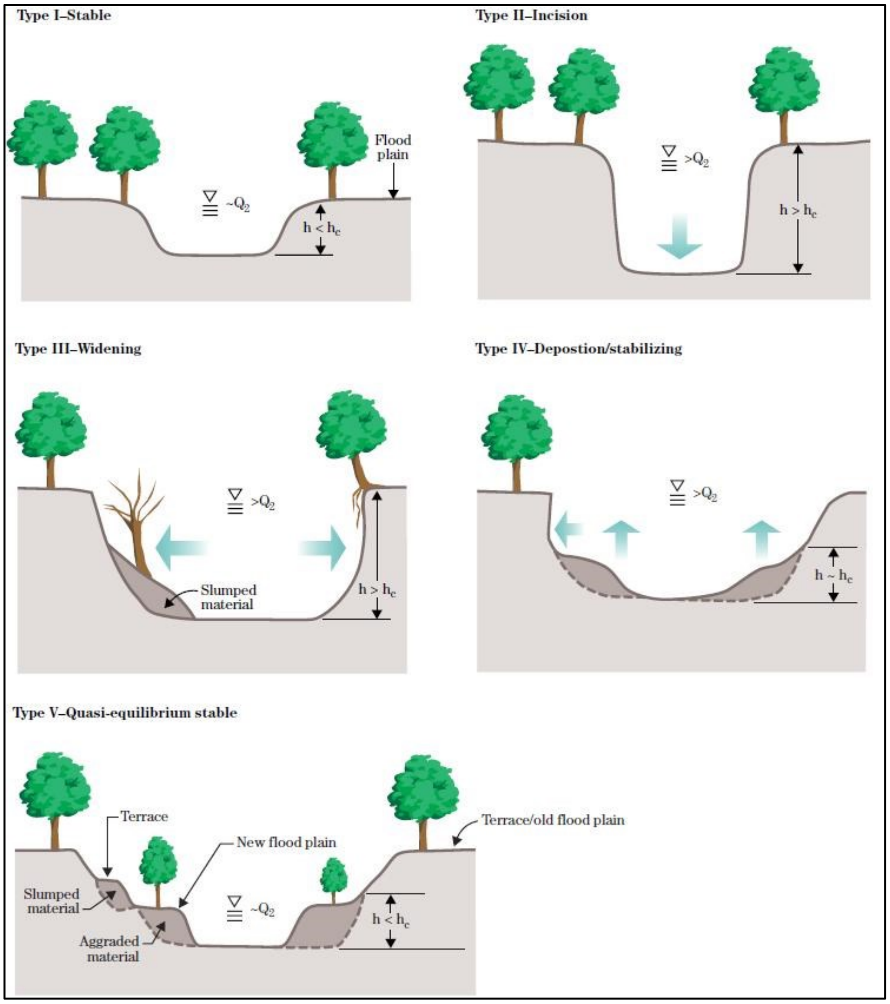


Figure 4-56. Cross-section view of the five types of channels in the CEM (NRCS 2007).

A CEM Type I reach is located upstream of a headcut and is considered stable. A CEM Type II reach is defined as actively incising, however, bank heights are still below critical bank height so bank failures are not present. In CEM Type III, bank heights are now above critical bank height, which results in mass bank failures and channel widening. In CEM Type IV, the channel begins to tend toward a stable state due to aggradation from an influx of sediment from the eroded banks. Bank failures may still be present in this stage of evolution. Finally, CEM Type V is when the channel has recovered because a new balance between sediment-transport capacity and supply has been reached. CEM stage was determined by walking the stream lengths in an upstream to downstream direction. The channel was visually assessed for signs of incision, bank failures, aggradation, and terracing to help determine stage. If definitive breaks in CEM score were seen along the stream, different reach scores would be assigned. CEM stage scores ranged from Stage 1 to Stage 5 in 0.5 increments.

4.9.3. Reference Conditions

The current condition of a stream is evaluated relative to a defined reference condition. Inherent within the PFC scoring of functioning condition is the idea of potential, which is defined as the "highest ecological status an area can attain given no political, social, or economic constraints" (Schumm et al. 1984). Likewise, for CEM stage the reference condition would be a Stage 1 channel type where the sediment supply is in balance with sediment transport, creating a stable channel. It was assumed for these historically prairie ecosystems that the reference condition for the streams would be based upon a stable channel whose flow and sediment regime had not been altered in any way. The PFC and CEM framework is translated into a NRCA condition status rating as follows:

Resource is in good condition – Proper Functioning Condition rating with CEM Type I (historical) or Type V (restored/rehabilitated) channel.

Resource warrants moderate concern – Functional At-Risk rating often with a downward or no apparent trend CEM Type II, or with an upward or no apparent trend CEM Type IV channel.

Resource warrants significant concern – Nonfunctional PFC rating often with CEM Type III channel.

4.9.4. Condition and Trend

Pipestone Creek was rated Functional – At Risk with No Apparent trend. Four criteria were rated positively; nine negatively; and three rated N/A for beaver presence, large woody material, and point-bar revegetation. There are signs of recent beaver activity and park staff said beaver have been present historically but were not observed in 2013. Point-bar revegetation was scored N/A due to the higher gradient channel that would not form point bars naturally. From Winnewissa Falls upstream for 13.9 miles, the stream was channelized in the early 1900s turning Pipestone Creek largely into an agricultural drainage ditch (Figure 4-56). Downstream of the waterfall, the channel has a steep gradient with large cobbles and boulders along the bottom, including underneath the toe of the banks (Figure 4-57). Fluvial erosion along the bank toe above the coarse-bed material has led to channel widening. Reed canary grass (*Phalaris arundinacea)*, a non-native species, is dominant along the banks and is not providing root masses capable of preventing erosion. As the banks become deeply undercut, the reed canary grass mats slough into the channel and sometimes create islands (Figure 4-58). Sparse sections of false indigo (*Amorpha* spp.) are found along the stream edge but not in enough quantity to help with bank stabilization. The stream was scored CEM Stage 2 due to the undercutting that was leading to some channel widening. The stream is not expected to incise due to the large bed material but instead possibly continue widening.

A stream gage operated by the Minnesota Department of Natural Resources (MDNR) is located on Pipestone Creek upstream of the monument that records stage but the data appear to be unreliable due to an unrealistic stage recording over a 4-year period that led to an upward shift in baseflow by 7 ft. (Figure 4-59). Historically, Pipestone Creek had several shallow channels that flowed over

Winnewissa Falls with the main channel located approximately 200 ft. south of where it is presently (Figure 4-60). When land use switched from prairie to agriculture the stream was channelized upstream of the monument including creating the current deep single-thread channel over the falls. Stream channelization was completed to create more arable land upstream and help convey agricultural runoff from fields upstream. However, this process directly changed the geomorphology and hydrology of the stream by decreasing natural sinuosity and disconnecting the stream from the floodplain. This effectively increases velocities within the channel that can cause increased erosion and quicker delivery of water to unchannelized sections downstream such as in Pipestone National Monument. Furthermore, the conversion of prairie and pastures to row crop agriculture has been shown to affect streams by increasing erosion and sedimentation, decreasing the riparian buffer, negatively impacting water quality, and decreasing aquatic habitat (Lau *et al*., 2006).

Figure 4-57. Upstream of the park, 13.9 miles of Pipestone Creek was channelized in the early 1900s turning the creek into a network of agricultural ditches. (CSU photo)

Figure 4-58. Typical fluvial erosion of the bank toes creating undercut banks. Reed canary grass (*Phalaris arundinacea*) roots do not have enough mass to help prevent this erosion.

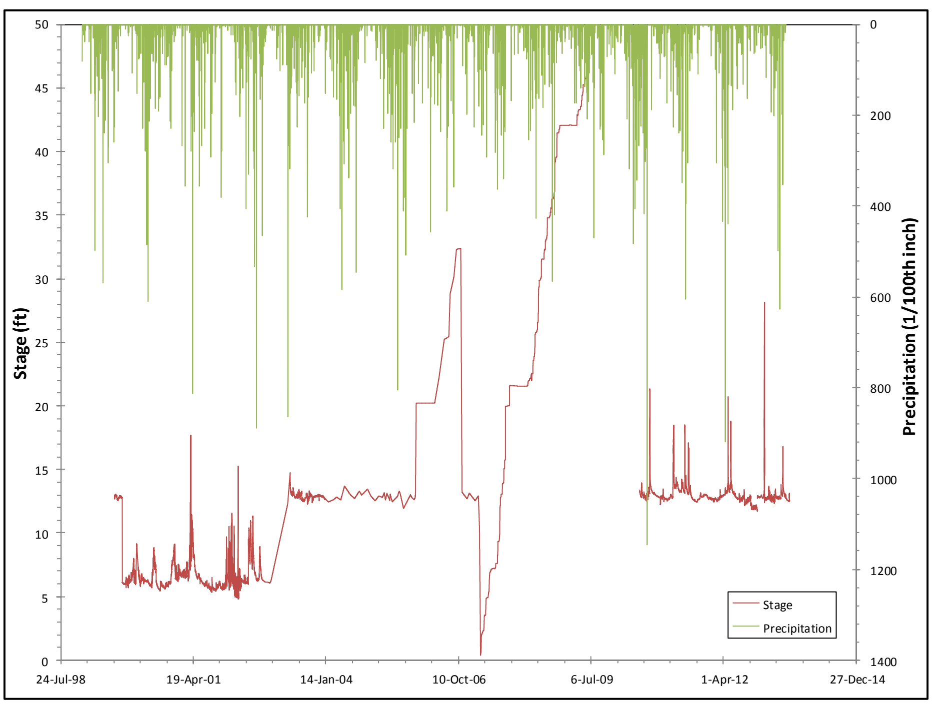


Figure 4-59. Minnesota DNR stream gauge data from Pipestone Creek upstream from the Monument.

Figure 4-60. Historical channel over the falls (blue line) is located 200 ft. south of the current constructed channel.

Within the monument, a dam upstream from the footpath crossing the creek has created Lake Hiawatha. A second smaller natural pond is downstream from the footpath. Bed material consists of boulders and cobbles and appears armored against future incision. Slight aggradation of sand and small gravel is occurring around larger boulders. Reed canary grass (*Phalaris arundinacea*) is planted for hay production in the area and it is assumed this is how it became introduced within the park. The shorter and less dense root mats of reed canary grass, in combination with historical changes in land use and the channelization of Pipestone Creek which have altered the hydrology and geomorphology of the stream, have ultimately resulted in some channel widening within the monument.

Based on this information, stream hydrology and geomorphology at Pipestone National Monument warrants moderate concern with an unchanging trend (Table 4-32).

Table 4-32. Condition and trend summary for stream hydrology and geomorphology at Pipestone National Monument, Minnesota.

Indicator	Condition Status/Trend	Rationale
Stream Hydrology and Geomorphology (overall)		**Condition warrants moderate concern with an unchanging trend. Confidence in the assessment is medium.**
Proper Functioning Condition/CEM		The stream was rated functional at-risk using PFC methodology and was assigned a CEM stage 2 channel with bank undercutting.

4.9.5. Uncertainty and Data Gaps

Stage data recorded by the MDNR appear to be erroneous. Contact was made with the MDNR about the data but at the time of writing no response was received.

4.9.6. References

Bureau of Land Management (BLM). 1998. Riparian area management: a user guide to assessing proper functioning condition and the supporting science for lotic areas. Technical Reference 1737-15, U.S. Department of the Interior, BLM, National Business Center, Denver, CO, September, 136 p.

Harris, M.A., B.C. Kondratieff, and T.P. Boyle. 1991. Water quality work plan for Pipestone National Monument. Denver, CO: National Park Service Report to Midwestern Regional Science office.

Lau, J.K., T.E. Lauer, and M.L. Weinman (2006). Impacts of channelization on stream habitats and associated fish assemblages in east central Indiana. The American Midland Naturalist 56(2):319–330

National Park Service (NPS). 2006. National Park Service management policies. USDI National Park Service.

National Park Service (NPS). 2013. Pipestone National Monument, Nature and Science. http://www.nps.gov/pipe/naturescience/index.htm (accessed 20 November 2013).

Natural Resources Conservation Service (NRCS). 2007. Part 654, stream restoration design – national engineering handbook. U.S. Department of Agriculture, NRCS eDirectives – Electronic Directive System, August, 1600+ pp.

Poff, N.L., B.P. Bledsoe, and C.O. Cuhaciyan. 2006. Hydrologic alterations due to differential land use across the contiguous United States: geomorphic and ecological consequences for stream ecosystems. Geomorphology 79(3-4):264–285.

Roesner, L.A., B.P. Bledsoe, and R.W. Brashear. 2001. Are BMP criteria really environmentally friendly? Journal of Water Resources Planning and Management 127(3):150–154.

Schumm, S.A., M.D. Harvey, and C.C. Watson. 1984. Incised channels: morphology, dynamics and control. Water Resources, Littleton, CO.

Watson, C.C., D.S. Biedenharn, and B.P. Bledsoe. 2002. Use of incised channel evolution models in understanding rehabilitation alternatives. Journal of the American Water Resources Association 38(1):151–160.

4.10. Water Quality

4.10.1. Background and Importance

Winnewissa falls (NPS photo)

Surface waters at Pipestone National Monument (PIPE) include Pipestone Creek and Lake Hiawatha. Pipestone Creek is a significant natural and ethnographic resource for the monument. It has important cultural value, including its use for cleansing rituals associated with traditional quarrying. It also provides habitat for the federally endangered Topeka shiner and the aquatic macroinvertebrate community and provides landscape and habitat diversity for flora and fauna, including woodland riparian habitat. Pipestone Creek flows through the monument from east to west and fills Lake Hiawatha after flowing over Winnewissa falls (Figure 4-61) (NPS 2013a). It originates as a series of agricultural drainage ditches to the northeast near the town of Holland. The creek is subject to flooding, rising by several meters over a 24hr period.

Pipestone creek water quality is largely affected by agricultural runoff due to its proximity to large agricultural areas and drainage ditches fed by drain tile outlets providing flow to the creek (Harris et al. 1991). The main stem of the stream reach immediately upstream from the monument boundary is a straightened ditch with smaller ditches and natural small streams feeding it. There are no wastewater treatment facilities or livestock facilities with National Pollutant Discharge Elimination System (NPDES) permits that contribute to this reach (MPCA 2008b). Watershed characteristics are further described in the *Stream Hydrology and Geomorphology* and *Land Cover and Land Use* sections of this report.

The federal Clean Water Act (as amended 1972) requires states to adopt water quality standards to protect lakes, streams, and wetlands from pollution. The standards define how much of a pollutant can be in the water and still meet designated uses, such as drinking, fishing, and swimming. A water body is “impaired” if it fails to meet one or more water quality standards. To identify and restore impaired waters, Section 303(d) of the Clean Water Act requires states to assess all waters to determine if they meet water quality standards, list waters that do not meet standards (also known as the 303d list) and update the list every even-numbered year, and conduct total maximum daily load (TMDL) studies to establish pollutant-reduction goals needed to restore waters. Federal and state regulations and programs also require implementation of restoration measures to meet TMDLs. Delisting of impaired waters only occurs when new and reliable data indicates that the waterbody is no longer impaired (Minnesota Pollution Control Agency 2013).

Pipestone creek has been listed as a 303(d) impaired stream for fecal coliforms and turbidity (MPCA 2008b). The “Main Ditch” southeast of Pipestone is the primary contributor of water flow and contaminants to the segment of Pipestone Creek flowing through the monument, and has been listed as an impaired reach by the State (Figure 4-61). A TMDL report for that reach was prepared in 2008 (MPCA 2008b).

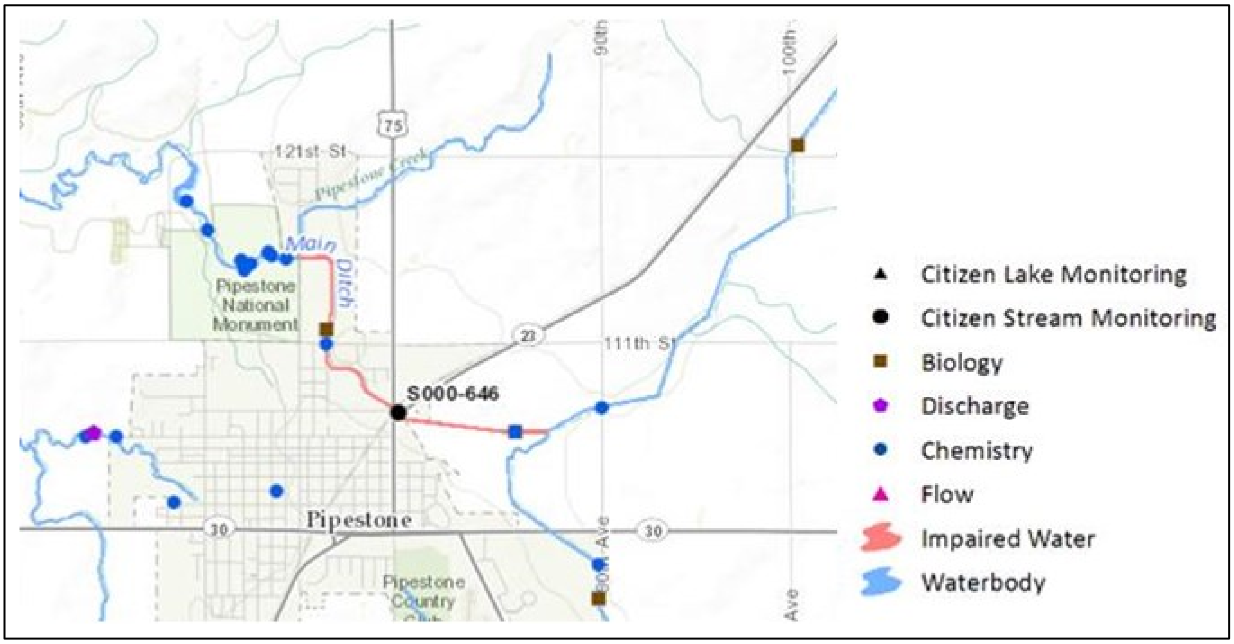


Figure 4-61. Stream segment impairment status in the vicinity of Pipestone National Monument (MPCA 2013).

Pipestone creek contains several species of fish including the fathead minnow (*Pimephales promelas*), creek chub (*Semotilus atromaculatus*) and the federally endangered Topeka shiner (*Notropis topeka*) (Dodd et al. 2010). Lake Hiawatha provides habitat for painted turtles (*Chrysemys picta*), snapping turtles (*Chelydra serpentina*), and many small fish (NPS 2013).

Indicators and Measures

Total dissolved solids

Total dissolved solids (TDS) is a measure of the total concentration of dissolved substances in water (Safe Drinking Water Foundation 2013). TDS may consist of inorganic minerals or salts in ionic and organic material. TDS for a sample of water is measured by passing the sample through a 0.45 micron filter to remove suspended solids, the remaining water is evaporated and the remaining residue represents the TDS concentration in milligrams per liter (mg/L) (Bureau of Reclamation 2013). Common sources of TDS include natural sources, such as mineral springs and urban runoff but may also come from industrial sources, sewage, fertilizers, road runoff, and soil erosion. TDS concentrations can impact the water balance of cells within aquatic organisms by causing the cells to swell when TDS is too low and to shrink when TDS is too high (EPA 2013a).

Chloride

Chloride is an inorganic salt that may be deposited into surface waters from a variety of sources such as road salting, oil and gas wells, and agricultural runoff (McDaniel 2012). High levels of chloride can be toxic to freshwater fish and macroinvertebrates. The toxicity of chloride is increased when mixed with potassium or magnesium, as it is with certain road salts (NHDES 2008). When these metals are released from chloride, the dissolved oxygen levels are reduced which causes additional stress to aquatic life (NHDES 2008). Additionally, high chloride levels can facilitate some fast growing invasive plants, such as Eurasian water milfoil, which can out-compete native fauna (Evans and Frick 2001).

Sulfate
Sulfate is a constituent of TDS and may form salts with sodium, potassium, calcium, magnesium, and other cations. Sulfate can be found naturally in surface waters but anthropogenic sources such as reverse osmosis reject water, waste from pyrite oxidation, and coal preparation waste water may lead to elevated levels of sulfate. Elevated levels of sulfate may be toxic to some macroinvertebrates while fish are more tolerant of excess sulfate (Iowa Department of Natural Resources 2013).

Dissolved oxygen
Dissolved oxygen (DO) in water bodies is critical for aquatic fauna. Oxygen enters water bodies from the atmosphere as well as ground water discharge. Photosynthesis also plays a key role in DO availability because of the effect of water clarity and duration of sunlight on water temperature (USGS 2013a). The amount of DO in a water body is related to the temperature of the water body; cold water holds more oxygen than warm water (USGS 2013a). Physical characteristics of the stream can also ameliorate low DO through mixing of water with the atmosphere. All forms of aquatic life use DO and therefore, DO is used to measure the "health" of lakes and streams. Depletion of DO from water bodies leads to eutrophication, especially when combined with excessive nutrient inputs.

Coliform bacteria
Coliform bacteria are measured by total coliform through a laboratory test examining the number of bacteria colonies that grow on a prepared medium (USGS 2013b). Fecal coliforms and E. coli are coliform bacteria found in the intestinal tract of warm-blooded animals such as humans and livestock. The presence of fecal coliform bacteria in water suggests the presence of fecal matter and associated harmful bacteria (e.g., some strains of *E. coli*), viruses and protozoa (e.g., Giardia and Cryptosporidium) that are pathogenic to humans when ingested (EPA 2001). Coliform bacteria can cause a variety of illnesses and have been used to establish microbial water quality criteria (USGS 2013b).

Turbidity
Turbidity is a measure of the clarity of a liquid. Turbidity of water is influenced by the amount of clay, silt, organic and inorganic matter, algae, plankton, and microscopic organisms present in the water (USGS 2013c). High concentrations of particulate matter can impact water temperature by blocking sunlight from the lower strata of the water column. Large particulate loads can also result in sedimentation which can have negative impacts on aquatic life. Turbidity also provides food and shelter for pathogens that may impact aquatic life as well as human health (USGS 2013c).

Aquatic macroinvertebrates
Macroinvertebrates are organisms that are visible by the naked eye. Aquatic macroinvertebrates live in the water for all or part of their lives and are dependent on water quality (NYNRM 2013). Aquatic

macroinvertebrates are a significant part of a water body because they are an essential part of the food chain in aquatic environments. They are sensitive to chemical, physical, and biological water conditions, and are a good indicator of water quality (EPA 2013b). Some aquatic macroinvertebrates such as stonefly nymphs are more sensitive to water quality than others. Stonefly nymphs cannot survive low DO levels and their absence may indicate the "health" of a water body (EPA 2013b). Aquatic macroinvertebrates are assessed independently in a separate section of this chapter.

Threats and Stressors

The most immediate threat and stressor to water quality in PIPE is agricultural land use upstream. The primary sources of water for Pipestone Creek are irrigation ditches to the east of PIPE. The irrigation ditches are able to carry sediment, excess nutrients, and other constituents which negatively affect water quality. According the State, there are no point sources for the agricultural landuse practices and agricultural inputs used in the contributing watershed above the monument (MPCA 2008b). According to the 2008 TMDL Report, the primary contributing sources to fecal coliform bacteria are potentially livestock on overgrazed riparian pasture, surface-applied manure on cropland and feedlots lacking adequate runoff controls. The primary contributing sources to the turbidity impairments appear to be soil erosion in the riparian zone from livestock, streambank erosion/slumping from livestock and increased flow related to land use, upland soil loss from row cropland and possibly nutrient additions leading to algae growth (MPCA 2008b). Because water quality in this area is influenced by many small contributors, it will be difficult to make significant improvements.

Climate change may be another stressor to water quality at PIPE. Drought years and high temperatures may reduce the volume of water, lower DO concentrations, and help concentrate pollutants.

4.10.2. Reference Conditions

The reference conditions for PIPE's water quality are the Minnesota Pollution Control Agency (MPCA) water quality standards for surface waters, which provide limits for health of freshwater organisms, as well as drinking water standards (Table 4-33). The Environmental Protection Agency (EPA) standards are also listed for reference purposes.

Table 4-33. Minnesota Pollution Control Agency (MPCA) and Federal EPA standards for surface-water quality (MPCA 2008a, EPA 2013c).

Parameter	MPCA standard	EPA standard
Total dissolved solids	≤ 500 mg/L*	≤ 250 mg/L*
Chloride	≤ 230 mg/L	≤ 230 mg/L* (≤860 for fresh water)
Sulfate	≤ 250 mg/L*	≤ 250 mg/L*
Dissolved oxygen	≥ 7.0 mg/L	≥ 4.0 mg/L
Coliform bacteria	≤ 126 CFU/ 100 mL	≤ 200 CFU/100mL
Turbidity	10 NTU	7.83 NTU^{+}

* standard for drinking water

\+ based on aggregate eco-region V nutrient criteria (EPA 2013d)

4.10.3. Data and Methods

The NPS (1999) had previously compiled surface-water quality data for PIPE using six of the EPA's national databases: Storage and Retrieval (STORET) water quality database management system, River Reach File (RF3), Industrial Facilities Discharge (IFD), Drink Water Supplies (DRINKS), Flow Gages (GAGES), and Water Impoundments (DAMS). The retrieval resulted in 4,954 observations at 50 different monitoring stations. There were 13 stations located within the park boundary. Five of the 13 stations (PIPE0015, PIPE0019, PIPE0021, PIPE0027, PIPE0029) located within the park contained longer-term (1983 – 1988) records. These longer-term records are used to examine the condition and trend of water quality within PIPE. Additionally, a station immediately upstream of PIPE's boundary (PIPE 0014) had multiple years (1992 – 1994) of monitoring data and is used here to assess water entering PIPE.

In addition to the 1999 NPS report, a mostly qualitative report released by MPCA in 2014 was used to update condition ratings and determine trend of indicators where available. Data for total dissolved solids and sulfates were not included in this report, therefore trends and updated condition ratings were unavailable for these two indicators. The data used from MPCA 2014 are from stations 10EM124 and 04MS055. These stations are located on the previously mentioned "Main Ditch" less than one mile southeast of PIPE, and represent water quality conditions as they enter the park. This data is from the most recent 10 year period as of the creation of the MPCA document. See MPCA 2014 for more information on period of record used.

4.10.4. Condition and Trend

Total Dissolved Solids

There are no recorded values of Total Dissolved Solids that have been published for water quality monitoring stations within, or upstream, of PIPE. A current condition and trend cannot be determined.

Chloride

MPCA standards state that the acceptable level of chloride for freshwater aquatic life is less than or equal to 230 mg/L (MPCA 2008a). The MPCA standard is more restrictive than the EPA standard of 860 mg/L for freshwater aquatic life.

NPS (1999) reviewed a total of 103 chloride observations among 5 monitoring stations within PIPE's boundary and 21 observations from PIPE 0014 immediately upstream of PIPE's boundary. None of the observations exceeded the MPCA limit of 230 mg/L; all values were well below this standard. The maximum chloride value between 1983 and 1988 was 85 mg/L, observed at station PIPE 0019. The data from PIPE 0014 (1992 – 1994) expressed the lowest mean concentration of chloride at 31.6 mg/L. Data from MPCA 2014 indicates no change in condition for this indicator. Table 4-34 displays the chloride values from each station.

Table 4-34. Chloride measurements from five monitoring stations including minimum, maximum, and mean values (mg/L) (NPS 1999). Last record is from monitoring stations just upstream of PIPE used in MPCA 2014.

Station	Period of record	# observations	Minimum	Maximum	Mean	MPCA Evaluation
PIPE 0014	9/92 – 10/94	21	22	42	31.6	Meets Criteria
PIPE 0015	8/83 – 5/88	24	22	80	41.9	Meets Criteria
PIPE 0019	8/83 – 5/88	20	22	85	41.7	Meets Criteria
PIPE 0021	6/84 – 9/86	14	28	48	33.9	Meets Criteria
PIPE 0027	8/83 – 5/88	24	22	75	38.2	Meets Criteria
PIPE 0029	8/83 – 9/86	21	25	80	40.5	Meets Criteria
10EM124/04MS055	*	n/a	n/a	n/a	n/a	Meets Criteria

* MPCA 2014 uses data collected over the most recent 10 year period. See MPCA 2014 pg. 14 for complete explanation.

Based on the available information, chloride is in good condition with an unchanging trend and medium confidence in the assessment.

Sulfate

MPCA standards state that the acceptable level of sulfate for freshwater aquatic life is less than or equal to 250 mg/L (MPCA 2008a). The MPCA standard for sulfate matches that of the EPA for freshwater aquatic life.

NPS (1999) reviewed a total of 103 observations among 5 monitoring stations within PIPE's boundary and 21 observations from PIPE 0014, immediately upstream of PIPE's boundary. None of the observations exceeded the limit of 250 mg/L. The maximum sulfate value between 1983 and 1988 was 200 mg/L, observed at station PIPE 0027. The most recent data from PIPE 0014 (1992 – 1994) expressed the lowest mean concentration of sulfate at 71.4 mg/L. Table 4-35 displays the sulfate values from each station

Table 4-35. Sulfate measurements from five monitoring stations including minimum, maximum, and mean values (mg/L) (NPS 1999).

Station	Period of record	# observations	Minimum	Maximum	Mean
PIPE 0014	9/92 – 10/94	21	45	90	71.4
PIPE 0015	8/83 – 5/88	24	5	160	81.3
PIPE 0019	8/83 – 5/88	20	10	120	79.0
PIPE 0021	6/84 – 9/86	14	60	160	92.9
PIPE 0027	8/83 – 5/88	24	5	200	82.6
PIPE 0029	8/83 – 9/86	21	13	160	83.1

Based on the available information, sulfate may be in good condition with an unknown trend and low confidence in the assessment due to the age of the monitoring data.

Dissolved oxygen

MPCA standards state that the acceptable level of dissolved oxygen for freshwater aquatic life is greater than or equal to 7 mg/L (MPCA 2008a). The EPA standard is less restrictive at greater than or equal to 4 mg/L.

NPS reviewed a total of 93 observations among 5 monitoring stations within PIPE's boundary. Data from MPCA 2014 indicates condition has not changed for this indicator. Although some of the minimum values are below standards, MPCA uses mean values to determine whether an indicator meets or does not meet criteria. Table 4-36 displays the dissolved oxygen values from each station.

Table 4-36. Dissolved oxygen measurements from five monitoring stations including minimum, maximum, and mean values (mg/L) (NPS 1999). Last record is from monitoring stations just upstream of PIPE used in MPCA 2014.

Station	Period of record	# observations	Minimum	Maximum	Mean	MPCA Evaluation
PIPE 0014	n/a	n/a	n/a	n/a	n/a	Meets Criteria
PIPE 0015	5/84 – 5/88	21	5.6	14.8	8.2	Meets Criteria
PIPE 0019	5/84 – 5/88	17	6.6	11.6	8.5	Meets Criteria
PIPE 0021	6/84 – 9/86	15	6.8	9.9	8.1	Meets Criteria
PIPE 0027	5/84 – 5/88	21	4.7	13.0	8.0	Meets Criteria
PIPE 0029	5/84 – 9/86	19	3.8	10.6	8.0	Meets Criteria
10EM124/04MS055	*	n/a	n/a	n/a	n/a	Meets Criteria

* MPCA 2014 uses data collected over the most recent 10 year period. See MPCA 2014 pg. 14 for complete explanation.

Based on the available information, DO levels are in good condition, with an unchanging trend and medium level of confidence.

Coliform bacteria

MPCA standards state that the acceptable level of total coliforms is less than or equal to 126 Colony Forming Units (CFU) per 100 ml (MPCA 2008a). The EPA standard of less than or equal to 200 CFU/100ml is less restrictive than the Minnesota state standard.

NPS (1999) reviewed a total of 6 observations among 4 monitoring stations within PIPE's boundary and 21 observations from PIPE 0014, immediately upstream of PIPE's boundary. The mean value for all three of the stations exceeded the MPCA and EPA coliform standards. PIPE 0019 and PIPE 0027 each had a mean value of 1050 CFU/100ml, while PIPE 0014 had a mean value of 2000.1 CFU/100ml. The maximum total coliform value was recorded at PIPE 0014 at 24,000 CFU/100ml. Table 4-37 displays the total coliform measurements from each monitoring station. The MPCA sampled the MPCA S000650 monitoring site (0.8 miles North of PIPE) one time in 2003 for fecal coliforms and recorded 800 CFU/100ml. Data from MPCA 2014 indicates no change in condition for this indicator.

Table 4-37. Total coliform measurements from six monitoring stations including minimum, maximum, and mean values (CFU/100 ml) (NPS 1999). Last record is from monitoring stations just upstream of PIPE used in MPCA 2014.

Station	Period of record	# observations	Minimum	Maximum	Mean	MPCA Evaluation
PIPE 0014	9/92 – 10/94	21	0.5	24000	2000.1	Exceeds Criteria
PIPE 0015	5/84 – 5/88	1	100	100	100.0	Exceeds Criteria
PIPE 0019	5/84 – 7/84	2	100	2000	1050.0	Exceeds Criteria
PIPE 0021	n/a	n/a	n/a	n/a	n/a	Exceeds Criteria
PIPE 0027	5/84 – 7/84	2	100	2000	1050.0	Exceeds Criteria
PIPE 0029	5/84 – 5/84	1	100	100	100.0	Exceeds Criteria
S00650	8/03	1	800	800	800.0	Exceeds Criteria
10EM124/04MS055	*	n/a	n/a	n/a	n/a	Exceeds Criteria

* MPCA 2014 uses data collected over the most recent 10 year period. See MPCA 2014 pg. 14 for complete explanation.

TMDL plans for turbidity and fecal coliform were completed in 2008 for the impaired segment of Pipestone Creek (the Main Ditch) upstream from the monument boundary (MPCA 2008b). For the regional Pipestone Creek segments addressed by the 2008 TMDL Report, including the Main Ditch segment outside the monument Boundary, the primary contributing sources to fecal coliform bacteria are believed to be livestock on overgrazed riparian pasture, surface-applied manure on cropland and feedlots lacking adequate runoff controls. The primary contributing sources to the turbidity impairments appear to be soil erosion in the riparian zone from livestock, streambank erosion/slumping from livestock and increased flow related to land use, upland soil loss from row cropland and possibly nutrient additions leading to algae growth (MPCA 2008).

Based on the available data and the impairment of Pipestone Creek by fecal coliforms, the condition warrants significant concern. The trend is unchanging and the assessment is made with medium confidence.

Turbidity

The MPCA standard for turbidity is less than or equal to 10 NTUs. The EPA standard is more restrictive at 7.83 NTUs. Pipestone Creek is listed as being impaired by turbidity and each of the mean NTU values from the five monitoring stations on Pipestone Creek show levels greater than the established standards. Data from MPCA 2014 indicates no change in condition for this indicator.

Table 4-38. Turbidity measurements from five monitoring stations including minimum, maximum, and mean values (CFU/100 ml) (NPS 1999). Last record is from monitoring stations just upstream of PIPE used in MPCA 2014.

Station	Period of record	# observations	Minimum	Maximum	Mean	MPCA Evaluation
PIPE 0015	4/85 – 4/87	14	5	100	24.95	Exceeds Criteria
PIPE 0019	4/85 – 4/87	11	1.2	49	17.28	Exceeds Criteria
PIPE 0021	4/85 – 9/86	11	4.2	100	24.37	Exceeds Criteria
PIPE 0027	4/85 – 4/87	14	6	100	23.66	Exceeds Criteria
PIPE 0029	4/85 – 9/86	13	4.5	100	21.32	Exceeds Criteria
10EM124/04MS055	*	n/a	n/a	n/a	n/a	Exceeds Criteria

* MPCA 2014 uses data collected over the most recent 10 year period. See MPCA 2014 pg. 14 for complete explanation.

Based on the available data and the impairment of Pipestone Creek by turbidity, the condition warrants significant concern. The trend is unchanging and the assessment is made with medium confidence.

Aquatic macroinvertebrates

Macroinvertebrates are considered an indicator of stream health. For a detailed description of PIPE's aquatic macroinvertebrates, refer to the *Aquatic Macroinvertebrates* assessment section within this document.

Condition Summary

The current condition of water quality in PIPE warrants significant concern due to the impairments of fecal coliform and turbidity as well as the available data indicating levels of fecal coliforms and turbidity that are outside of the established standards (Table 4-39). Where sufficient historical data are available, we have assigned condition ratings relative to reference conditions, which for water quality are published compliance standards. Current trend for total dissolved solids cannot be determined due to lack of data, and trend for sulfates could not be determined due to the age of the available data. Although chloride and dissolved oxygen are both meeting criteria, overall condition was determined to be poor due to weighting total coliform and turbidity more heavily due to the degree of impairment in these inidcators. The overall trend is unchanging, with medium confidence in the assessment.

Table 4-39. Condition and trend summary for water quality for Pipestone National Monument.

Indicator	Condition Status/Trend	Rationale
Water Quality		**Overall water quality condition warrants significant concern, with an unchanging trend, and confidence is medium.**
Total dissolved solids		There is no available data for TDS in PIPE
Chloride		Recorded chloride levels are within established standards but the data are old. Data from the last 10 years indicates no change in condition.
Sulfate		Sulfate levels are within established standards but the data are old.
Dissolved oxygen		Data indicate that DO levels meet established criteria.
Total coliform		Pipestone Creek is impaired by Fecal coliform and available data indicates levels that greatly exceed the established standards and warrant significant concern.
Turbidity		Pipestone Creek is impaired by turbidity and available data indicates levels of turbidity that greatly exceed established standards.

4.10.5. Uncertainties and Data Gaps

There are currently large gaps in the water quality monitoring data due to inconsistent water quality monitoring within the monument. The MPCA monitors water quality along Pipestone creek (stations 11MS038 & 04MS021) approximately 3 miles downstream of PIPE, and less than one mile upstream of the park (stations 10EM124 & 04MS055). The majority of water quality monitoring within PIPE was carried out in the 1980s and may not reflect current water quality conditions of Pipestone creek within PIPE. In order to effectively understand the condition of water quality at PIPE, regular monitoring needs to occur along the Pipestone creek within and near PIPE's boundaries.

4.10.6. Sources of expertise

The National Park Service's Water Resources Division is the primary source of expertise for water quality within PIPE. The Pipestone County Conservation and Zoning office and Minnesota Pollution Control Agency are the secondary sources of expertise for water quality within PIPE.

Mark Hanson, Project Manager, Minnesota Pollution Control Agency

Kyle Krier, Planning and Zoning Administrator, Pipestone County

4.10.7. Literature cited

Bureau of Reclamation (BOR). 2013. Total dissolved solids fact sheet. http://www.usbr.gov/pmts/water/publications/reportpdfs/Primer%20Files/08%20-%20TDS.pdf (accessed 19 November 2013).

Dodd, H. R., L. W. Morrison and D. G. Peitz. 2010b. Fish community monitoring at Pipestone National Monument: 2001 – 2008 trend report. Natural Resource Technical Report NPS/HTLN/NRTR—2010/366. National Park Service, Fort Collins, Colorado.

Environmental Protection Agency (EPA). 2001. Protocol for developing pathogen TMDLs. EPA 841-R-00-002. Office of Water (4503F). United States Environmental Protection Agency, Washington,

Environmental Protection Agency (EPA). 2013a. Total solids. http://water.epa.gov/type/rsl/monitoring/vms58.cfm (accessed 19 November 2013).

Environmental Protection Agency (EPA). 2013a. Total solids. http://water.epa.gov/type/rsl/monitoring/vms58.cfm (accessed 19 November 2013).

Environmental Protection Agency (EPA). 2013b. Macroinvertebrates and habitat. http://water.epa.gov/type/rsl/monitoring/vms40.cfm (accessed 19 November 2013).

Environmental Protection Agency (EPA). 2013c. National recommended water quality criteria. http://water.epa.gov/scitech/swguidance/standards/criteria/current/index.cfm (accessed 20 November 2013).

Environmental Protection Agency (EPA). 2013d. Summary table for the nutrient criteria documents. http://water.epa.gov/scitech/swguidance/standards/criteria/nutrients/upload/2007_09_27_criteria_nutrient_ecoregions_sumtable.pdf (accessed 17 December 2013).

Evans, M. and C. Frick. 2001. The effects of road salts on aquatic ecosystems. NWRI contribution series no. 02:308, National Water Research Institute and University of Saskatchewan, Saksatoon, SK, Canada.

Harris, M.A., B.C. Kondratieff, and T.P. Boyle. 1991. Water quality work plan for Pipestone National Monument. Denver, CO: National Park Service Report to Midwestern Regional Science office.

Iowa Department of Natural Resources (IDNR). 2013. Water quality standards review: chloride, sulfate and total dissolved solids. http://www.dnr.mo.gov/env/wpp/rules/rir/so4-cl-ws_review_idnr_so4-cl.pdf (accessed 19 November 2013).

McDaniel, L. 2013. Understanding Iowa's water quality standards. http://www.iowadnr.gov/portals/idnr/uploads/water/standards/ws_fact.pdf (accessed 19 November 2013).

Minnesota Pollution Control Agency (MPCA). 2008a. Chapter 7050 Minnesota Pollution Control Agency waters of the state: water quality standards for protection of waters of the state. Available at: http://water.epa.gov/scitech/swguidance/standards/upload/2008_06_23_standards_wqslibrary_mn_7050.pdf (accessed 20 November 2013).

Minnesota Pollution Control Agency (MPCA). 2008b. Pipestone creek fecal coliform bacteria and turbidity total maximum daily load report. Available online at http://www.pca.state.mn.us/index.php/view-document.html?gid=8139 (accessed 20 November 2013).

Minnesota Pollution Control Agency (MPCA). 2013. Minnesota's impaired waters and TMDLs. http://www.pca.state.mn.us/ (accessed November 2013).

Minnesota Pollution Control Agency (MPCA). 2014. Missouri River Basin (Upper Big Sioux, Lower Big Sioux, Little Sioux, and Rock River Watersheds) Monitoring and Assessment Report. Available at: http://www.pca.state.mn.us/index.php/view-document.html?gid=21888 (accessed 13 October 2015).

National Park Service (NPS). 1999. Baseline water quality data inventory and analysis: Pipestone National Monument. Technical Report NPS/NRWRD/NRTR-98/198. National Park Service, Water Resources Division, Fort Collins, Colorado.

National Park Service (NPS). 2013. Pipestone National Monument, nature & science. http://www.nps.gov/pipe/naturescience/index.htm (accessed 20 November 2013).

New Hampshire Department of Environmental Services (NHDES). 2013. Environmental, health and economic impacts of road salt. http://des.nh.gov/organization/divisions/water/wmb/was/salt-reduction-initiative/impacts.htm# (accessed 19 November 2013).

Northern and Yorke Natural Resources Management (NYNRM). 2013. Water facts: water quality and macroinvertebrates. http://nynrm.sa.gov.au/portals/7/pdf/landandsoil/17.pdf (accessed 19 November 2013).

Safe Drinking Water Foundation (SDWF). 2013. Total dissolved solids and pH. http://www.safewater.org/PDFS/resourcesknowthefacts/TDS_AND%20_pH.pdf (accessed 19 November 2013).

U.S. Geological Survey (USGS). 2013a. Water properties: dissolved oxygen. http://ga.water.usgs.gov/edu/dissolvedoxygen.html (accessed 19 November 2013).

U.S. Geological Survey (USGS). 2013b. Bacteria in water. http://ga.water.usgs.gov/edu/bacteria.html (accessed 19 November 2013).

U.S. Geological Survey (USGS). 2013c. Turbidity. http://ga.water.usgs.gov/edu/turbidity.html (accessed 17 December 2013).

4.11. Prairie Vegetation

4.11.1. Background and Importance

Tallgrass prairie once covered some 570,00 km^2 of central North America, extending eastward from Nebraska and Kansas through the "Prairie Peninsula" of Iowa, Illinois, parts of Minnesota, Missouri, and Wisconsin, and western Indiana, and north to eastern portions of the Dakotas and southern Canada (Transeau 1935, Risser et al. 1981, Anderson 2006). Although the tallgrass prairie developed in areas where precipitation levels are favorable for the growth of trees and shrubs, in pre-settlement times, fire, drought, and ungulate grazing acted to prevent invasion by shrubs and trees, and favored warm-season grass species (Stubbendieck and Willson 1986, Sims and Risser 2000, Anderson 2006). Within the region, areas formerly dominated by tallgrass prairie are now largely converted to cultivated agriculture, and examples of this vegetation are reduced to scattered remnant unplowed tracts and small restored area such as that at PIPE.

PIPE lies within the Northern Tallgrass Prairie ecoregion, which encompasses more than 73,230 square miles from Lake Manitoba in Canada, south to Des Moines, Iowa (Figure 4-62). Historically, the southwestern Minnesota region was dominated by tallgrass prairie and emergent prairie wetlands, interspersed with scattered riparian woodlands, oak savannas and aspen parkland (Albert 1995). Although species composition was highly variable, dominant grasses included big bluestem (*Andropogon gerardii*), prairie dropseed (*Sporobolus heterolepis*), porcupinegrass (*Hesperostipa spartea)*, Indian-grass (*Sorghastrum nutans*) and mat muhly (*Muhlenbergia richardsonis*) (TNC 1998). The tallgrass prairie at Pipestone supports more than 500 native vascular plant species, including the western prairie fringed orchid, federally listed as threatened.

The history of early prairie management at the park is described by Stubbendieck and Willson (1986). Prior to the establishment of the monument in 1937, the vegetation would have been periodically subjected to fire, mowing for hay, and periodic heavy grazing. The western 80 acres was under cultivation until 1957. After establishment, mowing was used for weed control and general appearance maintenance (Stubbendieck and Willson 1986). About 260 acres are currently managed as three prairie types at PIPE (Stubbendieck and Willson 1986, James 2011): Sioux quartzite prairie (evaluated in section 4.12 within this chapter), remnant native tallgrass prairie, and former agricultural land that is the focus of restoration efforts (Stubbendieck and Willson 1986, NPS 2008) (Figure 4-63). Vegetation communities at the park were classified and mapped using field data and imagery from 2012 (Diamond et al. 2014) (Table 4-40).

The prairie management plan (Becker et al. 1986) divided PIPE into six sections. Section 1 is the southeastern portion of the monument and is native prairie (including the rock outcrop prairie) that has been invaded by smooth brome (*Bromus inermis*), Kentucky bluegrass (*Poa pratensis*), and other non-natives. Section 2 includes the south central portions of the monument, descending from the rock outcrops. It is native bluestem prairie with a few invasive grasses such as smooth brome. Section 3 encompasses the southwestern corner of the monument, and is primarily old-field dominated by smooth brome, except in lower lying areas near the road. Section 4 is located in the northwest portion of the monument, and was also previously cultivated on the western half. Smooth brome and Kentucky bluegrass are the dominant species, with some native prairie species plants present in the eastern portion. Section 5 includes the north central portion of the monument, and is native bluestem prairie, degraded in the northern portion. Section 6 is the northeast portion of the monument and is degraded native prairie. Bluestem prairie vegetation predominates in Sections 1, 2, 5, 6, and on the eastern portions of 3and 4 and these areas are generally in good condition. Many native prairie species are still present and, although the incidence of woody vegetation is increased over what it would have been prior to settlement, significant restoration efforts have addressed this issue.

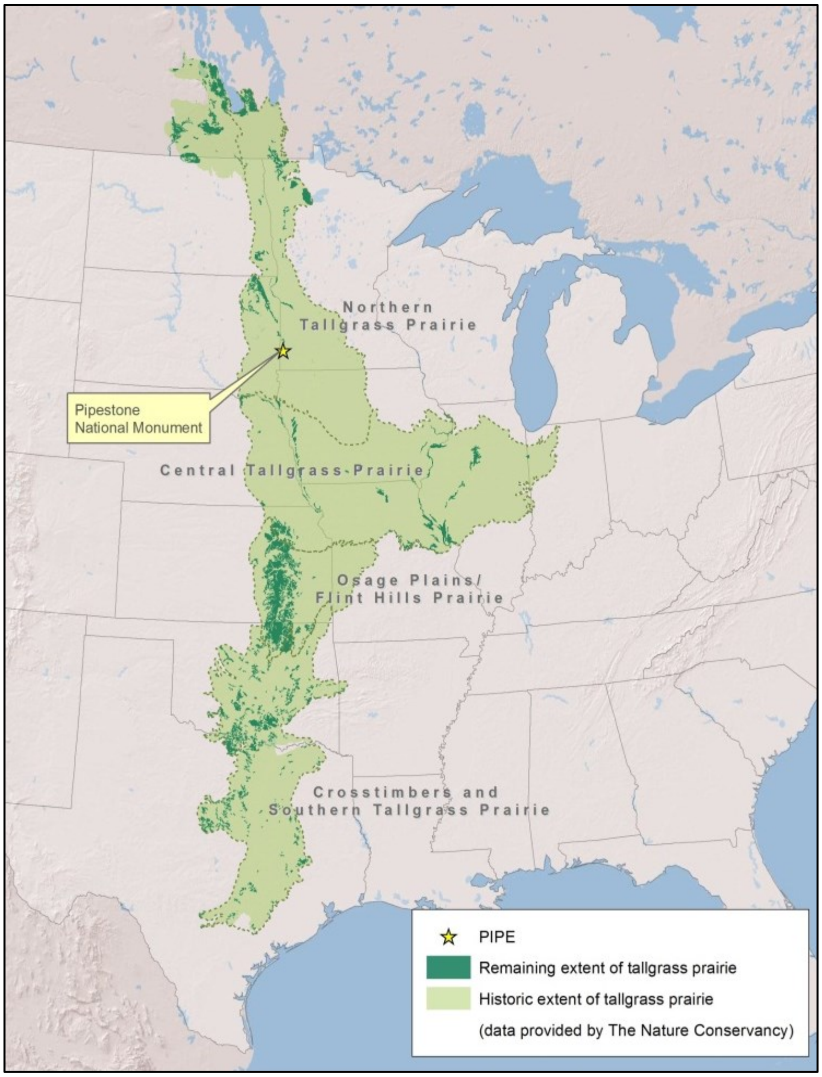


Figure 4-62. Location of Pipestone National Monument within the tallgrass prairie region.

