National Park Service
U.S. Department of the Interior

Natural Resource Stewardship and Science

Fort Union Trading Post National Historic Site

Natural Resource Condition Assessment

Natural Resource Report NPS/FOUS/NRR—2014/774

ON THE COVER
Photo from a rendezvous at Fort Union Trading Post
Photograph by: Courtesy of FOUS

Fort Union Trading Post National Historic Site

Natural Resource Condition Assessment

Natural Resource Report NPS/FOUS/NRR—2014/774

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February 2014

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

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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.

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Please cite this publication as:

Komp, M. R., E. Iverson, A. J. Nadeau, S. Amberg, L. Danielson, L. Danzinger., J. Sopcak, and B. Drazkowski. 2014. Fort Union Trading Post National Historic Site: Natural resource condition assessment. Natural Resource Report. NPS/FOUS/NRR—2014/774. National Park Service, Fort Collins, Colorado.

NPS 436/123908, February 2014

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Executive Summary

The Natural Resource Condition Assessment (NRCA) Program aims to provide documentation about the current conditions of important park natural resources through a spatially explicit, multi-disciplinary synthesis of existing scientific data and knowledge. Findings from the NRCA, including the report and accompanying map products, will help Fort Union Trading Post managers to develop near-term management priorities; engage in watershed- or landscape-scale partnership and education efforts; conduct park planning (e.g., Resource Stewardship Strategy); and report program performance (e.g., Department of the Interior's Strategic Plan "land health" goals, Government Performance and Results Act).

The objectives of this assessment are to evaluate and to report on current conditions of key park resources, to evaluate critical data and knowledge gaps, and to highlight selected existing stressors and emerging threats to resources or processes. For the purpose of this NRCA, staff from the National Park Service (NPS) and Saint Mary's University of Minnesota – GeoSpatial Services (SMUMN GSS) identified key resources, referred to as "components" in the project. The selected components include natural resources and processes that are currently of the greatest concern to park management at FOUS. The final project framework contains 11 resource components, each featuring discussions of measures, stressors, and reference conditions.

This study involved reviewing existing literature and, where appropriate, analyzing data for each natural resource component in the framework to provide summaries of current condition and trends in resources. When possible, existing data for the established measures of each component were analyzed and compared to designated reference conditions. A weighted scoring system was applied to calculate the current condition of the components. Weighted condition scores, ranging from zero to one, were divided into three categories of condition: low concern, moderate concern, and significant concern. These weighted condition scores help to determine the overall current condition of each resource.

Existing literature and short- or long-term datasets, as well as expertise from NPS and other outside agency or organization scientists support condition designations for components in this assessment. However, in a number of cases, FOUS components lack historic data, a quantitative reference condition that lends itself to comparison, or current data or monitoring information. Thus, in these cases, it was not possible to assign condition for these components. The discussions for each component, found in Chapter 4 of this report, represent a comprehensive summary of current available data and information for these resources, as well as unpublished park information and perspectives of park resource managers, and present a current condition designation when appropriate. FOUS park resource managers and NPS Northern Great Plains Network (NGPN) Inventory and Monitoring (I&M) specialists reviewed and provided feedback regarding the assessment of all components in Chapter 4.

For those components with sufficient available data, the overall condition assignments are of moderate or significant concern. The condition of two of the ecological community components (natural and reconstructed prairie) are of moderate concern with unknown trend, due to recent adoption of a standard monitoring protocol. The condition of the air quality component is of moderate concern as well, but stable. The condition of the river and stream geomorphology component is of significant concern with a declining trend, largely due to erosion factors. Many

of the resources in the park are subject to threat and stressor factors beyond the control of park management, often related to human development. Chapters 4 and 5 present the detailed information and conclusions for all components.

Acknowledgments

We acknowledge Fort Union Trading Post National Historic Site staff for their insight regarding resource components, timely feedback regarding component reviews, and engaged dialogue throughout the duration of the project, especially Andy Banta and Audrey Barnhart. Northern Great Plains Inventory and Monitoring Staff, including Kara Paintner-Green, Stephen Wilson, and Marcia Wilson, provided logistical insight throughout the duration of the project and critical review of interim documents. Ellen Porter (NPS-Air Resources Division) assisted with development of the air quality component and Jalyn Cummings provided feedback regarding the river and stream geomorphology component. Isabel Ashton and Michael Prowatzke of NGPN and Amy Symstad of USGS provided review of the plant community components. Carmen Thomson, NPS Midwest Region Inventory and Monitoring Coordinator, helped with project implementation. Jeff Albright, Natural Resource Condition Assessment Coordinator, provided program guidance.

Acronyms and Abbreviations

BBS - Breeding Bird Survey

BCR - Bird Conservation Region

CAA - Clean Air Act

CBC - Christmas Bird Count

dB - Decibels

DEM - Digital elevation model

DO - Dissolved oxygen

EPA - Environmental Protection Agency

EPMT- Exotic Plant Management Team

FOUS – Fort Union Trading Post National Historic Site

MDEQ - Montana Department of Environmental Quality

NAAQS - National Ambient Air Quality Standards

NGPN - Northern Great Plains Inventory and Monitoring Network

NLCD - National Land Cover Dataset

NPS - National Park Service

NPS ARD - National Park Service, Air Resources Division

NRCA - Natural Resource Condition Assessment

NSR - Native Species Richness

PIF - Partners in Flight

PM - Particulate Matter

RMBO - Rocky Mountain Bird Observatory

SMUMN GSS - Saint Mary's University of Minnesota GeoSpatial Services

STORET - EPA Storage and Retrieval Data Warehouse

USACE – United States Army Corps of Engineers

USFWS – United States Fish and Wildlife Service

USGS - United States Geological Survey

VOC - Volatile Organic Compounds

Chapter 1 NRCA Background Information

Natural Resource Condition Assessments (NRCAs) evaluate current conditions for a subset of natural resources and resource indicators in national park units, hereafter "parks". For these condition analyses they also report on trends (as possible), critical data gaps, and general level of confidence for study findings. The resources and indicators emphasized in the project work depend on a park's resource setting, status of resource stewardship planning and science in identifying high-priority indicators for that park, and availability of data and expertise to assess current conditions for the things identified on a list 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 logical reference conditions/values to compare current condition data against[3,4]
- emphasize spatial evaluation of conditions and GIS (map) products[5]
- summarize key findings by park areas[6]
- 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 current condition reporting relative to logical forms of reference conditions and values is the primary objective, NRCAs also report on trends for any study indicators where the underlying data and methods support it. Resource condition influences are also addressed. This can include past activities or conditions that provide a helpful context for understanding current

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[1] However, 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 reporting 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

[4] 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")

[5] As possible and appropriate, NRCAs describe condition gradients or differences across the park for important natural resources and study indicators through a set of GIS coverages and map products

[6] 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

park resource conditions. It also includes present-day condition influences (threats and stressors) that are best interpreted at park, watershed, or landscape scales, though NRCAs do not judge or report on condition status per se for land areas and natural resources beyond the park's boundaries. Intensive cause and effect analyses of threats and stressors or development of detailed treatment options is outside the project scope.

Credibility for study findings derives from the data, methods, and reference values used in the project work—are they appropriate for the stated purpose and adequately documented? For each study indicator where current condition or trend is reported it is important to identify critical data gaps and describe 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: 1) to assist selection of study indicators; 2) to recommend study data sets, methods, and reference conditions and values to use; and 3) to help provide a multi-disciplinary review of draft study findings and products.

NRCAs provide a useful complement to more rigorous NPS science support programs such as the NPS Inventory and Monitoring Program. 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 bring in relevant non-NPS data to help evaluate current conditions for those same Vital Signs. In some cases, NPS inventory data sets are also incorporated into NRCA analyses and reporting products.

In-depth analysis of climate change effects on park natural resources is outside the project scope. However, existing condition analyses and data sets developed by a NRCA will be useful for subsequent park-level climate change studies and planning efforts.