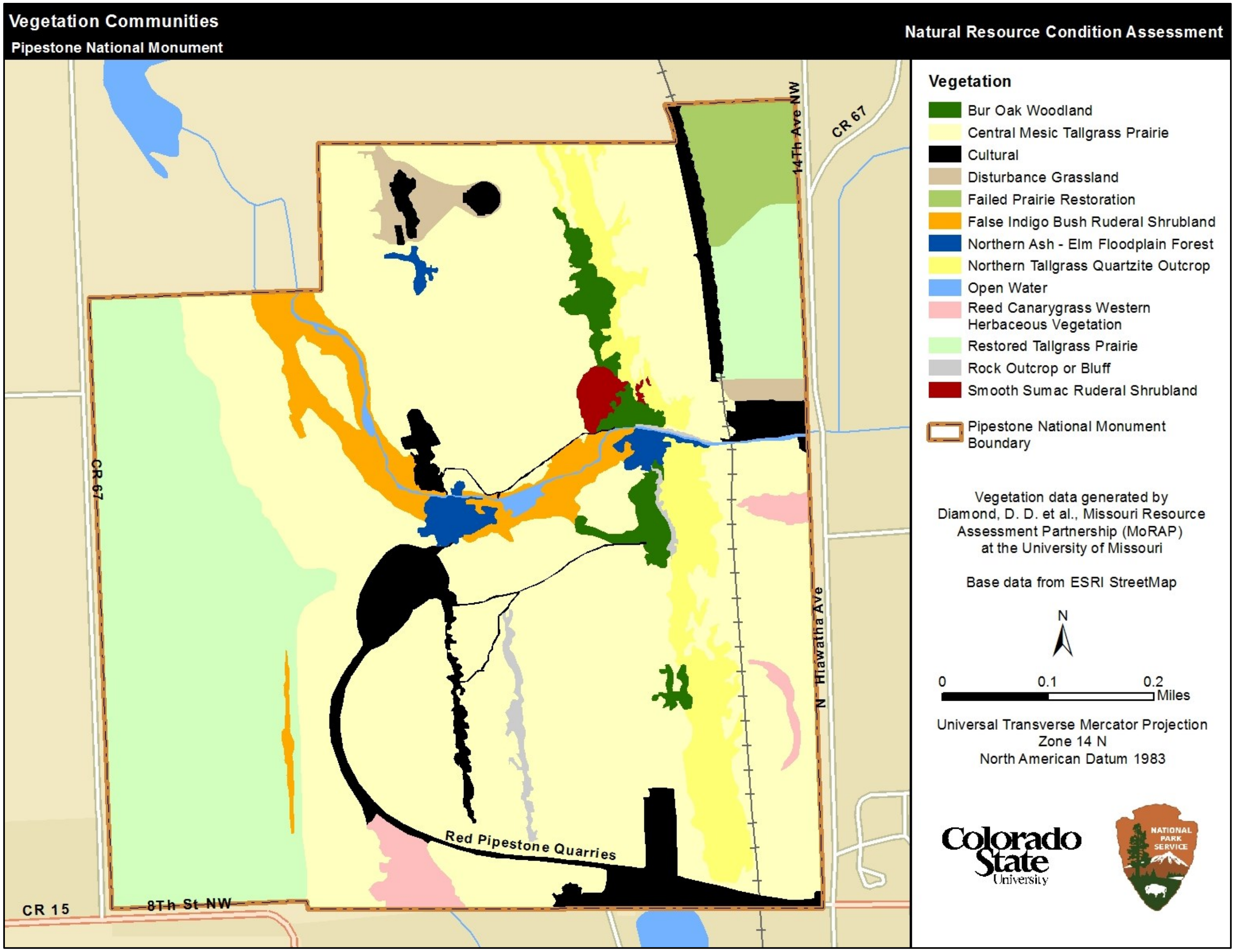


Figure 4-63. Vegetation communities, Pipestone National Monument (data from Diamond et al. 2014).

Table 4-40. Extent of mapped vegetation communities at Pipestone National Monument (Diamond et al. 2014).

Vegetation Physiognomy	Mapped Type Name	Description	Acres	Hectares
Forest and Woodlands	Bur Oak Woodland	*Quercus macrocarpa* Northern Tallgrass Wooded Herbaceous Vegetation	5.4	2.2
	Northern Ash-Elm Floodplain Forest	*Fraxinus pennsylvanica - Celtis occidentalis - Tilia americana - (Quercus macrocarpa)* Forest	2.9	1.2
Shrubland Vegetation	False Indigo Bush Ruderal Shrubland	*Amorpha fruticosa* Shrubland	10.4	4.2
	Smooth Sumac Ruderal Shrubland	*Rhus glabra* Shrubland	1.3	0.5
Herbaceous Vegetation	Central Mesic Tallgrass Prairie	*Andropogon gerardii - Hesperostipa spartea - Sporobolus heterolepis* Herbaceous Vegetation	156.9	63.5
	Disturbance Grassland	*Bromus inermis - Oligoneuron rigidum - Achillea millefolium - Elymus repens - Cirsium* spp. Herbaceous Vegetation	3.5	1.4
	Failed Prairie Restoration	*Elymus repens - Ambrosia artemisiifolia - Trifolium pratense* - *Cirsium* spp. Herbaceous Vegetation	7.1	2.9
	Northern Tallgrass Quartzite Outcrop	Quartzite-Granite Rock Outcrop Sparse Vegetation	14.8	6.0
	Reed Canarygrass Western Herbaceous Vegetation	*Phalaris arundinacea* Western Herbaceous Vegetation	4.5	1.8
	Restored Tallgrass Prairie	*Andropogon gerardii* Herbaceous Vegetation	66.3	26.8
		Total non-cultural Vegetation	273.1	110.5
Non-vegetated or Cultural Types	Cultural		18.5	7.5
	Open Water		1.5	0.6
	Rock Outcrop or Bluff (unsampled)		1.6	0.6
		Total Non-vegetated or Cultural Types	21.6	8.7
Mapped Total			**294.7**	**119.2**

Fire is the principal disturbance on the landscape at Pipestone National Monument, both historically and currently. The fire regime at PIPE is discussed in detail in section 4.6. The role of fire and its importance to a healthy prairie ecosystem is well documented throughout the ecological literature (Anderson et al. 1970, Bragg and Hulbert 1976, Buell and Facey 1960, Hartnett et al. 1996, Wright and Bailey 1982). In recent years, scientists and land managers have recognized the importance of creating heterogeneity on the landscape to promote diversity, sustain species adapted to natural disturbance regimes, and foster a variety of faunal habitat structures (Wiens 1997, Fuhlendorf and Engle 2001, Reinking 2005). In tallgrass prairie, the primary disturbance agents of fire and grazing interact with other biotic and abiotic factors to maximize heterogeneity and species diversity on the landscape (Fuhlendorf et al. 2006, Hamilton 2007, Knapp et al. 1999).

The fire return interval for PIPE burn units averaged less than 4 years in the period leading up to 2010, and little prescribed burning has been implemented since then (units 1 and 4 were burned in 2014 and unit 3 was burned in 2015). In general, prescribed burns have been very successful in areas where native prairie was not highly degraded, but have not succeeded in eliminating invasive plant species such as Canada thistle, sweet clover, and introduced pasture grasses such as Kentucky bluegrass. Manual removal, spot spraying, and mowing have been used to supplement the effects of prescribed fire (NPS 2008). Livestock grazing and haying do not occur at the monument.

Restoration efforts on fields dominated by smooth brome began in the 1990s and used locally gathered seeds to reintroduce native grasses and forb species (James and DeBacker 2007). Exotics and persistent weeds predominate in formerly cultivated land, along the old railroad right-of-way, and in other disturbed areas. Vegetation in these areas consists of several exotic pasture and lawn grasses and legumes, including smooth brome (*Bromus inermis*), red clover (*Trifolium pratensis*), and Kentucky bluegrass (*Poa pratensis*), as well as weedy species such as white and yellow sweet clover (*Melilotus alba* and *M. officinalis*), quackgrass (*Agropyron repens*), leafy spurge (*Euphorbia esula*), Canada thistle (*Cirsium arvense*) and musk thistle (*Carduus nutans*). More than 90 nonnative plants are known to occur at PIPE. The species of greatest concern are common buckthorn (*Rhamnus cathartica*), leafy spurge, and smooth brome. Of somewhat less concern are yellow sweet clover and musk thistle and reed canary grass (*Phalaris arundinacea*) (NPS 2008).

Prairie vegetation community monitoring at PIPE is intended to describe the prairie species composition, structure and diversity, determine temporal changes in species composition, structure, and diversity, and determine the relationship between observed changes and environmental variables, including specific management efforts (James et al. 2009).

Threats

Primary threats to the condition of the prairie vegetation at PIPE are 1) invasion by nonnative invasive plant species, 2) altered disturbance regimes due to lack of native grazers and historical fire regime, and 3) invasion of grasslands by woody species. Over time, these stressors may lead to undesirable changes in species composition and reduced native species diversity.

Indicators and Measures

We evaluated the condition of the prairie community at PIPE using metrics for species composition, diversity, and vegetation structure:

- Species composition measured as proportion of native species cover by site.
- Native species richness by site (S)
- Native species diversity by site (Modified Shannon, Hill’s N1)

- Native species evenness by site (Hill's E5)
- Structure measured as native forb + native graminoid and woody cover by site
- Invasive exotic species: sub indicators include frequency, abundance, distribution, and state noxious weeds – details provided in section 4.13.

4.11.2. Data and Methods

The Heartland Inventory and Monitoring Network (HTLN) has been monitoring vegetation at PIPE since 1996. The years 1996-1997 were focused on establishing permanent sample sites and associated plots and transects; data from those years is not included in the analysis. Ten sites were originally established, and three were added in 2009 for a current total of 13 sites or sample locations. Three sites are located within the Sioux quartzite prairie community, four are located within the tallgrass prairie community and six are located within prairie restoration areas. At each site data are collected on two permanent parallel transects (50 m in length and 20 m apart), each with five 10 m^2 circular plots placed at 10 m intervals. Foliar cover is estimated in the 10 m^2 plot using a modified Daubenmire scale, and three nested frequency plots (1.0, 0.1, and 0.01 m^2) are read within the large plot. The 0.1 ha area between the two transects is used to collect data on the woody species greater than 5.0 cm dbh in the understory and overstory canopy layers. Summary data reported for each site (transect pair) consist of: 1) plant species richness and diversity, 2) the ratio of exotic to native species, 3) species abundance and frequency, (4) woody species density and basal area, (5) overstory canopy cover and (6) ground cover characteristics (James et al. 2009).

Invasive exotic plants data are described in section 4.13, and is based on field sampling/surveys in 2006 and 2009.

4.11.3. Reference Conditions

Because we can only indirectly address the condition of prairie vegetation within PIPE, we used metrics that could be derived from the HTLN vegetation monitoring data. A resource condition rating framework integrating the reference condition concepts discussed below is shown in Table 4-41.

The ideal condition for PIPE would be the complete absence of non-native species, representing conditions during pre-settlement times. Because this type of reference condition is not feasible for a unit with the history of PIPE, we instead consider a baseline reference condition as a "best attainable condition" (*sensu* Stoddard et al. 2006) under which the composition, diversity, and structure of prairie vegetation at PIPE is sufficient to maintain the plant community in a stable or improving condition.

Threshold levels of non-native species cover have not been rigorously defined. Spyreas et al. (2004) found an average of 36% relative percent cover of non-native species in Illinois prairie grasslands. Miles and Knops (2009) reported that sites dominated by (i.e., having >60% relative cover) native prairie grasses (*A. gerardii* and *S. scoparium*) were more likely to follow successional patterns typical of prairie communities. We used a level of 60% relative cover of native plant species as a threshold below which the prairie vegetation community is likely to face significant challenges in recovery to a functioning condition. An upper threshold of 80% indicating good condition for native plant species cover is based on levels specified by NatureServe and Natural Heritage Program ecologists for good to excellent condition ranking in other types of remnant prairie communities (e.g., Decker 2007, WANHP 2011), and on values observed at remnant tallgrass prairie sites in the Midwest (Taft et al. 2006, Sivicek and Taft 2011).

Table 4-41. Resource condition indicator rating framework for prairie vegetation indicators at Pipestone National Monument.

Indicator	Good Condition	Warrants Moderate Concern	Warrants Significant Concern
Composition	>= 80% relative cover of native species	60 to <80% relative cover of native species	< 60% relative cover of native species
Species diversity			
Native species richness	>85% of 1998 mean	70-85% of 1998 mean	<70% of 1998 mean
Native species diversity	>85% of 1998 mean	70-85% of 1998 mean	<70% of 1998 mean
Native species evenness	>85% of 1998 mean	70-85% of 1998 mean	<70% of 1998 mean
Structure			
Native graminoid+forb	relative cover of native graminoids or forbs 20-80% of combined cover for those two groups	relative cover of native graminoids or forbs 10-20% of combined cover for those two groups	relative cover of native graminoids or forbs <10% of combined cover for those two groups
Woody plants	woody plant cover < 15%	woody plant cover 15-25%	woody plant cover >25%
Invasive exotic plants	see details in section 4.13	see details in section 4.13	see details in section 4.13

Indices of richness and diversity are intended to estimate biological variability and quality in a way that allows comparison of different sites within a community type, or the same site over time (Heip et al. 1998). Such indices are relatively easy to generate, but can be difficult to interpret in relation to the expected condition and trajectory of real-world species assemblages. Moreover, diversity indices summarize the structure of a community, not its functioning (Heip et al. 1998). Expected values of these indices for particular community types have not been, and probably cannot be defined (Hurlbert 1971, Ludwig and Reynolds 1988). Variation in both historical and microsite characteristics can produce significant differences in the composition and structure of two nominally identical plant communities (Sluis 2002, Hanson et al. 2008). There is, however, some evidence that plant species richness, diversity, and evenness is generally greater in remnant prairies than in restored prairies (Kindscher and Tieszen 1998, Sluis 2002, Polley et al. 2005, Taft et al. 2006), so that higher index values are broadly indicative of higher quality. In the absence of well-defined standards for such metrics, we have adopted an approach for this assessment where values in the first year of vegetation monitoring with the current protocol (1998) represent a reference point or baseline for comparison with subsequent years.

We assessed three indices of diversity and evenness for native species in PIPE prairie vegetation. The first, most straightforward measure of community richness is the number of all native species (S) in the sample, regardless of their abundances. Our second measure of diversity is Hill's N1 (a modified Shannon's index), which estimates the number of *abundant* species in the sample, downweighting the contribution of rare species and giving additional insight into the relative importance of each community member. Finally, we calculated the modified Hill's ratio evenness index (E5), which approaches zero as a single species becomes more dominant.

Comparison of functional group structure between years involves a combination of quantitative and qualitative evaluation. Because no expected values for relative cover of native forbs vs. native grasses have been established, we compare the relative proportion of the two groups as a baseline, with the expectation that both groups should be well represented. In some prairie restorations, the abundance of native forbs has been relatively low compared to remnant prairies because few native forb seeds were used in the seeding mix or native forbs were sometimes historically impacted in the course of controlling broad-leaved weeds using non-selective herbicides. Woody species cover indicator levels are based on long term average values for woody guild cover in prairie vegetation. These levels are in broad agreement with the LANDFIRE Biophysical Setting Model for Northern Tallgrass Prairie (LANDFIRE 2008), where about 5% of the landscape is expected to be in a woody succession class with up to 20% woody cover. Because woody species are being actively managed by fire, cutting and herbicides, we anticipate that values should remain at or below 1998 levels.

4.11.4. Condition and Trend

Species Composition

The relative cover of native plant species (proportion of native cover vs. total cover) present at monitoring sites has fluctuated among years (Figure 4-64). Native prairie has maintained a mean of 80% or greater in nearly all monitoring years since 1998, although 90% confidence intervals often overlap this threshold. Restored prairie areas have had a mean of at least 60% in all years, and in half of the monitoring years above the 80% threshold. Mean relative native plant cover in the Sioux quartzite prairie is above the 60% threshold in all years, but has comparatively wide 90% confidence intervals, indicating that at that level of confidence the sampling design is relatively insensitive to changes that may be happening. Overall, species composition results warrant moderate concern with an unchanging trend and medium confidence due to small sample sizes. Species-level analysis using historical (pre-1998) data could increase the confidence associated with the assessment.

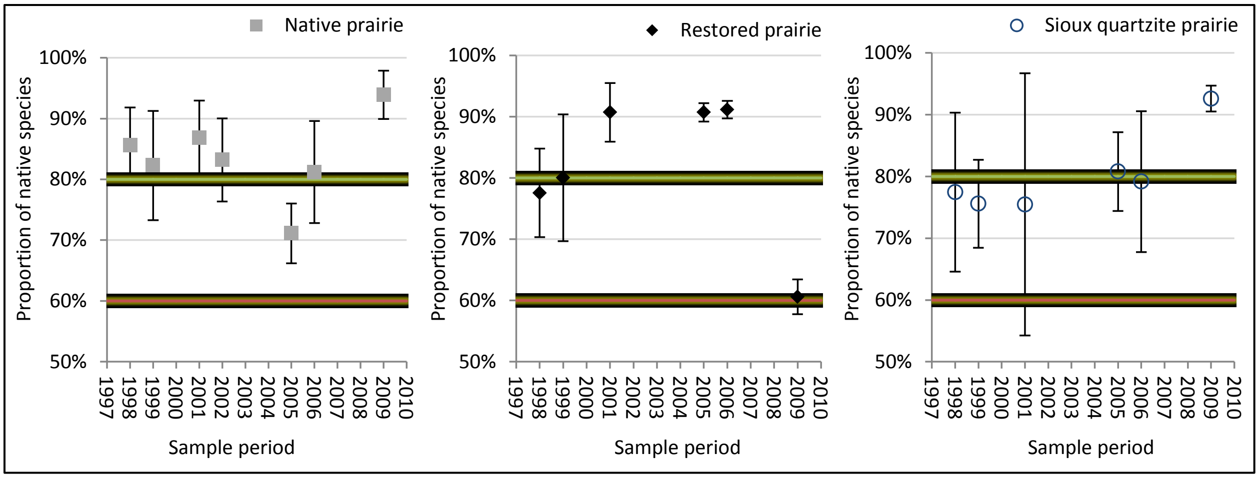


Figure 4-64. Means and 90% confidence intervals for relative cover of native plant species compared to total plant cover for three prairie vegetation types at PIPE during monitoring years 1998-2009. Upper (green) line represents good condition threshold, lower (red) line represents significant concern threshold.

<u>Native Species Diversity</u>

Native species richness for prairie communities at PIPE has remained reasonably stable during the monitoring period from 1998 to 2009, averaging between 34 and 61 species per site (Figure 4-65a). Native species richness is, as expected, higher in native and Sioux quartzite prairie than in restored prairie. With the exception of restored prairie in 2009, all types have maintained a mean of at least 80% that of the 1998 reference point, indicating good condition and an unchanging trend.

A similar pattern is observed for native species diversity (measured by Hill's N1), which averaged between 15.1 and 32.8 "abundant species" (Figure 4-65b). Native prairie sites have maintained a mean richness >85% of the 1998 reference point in all subsequent years, but restored and Sioux quartzite prairie have each slipped below this threshold in a single year. However, the overall result indicates good condition and an unchanging trend.

Results for native species evenness, as measured by Hill's E5, are highly variable, with index values falling below the 70% of 1998 threshold in a number of years. However, means do not show a definite directional trend between 1998 and 2009 (Figure 4-65c). Evenness values in general appear to be very low and there is considerable uncertainty regarding the reference value for this indicator. These results warrant moderate concern with an unchanging trend.

Overall, the prairie vegetation condition as measured by native species diversity is good, with an unchanging trend. Confidence in the assessment is medium due to the relatively short period represented by the data, uncertainties related to reference condition, and low statistical inference due to small sample sizes and year to year variability.

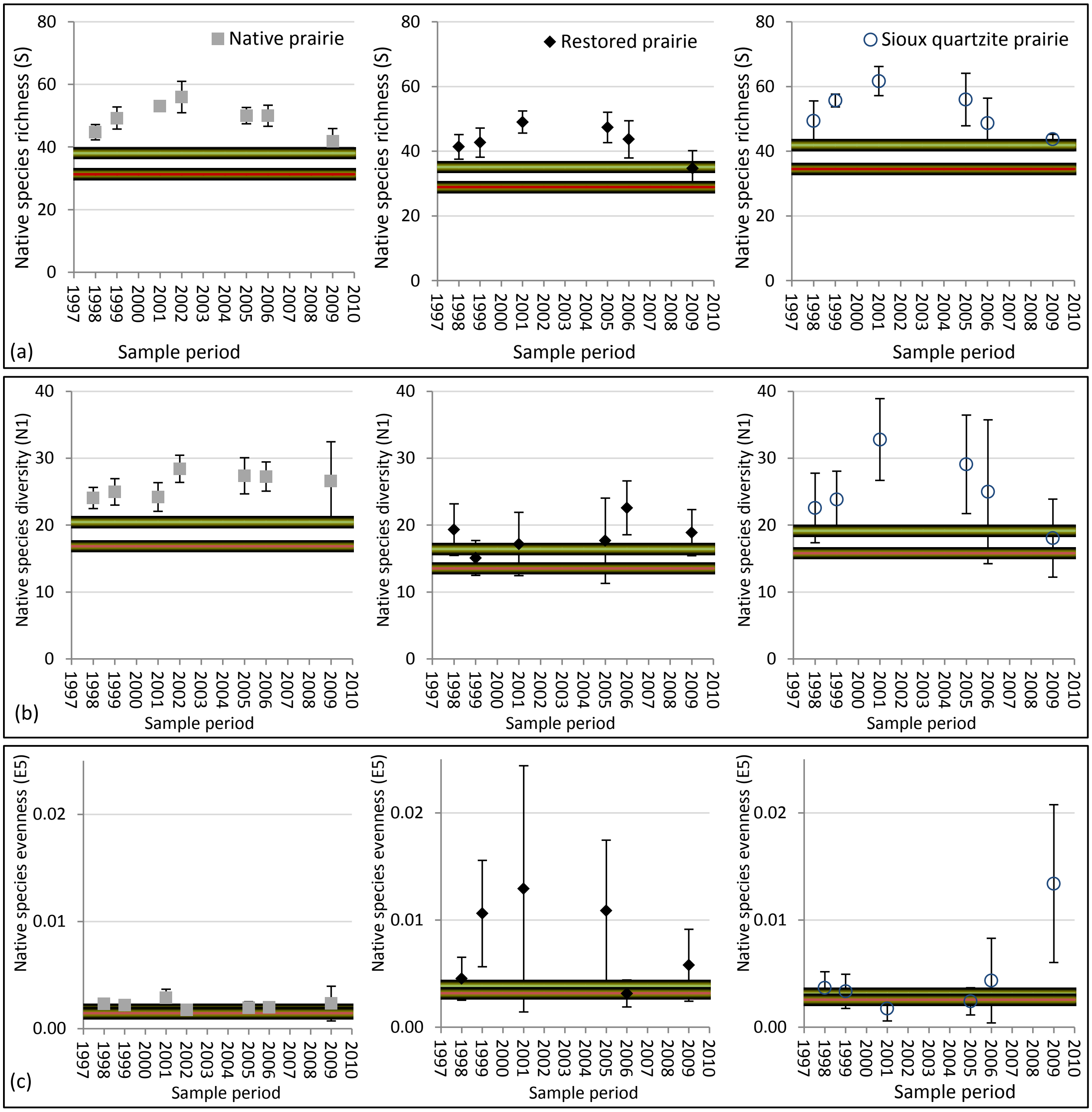


Figure 4-65. Means and 90% confidence intervals for (a) native species richness (b) native species diversity, and (c) evenness for PIPE during monitoring years 1998-2009. Results for native prairie samples are on the left, restored prairie are in the center, and Sioux quartzite prairie are on the right. Upper (green) line represents 85% of the 1998 mean, lower (red) line represents 70% of the 1998 mean.

<u>Structure</u>

In the three prairie types combined at PIPE, native graminoids typically account for about 38.5% of the cover values of all native plant species combined. Relative proportions are variable between years and between the different prairie types (Figure 4-66). Native prairie has the highest mean forb component at 66%, while Sioux Quartzite prairie has the lowest at 57%. In all years, with the exception of restored prairie in 2009, the native graminoid / native forb split included at least 20% of each functional group. There is a slight trend for restored prairie toward increasing dominance of forb species, but overall this metric indicates that the herbaceous structure is in good condition with an unchanging trend.

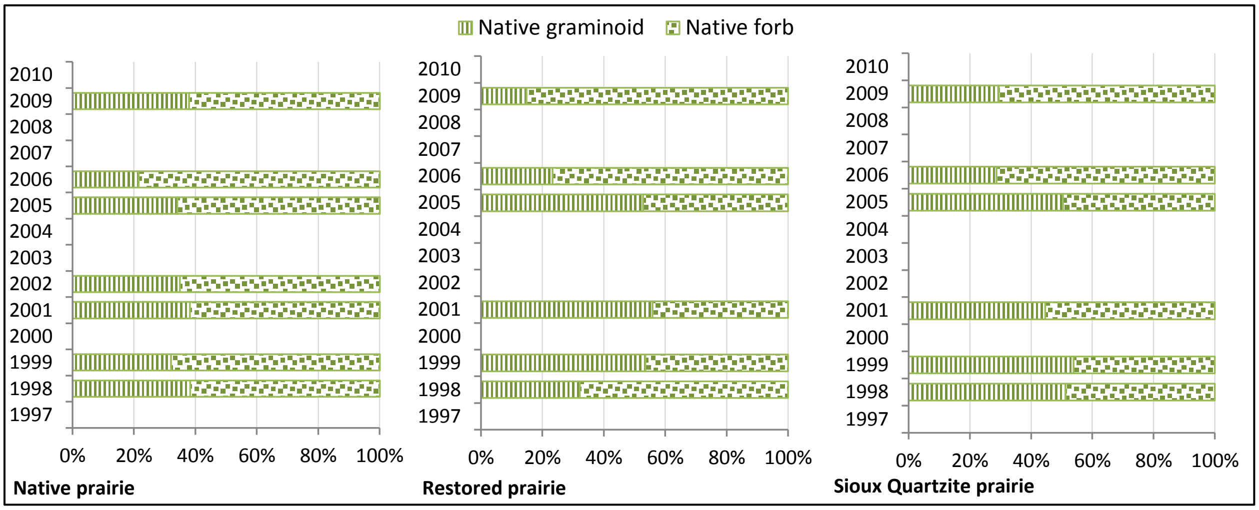


Figure 4-66. Cover of native forbs and graminoids at PIPE as a proportion of the combined total cover of the two functional groups.

Over all prairie types, the contribution of woody species to prairie structure at PIPE is less than 15%, and it is lowest in restored prairie (Figure 4-67). Native prairie has had mean woody cover below 15% in three of seven monitoring years, and restored prairie has been below 15% in all monitoring years, indicating good condition. Sioux Quartzite prairie had a mean woody cover of 23.8% during monitoring years 1998-2009, indicating moderate concern, however, because 90% confidence intervals are wide it is more difficult to establish the true level of woody cover for this type.

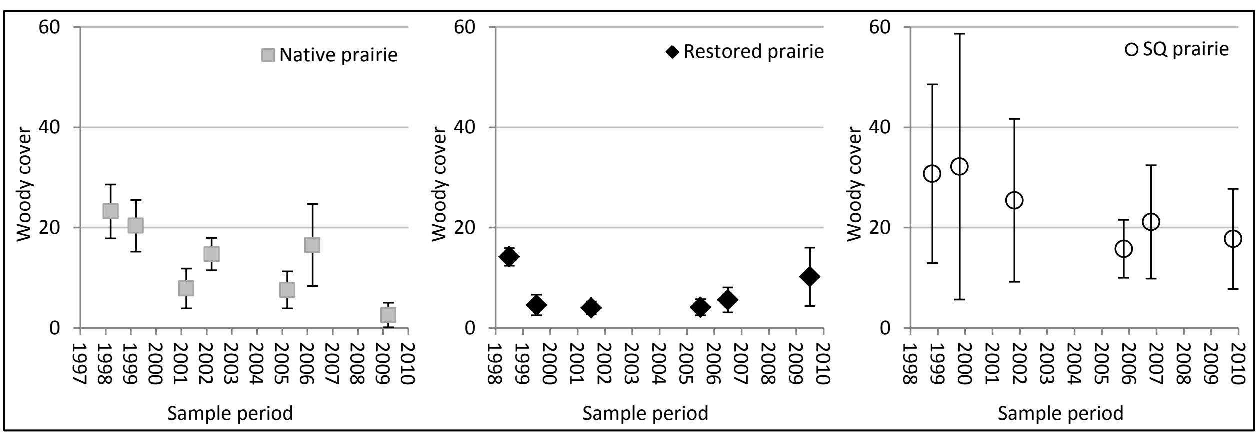


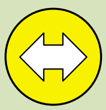
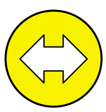
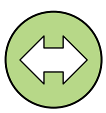
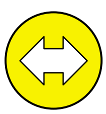
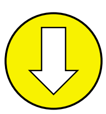
Figure 4-67. Percent woody cover at PIPE during monitoring years 1998-2009. Error bars represent 90% confidence intervals around the mean.

Some Sioux Quartzite prairie samples are located in rock outcrop areas that are somewhat protected from fire. In most years, woody cover has not increased to levels greater than that observed in 1998, indicating an unchanging trend.

Invasive Exotic Plants
Invasive exotic plants (IEP) at PIPE are evaluated in section 4.13 and cross-referenced and applied here as an indicator of prairie vegetation condition. Because of the number, frequency, and abundance of IEP species at PIPE, including state-listed noxious weeds, this indicator warrants moderate concern, with a deteriorating trend.

Overall Condition
Values for the native species diversity indicators are generally good, and appear to be unchanging. Community composition and vegetation structure are of moderate concern with an unchanging trend at PIPE, due to the significant proportion of non-native species present, and a moderately high level of woody species present in some years and sites. Invasive exotic plant species also warrant moderate concern, with a deteriorating trend. The overall condition of prairie vegetation at PIPE warrants moderate concern, and is unchanging for the time period covered by this assessment (Table 4-42). Confidence in the assessment is medium due to small sample sizes and high variability across samples and years.

Table 4-42. Condition and trend summary for prairie vegetation, Pipestone National Monument.

Indicator	Condition Status/Trend	Rationale
Prairie (overall)		**The prairie vegetation condition warrants moderate concern with an unchanging trend. Confidence in the assessment is medium.**
Community Composition		All prairie types have maintained a mean of at least 60% cover of native plant species, although 90% confidence intervals are comparatively wide for Sioux quartzite prairie.
Native Species Diversity		Native species richness for prairie communities at PIPE has remained reasonably stable, averaging 34-61 species per site and 15-33 abundant species per site. Species evenness is highly variable.
Vegetation Structure		Native forbs and graminoids are generally well represented in all prairie types, but levels of woody vegetation cover greater than 15% have been observed in both native and Sioux Quartzite prairie communities.
Invasive Exotic Plants		The number, frequency, and abundance of IEP species at PIPE, including six state-listed noxious weeds, results in a rating of moderate concern with a deteriorating trend (see section 4.13).

4.11.5. Uncertainties and Data Gaps
Restoration and maintenance of prairie communities at PIPE is extremely challenging given the effects of nonnative invasives and altered disturbance regimes. High variability in sample data due to interannual weather differences, phenology and small sample sizes can make it difficult to interpret data and detect statistically significant changes or lack thereof over time. Modifying the sampling

design to increase sample sizes and statistical sensitivity to changes in the resource may better help managers to adapt approaches accordingly.

4.11.6. Literature Cited

Albert, D.A. 1995. Regional landscape ecosystems of Michigan, Minnesota and Wisconsin: A working map and classification. General Technical Report NC-178, U.S. Department of Agriculture, Forest Service, North Central Forest Experiment Station, St. Paul, MN. 250 pp.

Anderson, K. L., E.F. Smith, and C.E. Owensby. 1970. Burning bluestem range. Journal of Range Management 23:81-92.

Anderson, R.C. 2006. Evolution and origin of the central grassland of North America: climate, fire, and mammalian grazers. Journal of the Torrey Botanical Society 133:626:647.

Becker, D.A., T.B. Bragg, and D.M. Sutherland. 1986. Vegetation survey and prairie management plan for Pipestone National Monument. Prepared by Ecosystems Management for National Park Service, Department of Interior.

Bragg, T. B., and L.C. Hulbert. . 1976. Woody plant invasion of unburned Kansas bluestem prairie. Journal of Range Management 29:19-24.

Buell, M. F. and V. Facey. 1960. Forest-prairie transition west of Itasca Park, Minnesota. Bulletin of the Torrey Botanical Club 87:46-58.

Decker, K. 2007. Central mixedgrass prairie ecological integrity assessment (Central Shortgrass Prairie Ecoregion Version). Colorado Natural Heritage Program, Colorado State University, Fort Collins, Colorado. Available at: http://www.cnhp.colostate.edu/download/documents/2007/Central_Mixedgrass_Prairie_EIA.pdf

Diamond, D. D., L. F. Elliott, M. D. DeBacker, K. M. James, D. L. Pursell, and A. Struckhoff. 2014. Vegetation mapping and classification of Pipestone National Monument, Minnesota: project report. Natural Resource Report NPS/PIPE/NRR—2014/802. National Park Service, Fort Collins, Colorado.

Fuhlendorf, S. D. and D. M. Engle. 2001. Restoring heterogeneity on rangelands: ecosystem management based on evolutionary grazing patterns. BioScience 51:625-632.

Fuhlendorf, S.D., W.C. Harrel, D.M. Engle, R.G. Hamilton, C.A. Davis, and D.M. Leslie Jr. 2006. Should heterogeneity be the basis for conservation? Grassland bird response to fire and grazing. Ecological Applications 16:1706–1716.

Hamilton, R.G. 2007. Restoring heterogeneity on the Tallgrass Prairie Preserve: applying the fire-grazing interaction model. In Masters, R. E. and K. Galley (eds.). Proceedings of the 23rd Tall Timbers Fire Ecology Conference: fire in grassland and shrubland ecosystems. 261p.

Hanson, T., Y. Sánchez-deLeón, J. Johnson-Maynard, and S. Brunsfeld. 2008. Influence of soil and site characteristics on palouse prairie plant communities. Western North American Naturalist 68:231-240.

Hartnett, D. C., K. R. Hickman, and L. E. F. Walter. 1996. Effects of bison grazing, fire, and topography on floristic diversity in tallgrass prairie. Journal of Range Management 49:413-420.

Heip, C.H.R., P.M.J. Herman, and K. Soetaert. 1998. Indices of diversity and evenness. Océanis 24:61-87.

Hurlbert, S.H. 1971. The nonconcept of species diversity: a critique and alternative parameters. Ecology 52:577-586.

James, K. M.. 2011. Vegetation community monitoring at Pipestone National Monument, Minnesota: 1997-2009. Natural Resource Data Series NPS/HTLN/NRDS—2011/145. National Park Service, Fort Collins, Colorado.

James, K., and DeBacker, M. 2007. Plant community monitoring trend report, Pipestone National Monument. Natural Resource Technical Report NPS/HTLN/NRTR—2007/029. National Park Service, Fort Collins, Colorado.

James, K. M., M. D. DeBacker, G. A. Rowell, J. L. Haack and L. W. Morrison. 2009. Vegetation community monitoring protocol for the Heartland Inventory and Monitoring Network. Natural Resource Report NPS/HTLN/NRR — 2009/141. National Park Service, Fort Collins, Colorado.

Kindscher, K. and L.L. Tieszen. 1998. Floristic and soil organic matter changes after five and thirty-five years of native tallgrass prairie restoration. Restoration Ecology 6:181-196.

Knapp, A.K., J.M. Briggs, S.L. Collins, D.C. Hartnett, L.C. Johnson, and E.G. Towne. 1999. The keystone role of bison in North American tallgrass prairie. BioScience 49:39–50.

Ludwig, J.A. and J.F. Reynolds. 1988. Statistical Ecology: a Primer on Methods and Computing. John Wiley & Sons, Inc. New York.

LANDFIRE. 2008. LANDFIRE biophysical setting Models. Biophysical Setting 3914200, Northern Tallgrass Prairie. USDA Forest Service; U.S. Department of Interior. Available at: http://www.landfire.gov/national_veg_models_op2.php

Miles, E.K. and J.M.H. Knops. 2009. Grassland compositional change in relation to the identity of the dominant matrix-forming species. Plant Ecology and Diversity 2:265-275.

National Park Service. 2008. Pipestone National Monument final General Management Plan / Environmental Impact Statement. National Park Service, U.S. Department of the Interior, Pipestone National Monument, Pipestone County, Minnesota.

Polley, H.W., J.D. Derner, and B.J. Wilsey. 2005. Patterns of plant species diversity in remnant and restored tallgrass prairies. Restoration Ecology 13:480-487.

Reinking, D. L. 2005. Fire regimes and avian responses in the central tallgrass prairie. Studies in Avian Biology 30:116-126.

Risser, P. G., E. C. Birney, H. D. Blocker, S.W. May, J. F. Parton, and J. A. Weins. 1981. The True Prairie Ecosystem. Hutchinson-Ross Publishing Company, Stroudsburg, PA. 557 p.

Sims, P.L., and P.G. Risser. 2000. Grasslands. In: Barbour, M.G., and W.D. Billings, eds., North American Terrestrial Vegetation, second edition. Cambridge University Press, New York, pp.323-356.

Sivicek, V.A. and J.B. Taft. 2011. Functional group density as an index for assessing habitat quality in tallgrass prairie. Ecological Indicators 11:1251-1258.

Sluis, W.J. 2002. Patterns of species richness and composition in re-created grassland. Restoration Ecology 10:677-684.

Spyreas, G., J. Ellis, C. Carroll, and B. Molano-Flores. 2004. Non-native plant commonness and dominance in the forests, wetlands, and grasslands of Illinois, USA. Natural Areas Journal 24:290-299.

Stoddard, J.L., D.P. Larsen, C.P. Hawkins, R.K. Johnson, and R.H. Norris. 2006. Setting expectations for the ecological condition of streams: the concept of reference condition. Ecological Applications 14:1267-1276.

Stubbendieck, J. and G. Willson. 1986. An identification of prairie in National Park units in the Great Plains. NPS Occasional Paper No. 7. U.S. Department of the Interior, National Park Service, Washington, D.C.

Taft, J.B., C. Hauser, and K.R. Robertson. 2006. Estimating floristic integrity in tallgrass prairie. Biological Conservation 131:42-51.

The Nature Conservancy (TNC) Northern Tallgrass Prairie Ecoregional Planning Team. 1998. Ecoregional planning in the northern tallgrass prairie. The Nature Conservancy, Midwest Regional Office, Minneapolis, MN, USA. 208 pp.+ iv.

Transeau, E.N. 1935. The prairie peninsula. Ecology 16:423-437.

Washington Natural Heritage Program (WANHP). 2011. Ecological integrity assessment: Columbia Basin Palouse Prairie. Washington State Department of Natural Resources. Available: http://*www1.dnr.wa.gov/nhp/refdesk/communities/pdf/eia/cb_palouse.pdf*

Wiens, J.A. 1997. The emerging role of patchiness in conservation biology. Pages 93–107 *in* S.T.A. Pickett, R.S. Ostfeld, M. Shachak, and G.E. Likens (eds.). The Ecological Basis for Conservation: Heterogeneity, Ecosystems, and Biodiversity. Chapman and Hall, New York.

Wright, H. A. and A. W. Bailey. 1982. Fire Ecology, United States and Southern Canada. John Wiley & Sons, New York.

4.12. Western Prairie Fringed Orchid

4.12.1. Background and Importance

Western prairie fringed orchid in bloom (NPS photo).

The western prairie fringed orchid (*Platanthera praeclara*) is a long-lived perennial with a showy open raceme of holding as many as two dozen white to creamy white flowers, each with a long nectar spur and sepals tinged with pale green. The lip or lower petal of each flower is deeply three-lobed and fringed. The single smooth stem is up to 85 cm (34 in.) tall. Plants usually have 1 to 3 smooth, elongate basal leaves (MDNR 2000). The western prairie fringed orchid was listed as federally threatened in the United States in 1989. It listed as a state endangered species protected by Minnesota's Endangered Species Statute (84.0895) administered by the Department of Natural Resources (MDNR 2000). Under the state endangered designation the species is considered threatened with extinction throughout all or a significant portion of its range within Minnesota. The species has a NatureServe Global Ranking of vulnerable (G3).

Sheviak and Bowles (1986) separated the prairie fringed orchid (*Platanthera leucophaea*) into two distinct species on the basis of pollination mechanisms, morphology and geographic distribution. The eastern species retained the specific epithet of *leucophaea*, while the western species was described as *P. praeclara*. The historical range (Figure 4-68) of the western prairie fringed orchid encompassed much of the tallgrass prairie in the western Central Lowlands and eastern Great Plains, from southern Canada to northern Oklahoma (USFWS 1996, 2009). The western prairie fringed orchid occurs only west of the Mississippi River; the eastern species (also federally protected) is found in eastern Iowa and east of the Mississippi River (USFWS 1996, MDNR 2000). Conversion of native prairie to agricultural use has eliminated most of the species' habitat. Extant populations are known from Minnesota, North Dakota, Nebraska, Iowa, Kansas, Missouri, and Manitoba, Canada (Catling and Brownell 1987, Bray and Wilson 1992, USFWS 2009). The largest numbers of plants are in the northern portion of the range. The population at PIPE may represent one of the largest populations of western prairie fringed orchids in the North Central Glaciated Plains section of the Prairie Parkland Province, making it an important piece of the recovery effort for the species in the region (Young et al. 2007). Within the North Central Glaciated Plains section, approximately 63 percent of plants occur on sites with high levels of conservation protection (USFWS 2009).

The western prairie fringed orchid is now found almost exclusively in essentially undisturbed remnant native prairies and sedge meadows. Sites are generally mesic to wet tallgrass prairie on calcareous till or sandy soils (Sheviak and Bowles 1986, MDNR 2000). Associated native prairie plant species include big bluestem (*Andropogon gerardii*), little bluestem (*Schizachyrium scoparium*), sedges (*Carex* spp.), switchgrass (*Panicum virgatum*), and prairie sandreed (*Calamovilfa longifolia*) (Sheviak and Bowles 1986). Occupied habitat at PIPE is more-or-less restricted to mesic prairie in the south central portion of the monument in management units 2B and 3B (Young et al. 2007).

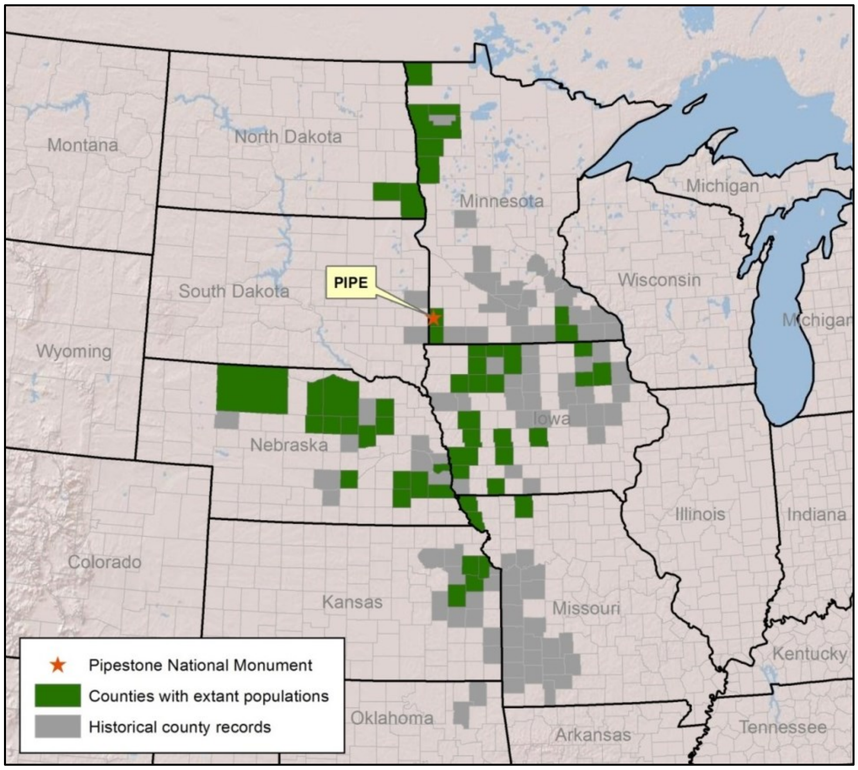


Figure 4-68. Generalized distribution map of western prairie fringed orchid.

<u>Orchid Management and Wildland Fire</u>

Any fire activity in the western prairie fringed orchid population could negatively impact the population. The degree of impact varies depending upon when the fire occurs in the growing season, the intensity of the burn, and weather conditions prior to and at the time of the burn and during the time of flowering (USFWS 1996). Prescribed fire management is beneficial to the orchid by reducing litter accumulation and stimulating flowering (Bowles 1983, USFWS 1996). To better manage the timing of prescribed fires on western prairie fringed orchid populations, a burn sub-unit was created within the existing Fire Management Unit 1. The timing and frequency of prescribed fires can be based on monitoring, research and weather variables. Burning in drought years is not recommended (Pleasants 1998). The invasion of introduced exotic plants can be controlled along the perimeter of the orchid population by conducting burns later in the year (DeCoster et al. 2004). For smooth brome (*Bromus inermis*) control, Willson and Stubbendiek (1997) recommend burning when the node or five leaves are present on the grass. This typically would occur in later spring and most often when new orchid plants are above the ground surface. Therefore, prescribed fires at this time could cause negative impacts to the orchids. The US Fish and Wildlife recovery plan (USFWS 1996) recommends that the best management for this species is that which best maintains the quality of the grassland and prairie habitats.

Threats and Stressors

Regional threats affecting WPFO to varying degrees within its range include conversion of habitat to cropland, overgrazing, intensive hay mowing that may reduce primary productivity and seed dispersal and facilitate invasion of exotic cool season grasses, lack of prairie management leading to woody plant invasion, competition and invasion by exotic plants including cool season grasses, herbicide and pesticide impacts on western prairie fringed orchid and its pollinators, mechanical plant management, hydrologic alterations that directly or indirectly lower water levels in the *P. praeclara* rooting zone, and low seed set in small and isolated populations (USFWS 1996, 2009). Where populations are on unprotected sites, multiple threats and stressors are likely at work. Threats that may be affecting WPFO population at PIPE include:

- competition from invasive woody plants, grasses and forbs;
- reductions in insect pollinators;
- off-site hydrologic alterations that may reduce available water to plants during dry years;
- herbicides use in and around the park;
- use of prescribed fire during periods of plant growth or reproduction (not currently a threat); and
- climate change.

Indicators and Measures

- Population size
- Plant vigor (mean height and number of flowers per plant)
- Fire regime considerations
- Vulnerability to climate change

4.12.2. Data and Methods

The WFPO population at PIPE is monitored on an annual basis, according to a protocol formalized in Young et al. (2007). Monitoring is limited to flowering plants, and other minimum-impact methods are used to limit damage from the impacts of researchers. Monitoring objectives are: 1) to track temporal and spatial changes in the abundance and vigor (as measured by height, flowering, and fruit production) of flowering orchids at PIPE in relation to fire, soil moisture, and precipitation, and 2) to track changes in orchid habitat structure in relation to fire and precipitation (Young et al. 2007). Due to the sensitive nature of this population of a threatened plant species, detailed monitoring data are not publically available. Summary data (annual counts, mean numbers of flower/plant, and mean plant heights) were provided by HTLN staff.

We present the three summary statistics graphically both as a baseline, and to interpret trends. Yearly count data from 1993-2012 were used to estimate population parameters, as recommended by Morris et al. (1999), using the methods and notation of Dennis et al. (1991). The year 1998, when no plants were observed, was treated as a missing observation. Population parameters (mean, μ and standard deviation, σ^2) are estimated by a linear regression with intercept forced to zero using transformed values of the years in which counts were taken (x) and the counts of plants in each year (y).

Transformations are: $x = \sqrt{year(j)-year(i)}$, and $y = \ln(N(j)/N(i))/x$ for each pair. The slope of the resulting regression line is an estimate of the parameter μ, and the mean squared residual is an estimate of the parameter σ^2 (Morris et al. 1999, Dennis et al. 1991).These calculations were then used to estimate the average value of the population growth rate ($\bar{\lambda}$), and an approximate 95% confidence interval for that rate. Spreadsheet formulas given in Morris et al. (1999) were used to calculate the finite rate of increase $\lambda = \exp[\mu + ½ \sigma^2]$ as defined in Dennis et al. (1991).

Willson and Akyuz (2010) monitored 30 marked individual WPFO plants at PIPE during the period 1995-2004, and present annual stage data for each plant. Plants were identified as reproductive (flowering) adults, and classified as either flowering, vegetative, or absent in subsequent years. We used these stage data to produce a stage transition diagram and calculated the proportion of plants moving between classes for each year.

Fire history from park records is available for the period of record and fire regime has been examined comprehensively in the context of the prairie context in Section 4.6. Little information was available regarding the use of prescribed fire in the orchid burn sub-unit.

The vulnerability of the orchid to climate change effects was evaluated using the Climate Change Vulnerability Index (CCVI) (Young et al. 2011). The CCVI is a Microsoft Excel-based spreadsheet tool developed by NatureServe. It is designed as a rapid-assessment tool intended to be used primarily for practical planning purposes by natural resources managers and USFWS staff. It is designed to be complementary to the NatureServe Conservation Status ranks and other information, but it does not duplicate information in those ranks such as the size of a specific population. The intended application scale of the tool is up to the state or province level. The primary purpose of the CCVI is to produce a relative ranking or priority list for species of concern with respect to climate change vulnerability. The CCVI divides vulnerability into two components: 1) exposure to climate change within the assessment area (e.g., a highly sensitive species will not suffer if the climate where it occurs remains stable), and 2) sensitivity of the species to climate change (e.g., an adaptable species will not decline even in the face of significant changes in temperature and/or precipitation).

4.12.3. Reference Conditions

The ideal condition for WPFO at PIPE is the continued presence of a stable or increasing population, with genetic diversity sufficient to allow the population to adapt to changing environmental conditions. Because this population is thought to be reproductively isolated, we consider a baseline reference condition as the continued presence of flowering individuals during annual monitoring periods. A condition rating framework based on reference conditions is shown in Table 4-43. The 95% confidence interval of the estimated population finite rate of increase (λ) was used to evaluate trends in population size. Confidence interval estimates for λ exceeding 1 are considered to be improving, those including 1 are considered to be unchanging and those less than 1 are considered to be deteriorating. Stage transition probabilities are presented as a baseline but are not used to assess condition or trend. The results for climate change vulnerability were not used in the condition rating, but did weight in for the trend rating.

Table 4-43. Resource condition indicator rating framework for western prairie fringed orchid, Pipestone National Monument.

Indicator	Good Condition	Condition Warrants Moderate Concern	Condition Warrants Significant Concern
Population size	Multiple flowering individuals are detected in every monitoring year.	Flowering individuals are detected in most years, although sometimes only a few.	Flowering individuals are not found in most years.
Plant vigor	Plant heights and flowering patterns are within normal variation: mean height 50.6 cm ±7.63 mean flower number 8 ± 1.2	Plant heights and flowering patterns appear to be normal for most years, but are below the 1993-2012 range for recent years.	Plant heights and flowering patterns are well below those observed in the years 1993-2012
Fire regime	Fire regime highly favorable to prairie restoration; seasonal and drought considerations often applied in orchid burn sub-unit.	Fire regime moderately favorable to prairie restoration; seasonal and drought considerations occasionally applied in orchid burn sub-unit.	Fire regime moderately favorable to prairie restoration; seasonal and drought considerations rarely or never applied in orchid burn sub-unit.

4.12.4. Condition and Trend

<u>Population Size</u>

Plant numbers detected during monitoring are highly variable among years (Figure 4-69). Accurate monitoring of the orchid is complicated by its erratic aboveground growth pattern and variable lifespan. In some years an orchid may produce a tall, visible flower stalk, while in others it produces only one to three basal leaves or no aboveground growth (Willson and Akyuz 2010). Although summary metrics for WPFO at PIPE appear to indicate an increasing population, there are several years during which no or very few plants were observed. The estimation of population parameters (Table 4-44), also indicates that the population is increasing. Although the 95% confidence interval for λ is wide, the lower limit is still greater than one, indicating an increasing trend.

Table 4-44. Estimated values for the population mean, standard deviation, and average value of the population growth rate from a series of counts from a population, following the method of Dennis et al. (1991). A value of >1 for λ indicates an increasing population.

Population parameter	Value
Estimated population mean (μ):	0.16
Estimated standard deviation ($\sigma2$):	2.84
Approximate lower 95% confidence limit for λ:	1.44
Average finite rate of increase, λ:	4.86
Approximate upper 95% confidence limit for λ:	16.43

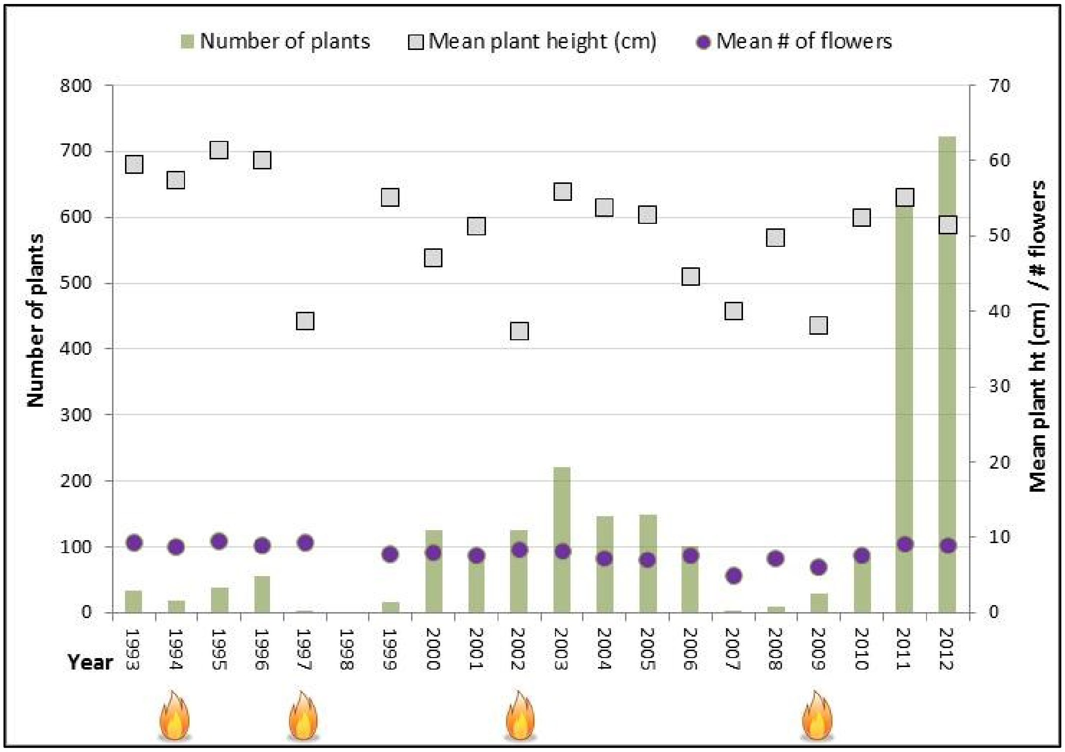


Figure 4-69. Number of flowering western prairie fringed orchids observed 1993-2012. Years in which prescribed burns were conducted are indicated by flame icons.

Based on these results, the indicator warrants moderate concern with an improving trend. Confidence in the assessment is low.

<u>Plant Vigor</u>

Mean plant height is more-or-less stable, with an overall mean of just over 50 cm for the reporting period. Number of flowers per plant is also fairly constant, with an overall average of eight. Both mean plant height and mean number of flowers per plant were not significantly correlated with mean number of flowering plants over time. These two parameters are assumed to represent a characteristic baseline level for this population. Ongoing research may be able to detect interactions between weather patterns and reproductive success, enabling the establishment of more meaningful thresholds.

Life-cycle stages of reproductive orchids and estimated transition probabilities indicate that most individuals flower for a single year (Figure 4-70). However, there is about a 16% chance that an individual will flower in consecutive years, and a vegetative individual that presumably has previously flowered may flower again after an interval of more than a year. There is even a slight probability that individuals not detected in a previous year may reappear as either flowering or vegetative plants. Additional research on the production and persistence of seeds would allow the diagram to be expanded to include additional life-cycle stages. Based on these results, the condition of the indicator is good with an unknown trend. Confidence in the assessment is low.

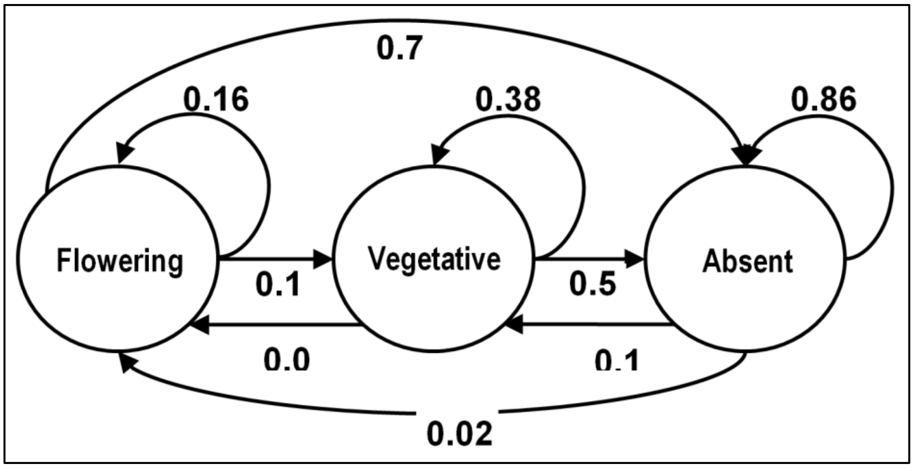


Figure 4-70. Stage-transition diagram for western prairie fringed orchid adult individuals. Arrows are labeled with the average proportion of surviving stems moving between stage classes or staying in the same class. Data from Willson and Akyuz (2010).

Fire Regime Management for the WPFO

Under the current Fire Management Plan (DeCoster et al. 2004) the monument uses prescribed fires to manage the prairie in conjunction with mechanical and chemical exotic vegetation control. The monument's six prairie management units are organized into four burn units. The two fire seasons at the monument are spring (April through early June) and fall (September through late October). The burn units are typically burned on a 3-5 year rotation intended to include spring and fall burns. Managed fire frequency aims to be shorter than the historical average (Wright and Bailey 1982), as frequent fire is recommended by the *Prairie Management Plan* (Becker et al. 1986) and the scientific literature to prevent and reduce exotic and woody vegetation during prairie restoration. Once the desired future conditions are met for species composition, introduced exotics, and woody plants the monument plans to burn on a more historical burn frequency of every 5 to 10 years to maintain the prairie.

The fire regime at PIPE is evaluated relative to general prairie management goals in Section 4.6 of this document. Indicators of the condition of the fire regime as a natural agent of change included fire frequency, fire seasonality, fire severity and fire extent. In the context of desired conditions for the prairie, the condition of the fire regime warrants moderate concern with an unchanging trend. Confidence in the assessment is medium due to variability in implementation of prescribed burns. The fire seasonality indicator condition warrants moderate concern with an unchanging trend and medium confidence. There is generally a lack of variability in the seasonality of burning, with the vast majority of fires being conducted during the spring. This may adversely affect orchid populations. Creation of a burn sub-unit within the existing Fire Management Unit 1 is a necessary step toward managing the timing of prescribed fires on western prairie fringed orchid populations at PIPE, but there is little evidence that the fire regime being applied to the management unit is meeting prescribed burn goals while avoiding late spring burns that may adversely affect orchids. Therefore, in the context of WPFO management, the fire regime warrants moderate concern with an unchanging trend and medium confidence.

Climate Change Vulnerability

Throughout its current range in the Unites States, the western prairie fringed orchid (WPFO) was found to be extremely vulnerable to climate change (Table 4-45). The primary factors driving this score are 1) moderately-high increases in mean temperature and reduced soil moisture by midcentury (exposure), 2) the presence of significant anthropogenic barriers to movement throughout the species range (indirect exposure), and 3) physiological hydrological niche (species sensitivity). The orchid survives in a small number of locations within the region and is dependent on wetland habitat. Occurrences are generally small and surrounded by agricultural cropland and pasture, limiting potential habitat for the species are well as suitable migration corridors. The orchid also relies on a small number of moth species for pollination and requires specific mycorrhizae for seed germination, thus further reducing its resiliency to climate change.

Within Pipestone National Monument the WPFO was rated moderately vulnerable to climate change. The primary factors driving the park-scale score are 1) severe increases in mean temperature by midcentury (exposure), and 2) physiological hydrological niche (species sensitivity). The difference in vulnerability from the range-wide score may be due to somewhat less exposure to drying within the confines of PIPE versus the entire range, which includes much habitat to the south where greater changes in available moisture are predicted. Additionally, the WPFO has experienced greater temperature variations at PIPE compared to the species' range making it more potentially resilient to the effects of temperature changes at a local scale. Anthropogenic barriers to WPFO movement within PIPE are negligible, compared to significant expanses of agricultural lands within the species' range. Moreover, rangewide the habitat for WPFO is expected to be subject to more pressure from energy development than at the local scale. Confidence in the CCVI species information was moderate for the regional analysis and very high for the park analysis. The climate change indicator was assigned an *insufficient data* status and low level of confidence. However, the estimated vulnerability was used as a trend indicator along with other indicators.

Table 4-45. Summary of CCVI factor ratings for the western prairie fringed orchid.

	DEGREE TO WHICH FACTOR INFLUENCES VULNERABILITY	
Factor Influencing Vulnerability	**Rangewide/State**	**Pipestone National Monument**
Indirect Exposure to Climate Change		
1) Exposure to sea level rise	Neutral	Neutral
2a) Distribution relative to natural barriers	Neutral	Neutral
2b) Distribution relative to anthropogenic barriers	Greatly Increase-Increase	Somewhat Increase
3) Predicted impact of land use changes resulting from human responses to climate change	Somewhat Increase	Neutral
Sensitivity to Climate Change		
1) Dispersal and movements	Neutral	Neutral
2ai) Predicted sensitivity to changes in temperature: historical thermal niche	Neutral-Somewhat Decrease	Somewhat Decrease
2aii) Predicted sensitivity to changes in temperature: physiological thermal niche	Neutral	Neutral
2bi) Predicted sensitivity to changes in precipitation, hydrology, or moisture regime: historical hydrological niche	Somewhat Increase	Somewhat Increase
2bii) Predicted sensitivity to changes in precipitation, hydrology, or moisture regime: physiological hydrological niche	Increase	Increase
2c) Dependence on a specific disturbance regime likely to be impacted by climate change	Neutral	Neutral
2d) Dependence on ice, ice-edge, or snow-cover habitats	Neutral	Neutral
3) Restriction to uncommon geological features or derivatives	Neutral	Neutral
4a) Dependence on other species to generate habitat	Neutral	Neutral
4b) Dietary versatility (animals only)	Neutral	Neutral
4c) Pollinator versatility (plants only)	Somewhat Increase	Somewhat Increase
4d) Dependence on other species for propagule dispersal	Neutral	Neutral
4e) Forms part of an interspecific interaction not covered by 4a-d	Neutral	Neutral
5a) Measured genetic variation	Neutral	Neutral
5b) Occurrence of bottlenecks in recent evolutionary history	Neutral	Unknown
6) Phenological response to changing seasonal temperature and precipitation dynamics	Unknown	Unknown

Overall Condition and Trend

The preponderance of evidence indicates that condition of the resource warrants moderate concern. Despite an increasing trend in population size, the trend is considered unchanging due to anticipated declines associated with adverse climate change effects. Because of high variability associated with WPFO monitoring data, confidence in this assessment is low (Table 4-46).

Table 4-46. Condition and trend summary for western prairie fringed orchid at Pipestone National Monument.

Indicator	Condition Status/Trend	Rationale
Western prairie fringed orchid (overall)		The condition warrants moderate concern with an unchanging trend. Confidence in the assessment is low.
Population size		Although recent years have had much larger numbers of flowering individuals observed, there have been several years with very few or no individuals found. Confidence is low due to difficulties in monitoring this taxon and large differences in population estimates from year to year.
Plant vigor (mean height and number of flowers per plant)		Baseline values for plant height and flower numbers are given as default good condition. More information is needed to evaluate appropriate thresholds for this factor.
Fire regime management for the orchid		See the Fire Regime section of this document for more details. The overall condition of the fire regime and the seasonality indicator warrant moderate concern, an unchanging trend and medium confidence. Prescribed fires are helping to minimize stressors on prairie vegetation but most of the fires are conducted in spring and may not be optimized for orchid management. Confidence is low due to knowledge gaps regarding relationships between fire and this orchid.
Climate change vulnerability		The western prairie fringed orchid was found to be extremely vulnerable to climate change throughout its current range in the United States and moderately vulnerable within Pipestone National Monument. Only the trend in this indicator is applied to the overall rating of this resource. Confidence in the species information used in the CCVI rating is moderate for the rangewide analysis and very high for the park analysis.

4.12.5. Sources of Expertise

Heartland Network Staff including Mike DeBacker, Craig Young and Lloyd Morrison, who have been involved with orchid monitoring at PIPE and elsewhere. Jennifer Haack-Gaynor provided a review of the Climate Change Vulnerability Index analysis for this taxon.

Nancy Sather, Botanist/Ecologist, MN Biological Survey, Minnesota Department of Natural Resources. Ms. Sather provided valuable comments on the intricacies and uncertainties associated with monitoring orchids and significant caveats associated with evaluating potential effects of climate change on the orchid. She emphasized caution when presented with incomplete data or knowledge, and emphasized the need for collaboration and communication among WPFO experts.

4.12.6. Uncertainties and Data Gaps

Uncertainties and knowledge gaps for the western prairie fringed orchid include incomplete understanding of orchid ecology and interrelationships between orchid populations, reproduction and factors such as fire, hydrology, plant competition and climate change. Because of the orchid's status as a federally threatened species, the orchid has attracted considerable attention in the region. Fragmented distribution and difficulties with regard to monitoring (discussed above) continue to present challenges in managing orchid populations effectively.

4.12.7. Literature Cited

Becker, D.A., T.B. Bragg, and D.M. Sutherland. 1986. Vegetation survey and prairie management plan for Pipestone National Monument. Prepared by Ecosystems Management for National Park Service, Department of Interior.

Bowles, M.L. 1983. The tallgrass prairie orchids: *Platanthera leucophaea* (Nutt.) Lindl. and *Cypridedium candidum* Muhl. Ex. Willd.: some aspects of their status, biology, and ecology, and implications toward management. Natural Areas Journal 3(4):14-37.

Bray, T.E. and B.L. Wilson. 1992. Status of *Platanthera praeclara* Sheviak & Bowles (western prairie fringed orchid) in the Platte River Valley in Nebraska from Hamilton to Garden Counties. Transactions of the Nebraska Academy of Sciences and Affiliated Societies. Paper 129. http://digitalcommons.unl.edu/tnas/129

Catling, P.M. and V.R. Brownell. 1987. New and significant vascular plant records for Manitoba. Canadian Field-Naturalist 101:437-439.

DeCoster, J., K. Legg, R. O'Sullivan, D. Soliem and G. Wagner. 2004. Pipestone National Monument fire management plan. USDI National Park Service.

Dennis, B., P.L. Munholland, and J.M. Scott. 1991. Estimation of growth and extinction parameters for endangered species. Ecological Monographs 61:115-143.

Minnesota Department of Natural Resources (MDNR). 2000. Western prairie fringed orchid: a threatened midwestern prairie plant. Available at: http://files.dnr.state.mn.us/natural_resources/ets/fringed_orchid.pdf

Morris, W., D. Doak, M. Groom, P. Kareiva, J. Fieberg, L. Gerber, P. Murphy, and D. Thomson. 1999. A practical handbook for population viability analysis. The Nature Conservancy, Arlington, VA.

Pleasants, J.M. 1998. The effects of spring burns on the western prairie fringed orchid (*Platanthera praeclara*). Proceedings of the 14th Annual North American Prairie Conference.

Sheviak, C. J., and M. L. Bowles. 1986. The prairie fringed orchids: a pollinator-isolated species pair. Rhodora 88:267-290.

U.S. Fish and Wildlife Service (USFWS). 1996. *Platanthera praeclara* (western prairie fringed orchid) recovery plan. U. S. Fish and Wildlife Service, Ft. Snelling, Minnesota. 99 pages + appendices.

U.S. Fish and Wildlife Service (USFWS). 2009. Western prairie fringed orchid (*Platanthera praeclara*) 5-year review: summary and evaluation. U. S. Fish and Wildlife Service, Twin cities Field Office, Bloomington, Minnesota. 39 pages.

Willson, G.D. and F.A. Akyuz. 2010. Survival of the western prairie fringed orchid at Pipestone. Parks Science 27. Available: http://www.nature.nps.gov/ParkScience/index.cfm?ArticleID=407&Page=1

Willson, G.D. and J. Stubbendieck. 1997. Fire effects on four growth stages of smooth brome (*Bromus inermis* Leyss.). Natural Areas Journal. 17:306-312.

Wright, H. A. and A. W. Bailey. 1982. Fire Ecology, United States and Southern Canada. John Wiley & Sons, New York.

Young, C. C., G. D. Willson, M. D. DeBacker, L. W. Morrison, H. J. Etheridge, and J. L. Haack. 2007. Western prairie fringed orchid monitoring protocol for Pipestone National Monument. Natural Resource Report NPS/HTLN/NRR—2007/013. National Park Service, Fort Collins, Colorado.

Young, B., E. Byers, K. Gravuer, K. Hall. G. Hammerson and A. Redder. 2011. Guidelines for using the NatureServe Climate Change Vulnerability Index. Release 2.1. Arlington, VA.

4.13. Sioux Quartzite Prairie

4.13.1. Background and Importance

Sioux quartzite outcrop community (photo from Diamond et al. 2014)

Pipestone National Monument lies within the historical range of the tallgrass prairie grassland ecosystem. These mesic grasslands characterized by the dominance of big bluestem (*Andropogon gerardii*) once covered more than 220,000 square miles in central North America, ranging from southern Manitoba to eastern Oklahoma (Sims and Risser 2000). Nearly all the original tallgrass prairie has been converted to cultivated fields or other agricultural use, and only a few isolated tracts of intact native prairie remain. Pipestone NM preserves a small remnant of the original unplowed ecosystem. Within PIPE, 240 acres of tallgrass prairie is managed to promote native species diversity, composition and prairie function in order to protect the integrity of the rare prairie community types and associated rare plant species (James 2011). Three prairie community types are present: tallgrass prairie, restored tallgrass prairie, and the rare Sioux quartzite prairie, which is classified by the US National Vegetation Classification System (NVCS) as the Quartzite - Granite Rock Outcrop Sparse Vegetation Association (CEGL002298). The Sioux quartzite prairie at PIPE was one of the contributing elements leading to Pipestone Natinoal Monument being placed on the Minnesota Natural Heritage Register in 1983 (MDNR 1983).

Sioux quartzite occurs as sporadic outcrops in a band trending generally east to west in southeastern South Dakota, southwestern Minnesota, and the very northwestern corner of Iowa (Berg 1938, Southwick et al. 1986). Much of the region is overlain by glacial till, broken by widely scattered exposures of quartzite that rise no more than a few meters above the surrounding plain (Berg 1938, Ojakangas and Weber 1984). Outcrops have been identified in a fairly narrow band over a distance of about 185 miles (300 km) from about 8 km east of Mitchell, South Dakota, to about 8 km southeast of New Ulm, Minnesota (Ojakangas and Weber 1984). The Sioux quartzite is believed to be of Early Proterozoic age (1,760-1,630 mya) representing a red-bed sandstone sequence that was deposited by braided streams flowing over a deeply weathered land surface of moderate relief (Southwick et al. 1986), and subsequently metamorphosed into hard quartzite.

At PIPE, the Sioux quartzite is exposed as a west-facing escarpment 10-30 feet high. The thin soils and ephemeral pools in water-retaining depressions that characterized the outcrop microhabitats support an unusual suit of prairie species, including several Minnesota state listed rare plants (James 2011). This uncommon community type has been documented from a handful of sites in southwestern Minnesota (Figure 4-71), and may occur in South Dakota as well. Occurrences of a quartzite barren community in the Baraboo Hills quartzite rock outcrops of south-central Wisconsin are believed to represent a similar but distinct community type (NatureServe 2012). Thus, the entire global range of this type spans a range of less than 10,000 square miles. The Sioux Quartzite prairie community at PIPE represents one of the least disturbed examples of a globally significant and endangered plant community (NPS 2008).

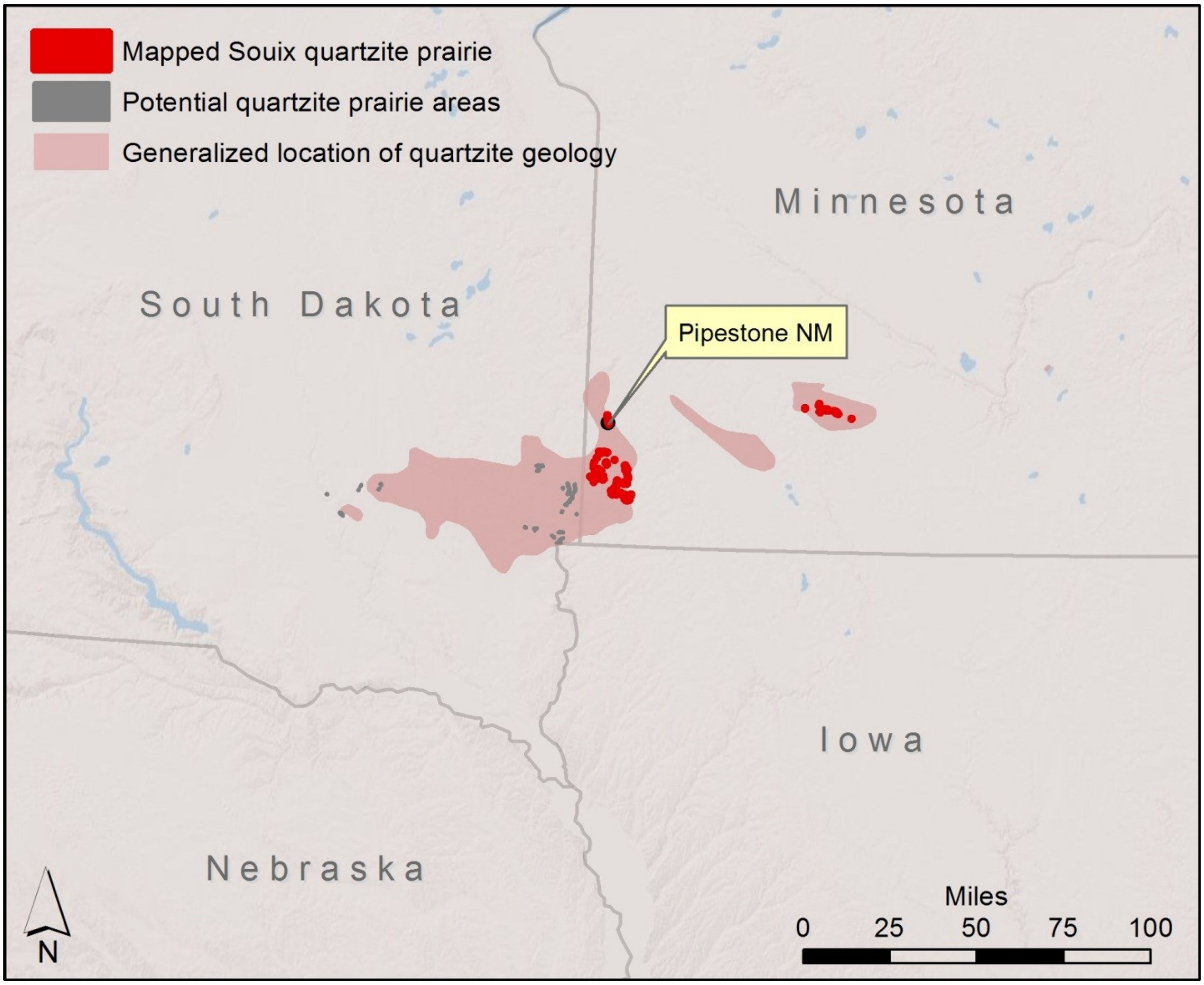


Figure 4-71. Distribution of quartzite prairie (Minnesota DNR data Feb 2014).

The Sioux quartzite prairie community was first mapped as part of the development of the Pipestone National Monument Prairie Management Plan (Becker et al. 1986, Figure 14). The mapped prairie was largely confined to a north-south band extending along and to the east of the quartzite escarpment in the Rock Outcrop-Ihlen Complex, with smaller pockets of quartzite prairie occurring along the quarry line in the Ihlen-Rock Outcrop Complex soil type. The acreage of quartzite prairie associated with the Becker et al. report is unknown.

Mapping of the community from 2012 imagery was completed in 2014 (Diamond et al. 2014) (Figure 4-63). The band of vegetation classified as the Quartzite-Granite Rock Outcrop Sparse Vegetation Association (NVC code CEGL002298) and extending from the south to north boundary of the park totaled 14.8 acres.

Because this community is tightly associated with rock outcrops and shallow substrates it is unlikely that the acreage within the park has changed significantly over time. However, stressors such as altered fire regimes and human land uses may have reduced the natural expression of the type. Sources of change could include areas disturbed by catlinite mining, areas significantly invaded by non-native plants, and areas invaded by woody plants and trees – becoming woodlands or shrublands - especially along the main quartzite outcrop. Although comparison of the current map with previous maps is not possible due to differences in methodology and vegetation classification, there is ample evidence that woody plant encroachment since the time of European settlement has been significant along the quartzite outcrop and along Pipestone Creek. It is likely that the acreage of the quartzite prairie has diminished since the monument was created in 1937, primarily due to changes in the fire regime and disturbances associated with quarries.

The Sioux quartzite prairie community is part of the Rock Outcrop System in the Southern Floristic Region as defined by MDNR (2013a). These are generally dry, open, sparsely vegetated plant communities on areas of exposed bedrock where lichens and bryophytes dominate. There is little soil development, and most plant species present grow in shallow, dry soil that collects in small depressions on sloping rock faces. Herbaceous plant cover is patchy, often concentrated in crevices or in pockets of deeper soil where typical prairie grasses including big bluestem, little bluestem *(Schizachyrium scoparium)*, blue grama *(Bouteloua gracilis)*, Indian grass *(Sorghastrum nutans)*, and prairie dropseed *(Sporobolus heterolepis)* can become established. Woody cover is generally absent or sparse; characteristic native species include sand cherry *(Prunus pumila)* and blackberries *(Rubus* spp.). Ephemeral or persistent pools sustained by rainwater are often found within this community, supporting a variety of rare and common aquatic plant and animal species. All of the state-listed species at Pipestone are associated with the Sioux quartzite prairie.

The Minnesota Biological Survey described the Sioux Quartzite prairie at PIPE as Crystalline Bedrock Outcrop (Prairie): Sioux Quartzite Subtype (ROs12a2). This rare type has been documented on quartzite at scattered locations in Rock, Pipestone, and Cottonwood counties. The Sioux Quartzite Subtype is distinguished from the more northern Minnesota River Subtype (ROs12a1) by the presence of buffalo grass *(Buchloe dactyloides)*, tumble grass *(Schedonnardus paniculatus)*, popcorn flower *(Plagiobothrys scouleri)*, slender plantain *(Plantago elongata)*, prairie quillwort *(Isoetes melanopoda)*, and hairy waterclover *(Marsilea vestita)* (MDNR 2013a).

Threats

Within the region, primary threats to this community include cultivation, herbicides, rock mining, invasive exotic plants and poor grazing practices. At Pipestone, this community is relatively well-protected, although the site hydrology and seasonal flooding of ephemeral pools may be impacted by drain tiling east of the outcrop and the historical lowering of Pipestone Creek at and above Winnewissa Falls. Some invasive exotic plants and other non-natives are present and may increase over time. Visitor access to quartzite prairie areas is very limited, and generally consists of management or monitoring activities and low levels of dispersed Native American ceremonial use. Therefore there is currently very little physical disturbance to the plant communities and ephemeral pools.

Indicators and Measures

- Floristic quality
  - floristic quality (Mean coefficient of conservatism - Floristic Quality Index))
  - relative cover of native plant species
- State element occurrence ranking
- Status of state plants of concern associated with Sioux quartzite prairie
- Climate change vulnerability of diagnostic plant species

4.13.2. Data and Methods

The Heartland Inventory and Monitoring Network has been monitoring vegetation at PIPE since 1997. Of the 13 sites monitored on the monument, three are in Sioux quartzite prairie. Data collected at each location include species composition and foliar cover estimates.

Sample species composition data was used to evaluate the condition of Sioux quartzite prairie at PIPE. A floristic quality assessment index score (mean coefficient of conservatism, or Mean C) was used to evaluate the species composition of each plot. The coefficient of conservatism (C) is the basis of the floristic quality index (FQI) calculation, where a conservatism value from 0 to 10 is assigned to each species on a state-wide basis. Each native species is assigned a value that represents the probability that this plant species is likely to occur in landscapes relatively unaltered from those of pre-settlement times. Plant species with high C values are relatively specialized in their requirements, and thus are found in more restricted habitats. The Mean C score is the average "conservatism" of all native species documented within in the area sampled (Wilhelm and Ladd 1988). Conservative species are those that have evolved with and are closely adapted to a specific set of biotic and abiotic factors, interactions, and natural disturbances (Wilhelm and Ladd 1988, Wilhelm and Masters 1996). Although generally indicative of habitat stability, conservative species are not completely restricted to relatively stable habitats but can also occur in periodically disturbed habitats. However, their narrower tolerance means they are sensitive to disturbance, and they will gradually decline or disappear under conditions that exceed the natural range of variation under which they evolved (Wilhelm and Masters 1996). Non-conservative or generalist species are those which have a broader ecological niche and don't show fidelity to a specific set of environmental parameters. Cover and frequency data from 8 Sioux quartzite outcrop sample sites (Diamond et al. 2014) was also examined.

The floristic quality assessment method uses the proportion of conservative plants in a plant community to assess the degree of "naturalness" of an area, recognizing that all plant species, not just the dominant or rare species, contribute useful information about a site's quality due to each species' ability to adapt to a unique set of biotic and abiotic conditions (Herman et al. 1997). Each species is assigned a C value in Table 4-47.

Table 4-47. Description of C values used to assess the naturalness of areas at PIPE.

C Value	Description
C = 0-3	Species very prevalent in non-natural areas. They have a wide ecological tolerance and do not show any fidelity to high-quality natural areas.
C = 4-6	Species that show weak affinity to natural areas but provide no indication of quality. Many matrix-forming or dominant species fall into this category.
C = 7-9	Species that are obligate to natural areas but can sustain some habitat degradation.
C = 10	Species which are obligate to high-quality natural areas and cannot tolerate any habitat degradation.

Species names from the vegetation monitoring database associated with the PIPE Sioux quartzite plots were cross-walked with species names scored by the Northern Great Plains Floristic Quality Assessment Panel (2001). The Mean C score is calculated by summing the C values for each plot, and dividing by the total number of native species.

Additionally, the relative cover of native plant species vs. non-native species and number of non-native species present were summarized for each plot. Relative native cover was calculated by converting cover classes to midpoint values and summing for each plot, then calculating the proportion of cover formed by native species. Cover and frequency data from 8 Sioux quartzite outcrop sample sites (Diamond et al. 2014) was also examined.

The vulnerability of the community to climate change effects was evaluated using the Climate Change Vulnerability Index (CCVI) Version 2.1 (Young et al. 2011). The CCVI is a Microsoft Excel-based spreadsheet tool developed by NatureServe. It is designed as a rapid-assessment tool intended to be used primarily for practical planning purposes by natural resources managers and USFWS staff. It is designed to be complementary to the NatureServe Conservation Status ranks and other information, but it does not duplicate information in those ranks such as the size of a specific population. The intended application scale of the tool is up to the state or province level. The primary purpose of the CCVI is to produce a relative ranking or priority list for species of concern with respect to climate change vulnerability. The CCVI divides vulnerability into two components: 1) exposure to climate change within the assessment area (e.g., a highly sensitive species will not suffer if the climate where it occurs remains stable), and 2) sensitivity of the species to climate change (e.g., an adaptable species will not decline even in the face of significant changes in temperature and/or precipitation).

Communities are interacting associations of species and the loss of one or more species alters community characteristics. Community vulnerability to climate change was assessed by evaluating the vulnerability of those species that are diagnostic of the community. Sioux quartzite prairie communities can be characterized as a mosaic of microhabitats, each with a suite of species adapted to the environmental conditions in those microsites. Plant species that occupy ephemeral pool microhabitats in this prairie community both distinguish this community from other, more common outcrop communities and, because of their narrow environmental tolerances, are most vulnerable to a changing climate. The CCVI evaluation for this community focused on the following seven plant species, many of which are listed as sensitive in Minnesota: buffalo grass (*Buchloe dactyloides*), tumble grass (*Schedonnardus paniculatus*), popcorn flower (*Plagiobothrys scouleri*), blackfoot quillwort (*Isoetes melanopoda*), hairy waterclover (*Marsilea vestita*), blue mudplantain (*Heteranthera limosa*), and slender plantain (*Plantago elongata*).

4.13.3. Reference Conditions

We assess the condition of Sioux quartzite prairie within PIPE indirectly using a variety of indicators and metrics (Table 4-48). Our primary quantitative indicators are the Mean C index and the relative cover of native plant species.

Mean C is obviously related to condition, but also to the intrinsic expected Mean C of the plant community in question (Rooney and Rogers 2002, Milburn et al. 2007). Although this metric has not been rigorously quantified, some communities can be expected to have naturally lower Mean C values than others. Rather than assign an expected Mean C to Sioux Quartzite prairie, we have relied on results from previous work (Wilhelm and Masters 1996, Herman et al. 2001) showing that sites with a Mean C of 3.0 or less are unlikely to achieve higher C values. This value can be considered a threshold below which restoration efforts are unlikely to succeed. This value was chosen to represent the minimum integrity threshold reference condition. This is assumed to represent conditions under which few to no aggressive invasive species are present, and other non-native species, or native species that increase with disturbance are present only with very low frequency.

For dominance by native vegetation, we consider a baseline reference condition as a "best attainable condition" (*sensu* Stoddard et al. 2006) under which the integrity of Sioux Quartzite prairie at PIPE is sufficient to maintain the plant community in a stable or improving condition. Threshold levels of non-native species cover have not been rigorously defined. Spyreas et al. (2004) found an average of 36% relative percent cover of non-native species in Illinois prairie grasslands. Miles and Knops (2009) reported that sites dominated (>60% relative cover) by native prairie grass (*A. gerardii* and *S. scoparium*) were more likely to follow successional patterns typical of prairie communities. We used a level of 60% relative cover of native plant species as a threshold below which the Sioux Quartzite prairie community is likely to face significant challenges in recovery to a functioning condition. An upper threshold of 80% indicating good condition for native plant species cover is based on levels specified by NatureServe and Natural Heritage Program ecologists for good to excellent condition ranking in other types of remnant prairie communities (e.g., Decker 2007, WANHP 2011). There is insufficient data to establish a reference condition for state rare plants of concern.

The reference conditions for the remaining indicators are largely qualitative and assessed using professional opinion and available data. The results for climate change vulnerability were not used in the condition rating, but did weight in for the trend rating.

Table 4-48. Resource condition indicator rating framework for Sioux quartzite prairie, Pipestone National Monument.

Indicator	Good Condition	Warrants Moderate Concern	Warrants Significant Concern
Floristic quality Mean C	Mean C > 4.5	Mean between 3.5 and 4.5	Mean C <3.5
Relative cover of native plants	>= 80% relative cover of native species	60 to <80% relative cover of native species	<60% relative cover of native species
Element occurrence ranking criteria	condition resembles "A" rank description	condition resembles "B" rank description	condition resembles "C" rank description
State plants of concern	insufficient data	insufficient data	insufficient data

4.13.4. Condition and Trend

Floristic Quality

Mean C values for the three Sioux quartzite plots range from 3.53 at location 5 in 2001 to 4.78 at site 10 in 2009 (Figure 4-72). Mean C values are generally above the threshold value of 4.0 for good condition over time. Mean C ranges are also relatively stable from year to year over the period of sampling.

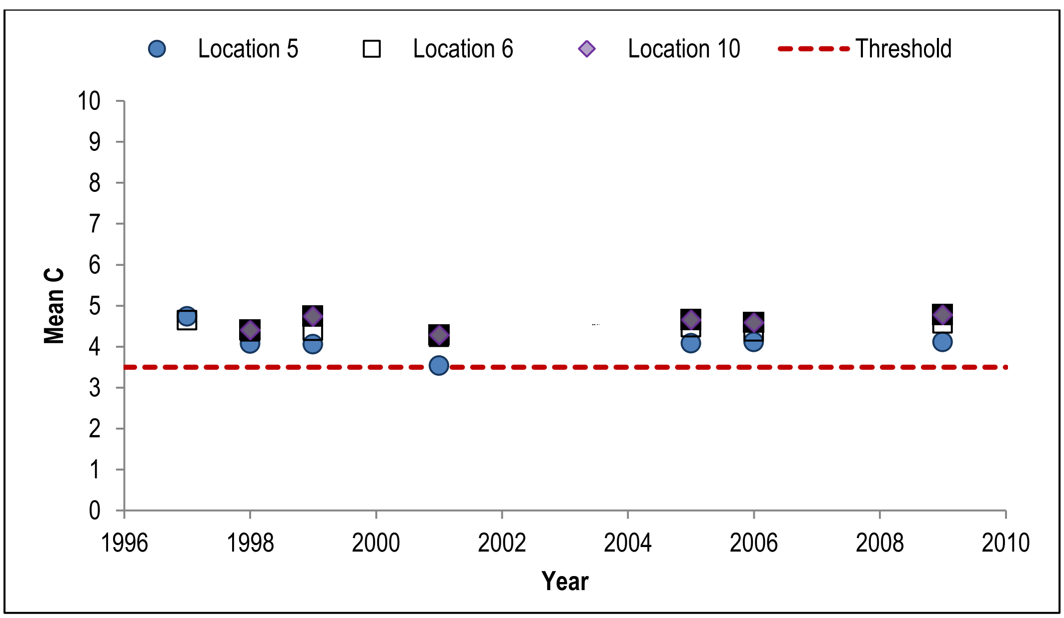


Figure 4-72. Mean C values for Sioux quartzite prairie samples at PIPE.

A total of 23 non-native species have been identified as present in the Sioux Quartzite prairie plot locations. Relative cover of native species is variable both seasonally within years, and between years (Figure 4-73 a-c). Although Sioux quartzite prairie plots (especially Location 5) are below the good condition threshold in many sample periods, long-term averages for each location is 79%

relative cover of native species. Location 6 is generally near or above the 85% threshold (Table 4-49).

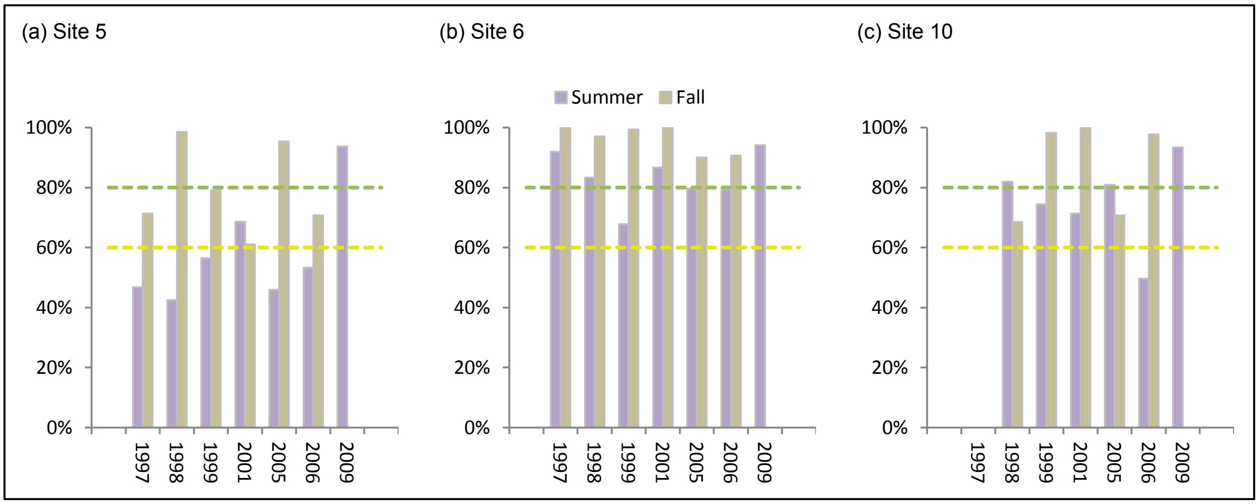


Figure 4-73. Relative percent canopy cover of native species by season and year on Sioux Quartzite prairie plots at PIPE. Upper (green) dashed line represents good condition threshold (80%), lower (yellow) dashed line represents moderate concern condition threshold (60%).

Table 4-49. Summary of relative percent cover of native species in Sioux Quartzite prairie locations at PIPE.

Season	Location 5	Location 6	Location 10	Mean
Summer only (1997-2009)	58%	83%	75%	72%
Fall only (1997-2008)	79%	96%	87%	88%
All samples	**68%**	**89%**	**81%**	**79%**

Non-native species remain an important problem in Sioux Quartzite prairie at PIPE. Plot data for the three locations indicates that Kentucky bluegrass (*Poa pratensis*) is the most prevalent species, accounting for 17% relative cover over all plots. Native prairie grasses, especially little bluestem, big bluestem, prairie junegrass (*Koeleria macrantha*), blue grama and sideoats grama (*Bouteloua curtipendula*) are represented, and account for nearly a quarter (23.9%) of relative cover. The characteristic shrubs sandcherry and leadplant (*Amorpha canescens*) are present with 3-4% relative cover each. Tumble grass *(Schedonnardus paniculatus)* is the only distinguishing species detected in vegetation plots.

Coefficient of conservatism scores for Sioux quartzite prairie at PIPE indicates that the area is in good condition with regard to native prairie species, although we do know that a number of rare species are not present that are known historically from the monument. The prevalence of non-native species within this prairie remnant is a source of concern. The condition of these floristic quality indicators warrants moderate concern with an unchanging trend. Confidence in the rating is medium due to uncertainties associated with the FQI reference condition.

State Element Occurrence Ranking

Element occurrences are ranked by the State of Minnesota according to quality and condition characteristics that indicate their degree of naturalness (i.e., how close they resemble presettlement conditions). “A” rank indicates an excellent quality natural community, while “D” indicates a poor quality natural community. Exemplary occurrences ranked B or higher are considered natural areas of statewide significance. The last formal evaluation of the Sioux quartzite prairie element occurrence at the monument by the State took place in 1983 (NPS 2008, Appendix C). Ranking criteria were examined relative to existing information and data, primarily HTLN vegetation monitoring data and summaries associated with recent vegetation classification and mapping of the monument (Diamond et al. 2014) (Table 4-50).

The agreement (low, moderate, high) of each criterion with conditions at the monument was assigned (Table 4-51). High quality elements included proximity to high-quality prairie, trace presence of *Phlox pilosa*, moderate abundance of *Koeleria macrantha*, presence of pool-associated species such as *Selaginella rupestris* and *Limosella aquatic*, and moderate representation of dry, mesic, and wet prairie species (wet mesic representation by *Spartina pectinata* was very sparse). However, several invasive plants such as *Bromus inermis, Poa pratensis* and *Poa compressa* are common and difficult to manage. Also, several rare plants associated with ephemeral pools and known historically from the monument are possibly no longer present. The A Rank criteria had the highest affinity to available data, with the majority of criteria assigned a value of moderate or higher, but the abundance of nonnative invasive plants downgrades the community to a B Rank. Further botanical surveys and evaluation of the element occurrence by qualified MDNR staff is recommended. The results for this indicator warrant moderate concern with a deteriorating trend due to increasing threats from invasives. Confidence in the assessment is low due to information gaps related to rare plants and the need for additional on-the-ground assessment.

State-listed Plants Associated with Sioux Quartzite Prairie

In addition to supporting an unusual prairie community, the exposed bedrock of the Sioux quartzite permits the formation of ephemeral rainwater pools in late spring that provide habitat for a group of plant species not found in other, more permanent wetlands in the region (Harris 2010). Rainwater pools tend to be small and temporary and do not persist nearly as long as those in the northern type (MDNR 2013a). These small, temporary habitats support a variety of rare and common aquatic species. Harris (2010) listed 10 species of ephemeral rainwater pools in Sioux quartzite prairie (Table 4-52). Of these, eight have been documented within PIPE. Eight of the ten species are rare enough to be designated by state status of special concern, threatened, or endangered in Minnesota (MDNR 2013b). All of the state-listed species at Pipestone are associated with the Sioux quartzite prairie. There are two state-endangered, three state-threatened, and five state "of special concern" plants (NPS 2008).

There is limited information on the presence, abundance and locations of these species on PIPE, especially the more rare state endangered (blackfoot quillwort, hairy water clover) and state threatened (short-pointed umbrella sedge, mud plantain and slender plantain) species. The majority of these species have not been documented at Pipestone since the 1960s. The small size and ephemeral nature of some species can make them difficult to find, and plants may be present although they have not been observed in recent years. Available information indicates that some rare plant species historically found in ephemeral pools and mesic sites within the Sioux quartzite prairie at the monument may no longer occur there. Currently there is insufficient information to determine the condition and trend for these rare species associated with Sioux quartzite prairie.

Table 4-50. Species found within at least three of eight plots within the Northern Tallgrass Quartzite Outcrop vegetation type. (Data from Diamond et al. 2014)

Life Form	Scientific Name	Common Name	Frequency Decimal	Cover (%)	Dominance (frequency X cover)
Shrub	*Rosa arkansana*	prairie rose	0.50	0.5	0.3
Forb	*Amorpha canescens*	leadplant	1.00	4.8	4.8
	Ambrosia psilostachya	Cuman ragweed	0.75	1.3	1.0
	Selaginella rupestris	northern selaginella	1.00	0.8	0.8
	Phemeranthus parviflorus	sunbright	0.88	0.5	0.4
	Hedeoma hispida	rough false pennyroyal	0.88	0.5	0.4
	Tragopogon dubius	yellow salsify	0.75	0.5	0.4
	Symphyotrichum oblongifolium	aromatic aster	0.75	0.5	0.4
	Solidago missouriensis	Missouri goldenrod	0.75	0.5	0.4
	Opuntia fragilis	brittle pricklypear	0.75	0.5	0.4
	Plantago patagonica	woolly plantain	0.63	0.5	0.3
	Oxalis stricta	common yellow oxalis	0.63	0.5	0.3
	Erigeron strigosus	prairie fleabane	0.63	0.5	0.3
	Symphyotrichum ericoides	white heath aster	0.50	0.5	0.3
	Silene antirrhina	sleepy silene	0.50	0.5	0.3
	Polygonum ramosissimum	bushy knotweed	0.50	0.5	0.3
	Lepidium densiflorum	common pepperweed	0.50	0.5	0.3
	Solidago nemoralis	gray goldenrod	0.38	0.5	0.2
	Potentilla arguta	tall cinquefoil	0.38	0.5	0.2
	Conyza canadensis	Canadian horseweed	0.38	0.5	0.2
	Comandra umbellata	bastard toadflax	0.38	0.5	0.2

Table 4-50 (continued). Species found within at least three of eight plots within the Northern Tallgrass Quartzite Outcrop vegetation type. (Data from Diamond et al. 2014)

Life Form	Scientific Name	Common Name	Frequency Decimal	Cover (%)	Dominance (frequency X cover)
Forb (continued)	*Artemisia frigida*	prairie sagewort	0.38	0.5	0.2
Graminoid	*Schizachyrium scoparium*	little bluestem	1.00	13.3	13.3
	Sporobolus heterolepis	prairie dropseed	1.00	11.8	11.8
	Poa pratensis	Kentucky bluegrass	1.00	10.2	10.2
	Bromus inermis	smooth brome	0.63	12.3	7.7
	Poa compressa	Canada bluegrass	0.88	3.3	2.9
	Andropogon gerardii	big bluestem	1.00	2.7	2.7
	Bouteloua dactyloides	buffalograss	0.88	1.9	1.7
	Bouteloua gracilis	blue grama	0.75	2.2	1.7
	Koeleria macrantha	prairie Junegrass	1.00	1.4	1.4
	Bouteloua curtipendula	sideoats grama	0.75	1.3	1.0
	Sporobolus compositus	composite dropseed	0.38	2.2	0.8
	Hesperostipa spartea	porcupinegrass	1.00	0.8	0.8
	Muhlenbergia cuspidata	plains muhly	0.75	0.9	0.7
	Pascopyrum smithii	western wheatgrass	0.75	0.9	0.7
	Bromus arvensis	field brome	0.63	1.0	0.6
	Dichanthelium oligosanthes	Heller's rosette grass	1.00	0.5	0.5
	Agrostis scabra	rough bentgrass	0.75	0.5	0.4

Table 4-51. Element occurrence ranking criteria for the Mesic Prairie (Southwest Section) Crystalline Bedrock Subtype (MDNR 2001) and relationship to current information.