NRCAs do not establish management targets for study indicators. Decisions about management targets must be made through sanctioned park planning and management processes. NRCAs do provide science-based information that will help park managers with an ongoing, longer term effort to describe and quantify their park's desired resource conditions and management targets. In the near term, NRCA findings assist strategic park resource planning[7] and help parks

Important NRCA Success Factors …

Obtaining good input from park and other NPS subjective 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

[7] NRCAs are an especially useful lead-in to working on a park Resource Stewardship Strategy(RSS) but study scope can be tailored to also work well as a post-RSS project

report to government accountability measures[8].

Due to their modest funding, relatively quick timeframe for completion and reliance on existing data and information, NRCAs are not intended to be exhaustive. Study methods typically involve 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 our present data and knowledge bases across these varied study components.

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 credible and has practical uses for a variety of park decision making, planning, and partnership activities.

Over the next several years, the NPS plans to fund a NRCA project for each of the ~270 parks served by the NPS Inventory and Monitoring Program. Additional NRCA Program information is posted at: http://www.nature.nps.gov/water/NRCondition_Assessment_Program/Index.cfm.

NRCA Reporting Products…

Provide a credible snapshot-in-time evaluation for a subset of important park natural resources and indicators, to help park managers:

Direct limited staff and funding resources to park areas and natural resources that represent high need and/or high opportunity situations

(near-term operational planning and management)

Improve understanding and quantification for desired conditions for the park's "fundamental" and "other important" natural resources and values

(longer-term strategic planning)

Communicate succinct messages regarding current resource conditions to government program managers, to Congress, and to the general public

("resource condition status" reporting)

[8] 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

Chapter 2 Introduction and Resource Setting

2.1 Introduction

2.1.1 Enabling Legislation

American Fur Company established Fort Union Trading Post in 1828. From then to 1867, it was the largest and most important fur trading post on the upper Missouri River. During this time, many Native American tribes came to the fort to trade buffalo robes and other goods. The trading post was the center of peaceful economic and social interactions between Euro-Americans and Native Americans. The President of the United States and Congress passed public law 89-458 (80 Stat. 211) on June 20, 1966, authorizing the establishment of Fort Union Trading Post National Historic Site (FOUS) "…to commemorate the significant role played by Fort Union as a fur trading post on the upper Missouri River" (NPS 2010).

2.1.2 Geographic Setting

Fort Union is a 180-hectare (444-acre) park located in Williams and McKenzie Counties, North Dakota, and Roosevelt and Richland Counties, Montana. The fort structure is located near the north bank of the Missouri River, and park lands are adjacent to the Missouri River and the Montana-North Dakota border (Ellis 2008). The river, up to the banks of normal high water, remains property of the adjoining state.

Williams County is the most populated and has a human population density of 3.67 persons per square kilometer, which is above the average for North Dakota (3.59 persons per square kilometer) (USCB 2010).

FOUS lies within the sedimentary Williston Basin. Most of FOUS lies on Quaternary-aged alluvium from the Missouri River. The northern upland section lies within the Bullion Creek Formation, which is a Paleocene deposit. The Sentinel Butte Formation lies on top of the Bullion Creek Formation just outside the park to the northeast (Salas and Pucherelli 2002).

North Dakota has a continental semi-arid climate due to the fact that it is located in the center of North America. The summers are dry and hot, with cold, dry arctic air masses creating harsh winters. The average temperature frequently drops to -17.8°C (0°F) (Table 1). Large fluctuations in temperature can be expected with low relative humidity (Salas and Pucherelli 2002). Extreme low temperatures are much colder.

Table 1. Monthly temperature and precipitation normals (1971-2000) for FOUS (Station 148, Williston Exp Farm) (NCDC 2002).

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Average Temperature (°C)													
Max	-6.16	-1.38	5.6	14.38	21.3	26.0	29.4	29.3	22.6	15.3	3.16	-3.67	13.0
Min	-16.9	-12.3	-6.6	-0.11	6.5	11.4	14.0	13.1	7.1	0.94	-7.16	-14.1	-0.33
Average Precipitation (cm)													
Total	1.2	0.9	1.6	2.9	5.3	6.9	6.2	4.1	3.9	2.4	2.0	1.1	38.1

2.1.3 Visitation Statistics
According to surveys taken during the calendar years of 2005-2009, approximately 14,000 people come to visit the fort annually. The largest event is the Fort Union Rendezvous, where visitors can experience a fur trade fair, demonstrations, and re-enactments. This event averages 5,000 visitors each year. Ninety-five percent of visitation occurs between the months of May and September and the lowest occurs from December to February (NPS 2010). Visitors have the opportunity to explore inside the fort, hike on trails, and watch informational videos. There are many exhibits featuring artifacts, maps, historic photos, art work, and hands-on-displays. FOUS also offers a Junior Trader program, designed for children ages 8-12 (NPS 2010). There are many special events and community programs. Other events include Fort Union Living History Weekend, Last Bell Tours, Fort Buford Cemetery Walk, Engages Christmas, and American Indian Youth Partnership presentations (NPS 2010).

2.2 Natural Resources

2.2.1 Ecological Units and Watersheds
FOUS is part of the EPA's Northwestern Great Plains Ecoregion. The following is a description of this ecoregion.

> Encompasses the Missouri Plateau section of the Great Plains. It is a semiarid rolling plain of shale, siltstone, and sandstone punctuated by occasional buttes and badlands. Native grasslands persist in areas of steep or broken topography, but they have been largely replaced by spring wheat and alfalfa over most of the ecoregion. Agriculture is limited by erratic precipitation patterns and limited opportunities for irrigation (USGS 2006).

The EPA divides Level III Ecoregions into smaller Level IV Ecoregions. The Northwestern Great Plains consists of eleven Level IV Ecoregions. FOUS is located in the River Breaks Level IV ecoregion; the USGS Northern Prairie Wildlife Research Center offers the following description of this geographic area:

> The River Breaks form broken terraces and uplands that descend to the Missouri River and its major tributaries. They have formed particularly in soft, easily erodible strata, such as Pierre shale. The dissected topography, wooded draws, and uncultivated areas provide a haven for wildlife. Riparian gallery forests of cottonwood and green ash persist along major tributaries such as the Moreau and Cheyenne rivers, but they have largely been eliminated along the Missouri River by impoundments (Bryce et al. 1998).

FOUS is located in the Missouri River watershed, region 10. Locally, it lies in cataloging unit 10060005, Charlie-Little Muddy, which is 3,108 km^2 in area (Seaber et al. 1994).

2.2.2 Resource Descriptions
Archaeological, historical, and cultural features are primary resources at FOUS. No original buildings remained when congress declared the post a historical site. Local citizens organized as the Friends of Fort Union, who supported the reconstruction. Using historical images and archaeological investigations, the fort was rebuilt in the exact location of the original post. Archaeological work began in 1968. During that time, more than 559,000 artifacts were found.

Following additional excavations from 1986-1988 the artifact collection grew to include 800,000 objects (NPCA 2006).

The uplands in the park are predominantly composed of native and reconstructed mixed grass prairies dominated by mid-sized and short grasses and upland sedges. The Missouri River also adds a woodland component composed of ash (*Fraxinus* spp.), elm (*Ulmus* spp.), and cottonwood (*Populus deltoides*). Shrubs include snowberry (*Symphoricarpos* spp.), chokecherry (*Prunus virginiana*), buffaloberry (*Shepherdia*) and willow (*Salix* spp.) (Salas and Pucherelli 2002).

Photo 1. Prairie and woodland, as viewed from FOUS (Photo by Barry Drazkowski, SMUMN GSS 2010).

There are many small mammals present at the site, including various mice (Muridae), shrews (Soricidae), voles (Cricetidae), gophers (Geomyidae), and ground squirrel (Sciuridae) species. Cottontail rabbit (*Sylvilagus* sp.), raccoon (*Procyon lotor*), and porcupine (*Erethizon dorsatum*) can also be observed at the historical site (Schmidt et al. 2004). There are four species of bats present at FOUS: big brown bat (*Eptesicus fuscus*), western small-footed bat (*Myotis ciliolabrum*), little brown myotis (*M. lucifugus*), and long-legged myotis (*M. volans*) (Schmidt et al. 2004).