Element Occurrence Rank Criteria	Pipestone NM Agreement With Criterion
Rank A -	
The occurrence contains a significant exposure of Sioux quartzite that grades into a high-quality mesic prairie dominated by species such as *Andropogon gerardi*, *Sorghastrum nutans*, *Schizachyrium scoparius*, and *Bouteloua curtipendula* or *Bouteloua gracilis*.	moderate/high
Site may have a history of light cattle grazing or haying, but species diversity remains high.	moderate/high
Forbs include those not resilient to grazing, such as *Phlox pilosa*, *Gentiana pubercula*, *Coreopsis palmate* and *Prenanthes aspera*.	low/moderate

Table 4-51 (continued). Element occurrence ranking criteria for the Mesic Prairie (Southwest Section) Crystalline Bedrock Subtype (MDNR 2001) and relationship to current information.

Element Occurrence Rank Criteria	Pipestone NM Agreement With Criterion
Rank A (continued) -	
Rock outcrops within the prairie support species such as *Koeleria macrantha* and *Opuntia humifusa*, and numerous lichens and mosses.	moderate
Pools in depressions in the rock outcrops sometimes contain species such as *Bacopa rotundifolia*, *Selaginella rupestris*, and *Limosella aquatica*.	moderate/high
Crystalline bedrock prairies often support populations of the federally protected species *Lespedeza leptostachya*. The presence of this species is important, but does not automatically make the occurrence highly ranked.	no
The best sites often have marked heterogeneity, with patches of dry, mesic, and wet prairie present. These patches are associated with differences in soil moisture related to depth to the underlying bedrock.	moderate
Rank B –	
The occurrence is similar in species composition to an A-rank occurrence.	moderate
However, light to moderate disturbance, typically by grazing or haying, has slightly altered the original composition of prairie species. In such occurrences, the species composition may vary seasonally, depending on the history of grazing or haying. For example, sites that have had summer grazing may have excellent spring flora but degraded summer flora, while sites that have been hayed in late summer often have good spring and early-summer flora but poor late-summer and fall flora.	?/low
Exotic species are present, but are not common. Some exotic species that tend to invade grazed crystalline bedrock prairies are *Bromus inermis*, *Trifolium pratense*, and *Phleum pratense*.	moderate
With cessation of disturbance and reintroduction of periodic fire, B-rank occurrences typically recover to more natural conditions.	?
Rank C –	
The occurrence still maintains native prairie species but original character has been substantially altered and native weedy species and exotic species are a substantial component of the flora.	moderate
A long history of grazing, haying with interseeding of tame grasses, or use of herbicides has caused greatly reduced native species diversity, dramatically increased native weedy species, and establishment and spread of exotic species.	low
In general, mesic areas within the site change most, with replacement of conservative species by large populations of weedy species such as *Solidago canadensis* and *Verbena stricta*.	low
Areas where heavy grazing occurred in the past but has now ceased often have large clones of woody plants such as *Rhus glabra*, *Ribes americana*, and *Symphoricarpos occidentale*.	low
Dry and dry-mesic areas typically maintain many of their dominant native prairie species but have significant increases in *Poa compressa*.	low

Table 4-52. Species of ephemeral rainwater pools in Sioux quartzite prairie and other species of state concern associated with Sioux quartzite prairie, and their occurrence on the monument (Harris 2010). Notes on monument occurrence are from NPS (2008) Appendix C.

Scientific name*	Common Name	Status	Notes
Documented at PIPE			
Bacopa rotundifolia	disk waterhyssop	Special concern in MN	Collected in the monument in 1963, has not been found since then.
Callitriche heterophylla	water starwort	none	
Elatine triandra	waterwort	none	
Heteranthera limosa	blue mudplantain	State threatened	Collected in or near the monument in 1956. Has not been found since then despite numerous surveys.
Isoetes melanopoda	black quillwort	State endangered	First collected at the monument in 1979.
Limosella aquatica	water mudwort	Special concern in MN	Population verified in 1979 and more recently. Population is small but well-established.
Marsilea vestita	hairy waterclover	State endangered	Collected in the monument in 1946, was not found in 1979 survey.
Plantago elongata	prairie or slender plantain	State threatened	Collected in the monument in 1962, was not found in 1979/1980 survey.
Undocumented at PIPE			
Crassula aquatica	water pygmyweed	State threatened	In adjacent Rock County (MDNR 2013)
Eleocharis wolfii	Wolf's spikerush	State endangered	In Pipestone County (MDNR)

*Specimens housed at the Bell Museum of Natural History, University of Minnesota Herbarium.

Vulnerability to Climate Change

Sioux quartzite prairie communities were found to be extremely vulnerable to climate change throughout their current range in the United States and within Pipestone National Monument. Confidence in the species information (generated by the CCVI software) is moderate rangewide and very high for within the park. The components of the CCVI that contributed the most to the extremely vulnerable rating included moderately high increases in modeled mean temperatures (climate change exposure); anthropogenic barriers (indirect effects); and dispersal and movements, historical hydrological niche and physiological hydrological niche, and restriction to specific geological features (species sensitivity to climate change) (Table 4-53). Some of these factors are caused by or compounded by extensive conversion of habitat from a tallgrass prairie-wetland matrix to cropland matrix. Impacts from habitat conversion include loss of habitat suitable for the species that characterize the community; fragmentation of native habitat into small, disconnected habitat islands where ecological functions, particularly hydrologic functions, are decoupled from environmental processes; diminished resiliency to environmental perturbations due to invasive species pressures and altered disturbance regimes; and loss of connectivity which inhibits migration that enables genetic exchange, population of new sites and migration in the face of climate change. The climate change indicator was assigned an *insufficient data* status and low level of confidence. However, the estimated vulnerability was used as a trend indicator along with other indicators.

Table 4-53. Summary of CCVI factor ratings for the Sioux quartzite prairie plant community.

	Degree to Which Factor Influences Vulnerability	
Factor Influencing Vulnerability	**Rangewide/State**	**Pipestone National Monument**
Indirect Exposure to Climate Change		
1) Exposure to sea level rise	Neutral	Neutral
2a) Distribution relative to barriers Natural barriers	Somewhat Increase	Neutral
2b)Distribution relative to Anthropogenic barriers	Greatly Increase	Greatly Increase
3) Predicted impact of land use changes resulting from human responses to climate change	Somewhat Increase	Somewhat Increase
Sensitivity to Climate Change		
1) Dispersal and movements	Increase	Increase
2ai)Predicted sensitivity to changes in temperature: historical thermal niche	Neutral	Neutral
2aii) Predicted sensitivity to changes in temperature: physiological thermal niche	Neutral	Neutral
2bi)Predicted sensitivity to changes in precipitation, hydrology, or moisture regime: historical hydrological niche	Greatly Increase	Greatly Increase
2bii) Predicted sensitivity to changes in precipitation, hydrology, or moisture regime: physiological hydrological niche	Greatly Increase	Greatly Increase
2c) Dependence on a specific disturbance regime likely to be impacted by climate change	Neutral	Neutral
2d) Dependence on ice, ice-edge, or snow-cover habitats	Neutral	Neutral
3) Restriction to uncommon geological features or derivatives	Increase	Increase
4a) Dependence on other species to generate habitat	Neutral	Neutral
4b) Dietary versatility (animals only)	not applicable	not applicable
4c) Pollinator versatility (plants only)	Unknown	Unknown
4d) Dependence on other species for propagule dispersal	Neutral	Neutral
4e) Forms part of an interspecific interaction not covered by 4a-d	Unknown	Unknown
5a) Measured genetic variation	Unknown	Unknown
5b) Occurrence of bottlenecks in recent evolutionary history	Neutral	Neutral
6) Phenological response to changing seasonal temperature and precipitation dynamics	Somewhat Increase	Somewhat Increase

Condition Summary for Sioux Quartzite Prairie

The condition of the resource indicators warrants moderate concern with a downward to unchanging trend (Table 4-54). Confidence in the assessment is medium. The Sioux quartzite prairie community is one of only several examples of a regional mesic subtype recognized by the State. The landform is intact, historical disturbance is relatively low due to due to lack of cultivation; the history of livestock grazing at the site is unknown. The possible long-term effects on the community of drain tiling east of the outcrop and the historic lowering of Pipestone Creek at and above Winnewissa Falls are unknown. Some invasive exotic plants and other non-natives are present and may increase over time. Physical disturbances to the community are very limited, as visitor access to quartzite outcrop areas is restricted; management and monitoring activities and Native American ceremonial use levels are generally low. The intended frequent fires within the park are favorable to prairie diversity and native species, and help to control and manage woody vegetation. Rlelatively long fire return intervals may degrade this community and the surrounding tallgrass prairie as result in accelerated establishment or spread of invasive exotic plants. The diagnostic plant species in the community are considered extremely vulnerable to climate change.

Table 4-54. Condition and trend summary for Sioux quartzite prairie at Pipestone National Monument.

Indicator	Condition Status/Trend	Rationale
Sioux quartzite prairie (overall)		The condition of the resource warrants moderate concern, with an unchanging trend. The overall score is weighted toward floristic quality. Confidence in the assessment is medium to low.
Floristic Quality		FQI ratings are acceptable but the prevalence of non-native species within this prairie remnant is a source of concern.
Element Occurrence Quality		The majority of criteria had affinity to the A Rank, but the abundance of nonnative invasive plants downgrades the community to an AB or B Rank. Further botanical surveys and evaluation of the element occurrence by qualified MDNR staff is recommended.
State-listed Plants Associated with Sioux Quartzite Prairie		Some rare plant species historically found in ephemeral pools and mesic sites within the Sioux quartzite prairie at the monument may no longer occur there. Currently there is insufficient information to determine the condition and trend for these rare species associated with Sioux quartzite prairie.
Climate Change Vulnerability of Diagnostic Species		Sioux quartzite prairie communities were found to be extremely vulnerable to climate change throughout their current range in the United States and within Pipestone National Monument. Only the trend in this indicator is applied to the overall rating of this resource. Confidence in the CCVI species information is moderate rangewide and very high for within the park.

4.13.5. Sources of Expertise

Information to support this analysis was gleaned from published reports and peer-reviewed literature, information from the Minnesota Department of Natural Resources Natural Heritage and Nongame Research Program, and NatureServe.

4.13.6. Information Gaps and Needs

This vegetation community type is complex and patchy where it occurs, whereby areas of shallow soils overlying bedrock are interspersed with patches of deeper soils characterized by more typical prairie vegetation. Due to the spatial scales used for sampling, vegetation community data collected at Sioux quartzite prairie sites/plots in these mosaics may be influenced by the presence prairie patches in deeper soils.

Rare plant surveys - There is limited information on the presence, abundance and locations of these species on PIPE, especially the more rare state endangered (blackfoot quillwort, hairy water clover) and state threatened (short-pointed umbrella sedge, mud plantain and slender plantain) species. The majority of these species have not been documented at Pipestone since the 1960s. The small size and ephemeral nature of some species can make them difficult to find, and plants may be present although they have not been observed in recent years.

Vegetation monitoring – A more robust monitoring plan for this community to increase the number of sampling sites from three would improve the ability to characterize status and trends in this community.

Ephemeral fauna data are lacking – since ephemeral pools are an integral part of this natural community, the presence and abundance of aquatic invertebrates would provide a useful indicator of hydrologic processes and status.

4.13.7. Literature Cited

Becker, D.A., T. Bragg and D. Sutherland. 1986. Pipestone National Monument prairie management plan. USDI National Park Service.

Berg, E.L. 1938. Notes on catlinite and the Sioux quartzite. American Mineralogist 23: 258-268.

Decker, K. 2007. Central mixedgrass prairie ecological integrity assessment (Central Shortgrass Prairie Ecoregion Version). Colorado Natural Heritage Program, Colorado State University, Fort Collins, Colorado. Available at: http://www.cnhp.colostate.edu/download/documents/2007/Central_Mixedgrass_Prairie_EIA.pdf

Diamond, D. D., L. F. Elliott, M. D. DeBacker, K. M. James, D. L. Pursell, and A. Struckhoff. 2014. Vegetation mapping and classification of Pipestone National Monument, Minnesota: project report. Natural Resource Report NPS/PIPE/NRR—2014/802. National Park Service, Fort Collins, Colorado.

Harris, F. 2010. Recent rediscovery of rare plants of ephemeral rainwater pools in Sioux quartzite prairies in southwestern Minnesota. In: Williams, D. B. Butler, and D. Smith, eds., Proceedings of the 22nd North American prairie conference. Available at http://napc2010.org/pdf/22nd%20NAPC%20Proceed(low%20res).pdf

Herman, K.D., L.A. Masters, M.R. Penskar, A.A. Reznicek, G.S. Wilhelm, and W.W. Brodowicz. 1997. Floristic quality assessment: development and application in the State of Michigan (USA). Natural Areas Journal 17(3): 265-279.

Herman, K.D., L.A. Masters, M.R. Penskar, A.A. Reznicek, G.S. Wilhelm, W.W. Brodovich, and K.P. Gardiner. 2001. Floristic quality assessment with wetland categories and examples of computer applications for the State of Michigan – revised, 2nd edition. Michigan Department of Natural Resources, Wildlife, Natural Heritage Program. Lansing, Michigan. 19 pp. + Appendices.

James, K. M. 2011. Vegetation community monitoring at Pipestone National Monument, Minnesota: 1997-2009. Natural Resource Data Series NPS/HTLN/NRDS—2011/145. National Park Service, Fort Collins, Colorado.

Milburn, S.A., M. Bourdaghs, and J.J. Husveth. 2007. Floristic quality assessment for Minnesota wetlands. Minnesota Pollution Control Agency, St. Paul, Minnesota.

Miles, E.K. and J.M.H. Knops. 2009. Grassland compositional change in relation to the identity of the dominant matrix-forming species. Plant Ecology and Diversity 2:265-275.

Minnesota Department of Natural Resources (MDNR). 1983. Memorandum of Understanding for including Pipestone Natinoal Monument on the Minnesota Natural Heritage Register.

MDNR. 2001. Draft natural community element occurrence ranking guidelines, MDNR Minnesota Natural Heritage Program. Available at: ftp://ftp.dnr.state.mn.us/pub/gisftp/barichar/MLCCS/manual_version_5.4/eoranks2001.pdf

MDNR. 2013a. Ecological system summaries and class factsheets – upland grasslands, shrublands, and sparse vegetation. Available at: http://www.dnr.state.mn.us/npc/uplandgrassland.html

MDNR. 2013b. Rare species guide. Available at: http://www.dnr.state.mn.us/rsg/index.html

National Park Service (NPS). 2008. Final General Management Plan and Environmental Impact Statement. Pipestone National Monument. National Park Service, U.S. Department of the Interior. Available at: http://www.nps.gov/pipe/parkmgmt/

NatureServe. 2012. NatureServe Explorer: An online encyclopedia of life. Version 7.1. NatureServe, Arlington, Virginia. Available: http://www.natureserve.org/explorer

Northern Great Plains Floristic Quality Assessment Panel. 2001. Coefficients of conservatism for the vascular flora of the Dakotas and adjacent grasslands. U.S. Geological Survey Information and Technology Report USGS/BRD/ITR-2001-001.

Ojakangas, R.W. and R.E. Weber. 1984. Petrography and paleocurrents of the lower proterozoic Sioux quartzite, Minnesota and South Dakota. In: Southwick, D.L. ed. Shorter contributions to the geology of the Sioux quartzite (early Proterozoic), southwestern Minnesota. Report of Investigations 32, Minnesota Geological Survey, University of Minnesota, Saint Paul, Minnesota.

Rooney, T P. and D.A. Rogers. 2002. The modified floristic quality index. Natural Areas Journal 22:340-344.

Sims, P.L. and P.G. Risser. 2000. Grasslands. In: Barbour, M.G., and W.D. Billings, eds., North American Terrestrial Vegetation, Second Edition. Cambridge University Press, New York, pp.323-356.

Southwick, D.L., G.B. Morey, and J.H. Mossler. 1986. Fluvial origin of the lower Proterozoic Sioux Quartzite, southwestern Minnesota. Geological Society of America Bulletin 97:1432-1441.

Spyreas, G., J. Ellis, C. Carroll, and B. Molano-Flores. 2004. Non-native plant commonness and dominance in the forests, wetlands, and grasslands of Illinois, USA. Natural Areas Journal 24:290-299.

Stoddard, J.L., D.P. Larsen, C.P. Hawkins, R.K. Johnson, and R.H. Norris. 2006. Setting expectations for the ecological condition of streams: the concept of reference condition. Ecological Applications 14:1267-1276.

Washington Natural Heritage Program (WANHP). 2011. Ecological integrity assessment: Columbia Basin Palouse Prairie. Washington State Department of Natural Resources. Available: http://www1.dnr.wa.gov/nhp/refdesk/communities/pdf/eia/cb_palouse.pdf

Wilhelm, G. and D. Ladd. 1988. Natural area assessment in the Chicago region. Pp 361-375 in R.E. McCabe, editor, Transactions of the 53rd North American Wildlife and Natural Resources Conference. Wildlife Management Institute, Washington D.C.

Wilhelm, G. and L. Masters. 1996. Floristic quality assessment in the Chicago region. The Morton Arboretum, Lisle, Illinois.

Young, B., E. Byers, K. Gravuer, K. Hall. G. Hammerson and A. Redder. 2011. Guidelines for using the NatureServe Climate Change Vulnerability Index. Release 2.1. Arlington, VA.

4.14. Invasive Exotic Plants (IEP)

4.14.1. Background and Importance

The terms non-native, alien, and exotic are all used to describe species that have been introduced to an area. Introduced species vary widely in their potential to cause harmful changes to ecosystems; most non-native species are not invasive, although they are usually indicative of some type of disturbance. Executive Order (EO) 13112 defines an invasive species as "…an alien (or non-native) species whose introduction does, or is likely to cause economic or environmental harm or harm to human health". Under the EO, federal agencies are directed to prevent introductions, provide control and minimize the economic, ecologic and human health impacts of invasive species. Invasive species include all taxa of organisms, not just plants. These species can degrade habitat quality by displacing native species that provide important food, nesting material, or cover (e.g., Jakle and Gatz 1985, Trammel and Butler 1995). Wilcove et al. (1998) identified the spread of alien species as the second most important threat to biodiversity in the U.S. Heavy infestation of non-native species can also alter fire, soil water, and nutrient dynamics (Sheley and Petroff 1999). Finally, such infestations may hamper recreational activities, detract from visitor experiences, and present a significant challenge to the NPS directive to maintain natural resources unimpaired for future generations (NPS 2009, 2013).

Management and monitoring of invasive exotic plants is a priority for the Heartland I&M Network. During the vital signs selection process in 2003, invasive exotic plants were identified as the third most important management issue for PIPE (Young et al. 2007). Invasive exotic plants are spread into NPS units by various pathways, including roads, trails, and riparian corridors (Young et al. 2007). The number of non-native plant species is correlated with visitation levels and extent of backcountry trails and riparian areas (Allen et al. 2009).

Invasive exotic plants are of concern at PIPE because of their potentially detrimental effects on the native and restored tallgrass prairie and the rare Sioux quartzite prairie plant communities. A number of highly invasive exotic plants have become established on PIPE (Young et al. 2010), including common buckthorn (*Rhamnus cathartica)*, crownvetch (*Securigera varia*), leafy spurge (*Euphorbia esula*), reed canarygrass (*Phalaris arundinacea*), smooth brome (*Bromus inermis*), sweetclover (*Melilotus officinalis*), and Tatarian honeysuckle (*Lonicera tatarica*). An aggressive program to control invasive exotic plants is in place at PIPE. Fire is used as a management tool for the control of smooth brome at the monument, but must be timed to protect the endangered western prairie fringed orchid that is also resident in the prairie communities.

Threats and Stressors

Threats to the condition of PIPE from the presence of invasive exotic plant species include 1) the alteration of native species dominance and loss of rare species, 2) changes in nutrient cycles, soil chemistry, and water availability, and 3) overall shifts in community productivity.

Indicators and Measures

We assessed the condition of invasive exotic plants at PIPE by evaluating:

- Introduced exotic plant frequency
- Introduced exotic plant abundance

- Introduced exotic plant distribution
- State noxious weed presence/status

4.14.2. Data and Methods

The Heartland I&M Network has developed an invasive exotic plant monitoring protocol (Young et al. 2007) that uses a prioritization database for species to be monitored on network parks. High priority exotic plants are designated based on a consensus of state and regional exotic plants lists, and the designation is intended to identify those exotic plant species that are likely to be highly invasive in natural areas. PIPE has three watch lists: 1) the early detection watch list, identifying high priority species known to occur in the state but not known to occur in the park based on the NPSpecies database; 2) the park-established watch list, containing high priority species known to occur in the unit based on the NPSpecies database; and 3) the park-based watch list, which includes plants selected by park managers or network staff and that may not have been included on the other lists due to incomplete information in NPSpecies or USDA Plants (e.g., state distribution information was inaccurate) databases or due to differing opinions regarding network designation of a plant as a high priority (Table 4-55). Seven of the park-listed species are considered noxious weeds by the state of Minnesota: *Carduus nutans, Cirsium arvense, C. vulgare, Euphorbia esula, Lythrum salicaria, Rhamnus cathartica,* and *Sonchus arvensis.* Of those seven listed, all except *Lythrum salicaria* were documented. Although aquatic species are included on the watch lists, surveys have focused on terrestrial communities, only occasionally documenting aquatics.

Sampling of invasive exotic plants at PIPE took place in 2006 and 2009. For small parks, including PIPE, the HTLN protocol specified that exotic plant search units be created by dividing park management units into search units that were generally 1-3 acres (0.4-1.2 ha) in size with a target size of 2 acres. At PIPE, this resulted in 114 search units, with a size range of 0.8-4.1 acres with a mean of 2.4 acres representing 278 acres within the park (Figure 4-74). Within each search unit, three equally spaced east-west belt transects of 3 to 12 m width are surveyed, and canopy cover classes are estimated for each species of interest (Young et al. 2007). Because of the variability in the size of each search unit and the width of the belt transects, the area sampled within each search unit varies. Cover classes were: 0=0, 1=0.1-0.9 m^2, 2=1-9.9 m^2, 3=10-49.9 m^2, 4= 50-99.9 m^2, 5=100-499.9 m^2, 6= 499.9-999.9 m^2, and 7 $\geq$ 1,000 m^2). The widest belt possible

Figure 4-74. Exotic plant search units at Pipestone National Monument (Young et al. 2007).

given site conditions was used.

Table 4-55. Watch lists for invasive exotic plants at PIPE.

Scientific name	Common name	Scientific name	Common name
NPS Early Detection Watch List			
Acer ginnala	Amur maple	*Lonicera morrowii*	Morrow's honeysuckle
Acer platanoides	Norway maple	*Lonicera X bella*	Showy fly honeysuckle
Alliaria petiolata	Garlic mustard	*Lotus corniculatus*	Bird's-foot trefoil
Alnus glutinosa	European alder	*Lotus tenuis*	Narrow-leaf bird's-foot foil
Azolla spp.	Mosquitofern	*Lysimachia mularia*	Creeping jenny
Berberis thunbergii	Japanese barberry	*Lythrum salicaria*	Purple loosestrife
Berteroa incana	Hoary alyssum	*Miscanthus saccharifolius*	Amur silvergrass
Butomus umbellatus	Flowering rush	*Morus alba*	White mulberry
Caragana arborescens	Siberian peashrub	*Myriophyllum spicatum*	Eurasian watermilfoil
Centaurea biebersteinii	Spotted knapweed	*Pastinaca sativa*	Wild parsnip
Centaurea solstitialis	Yellow star-thistle	*Phragmites australis*	Common reed
Cynanchum louiseae	Louise's swallow-wort	*Plantago lanceolata*	Narrowleaf plantain
Dactylis glomerata	Orchardgrass	*Polygonum cuspidatum*	Japanese knotweed
Daucus carota	Queen Anne's lace	*Polygonum sachalinense*	Giant knotweed
Digitalis lanata	Grecian foxglove	*Populus alba*	White poplar
Dipsacus laciniatus	Cutleaf teasel	*Potamogeton crispus*	Curly pondweed
Frangula alnus	Glossy buckthorn	*Robinia pseudoacacia*	Black locust
Glechoma hederacea	Ground ivy	*Rosa multiflora*	Multiflora rose
Hieracium aurantiacum	Orange hawkweed	*Tanacetum vulgare*	Common tansy
Humulus japonicus	Japanese hop	*Typha angustifolia*	Narrowleaf cattail
Iris pseudacorus	Paleyellow iris	*Viburnum opulus*	European cranberrybush
Leucanthemum vulgare	Oxeye daisy	*Vicia cracca*	Bird vetch
Lolium arundinaceum	Tall fescue	*Vicia villosa*	Winter vetch
Lolium pratense	Meadow fescue	*Vinca minor*	Common periwinkle
Lonicera maackii	Amur honeysuckle		

Table 4-55 (continued). Watch lists for invasive exotic plants at PIPE

Scientific name	Common name	Scientific name	Common name
Park-Established Watch List			
Arctium minus	Lesser burdock	*Melilotus officinalis*	Yellow sweetclover
Bromus inermis	Smooth brome	*Phalaris arundinacea*	Reed canarygrass
Bromus tectorum	Cheatgrass	*Poa compressa*	Canada bluegrass
Carduus nutans	Musk (nodding plumeless) thistle	*Poa pratensis*	Kentucky bluegrass
Cirsium arvense	Canada thistle	*Potentilla recta*	Sulphur cinquefoil
Cirsium vulgare	Bull thistle	*Rhamnus cathartica*	Common buckthorn
Elaeagnus angustifolia	Russian olive	*Securigera varia*	Crownvetch
Euphorbia esula	Leafy spurge	*Solanum dulcamara*	Climbing nightshade
Hesperis matronalis	Dames rocket	*Sonchus arvensis*	Field sowthistle
Linaria vulgaris	Butter and eggs	*Ulmus pumila*	Siberian elm
Lonicera tatarica	Tatarian honeysuckle	*Verbascum thapsus*	Common mullein
Park-Based Watch List			
Bromus racemosus	Bald brome	*Lolium perenne*	Perennial ryegrass
Elymus repens	Quackgrass	*Phleum pratense*	Timothy
Leucanthemum vulgare	Oxeye daisy		

Entire polygons were not searched. For each species a minimum cover estimate for the park was calculated as the sum of lower endpoints of cover classes divided by the calculated maximum area searched (102 acres or 36.8% of the monument), resulting in a park-wide estimate of the lowest possible cover within the greatest possible area searched. Likewise, the maximum cover estimate was calculated as the sum of cover class upper endpoints divided by the calculated minimum area searched (9.2% of the monument), representing an estimate of the highest possible cover within the smallest area searched. These minimum and maximum cover estimates provide an estimated range of cover that accounts for the uncertainty arising from the sampling method (Young et al. 2010). Monitoring began in 2006, was repeated in 2009 and will be repeated every five years.

Frequency and cover data were abstracted from Young et al. (2010). Changes in cover by search unit were evaluated using data from INP_Accessv2.0.mdb database provided by Heartland I&M Network staff. Cover classes were converted to midpoints and summed across species for each search unit.

Exotic species located during surveys conducted at PIPE during 1989-91 were ranked using the Exotic Species Ranking System (Hiebert and Stubbendieck 1993), and are summarized here. A total of 71 exotic plant species were ranked (Table 4-56), and of these, 11 were considered both a serious ecological threat and difficult to control (points in upper left quadrant of Figure 4-74). These species include five Minnesota noxious weed species that were ranked during that study (labeled as red diamonds in Figure 4-75). Other species determined to be a significant threat included *Bromus inermis, Lonicera tatarica, Poa pratensis and Poa compressa.* Of those latter species, only *Bromus inermis* and *Lonicera tatarica* were documented during recent monitoring. The software used to calculate rankings for the current level of impact, the innate ability to become a pest, the total significance of impact, the feasibility of control, and urgency could not be used with current computer operating systems, so current rankings were not developed as part of this assessment. The software is available from the USGS at http://www.npwrc.usgs.gov/resource/literatr/aprs/.

Table 4-56. Ranking of exotic plant species at PIPE (Hiebert and Stubbendieck 1993).

Species	Current level of impact	Innate ability to become a pest	Total significance of impact	Feasibility of control	Urgency
Agropyron cristatum	-8	27	19	56	Low
Agropyron repens	28	36	64	16	Medium
Agrostis stolonifera	7	25	32	41	Low
Asparagus officinalis	4	25	29	65	Low
Brassica kaber	-8	16	8	65	Low
Bromus inermis	42	43	85	18	Medium
Bromus japonicus	18	20	38	51	Low
Bromus tectorum	17	20	37	38	Low
Campanula rapunculoides	6	26	32	46	Low
Capsella bursa-pastoris	-2	17	15	37	Low
Carduus nutans	19	34	53	31	Medium
Chenopodium album	-5	18	13	56	Low
Cirsium arvense	19	40	59	17	High
Cornilla varia (Securigera varia)	12	32	44	34	Medium
Dianthus armeria	4	16	20	60	Low
Digitaria sanguinalis	13	24	37	36	Medium
Eleagnus angustifolia	17	30	47	30	Medium
Eragrostis cilianensis	-8	16	8	50	Low
Euphorbia esula	24	48	72	31	High
Hesperis matronalis	-4	19	15	63	Low
Kochia scoparia	-8	31	23	55	Low
Lactuca serriola	-4	17	13	49	Low

Table 4-56 (continued). Ranking of exotic plant species at PIPE (Hiebert and Stubbendieck 1993).

Species	Current level of impact	Innate ability to become a pest	Total significance of impact	Feasibility of control	Urgency
Lappula echinata	7	32	39	50	Low
Lappula redowskii	6	30	36	50	Low
Leonurus cardiacea	9	19	28	43	Low
Lepidium campestre	13	20	33	33	Low
Linaria vulgaris	18	29	47	41	Medium
Lithospermum arvense	4	23	27	65	Low
Lolium perenne	-8	19	11	50	Low
Lonicera tatarica	33	39	72	25	Medium
Matricaria matricariodes	-8	17	9	65	Low
Medicago lupulina	-5	24	19	41	Low
Medicago sativa	10	34	44	34	Low
Melilotus alba	17	34	51	48	Medium
Melilotus officianilis	14	34	48	42	Medium
Nepeta cataria	9	21	30	46	Low
Philadelphus coronarius	9	22	31	45	Low
Phleum pratense	10	30	40	36	Low
Plantago major	-8	24	16	30	Low
Poa compressa	33	34	67	21	Medium
Poa palustris	18	20	38	51	Low
Poa pratensis	38	43	81	23	Medium
Polygonum achoreum	-8	22	14	60	Low
Polygonum aviculare	-4	22	18	46	Low
Polygonum hydropiper	3	30	33	30	Low
Polygonum persicaria	13	21	34	45	Low
Populus nigra	6	30	36	45	Low
Portulaca oleracea	10	24	34	31	Low
Potentilla fruticosa	6	25	31	60	Low
Potentilla recta	18	22	40	31	Low
Ranunculus testiculatus	-8	21	13	75	Low

Table 4-56 (continued). Ranking of exotic plant species at PIPE (Hiebert and Stubbendieck 1993).

Species	Current level of impact	Innate ability to become a pest	Total significance of impact	Feasibility of control	Urgency
Rhamnus cathartica	45	44	89	18	Medium
Rumex crispus	-6	27	21	35	Low
Salsola iberica	-6	31	25	75	Low
Setaria faberi	-8	26	18	55	Low
Setaria glauca	-8	29	21	55	Low
Setaria viridis	-2	26	24	38	Low
Silene cserei	-8	16	8	60	Low
Silene pratensis	-8	19	11	60	Low
Sisymbrium altissimum	-8	21	13	60	Low
Solanum dulcamara	-1	22	21	50	Low
Sonchus arvensis	20	39	59	22	Medium
Taraxacum officinale	-4	33	29	34	Low
Thalspi arvense	-8	18	10	55	Low
Tragopogon dubius	7	26	33	31	Low
Trifolium hybridum	-8	25	13	50	Low
Trifolium pratense	18	23	41	36	Low
Trifolium repens	11	29	40	36	Low
Ulmus pumila	18	29	47	36	Low
Verbascum thapsus	15	22	37	36	Medium
Veronica arvensis	6	19	25	55	Low

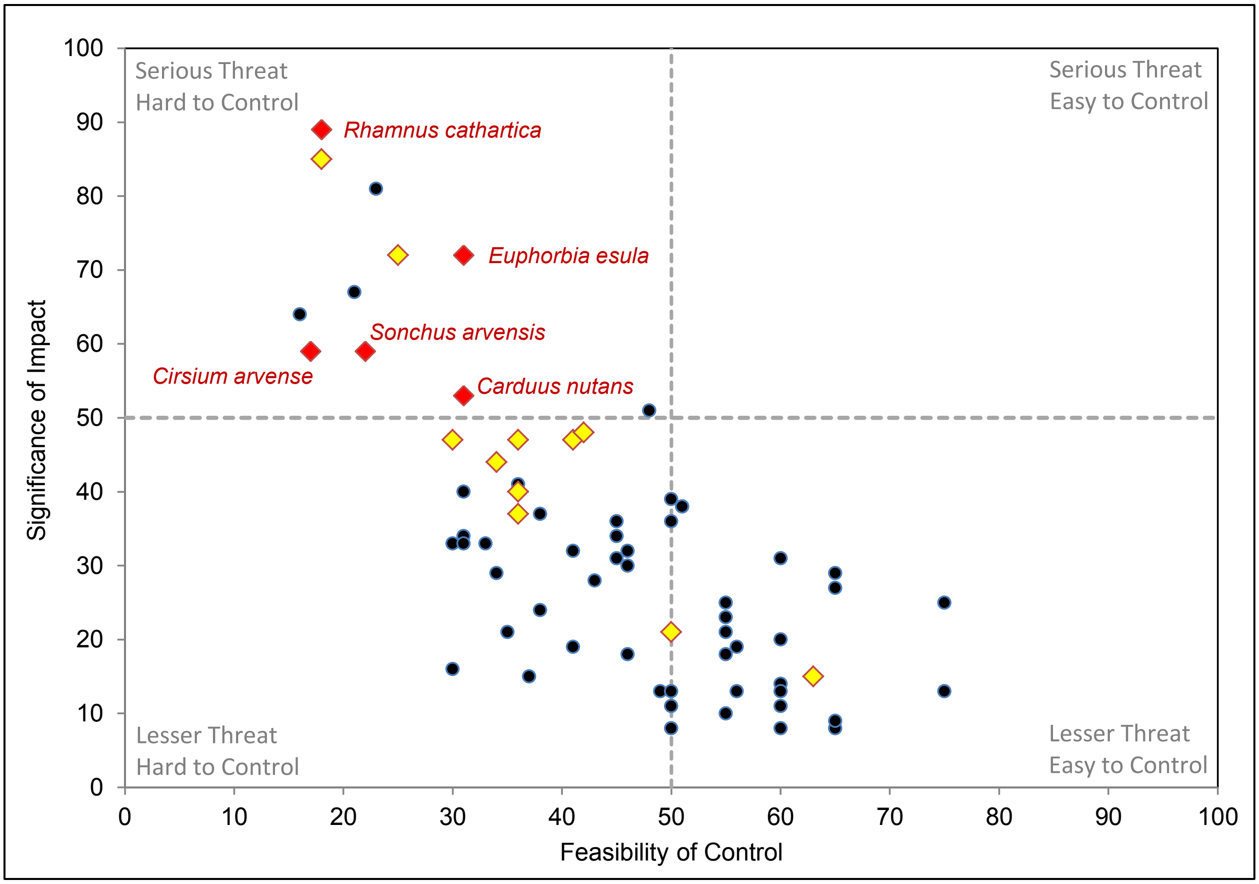


Figure 4-75. Significance of impact vs. feasibility of control for exotic plant species at PIPE (adapted from Hiebert and Stubbendieck 1993). Species detected during IEP monitoring at PIPE in 2006 and 2009 are shown as diamonds; red filled diamonds are state-listed noxious weed species.

4.14.3. Reference Conditions

The ideal condition for PIPE would be the complete absence of non-native species, representing conditions during pre-settlement times. Because this type of reference condition is not feasible for a unit with the history of PIPE, we instead consider a baseline reference condition as conditions under which the integrity of monument plant communities remains essentially unimpaired, and natural processes that are affected by species composition are able to operate within the natural range of variation. We used a three-class condition scale to evaluate the condition and trend for the monument with reference to invasive plant species (Table 4-57, Table 4-58). A good condition ranking would be achieved under conditions where IEP species are present but at generally low frequency and cover, and in only isolated patches. Conditions where many IEP species are present with substantial cover for some species, and the problem is widespread, indicate a condition warranting significant concern. Because species numbers and distribution are naturally variable from year to year even in the absence of control efforts, we focused our trend evaluation on the largest change classes, instead of on those of a few percentage points. A combined change in cover of more than 500 percentage points for all species sampled in the polygon is used to indicate "substantial" increase or decrease.

Table 4-57. Reference condition rating framework for invasive exotic plants, Pipestone National Monument.

Condition	Frequency	Abundance	Distribution	State noxious weeds
Good	In the most recent monitoring period, no IEP species are present with >50% frequency	In the most recent monitoring period, no IEP species are present with estimated cover range that exceeds 15% of total park acres	In the most recent monitoring period, <10% of search units have >5 IEP species present	No state noxious weed species are present
Moderate concern	In the most recent monitoring period, a few IEP species (1-3) are present with >50% frequency	In the most recent monitoring period, a few IEP species (1-3) are present with cover range that exceeds 15% of total park acres	In the most recent monitoring period, >10% of search units have >5 IEP species present, AND <25% have 10 or more IEP species present	1-3 state noxious weed species are present, AND state noxious weed species acreage is <1% of Preserve area
Significant concern	In the most recent monitoring period, many IEP species (>3) are present with >50% frequency	In the most recent monitoring period, many IEP species (>3) are present with cover range that exceeds15%of total park acres	In the most recent monitoring period, >25% of search units have 10 or more IEP species present	More than 3 state noxious weed species are present OR state noxious weed species acreage is >1% of Preserve area

Table 4-58. Reference condition rating framework for invasive exotic plants, Pipestone National Monument.

Trend	Inidicator Arrow	Change in IEP cover from 2006 to 2009
Improving	⇧	25% or more of search units have a substantial decrease in IEP cover AND fewer than 15% have a substantial increase in IEP cover
Unchanging	⬄	>75% of search units have no substantial increase or decrease in IEP cover AND <25% of search units have a substantial decrease in IEP cover
Deteriorating	⇩	>25% of search units have a substantial increase in IEP cover

4.14.4. Condition and Trend

<u>Frequency</u>

A cumulative total of 20 IEP species have been detected at PIPE during the two monitoring periods. In 2009, several species previously detected (*Phleum pratense* and *Solanum dulcamara*) were not found, and a single new species (*Sonchus arvensis*) was documented. Three species (*Bromus inermis*, *Poa* spp., and *Cirsium arvense*) had frequencies above 50% (Figure 4-76). Frequency for many species decreased from 2006 to 2009. Results for this indicator warrant moderate concern, with an improving trend and high confidence.

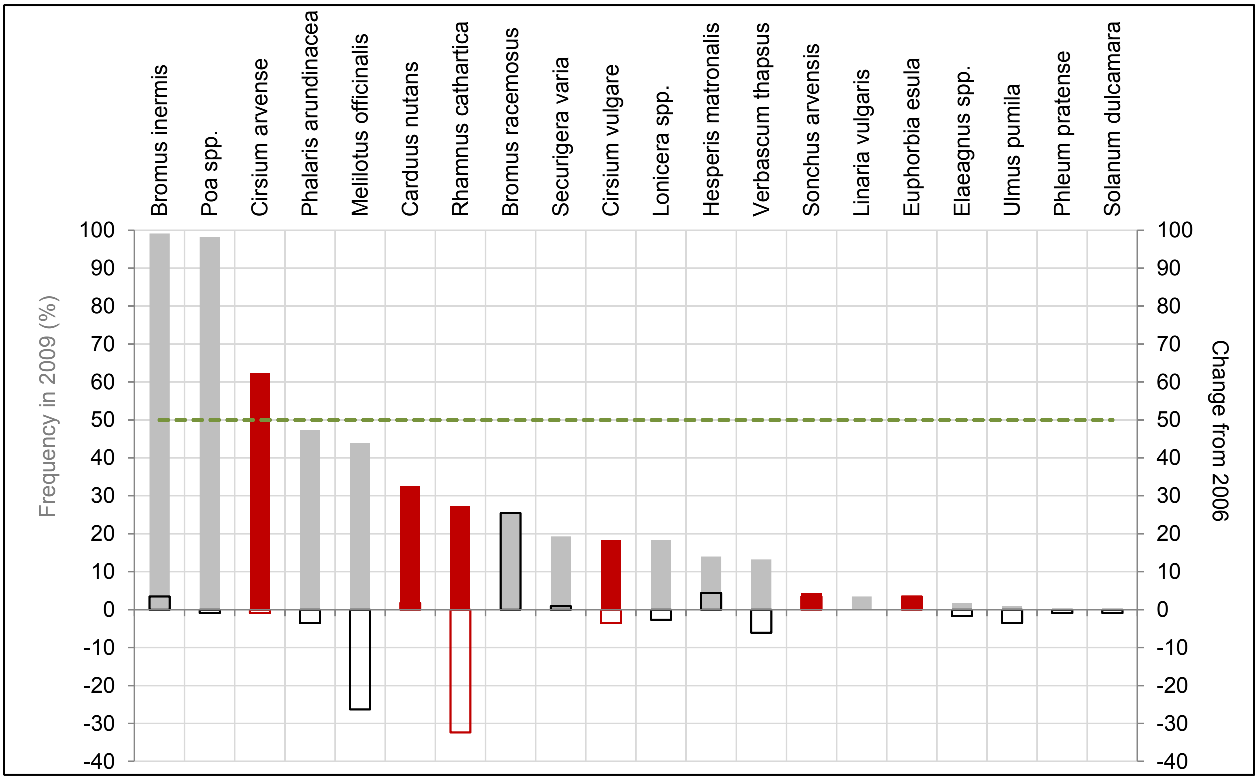


Figure 4-76. Frequency of IEP species at PIPE in 2009 (solid bars), and change in frequency from 2006 (open bars). Species are sorted by decreasing percent frequency. The 50% frequency threshold (see text) is indicated by a dashed line. Minnesota state-listed noxious species are shown in red.

Abundance

Estimated cover ranges as reported by Young et al. (2010) indicate that invasive grasses are a primary concern at PIPE. Four species (*Bromus inermis*, *Poa* spp., reed *Phalaris arundinacea*, and *Melilotus officinalis*) have cover in 2009 exceeding 15% of the total undeveloped acreage of the monument (Figure 4-77). Change in cover was generally increasing. Results for this indicator warrant moderate concern, with a deteriorating trend and a high confidence level.

Distribution

There are no search units at PIPE without IEP species present (Figure 4-78a). Over half of all units (58%) have 1-5 IEP species. The majority of the remaining units (42%) have fewer than 10 IEP species. Twenty-seven percent of search units had a substantial increase in IEP cover (Figure 4-78b). Results for this indicator warrant moderate concern, with a deteriorating trend and a high confidence level.

State Noxious Weeds

Six Minnesota state-listed noxious weed species (*Carduus nutans, Cirsium arvense, C. vulgare, Euphorbia esula, Rhamnus cathartica,* and *Sonchus arvensis.*) were present in 2009 (Figure 4-76), with combined cover of 17.45 acres, or 6.5% of total monument acreage. Results for this indicator warrant moderate concern, with a deteriorating trend and a high confidence level.

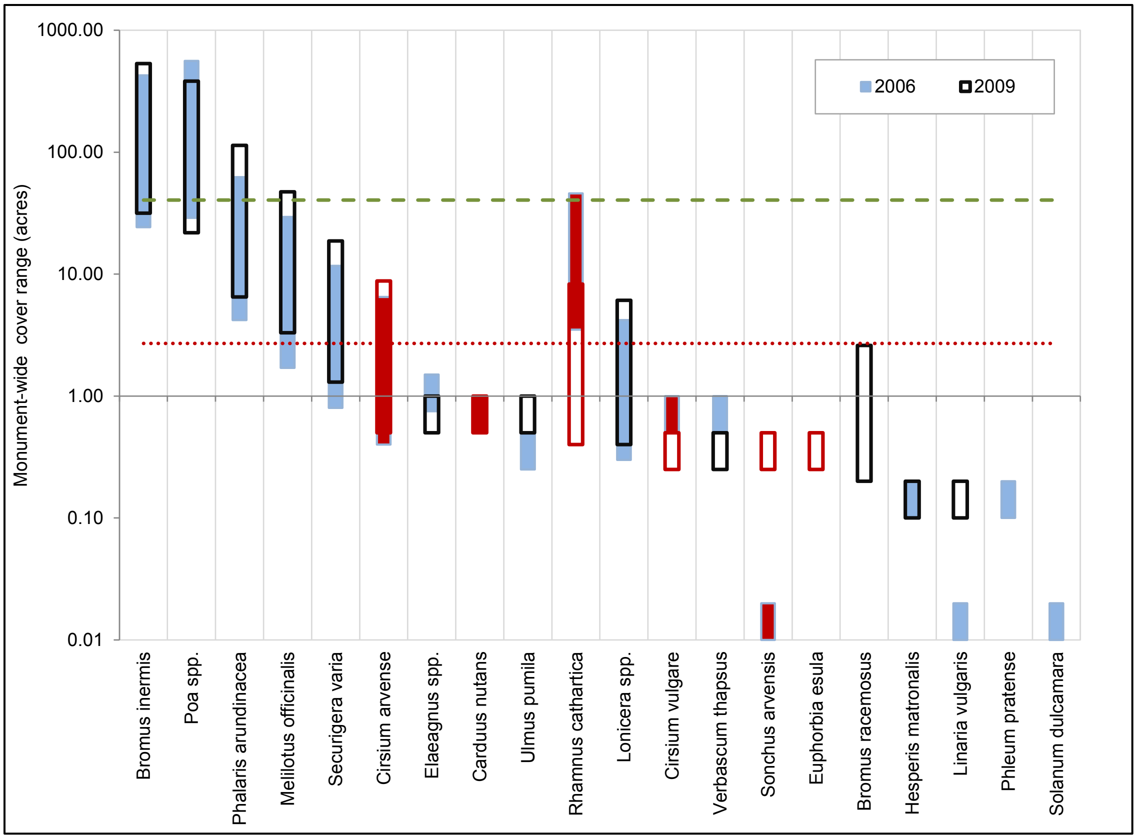


Figure 4-77. Cover ranges of IEP species at PIPE in 2006 and 2009. Species sorted by decreasing 2009 cover acreage (note log scale). The 15% cover threshold for all IEP species (see text) is indicated by a dashed line. Values for Minnesota state-listed noxious species are shown in red, and the 1% state-noxious cover threshold is shown as a dotted line.

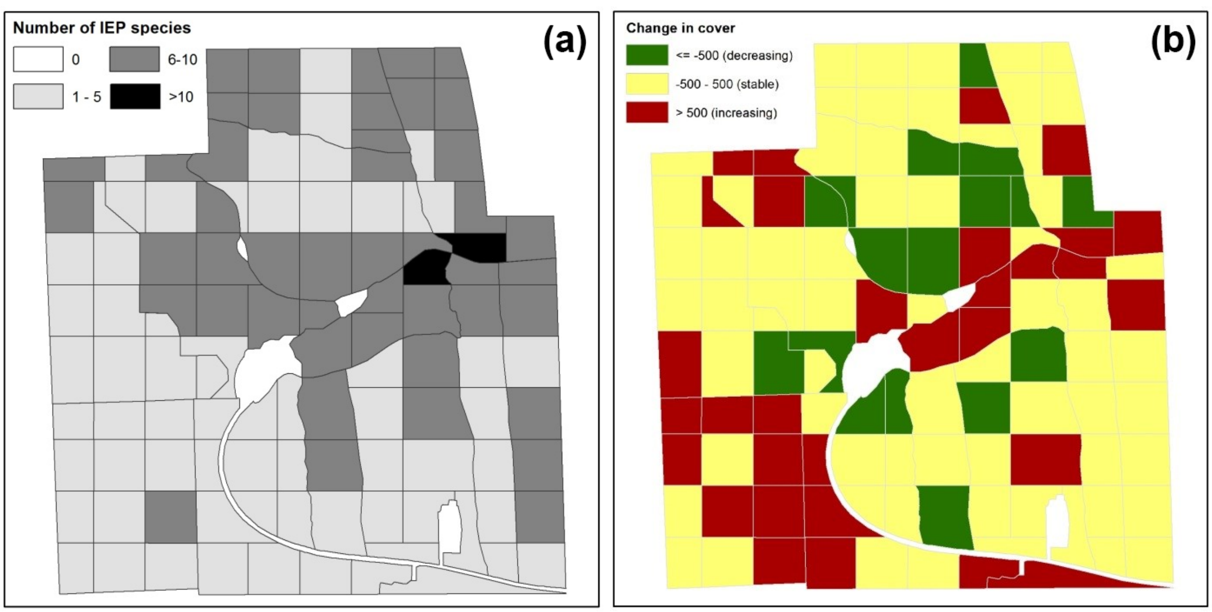


Figure 4-78. Number of IEP species by search unit in 2009 (a) and net change in cover class of each species (combined) between 2006 and 2009 (b).

Overall Condition and Trend

The IEP monitoring data are rich in spatial and non-spatial information, and presents challenges in determining an overall rating for the Preserve (Table 4-59). Trends in individual species are more straightforward to assess and interpret than composition changes due to multiple species and abundances. Based on the four indicators evaluated, the condition of the monument warrants moderate concern, with a deteriorating trend. The lack of more than two years of monitoring data, the necessity of estimating cover ranges from transects, and uncertainties associated with defining reference conditions result in a medium level of confidence for the assessment.

Table 4-59. Condition and trend summary for invasive exotic species at Pipestone National Monument.

Indicator	Condition Status/Trend	Rationale
IEP species (overall)		**The overall condition of invasive exotic plants warrants moderate concern with a deteriorating trend. Confidence in the assessment is high.**
Frequency		Several IEP species are present with high frequency. In particular, the grasses smooth brome and bluegrass are ubiquitous within the monument, and are likely to have some impact on the functioning of native grasslands.
Abundance		Several IEP species have estimated cover ranges greatly exceeding 25% of the total acreage of the monument. Invasive grasses constitute a large percent of the grassland cover, and may affect capability of native grasslands to recover from disturbance in a characteristic fashion.
Distribution		A significant portion of search units have more than 5 IEP species present, indicating that IEP species are widespread within some areas of the monument.
State noxious weeds		Six Minnesota state-listed noxious weed species are present, and their combined acreage is greater than 1% of the monument.

4.14.5. Uncertainties and Data Gaps

The available data reflects intensive surveys covering all areas of the park and addressing park-based watch lists. Spatial and temporal resolution of the data are high.

4.14.6. Sources of Expertise

Craig Young, Biologist and Invasive Plant Program Leader for the NPS Heartland I&M Network, provided reviews for this chapter.

4.14.7. Literature Cited

Allen, J.A., C.S. Brown, and T.J. Stohlgren. 2009. Non-native plant invasions of United States National Parks. Biol. Invasions 11:2195-2207.

Hiebert, R.D. and J. Stubbendieck. 1993. Handbook for ranking exotic plants for management and control. Natural Resources Report NPS/NRMWRO/NRR-93/08. U.S. Department of the Interior, National Park Service, Natural Resources Publication Office, Denver, Colorado.

Jakle, M.D. and T.A. Gatz. 1985. Herpetofaunal use of four habitats on the middle Gila River drainage, Arizona, pages 355-58 *in* Johnson, R. Roy; Ziebell, Charles D.; Patton, David R.; Ffolliott, Peter F.; Hamre, R. H., tech. coords. Riparian ecosystems and their management: reconciling conflicting uses. First North American riparian conference; 1985 April 16-18; Tucson, AZ. Gen. Tech. Rep. RM-GTR-120. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station. 523p.

National Park Service (NPS). 2009. National Park Service invasive species management (webpage). http://www.nature.nps.gov/biology/invasivespecies/. Accessed August 2012. Content last updated August 2009.

National Park Service (NPS). 2013. National Park Service, Natural Resource Stewardship and Science Directorate (website). Available: http://www.nature.nps.gov/index.cfm

Sheley, R.L. and J.K. Petroff. 1999. Biology and Management of Noxious Rangeland Weeds. Oregon State University Press. 460 p.

Trammel, M.A. and J.L. Butler. 1995. Effects of exotic plants on native ungulate use of habitat. J. Wildl. Manage. 59:808-16.

Young, C.C, J.L. Haack, J.T. Cribbs, K.E. Mlekush, and H.J. Etheridge. 2007. Invasive exotic plant monitoring at Pipestone National Monument: Year 1 (2006). Natural Resource Technical Report NPS/HTLN/NRTR—2007/002. National Park Service, Fort Collins, Colorado.

Young, C. C., M .F. Short, L. W. Morrison, C. S. Gross, and J. L. Haack. 2010. Invasive exotic plant monitoring at Pipestone National Monument: Year 2 (2009). Natural Resource Technical Report NPS/HTLN/NRTR—2010/294. National Park Service, Fort Collins, Colorado.

Wilcove, D.S., D. Rothstein, J. Dubow, A. Phillps, and E. Losos. 1998. Quantifying threats to imperiled species in the United States. BioScience 48:607-615.

4.15. Aquatic Macroinvertebrates

4.15.1. Background and Importance

Stonefly nymph. Stonefly nymphs are especially sensitive to changes in water quality (NPS 2010).

Macroinvertebrates are organisms that are visible to the naked eye. Aquatic macroinvertebrates complete all or part of their life cycle in water, and because of this are dependent on water quality (NYNRM 2013). Aquatic macroinvertebrates are an important component in the ecology of a water body because they are an essential part of the food chain in aquatic environments. Aquatic macroinvertebrates are often used as indicators of water quality and overall watershed health (EPA 2013). Some species are tolerant of pollution or poor water quality, while others are highly sensitive to it. The presence or absence of tolerant and intolerant taxa can therefore be an indication of a water body's condition and water quality (EPA 2013). Species diversity can also be an indicator of habitat health, as a diverse habitat with more ecological "niches" can generally support more species. For these reasons, aquatic macroinvertebrate indices are included in this condition assessment to indicate aquatic habitat diversity and suitability, condition of natural processes, and also as a proxy for water quality. Physical and chemical water quality attributes are examined in the *Water Quality* section of this report.

The various anthropogenic disturbances described in the following section have a significant potential for disrupting the ecological integrity and functioning of the Pipestone Creek ecosystem. To address these concerns, the National Park Service (NPS) began monitoring the aquatic invertebrates of Pipestone Creek within PIPE beginning in 1989 (Harris et al. 1991). From 1992-1995, the NPS Midwest Regional Office funded additional aquatic invertebrate sampling efforts within the creek. However, sampling was sporadic and mostly outside the collection season of interest (summer) for this report. Concerted monitoring efforts began in 1996-1997, following creation of the Prairie Cluster Prototype Long-term Ecological Monitoring Program, now known as the Heartland Inventory and Monitoring Network and Prairie Cluster Prototype Monitoring Program. Peitz and Cribbs (2005) reported on status and trends of the aquatic invertebrate community at PIPE from inception of monitoring through 2004, and Bowles (2009) reported on status and trends for 2005 to 2007. After the 2007 monitoring season, sampling frequency was decreased from three times every year to once every three years so that more parks within the network could be sampled (Bowles et al. 2008). This assessment examines the data collected at PIPE since the baseline year of 1989 and determines condition status and trends for individual aquatic invertebrate indicators and overall condition of the Pipestone Creek ecosystem.

Threats and Stressors
Water pollution within the watershed is primarily agricultural in origin, but the city of Pipestone, Minnesota releases effluent into Pipestone Creek below the monument boundary. The NPS, Water Resources Division, conducted an extensive review of historical water quality data for an area 4.8 kilometers upstream and 1.6 kilometers downstream of the park (NPS WRD 1999). This report noted that since 1974 dissolved oxygen, pH, cadmium, copper, lead, and zinc have periodically exceeded their respective EPA criteria for freshwater aquatic life use. Additionally, concentrations of nitrate, nitrite plus nitrate, chloride, cadmium, lead and methylene chloride have exceeded EPA drinking water criteria during monitoring events since 1974 (NPS WRD 1999). Pipestone Creek is also listed by the state of Minnesota as a 303d waterway due to fecal coliform contamination and elevated turbidity (Minnesota Pollution Control Agency 2007), because concentrations of these contaminants have exceeded limits for freshwater bathing and aquatic life uses, respectively. Altered hydrologic patterns due to drain tiling of agricultural fields upstream from the monument are a compounding stressor.

Indicators and Measures

Richness and Diversity

- Family Richness
- Genus Richness
- Genus Evenness
- EPT Richness
- EPT Ratio
- Shannon Index (or Shannon-Weiner Index)

Pollution Tolerance

- Hilsenhoff Biotic Index (HBI)

4.15.2. Data and Methods

Since 2006, methods and procedures used for sampling aquatic macroinvertebrates at PIPE follow Bowles et al. (2008), Monitoring Protocol for Aquatic Invertebrates of Small Streams in the Heartland Inventory & Monitoring Network. For sampling procedures prior to 2006, see Peitz and Cribbs (2005). The data addressed in this report are only those collected during the July-August index period from the general sampling reach described in Bowles et al. (2008), and it does not include all historical data summarized in Peitz and Cribbs (2005).

Three benthic invertebrate samples were collected from each of three successive riffles using a Surber stream bottom sampler (500 μm mesh, 0.093 m^2). Samples were sorted in the laboratory following a subsampling routine described in Bowles et al. (2008), and taxa were identified to the lowest practical taxonomic level (usually genus) and counted.

The primary interest in the analysis and interpretation of the data presented in this report is the magnitude of change rather than change per se (Bowles et al. 2008), and whether it represents something biologically important. Null hypothesis significance testing in the strict sense may not be the best approach given these goals (Morrison 2007). Therefore, 90% confidence intervals are shown to illustrate the general trend of invertebrate community metrics and provide a visual tool for managers to determine which variables may require more in-depth analyses or management action in the future.

Data collected from 1996 to 2010 are evaluated against the data collected during the baseline year of 1989. A trend analysis of invertebrate metrics data across years was conducted using a non-parametric Mann-Kendall trend test (α=0.05) (JMP Pro 10.0.0, SAS Institute Inc. 2012). The non-parametric Mann-Kendall test is directly analogous to linear regression, but it does not assume any particular distributional form and it tests whether Y values tend to increase or decrease with time (Esterby 1993, Helsel and Hirsch 2002, Stark and Fowles 2006). Stark and Fowles (2006) recommended the Mann-Kendall test over other trend tests for the evaluation of stream invertebrate samples. The Mann-Kendall test can detect either a positive or negative trend.

4.15.3. Reference Conditions

As previously mentioned, the data collected from PIPE in 1989 will be used in this report as reference values for the aquatic macroinvertebrate indicators that follow. The baseline values for diversity and pollution tolerance are listed in Table 4-60. Summary data from 1989-2007 for invertebrate community metrics, including family and genus richness, Ephemeroptera, Plecoptera, Trichoptera (EPT) richness, ETP/Chironomidae ratio, Shannon index, Shannon evenness index (genus evenness), and Hilsenhoff Biotic Index (HBI) are shown in Table 3 of Bowles (2009).

Table 4-60. Means and 90% confidence intervals for invertebrate metrics collected from Pipestone Creek, Pipestone National Monument in 1989. Genus evenness and Shannon Index at the genus level were not calculated for the 1989 monitoring year. The 1996 values are used as baselines for these latter indicators. N=10 (Bowles 2009).

Metric	Site Mean	CI_{90}
Family Richness	8.80	N/A; standard error was 0.00
Genus Richness	12.50	11.95 - 13.05
EPT Richness	3.10	2.92 - 3.28
EPT Ratio	0.63	0.54 - 0.72
Shannon Index	1.73	1.44 - 2.02
Genus Evenness	0.79	0.70 - 0.88
Hilsenhoff Biotic Index	5.32	5.06 - 5.58

4.15.4. Condition and Trend

The framework for determining resource condition ratings is shown in Table 4-61. These ratings are based on reference values obtained from best available data.

Table 4-61. Resource condition indicator rating framework for aquatic macroinvertebrate communities at Pipestone National Monument.

Indicator	Good Condition	Warrants Moderate Concern	Warrants Significant Concern
Family richness[1]	>10	5-10	<5
Genus richness[1]	>15	7-15	<7
Genus evenness	Unknown	Unknown	Unknown
EPT richness[2]	>14	8-14	<8
EPT ratio[3]	>0.75	0.25-0.75	<0.25
Shannon index[4]	>2.5	1-2.5	<1
Hilsenhoff biotic index[5]	0.00-4.25	4.26-6.50	6.51-10.00

[1]Bowles (2009): values for these metrics were obtained by combining the author's valuation of Pipestone Creek as "mildly impaired" with values of these metrics from 1989-2007

[2]Bukantis (1998)

[3]Vermont Department of Environmental Conservation Water Quality Division (2008): values from this report are from a small, high gradient stream and are used here as an estimate for PIPE. Confidence in these reference values are low

[4]Wilhm (1970)

[5]Hilsenhoff (1988).

Metric values from sampling in 2010 are shown in Table 4-62. The results of Mann-Kendall tests are shown in Table 4-63. The results of these tests will be used to indicate whether a trend is statistically significant or not. Results for individual indicators generally show that most annual means did not change substantially (Figures 4.14-1 to 4.14-8).

Table 4-62. Mean and 90% confidence interval of aquatic macroinvertebrate metrics collected from Pipestone Creek, Pipestone National Monument in 2010. N=9 is the total number of replicates sampled.

Metric	Site Mean	CI_{90}
Family Richness	15.44	13.53-17.34
Genus Richness	16.22	14.28-18.16
Genus Evenness	0.73	0.70-0.76
EPT Richness	4.78	4.60-4.96
EPT Ratio	0.72	0.62-0.82
Shannon Index	2.04	1.88-2.20
Hilsenhoff Biotic Index	6.56	6.26-6.86

Table 4-63. Results of Mann-Kendall testing for statistical significance of metric trends.

Metric	τ	*P*-value
Family Richness	0.43	**0.04**
Genus Richness	0.18	0.39
Genus Evenness	-0.05	0.81
EPT Richness	0.18	0.39
EPT Ratio	0.19	0.36
Shannon Index	0.67	0.17
Hilsenhoff Biotic Index	0.23	0.27

Family Richness

Family Richness is calculated as the sum of families represented in replicate samples. Family richness generally increases with improving water quality, habitat diversity, or habitat suitability (Rabeni et al. 1997). Means for family richness at Pipestone ranged from 3.33 to 10.00 between the 1989 and 2007 (Figure 4-79). In 2010, Family richness was measured at 15.44, indicating that the water quality and/or aquatic habitat condition of Pipestone Creek may be improving. Results of the Mann-Kendall trend statistic indicate that this trend is statistically significant.

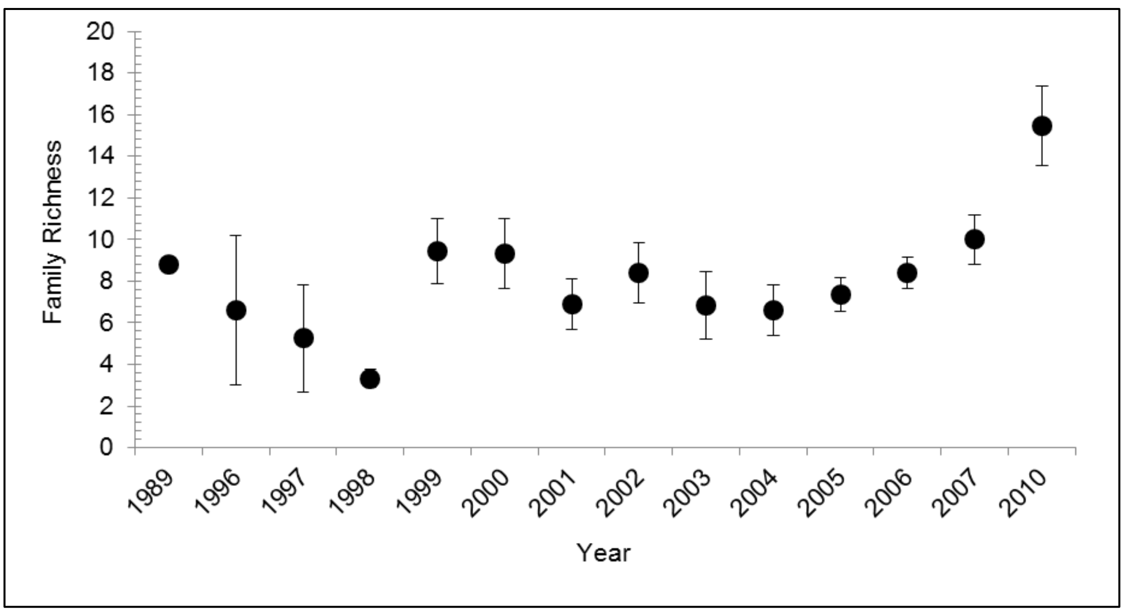


Figure 4-79. Yearly means and 90% confidence intervals for family richness at Pipestone Creek.

Taxa/Genus Richness

Genus Richness is calculated as the number of invertebrate genera present in a replicate sample. Lower genus richness may indicate habitat or water quality impairment (Resh and Grodhaus 1983). Means for genus richness at Pipestone ranged from 4.22 to 15.03 between the 1989 and 2007 (Figure

4-80). In 2010, genus richness was estimated at 16.22, indicating that the water quality and/or aquatic habitat condition of Pipestone Creek may be improving. However, this trend is not statistically significant.

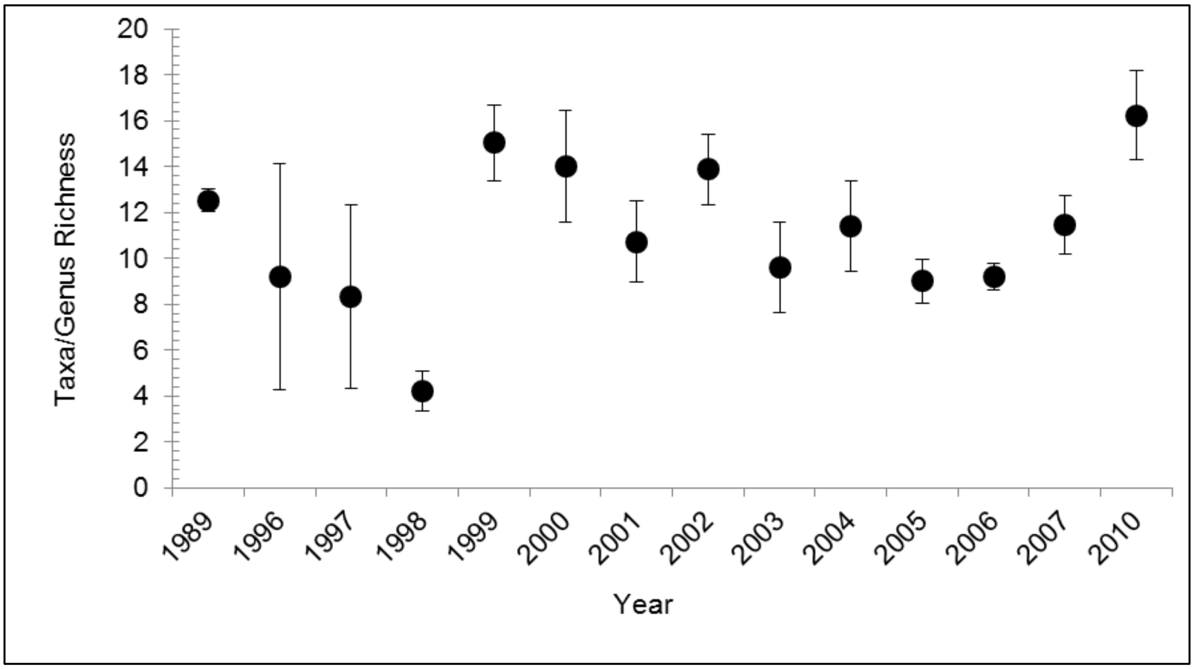


Figure 4-80. Yearly means and 90% confidence intervals for taxa/genus richness at Pipestone Creek.

<u>EPT Richness</u>

EPT Richness is calculated as the total number of genera in the insect orders Ephemeroptera, Plecoptera, and Trichoptera (EPT). Lower richness may indicate stream impairment. Most taxa in these three orders are intolerant to pollution (Resh and Jackson 1993). Means for EPT richness at Pipestone ranged from 1.23 to 6.20 between 1989 and 2007 (Figure 4-81). In 2010, EPT richness was measured at 4.78, within the relatively narrow range of values found between the years 1999 and 2007. Although these values have remained relatively constant since 1999, there seems to be an increase in EPT richness when compared to the baseline 1989 value. However, this trend is not statistically significant.

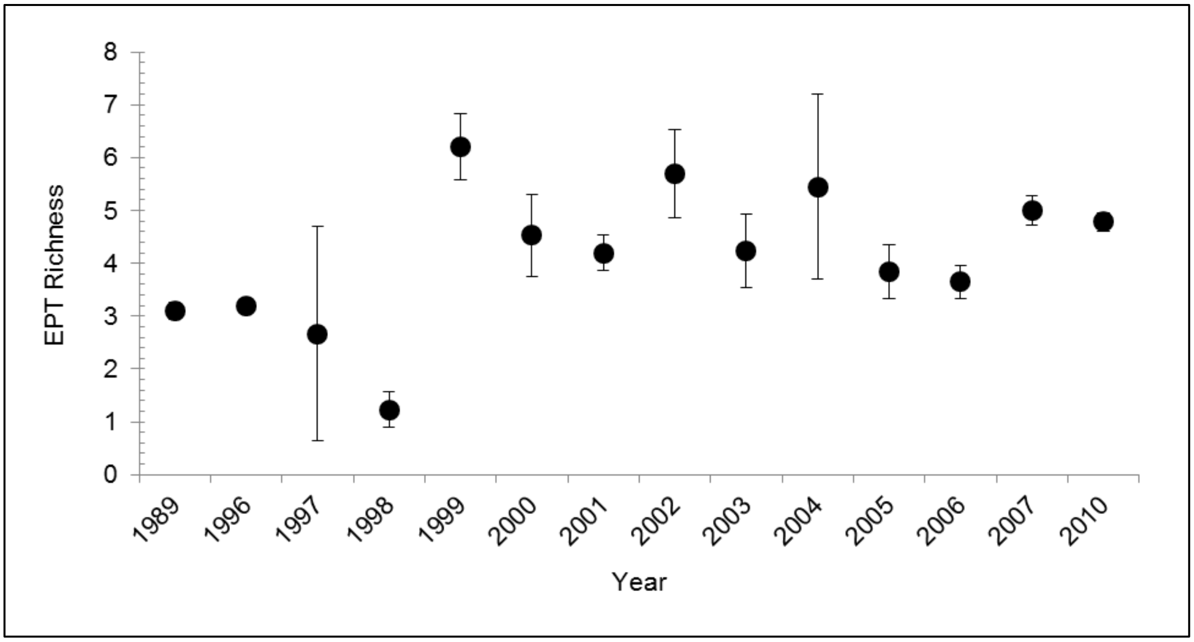


Figure 4-81. Yearly means and 90% confidence intervals for EPT richness for Pipestone Creek.

<u>EPT Ratio</u>

EPT Ratio is the ratio of Ephemeroptera, Plecoptera, and Trichoptera (EPT) abundance to Chironomidae abundance plus EPT abundance (EPT/(EPT + Chironomidae)). As discussed previously, EPT orders are generally intolerant of pollution. The Chironomidae (a family within the order Diptera, or true flies) often are more tolerant of disturbance and an increase in their density relative to EPT abundance may signal impairment (Peitz and Cribbs 2005).

Means for EPT ratio at Pipestone ranged from 0.21 to 0.77 between 1989 and 2007 (Figure 4-82). In 2010, EPT ratio was measured at 0.72. With the exception of 2006, EPT ratio has remained constant since 2003, and is not markedly higher than the baseline value of 0.63 in 1989. One reason EPT ratio has remained consistent while EPT richness has increased could be that the increases in family and genus richness discussed earlier were due to habitat improvements that allowed EPT and Chironomidae populations to increase simultaneously and proportionally.

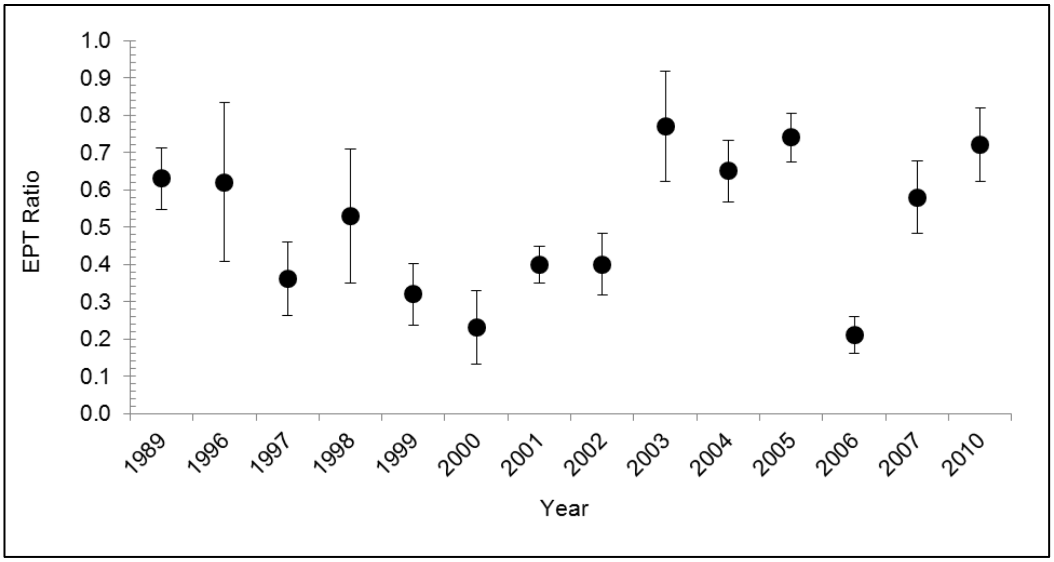


Figure 4-82. Yearly means and 90% confidence intervals for EPT Ratio at Pipestone Creek.

<u>Shannon Index</u>
Shannon Index as a measure of taxa diversity assesses how the total number of individuals in a sample is distributed among the total species in the sample. High diversity generally implies better stream condition and normally decreases with declining water quality because of reductions in both richness and evenness (Resh and Jackson 1993). This index is calculated for the genus level. The calculation of this index at the family level was discontinued in 2005.

Means for Shannon Index at Pipestone ranged from 1.24 to 1.73 between 2005 and 2007 (Figure 4-83). In 2010, Shannon Index was measured at 2.04, showing an increase in genus level diversity. However, this trend is not statistically significant.

<u>Genus Evenness</u>
Genus evenness is a measure of how evenly the total number of individuals in a sample is distributed across genera. Lower genus evenness may indicate that the water body has been subject to a disturbance and is being populated by fewer, pollution tolerant organisms (Peitz and Cribbs 2005). This metric is calculated using the values of the Shannon Index. Means for genus evenness at Pipestone ranged from 0.59 to 0.71 between 1996 and 2007 (Figure 4-84). In 2010, genus evenness was measured at 0.68, similar to other values measured during previous years.

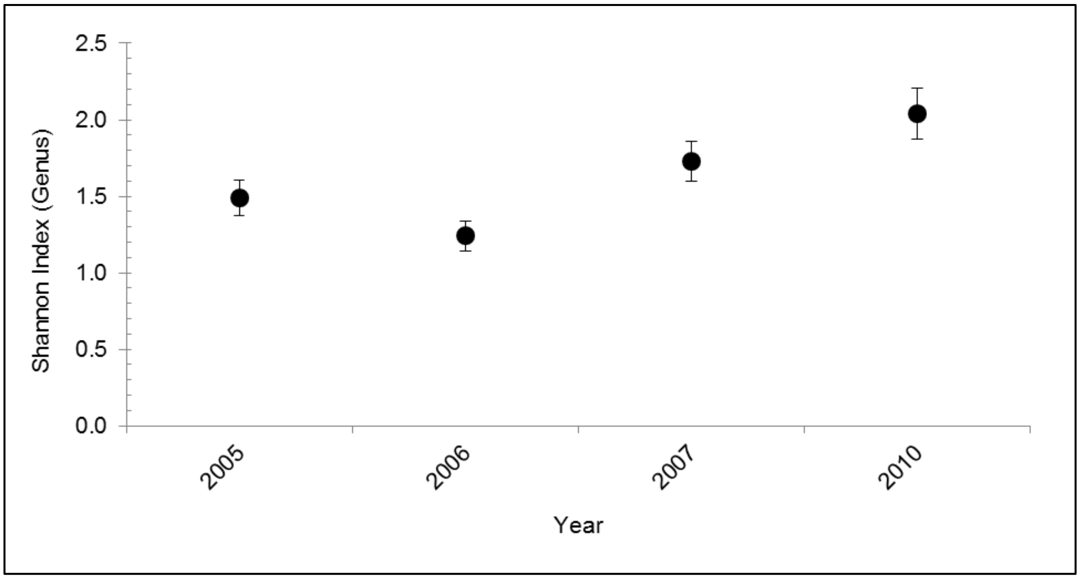


Figure 4-83. Yearly means and 90% confidence intervals for Shannon Index (genus level) at Pipestone Creek.

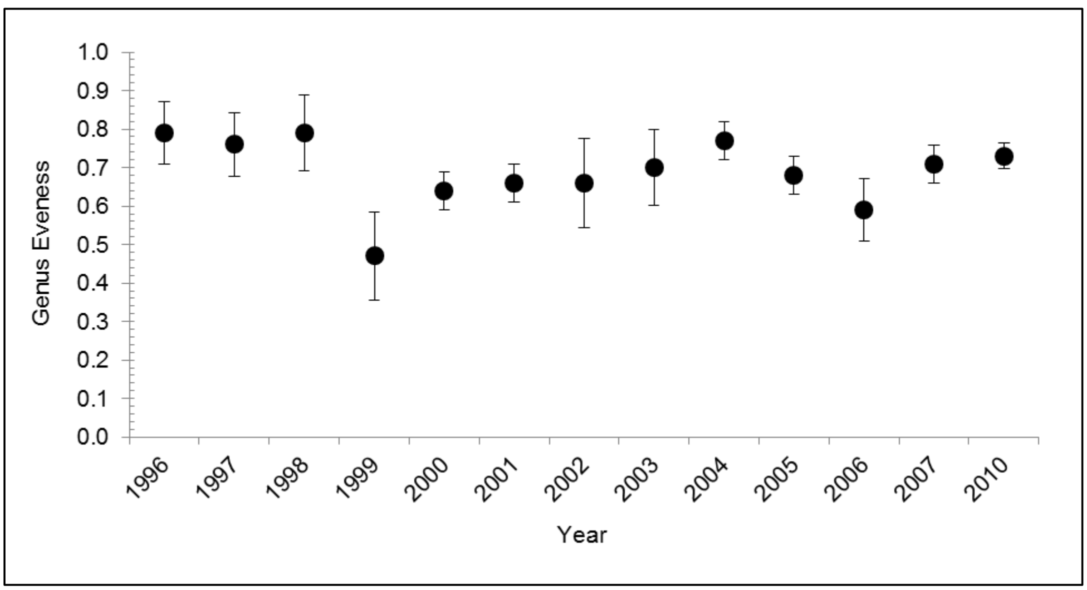


Figure 4-84. Yearly means and 90% confidence intervals for genus evenness at Pipestone Creek.

<u>Hilsenhoff Biotic Index</u>

The Hilsenhoff Biotic Index (HBI) was first developed by Hilsenhoff (1982) and subsequently modified by Hilsenhoff (1988). Each taxon is assigned a pollution tolerance value related to its assumed or known tolerance of water quality degradation. Tolerance values used in this report are adapted from Hilsenhoff (1988). HBI is an indicator of organic water pollution, such as from livestock or sewage. The HBI increases with increasing impairment (Table 4-60).

Means for Hilsenhoff Biotic Index (HBI) at Pipestone have ranged from 4.13 to 5.64 between 1989 and 2007 (Figure 4-85). In 2010, HBI was measured at 6.56, showing an increase in this metric in the last several years. The increase in this index may indicate an increase in organic pollutants. Although HBI has been increasing, the trend is not statistically significant.

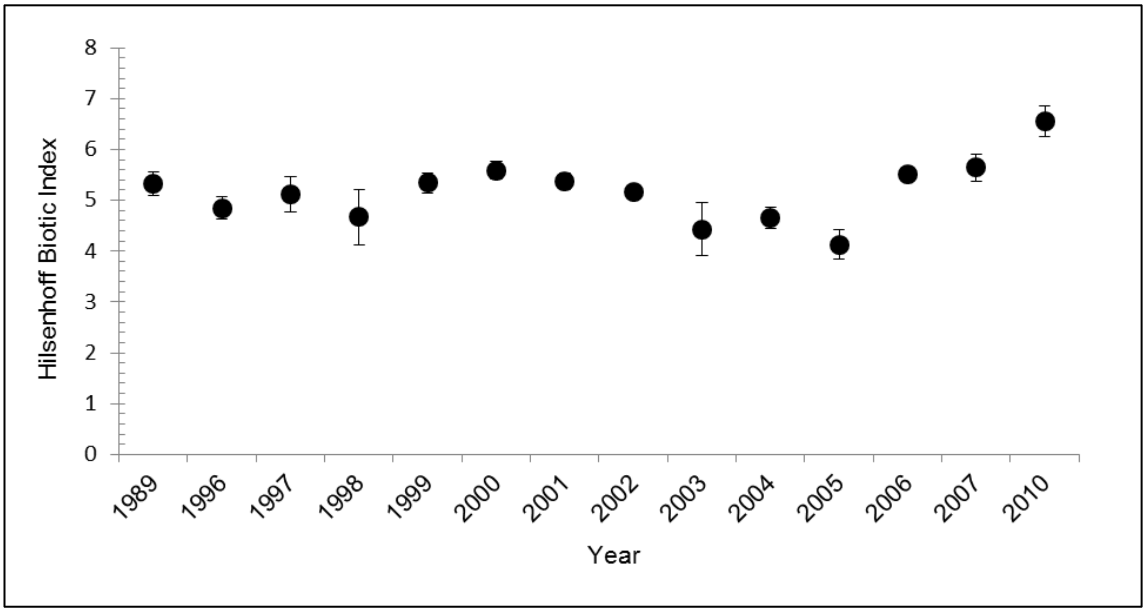


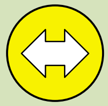
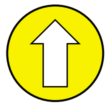
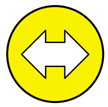
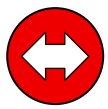
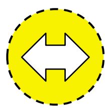
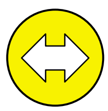
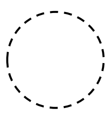
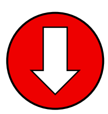
Figure 4-85. Yearly means and 90% confidence intervals for Hilsenhoff Biotic Index at Pipestone Creek.

<u>Overall Condition</u>
Based on the evaluation of aquatic macroinvertebrate metrics, condition of the resource warrants moderate concern, with an unchanging trend. Confidence in the assessment is medium. Impacts to aquatic macroinvertebrate communities appear to be largely from upstream sources that are out of NPS control (Table 4-64).

4.15.5. Uncertainty and Data Gaps
Although indicator reference values are not generally available for Pipestone Creek, the use of reference values for similar systems allowed for a condition status valuation with medium confidence. The exceptions to this were for genus evenness and EPT ratio, where a low confidence was given in the assessment due to lack of a reliable reference value for these indicators.

The trends for all indicators (with the exception of genus evenness) were inferred with a robust level of certainty given the sampling range (more than 20 years) and use of the Mann-Kendall non-parametric test to provide a quantitative assessment of trend. According to NPS guidelines, when a resource or metric is not given a condition rating due to low confidence, that resource or metric should also not be given a trend due to this lack of confidence.

Table 4-64. Condition and trend summary for aquatic macroinvertebrate community at PIPE.

Indicators	Condition Status/Trend	Rationale
Aquatic Macroinvertebrate Community (overall)		**Condition of the resource warrants moderate concern with an unchanging trend. Confidence in the assessment is medium.**
Family Richness		There was a slight upward trend from 2004 to 2007 with a marked increase in 2010. The slope for this upward trend is statistically significant, indicating an improving trend.
Taxa/Genus Richness		There was a slight upward trend from 2005 to 2007 with a marked increase in 2010. However, this trend was not found to be statistically significant.
EPT Richness		Means and confidence intervals for this metric are sporadic with no trend.
EPT Ratio		Means and confidence intervals for this metric are sporadic with no trend or change in condition. Confidence in the condition is low due to lack of reference data.
Shannon Index		Visually, there is an upward trend in this index. However, the trend is not statistically significant.
Genus Evenness		Genus evenness shows no trend. Genus Evenness for 2010 is similar to the initial year this metric was calculated in 2005. Current condition is unknown due to lack of availability of reference values for the Genus Evenness metric.
Hilsenhoff Biotic Index (HBI)		The confidence intervals for this metric indicate that HBI was markedly higher in 2010 than it was in 1989. HBI has also risen overall since 2003. An increase in this metric indicates an increase in organic pollution.

4.15.6. Sources of expertise

No outside sources of expertise were used for this section.

4.15.7. Literature cited

Bowles, D. E., M. H. Williams, H. R. Dodd, L. W. Morrison, J. A. Hinsey, C. E. Ciak, G. A. Rowell, M. D. DeBacker, and J. L. Haack. 2008. Monitoring protocol for aquatic invertebrates of small streams in the Heartland Inventory & Monitoring Network. Natural Resource Report NPS/HTLN/NRR—2008/042. National Park Service, Fort Collins, Colorado.

Bowles, D. E. 2009. Aquatic invertebrate monitoring at Pipestone National Monument: 2005-2007 trend report. Natural Resource Technical Report NPS/HTLN/NRTR—2009/241. National Park Service, Fort Collins, Colorado.

Bukantis, R. 1998. Rapid bioassessment macroinvertebrate protocols: sampling and sample analysis SOP's. Working draft, April 22, 1997. Montana Department of Environmental Quality. Planning Prevention and Assistance Division. Helena, Montana.

Environmental Protection Agency (EPA). 2013. Macroinvertebrates and habitat. http://water.epa.gov/type/rsl/monitoring/vms40.cfm (accessed 19 November 2013).

Esterby, S.R. 1993. Trend analysis methods for environmental data. Environmentrics 4:459-481.

Harris, M. A., B. C. Kondratieff, and T. P. Boyle. 1991. Invertebrate assemblages and water quality in six National Park units in the Great Plains. National Park Service, Water Resources Division, Fort Collins, Colorado.

Helsel, D.R., and R.M. Hirsch. 2002. Statistical methods in water resources techniques of water resources investigations, Book 4, chapter A3. U.S. Geological Survey.

Hilsenhoff, W.L. 1988. Rapid field assessment of organic pollution with a family-level biotic index. Journal of the North American Benthological Society 7:65-68.

Morrison, L. W. 2007. Assessing the reliability of ecological monitoring data: power analysis and alternative approaches. Natural Areas Journal 27:83–91.

Minnesota Pollution Control Agency. 2007. Pipestone Creek fecal coliform bacteria an turbidity total maximum daily load report. Available at: http://www.pca.state.mn.us/.

National Park Service Water Resources Division (NPS WRD). 1999. Baseline water quality data inventory and analysis: Pipestone National Monument. National Park Service, Water Resources Division, Fort Collins, Colorado.

Northern and Yorke Natural Resources Management (NYNRM). 2013. Water facts: water quality and macroinvertebrates. http://nynrm.sa.gov.au/portals/7/pdf/landandsoil/17.pdf (accessed 19 November 2013).

Peitz, D. G., and J. T. Cribbs. 2005. Bio-monitoring of water quality using aquatic invertebrates and in-stream habitat and riparian condition assessment: status report for Pipestone Creek, Pipestone National Monument, Minnesota 1989-2004. U.S. National Park Service, Heartland I&M Network and Prairie Cluster Prototype Monitoring Program, Wilson's Creek National Battlefield, Republic, Missouri.

Rabeni, C. F., R. J. Sarver, N. Wang, G. S. Wallace, M. Weiland, and J. T. Peterson. 1997. Development of regionally based biological criteria for streams of Missouri. A report to the Missouri Department of Natural Resources. Cooperative Fish and Wildlife Research Unit, 112 Stephens Hall, University of Missouri, Columbia, MO.

Resh, V.H. and G. Grodhaus. 1983. Aquatic insects in urban environments. Pages 247-276 *In* Urban Entomology: Interdisciplinary Perspectives. G.W. Frankie and C.S. Koehler, editors. Praeger Publishers, New York.

Resh, V. H., and J. K. Jackson. 1993. Rapid assessment approaches to biomonitoring using benthic macroinvertebrates. Pages 195-223 in D.M. Rosenberg and V.H. Resh, editors. Freshwater Biomonitoring and Benthic Macroinvertebrates. Chapman & Hall, NewYork, NY.

Stark, J. D., and C. R. Fowles. 2006. An approach to the evaluation of temporal trends in Taranaki state of the environment macroinvertebrate data. Report prepared for Taranaki Regional Council, Stratford, New Zealand.

Vermont Department of Environmental Conservation, Water Quality Division. 2008. Summary of biological and chemical assessments conducted in 2005 & 2007 within the Lamoille River and Missisquoi River watersheds in Lowell and Eden Vermont. http://www.anr.state.vt.us/dec/wastediv/sms/VAG/Reports/1014.Final2008VAGBASS.Summary.pdf. (Accessed 13 May 2014).

Wilhm, J. L. 1970. Range of diversity index in benthic macroinvertebrate populations. Journal of the Water Pollution Control Federation, 42(5), R221-&.

4.16. Bird Community

4.16.1. Background and Importance

Grassland and woodland birds are conspicuous components of those parks residing within prairie ecotones and compose an important natural resource within grassland parks of the Heartland Inventory and Monitoring Network (HTLN). In addition, grassland birds have been in consistent decline since the 1970s (Sauer et al. 2000). This decline has been caused by multiple factors including the conversion of grassland to other land cover types, habitat fragmentation, and mowing regimes (Lookingbill et al. 2012). In 2005, NPS formally recognized this decline and began taking actions to combat the loss of grassland birds (Peterjohn 2006). The NPS recommends a species-specific approach to park management of this critical resource that focuses on obligate grassland species. An obligate grassland bird is defined as "any species that has become adapted to and reliant on some variety of grassland habitats for part or all of its life" (Vickery et al. 1999).

Grassland bird populations are excellent indicators of environmental condition because individual species assemblages associate with specific grassland types, they occur across a continuum of anthropogenic disturbances, species assemblages are predictive of these disturbance levels, birds are easily detected and through the use of numerous standardized methods they are well researched, providing a baseline against which change can be assessed (Bibby et al. 2000, Canterbury et al. 2000, Browder et al. 2002, Bryce et al. 2002, NABCI 2009). In addition, birds are well liked by the public, the public can relate to concerns about bird communities, birding is a popular activity at most parks, and bird songs contribute to the natural soundscape.

The upland grassland habitat present at PIPE support wintering, feeding, and breeding populations of both resident and migrating avian species. Because of the rarity of non-agricultural lands in the region, PIPE is especially valuable by providing relatively unfragmented patches of native prairie that serve as a refuge within a highly altered agricultural landscape. Monitoring the change in avian community composition and abundance in these habitats is important for detecting ecosystem change. The habitat fragmentation and conversion of native vegetation to agricultural and urban landscapes occurring outside the park will negatively impact populations of some bird species resident to PIPE, particularly specialist species that have evolved within stable environments (Devictor et al. 2008, La Sorte 2006). Avian community composition and diversity should improve with the restoration of native prairie and woodland plant communities both within PIPE and within the surrounding landscape (Johnson 2006, Boren et al. 1999).

<u>Threats</u>

The threats at PIPE to the bird community include the conversion of habitats to agricultural and urban uses including cultivation and livestock grazing and residential, commercial, and industrial development locally, regionally and within the extent of migratory patterns (Hansen and Gryskiewicz 2003). These uses result in habitat loss, habitat fragmentation, water pollution and the disruption of hydrologic flow regimes. In turn, these modifications disrupt ecological functions important to ecosystem integrity and important to maintaining the community and composition of species at PIPE comparable to that of the natural habitat of the region (Jorgensen and Müller 2000). Consequently, the ecological functioning of PIPE depends upon maintaining the natural systems outside the monuments boundaries. These changes in land use are linked to ecological function by five mechanisms (Hansen and Gryskiewicz 2003):

1) land use activities reduces the functional size of a reserve, eliminating important ecosystem components lying outside the park boundary;
2) land use activities alter the flow of energy or materials across the landscape irrespective of the monuments political boundary, disrupting the ecological processes dependent upon those flows both outside and inside the monument and across its boundaries;
3) habitat conversion outside the reserve may eliminate unique habitats, such as seasonal habitats and migration corridors;
4) the negative influences of land use activities may extend into the reserve and create edge effects; and
5) increased population density may directly impact parks through increased recreation and human disturbance.

Indicators and Measures

- Native species richness (S)
- Bird index of biotic integrity (IBI)
- Occurrence and status of bird species of conservation concern

4.16.2. Data and Methods

The HTLN has implemented long-term monitoring of birds at parks within the HTLN network including PIPE. The purpose of this monitoring is to track changes in bird community composition and abundance, and to monitor bird response to changes in habitat structure and other habitat variables related to management activities (Peitz et al. 2008). In 2009, the HTLN began systematic surveys of breeding birds and their habitat at PIPE as part of the HTLN program. Monitoring was conducted every year at a subsample of 68 permanent sites arranged in a systematic grid of 100 x 100 meter cells (originating from a random start point) (Peitz 2010). This grid was rotated 45 degrees from north to avoid station survey points from being impacted by roads, fences and other structures (Figure 4-86). Peitz (2010) classified all 68 of the permanent plots as grassland. For this analysis, the seven sites numbered 9, 21, 27, 28, 33, 34, 40 were classified as woodland, while the other 61 sites were analyzed as grassland. Data from the 61 grassland sample sites were used to determine the condition of the grassland bird community while the other seven sites were used to determine condition of the woodland bird community. The number of sites sampled per year varied, ranging from 28 to 61 for the grassland sites and 6 to 7 for the woodland sites. Variable circular plot methodology was used, wherein all birds seen or heard at plots during 3 to 5-min sampling periods were recorded along with their corresponding distance from the observer (Peitz et al. 2008).

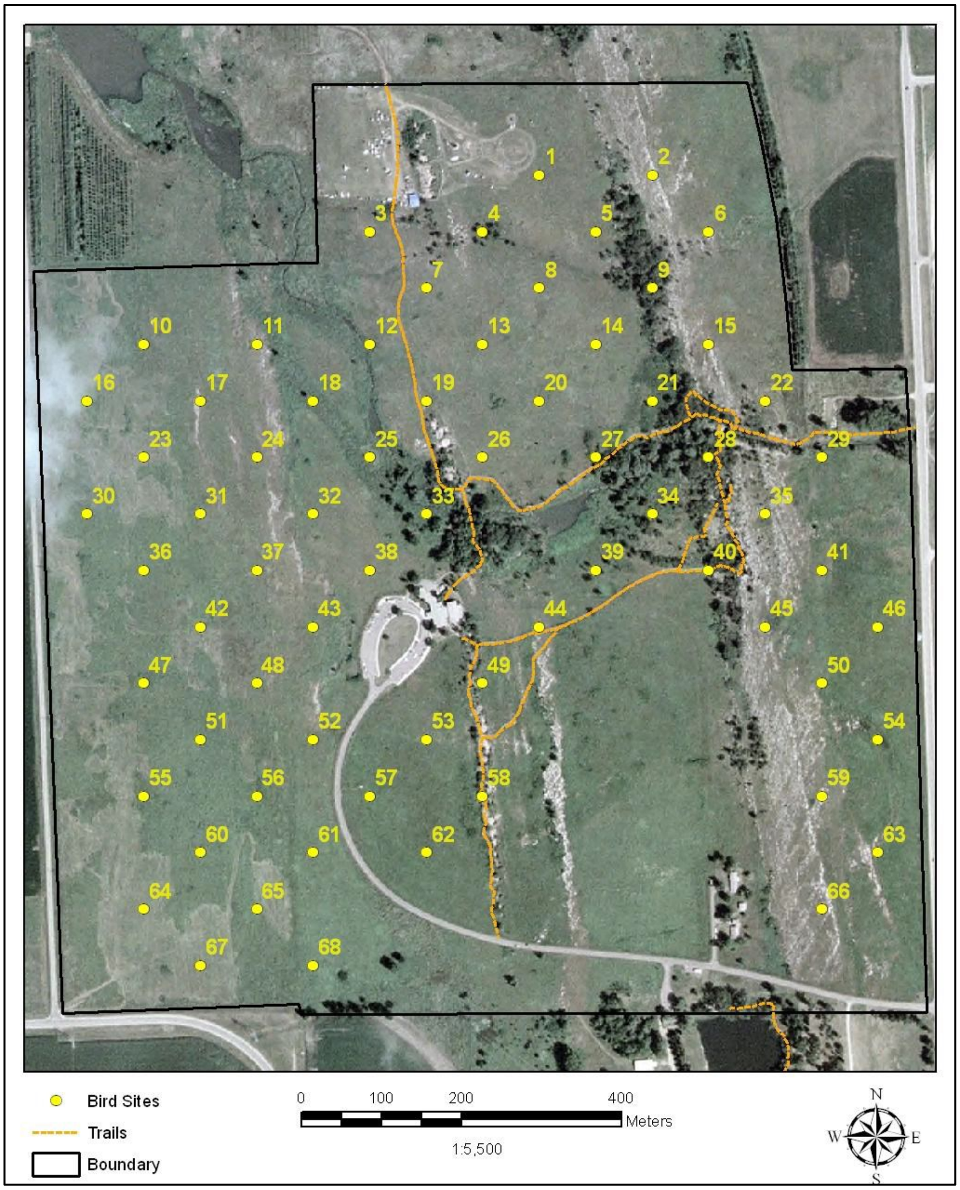


Figure 4-86. Bird plot locations on Pipestone National Monument, Minnesota (Peitz 2010).

To evaluate trends over time, we compared the occurrence of species detected during the initial survey conducted at PIPE in 2009 to species detected during the 2012 survey. We compared species richness between the two years, 2009 and 2012, separately for the grassland and woodland sample sites. Only native species were included in calculations of species richness, as the inclusion of exotic/non-native species would make interpretation of richness results problematic from a biotic integrity standpoint.

Bird Index of Biotic Integrity (IBI) values were calculated separately for the grassland and woodland samples, and included a guild for exotic/non-natives and compared this index between the years 2009 and 2012. The bird IBI is based on the methodology developed for bird communities of the mid-Atlantic Highlands (O'Connell et al. 1998a). It is important to note that the bird IBI was modified from O'Connell et al. (1998a) to reflect the land-use and land-cover types of the HTLN (e.g., grassland for the grassland IBI and riparian woodland for the woodland IBI and pasture and row crop, urban and suburban area for both IBIs). Specialist guilds included in the IBI tend to be associated with either extensive grassland cover or extensive woodland cover. Therefore, higher IBI scores reflect bird communities associated with aspects of mature grassland structure, function, and composition for the grassland IBI and mature woodland structure, function, and composition for the woodland IBI. For example, sites with higher grassland bird IBI scores consist of a bird community with more grassland-dependent species, ground cleaners, and single-brooded or open ground nesters (i.e. specialists) but with fewer omnivores, exotic/non-natives, nest predators/brood parasites and residents (i.e. generalists). An extensive discussion for why these guilds are chosen over others can be found in Standard Operating Procedure #9 – Bird Community Index (Marshall et al. undated).

The biotic or ecological "condition" described by the bird IBI, then moves along a disturbance gradient from relatively intact, extensive, mature grassland or woodland with high IBI scores to more disturbed, developed or urban grassland or woodland with low IBI scores. Some riparian forest birds were recorded at the grassland sample sites, however, forest guilds (i.e. bark prober, upper-canopy forager, lower-canopy forager, aerial screener, aerial sallier, canopy nester, forest-ground nester, forest generalist, interior forest obligate, and riparian dependent) were not used to calculate the grassland bird IBI score. The reverse was true of the woodland sites and grassland guilds (i.e. grassland ground cleaner, grassland ground nester, and grassland dependent) were not used to calculate the woodland bird IBI. The response guilds incorporated into the grassland and woodland bird IBIs are listed in Table 4-65.

<u>Conservation Context – The Occurrence and Status of Species of Conservation Concern</u>
Our intent for this context was to determine which species that occur at PIPE are considered as species of concern at either a national or local scale, 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 conserving those species. This analysis was restricted to those species that were either breeding at the monument or that were residents. Those species occurring at the monument during migration only and incidental occurrences of species outside of their normal range were excluded.