Photo 2. White pelicans (USFWS photo).

Because FOUS is along a major flyway, a variety of migratory and non-migratory birds utilize the park in some fashion. In total, at least 90 bird species utilize FOUS (Panjabi 2005). Some of the better known large species include Canada geese (*Branta canadensis*), white pelicans (*Pelecanus erythrorhynchos*), golden (*Aquila chrysaetos*) and bald eagles (*Haliaeetus leucocephalus*). Some of the smaller species include the American goldfinch (*Carduelis tristis*), lazuli bunting (*Passerina amoena*), black-headed grosbeak

(*Pheucticus melanocephalus*), and yellow warbler (*Dendroica petechia*) (NPS 2006).

Reptiles present at FOUS include gopher snakes (*Pituophis catenifer*), racer (*Coluber constrictor*), and red-sided and plains garter snakes *(Thamnophis sirtalis* and *T. radix)* (NPS 2012). Amphibians include: Woodhouse's toad (*Bufo woodhousii*), northern leopard frog (*Rana pipiens*), western chorus frog (*Pseudacris triseriata*), tiger salamander (*Ambystoma tigrinum*), Great Plains toad (*Bufo cognatus*), and the plains spadefoot (*Spea bombifrons*) (NPS 2012).

Photo 3. Gopher snake (NPS photo).

2.2.3. Resource Issues Overview

Fort Peck Dam (approximately 298 km upstream of FOUS) was completed in 1940 and changed the hydraulic regime of the Missouri River. Regulation of the river has altered the floodplain forest composition. Cottonwood and willow forests originate when the seeds of these two species germinate in bare, moist river sediments deposited by floods. Because of the dam's flood regulation, regeneration of cottonwood forests has been brought to a standstill. In addition, erosion is removing existing cottonwood stands. The disappearance of the cottonwood forests is damaging the aesthetic and scenic quality of the view from the trading post (Ellis 2006). There is also a specific concern for bats, due to loss of habitat. The riparian woodlands once provided optimal habitat for many bat species (Ellis 2006). Erosion is not the only factor that threatens the riparian community. Agriculture accounts for a more rapid rate of degradation (USACE 1995, as cited by Ellis 2006).

Like all parks in the Northern Great Plains, exotic or invasive plants are a concern at FOUS. These species out-compete native plants, altering the structure and composition of native plant communities. This in turn can alter natural processes, such as nutrient cycling and fire regime, ultimately compromising the integrity of wildlife habitats. Exotic plant species in FOUS, present in small clumps or isolated patches, have created a change in the quality of the cultural landscape at FOUS. Canada thistle (*Cirsium arvense*), Russian olive (*Elaeagnus angustifolia*), leafy spurge (*Euphorbia esula*), smooth brome (*Bromus inermis*), crested wheatgrass (*Agropyron cristatum*), cheatgrass (*Bromus tectorum*), and tamarisk (*Tamarix ramosissima*) are exotic plants of particular concern in FOUS (NPS 2005), although not all of these currently occur in the park.

2.3 Resource Stewardship

2.3.1 Management Directives and Planning Guidance

FOUS does not have a current General Management Plan. However, they have created a long-range interpretive plan (NPS 2010) and a Fire Management Plan (NPS 1999). The Northern Great Plains Exotic Plant Management Plan and Environmental Assessment (NPS 2005) also describes park management goals.

Over the next seven to ten years, FOUS will provide visitors with resources to increase their understanding and appreciation for the park and its resources. It will also engage in local educational opportunities and participate in nationally significant events. The goal is to ensure responsible management and protections for park resources.

The main goals expressed in the Fort Union Trading Post National Historic Site Long-Range Interpretive Plan (NPS 2010) are to

- Highlight the unique fur trading fort experience
- Improve personal services
- Host special events
- Strengthen tribal relations and interpretive connections
- Increase community outreach
- Improve the park website
- Develop and provide curriculum-based education programs
- Increase the volunteer program
- Facilitate the development and growth of existing and future partnerships
- Contact a variety of visitors
- Upgrade and improve site-specific interpretation

The FOUS Fire Management Plan (NPS 1999) was established to maintain the cultural integrity of the prairie surrounding the park, as well as treat the floodplain and riverbanks in an on-going exotic plant abatement program.

Specific Fire Management Plan objectives for the prairie areas are to

- Use prescribed fire to restore natural ecosystem processes
- Reduce the extent of exotics, and increase the extent of natural species
- Maintain and increase richness of natural species
- Reduce cover of woody species
- Reduce hazard fuels around historic structures

Specific Fire Management Plan objectives for the riparian areas are to

- Use prescribed fire to restore ecosystem processes

- East of the fort, use fire to remove cover of willow without causing willow mortality and reduce dead and down woody ground cover

- West of the fort, use fire to reduce dead and down woody ground cover without causing mortality in the mature forest.

The Northern Great Plains Exotic Plant Management Plan and Environmental Assessment define goals for exotic plant management efforts. The primary goal defined in this plan is to reduce the negative effects of exotic plants on native plant communities as well as other natural and cultural resources within the park (NPS 2005).

More specific goals and objectives defined in the Northern Great Plains Exotic Plant Management Plan and Environmental Assessment (NPS 2005) are to

- Restore native plant communities and to reduce the need for ongoing management

- Prevent unacceptable levels of exotic plant damage, using environmentally sound, cost-effective management strategies that pose the least possible risk to people, park resources, and the environment

- Decrease exotic plant cover and increase native plant cover

2.3.2 Status of Supporting Science

The Northern Great Plains Inventory and Monitoring Network (NGPN) identifies key resources network-wide and for each of its parks that can be used to determine the overall health of the parks. These key resources are called Vital Signs. In 2010, the NGPN completed and released a Vital Signs monitoring plan (Gitzen et al. 2010). The Vital Signs selected for monitoring at FOUS are presented in Table 2.

Table 2. NGPN Vital Signs selected for monitoring in FOUS (Gitzen et al. 2010). Bolded items are being monitored by the park, another NPS program, or another federal agency. Italicized items are/will be monitored by NGPN using Vital Signs funding.

Category	NGPN Vital Signs
Air and Climate	**Weather and Climate**
Geology & Soils	*Stream & river channel characteristics*
Water	**Surface water dynamics**
Biological integrity	*Upland plant communities, land birds*
Human use	**Treatments of exotic infestations, visitor use**
Landscapes (ecosystem pattern and process)	**Fire and fuel dynamics,** *land cover and use*, *extreme disturbances*, *soundscape*, *viewscape*, *night sky*

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Chapter 3 Study Scoping and Design

This NRCA is a collaborative project between the National Park Service (NPS) and Saint Mary's University of Minnesota Geospatial Services (SMUMN GSS). Project stakeholders include the FOUS resource management team and NGPN Inventory and Monitoring Program staff. Before embarking on the project, it was necessary to identify the specific roles of the NPS and SMUMN GSS. Preliminary scoping meetings were held, and a task agreement and a scope of work document were created cooperatively between the NPS and SMUMN GSS.

3.1 Preliminary scoping

A preliminary scoping meeting was held on 31 August-1 September 2010. At this meeting, SMUMN GSS and NPS staff confirmed that the purpose of the FOUS NRCA was to evaluate and report on current conditions, critical data and knowledge gaps, and selected existing and emerging resource condition influences of concern to FOUS managers. Certain constraints were placed on this NRCA, including the following:

- Condition assessments are conducted using existing data and information.
- Identification of data needs and gaps is driven by the project framework categories.
- The analysis of natural resource conditions includes a strong geospatial component.
- Resource focus and priorities are primarily driven by FOUS resource management.