To identify priority conservation species we used lists developed by Partners in Flight (PIF), a cooperative effort among federal, state and local government agencies that identifies and assesses species of conservation concern based on biological criteria including population size, breeding distribution, non-breeding distribution, threats to breeding, threats to non-breeding, and population trend (Panjabi et al. 2005). PIF assessments are conducted at both the national and regional scale. At the national scale, the PIF North American Landbird Conservation Plan identifies what are considered "Continental Watch List Species" and "Continental Stewardship Species" (Rich et al. 2004). Conservation Watch List Species are considered by PIF as those with the greatest need for conservation 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 significant percentage of their world breeding and/or nonbreeding population (i.e., breeding population for migratory birds) confined to a specific avifaunal biome.

Avifaunal biomes are adjoining areas in North America that share similar avifaunas as identified through cluster analysis (Rich at al. 2004). We consulted the PIF Conservation Watch List and Stewardship species list to identify birds at PIPE that are of national conservation priority.

Table 4-65. Bird species guilds used to calculate IBI scores.

Biotic Integrity Element	Guild Category	Response Guild	Number of Species in Guild	Guild Classification
Grassland IBI				
Functional	Trophic	omnivore	26	generalist
	Insectivore Foraging Behavior	grassland ground gleaner	10	specialist
Compositional	Origin	exotic/non-native	4	generalist
	Migration Status	resident	20	generalist
		temperate migrant	21	generalist
	Number Of Broods	single-brooded	34	specialist
	Population Limiting	nest predator/brood parasite	6	generalist
Structural	Nest Placement	grassland ground nester	20	specialist
		shrub nester	11	generalist
	Primary Habitat	grassland dependent	6	specialist
Woodland IBI				
Functional	Trophic	omnivore	12	generalist
	Insectivore Foraging Behavior	bark prober	0	specialist
		upper canopy forager	0	specialist
		lower canopy forager	5	specialist
		aerial sallier	0	specialist
		aerial screener	3	specialist
Compositional	Origin	exotic/non-native	1	generalist
	Migration Status	resident	11	generalist
		temperate migrant	10	generalist
	Number Of Broods	single-brooded	14	specialist
	Population Limiting	nest predator/brood parasite	6	generalist
Structural	Nest Placement	canopy nester	8	specialist
		forest ground nester	0	specialist
		shrub nester	8	generalist
	Primary Habitat	forest generalist	4	generalist
		interior forest obligate	0	specialist
		riparian dependent	3	specialist

PIF has also adopted Bird Conservation Regions (BCRs), after the North American Bird Conservation Initiative. BCRs are ecologically distinct regions in North America with similar bird communities, habitats and resource management issues. Regional bird conservation plans are developed by PIF using the BCRs as the unit of planning and the same principles of concern (Watch List and Continental Stewardship species) are applied at the scale of the BCR. This approach recognizes that some species may be declining dramatically at the local scale, even though they are not of high concern nationally. PIPE is within the Northern Tallgrass Prairie physiographic area and the conservation plan for this area was also consulted to identify those bird species that are of conservation priority within the local area, but may not be of national concern (Fitzgerald et al. 1998).

4.16.3. Reference Conditions
Little historical survey data exists for Pipestone National Monument. Bird surveys using the point count method at eight sample points were conducted at PIPE in 1998 (Powell 2000). A more comprehensive and statistically rigorous sample using methods described in Peitz et al. (2008) was first implemented in 2009. Bird reference condition for both the grassland and woodland sample sites is based on the initial HTLN 2009 bird survey results. Maintaining or exceeding the level of biodiversity as defined by initial calculation of native species richness (as an index of diversity) and the initial quality of bird community composition as defined by the initial IBI score are considered good condition. A condition rating framework for birds is shown in Table 4-66.

The grassland Bird IBI score reflects a disturbance gradient from relatively intact and extensive grassland with high IBI scores to more disturbed, developed or urban grassland with low IBI scores. To calculate the IBI score, species are first assigned to guilds (some species may be assigned to more than one guild, depending on their life history traits). The proportional species richness of each guild is then calculated by dividing the number of species detected within a specific guild by the total number of species detected. The next step in the bird IBI is to rank each category of proportional species richness for each guild on a scale of 5 (high integrity) to 0 (low integrity) (O’Connell et al. 1998a, 1998b, 2000). For specialist guilds, the highest- occurrence category is ranked a “5,” the next highest a “4,” etc. For generalist guilds, the ranking is reversed; a “5” is assigned to the lowest-occurrence category. Therefore, a site can receive a rank of “5” for a guild if the site supports the highest category of proportional species richness for a specialist guild or the lowest category of proportional species richness for a generalist guild. The final bird IBI score is then calculated by summing the rank for each guild’s proportional species richness, across all guilds.

A community at the theoretical maximum high IBI score, or highest integrity, consists of a bird community with only specialist guilds and without any generalist guilds. The integrity represented by a particular IBI score is based upon a theoretical maximum community at PIPE receiving a grassland bird IBI score of 44 and the theoretical minimum community, a score of 10, which corresponds to either only species from “specialist guilds” being detected or only species from “generalist guilds” being detected, respectively. Similarly calculated, the theoretical maximum and minimum woodland bird IBI scores at PIPE are 86 and 23.5, respectively. As with the grassland bird community, a woodland bird community with a high IBI score will contain more specialist guild members and fewer generalist guild members.

Threshold levels for bird IBI scores have not been rigorously defined, but O'Connell et al. (2000) established thresholds that include four categories of condition corresponding to the proportional species richness of each specialist guild and generalist guild. For the grassland bird IBI score at PIPE these thresholds include the following categories: 1) excellent (highest integrity) – score of 34.1-44.0; 2) good (high integrity) – score of 29.1-34.0; 3) fair (medium integrity) – score of 22.1-29.0; and 4) poor (low-integrity rural and low-integrity urban) – score of 10.0-22.0. For the woodland bird IBI the values and ranges for these corresponding four categories were: 1) 67.1-86.0, 2) 58.1-67.0, 3) 45.1-58.0, and 4) 23.5-45.0. The condition classes were modified to determine the resource condition indicator scoring for the PIPE bird IBI (Table 4-66) using a three-tiered rating system.

We also compared the candidate list of species of concern to the actually list of species observed at PIPE during the 2012 survey. We used the number of species of concern recorded in the initial survey year of 2001 as the reference condition for comparison. The condition of the resource is considered higher if more species of concern are observed. This implies that the populations of those species are increasing and/or they are using the park more.

Table 4-66. Resource condition rating framework for grassland birds at Pipestone National Monument.

		Condition Status	
Indicator	**Resource is in Good Condition**	**Condition Warrants Moderate Concern**	**Condition Warrants Significant Concern**
Native Species Richness (S)			
Grassland birds	>85-100+ % of 2009 value	70-85% of 2009 value	<70% of 2009 value
Woodland birds	>85-100+ % of 2009 value	70-85% of 2009 value	<70% of 2009 value
Index of Biotic Integrity			
Grassland birds	29.1 – 44.0	22.1 – 29.0	10.0 – 22.0
Woodland birds	58.1 – 86	45.1 – 58.0	23.5 – 45.0
Bird Species of Conservation Concern			
Grassland birds	85-100+ % of 2009 value	70-85% of 2009 value	<70% of 2009 value
Woodland birds	85-100+ % of 2009 value	70-85% of 2009 value	<70% of 2009 value

4.16.4. Condition and Trend

<u>Grassland Birds</u>

Species Richness

A total of 41 native species and 43 species in total were recorded at grassland sampling stations in 2012. The most common species was the common grackle (*Picoides pubescens*). The bobolink (*Dolichonyx oryzivorus*), ring-necked pheasant (*Phasianus colchicus*), red-winged blackbird

(*Agelaius phoeniceus*) and American goldfinch (*Carduelis tristis*) were all moderately common (Table 4-67). This total is more than the 34 native and 35 total species that were recorded during the 2009 bird survey at PIPE (Table 4-67).

Table 4-67. Bird species recorded in 2012 and 2009 at prairie survey stations on Pipestone National Monument.

			Number observed	
Common name	**Species name**	**AOU code**	**2012**	**2009**
American coot	*Fulica americana*	AMCO	16	0
American crow	*Corvus brachyrhynchos*	AMCR	14	9
American goldfinch	*Carduelis tristis*	AMGO	127	65
American robin	*Turdus migratorius*	AMRO	115	71
Bank swallow	*Carpodacus mexicanus*	BANS	0	12
Barn swallow	*Hirundo rustica*	BARS	89	7
Belted kingfisher	*Megaceryle alcyon*	BEKI	2	0
Black-capped chickadee	*Poecile atricapillus*	BCCH	7	0
Blue jay	*Cyanocitta cristata*	BLJA	2	0
Blue-winged teal	*Anas discors*	BWTE	51	0
Bobolink[2]	*Dolichonyx oryzivorus*	BOBO	206	188
Brown thrasher[1]	***Toxostoma rufum***	**BRTH**	**0**	**13**
Brown-headed cowbird	*Molothrus ater*	BHCO	57	60
Canada goose	*Branta canadensis*	CAGO	0	44
Cedar waxwing	*Bombycilla cedrorum*	CEDW	0	3
Chipping sparrow	*Spizella passerina*	CHSP	9	0
Clay-colored sparrow[2]	*Spizella pallida*	CCSP	58	31
Common grackle	*Picoides pubescens*	COGR	241	119
Common yellowthroat	*Geothlypis trichas*	COYE	84	0
Dickcissel[1]	***Spiza americana***	**DICK**	**107**	**1**
Eastern kingbird	*Archilochus colubris*	EAKI	28	8
Eastern meadowlark[2]	*Sturnella magna*	EAME	9	9
European starling	*Sturnus vulgaris*	EUST	29	0
Field sparrow	*Spizella pusilla*	FISP	24	29

[1] Bolded names are those Partners in Flight species considered of continental importance.

[2] Highlighted names are those Partners in Flight Priority Species for Physiographic Area 40: The Northern Tallgrass Prairie.

Table 4-67 (continued). Bird species recorded in 2012 and 2009 at prairie survey stations on Pipestone National Monument.

Common name	Species name	AOU code	Number observed 2012	Number observed 2009
Grasshopper sparrow[1]	***Ammodramus savannarum***	**GRSP**	**73**	**44**
Gray catbird	*Dumetella carolinensis*	GRCA	0	4
Great blue heron	*Ardea herodias*	GBHE	7	3
Green (green-backed) heron	*Butorides striatus*	GRHE	33	0
Henslow's sparrow[1]	***Ammodramus henslowii***	**HESP**	**6**	**0**
House wren[2]	*Troglodytes aedon*	HOWR	5	1
Killdeer	*Charadrius vociferus*	KILL	26	2
Mallard	*Anas platyrhynchos*	MALL	22	4
Mourning dove	*Zenaida macroura*	MODO	33	28
Northern (Baltimore) oriole	*Icterus galbula*	BAOR	25	0
Northern (Yellow-shafted) flicker[2]	*Colaptes auratus*	YSFL	4	1
Northern harrier	*Circus cyaneus*	NOHA	0	8
Northern rough-winged swallow	*Stelgidopteryx serripennis*	NRWS	19	13
Northern shoveler	*Anas clypeata*	NSHO	0	18
Red-winged blackbird	*Agelaius phoeniceus*	RWBL	154	81
Ring-necked pheasant	*Phasianus colchicus*	RPHE	165	61
Savannah sparrow	*Passerculus sandwichensis*	SAVS	15	0
Sedge wren[2]	*Cistothorus platensis*	SEWR	51	10
Song sparrow	*Melospiza melodia*	SOSP	19	4
Swainson's hawk[1]	***Buteo swainsoni***	**SWHA**	**4**	**0**
Tree swallow	*Tachycineta bicolor*	TRES	46	19
Upland sandpiper	*Bartramia longicauda*	UPSA	0	1
Western meadowlark	*Sturna neglecta*	WEME	35	14
White-crowned sparrow	*Zonotrichia leucophrys*	WCSP	0	7
Wild turkey	*Meleagris gallopavo*	WITU	24	0
Wood duck[2]	*Aix sponsa*	WODU	27	0
Yellow warbler	*Setophaga petechia*	YWAR	17	0
Yellow-headed blackbird[1]	***Xanthocephalus xanthocephalus***	**YHBL**	**38**	**0**

[1] Bolded names are those Partners in Flight species considered of continental importance.

[2] Highlighted names are those Partners in Flight Priority Species for Physiographic Area 40: The Northern Tallgrass Prairie.

The slope of the linear regression line for native grassland bird species richness was positive and statistically significant ($r^2 = 0.27$, $p < 0.05$), suggesting an increasing trend in the richness of the grassland bird community at PIPE. However, the 90 percent confidence intervals for annual native species richness for the years 2009 to 2012 overlap, suggesting richness has remained stable since 2009, when monitoring was first initiated at PIPE (Figure 4-87). In 2012, there were 41 native grassland bird species recorded at PIPE, greater than the management target of 35, the number recorded in 2009 when monitoring was initiated at PIPE.

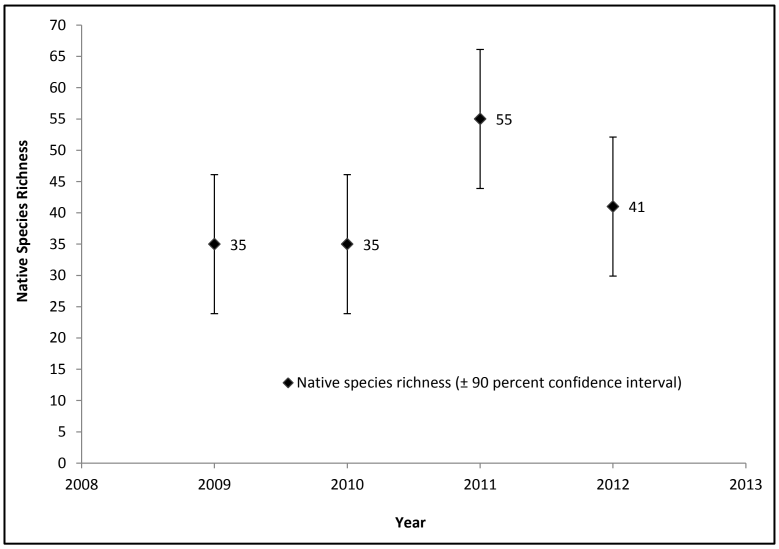


Figure 4-87. The trend in native grassland bird species richness at Pipestone National Monument from 2009 to 2012 with 90 percent confidence intervals.

<u>Index of Biotic Integrity</u>

The Bird IBI score in 2012 was 26.5 compared to the 2009 score of 30.0. This IBI score indicates that composition of the bird community at PIPE is in moderate condition (Table 4-66). The slope of the linear regression line for the grassland bird IBI scores was negative, but insignificant indicating stability in the biotic integrity of the bird community between 2009 and 2012. The 90 percent confidence intervals for the scores overlap, also suggesting the biotic integrity of the bird community has remained stable since 2009, when monitoring was first initiated at PIPE (Figure 4-88). In 2012, the grassland IBI score at PIPE was 26.5, less than the management target of $\geq$ 30.0, which was the score recorded in 2009, the initial year of monitoring at PIPE.

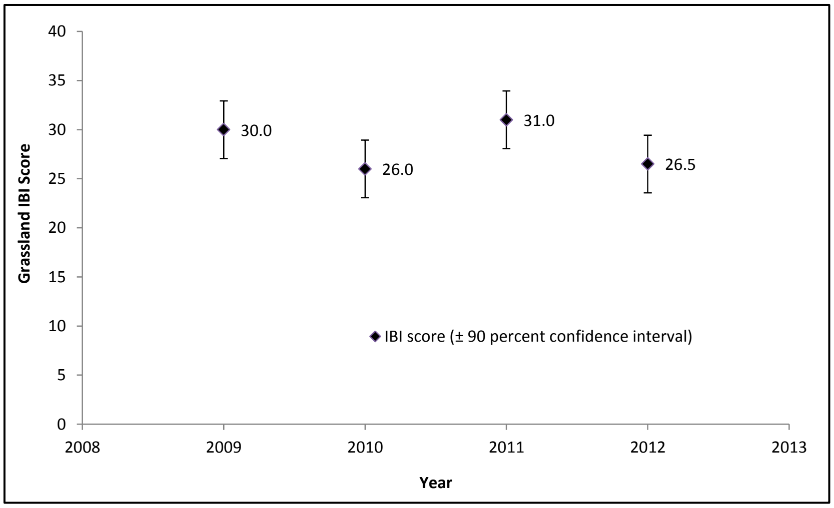


Figure 4-88. Mean grassland bird species IBI scores at Pipestone National Monument from 2009 to 2012 with 90 percent confidence intervals.

Species of Concern

Nine species recorded during the 2012 grassland bird survey are listed as Partner in Flight birds of concern (Rich et al. 2004, Fitzgerald et al. 1998), which is three less than the 12 species of concern reported in 2009 (Table 4-67). Eight grassland obligate species were recorded at PIPE in 2012 including the bobolink, dickcissel (*Spiza Americana*), eastern meadowlark (*Sturnella magna*), grasshopper sparrow (*Ammodramus savannarum*), Henslow's sparrow (*Ammodramus savannarum*), sedge wren (*Cistothorus platensis),* upland sandpiper (*Bartramia longicauda*) and western meadowlark (*Sturna neglecta*). This is the same as the eight grassland obligate species recorded in 2009 with Henslow's sparrow being substituted for the northern harrier (*Circus cyaneus*) in the 2012 survey list. The most common species of concern recorded at PIPE in 2012 were the boblink and dickcissel. Most of the species of concern increased in number from the 2009 survey to the 2012 survey (Table 4-67).

The slope of the linear regression line for the grassland bird species of concern was positive, but insignificant, suggesting a stable trend in the number of bird species of concern present at PIPE. The 90 percent confidence intervals for the number of species of concern all overlap, also suggesting their numbers have remained stable since 2009, when monitoring was first initiated at PIPE Figure 4-89). In 2012, bird species of concern at PIPE numbered 12, more than the management target of ≥ 9, the score recorded in 2009 when monitoring was initiated at PIPE.

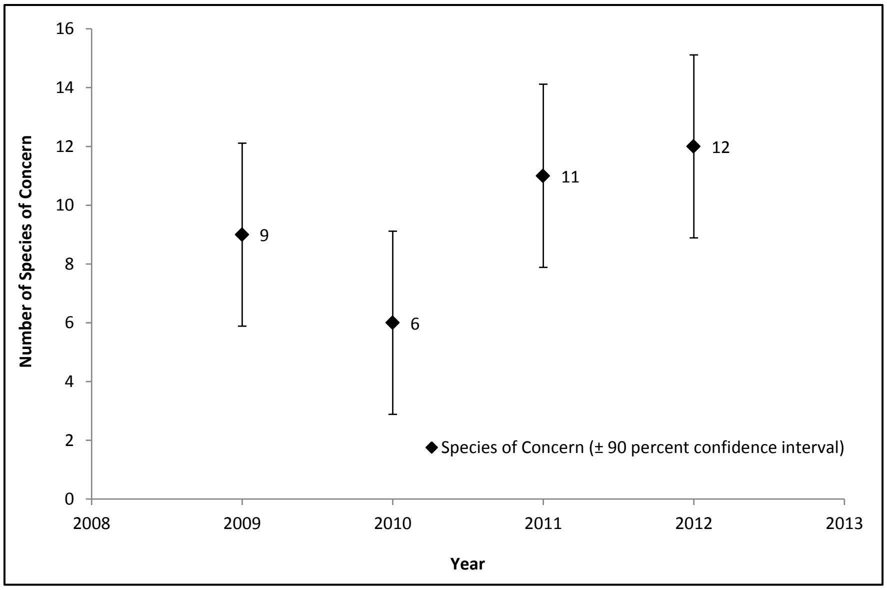


Figure 4-89. Mean number of grassland bird species of concern at Pipestone National Monument from 2009 to 2012 with 90 percent confidence intervals.

<u>Woodland Birds</u>

Species Richness

A total of 20 species were recorded at grassland sampling stations in 2012, the most common species was the common grackle (*Picoides pubescens*). The American robin (*Turdus migratorius*), mourning dove (*Zenaida macroura*) and American goldfinch (*Carduelis tristis*) were all moderately common. This total is similar to the 19 species that were recorded during the 2009 bird survey at PIPE (Table 4-68). The slope of the linear regression line for native woodland bird species richness was positive, but not statistically significant, suggesting a stable trend in the richness of the woodland bird community at PIPE. The 90 percent confidence intervals for annual native species richness for the years 2009 to 2012 all overlap, also suggesting native species richness has remained stable since 2009, when monitoring was first initiated at PIPE (Figure 4-90). In 2012, there were 19 native woodland bird species recorded at PIPE, greater than the management target of 18, the number recorded in 2009 when monitoring was initiated at PIPE.

Table 4-68. Bird species recorded in 2012 and 2009 at woodland survey stations on Pipestone National Monument.

Common name	Species name	AOU code	Number observed 2012	Number observed 2009
American crow	*Corvus brachyrhynchos*	AMCR	4	0
American goldfinch	*Carduelis tristis*	AMGO	19	10
American robin	*Turdus migratorius*	AMRO	23	19
Barn swallow	*Hirundo rustica*	BARS	5	0
Belted kingfisher	*Megaceryle alcyon*	BEKI	0	1
Black-capped chickadee	*Poecile atricapillus*	BCCH	11	0
Blue jay	*Cyanocitta cristata*	BLJA	2	0
Brown thrasher[1]	***Toxostoma rufum***	**BRTH**	**0**	**4**
Brown-headed cowbird	*Molothrus ater*	BHCO	9	27
Canada goose	*Branta canadensis*	CAGO	7	9
Cedar waxwing	*Bombycilla cedrorum*	CEDW	7	0
Clay-colored sparrow[2]	*Spizella pallida*	CCSP	10	10
Common grackle	*Picoides pubescens*	COGR	28	9
Common nighthawk	*Chordeiles minor*	CONI	7	0
Common yellowthroat	*Geothlypis trichas*	COYE	0	5
Dickcissel[1]	***Spiza americana***	**DICK**	**1**	**1**
Eastern kingbird	*Archilochus colubris*	EAKI	4	0
Field sparrow	*Spizella pusilla*	FISP	5	5
Gray catbird	*Dumetella carolinensis*	GRCA	0	6
House wren[2]	*Troglodytes aedon*	HOWR	14	1
Killdeer	*Charadrius vociferus*	KILL	0	2
Mallard	*Anas platyrhynchos*	MALL	0	1
Mourning dove	*Zenaida macroura*	MODO	20	0
Northern (Baltimore) oriole	*Icterus galbula*	BAOR	15	0
Red-winged blackbird	*Agelaius phoeniceus*	RWBL	0	17
Ring-necked pheasant	*Phasianus colchicus*	RPHE	6	9
Tree swallow	*Tachycineta bicolor*	TRES	5	0
Yellow warbler	*Setophaga petechia*	YWAR	0	15
Yellow-rumped warbler	Dendroica coronata	MYWA	0	5

[1] Bolded names are those Partners in Flight species considered of continental importance.

[2] Highlighted names are those Partners in Flight Priority Species for Physiographic Area 33: The Osage Plains.

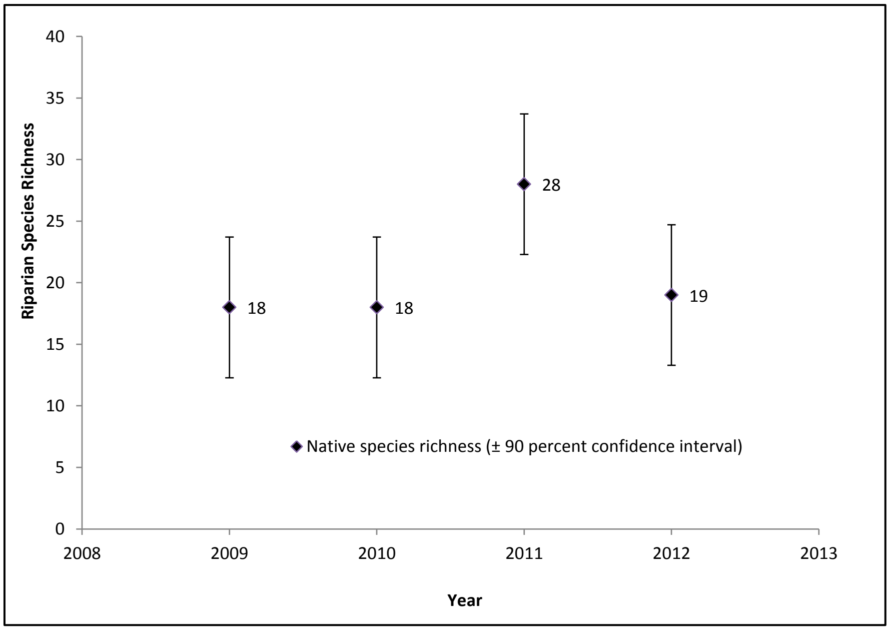


Figure 4-90. Mean woodland bird species richness at Pipestone National Monument from 2009 to 2012 with 90 percent confidence intervals.

Index of Biotic Integrity

The bird IBI score in 2012 of 43.5, although higher than the 2009 score of 35.5, indicates that composition of the riparian woodland bird community at PIPE is of low integrity (Table 4-66). The slope of the linear regression line for the grassland bird IBI scores is positive, but not statistically significant, suggesting a stable trend in the IBI scores at PIPE. The 90 percent confidence intervals for the scores all overlap, also suggesting the scores have remained stable since 2009, when monitoring was first initiated at PIPE (Figure 4-91). In 2012, the woodland IBI score at PIPE was 43.5, greater than the management target of ≥ 35.5, the score recorded in 2009 when monitoring was initiated at PIPE.

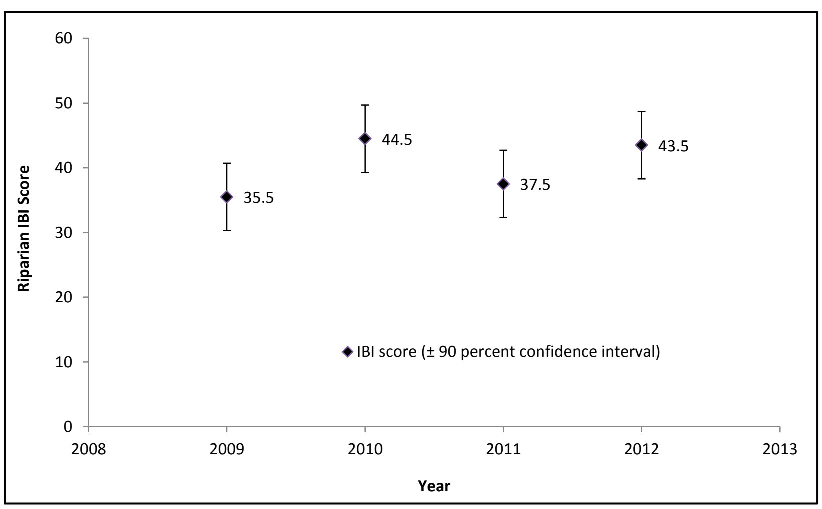


Figure 4-91. Mean woodland bird species IBI scores at Pipestone National Monument from 2009 to 2012 with 90 percent confidence intervals.

Species of Concern

Three species found at PIPE during the 2012 riparian woodland bird survey are listed as Partner in Flight birds of concern (Rich et al. 2004, Fitzgerald et al. 1998). This is similar to the four species of concern recorded in 2009 at PIPE, the initial year of monitoring (Table 4-68, Figure 4-92). No riparian obligate species were observed at PIPE in 2012, but the belted kingfisher (*Megaceryle alcyon*), mallard (*Anas platyrhynchos*) and red-winged Blackbird (*Agelaius phoeniceus*) were recorded in 2009. The most common species of concern recorded and their habitats at PIPE in 2012 were the house wren (*Troglodytes aedon*) (open woodland, shrubland, farmland and suburbs) and clay-colored sparrow (*Spizella pallida*) (open grassland habitats, with sparsely scattered trees or shrubs). Another PIF species of concern, the brown thrasher (*Toxostoma rufum*), was recorded in 2009 but not in 2012 (Table 4-68).

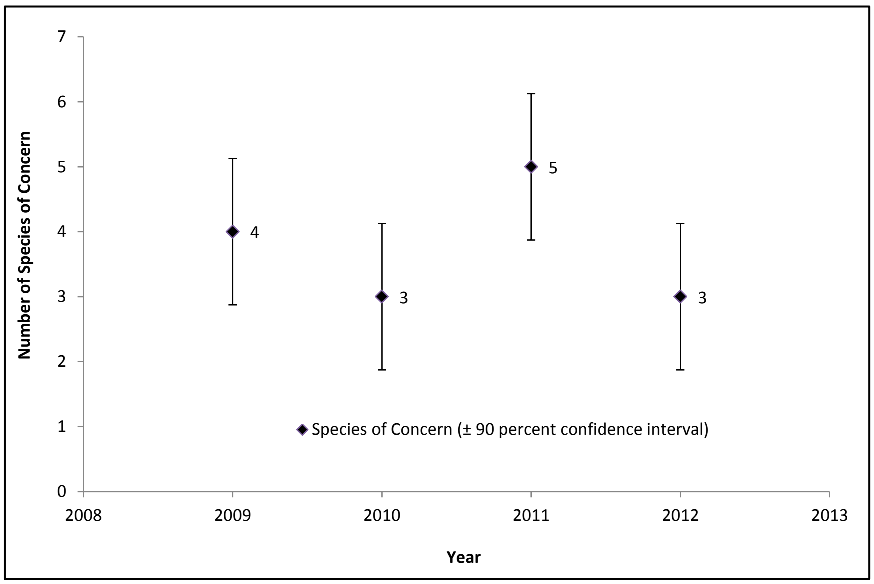


Figure 4-92. Mean number of grassland bird species of concern at Pipestone National Monument from 2009 to 2012 with 90 percent confidence intervals.

Overall Condition and Trend

The values for the metrics of native species richness, the bird IBI, and the number of species of concern present in 2012 indicate that the condition of the bird communities at PIPE warrants moderate concern, with a number of obligate grassland birds and a community structure that is representative of a moderately disturbed landscape (Table 4-69). Additionally, the values for these metrics calculated for the years 2009 to 2012, suggest a stable trend in bird community diversity and structure at PIPE. The overall condition of the bird community is good with an unchanging trend; confidence in the assessment is medium. The overall rating is weighted toward the result for grassland birds.

Table 4-69. Condition and trend summary for birds at Pipestone National Monument.

Indicator	Condition Status/Trend	Rationale
All Birds (overall)		**Condition is good with an unchanging trend. Confidence in the assessment is medium.**
Grassland Birds (overall)		**Condition is good with an unchanging trend. Confidence in the assessment is medium.**
Native Species Richness (S)		Native grassland bird species richness has fluctuated between 35 and 55 species from 2009 to 2012 with richness equaling 41 in 2012. Analysis of the bird monitoring data indicates that native species richness increased between 2009 and 2012.
Bird Index of Biotic Integrity		The grassland bird IBI score was 26.5 (medium integrity) in 2012. Analysis of the grassland bird IBI scores between 2009 and 2012 indicates that the biotic integrity of the bird community has remained stable during this time period.
Species of Conservation Concern		The number of bird species of concern fluctuated between 6 and 12 species between 2009 and 2012 with 12 species of concern present in 2012. Analysis of the data for the bird species of concern indicates stability in their number.
Woodland Birds (overall)		Condition is good with an unchanging trend. Confidence in the assessment is medium.
Native Species Richness (S)		Native woodland bird species richness has fluctuated between 18 and 28 species from 2009 to 2012 with richness equaling 19 in 2012. Analysis of the bird monitoring data indicates that native species richness remained stable between 2009 and 2012.
Bird Index of Biotic Integrity		The woodland bird IBI score was 43.5 (low integrity) in 2012. Analysis of the grassland bird IBI scores between 2009 and 2012 indicates that the biotic integrity of the bird community has remained stable during this time period.
Species of Conservation Concern		The number of woodland bird species of concern fluctuated between 3 and 5 species between 2009 and 2012 with 3 species of concern present in 2012. Analysis of the data for the number of bird species of concern present indicates a stable trend in the number present.

4.16.5. Sources of Expertise

David Peitz, Wildlife Ecologist, Heartland I&M Network. David is responsible for collecting the monitoring data at PIPE upon which this assessment is based and also for leading the design of the protocol used to monitor birds in the network.

4.16.6. Data Gaps and Uncertainty

Confidence in this assessment was medium as is the confidence in the trend analyses. The key uncertainty related to the assessment of the bird community at PIPE is in the limited years of data upon which the assessment is based. Assessments using species richness, biotic integrity, and the presence of species of concern should be use longer-term data than the four years of monitoring data available for this assessment. Comprehensive data collected over an extended time period is needed to assess the natural temporal fluctuation of the condition indicators used in this assessment and to assure the accuracy of the assessment (Dornelas et al. 2012). However, comprehensive data are not available for the bird community at PIPE. Also, this assessment is based upon monitoring data collected over multiple years by multiple observers with varying skills in conducting point counts. This variation could introduce measurement error into the data, leading to bias in the detection probabilities of different observers. This bias can reduce the ability to identify statistically significant trends in the indicators (Dornelas et al. 2012).

The bias associated with data collection could be reduced by establishing a training program for all data collectors and by retaining collectors over multiple years. Another factor affecting the quality of the data is the probability that a bird that is present during the time the point count is occurring is detected. The protocols used for monitoring birds in the HTLN rely on a 5-minute count interval, extending the interval to 10 minutes would improve the probability of detecting a species, but because points are surveyed only once per year, there is always the chance that rare or less vocal species go undetected. This can be a problem when calculating the index of biotic integrity, which is calculated based on the number of species within different guilds.

4.16.7. Literature Cited

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

Boren J. C., D. M. Engle, M. W. Palmer, R. E. Masters and T. Criner. 1999. Land use change effects on breeding bird community composition. Journal of Range Management 52:420-430.

Browder, S.F., D.H. Johnson, and I.J. Ball. 2002. Assemblages of breeding birds as indicators of grassland condition" (2002). USGS Northern Prairie Wildlife Research Center. Paper 201. http://digitalcommons.unl.edu/usgsnpwrc/201

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

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

Dornelas, M., A. E. Magurran, S. T. Buckland, A. Chao, R. L. Chazdon, R. K. Colwell, T. Curtis, K. J. Gaston, N. J. Gotelli, M. A. Kosnik, B. McGill, J. L. McCune, H. Morlon, P. J. Mumby, L. Ovreas, A. Studeny and M. Vellend. 2012. Quantifying temporal change in biodiversity: challenges and opportunities. Proceedings of The Royal Society B 280, 1-10.

Devictor V., R. Julliard, J. Clavel, F. Jiguet, A. Lee and D. Couvet. 2008. Functional biotic homogenization of bird communities in disturbed landscapes. Global Ecology and Biogeography 17, 252-261.

Fitzgerald, J A., N. Pashley, S. J. Lewis and B. Pardo. 1998. Partners in Flight bird conservation plan for the Northern Tallgrass Prairie (Physiographic Area 40): Version 1.0. PIF Midwest Region, Brentwood, Missouri.

Hansen, A. and D. Gryskiewicz. 2003. Interactions between Heartland National Parks and surrounding land use change: development of conceptual models and indicators for monitoring. Final Report to the National Park Service Heartland Network. 72 pp.

Johnson, T. N. 2006. Ecological restoration of tallgrass prairie: grazing management benefits plant and bird communities in upland and riparian habitats. Masters of Science thesis, Kansas State University. Manhattan Kansas. 84 pp.

Jorgenson, S. E. and F. Muller (eds.). 2000. Handbook of Ecosystem Theories and Management. CRC Press. Boca Raton, Florida.

La Sorte, F.A. 2006. Geographical expansion and increased prevalence of common species in avian assemblages: implications for large-scale patterns of species richness. Journal of Biogeography 33:1183–1191.

Lookingbill T., C.N. Bentsen, T.J.B. Carruthers, S. Costanzo, W.C. Dennison, C. Doherty, S. Lucier, J. Madron, E. Poppell, and T. Saxby. 2012. Colonial National Historical Park natural resource condition assessment. Natural Resource Report NPS/COLO/NRR—2012/544. National Park Service, Fort Collins, Colorado.

Marshall, M., Mattsson, B., Callahan, K., and T. Master. Undated. standard operating procedures for the streamside bird monitoring protocol for the Eastern Rivers and Mountains Network. Available from http://science.nature.nps.gov/im/units/ermn/monitor/streambirds.cfm (accessed August 2013).

North American Bird Conservation Initiative (NABCI), U.S. Committee. 2009. The state of the birds, United States of America, 2009. U.S. Department of the Interior, Washington, D.C.

O'Connell, T. J., L. E. Jackson and R. P. Brooks. 1998a. A bird community index of biotic integrity for the mid-Atlantic Highland. Environmental Monitoring and Assessment 51:145-156.

O'Connell, T. J., L. E. Jackson and R. P. Brooks. 1998b. The bird community index: a tool for assessing biotic integrity for the mid-Atlantic Highlands, final report. Penn State Cooperative Wetlands Center, Report No. 98-4. Forest Resources Laboratory, Pennsylvania State University, University Park, PA 16802, USA. 57 pp.

O'Connell, T. J., L. E. Jackson and R. P. Brooks. 2000. Bird guilds as indicators of ecological condition in the central Appalachians. Ecological Applications 10:1707-1721.

Panjabi, A. O., E. H. Dunn, P. J. Blancher, W. C. Hunter, B. Altman, J. Bart, C. J. Beardmore, H. Berlanga, G. S. Butcher, S. K. Davis, D. W. Demarest, R. Dettmers, W. Easton, H. Gomez de Silva Garza, E. E. Inigo-Elias, D. N. Pashley, C. J. Ralph, T. D. Rich, K. V. Rosenberg, C. M.

Rustay, J. M. Ruth, J. S. Wendt, and T. C. Will. 2005. The Partners in Flight handbook on species assessment. Version 2005. Partners in Flight Technical Series No. 3. Rocky Mountain Bird Observatory website. Available at: http://www.rmbo.org/pubs/downloads/Handbook2005.pdf.

Powell, A. N. 2000. Grassland bird inventory of seven prairie parks. Final report to the Great Plains Prairie Cluster Long-Term Ecological Monitoring Program, National Park Service, Wilson's Creek National Battlefield, Republic, Missouri. 47 p.

Peitz, D.G. 2010. Bird community monitoring at Pipestone National Monument, Minnesota: 2009 status report. Natural Resource Data Series NPS/HTLN/NRDS—2010/045. National Park Service, fort Collins, Colorado.

Peitz, D.G., G.A. Rowell, J.L. Haack, K.M. James, L.W. Morrison, and M.D. DeBacker. 2008. Breeding bird monitoring protocol for the Heartland Network Inventory and Monitoring Program. Natural Resource Report NPS/HTLN/NRR- 2008/044. National Park Service, Fort Collins, Colorado.

Peterjohn, B. 2006. Conceptual ecological model for management of breeding grass-land birds in the Mid-Atlantic region. Natural Resources Report NPS/NER/NRR–2006/005. National Park Service, Philadelphia, PA.

Rich, T. D., C. J. Beardmore, H. Berlanga, P. J. Blancher, M. S. W. Bradstreet, G. S. Butcher, D. W. Demarest, E. H. Dunn, W. C. Hunter, E. E. Iñigo-Elias, J. A. Kennedy, A. M. Martell, A. O. Panjabi, D. N. Pashley, K. V. Rosenberg, C. M. Rustay, J. S. Wendt, T. C. Will. 2004. Partners in Flight North American landbird conservation plan. Cornell Lab of Ornithology. Ithaca, NY. Partners in Flight website. http://www.partnersinflight.org/cont_plan/ (VERSION: March 2005).

Sauer, J. R., J. E. Hines, I. Thomas, J. Fallon, and G. Gough. 2000. The North American breeding bird survey, results and analysis 1966 – 1999. Version 98.1, USGS Patuxent Wildlife Research Center, Laurel, Maryland. Available at http://www.mbrpwrc. usgs.gov/bbs/bbs.html.

Vickery, P. D., J. R. Herkert, F. L. Knopf, J. Ruth, & C. E. Keller. 1999. Grassland birds: an overview of threats and recommended management strategies. Pp. 74-77 In: Strategies for bird conservation: the Partners In Flight planning process (R. Bonney, D. N. Pashley, R. J. Cooper, and L. Niles, eds.). RMRS-P-16. U.S. Department of Agriculture, Forest Service.

4.17. Fish Community

4.17.1. Background and Importance

The National Park Service protects, preserves, and manages biological resources and related ecosystem processes in the national park system including aquatic resources. Prairie stream fish are components of these aquatic systems and are important components of grassland parks of the Heartland Inventory and Monitoring Network (HTLN). North American freshwater fish, including prairie stream fish, have been in decline since the early 20th century (Hoagstrom et al. 2006, Jelks et al. 2008, Barrineau et al. 2010). This decline has been caused by multiple factors including conversion of uplands to cropland or livestock pasture (beginning in 1880) (Knopf and Samson 1996), habitat fragmentation caused by reservoir construction (beginning in the 1950s), reduced discharge caused by groundwater withdrawal (beginning in the 1960s), and invasion by non-native fishes (Gido et al. 2010). In 2001, NPS formally recognized the decline of the Topeka shiner at HTLN Parks. In 2008 this concern was extended to all native fish and actions were initiated to combat the loss of prairie stream fish (Dodd et al. 2008). The NPS recommends an approach to managing this critical resource that focuses on monitoring the prairie stream fish community to understand community condition and trend and how they correlate with management actions.

Prairie stream fish populations are excellent indicators of environmental condition because certain species are intolerant of chemical pollutants or habitat changes, making their assemblages indicative of water and habitat quality (Pflieger 1997, Barbour et al. 1999, Schrank et al. 2001). For this reason, fish community composition offers an indication of stream environmental health. In addition, fish offer recreational opportunities to the public making their status a valuable interpretive topic for park visitors.

NPS lands provide some of the least impacted stream habitat remaining in the Midwest and streams at PIPE offer quality habitat for native fishes (Dodd et al. 2010a). Because of the rarity of non-agricultural lands in the region, PIPE is especially valuable by providing relatively undisturbed patches of stream habitat critical for sustaining native prairie fishes within a highly altered agricultural landscape (Dodd et al. 2008). The habitat fragmentation and conversion of native vegetation to agricultural and urban landscapes occurring outside the park will negatively impact populations of some fish species resident to PIPE, particularly intolerant species that have evolved within stable environments (Knopf and Samson 1996, Gido et al 2010). Fish community composition and diversity should improve with restoration projects, such as native prairie restoration, water treatment plants, flow modifications, dam removal, or cessation of groundwater pumping both within PIPE and within the surrounding landscape (Gido et al. 2010).

<u>Threats</u>

The fish community at PIPE has been affected by habitat destruction, degradation, modification, fragmentation, and introduced predaceous fish (NPS 2008). Agriculture and development in the surrounding landscape have resulted in siltation, reduced water quality, tributary impoundment, stream channelization, instream gravel mining, and changes in stream hydrology (NPS 2008). The combined and interacting effects of these influences have resulted in population declines and range reduction of freshwater fish not only at PIPE, but also in the area surrounding the park.

Protection of freshwater biodiversity is difficult because it is influenced by the upstream drainage network, the surrounding land, and activity in the riparian zone (Dudgeon et al. 2006). The modifications to the surrounding landscape disrupt ecological functions important to ecosystem integrity and important to maintaining the community and composition of species at PIPE comparable to that of the natural habitat of the region (Jorgensen and Müller 2000). Consequently, the ecological functioning of PIPE depends upon maintaining the natural systems outside the park boundaries. These changes in land use are linked to ecological function at PIPE by five mechanisms (Hansen and Gryskiewicz 2003):

1) land use activities reduces the functional size of a reserve, eliminating important ecosystem components lying outside the park boundary;
2) land use activities alter the flow of energy or materials across the landscape irrespective of the park political boundary, disrupting the ecological processes dependent upon those flows both outside and inside the park and across its boundaries;
3) habitat conversion outside the reserve may eliminate unique habitats, such as seasonal habitats and migration corridors;
4) the negative influences of land use activities may extend into the park and create edge effects; and
5) increases in human population density may directly impact parks through increased recreation and human disturbance.

<u>Indicators and Measures</u>

- Native species richness (S)
- Fish index of biotic integrity (IBI)
- Occurrence and status of fish species of conservation concern

4.17.2. Data and Methods

The HTLN has implemented long-term monitoring of fish at parks within the HTLN network including PIPE (Dodd et al. 2008). The purpose of this monitoring is to determine the status and long-term trends in fish community composition and abundance, and to correlate this community data to water quality and habitat conditions. This allows for monitoring how fish respond to alterations in habitat structure and other habitat variables related to land use changes and management activities (Dodd et al. 2008). In 2001, the HTLN began systematic surveys of fish and their habitat at PIPE as part of the HTLN program (Dodd et al. 2010b). The number of stream reaches sampled per year varied, ranging from 4 (2001 to 2006) to 2 (2007 to 2011) (Figure 4-93). Data from both the 4 reaches sampled from 2001 to 2006 and the two sampled from 2007 to 2011 (reaches in yellow Figure 4-93) were used to determine the condition of the fish community. Because the number of sites sampled was not equivalent across years, the mean values of the indicators per sample reach were used to assess condition and trend in the fish community at PIPE. Fish sampling was conducted in August and September using a common sense seine. All fish were counted and identified to species and starting in 2006, 30 individuals per species at each reach were also measured and weighed, and any diseases or anomalies were recorded.

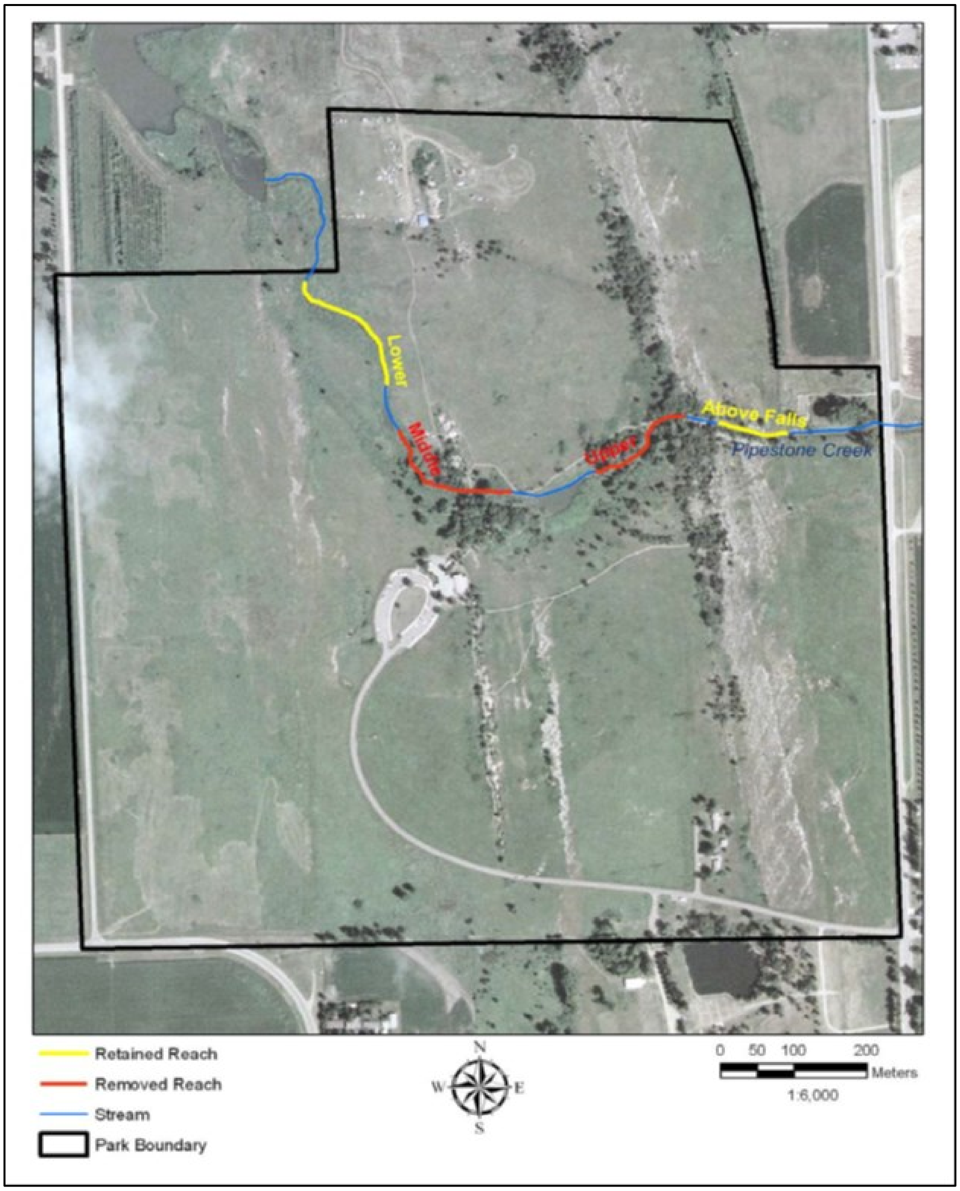


Figure 4-93. Fish sample reach locations on Pipestone National Monument, Minnesota (Dodd et al. 2010b).

To evaluate trends over time, we compared the occurrence of species detected during the initial survey conducted at PIPE in 2001 to species detected during the 2011 survey. Only native species were included in calculations of species richness, as the inclusion of exotic/non-native species would make interpretation of richness results problematic from a biotic integrity standpoint.

Fish Index of Biotic Integrity (IBI) values were calculated and compared between the years 2001 and 2011. The fish IBI is based on methodology developed for fish communities of the Ozark Highland streams (Dauwalter et al. 2003). It is important to note that the fish IBI was modified from Dauwalter et al. (2003) to reflect the prairie stream fish species that are present at PIPE. Specialist guilds included in the IBI tend to be associated with more pristine and less degraded freshwater habitats.

Therefore, higher IBI scores reflect fish communities associated with habitats where water quality is high and with fewer land-use changes in the upland affecting instream conditions. For example, sites with higher fish IBI scores consist of a fish community with more insectivores; carnivores; darter, sculpin and madtom species; and lithophilic spawners (i.e. specialist guilds), but with fewer algivorous/herbivorous, invertivorous and piscivorous species; green sunfish, bluegill, yellow bullhead and channel catfish (i.e. generalist guilds); and with less occurrence of black spot or other anomalies. An extensive discussion for why these guilds are chosen over others can be found in Dauwalter et al. (2003).

The biotic or ecological "condition" described by the fish IBI, then moves along a disturbance gradient from a relatively intact, pristine, high water quality stream with high IBI scores to more disturbed, developed or urban landscape with lower water quality and with low IBI scores. Classification of the fish species observed at PIPE into trophic and reproductive behavior guilds followed the classifications of Smogor and Angermeier (1999) as reported in Dauwalter et al (2003). The response guilds incorporated into the fish IBIs are listed in Table 4-70.