This condition assessment provides a "snapshot-in-time" evaluation of the condition of a select set of park natural resources that were identified and agreed upon by the project team. Project findings will aid FOUS resource managers in the following objectives:

- Develop near-term management priorities (how to allocate limited staff and funding resources);
- Engage in watershed or landscape scale partnership and education efforts;
- Consider new park planning goals and take steps to further these;
- Report program performance (e.g., Department of Interior Strategic Plan "land health" goals, Government Performance and Results Act [GPRA]).

Specific project expectations and outcomes included the following:

- For key natural resource components, consolidate available data, reports, and spatial information from appropriate sources including: FOUS resource staff, the NPS Integrated Resource Management Application (IRMA) website, Inventory and Monitoring Vital Signs, and available third-party sources. The NRCA report will provide a resource assessment and summary of pertinent data evaluated through this project.

- When appropriate, define a reference condition so that statements of current condition may be developed. The statements will describe the current state of a particular resource with respect to an agreed upon reference point.

- Clearly identify "management critical" data (i.e., those data relevant to the key resources). This will drive the data mining and gap definition process.

- Where applicable, develop GIS products that provide spatial representation of resource data, ecological processes, resource stressors, trends, or other valuable information that can be better interpreted visually.

- Utilize "gray literature" and reports from third party research to the extent practicable.

3.2 Study Design

3.2.1 Indicator Framework, Focal Study Resources and Indicators

Selection of Resources and Measures

As defined by SMUMN GSS in the NRCA process, a "framework" is developed for a park or preserve. This framework is a way of organizing, in a hierarchical fashion, bio-geophysical resource topics considered important in park management efforts. The primary features in the framework are key resource components, measures, stressors, and reference conditions.

"Components" in this process are defined as natural resources (e.g., birds), ecological processes or patterns (e.g., natural fire regime), or specific natural features or values (e.g., geological formations) that are considered important to current park management. Each key resource component has one or more "measures" that best define the current condition of a component being assessed in the NRCA. Measures are defined as those values or characterizations that evaluate and quantify the state of ecological health or integrity of a component. In addition to measures, current condition of components may be influenced by certain "stressors," which are also considered during assessment. A "stressor" is defined as any agent that imposes adverse changes upon a component. These typically refer to anthropogenic factors that adversely affect natural ecosystems, but may also include natural processes or disturbances such as floods, fires, or predation (adapted from GLEI 2010).

During the FOUS NRCA scoping process, key resource components were identified by NPS staff and are represented as "components" in the NRCA framework. While this list of components is not a comprehensive list of all the resources in the park, it includes resources and processes that are unique to the park in some way, or are of greatest concern or highest management priority in FOUS. Several measures for each component, as well as known or potential stressors, were also identified in collaboration with NPS resource staff.

Selection of Reference Conditions

A "reference condition" is a benchmark to which current values of a given component's measures can be compared to determine the condition of that component. A reference condition may be a historical condition (e.g., flood frequency prior to dam construction on a river), an established ecological threshold (e.g., EPA standards for air quality), or a targeted management goal/objective (e.g., a bison herd of at least 200 individuals) (adapted from Stoddard et al. 2006).

Reference conditions in this project were identified during the scoping process using input from NPS resource staff. In some cases, reference conditions represent a historical reference before human activity and disturbance was a major driver of ecological populations and processes, such as “pre-fire suppression.” In other cases, peer-reviewed literature and ecological thresholds helped to define appropriate reference conditions.

Finalizing the Framework

An initial framework was adapted from the organizational framework outlined by the H. John Heinz III Center for Science’s “State of Our Nation’s Ecosystems 2008” (Heinz Center 2008). Key resources for the park were adapted from the NGPN Vital Signs monitoring plan (Gitzen et al. 2010). This initial framework was presented to park resource staff to stimulate meaningful dialogue about key resources that should be assessed. Significant collaboration between SMUMN GSS analysts and NPS staff was needed to focus the scope of the NRCA project and finalize the framework of key resources to be assessed.

The NRCA framework was finalized in March 2011 following acceptance from NPS resource staff. It contains a total of 11 components (Table 3) and was used to drive analysis in this NRCA. This framework outlines the components (resources), most appropriate measures, known or perceived stressors and threats to the resources, and the reference conditions for each component for comparison to current conditions.

Table 3. Fort Union Trading Post National Historic Site natural resource condition assessment framework. Numbers in parentheses following measures represent *Significance Levels* used to assess *Weighted Condition Score* of components.

Fort Union Trading Post
Natural Resource Condition Assessment Framework

	Component	*Measures (Significance Level)*	*Expert Contact*	*Stessors*	*Reference Condition*
Biotic Composition					
Ecological Communities					
	Riparian Forest Community	Cottonwood regeneration (2), Species Composition (2). Other Tree Species Regeneration (3), Forest Structure (3), Exotic Species Abundance (3)	Amy Symstad, Andy Banta, Audrey Bamhart	Flow regulation	Active period of the Trading Post, and Symstad (2012) vegetation conditions
	Natural Prairie Community	Exotic Species Abundance (3), Native Species Richness/Evenness (2), Species Composition (2), Ground Cover (bare ground) (3), Growth Fom Composition (3)	Amy Symstad, Andy Banta, Audrey Bamhart	Drought, human disturbance (foot traffic)	Active period of the Trading Post, and Symstad (2012) vegetation conditions
	Reconstructed Prairie Community	Exotic Species Abundance (3), Native Species Richness/Evenness (2), Species Composition (2), Ground Cover (bare ground) (3), Growth Fom Composition (3)	Amy Symstad, Andy Banta, Audrey Bamhart	Drought, human disturbance (foot traffic)	Active period of the Trading Post, and Symstad (2012) vegetation conditions
Birds					
	Birds	Species Observed vs. Species Expected (1), Species Richness (3), Species Distribution (1), Raptor Abundance (1)	Marcia Wilson, Andy Banta, Audrey Bamhart	Habitat loss	Undefined
Mammals					
	Small Mammals	13-lined Ground Squirrel Abundance (1), Bat Population Abundance (1), Species Richness (3)	Marcia Wilson, Andy Banta, Audrey Bamhart	Non-native species, habitat loss, development	Active period of the Trading Post
Herptiles					
	Herptiles	Species of Concem - Relative Abundance (3)	Marcia Wilson, Andy Banta, Audrey Bamhart	Habitat loss, herbicides, feral cats	Active period of the Trading Post
Environmental Quality					
	Air Quality	S (3), N(3), Hg deposition(3), Ozone(3), Particulates(3)	Marcia Wilson, Andy Banta, Audrey Bamhart	Development - especially regarding energy production	EPA Standards
	Water Quality	Temperature (3), Turbidity (3), Sedimentation (3), E. Coli (3), pH (3), Macroinvertebrates (3)	Marcia Wilson, Andy Banta, Audrey Bamhart	Agricultural runoff	EPA Standards
	Soundscape	Occurence of Human-Caused Sound (3), Natural Ambient Soundlevel (3), Visitors' Natural Experience (1)	Marcia Wilson, Andy Banta, Audrey Bamhart	Traffic, oil development, coal power plants, trains	Active period of the Trading Post
	Viewshed	Protocol being developed with Steve Wilson (NGPN), will get park input upon developing this protocol	Steve Wilson, Andy Banta, Audrey Bamhart	Development	Active period of the Trading Post
Physical Characteristics					
Geologic & Hydrologic					
	River and Stream Geomorphology	Flooding Events (3), Discharge Pattems (3), Erosion Rates (3)	Marcia Wilson, Andy Banta, Audrey Bamhart, Lucy Ellis,	Dam operations	Active period of the Trading Post

3.2.2 General Approach and Methods

This study involved gathering and reviewing existing literature and data relevant to each of the key resource components included in the framework. No new data were collected for this study; however, where appropriate, existing data were further analyzed to provide summaries of resource condition or to create new spatial representations. After all data and literature relevant to the measures of each component were reviewed and considered, a qualitative statement of overall current condition was created and compared to the reference condition when possible.