Table 4-70. Fish species guilds used to calculate the IBI score.

Biotic Integrity Element	Guild Category	Response Guild	Guild Classification
Functional	Trophic composition	percent algivorous/herbivorous, invertivorous and piscivorous	generalist
		percent invertivorous	specialist
		percent carnivorous	specialist
Tolerance - Intolerance	Tolerant Species	percent green sunfish, bluegill, yellow bullhead and channel catfish	generalist
	Intolerant Species	number of darter, sculpin, and madtom species	specialist
Physical Condition	Fish Health	percent with black spot or an anomaly	generalist
Structural	Reproductive Behavior	Number of lithophilic spawning species	specialist

Conservation context is provided by assessing the current status (occurrence) of those species at the monument that are considered federal or state species of concern, and evaluating the potential for the monument to play a role in the conservation of those species. To identify fish species that are a conservation priority we used species listed as either endangered or threatened by the U. S. Fish and Wildlife Service (USFWS) under the Endangered Species Act; U. S. Forest Service (USFS) and Bureau of Land Management (BLM) sensitive species lists; NatureServe G1 to G3 and S1 ranked species; and State lists of endangered, threatened and special concern species. The globally rarest species, represented by ranks of G1 to G3 and the locally rarest species, represented by a rank of S1, were included in the condition assessment for fish at PIPE.

4.17.3. Reference Conditions

Little historical survey data exists for Pipestone National Monument. Fish surveys conducted at four stream reaches using a common sense seine were initiated in 2001 (Dodd et al. 2010b). This sampling procedure was modified in 2006, when sampling effort at PIPE was reduced from four reaches to two and this new protocol was continued through 2011 (Dodd et al. 2008, 2010b). Fish reference condition for both the sample reaches is based on the initial HTLN 2001 fish survey results, using data from that survey as a baseline. Maintaining or exceeding the level of biodiversity as defined by initial calculation of native species richness (as an index of diversity) and the initial quality of fish community composition as defined by the initial IBI score are considered good condition. A rating system for departure from good condition is shown in Table 4-71.

The fish IBI score reflects a disturbance gradient from relatively intact and high quality stream ecosystem with high IBI scores to more disturbed, developed or urban stream ecosystem with low IBI scores. To calculate the IBI score, species are first assigned to guilds based on taxonomic composition, trophic composition, reproductive composition and fish condition (some species may be assigned to more than one guild, depending on their life history traits). The proportional richness of each guild is then calculated by dividing the number of individuals or species detected within a specific guild by the total number of individuals or species detected.

The next step in the fish IBI is to standardize metrics to score from 0 to 10 by developing threshold limits and linear equations after Dauwalter et al. (2003). Threshold limits were minimum, 50th, and 95th percentile values for individual sample reaches of parks within the HTLN. After determining threshold limits, we adjusted each metric to score from 0 (very poor condition) to 10 (good condition) by using the equation:

$$MS = A + B\,(MR)$$

where MS = metric score, MR = raw metric value calculated from the sample reach data, A = the y-intercept in the regression of MS versus MR, and B = the slope in the regression of MS versus MR. Regressions were computed from the points for the upper and lower thresholds, which were assigned scores of 0 or 10 depending on a metric's relationship with stream site quality. Finally, IBI scores were standardized to score from 0 to 100. The final fish IBI score was calculated as follows:

$$IBI = \frac{\left(\sum_{i=1}^{N} MS_i\right) \times 10}{N}$$

where IBI = IBI score, MS = metric score of the i^{th} metric, and N = the number of metrics.

A community at the theoretical maximum high IBI score, or highest integrity, consists of a fish community with only specialist guilds and without any generalist guilds.

Threshold levels for fish IBI scores have not been rigorously defined, but Dauwalter et al. (2003) established thresholds that include four categories of condition corresponding to the standardized fish IBI score. For the fish IBI score at PIPE these thresholds include the following categories: 1) excellent (highest-integrity) – score of 80.1-100.0; 2) good (high-integrity) – score of 60.1-80.0; 3) fair (medium integrity) – score of 40.1-60.0; 4) poor (low-integrity rural and low-integrity urban) – score of 20.1-40.0; and 5) poorest (lowest integrity) – score of 0-20.0. The condition classes were modified by combining the two highest condition categories into a single category "high integrity" and the two lowest condition categories into a single category "low integrity" for the fish community at PIPE (Table 4-71) using a three-tiered rating system.

We also compared the candidate list of species of concern to the actual list of species observed at PIPE during the 2011 survey. We used the number of species of concern recorded in the initial survey year of 2001 as the reference condition for comparison. The condition of the resource is considered higher if more species of concern are observed. This implies that the populations of those species are increasing and/or they are using the park more.

Table 4-71. Resource condition rating framework for fish at Pipestone National Monument, Minnesota.

Indicator	Resource is in Good Condition	Condition Warrants Moderate Concern	Condition Warrants Significant Concern
Native Species Richness (S)	>85% of 2001 value	70-85% of 2001 value	<70% of 2001 value
Index of Biotic Integrity	60.1 - 100	40.1 – 60.0	0 – 40.0
Fish Species of Conservation Concern	>85% of 2001 value	70-85% of 2001 value	<70% of 2001 value

4.17.4. Condition and Trend

<u>Species Richness</u>

A total of 11 species were recorded at stream sampling stations in 2011, the most common species was the blacknose dace (*Rhinichthys altratulus*). This total is fewer than the 13 species recorded during the 2001 fish survey at PIPE (Table 4-72). The fathead minnow (*Pimephales promelas*) and creek chub (*Semotilus atromaculatus*) were moderately common (Table 4-72). Mean native species richness per sample reach in 2012 of 5.5 was also less than the 8.3 that were recorded in 2001 (Figure 4-94).

The slope of the linear regression line for mean native fish species richness per sample reach was positive, but insignificant (r2 = 0.06, p = 0.46), suggesting a stable trend in the richness of the fish community at PIPE. The 90 percent confidence intervals for native species richness for the years 2001 to 2012 all overlap, also suggest stability in native species richness since 2001 (Figure 4-94). In 2012, there were 5.5 mean native fish species per sample reach recorded at PIPE, which is only 66 percent of the 2001 value and less than the management target of 85% of 8.3, the value in 2001 when monitoring was initiated at PIPE. The mean native fish species richness per sample reach recorded in 2012, when compared to the 2001 value, warrants significant concern (Table 4-71).

Table 4-72. Fish species recorded in 2011 and 2001 at sample reaches on Pipestone National Monument.

Common name	Species name	Number observed 2011	Number observed 2001	USFS and Federal ESA List Status[1]	Nature Serve Global Rank	State List Status[2]
Bigmouth shiner	*Notropis dorsalis*	0	349		G5	
Blacknose dace	*Rhinichthys atratulus*	71	0		G5	
Brassy minnow	*Hybognathus hankinsoni*	0	2		G5	
Bluntnose minnow	*Pimephales notatus*	10	23		G5	
Central stoneroller	*Campostoma anomalum*	4	53		G5	
Common carp	*Cyprinus carpio*	1	0		G5	
Common shiner	*Luxilus cornutus*	8	40		G5	
Creek chub	*Semotilus atromaculatus*	17	76		G5	
Fathead minnow	*Pimephales promelas*	18	163		G5	
Johnny darter	*Etheostoma nigrum*	9	2		G5	
Northern pike	*Esox lucius*	0	1		G5	
Orangespotted sunfish	*Lepomis humilis*	0	17		G5	
Sand shiner	*Notropis ludibundus*	0	204		G5	
Stonecat	*Noturus flavus*	1	0		G5	
Topeka shiner	*Notropis topeka*	11	1	LE	G3	SC
White sucker	*Catostomus commersoni*	10	65		G5	

[1] U. S. Fish and Wildlife Service Federal Status: No value = not listed, LE = listed endangered, LT = listed threatened, P = proposed, C = canidate.

[2] State Status: No value = no status, SE = state endangered, ST = state threatened, SC = state special concern.

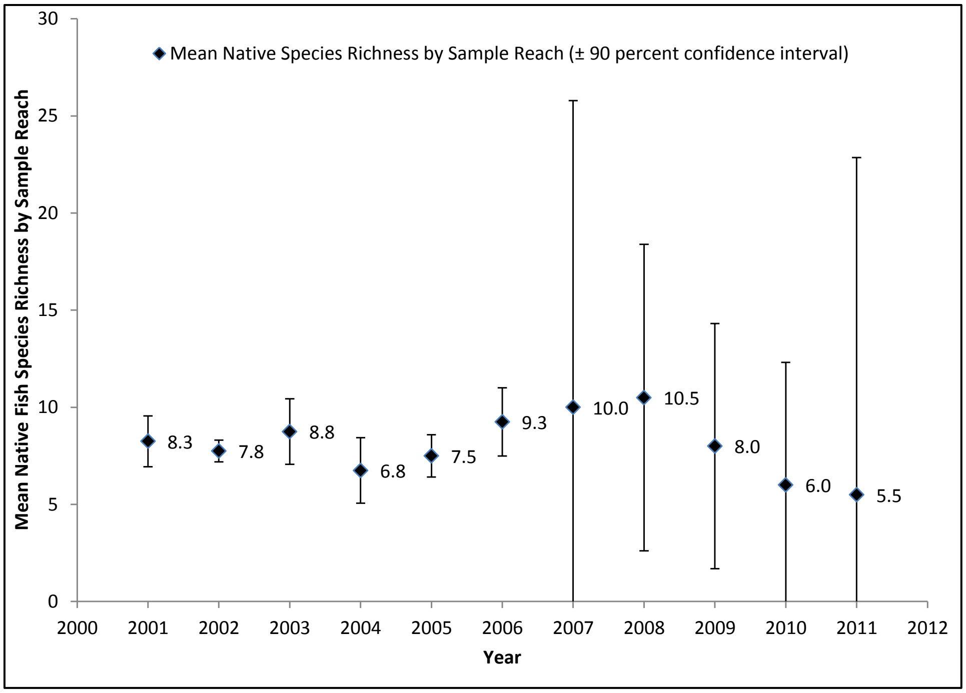


Figure 4-94. Mean native fish species richness at Pipestone National Monument from 2001 to 2011 with 90 percent confidence intervals.

<u>Index of Biotic Integrity</u>

The mean fish IBI score per sample reach in 2012 was 71.2 compared to the 2001 score of 75.7. This IBI score indicates that composition of the fish community at PIPE in 2012 was in good condition (Table 4-71). The slope of the linear regression line for the fish IBI scores was negative, but insignificant ($r^2 = 0.16$, $p = 0.22$), indicating stability in the biotic integrity of the fish community between 2001 and 2011. The 90 percent confidence intervals for the scores overlap, also suggesting the biotic integrity of the fish community has remained stable since 2001, when monitoring was first initiated at PIPE (Figure 4-95).

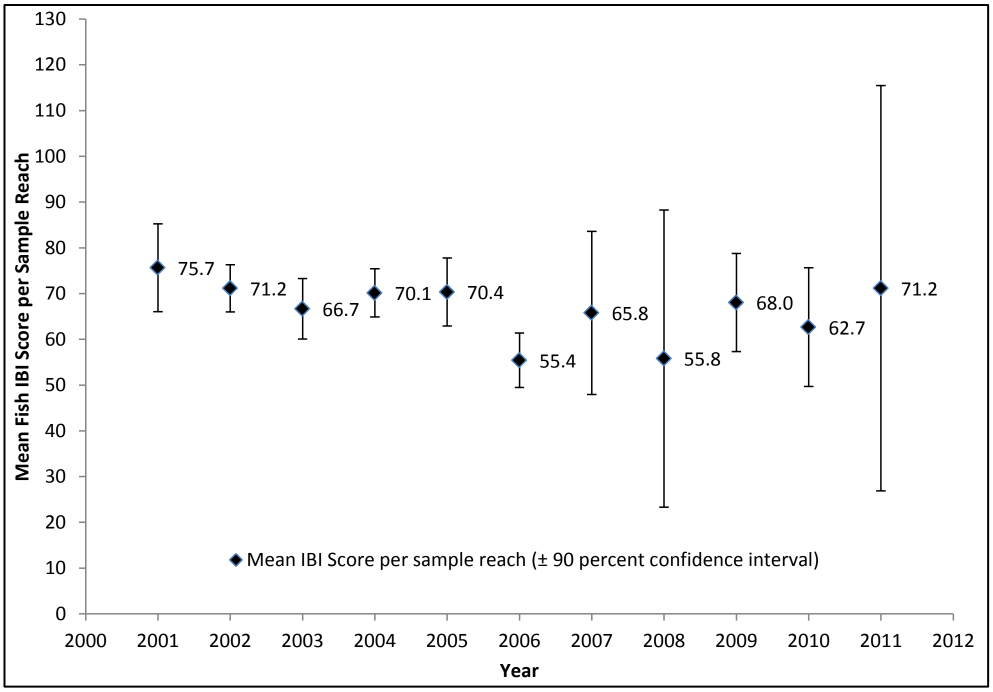


Figure 4-95. Mean fish species IBI scores at Pipestone National Monument from 2001 to 2012 with 90 percent confidence intervals.

<u>Species of Concern</u>

The Topeka shiner is listed as endangered by the USFWS under the Endangered Species Act and is also ranked G3 by NatureServe. This fish was recorded during both the 2001 and 2011 surveys with the number recorded increasing in 2011 (Table 4-72). Survey effort declined by 50%, from four sites surveyed in 2001 to only two in 2011, making it possible that the increase noted in 2011 is greater than that suggested by the absolute values recorded in Table 3. This increase, although in absolute terms included only 10 additional individuals, was an increase in the Topeka shiner population of over 1000 percent at PIPE.

The slope of the linear regression line for the mean number of fish species of concern per sample site was negative, but insignificant ($r^2 = 0.01$, $p = 0.77$), suggesting an unchanging trend in the PIPE populations. The 90 percent confidence intervals for the mean number of species of concern per sample site also suggest a stable trend since 2001 (Figure 4-96). In 2011, the mean number of fish species of concern per sample site at PIPE numbered 0.5, greater than the management target of 85 percent of 0.5, the number recorded in 2001 when fish monitoring was initiated at PIPE. Also, this value of 0.5 indicates the number of species of concern is in good condition relative to the value recorded in 2001.

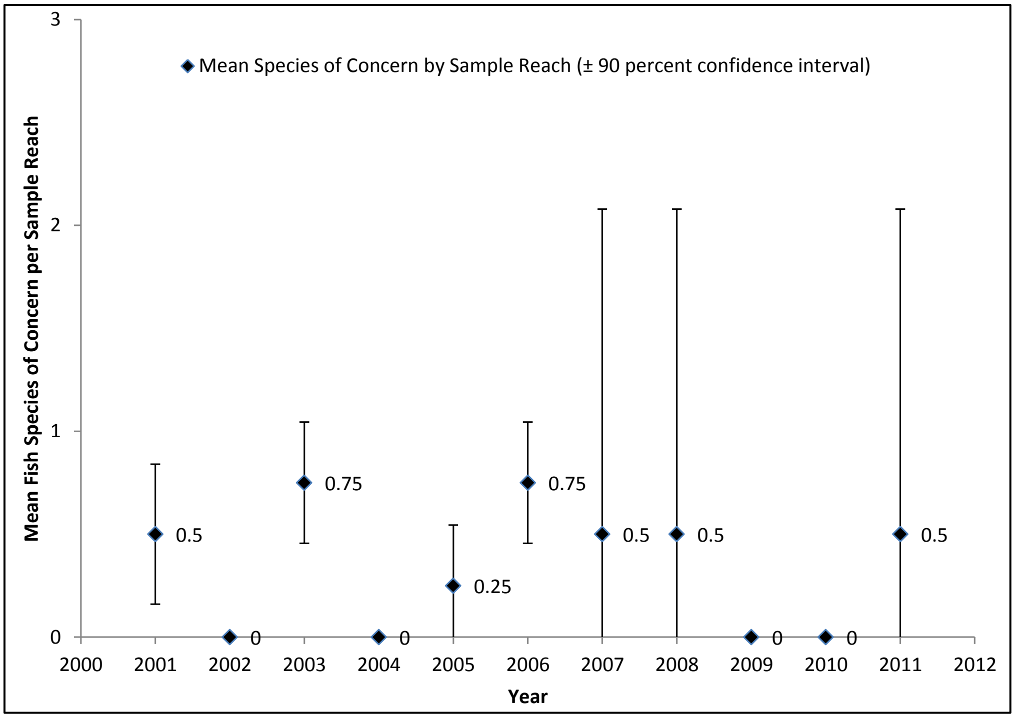


Figure 4-96. Mean number of fish species of concern at Pipestone National Monument from 2001 to 2011 with 90 percent confidence intervals.

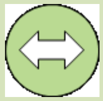
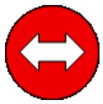
Overall Condition and Trend

The values for the metrics of native species richness, the fish IBI, and the number of species of concern present in 2011 indicate that the PIPE native fish communities warrant moderate concern, with federally listed endangered Topeka shiner present and a community structure that is representative of a moderately disturbed landscape (Table 4-73). Additionally, the values for these metrics calculated for the years 2001 to 2011 suggest an unchanging trend in fish community diversity and structure at PIPE.

4.17.5. Sources of Expertise

Hope Dodd, Fisheries Biologist, Heartland I&M Network. Hope is responsible for collecting the monitoring data at PIPE upon which this assessment is based and also for leading the design of the protocol used to monitor fish at parks of the HTLN (Dodd et al. 2008). Her research interests focus on anthropogenic disturbances in lotic systems and assessment of these long-term effects on water quality, habitat, and biota.

Table 4-73. Condition and trend summary for fish at Pipestone National Monument.

Indicator	Condition Status/Trend	Rationale
Fish Community (overall)		The resource is in good condition with an unchanging trend. Confidence in the assessment is medium.
Native Species Richness (S)		Mean native fish species richness per sample reach has fluctuated between 8.5 and 5.5 species from 2001 to 2011 with mean richness equaling 5.5 in 2011 (warrants significant concern), less than the management target of 85 percent of 8.5. Analysis of the fish monitoring data indicates a stable trend in native species richness from 2001 to 2011.
Fish Index of Biotic Integrity		In 2011, the mean fish IBI score per sample reach was 71.2 (good condition). Analysis of the mean fish IBI scores indicates an unchanging trend in the biotic integrity of the fish community between 2001 and 2011.
Species of Conservation Concern		The mean number of fish species of concern per sample site fluctuated between 0 and 0.75 species from 2001 to 2011 with 0.5 species of concern present in 2012 (good condition), greater than the management target of 85 percent of 0.5. Analysis of fish monitoring data indicates a stable trend the mean number of species of concern present between 2009 and 2012.

4.17.6. Data Gaps and Uncertainty

Confidence in this assessment was medium as is the confidence in the trend analyses. The key uncertainty related to the assessment of the fish community at PIPE is the limited years of data upon which the assessment is based. Assessments of ecological change should use long-term data spanning decades rather than the 10 years of monitoring data available for this assessment (Holmes 2010, Magurran et al. 2010). Continued monitoring could either support or refute the outcome of the current assessment. Comprehensive data collected over an extended time period is needed to assess the natural temporal fluctuation of the condition indicators used in this assessment and to assure the accuracy of the assessment (Dornelas et al. 2012). However, this comprehensive data are not available for the fish community at PIPE. Also, this assessment is based upon monitoring data collected over multiple years by multiple observers with varying skills in surveying fish populations. This variation could introduce measurement error into the data, leading to bias in the number of fish collected by different observers. This bias can reduce the ability to identify trends in the indicators (Dornelas et al. 2012). However, by plotting the point estimates of indicators with their confidence intervals against time, we can examine temporal changes in the indicators (Dornelas et al. 2012).

The bias associated with data collection could be reduced by establishing a training program for all data collectors and by retaining collectors over multiple years. Another factor affecting the quality of the data is the probability that a fish that is present during the time that seining is occurring is detected. The Heartland Network protocols used for monitoring fish rely on the use of a common sense seine. Electrofishing would likely improve the probability of detecting a species, but because each stream reach is surveyed only once per year, there is always the chance that rare species will go undetected. This can be a problem when assessing native species richness and the number of species of concern, and when calculating the index of biotic integrity, which is derived from the number of species within different guilds.

In addition, there were differences in sampling effort with the number of stream reaches sometimes varying by year. The issue that occurs when sampling for species in a community is that the greater the number of individual samples taken, the greater the number of species that will be found. This confounding influence makes it difficult to identify whether differences in the indicator values by year, result from true changes in their values or result because variable numbers of reaches were sampled across the years. This could be controlled for by sampling the same number of stream reaches in every year of monitoring. However, by comparing the mean value of the indicators per reach sampled, we control for unequal sample sizes and can examine differences in the values of the indicators by year.

4.17.7. Literature Cited

Barbour, M. T., J. Gerritsen, B. D. Snyder, and J. B. Stribling. 1999. Rapid bioassessment protocols for use in streams and wadeable rivers: periphyton, benthic macroinvertebrate, and fish, 2nd edition. EPA 841-B-99-002, U.S. Environmental Protection Agency, Washington, DC.

Barrineau, C.E., E.A. Bear and A.C. Senecal. 2010. Current distribution of rare fishes in eastern Wyoming prairie streams. The Prairie Naturalist 42(3/4):80-88.

Dauwalter, D. C., E. J. Pert and W. E. Keith. 2003. An index of biotic integrity for fish assemblages in Ozark Highland streams of Arkansas. Southeastern Naturalist 2:447-468.

Dodd H. R., D. G. Peitz, G. A. Rowell, D. E. Bowles and L. W. Morrison. 2008. Protocol for monitoring fish communities in small streams in the Heartland Inventory and Monitoring Network. National Park Service, Fort Collins, Colorado.

Dodd, H. R., L. W. Morrison and D. G. Peitz. 2010a. Fish communities at Pipestone National Monument. Resource Brief. National Park Service, Fort Collins, Colorado.

Dodd, H. R., L. W. Morrison and D. G. Peitz. 2010b. Fish community monitoring at Pipestone National Monument: 2001 – 2008 trend report. Natural Resource Technical Report NPS/HTLN/NRTR—2010/366. National Park Service, Fort Collins, Colorado.

Dornelas, M., A. E. Magurran, S. T. Buckland, A. Chao, R. L. Chazdon, R. K. Colwell, T. Curtis, K. J. Gaston, N. J. Gotelli, M. A. Kosnik, B. McGill, J. L. McCune, H. Morlon, P. J. Mumby, L. Ovreas, A. Studeny and M. Vellend. 2012. Quantifying temporal change in biodiversity: challenges and opportunities. Proceedings of The Royal Society B 280, 1-10.

Dudgeon, D., A. H. Arthington, M. O. Gessner, Z. Kawabata, D. J. Knowler, C. Le´veˆque, R. J. Naiman, A. Prieur-Richard, D. Soto, M. L. J. Stiassny and C. A. Sullivan. 2006. Freshwater biodiversity: importance, threats, status and conservation challenges. Biological Review 81:163-182

Gido, K. B., W. K. Dodds and M. E. Eberle. 2010. Retrospective analysis of fish community change during a half century of landuse and streamflow changes. Journal of the North American Benthological Society 29:970-987.

Hansen, A. and D. Gryskiewicz. 2003. Interactions between Heartland National Parks and surrounding land use change: development of conceptual models and indicators for monitoring. Final Report to the National Park Service Heartland Network. 72 pp.

Hoagstrom C. W., C. A. Hayer, J. G. Kral and S. S. Wall. 2006. Rare and declining fishes of South Dakota: a river drainage scale perspective. Proceedings of the South Dakota Academy of Sciences 85:171-211.

Holmes, R. T. 2010. Avian population and community processes in forest ecosystems: Long-term research in the Hubbard Brook Experimental Forest. Forest Ecology and Management 262:20-32.

Jelks, H. L., S. J. Walsh, N. M. Burkhead, S. Contreras-Balderas, E. Diaz-Pardo, D. A. Hendrickson, J. Lyons, N. E. Mandrak, F. McCormick, J. S. Nelson, S. P. Plantania, B. A. Porter, C. B. Renaud, J. J. Schmitter-Sotto, E. B. Taylor, and M. L. Warren, Jr. 2008. Conservation status of imperiled North American freshwater and diadromous fishes. Fisheries 33:372–407.

Jorgenson, S. E. and F. Muller (eds.). 2000. Handbook of Ecosystem Theories and Management. CRC Press. Boca Raton, Florida.

Knopf, F. L. and F. B. Samson. 1996. Prairie Conservation: Preserving North America's Most Endangered Ecosystem. Island Press, Washington, DC.

Magurran, A. E., S. R. Baillie, S. T.Buckland, J. McP. Dick, D. A. Elston, E. M. Scott, R. I. Smith, P. J.Somerfield and A. D.Watt. 2010. Long-term datasets in biodiversity research and monitoring: assessing change in ecological communities through time. Trends in Ecology and Evolution 25:574-582.

National Park Service. 2008. Final General Management Plan and Environmental Impact Statement. Pipestone National Monument. U. S. Department of the Interior, Washington, D.C.

Pflieger, W. L. 1997. The fishes of Missouri. Missouri Department of Conservation, Jefferson City, Missouri.

Schrank, S. J., C. S. Guy, M. R. Whiles and B. L. Brock. 2001. Influence of instream and landscape-level factors on the distribution of Topeka shiners *Notropis topeka* in Kansas streams. Copeia 2:413-421.

Smogor, R. A., and P. L. Angermeier. 1999. Effects of drainage basin size and anthropogenic disturbance on relations between stream size and IBI metrics in Virginia. Pp. 249-272, in T. P. Simon (Eds.), Assessing the Sustainability and Biological Integrity of Water Resources Using Fish Communities. CRC Press, Inc., Boca Raton, FL. 671 pp.

4.18. Topeka Shiner

4.18.1. Background and Importance

The Topeka shiner (*Notropis topeka*) is a member of Family Cyprinidae (carp, true minnows, and their relatives) and was historically found throughout the central prairie regions of the United States within portions of Iowa, Kansas, Minnesota, Nebraska, South Dakota, and Missouri (USFWS 2009). The species was listed as was listed as a special concern species by Minnesota in 1984, and as a federally endangered species by the U.S. Fish and Wildlife Service (USFWS) in 1998 under the authority of the Endangered Species Act of 1973 (USFWS 1998). This finding was based on the large number of historical records of occurrence and recent intensive surveys for the species, which indicate the species has undergone serious decline. Other reasons for the Topeka shiner's listing cited by the USFWS include habitat loss, predation by introduced fish, and the inadequacy of existing regulatory mechanisms.

Critical habitat for the species was designated by the USFWS in 2002 (USFWS 2002). Critical habitat is defined in the Endangered Species Act as: (i) the specific areas within the geographical area occupied by a species, at the time it is listed in accordance with the Act, on which are found those physical or biological features (I) essential to the conservation of the species and (II) that may require special management considerations or protection; and (ii) specific areas outside the geographical area occupied by a species at the time it is listed, upon a determination that such areas are essential for the conservation of the species. The designated critical habitat reflects the need for habitat complexes and individual stream reaches of sufficient size to provide habitat for Topeka shiner populations large enough to be self-sustaining over time, despite fluctuations in local conditions. In Minnesota, the Topeka shiner only exists in the Split Rock/Pipestone/Beaver Creek Complex. In and near the Park, critical habitat is within reach #3a consisting of Pipestone Creek from the Minnesota/South Dakota State border upstream through T106N, R46W, Section 1 (USFWS 2005).

Models developed for the Topeka shiner indicate that suitable habitat for the species at landscape scales include creeks and small rivers with alluvium parent material, stable flows, intermittent stream flow, medium to high potential for groundwater delivery to the streams and low channel slope (Wall et al. 2004). Within the distribution of the Topeka shiner, intermittent midbasin stream sections with low channel slope are often intersected by the water table, leaving isolated pools within the channel that are essential for maintaining the viability of populations. Other landscape-scale variables associated with Topeka shiners included streams bordered with more pasture, trees, grasses, uncultivated lands, and wetlands (Wall et al. 2004). At the reach or local scale, important habitat characteristics include stream reaches that have low animal use (i.e., livestock grazing) and therefore less erosion and sedimentation and more groundwater storage; overhanging vegetation affording shade and offering food resources to aquatic invertebrates; stream bank vegetation comprised of sedges and rushes aiding stream bank stability and filtration of runoff; low depositional zones which reduce sedimentation and preserve in-stream habitat heterogeneity; pool habitat including off channel oxbows and closed basin ponds; and fine gravel or cobble substrates important for spawning (Blausey 2001, Dahle 2001, Pflieger 1997)

Populations of the Topeka shiner are excellent indicators of environmental condition because the species is intolerant of chemical pollutants, habitat changes, and predation by introduced piscivorous fish species making their assemblages indicative of water and habitat quality (Pflieger 1997, Barbour et al. 1999, Schrank et al. 2001, USFWS 2009). For this reason, Topeka shiner populations offer an indication of stream environmental health.

The Topeka shiner is a small minnow not exceeding 3 inches in total length (75 millimeters). The head is short, with a moderately slanted mouth and the eye diameter is equal to or slightly longer than the snout. The Topeka shiner's dorsal and pelvic fins each contain 8 bony rays supporting the membranes of the fin while the anal and pectoral fins contain 7 and 13 rays respectively. The fishes back, or dorsal surface, is olive-green in color, with a distinct dark stripe preceding the dorsal fin. Along the lateral sides there is a dusky strip that runs the entire longitudinal length of the fish's body. The scales above this dusky stripe are darkly outlined and appear cross-hatched while below the line the scales lack coloring and appear silvery-white. During the breeding season, Topeka shiners have a dark chevron at the base of the caudal fin and males of the species take on a bright reddish-orange coloration.

Research conducted in Kansas indicates that Topeka shiner live to about three years of age with sizes ranging from approximately 34 millimeters at 12 months of age to 50 millimeters at 36 months (Kerns and Bonneau 2002). The majority of males reach sexual maturity in their second year while over 50 percent of females are reproductive in their first year, with 100 percent of females reaching reproductive status by their second year of life (Kerns and Bonneau 2002).

The Topeka shiner is mostly a diurnal forager that preys mainly on chironomids and ephemeropterans, but microcrustaceans, algae, vascular plants and detritus are also consumed (Kerns and Bonneau 2002, Hatch and Besaw 2001). Predators vary between northern populations of the species and their southern counterparts. In the northern portions of the range including Minnesota and South Dakota, black bullhead (*Ameiurus melas*), creek chubs (*Semotilus atromaculatus*) and green sunfish (*Lepomis cyanellus*) are the main native predators, while in the south introduced largemouth bass (*Micropterus salmoides*) are important predators limiting populations of Topeka shiners (Baker et al 2002, Schrank 2001, Winston 2000). In the north the main native predators are not highly piscivorous and unlikely impact Topeka shiner populations (Baker et al 2002). Three highly piscivorous fish, the largemouth bass, yellow perch (*Perca flavescens*) and northern pike (*Esox lucaus*) are uncommon, but do occur sporadically, in watersheds occupied by northern populations of Topeka shiners (Baker et al. 2002). However, they could impact local populations if they did become more widespread and abundant in these northern watersheds (Baker et al. 2002).

The species has declined throughout its historical distribution since the early 1900s (Cross and Moss 1987, Harlan and Speaker 1987), and has been extirpated from many localities. It currently exists in fragmented populations within a smaller portion of its range, but still occurs in all six states in its historical range (Figure 4-97) (Mammoliti 2004). Since the listing in 1998, the Topeka shiner has received much more attention and recent studies have shown that the species status in the northern extent of the range is much better than previously known. The extent of the species population decline is not as severe as originally presumed, and the vulnerability of many of the remaining populations is substantially lower than presumed at the time the species was listed by USFWS as an endangered species (NatureServe 2014). Most of the remaining occupied habitat is in South Dakota, Minnesota and Kansas (USFWS 2009), comprising less than 10% of its original geographic range (MDNR 2014).

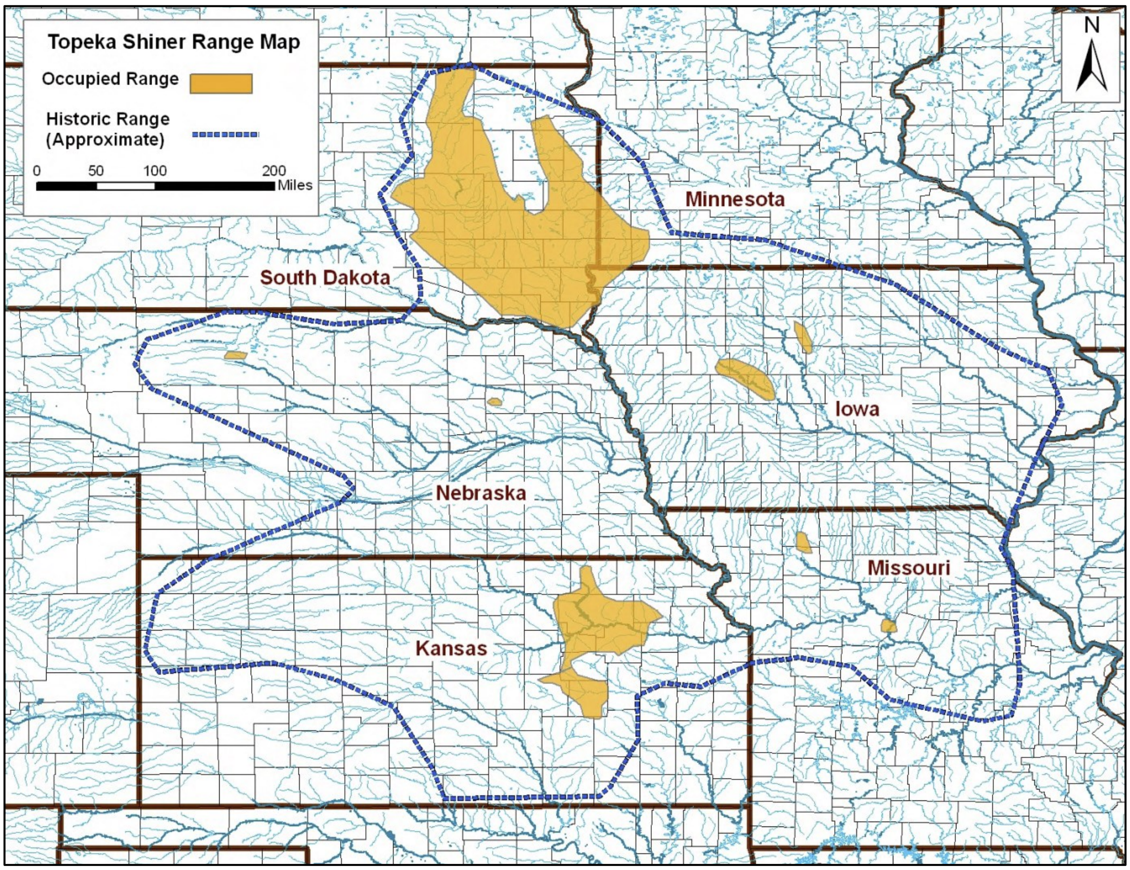


Figure 4-97. Current and historical geographic range of the Topeka shiner (USFWS 2014).

The Topeka shiner inhabits small to mid-sized, headwater, prairie streams of high water quality and with cool to moderate water temperatures (USFWS 1998). These streams generally are perennial, flowing year round, although some occupied streams may show periodic or intermittent flow during summer. During summer months, when surface flow ceases, pool water levels and cool water temperatures are maintained by groundwater seepage.

Stream substrate suitable for the Topeka shiner is predominantly clean gravel, cobble and sand, but bedrock and clay hardpan overlain by silt are not uncommon (Minckley and Cross 1959). The Topeka shiner is a multiple clutch spawner that lies its eggs from May through July in pool habitats over green sunfish (*Lepomis*) and orangespotted sunfish (*Lepomishumilis*) nests (Pflieger 1997) as well as on other silt-free substrates (USFWS 1998). The Topeka shiner reaches sexual maturity in their second summer with a lifespan that normally does not exceed three years. It is an opportunistic omnivore whose diet consists of aquatic insects, microcrustaceans, larval fish, algae, and detritus (Hatch and Besaw 2001). The species has a three year lifespan with four age classes present; 0, 1, 2, and 3-year age classes with the 0 and 1-year age classes dominating (Dahle 2001).

Primary predators of the Topeka shiner are other fish species and introduced piscivores are considered a serious threat to the Topeka shiner. The most common native predator is the green sunfish, which is found throughout the range of the Topeka shiner. The spotted Bass (*Micropterus punctulatus*) and largemouth bass (*M. salmoides*) are also native predators of the Topeka shiner, but they naturally occurred only in the downstream reaches of streams while Topeka shiners typically occupied stream headwaters. The introduction into stream headwaters of the piscivorous largemouth bass, crappie (*Pomoxis* spp.), and bluegill (*Lepomis macrochirus*) have typically eliminated Topeka shiner and other stream cyprinids (USFWS 2009).

At PIPE, the success of the Topeka shiner population depends upon maintaining the stream hydrology of Pipestone Creek and the water quality of existing instream pools. In addition, preventing introduction of piscivores will be important to protecting the Topeka shiner at PIPE. This can be difficult because activities miles away from the monument can affect water quality on PIPE.

<u>Threats</u>

Topeka shiner are intolerant of certain human-caused disturbances and habitat alterations including impoundment; channelization; increased sedimentation from cultivation, building projects, water diversion projects, and heavy and continuous grazing both onsite and upstream of PIPE; increased nutrient loading from cultivation including from cropland upstream of PIPE; and introduction of piscivores including introductions occurring upstream of PIPE.

Predation by introduced game fish, both native and nonnative, into areas not naturally occupied by these fish has been one of many factors resulting in the decline of Topeka shiner populations (Prophet et al. 1981). Game fish introduced into impoundments disperse into pools both up and downstream of the impoundment, where cyprinids can then no longer persist (Layher 1993).

Conversion of prairie to cropland and subsequent groundwater withdrawal has altered stream hydrology, resulting in both decreased surface and groundwater flows causing declines in stream water quality which coincide with declining Topeka shiner populations (Cross and Moss 1987). In addition, increased surface runoff attributed to agricultural drainage tiling and excessive grazing has contributed to increased stream sedimentation again reducing stream water quality (USFWS 2009).

Impoundments have caused the loss of Topeka shiner populations across its entire range. During times of drought and diminished stream flows Topeka shiner attempt to survive in impoundments, where they are subject to predation by piscivorous fishes (Mammoliti 2002).

Climate change is expected to contribute to changes that further stress Topeka shiner populations. Increases in temperature and changes in rainfall patterns will further alter the timing and amount of water recharge and runoff. Increases in precipitation projected for the Great Plains are not expected to offsite decreases in soil moisture and groundwater depletion (USFWS 2009).

<u>Indicators and Measures</u>

- Topeka shiner abundance
- Relative abundance of predators
- Vulnerability to climate change

4.18.2. Data and Methods

The HTLN has implemented long-term monitoring of fish at parks within the HTLN network including PIPE (Dodd et al. 2008) in order to determine the status and long-term trends in fish community composition and abundance, and to correlate this community data to water quality and habitat conditions. This allows for monitoring of how fish respond to changes in habitat structure and other habitat variables related to land-use changes and management activities (Dodd et al. 2008). In 2001, the HTLN began systematic surveys of fish and their habitat at PIPE as part of the HTLN program (Dodd et al. 2010). The number of stream reaches sampled per year varied, ranging from 4 (2001 to 2006) to 2 (2007 to 2011) (Figure 4-98). Data from the 4 reaches sampled from 2001 to 2006 and the two sampled from 2007 to 2011 (reaches in yellow Figure 4-98) were used to determine the condition of the Topeka shiner population. In four of the 11 years sampled no Topeka shiners were recorded and in five of the remaining seven years sampled, Topeka shiners were only recorded at one of the sampled reaches. For predaceous fish, their relative abundance defined as the percent abundance of predaceous fish relative to that of the Topeka shiner was used to determine condition. Relative abundance of predaceous fish was calculated as follows:

$$Relative\ Abundance = \frac{annual\ mean\ abundance\ of\ predaceous\ fish\ per\ sample\ reach}{annual\ mean\ abundance\ of\ Topeka\ shiner\ per\ sample\ reach}$$

No predaceous fish were recorded in 2004, 2007, 2009, and 2011 and in five of the remaining seven sample years predaceous fish were only recorded at one sample reach. For those sample reaches where no Topeka shiners were recorded, but predaceous fish were, the relative abundance of predaceous fish was set to 1. The mean abundance of the Topeka shiner per sample reach and the relative abundance of predaceous fish recorded per sample reach were used to assess condition and trend in the Topeka shiner population at PIPE. Fish sampling was conducted in August and September using a common sense seine. Topeka shiner were identified and counted and starting in 2006, individuals at each reach were also measured and weighed, and any diseases or anomalies were recorded.

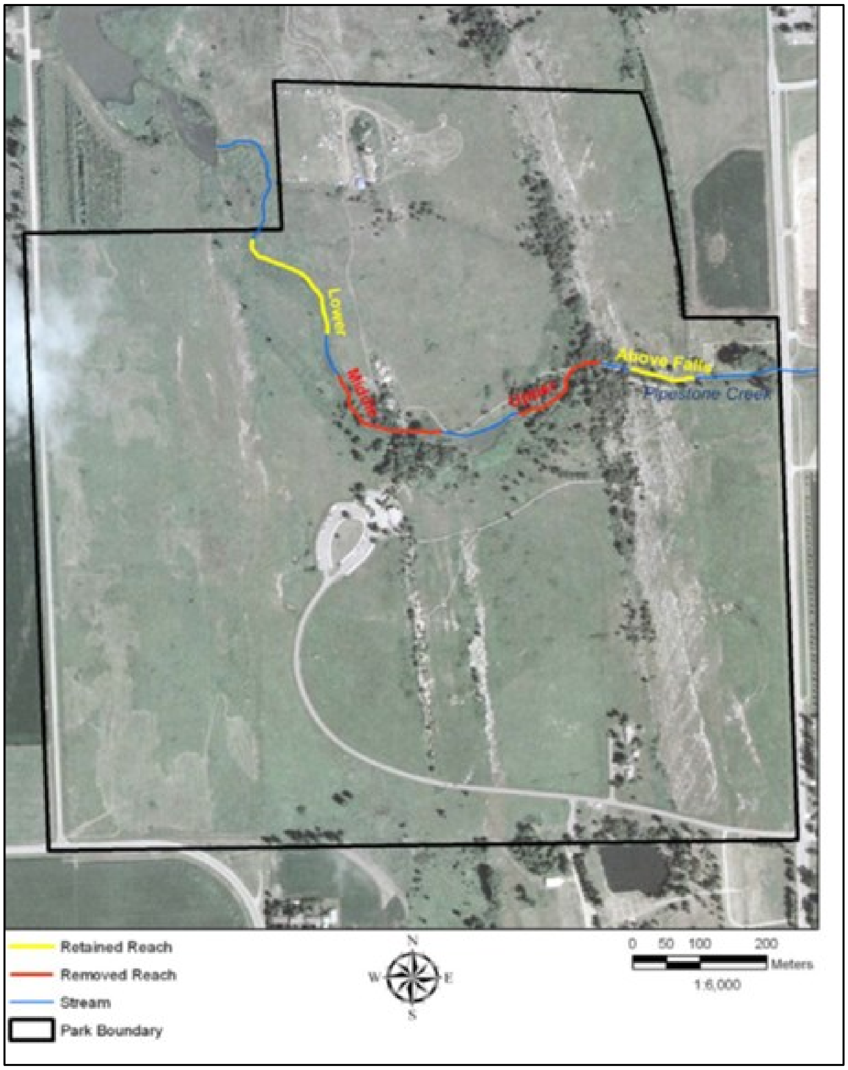


Figure 4-98. Fish sample reach locations on Pipestone National Monument, Minnesota (Dodd et al. 2010).

The vulnerability of the community to climate change effects was evaluated using the Climate Change Vulnerability Index (CCVI) (Young et al. 2011). The CCVI is a Microsoft Excel-based spreadsheet tool developed by NatureServe. It is designed as a rapid-assessment tool intended to be used primarily for practical planning purposes by natural resources managers and USFWS staff. It is designed to be complementary to the NatureServe Conservation Status ranks and other information, but it does not duplicate information in those ranks such as the size of a specific population. The intended application scale of the tool is up to the state or province level. The primary purpose of the CCVI is to produce a relative ranking or priority list for species of concern with respect to climate change vulnerability. The CCVI divides vulnerability into two components: 1) exposure to climate change within the assessment area (e.g., a highly sensitive species will not suffer if the climate where it occurs remains stable), and 2) sensitivity of the species to climate change (e.g., an adaptable species will not decline even in the face of significant changes in temperature and/or precipitation).

4.18.3. Reference Condition

A rating system for departure from good condition is shown in Table 4-74. Little historical survey data exists for Pipestone National Monument. Fish surveys conducted at four stream reaches using a common sense seine were initiated in 2001 (Dodd et al. 2010). This sampling procedure was modified in 2006, when sampling effort at PIPE was reduced from four reaches to two. The revised protocol was continued through 2011 (Dodd et al. 2008, 2010). Additionally, there was a great deal of variation observed in the annual abundance of Topeka shiner recorded during the 11 years of data that we analyzed, with no Topeka shiner recorded in four of the sample years. In order to account for this variation, and to evaluate trends over time, we compared the mean abundance of Topeka shiner per sample reach detected during the 2011 survey conducted at PIPE to the mean abundance in 2001, considering the 2001 values to represent the reference condition.

Maintaining or exceeding the level of mean Topeka shiner abundance per sample reach recorded in 2001 is considered good condition. As with Topeka shiner results, no predaceous fish were recorded in four of 11 years sampled and a wide range of relative abundance was recorded across the 11 years sampled (Figure 4-99). To account for this variation, and to evaluate trends over time, we compared the mean relative abundance of Topeka shiner per sample reach detected during the 2011 survey conducted at PIPE to the mean abundance calculated in 2001, considering this mean to represent the reference condition. Maintaining or reducing the level of mean relative abundance per sample reach of predaceous fish recorded in 2001 is considered good condition. The results for climate change vulnerability were not used in the condition rating, but did weight in for the trend rating.

Table 4-74. Resource condition rating framework for Topeka shiner at Pipestone National Monument, Minnesota.

		Condition Status	
Indicator	**Resource is in Good Condition**	**Warrants Moderate Concern**	**Warrants Significant Concern**
Topeka shiner abundance	>85-100+ % of 2001 value	70-85% of 2001 value	<70% of 2001 value
Relative abundance of predators	<70% of 2001 value	70-85% of 2001 value	85-100+ % of 2001 value

4.18.4. Condition and Trend

Topeka Shiner Abundance

The mean abundance per sample reach for the Topeka shiner recorded between 2001 and 2011 is highly variable, ranging from a low of 0 recorded in 2002, 2004, 2009, and 2010 to a high of 50 in 2006 (Figure 4-99). In 2011, mean abundance was 5.5, greater than the mean abundance per sample reach of 0.3 recorded in 2001. The slope of the linear regression line for Topeka shiner mean abundance per sample reach was positive but insignificant ($r^2 = 0.03$, $p = 0.6$) suggesting abundance of the Topeka shiner has not changed during the sampling period. The 90 percent confidence intervals for mean Topeka shiner abundance for the years 2001 through 2011 suggest no difference in the values and also indicated low precision in the calculated values for the years 2006 through 2008 and 2011.

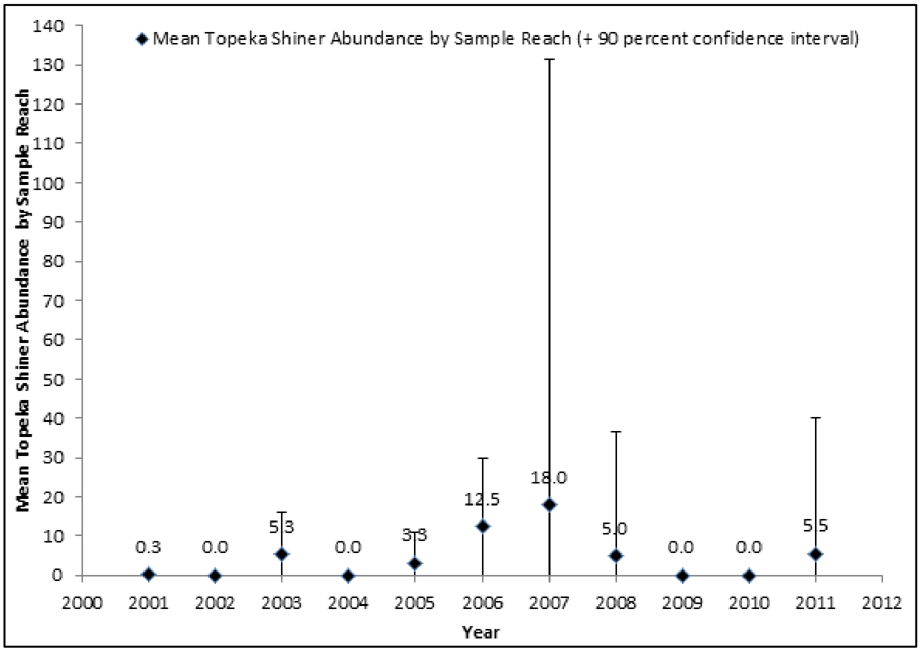


Figure 4-99. Mean Topeka shiner abundance at Pipestone National Monument from 2001 to 2011 with 90 percent confidence intervals.

Predaceous Fish Relative Abundance

The relative abundance of predaceous fish species recorded between 2001 and 2011 was relatively low, ranging from a low of 0 recorded in 2004, 2007, 2009, and 2011 to a high of 1.5 in 2006 (Figure 4-100). In 2011, mean abundance was 0, less than the mean predaceous fish relative abundance per sample reach of 0.25 recorded in 2001. The slope of the linear regression line for predaceous fish relative mean abundance per sample reach was positive but not statistically significant ($r^2 = 0.01$, $p = 0.73$) suggesting relative abundance of predaceous fish has not changed during the period of sampling. The 90 percent confidence intervals for mean predaceous fish relative abundance for the years 2001 through 2011 suggest no difference in the values and also indicated low prevision in the calculated values for the years 2003 and 2010. Results for this indicator suggest the resource is in good condition with an unchanging trend.