Data Mining

The data mining process (acquiring as much relevant data about key resources as possible) began at the initial scoping meeting, at which time FOUS staff provided data and literature in multiple forms, including: NPS reports and monitoring plans, reports from various state and federal agencies, published and unpublished research documents, databases, tabular data, and charts. GIS data were provided by NPS staff. Additional data and literature were also acquired through online bibliographic literature searches and inquiries on various state and federal government websites. Data and literature acquired throughout the data mining process were inventoried and analyzed for thoroughness, relevancy, and quality regarding the resource components identified at the scoping meeting.

Data Development and Analysis

Data development and analysis were highly specific to each component in the framework and depended largely on the amount of information and data available for the component and recommendations from NPS reviewers and sources of expertise including NPS staff from FOUS and the NGPN. Specific approaches to data development and analysis can be found within the respective component assessment sections located in Chapter 4 of this report.

Scoring Methods and Assigning Condition

A set of measures are useful in describing the condition of a particular component, but all measures may not be equally important. A “significance level” represents a numeric categorization (integer of 1-3) of the importance of each measure in explaining the condition of the component; each significance level is defined in Table 4. This categorization allows measures that are more important for determining condition (higher significance level) of a component to be more heavily weighted in calculating an overall condition.

Table 4. Scale for a measure’s significance level in determining a component’s overall condition.

Significance Level (SL)	Description
1	Measure is of low importance in defining the condition of this component.
2	Measure is of moderate importance in defining the condition of this component.
3	Measure is of high importance in defining the condition of this component.

After each component assessment is completed (including any possible data analysis), a condition level is assigned for each measure. This is based on a 0-3 integer scale and reflects the data mining efforts and communications with park experts (Table 5).

Table 5. Scale for condition level of individual measures.

Condition Level (CL)	Description
0	Of **NO** concern. No net loss, degradation, negative change, or alteration.
1	Of **LOW** concern. Signs of limited and isolated degradation of the component.
2	Of **MODERATE** concern. Pronounced signs of widespread and uncontrolled degradation.
3	Of **HIGH** concern. Nearing catastrophic, complete, and irreparable degradation of the component.

After the significance levels (SL) and condition levels (CL) are assigned, a weighted condition score (WCS) is calculated via the following equation:

$$WCS = \frac{\sum_{i=1}^{\#\ of\ measures}(SL_i * CL_i)}{3 * \sum_{i=1}^{\#\ of\ measures} SL_i}$$

The resulting WCS value is placed into one of three possible categories: condition of low concern (WCS = 0.0 – 0.33); condition of moderate concern (WCS = 0.34 - 0.66); and condition of significant concern (WCS = 0.67 to 1.00). Figure 1 displays all of the potential graphics used to represent a component's condition in this assessment. The colored circles represent the categorized WCS; red circles signify a significant concern, yellow circles a moderate concern and green circles a condition of low concern. Gray circles are used to represent situations in which data are currently insufficient to make a statement about the condition of a component. The arrows inside the circles indicate the trend of the condition of a resource component. An upward pointing arrow indicates the condition of the component has been improving in recent times. A right-pointing arrow indicates a stable condition and an arrow pointing down indicates a decline in the condition of a component in recent times. These are only used when it is appropriate to comment on the trend of condition of a component. A gray, triple-pointed arrow is reserved for situations in which the trend of the component's condition is currently unknown.

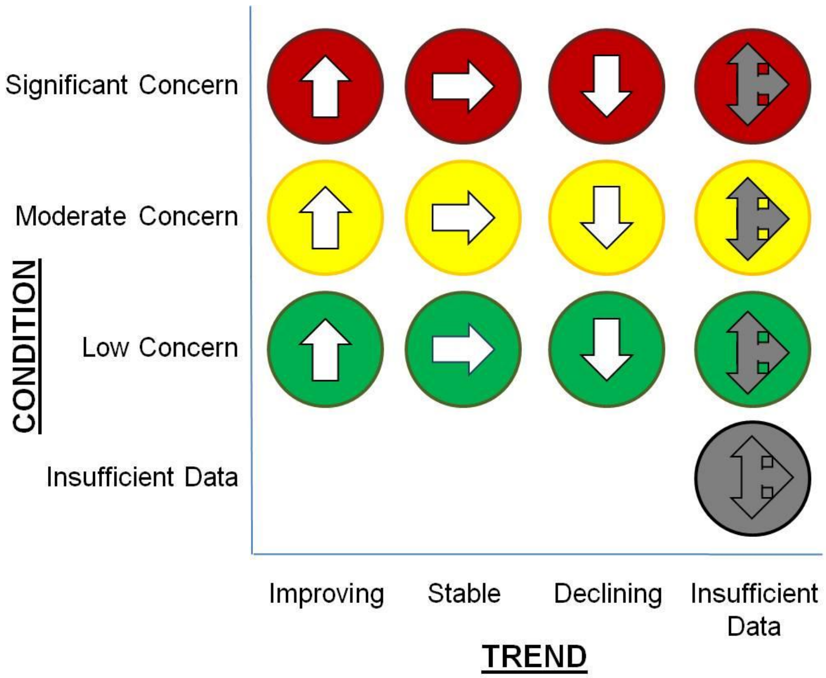

Figure 1. Symbols used for individual component assessments with condition or concern designations along the vertical axis and trend designations along the horizontal.

Preparation and Review of Component Draft Assessments
The preparation of draft assessments for each component was a highly cooperative process among SMUMN GSS analysts and FOUS and NGPN staff. Though SMUMN GSS analysts rely heavily on peer-reviewed literature and existing data in conducting the assessment, the expertise of NPS resource staff also plays a significant and invaluable role in providing insights into the appropriate direction for analysis and assessment of each component. This step is especially important when data or literature are limited for a resource component.

The process of developing draft documents for each component began with a detailed phone or conference call with an individual or multiple individuals considered local experts on the resource components under examination. These conversations were a way for analysts to verify the most relevant data and literature sources that should be used and also to formulate ideas about current condition with respect to the NPS staff opinions. Upon completion, draft assessments were forwarded to component experts for initial review and comments.

Development and Review of Final Component Assessments
Following review of the component draft assessments, analysts used the review feedback from resource experts to compile the final component assessments. As a result of this process, and based on the recommendations and insights provided by FOUS resource staff and other experts, the final component assessments represent the most relevant and current data available for each component and the sentiments of park resource staff and resource experts.

Format of Component Assessment Documents
All resource component assessments are presented in a standard format. The format and structure of these assessments is described below.

Description
This section describes the relevance of the resource component to the park and the context within which it occurs in the park setting. For example, a component may represent a unique feature of the park, it may be a key process or resource in park ecology, or it may be a resource that is of high management priority in the park. Also emphasized are interrelationships that occur among a given component and other resource components included in the broader assessment.

Measures
Resource component measures were defined in the scoping process and refined through dialogue with resource experts. Those measures deemed most appropriate for assessing the current condition of a component are listed in this section, typically as bulleted items.

Reference Conditions/Values
This section explains the reference condition determined for each resource component as it is defined in the framework. Explanation is provided as to why specific reference conditions are appropriate or logical to use. Also included in this section is a discussion of any available data and literature that explain and elaborate on the designated reference conditions. If these conditions or values originated with the NPS experts or SMUMN GSS analysts, an explanation of how they were developed is provided.

Data and Methods
This section includes a discussion of the data sets used to evaluate the component and if or how these data sets were adjusted or processed as a lead-up to analysis. If adjustment or processing of data involved an extensive or highly technical process, these descriptions are included in an appendix for the reader or a GIS metadata file. Also discussed is how the data were evaluated and analyzed to determine current condition (and trend when appropriate).

Current Condition and Trend
This section presents and discusses in-depth key findings regarding the current condition of the resource component and trends (when available). The information is presented primarily with text but is often accompanied by detailed maps or plates that display different analyses, as well as graphs, charts, and/or tables that summarize relevant data or show interesting relationships. Due to their low importance, measures that are assigned a significance level of 1 do not receive an in-depth analysis and are not addressed in the current condition section. These measures are briefly discussed in the overall condition section of the document (see below).

Threats and Stressor Factors
This section provides a summary of the threats and stressors that may impact the resource and influence to varying degrees the current condition of a resource component. Relevant stressors were described in the scoping process and are outlined in the NRCA framework. However, these are elaborated on in this section to create a summary of threats and stressor based on a combination of available data and literature, and discussions with resource experts and NPS natural resources staff.

Data Needs/Gaps
This section outlines critical data needs or gaps for the resource component. Specifically, what is discussed is how these data needs/gaps, if addressed, would provide further insight in

determining the current condition or trend of a given component in future assessments. In some cases, the data needs/gaps are significant enough to make it inappropriate or impossible to determine condition of the resource component. In these cases, stating the data needs/gaps is useful to natural resources staff who wish to prioritize monitoring or data gathering efforts.

Overall Condition

This section provides a qualitative summary statement of the current condition that was determined for the resource component using the WCS method. Condition is determined after thoughtful review of available literature, data, and any insights from NPS staff and experts, which are presented in the Current Condition and Trend section. The Overall Condition section summarizes the key findings and highlights the key elements used in determining and justifying the level of concern, if any, that analysts attribute to the condition of the resource component. Also included in this section are the graphics used to represent the component condition.

Sources of Expertise

This is a listing of the individuals (including their title and affiliation with offices or programs) who had a primary role in providing expertise, insight, and interpretation to determine current condition (and trend when appropriate) for each resource component.

Literature Cited

This is a list of formal citations for literature or datasets used in the analysis and assessment of condition for the resource component. Note, citations used in appendices and plates referenced in each section (component) of Chapter 4 are listed in that section's "Literature Cited" section.

Literature Cited

Gitzen, R., M. Wilson, J. Brumm, M. Bynum, J. Wrede, J. Millspaugh, and K. Paintner. 2010. Northern Great Plains Network Vital Signs monitoring plan. Natural Resource Report NPS/NGPN/NRR-2010/186. National Park Service, Fort Collins, Colorado.

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Stoddard. J. L., D. P. Larsen, C. P. Hawkins, R. K. Johnson, and R. J. Norris. 2006. Setting expectations for the ecological condition of streams: the concept of reference condition. Ecological Applications 16(4):1267-1276.

Symstad, A. J. 2012. A vegetation management plan for Fort Union Trading Post National Historic Site: Final report for interagency agreement number F154910005. Natural Resource Report NPS/FOUS/NRR--2012/502, National Park Service, Fort Collins, Colorado.

Chapter 4 Natural Resource Conditions

This chapter presents the background, analysis, and condition summaries for the 11 key resource components in the project framework. The following sections discuss the key resources and their measures, stressors, and reference conditions. The summary for each component is arranged around the following sections:

1. Description
2. Measures
3. Reference Condition
4. Data and Methods
5. Current Condition and Trend (including threats and stressor factors, data needs/gaps, and overall condition)
6. Sources of Expertise
7. Literature Cited

The order of components follows the project framework (Table 3):

4.1 Riparian Forest Community
4.2 Natural Prairie Community
4.3 Reconstructed Prairie Community
4.4 Birds
4.5 Small Mammals
4.6 Herptiles
4.7 Air Quality
4.8 Water Quality
4.9 Soundscape
4.10 Viewshed
4.11 River and Stream Geomorphology

4.1 Riparian Forest Community

4.1.1 Description

The closure of the Fort Peck and Garrison Dams greatly impacted the Missouri River, through changed natural sediment loads and altered natural hydrology (Ellis 2006). Regulation of the river-flows has altered the composition and extent of floodplain forest communities. Cottonwood (*Populus deltoides*) and willow (*Salix* spp.) species reproduce more effectively with the deposition of sediments, which aids in the germination process (Dixon et al. 2010). In addition, erosion caused by the Missouri River is removing some areas of cottonwood stands, which are not being replaced through regeneration (Ellis 2006). Other areas (e.g., deltas above reservoirs) are experiencing rising water tables, which can eventually cause cottonwood mortality (Dixon et al. 2010). The disappearance of the cottonwood forests negatively affects the aesthetic quality of the viewshed seen from the trading post (Ellis 2006).

Three forest and woodland types are present in the riparian portions of FOUS: Green Ash – Chokecherry Forest, Eastern Cottonwood Temporarily Flooded Woodland Alliance, and Cottonwood – Peachleaf Willow Floodplain Woodland (Salas and Pucherelli 2003). The diverse riparian plant community in FOUS provides habitat for 90% of the bird species present in the park (Panjabi 2005) and provides the most suitable habitat for amphibians and reptiles in the unit (Smith et al. 2004).

4.1.2 Measures

- Cottonwood regeneration
- Species composition
- Other tree species regeneration
- Forest structure
- Non-native species abundance

4.1.3 Reference Conditions/Values

The desired condition at FOUS is to maintain the landscape, including the riparian forest community, similar to the conditions at the fort circa 1828-1847, as represented in an 1833 painting of the area by Karl Bodmer (Symstad 2012). During the active period of Fort Union (1828-1867), the riparian portion of FOUS would have been comprised of a mixture of herbaceous, shrubby, and forested plant communities that would change in response to river flooding and meandering (Symstad 2012).

4.1.4 Data and Methods

Salas and Pucherelli (2003) mapped and categorized vegetation at FOUS using aerial photography and GIS analysis.

Godfread (2004) conducted a plant inventory of FOUS in 2003-2004, and reported common species found in the floodplain.

Dixon et al. (2009, 2010) studied cottonwood forests along the Missouri River, looking at several components of forest health including composition, structure, health, areal extent, and age distribution. FOUS falls within Segment 2 of the Dixon et al. (2010) study, which covers 365 river km (227 river mi). This segment encompasses the historic floodplain (approximately bluff-to-bluff) from the Fort Peck Dam to the Sakakawea Reservoir. Results of the study were compiled for the entire river segment; no data were presented on FOUS specifically.

4.1.5 Current Condition and Trend

Cottonwood Regeneration

Scott et al. (1997) found that successful cottonwood regeneration and survival followed infrequent large flooding events on elevated deposits at a study site along the Missouri River in Montana. Flow regulation of the Missouri River has reduced extreme events that occurred in the pre-dam era (Ellis 2006). The lack of a seasonal flood pulse along regulated rivers can negatively affect forest regeneration as deposition of sediments is restricted; this sediment deposition transports cottonwood seeds and nutrients (Dixon et al. 2009). Channel incision downstream of dams isolates the floodplain from the river, causing the level of the floodplain to rise relative to the river; this reduces the chance of flooding and, therefore, sediment deposition (Dixon et al. 2009). There have been no estimates of the level of cottonwood regeneration specifically in FOUS, although Ellis (2006) stated that cottonwood forests are not being replaced.

Species Composition

The Eastern Cottonwood Temporarily Flooded Forest Alliance, which also includes willow species, occurs in the riparian area of FOUS (Salas and Pucherelli 2003). Within this alliance is the Cottonwood - Peachleaf Willow Floodplain Woodland, which comprises 7.2 ha (17.7 ac) within FOUS. The conservation status of this vegetation community is ranked as vulnerable by Salas and Pucherelli (2003). The Green Ash - American Elm/Chokecherry Woodland vegetation association, also found in the riparian community, is considered globally imperiled (Salas and Pucherelli 2003, NatureServe 2011). This vegetation association covers 13.2 ha (32.6 ac) in FOUS (Salas and Pucherelli 2003).

Godfread (2004) conducted a plant inventory at FOUS in 2003-2004; species found in the FOUS floodplain are listed in Table 6.

Table 6. Plant species in the FOUS floodplain identified by Godfread (2004). This is not intended to be a complete list of species present in the floodplain forest community.