Vulnerability to Climate Change

Each CCVI component was scored and results were compiled into an overall CCVI rating. By 2050, within its current range within an approximate 150 X 150 mile area centered on Pipestone National Monument, the species was considered Moderately Vulnerable. Within PIPE, the species is also considered Moderately Vulnerable by 2050 (Table 4-75). Confidence in the CCVI species information is very high. There are factors of Topeka shiner biology that can make it susceptible to climate alterations. In particular, the Topeka shiner is dependent upon instream pools and off-channel wetlands that could be reduced in number and distribution within the streams that the fish inhabits within the region and at PIPE. This is particularly true during drought, which is predicted to increase in the region under climate change. Dependence on and connections to groundwater may help buffer the adverse effects of climate change on this species, and are accounted for in the CCVI analysis. It is particularly important for Topeka shiner to access these wet refugia during times of drought. With water withdrawal and impoundment predicted to increase in the future their habitat will become more fragmented, making it difficult for current population to access these refugia and to persist. The climate change indicator was assigned an *insufficient data* status and low level of confidence. However, the estimated vulnerability was used as a trend indicator along with other indicators.

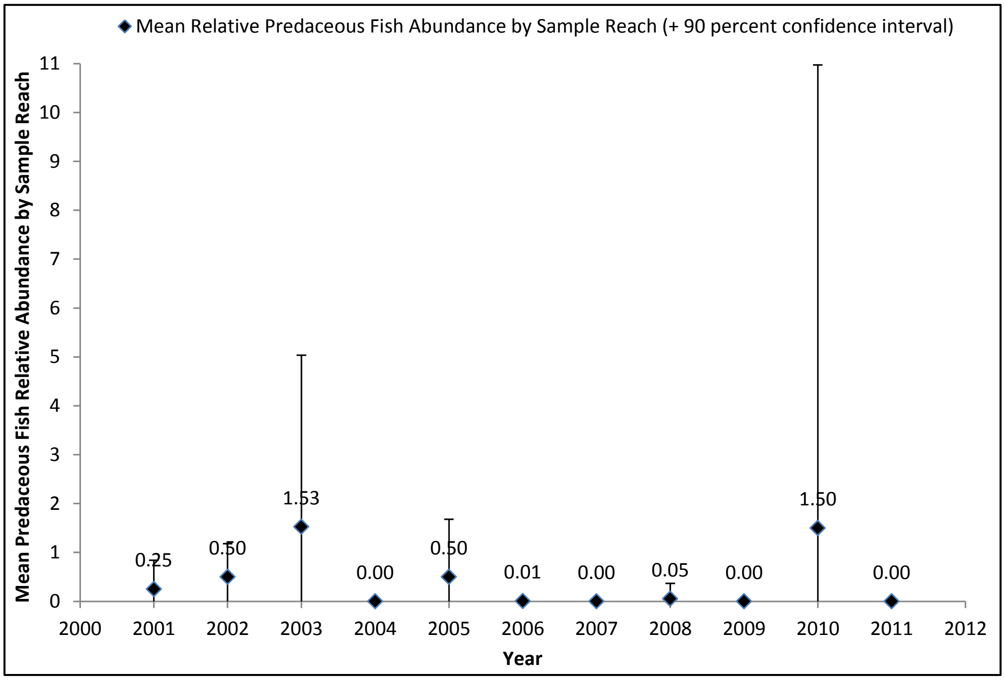


Figure 4-100 0-4. Mean predaceous fish relative abundance at Pipestone National Monument from 2001 to 2011 with 90 percent confidence intervals.

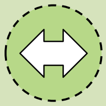
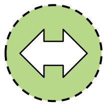
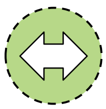
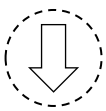
Overall Condition and Trend

The values for the metrics of mean Topeka shiner abundance and the relative abundance of predaceous fish present in 2011 indicate that the resource is in good condition; the federally-listed endangered Topeka shiner is present and a community of predaceous fish that prey upon the Topeka shiner is low in abundance (Table 4-76). Additionally, the values for these metrics calculated for the years 2001 to 2011, suggest an unchanging trend in condition at PIPE.

Table 4-75. Summary of CCVI factor ratings for the Topeka shiner.

Factor Influencing Vulnerability	Degree to Which Factor Influences Vulnerability	
	Rangewide/State	**Pipestone National Monument**
Indirect Exposure to Climate Change		
1) Exposure to sea level rise	Neutral	Neutral
2a) Distribution relative to natural barriers	Somewhat Increase	Somewhat Increase
2b)Distribution relative to anthropogenic barriers	Increase-Somewhat Increase	Increase-Somewhat Increase
3) Predicted impact of land use changes resulting from human responses to climate change	Increase	Increase
Sensitivity to Climate Change		
1) Dispersal and movements	Somewhat Increase	Somewhat Increase
2ai) Predicted sensitivity to changes in temperature: historical thermal niche	Somewhat Decrease	Somewhat Decrease
2aii) Predicted sensitivity to changes in temperature: physiological thermal niche	Increase	Increase
2bi) Predicted sensitivity to changes in precipitation, hydrology, or moisture regime: historical hydrological niche	Greatly Increase	Greatly Increase
2bii) Predicted sensitivity to changes in precipitation, hydrology, or moisture regime: physiological hydrological niche	Increase	Increase
2c) Dependence on a specific disturbance regime likely to be impacted by climate change	Neutral	Neutral
2d) Dependence on ice, ice-edge, or snow-cover habitats	Neutral	Neutral
3) Restriction to uncommon geological features or derivatives	Neutral	Neutral
4a) Dependence on other species to generate habitat	Neutral	Neutral
4b) Dietary versatility (animals only)	Neutral	Neutral
4c) Pollinator versatility (plants only)	Unknown	Unknown
4d) Dependence on other species for propagule dispersal	Neutral	Neutral
4e) Forms part of an interspecific interaction not covered by 4a-d	Neutral	Neutral
5a) Measured genetic variation	Neutral	Neutral
5b) Occurrence of bottlenecks in recent evolutionary history	Increase-Somewhat Increase	Increase-Somewhat Increase
6) Phenological response to changing seasonal temperature and precipitation dynamics	Unknown	Unknown

Table 4-76. Condition and trend summary for Topeka shiner at Pipestone National Monument.

Indicator	Condition Status/Trend	Rationale
Topeka shiner (overall)		Condition is good with an unchanging trend. Confidence in the assessment is low.
Topeka Shiner Abundance		Mean Topeka shiner abundance per sample reach has fluctuated between 0 and 18.0 species from 2001 to 2011 with mean abundance equaling 5.5 in 2011 (good condition), more than the management target of 85 percent of 0.3. Analysis of the fish monitoring data indicates a stable trend in mean Topeka shiner abundance from 2001 to 2011.
Relative Abundance of Predaceous Fish		In 2011, the mean relative abundance of predaceous fish per sample reach was 0 (good condition). Analysis of the mean relative abundance indicates a stable trend in the number of predaceous fish at PIPE between 2001 and 2011.
Climate Change Vulnerability		The Topeka shiner was found to be moderately vulnerable to climate change throughout its current range in the United States and within Pipestone National Monument. Only the trend in this indicator is applied to the overall rating of this resource. Confidence in the CCVI species information is very high for both scales of analysis.

4.18.5. Data Gaps and Uncertainty

Confidence in this assessment was low as is the confidence in the trend analyses. The key uncertainty related to the assessment of the Topeka shiner at PIPE is in the limited number of years and sample reaches from which data are available and upon which the assessment is based. Assessments of ecological change should preferably use long-term data spanning decades rather than the 11 years of monitoring data available for this assessment (Holmes 2010, Magurran et al. 2010). Comprehensive data collected over an extended time period is needed to assess the natural temporal fluctuation of the condition indicators used in this assessment and to assure the accuracy of the assessment (Dornelas et al. 2012). However, comprehensive data are not available for the Topeka shiner at PIPE. Also, this assessment is based upon monitoring data collected over multiple years by multiple observers with varying skills in surveying fish populations. This variation could introduce measurement error into the data, leading to bias in the number of Topeka shiner collected by different observers. This bias can reduce the ability to identify trends in the indicators (Dornelas et al 2012). However, by plotting the point estimates of indicators with their confidence intervals against time, we can examine temporal changes in the indicators (Dornelas et al. 2012).

The bias associated with data collection could be reduced by establishing a training program for all data collectors and by retaining collectors over multiple years. Another factor affecting the quality of the data is the probability that a Topeka shiner that is present during the time that seining is occurring is detected. The protocols used for monitoring fish in the HTLN rely on the use of a common sense seine. Electrofishing could improve the probability of detecting a individuals, but because each stream reach is surveyed only once per year, there is always the chance that rare species like the Topeka shiner will go undetected. This can be a problem when assessing rare species.

In addition, there were differences in sampling effort with more stream reaches being sampled in some years of monitoring. The issue that occurs when sampling for rare species is that the greater the number of individual samples taken, the greater is the number of individuals that will be found. This confounding influence makes it difficult to identify whether differences in the indicator values by year, result from true changes in their values or result because variable numbers of reaches were sampled across the years. This could be controlled for by sampling the same number of stream reaches in every year of monitoring. However, by comparing the mean value of the indicators per reach sampled, we control for unequal sample sizes and can examine differences in the values of the indicators by year.

4.18.6. Sources of Expertise

Hope Dodd, a Fisheries Biologist, Heartland I&M Network and Prairie Cluster Prototype Programs. Hope is responsible for collecting the monitoring data at PIPE upon which this assessment is based and also for leading the design of the protocol used to monitor birds at parks of the HTLN (Dodd et al 2008). Her research interests focus on anthropogenic disturbances in lotic systems and assessment of these long-term effects on water quality, habitat, and biota.

Shawn Dahle, a fishery biologist at the National Marine Laboratory, Alaska Fisheries Service Center, National Oceanic and Atmospheric Administration published his Master's thesis at the University of Minnesota on the life history of the Topeka shiner (Dahle 2001).

Jay Hatch, an Associate Professor, Postsecondary Teaching and Learning, University of Minnesota is an expert on the distribution and ecology of northern North American freshwater fishes, especially endangered and nongame fishes in Minnesota including the Topeka shiner.

4.18.7. Literature Cited

Baker, R. J., J.S. Dahle and J. T. Hatch. 2002. Gauging the Threat of Predation on the Topeka Shiner (*Notropis topeka*) in Minnesota: Final Report. Minnesota Department of Natural Resources, St. Paul, Minnesota.

Barbour, M.T., J. Gerritsen, B. D. Snyder, and J. B. Stribling. 1999. Rapid bioassessment protocols for use in streams and wadeable rivers: periphyton, benthic macroinvertebrate, and fish, 2nd edition. EPA 841-B-99-002, U.S. Environmental Protection Agency, Washington, DC.

Blausey, C.M. 2001. The status and distribution of the Topeka shiner *Notropis topeka* in eastern South Dakota. fvi.Sc. thesis, South Dakota State University, Brookings, S.D.

Cross, F.B. and R.E. Moss. 1987. Historic changes in fish communities and aquatic habitats in plains streams of Kansas. In Community and Evolutionary Ecology of North American Stream Fishes, W.J. Matthews and D.C. Heins (ed.). University of Oklahoma Press, Norman. pp. 155-165.

Dahle, S.P. 2001. Studies of Topeka shiner (*Notropis topeka*) life history and distribution in Minnesota. Masters Thesis, University of Minnesota, St. Paul, Minnesota.

Dodd, H.R., D.G. Peitz, G.A. Rowell, D.E. Bowles, and L.M. Morrison. 2008. Protocol for monitoring fish communities in small streams in the Heartland Inventory and Monitoring Network. Natural Resource Report NPS/HTLN/NRR—2008/052. National Park Service, Fort Collins, Colorado.

Dodd, H. R., L. W. Morrison and D. G. Peitz. 2010. Fish community monitoring at Pipestone National Monument: 2001 – 2008 trend report. Natural Resource Technical Report NPS/HTLN/NRTR—2010/366. National Park Service, Fort Collins, Colorado.

Dornelas, M., A. E. Magurran, S. T. Buckland, A. Chao, R. L. Chazdon, R. K. Colwell, T. Curtis, K. J. Gaston, N. J. Gotelli, M. A. Kosnik, B. McGill, J. L. McCune, H. Morlon, P. J. Mumby, L. Ovreas, A. Studeny and M. Vellend. 2012. Quantifying temporal change in biodiversity: challenges and opportunities. Proceedings of The Royal Society B 280, 1-10.

Harlan, J.R. and E.B. Speaker. 1987. Iowa fish and fishing. Iowa Department of Natural Resources Publication. 323 pp.

Hatch, J.T. and S. Besaw. 2001. Food use in Minnesota populations of the Topeka shiner (*Notropis topeka*). Journal of Freshwater Ecology 16(2): 229-233.

Kerns, H. A. and J. L. Bonneau. 2002. Aspects of the life history and feeding habits of the Topeka shiner (*Notropis topeka*) in Kansas. Transactions of the Kansas Academy of Science 105(3): 125-142.

Layher, W. G. 1993. Changes in fish community structure resulting from a flood control dam in a Flint Hills stream, Kansas, with emphasis on the Topeka shiner. University of Arkansas at Pine Bluff. Cooperative Fisheries Research Project AFC-93-1. 30 pp.

Magurran, A. E., S. R. Baillie, S. T.Buckland, J. McP. Dick, D. A. Elston, E. M. Scott, R. I. Smith, P. J.Somerfield and A. D.Watt. 2010. Long-term datasets in biodiversity research and monitoring: assessing change in ecological communities through time. Trends in Ecology and Evolution 25:574-582.

Mammoliti, C. S. 2002. The effects of small watershed impoundments on native stream fishes: A focus on Topeka shiners and hornyhead chub. Kansas Acad. Sci. Trans. 105(3-4):219-231.

Mammoliti, C. S. 2004. Recovery plan for the Topeka shiner (*Notropis Topeka*) in Kansas. The Watershed Institute, Tetra Tech Inc. Topeka, Kansas.

Minckley, W.L., and F.B. Cross. 1959. Distribution, habitat, and abundance of the Topeka shiner *Notropis topeka* (Gilbert) in Kansas. The American Midland Naturalist 61(1):210-217.

Minnesota Department of Natural Resources (MDNR). 2014. MDNR rare species guide web page. Available online at http://www.dnr.state.mn.us/rsg/index.html

NatureServe. 2014. NatureServe Explorer: An online encyclopedia of life [web application]. Version 7.1. NatureServe, Arlington, Virginia. Available http://explorer.natureserve.org. (Accessed: July 2, 2014).

Pflieger, W. L. 1997. The fishes of Missouri. Missouri Department of Conservation, Jefferson City, Missouri. 372 pp.

Prophet, C.W., R.J. Boles, and R. F. Clarke. 1981. Effects of a proposed watershed project on threatened and endangered animals inhabiting the South Fork of the Cottonwood River drainage, Kansas. Emporia State University. Emporia, Kansas. 43 pp.

Schrank, S.J., C.S. Guy, M. R. Whiles and B. L. Brock. 2001. Influence of instream and landscape-level factors on the distribution of Topeka shiners *Notropis topeka* in Kansas streams. Copeia 2:413-421.

U.S. Fish and Wildlife Service (USFWS). 1998. Final rule to list the Topeka shiner as endangered. Federal Register 63(240):69008-69021. 15 December 1998.

U.S. Fish and Wildlife Service (USFWS). 2002. Endangered and threatened wildlife and plants; proposed designation of critical habitat for the Topeka shiner: Federal Register 67(162):54262-54306. August 21, 1998.

U.S. Fish and Wildlife Service (USFWS). 2005. Final rule correction: final designation of critical habitat for Topeka shiner: Federal Register 70 (57):15239-15245. March 25, 2005.

U.S. Fish and Wildlife Service (USFWS). 2009. Topeka shiner (*Notropis topeka*) 5-year review: summary and evaluation. USFWS, Kansas Ecological Services Field Office, Manhattan, Kansas.

U.S. Fish and Wildlife Service (USFWS). 2014. Species profile for Topeka shiner. http://ecos.fws.gov/speciesProfile (Accessed June 27 2014).

Young, B., E. Byers, K. Gravuer, K. Hall. G. Hammerson and A. Redder. 2011. Guidelines for using the NatureServe Climate Change Vulnerability Index. Release 2.1. Arlington, VA.

4.19. Pipestone Quarries

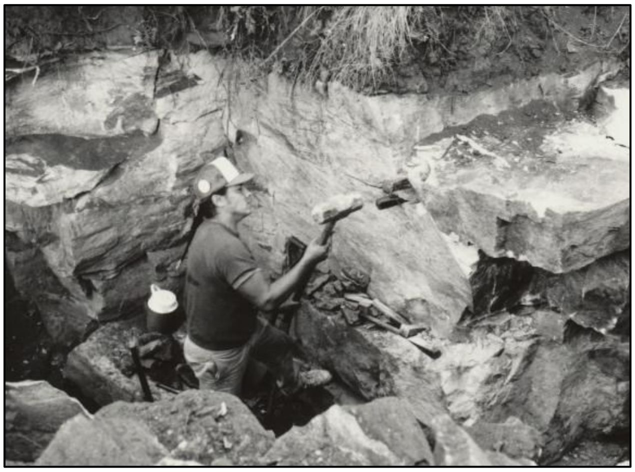
4.19.1. Background and Importance

Bison effigy pipe made from catlinite (NPS photo).

On the surface Pipestone National Monument may seem like a patch of ordinary prairie, but it is unique among the national parks for what lies beneath the layers of Sioux quartzite and its significance to many Native Americans throughout the region. The red pipestone, also known as catlinite, was of such great importance that upon ceding their lands to the U.S. Government the Yankton Sioux insisted upon continued access to the pipestone quarries. Access to the stone is as important as the stone itself as it is part of a living tradition connecting generations of Native Americans across time and space and not simply a monument to the past (Rothman and Holder 1992). The quarries and park itself are an integrated resource of sights, sounds, smells, feel (physical and emotional) and even taste (plants) and the feelings they generate for the visitor and user of the park. Being the only source of catlinite that has drawn people to this spot for generations the location is itself a connection between the past and present.

The archaeological record within Pipestone National Monument is somewhat sparse yet the importance of the pipestone is evident elsewhere in its widespread geographical and historical use (Zedeño and Basaldu 2004). The soft red stone is amenable to carving and has been used to produce objects for ritual, trade, and personal use, but is most commonly associated with the pipe. The "…sanctity [of the stone] comes from not only the use of the pipe in ritual and ceremony but also from the very nature of the stone, which according to certain oral traditions, comes from the very flesh and blood of the ancestors, or from the buffalo, or even from the creator him/herself" (Zedeño and Basaldu 2004 p.16). The pipestone gives power and sacredness to the place; the resource and cultural significance at PIPE are inseparable (pers. comm. Glen Livermont, December 2012). The power from the pipestone and the opportunity to quarry this material also adds significantly to the experience of the Sun Dance participants during Sun Dance ceremonial periods at PIPE (pers. comm. Mark Calamia, August 2013). For Native Americans Pipestone quarrying provides a tangible link to the past as well as a mechanism to build community and relationships while quarrying. The act of quarrying is itself culturally significant and acquiring the stone is only part of the importance of this location. It is continued access to the quarries that is of utmost importance as are the ceremonial areas and the maintenance and protection of the natural resources that are an integral part of the tradition use of the area.

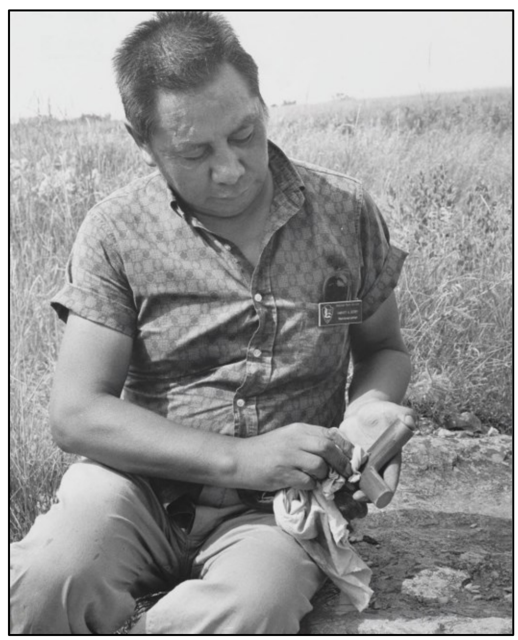
Although red pipestone (argillite) occurs at other locations on the plains (e.g. Kansas pipestone and various types found in glacial till) not all red pipestone is catlinite as this designation is specific to the claystone deposits found only at Pipestone National Monument (Gundersen 1991, Gundersen 1993). Gundersen describes generic red pipestones as "…generally very fine-grained, sound (non-slacking in water), dense (low permeability), soft (easily carvable), and red (hematite-bearing)…[and are]…characterized by a surprisingly small number of minerals [that consist of] diaspora, kaolinite, muscovite, pyrophyllite and quartz" (Gundersen 1991).



Pipestone quarrier at work (NPS photo).

Other inert minerals occur within the structure of pipestones most notably hematite which provides the red color. Yet this color is variable within and across varieties of red pipestones and as such color is a nondiagnostic attribute for determining a pipestones provenience. For example catlinites range from dark maroon to pale pinkish cream in color and even a "bleached" white variety is known to exist (Gundersen 1991). Catlinite is distinguishable from other similar looking pipestones by its core mineralogical constituents of diaspora, pyrophyllite and muscovite; the unique composition is not duplicated in any other known plains variety of pipestone. At Pipestone National Monument, the catlinite is interbedded with, and overlain by Sioux quartzite deposits. The quartzite is generally overlain by up to ten feet of un-stratified gravel and sand deposited by the Kansan glacial advance. Atop this is a generally thin soil ranging from only about 5-7cm to two meters in depth (Scott and Midwest Archeological Center 2006). The full areal extent of the catlinite deposits are inferred from core samples, but not known with certainty. Catlinite occurs is three distinct layers approximately 35 to 45 cm thick in each of the quarry areas (north and south). However, only about a 5 cm thick layer within a thicker layer is suitable for carving (Scott and Midwest Archeological Center 2006).

Quarrying, irrespective of the quantity of catlinite extracted, is an important social and cultural activity for the Native American's that participate in it. Quarrying takes place during the late summer and fall after the spring floods have receded and excess water can be pumped away and after the intense summer heat has abated. Seasonal flooding of the quarries occurs in the spring months as rains raise the water table such that quarry pits become inundated. Flooded pits are pumped dry by the park using small gas powered pumps making them once again usable. There is concern that climate change may increase the duration of flooding and render quarry pits inaccessible for longer periods during the year (pers. comm. Mark Calamia), but this relationship is poorly understood.



Quarrier and pipestone craftsman Harvey Derby (NPS photo).

No-cost annual quarry permits are required and are issued at the discretion of the park superintendent taking into consideration the number of permittees and their impact on the pipestone resource as well as the availability of a suitable quarry location. Permits are valid for the calendar year in which they are issued. Permits are issued only to individuals affiliated with an American Indian tribe and not a tribe as a whole (NPS 2008). Each year approximately 10 quarry permits are not renewed and there are over 150 names on the waiting list (pers. comm. Glen Livermont, December 2012). Quarriers coordinate with park staff prior to their arrival with regard to pumping out of quarry pits. Using gasoline-powered pumps, monument staff begins pumping water out of active quarries in the spring and summer in response to the request by permit holders.

Quarrying has taken place at Pipestone National Monument for hundreds, and likely thousands, of years (Zedeño and Basaldu 2004) using only hand tools and muscle and that is how it continues to this day. Quarrying is limited to what can be mined by hand; no mechanized extraction is permitted. Often several feet of overlying quartzite must be removed in order access the pipestone layers.

With these methods the eastward dip of the catlinite layers may over time make accessing the deposits more difficult and some quarries have been abandoned over the years (NPS 2008). These methods also pose certain safety hazards as the spoil piles of quartzite become larger. Quarriers are expected to construction retaining walls made of quarried quartzite boulders that are intended to prevent slides, collapses and cave-ins. Adequate compliance with permit safety requirements is determined by the park superintendent. Quarries are periodically assessed by park personnel. Compliance with safety requirements is a condition of the permit.

Threats and Stressors

Accessibility of the pipestone. For the purposes of this discussion quarriable catlinite would be that which can be manually excavated safely. This means the resource under consideration includes only that catlinite that can be acquired under these conditions (Figure 4-101). There is likely much more pipestone in the monument than can be recovered under these terms. The eventual inaccessibility of the pipestone via non-mechanical extraction techniques will ultimately exhaust the supply of available stone. This seems to be a remote threat as the pace of extraction, the reserve areas, and the oversight of the park superintendent all act ensure long-term availability of the pipestone for the foreseeable future.

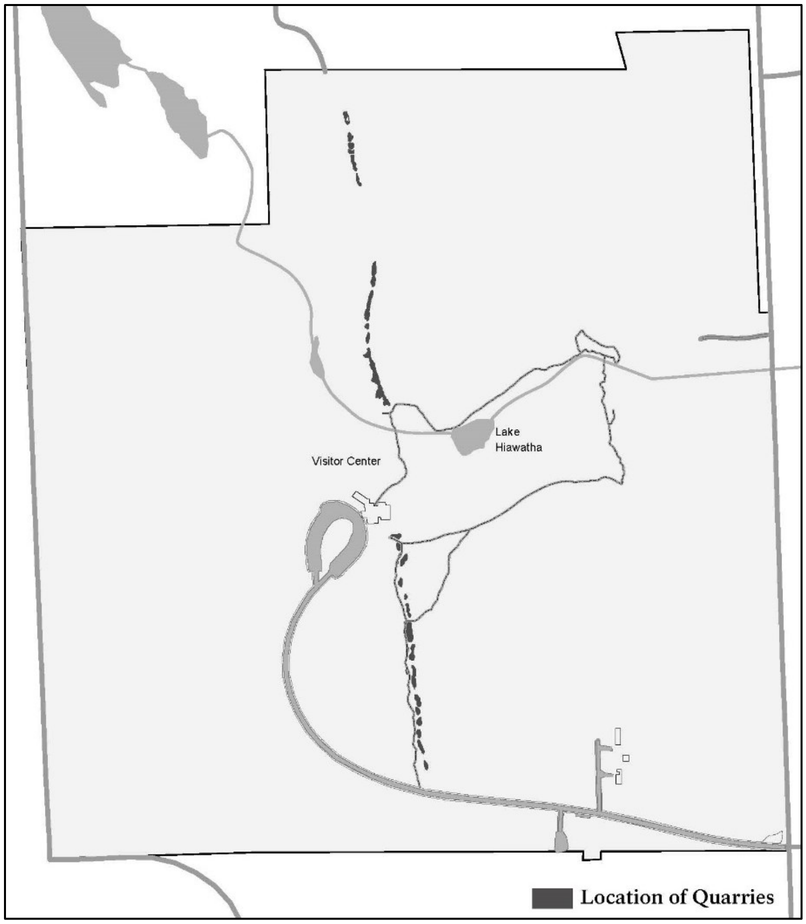


Figure 4-101. Schematic showing the locations of the catlinite quarry areas (source: Seth Hendricks 2015).

Flooding and water quality affecting quarry access and safety. Flooding of the quarries by groundwater flow seasonally impacts quarrying. Exposure to potentially contaminated water collecting in the quarries is also a management concern (pers. comm. Glen Livermont, December 2012). Pipestone Creek is listed as an impaired water body by the state of Minnesota because of elevated levels of fecal coliform (NPS 2008, Toupal et al. 2004). Ritual cleansing by native Americans in the waters of Pipestone Creek prior to quarrying has been discussed as an important cultural element (Toupal et al. 2004), but the current extent of this ritual practice is unknown.

<u>Indicators and Measures</u>

- Quarriable catlinite resource - the red pipestone that can be accessed through traditional hand excavation methods.
- Quarrier health and safety - the health, occupational and environmental risks associated with quarrying pipestone.

4.19.2. Data and Methods

This evaluation was conducted on the basis of written reports and documentation and personal communication with park staff describing the physical, natural and cultural significance of the quarries and the park.

4.19.3. Reference Conditions

The reference condition is considered to be the current condition of 56 active quarries (52 of which are allocated annually). The years have whittled away at the boundaries of what was once a square mile of reserve set aside for the preservation of the quarries (Rothman and Holder 1992). Agricultural and urban encroachment limit the ability to re-create the pre-contact conditions of open prairie with regard to the sights, sounds, smells, wildlife, vegetation, and water quality. However, the quarries remain accessible to Native Americans and the rate of extraction and eastward migration of the quarry lines is very low. The likelihood of exhausting the stone resource is minimal. The monument mission and management will ensure quarrying by Native Americans will continue for the foreseeable future. The condition status rating for the indicators are assigned based on a qualitative evaluation and professional opinion of monument staff.

4.19.4. Condition and Trend

Catlinite Resource

It is believed that the catlinite deposits formed as sedimentary lenses within the context of a braided stream and as such the distribution of the catlinite is patchy. Estimating the remaining minable catlinite is difficult and is based on a number of assumptions and considerations regarding the nature of the formation of the deposits. The Sioux Quartzite bedrock strikes to the north and dips approximately 5 to 10 degrees to the east. It consists of large lenses of quartz-rich strata which encapsulate lenses of catlinite (Morey 1983). It is estimated that most of the minable catlinite lies within a 200 to 300 foot wide swath roughly centered on the present quarry line. The modeled distribution of catlinite at Pipestone National Monument predicts that the catlinite beds will have patchy and discontinuous distributions with units that range in thickness from 1 or 2 inches to approximately 2 feet (Morey 1983). In his assessment of potential new quarry locations the depths to catlinite are on the order of 8 to 20 feet below the surface at the borehole locations, while others are at depths greater than 20 feet. At these depths minor variations in inclination can result in substantially different estimates of depth to catlinite. He also considered it unreliable to attempt to correlate bore hole data with surface exposures of catlinite that are less than one foot thick. In short, there is considerable variability and uncertainty surrounding an estimate of both the distribution and depth of the catlinite deposits (Morey 1983).

There are 83 quarry pits and spaces numbered 1-83. Pits 1-3, located south of the entrance road, have not been worked in many years. Quarries pits 4-35, located north of the entrance road, are referred to as the South Quarry Line, while pits 36-46 constitute the North Quarry Line. A number of spaces (47-68) remain in reserve. The Sundance Quarry Line (pits 69-83) is located near the northern boundary of the park. Of these pits 69 and 70 are inactive and pit 83 is reserved for Sun Dance participants (Scott and Midwest Archeological Center 2006). There are 56 active quarries located in three linear clusters; 52 are allocated annually while the remaining four are for short-term use.

Morey does not defined “minable” in certain terms and it is unclear if he is taking into consideration the methods used to access the stone. The overlying layers of quartzite are dense, thick and difficult to quarry manually. The fundamental concern is that the depth to the catlinite layers will increase as quarrying slowly moves eastward from the present quarry line, creating increased safety hazards and making it more difficult for Native Americans to quarry the material. It is the opinion of park staff that there remains plenty of minable catlinite in the park and that there is little risk that the supply will run out (pers. comm. Mark Calamia August 2013).

Based on observations at the monument, quarry depths currently range from 10-20 feet. Examination of spoil piles on the west sides of the quarries indicate that the quarry faces have migrated less than 10 feet to the east since their creation. At the current rate of quarry activity, the depth to the catlinite lenses will not increase appreciably in the near term. Management of spoil material should not pose significant challenges.

Based on catlinite studies from the 1980s, summarized above (NPS 2008, Morey 1983), it is the opinion of park staff through observation and communication with quarriers that there is more than sufficient catlinite remaining for the foreseeable future. Therefore the condition is considered to be good, and the trend is unchanging. Confidence associated with the volume of remaining catlinite deposits is medium; the supply seems to be very adequate based on current usage.

Quarrier Health and Safety

Health and safety include the potential for injury, illness or death as a result of quarrying. The primary health and safety concerns are the dangers of falling rock or cave-ins and quarrier exposure to contaminated water in the quarries. As the quarries get deeper and/or the spoil piles above them get higher the potential for injury or death increases as the potential for falls, cave-ins and collapses increases. The low rate of accidents related to quarry depth indicates that the current depths do not present significant dangers to the quarriers. In general it is at the discretion of the park superintendent as to whether a particular quarry is no longer safe. Quarrier health and safety warrants moderate concern with an unknown trend rating. Confidence is medium.

Overall Condition and Trend

Although catlinite may become more difficult and dangerous to mine as the quarry pits become deeper, the rate of mining is very low and therefore the depths of the quarries are not anticipated to increase more than several feet over several decades. There are numerous pits that are kept in reserve and are not currently quarried, which may help meet quarrying needs in the future. Seasonal standing water in the quarries is an ongoing issue that is managed by pumping but requires further examination to minimize degradation of the soundscape. The presence of hazardous contaminants in the quarry water is suspected but not documented. The overall condition of the catlinite quarries is considered good with an unchanging trend and a medium level of certainty as there is no expectation that the catlinite resource will become inaccessible due either to diminishing quantities or safety-related quarry conditions (Table 4-77).

Table 4-77. Condition assessment summary for pipestone quarries at Pipestone National Monument.

Indicator	Condition Status/Trend	Rationale
Pipestone Quarries (overall)		**Condition is good with an unchanging trend. Confidence in the assessment is medium.**
Catlinite Quantity		The rate of mining is relatively low, there are quarries in reserve, and there appears to be sufficient catlinite remaining for the foreseeable future.
Quarrier Health and Safety		Despite the risks inherent in this arduous activity, the accident rate seems to be relatively low, but there are uncertainties about risks associated with the water that collects seasonally in the quarries. Occupational risks may increase as the quarries deepen.

4.19.5. Uncertainty and Data Gaps

The precise areal extent of the catlinite deposits is not known and is inferred from core samples taken along section lines centered on individual quarries (Gundersen 1991). There is some uncertainty associated with the quality, extent, location and orientation (i.e., downward trending angle) of the catlinite deposits. Although the opinion of park staff is that long-term outlook of the resource is good there is insufficient data to estimate remaining quantities of catlinite and further study is needed (pers. comm. Mark Calamia August 2013). Links and relationships among land uses, seasonal flooding of the quarries and the water quality and potential health hazards associated with flooded quarries are poorly understood. If funded, a proposed study, expected to begin in 2016, would address issues of climate change and associated impacts on the quarries and quarrying.

4.19.6. Sources of Expertise

Glen H. Livermont, Park Superintendent, Pipestone National Monument

Mark A. Calamia, PhD. Cultural Resources Program Manager, Pipestone National Monument.

4.19.7. Literature Cited

Gundersen, J. N. 1991. The mineralogical characterization of catlinite from its sole provenance, Pipestone National Monument, Minnesota. Archaeometry Laboratories, Wichita State University and United States National Park Service. Midwest Region.

Gundersen, J. N. 1993. "Catlinite" and the spread of the calumet ceremony. American Antiquity 58 (3):560-562.

National Park Service (NPS). 2008. Final general management plan and environmental impact statement: Pipestone National Monument. National Park Service, U.S. Dept. of the Interior, Washington, D.C.

Rothman, H. and D. J. Holder. 1992. Managing the sacred and the secular: an administrative history of Pipestone National Monument. Hal K. Rothman and Associates. Henderson, Nevada.

Scott, D.D. and Midwest Archeological Center. 2006. An archeological inventory and overview of Pipestone National Monument, Minnesota. United States Department of the Interior, National Park Service, Midwest Archeological Center.

Toupal, R., R. Stoffle, N. O'Meara and J. Dumbauld. 2004. The everchanging pipestone quarries: Sioux cultural landscapes and ethnobotany of Pipestone National Monument, Minnesota. Bureau of Applied Research in Anthropology, University of Arizona.

Morey, G. B. 1983. Evaluation of catlinite resources, Pipestone National Monument, Minnesota. Minnesota Geological Survey and United States National Park Service, Midwest Region.

Zedeño, M. Nieves and R.C. Basaldu. 2004. Pipestone National Monument, Minnesota Native American cultural affiliation and traditional association study. Bureau of Applied Research in Anthropology, University of Arizona.

5. Summary and Discussion

This section summarizes condition and trend results by focal resource, highlights management implications and interrelationships among resources and between resources and landscape context elements, and consolidates data gaps across the assessment components.

5.1. Condition Summary and Management Implications

A total of 18 focal resources were examined: six addressing landscape context - system and human dimensions, three addressing chemical and physical attributes, eight addressing biological attributes, and one addressing an integrated natural-cultural topic. Status and trend assigned to each focal resource and a synopsis of supporting rationale are presented in Table 5-1.

5.1.1. Landscape Context –System and Human Dimensions

Landscape context - system and human dimensions included land cover and land use, night sky, soundscape, scenery, climate change and fire disturbance regime. Climate change and land cover/land use were not assigned a condition or trend – they provide important context to the park and many natural resources, and can be a source of stress and management concern. Those components that were assigned a resource condition uniformly warranted moderate concern with a deteriorating trend. It is no accident that the trend is similar for scenery, night sky and soundscape. These three resources are all affected by land cover and land use occurring inside and outside the park, and are anticipated to deteriorate as changes continue to occur. The park is particularly susceptible to these stressors due to its relatively small size, which minimizes internal buffering.

Many of these land cover and land use-related stressors at PIPE and in the larger region are related to the development of rural agricultural land and increases in population/housing over time. This trend in land development, coupled with the lack of significantly-sized and linked protected areas, presents significant challenges to the conservation of natural resources of Pipestone National Monument to also include dark night skies, natural sounds and scenery. Climate change is happening and is affecting resources, but is not considered *good* or *bad* per se. The information synthesized in that section is useful in examining potential trends in the vulnerability of several sensitive biological resources below. The fire regime is included here because in this region fire is a key natural process under which many biological components have evolved. Therefore, it is deemed a critical component of the long-term persistence of prairie species and the ecological integrity of the system as a whole. The fire regime warranted moderate concern with a downward trend, and might be significantly ameliorated via planning, programmatic and budgetary measures.

There are opportunities to mitigate the effects of local stressors through planning, management and mitigation. Stressors driven by more distant factors such as light pollution generated by urban centers and increase in regional transportation volumes affecting sights and sounds are more difficult to mitigate. Collectively, this context supports resource planning and management within the park, and provides a foundation for collaborative conservation with other landowners in the surrounding area.

Table 5-1. Summary of focal resource condition, trend and data gaps for Pipestone National Monument.

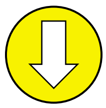
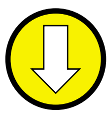
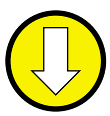
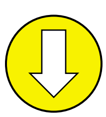
Resource	Condition and Trend	Rationale for Overall Condition/Trend Rating
Landscape Context –System and Human Dimensions		
Land Cover and Land Use	condition and trend not assigned	Most land cover and land use-related stressors at PIPE and in the larger region are related to the development of rural agricultural land and increases in population/housing over time. Conversion of hay and pasture lands to cropland is also a concern, as the former class has much higher conservation value. Development and a lack of significantly-sized and linked protected areas threatens the conservation of natural resources at the park to include dark night skies, natural sounds and scenery.
Night Sky		Light pollution from the town of Pipestone, nearby urban areas, and more distant urban centers degrades the quality of the monument's night skies. The monument is close to pockets of darker night skies, especially to the north and east.
Soundscape		Noise from anthropogenic sources is pervasive, and is related to encroachment from the city of Pipestone and other nearby development and transportation noise. Sound pressure levels exceeded threshold levels <10% of the time, but exceedence levels warranted moderate concern. Although natural sounds like birds, wind, and amphibians were heard nearly continuously, vehicles were also audible at least 98% of the time. Anthropogenic noise is significantly increasing the existing ambient sound level above the natural ambient sound level of the monument. Trend is based on anticipated increases in development and traffic over time.
Scenery and Views		Some scenic views are relatively high quality but some have been affected by development or other activities that can detract from the scenic quality. Power line support structures, power lines and rural residential housing degrade many of the key park views. Some views are significantly impacted by overabundant trees that are incongruent with the desired prairie landscape character. Park views are already impacted by several wind energy projects and there is potential for future wind farm development within the park's viewshed. Visibility is consistently poor.
Climate Change	condition and trend not assigned	All indications are that the climate in this park region is already becoming drier (despite increasing precipitation), hotter, and is more prone to more frequent and extreme weather events and drought. Trends in the indicators are projected to continue or accelerate by the end of the century.
Fire Disturbance Regime		Fire regime components vary in their ability to meet reference conditions. Although fire frequencies generally fall within the desired range, variability in the seasonality of fire may limit the restoration benefits and reduce heterogeneity within the prairie. Administrative uncertainties and inconsistent funding of prescribed burn management may adversely affect the condition of this resource over time and result in higher levels of invasive plants and woody species in the prairie.

Table 5-1 (continued). Summary of focal resource condition, trend and data gaps for Pipestone National Monument.

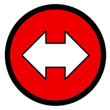
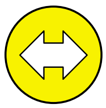
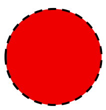
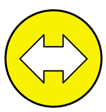
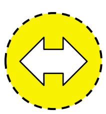
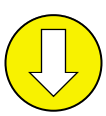
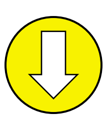
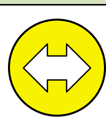
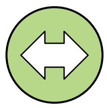
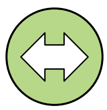
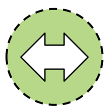
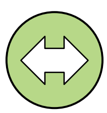
Resource	Condition and Trend	Rationale for Overall Condition/Trend Rating
Chemical and Physical Environment		
Air Quality		Ozone levels are moderate and may be improving since 2001, but the trend is not statistically significant. Wet deposition and visibility ratings are consistently poor for the monument.
Stream Hydrology and Geomorphology		Applying the Proper Functioning Condition and Channel Evolution Model frame work, Pipestone Creek was rated Functional – At Risk with No Apparent trend. Four criteria were rated positively; nine negatively; and three rated N/A for beaver presence, large woody material, and point-bar revegetation. The stream and watershed are highly altered due to channelization, drain tiling and agricultural conversions.
Water Quality		Pipestone creek has been listed as a 303(d) impaired stream for fecal coliforms and turbidity and these metrics continue to exceed established standards. Levels of chloride and sulfate are within established standards. The stream is impacted by agricultural runoff due to its proximity to large agricultural areas and drainage ditches fed by drain tile outlets providing flow to the creek Assessing the current condition and trend is challenging due to lack of existing or recent data for some metrics.
Biological - Plants		
Prairie Vegetation		Native species diversity indicators are generally good, but community composition (i.e., nativeness) is of moderate concern. Woody species encroachment and the presence and abundance of invasive plants continue to be management challenges.
Western Prairie Fringed Orchid		Although recent years have had much larger numbers of flowering individuals with high vigor observed, temporal variability is high and confidence in population estimates are low. The preponderance of spring fires may not be optimized for orchid management. The orchid was found to be moderately vulnerable to climate change within the park and extremely vulnerable within its current range. More information is needed to evaluate appropriate thresholds for this factor and to understand the effects of different management strategies.
Sioux Quartzite Prairie		The landform is intact, historical disturbance is relatively low, and regular prescribed fires benefit the community. However, the condition warrants moderate concern due to the prevalence of nonnative species and the community is considered extremely vulnerable to climate change throughout its current range and at the monument. Inadequate prescribed fire may lead to further degradation.
Invasive Exotic Plants		Several IEP species such as smooth brome and Kentucky bluegrass occur frequently and are likely to impact native grasslands. Several IEP species have estimated cover ranges greatly exceeding 25% of the total acreage of the monument. A significant portion of search units have more than 5 IEP species present. Six Minnesota state-listed noxious weed species are present; their combined acreage is greater than 1% of the monument.
Biological - Animals		
Aquatic Macroinverte-brates		The majority of species richness and diversity indices warranted moderate concern. The Hilsenhoff index of biotic integrity warranted significant concern, indicating an increase in organic pollution. The benthic community is likely being impacted by upstream sources and activities outside the park.

Table 5-1 (continued). Summary of focal resource condition, trend and data gaps for Pipestone National Monument.

Resource	Condition and Trend	Rationale for Overall Condition/Trend Rating
Biological – Animals (continued)		
Bird Community		Overall condition combined ratings for grassland and woodland bird communities. Native species richness was generally good. The bird index of biotic integrity rated moderate concern for grassland birds and significant concern for woodland birds. The number of obligate grassland birds and the bird community structure appears representative of a moderately disturbed landscape.
Fish Community		Native species richness, the fish IBI, and the number of species of concern present indicate that the native fish communities warrant moderate concern. The fish community structure appears representative of a moderately disturbed landscape. The federally endangered Topeka shiner is present.
Topeka shiner		The federally endangered Topeka shiner is present and a community of predaceous fish that prey upon the Topeka shiner is low in abundance. The species was found to be moderately vulnerable to climate change throughout its current range and within the monument.
Integrated Natural/Cultural		
Pipestone Quarries		Although catlinite may become more difficult and dangerous to mine as the quarry pits become deeper, the rate of mining is very low and the depths of the quarries are not anticipated to increase more than several feet over several decades. Numerous pits are kept in reserve and not currently quarried, which may help meet quarrying needs in the future. Seasonal standing water in the quarries is an ongoing issue that is managed by pumping but requires further examination to minimize degradation of the soundscape. The presence of hazardous contaminants in the quarry water is suspected but not documented.

5.1.2. Chemical and Physical Environment

The supporting chemical and physical environment at the monument includes its air quality, water quality and stream hydrology/geomorphology. Air and water quality warranted significant concern while stream hydrology and geomorphology warranted moderate concern. Conditions were estimated to be unchanging for two out of three resources. All components are significantly impacted by factors and activities related to land uses outside the park boundary. The condition of these resources adversely affects human dimensions of the park such as visibility and scenery as well as biological components such as stream biota.

5.1.3. Biological Component - Plants

The floral biological components examined included prairie vegetation, western prairie fringed orchid, Sioux quartzite prairie community, and invasive exotic plants. All faunal resources examined warranted moderate concern. Climate change vulnerability was integrated into the assessment of western prairie fringed orchid and Sioux quartzite prairie, and contributed to a deteriorating trend for the quartzite prairie. The park has some excellent examples of relatively rare species and communities. However, challenges related to invasive plant management and fire regime contribute to moderate ratings and some declining trends.

5.1.4. Biological Component - Animals

The faunal biological components examined included aquatic macroinvertebrates, the bird community, the fish community and the Topeka shiner. With the exception of aquatic invertebrates, faunal resources were considered to be in good condition. Based on available information, trends in all resources were unchanging.

5.1.5. Integrated Natural/Cultural

The pipestone quarries were examined as an integrated natural/cultural resource considered to be the cornerstone of the park's mission and purpose. The quarry resource was considered to be in good condition with an unchanging trend. Management concerns for this resource consist of water management within the quarries and exposure to potentially contaminated water. Planning for the sustainable use of the catlinite quarries is critical to bridging the cultural and natural landscape elements and meeting the park's primary mission.

5.2. Data Gaps and Uncertainties

The identification of data gaps during the course of the assessment is an important outcome of the NRCA (Table 5-2). In some cases significant data gaps contributed to low confidence in the condition or trend assigned to a resource. Primary data gaps and uncertainties encountered were lack of recent survey data; uncertainties regarding reference conditions; availability of consistent, long-term data; and scientific understanding of the ecology of rare resources.

Table 5-2. Data gaps identified for focal resources examined at Pipestone National Monument.

Resource	Data Gaps
Landscape Context –System and Human Dimensions	
Land Cover and Land Use	Condition/status of other protected lands in the region.
Night Sky	No night sky monitoring studies have been conducted at PIPE. The NSNSD national model of ambient light levels and anthropogenic sources of light were not available for this assessment.
Soundscape	Impacts of existing soundscape conditions on visitor experiences.
Views and Scenery	Further examination of key park views by monument staff is recommended incorporating the scenic quality protocols being developed by the NPS Scenery Conservation Program.
Climate Change	Climate change projections are complex and have inherently high uncertainty. More specific guidance for park-scale adaptation is needed.
Fire Disturbance Regime	Burn severity data.
Chemical and Physical Environment	
Air Quality	Local air monitoring stations would provide more accurate data.
Stream Hydrology and Geomorphology	Some stage data recorded by the MDNR appear to be erroneous. Nominal data gaps.
Water Quality	Water quality monitoring in Pipestone Creek within and near park boundaries is inconsistent.

Table 5-2 5.2 1 (continued). Data gaps identified for focal resources examined at Pipestone National Monument.

Resource	Data Gaps
Biological - Plants	
Prairie Vegetation	High variability in sample data due to interannual weather differences, phenology and small sample sizes can make it difficult to interpret data and detect statistically significant changes over time.
Western Prairie Fringed Orchid	Understanding of orchid ecology and interrelationships between orchid populations, reproduction and factors such as fire, hydrology, plant competition and climate change is incomplete.
Sioux Quartzite Prairie	Rare plant survey data are old, vegetation monitoring sampling design contains only three sample sites in this type, and no survey data are available for fauna within ephemeral pools.
Invasive Exotic Plants	Excellent data is available; no gaps were identified.
Biological - Animals	
Aquatic Macroinvertebrates	Reference conditions are poorly defined in this region.
Bird Community	No significant gaps were identified.
Fish Community	No significant gaps were identified.
Topeka shiner	No significant gaps were identified.
Integrated Natural/Cultural	
Pipestone Quarries	Links and relationships among land uses, seasonal flooding of the quarries and the water quality and potential health hazards associated with flooded quarries are poorly understood.

5.3. Conclusions

Ecosystem stressors impacting park resources and their management exist both inside and outside park boundaries. Altered disturbance regimes such as fire and flooding, conversion and fragmentation of natural habitats, spread of invasive exotic plants and animal species that threaten regional biological diversity, altered hydrology and channel degradation of streams, and water pollution appear to be significant stressors of biological resources. Other resources related to human dimensions (including cultural/ethnographic features) and visitation appeared to be stressed or directly affected by changes in land uses and land cover, population and housing densities, traffic and wind energy development. Climate change was estimated to contribute to the vulnerability of sensitive resources such as Sioux quartzite prairie, Topeka shiner and western prairie fringed orchid. Many of the resources were found to have interrelated stressors, the most common stressors being invasive plants, increased development and altered watershed characteristics.

Ultimately, measures that contribute to maintaining the sacred character of the site will tend to benefit natural resources and vice versa (personal comment, Glen Livermont, December 2012). Regional and park-specific mitigation and adaptation strategies are needed to maintain or improve the condition of some resources over time. Success will require acknowledging a "dynamic change context" that manages widespread and volatile problems while confronting uncertainties, managing natural and cultural resources simultaneously and interdependently, developing broad disciplinary and interdisciplinary knowledge, and establishing connectivity across broad landscapes beyond park borders (National Park Service Advisory Board Science Committee 2012).

5.4. Literature Cited

National Park System Advisory Board Science Committee. 2012. Revisiting Leopold: resource stewardship in the National Parks. Washington D.C.

NPS 372/131038, January 2016

National Park Service
U.S. Department of the Interior

Natural Resource Stewardship and Science
1201 Oakridge Drive, Suite 150
Fort Collins, CO 80525

www.nature.nps.gov