Scientific Name	Common Name	Scientific Name	Common Name
Acer negundo	box elder	*Lycopus asper*	rough bugleweed
Amaranthus albus	prostrate pigweed	*Mentha arvense*	wild mint
Apocynum cannabinum	dogbane	*Phalaris arundinacea*	reed canary grass
Artemisia cana	silver sagebrush	*Phragmites australis*	common reed
Asclepias speciosa	showy milkweed	*Plantago rugelii*	blackseed plantain
Aster brachyactis	rayless aster	*Poa palustris*	fowl bluegrass
Aster simplex	panicled aster	*Polygonum lapathifolium*	curlytop knotweed
Bidens vulgata	big devils beggartick	*Polygonum pensylvanicum*	Pennsylvania smartweed
Bromus inermis	smooth brome	*Polypogon monspeliensis*	annual rabbitsfoot grass
Carex americana	American woollyfruit sedge	*Potentilla anserina*	common silverweed
Carex aquatilis	water sedge	*Prunus virginiana*	chokecherry
Carex laeviconica	smoothcone sedge	*Ranunculus cymbalaria*	alkali buttercup
Cirsium arvense	Canada thistle	*Salix amygdaloides*	peachleaf willow
Cornus stolonifera	red osier dogwood	*Salix eriocephala*	Missouri river willow
Eleocharis acicularis	needle spikerush	*Salix exigua* ssp.*interior*	sandbar willow
Eleocharis erythropoda	bald spikerush	*Salix lutea*	yellow willow
Equisetum arvense	field horsetail	*Scirpus acutus*	hardstem bullrush
Equisetum laevigatum	smooth horsetail	*Scirpus maritimus*	alkali bullrush
Eragrostis hypnoides	teal lovegrass	*Sherperdia argentea*	silver buffaloberry
Fraxinus pennsylvanica	green ash	*Teucrium canadense*	Canada germander
Glycyrrhiza lepidota	American licorice	*Typha angustifolia*	narrowleaf cattail
Juncus nodosus	knotted rush	*Typha angustifolia x latifolia*	hybrid cattail
Juncus torreyi	Torrey's rush	*Typha latifolia*	common cattail
Leersia oryzoides	rice cutgrass	*Veronica anagalis-aquatica*	water speedwell
Lycopus americana	American water horehound		

Dixon et al. (2009) sampled 30 cottonwood stands between the Fort Peck Dam and the Sakakawea Reservoir (227 river miles) to determine, among other measurements, the species present in the stands. The average number of total species for all age classes in this stretch was 29.5 (Dixon et al. 2009). Cottonwood stands in this river segment supported an average of 2.6 tree species (Dixon et al. 2010). Comparable data within FOUS are not available, as the list of species compiled by Godfread (Table 6) includes species from the entire floodplain forest, not just the cottonwood stands.

<u>Other Tree Species Regeneration</u>

A number of woody species other than cottonwood occur in the riparian forest community of FOUS, such as green ash (*Fraxinus pennsylvanica*), boxelder (*Acer negundo*), and several species of willow. There are no quantitative estimates for regeneration of these species in FOUS.

Forest Structure
The structure of the riparian forest community during the active period of the Fort would have included a variety of successional stages with various canopy densities (Symstad 2012). The earliest successional stage occurs on ground that is seasonally flooded and is comprised of sparse sandbar vegetation. The second successional stage in the riparian community is comprised of dense stands of coyote willow (*Salix exigua*) up to 4 meters (13 ft) tall, and other woody saplings. Mid-successional stages are dominated by stands of young cottonwoods with moderately open canopies, an understory of willow, and abundant herbaceous cover. Stands dominated by older cottonwoods also include an understory with shrubs or herbaceous species. The oldest portions of the riparian zone are also the highest and driest of the successional zones, featuring an overstory of green ash, occasionally containing American elm (*Ulmus americana*) or boxelder, and an understory of chokecherry (*Prunus virginiana*) or western snowberry (*Symphoricarpos occidentalis*) shrubs (Salas and Pucherelli 2003).

The only current data on forest structure at FOUS comes from a single plot established by the Northern Great Plains Fire Effects Monitoring Program during 2005 in order to test the effects of prescribed fire on forest structure. Two years following the fire, the density of pole-sized cottonwoods decreased approximately 50 percent, and the density of larger cottonwood trees increased (NGP Fire Effects Monitoring Program, unpublished data, as cited in Symstad 2012).

Non-native Species Abundance
The FOUS vegetation management plan states that <1% of the riparian floodplain should be comprised of federal, state, or county listed noxious weeds (Symstad 2012). Since no quantitative estimates of non-native species abundance have been calculated in the riparian forest community of FOUS, their exact status is unknown.

Several non-native species are present in the FOUS floodplain, including reed canary grass (*Phalaris arundinacea*), Canada thistle (*Cirsium arvense*), smooth brome (*Bromus inermis*), leafy spurge (*Euphorbia esula*), and stinging nettle (*Urtica dioica*) (Salas and Pucherelli 2003, Godfread 2004). Canada thistle and leafy spurge are listed as noxious weeds by North Dakota and Montana (Symstad 2012). Non-native plant species management in the riparian forest community at FOUS has been restricted to Canada thistle and Russian olive. No surveys have been conducted in the riparian forest community to assess the effectiveness of these control efforts (Symstad 2012).

Threats and Stressor Factors
Flow regulation of the Missouri River negatively affects the riparian forest community by reducing regeneration of species such as cottonwood. The resulting erosion has reduced the area of riparian forests along the river in FOUS (Ellis 2006).

Non-native plant species are a threat to the native riparian plant communities in FOUS. A number of non-native plant species have been documented in FOUS, although there are no estimates of abundance. Canada thistle is the only species that has been managed (Symstad 2012). Tamarisk (*Tamarix* spp.) has been identified by FOUS as a priority species for non-native invasive plant management in the unit. Although the species has not been documented to date, tamarisk was included on the list of priority species because suitable riparian habitat exists in FOUS, allowing for a potential invasion (Symstad 2012).

Data Needs/Gaps

There has not been a thorough survey of the riparian forest community in FOUS and no quantitative sampling of the vegetation; limited data exist for all measures of this component.

Overall Condition

Cottonwood Regeneration

During initial scoping meetings, the project team assigned the measure of cottonwood regeneration a *Significance Level* of 2, indicating it is of moderate importance in describing the condition of this resource. Data have not been collected on cottonwood regeneration within the riparian forest community of FOUS, so a *Condition Level* cannot be assigned at this time.

Species Composition

A *Significance Level* of 2 was assigned to the measure of species composition. Symstad (2012) states that the riparian floodplain community is close to desired conditions because of the limited prevalence of non-native species, but mapping of non-native plant species is needed in order to confirm this. A *Condition Level* cannot be assigned at this time.

Other Tree Species Regeneration

A *Significance Level* of 3 was assigned to the measure of other tree species regeneration, indicating high importance in describing the condition of this resource. In addition to cottonwood, other tree species (e.g., green ash, boxelder, willow) are important components of the riparian forest community in FOUS. No data are available regarding the regeneration of these species; therefore, a *Condition Level* cannot be assigned.

Forest Structure

A *Significance Level* of 3 was assigned to the measure of forest structure. Several successional stages of riparian forest occur in FOUS (Salas and Pucherelli 2003). However, there are no quantitative data available on forest structure. A *Condition Level* cannot be assigned at this time.

Non-native Species Abundance

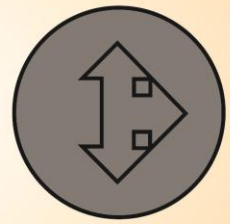
A *Significance Level* of 3 was assigned to the measure of non-native species abundance. Several non-native species are present in the riparian forest community. However, there have been no quantitative estimates of abundance so a *Condition Level* cannot be assigned.

Weighted Condition Score

A *Weighted Condition Score* cannot be determined for the riparian forest community in FOUS because condition levels were not assigned for component measures.

Riparian Forest Community

Measures	SL	CL
• Exotic Species Abundance	3	N/A
• Forest Structure	3	N/A
• Other Tree Species Regeneration	3	N/A
• Cottonwood Regeneration	2	N/A
• Species Composition	2	N/A



WCS = N/A

4.1.6 Sources of Expertise

Mark Dixon, Biologist, South Dakota State University
Amy Symstad, Research Ecologist, USGS

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4.2 Natural Prairie Community

4.2.1 Description

The potential natural vegetation in the upland portions of FOUS is primarily short-and mixed-grass prairie (Salas and Pucherelli 2003). Currently, this vegetation is only in the Bodmer Overlook unit, where three prairie vegetation associations occur. Western Wheatgrass – Blue Grama – Threadleaf Sedge Prairie and Needle-and-Thread – Blue Grama – Mixed Grass Prairie have likely been impacted by the domestic animal grazing that began when the Fort was established. The Crested Wheatgrass Semi-natural Grassland that dominates lower-lying areas of the Bodmer Overlook unit result from non-native forage and hay species being planted there and subsequent encroachment into native grassland; monitoring plots from these semi-natural grasslands are included in the data presented in this assessment. The open, unsettled prairie landscape surrounding the Fort was identified as a vital resource in FOUS (Symstad 2012). Prairie is one of the most endangered habitats worldwide; in North Dakota, nearly 80% of pre-settlement prairie habitat has been lost (NDPRD 1999). Exotic species pose a major threat to the natural prairie community and cultural landscape of FOUS (NPS 2005).

4.2.2 Measures

- Exotic species abundance
- Native species richness
- Species composition
- Ground cover
- Growth form composition

Photo 4. Fort Union on the Missouri, by Karl Bodmer.

4.2.3 Reference Conditions/Values

The desired condition at FOUS is to maintain the landscape, including the prairie community, similar to the conditions at the Fort circa 1828-1847, as represented in an 1833 painting of the area by Karl Bodmer (Symstad 2012, Photo 4). This reference condition requires that native grasses comprise a majority of the vegetation at FOUS (Symstad 2011). The current condition section of this document addresses specific goals established by NPS for managing the native prairie community in the park.

4.2.4 Data and Methods

Symstad (2012) measured vegetation in two plots established for long-term vegetation monitoring in the Bodmer Overlook unit of FOUS. These plots were deliberately chosen from the five randomly located monitoring plots to represent the highest quality prairie in the unit. The parameters measured in each plot correspond with the measures used in this document to evaluate condition: relative cover of growth forms, absolute cover of bare soil, species richness and diversity, and proportions of foliar cover and richness of non-native species. It is important to note that absolute cover measurements can result in proportions which total >100%. Two of the vegetation plots visited in 2010 are located within the natural prairie community of FOUS: PCM-129 and PCM-130 in the Bodmer Overlook area (see Plate 1).

Photo 5. Needle-and-Thread - Blue Grama - Threadleaf Sedge prairie (Salas and Pucherelli 2003).

NGPN also completed its first iteration of vegetation sampling according to its established monitoring protocol in 2011. NGPN sampled PCM-129 and PCM-133 in 2011, both of which are in the native prairie community. The annual report of the 2011 monitoring work (Ashton et al. 2011) highlights information regarding the measures utilized in this assessment, but does not provide complete data regarding the individual sampled plots for all measures. This assessment reports individual plot data from the annual report when available for 2011. Additional data from 2011 became available late in the project timeline.

4.2.5 Current Condition and Trend

<u>Exotic Species Abundance</u>

The FOUS Vegetation Management Plan (Symstad 2012) specifies that noxious weeds should comprise <1% of the Bodmer Overlook area of FOUS, and that non-native species in general should be <10% of overall cover. The NPS Certified Plant List for FOUS, developed by the NGPN, identified 55 exotic plant species in the unit. However, Symstad (2012) found only three exotic plant species in the natural prairie plots: common dandelion (*Taraxacum officinale*), crested wheatgrass (*Agropyron cristatum*), and Kentucky bluegrass (*Poa pratensis*) in plot PCM-129, and common dandelion and crested wheatgrass in PCM-130. All three exotics are common or abundant in FOUS (Godfread 2004). Exotic species abundance in these two plots was less than 1%. Leafy spurge (*Euphorbia esula*) was noted in the adjacent Green Ash – American Elm/Chokecherry Woodland (A. Symstad, pers. comm., 2011). Relative cover of exotics in the two Bodmer Unit plots visited by NGPN in 2011 was <1% in PCM-129 and 51% in PCM-133. Therefore, even in this management unit there are plots with a large proportion of exotics.

Native Species Richness

Native species richness (NSR) measures the average number of species in a given area. Table 7 displays native species richness in PCM-129 and PCM-130 based on data collected by Symstad in 2010. NSR in PCM-129 is higher than in PCM-130. Table 8 displays NSR values measured in other mixed-grass prairie communities in the United States. NSR in FOUS natural prairie plots is comparable to values measured in studies of other similar communities.

Table 7. Native species richness (NSR) in 1 m^2, 10 m^2, and total native species in natural prairie plots.

Plot	Average NSR in 1 m^2	Average NSR in 10 m^2	Total Native Species in all 10 m^2 plots
PCM-129	14	21	53
PCM-130	8.7	15.1	37
Mean	11.4	18.1	45
Standard Deviation	3.7	4.2	11.3

Table 8. Species richness values measured in mixed-grass prairie communities.

Study	Species Richness	Plot Size	Location
Adler and Levine (2007)	5-12 native species	1 m^2	central Kansas
Butler and Cogan (2004)	18-21 species (native and exotic)	100 m^2	Theodore Roosevelt National Park
Christian and Wilson (1999)	10 species (native and exotic)	0.5 m^2	Grasslands National Park (southwest Saskatchewan)
Stohlgren et al. (1999)	6.5 native species, 3.1 exotic species	1 m^2	Wind Cave National Park
Symstad et al. (2006)	10.1 species (native and exotic)	0.5 m^2	13 NPS units in North Dakota, South Dakota, Nebraska, and eastern Wyoming

Data from initial NGPN monitoring in 2011 include plots within the natural prairie community at FOUS. Ashton et al. (2012) found that PCM-133, included a high proportion of two exotic species: smooth brome and crested wheatgrass. They also found crested wheat grass in PCM-129. Following 5 years of the monitoring protocol, an in-depth analysis will provide clarity regarding the holistic status of the plant community at FOUS (Ashton et al. 2012).

Species Composition

Species composition is not addressed in the desired conditions section of the Vegetation Management Plan. However, FOUS established a goal that native species comprise 80% of total cover (Symstad 2012). The most common species by percent canopy cover in PCM-129, which may be representative of Needle-and-Thread – Blue Grama – Mixed Grass Prairie common on hilltops in the Bodmer Overlook unit, are needle-and-thread (*Hesperostipa comata*) and threadleaf sedge (*Carex filifolia*) at 17%, blue grama (*Bouteloua gracilis*) at 16%, and prairie junegrass (*Koeleria macrantha*) at 11%. Various forbs, grasses, and sedges comprise <10% total coverage respectively (Symstad 2012). PCM-130, which may be representative of Western Wheatgrass – Blue Grama – Threadleaf Sedge vegetation more common on lower slopes, is less diverse than PCM-129 and is comprised of 56% blue grama coverage and 18% coverage by western wheatgrass (*Pascopyrum smithii*) (Symstad 2012). Other species of grasses, forbs, and shrubs make up <10% of the plot coverage respectively. Both plots meet the goal of 80% coverage by natives, and exotic species account for <1% of total cover in these plots (Symstad 2012). However, in 2011, one additional plot in this unit was found to fail this definition with 34% exotic cover.

Ground Cover

The desired condition for prairie in FOUS states that bare ground can comprise up to 10% of total ground cover in the Bodmer Overlook area (Symstad 2012). Symstad (2012) measured 32% bare soil in plot PCM-129, compared to 34% litter cover as percentage of overall ground cover. Plot PCM-130 had 18% bare soil and 60% coverage by litter. Live vegetation comprised only 10% and 20% of ground cover in PCM-129 and PCM-130, respectively (Symstad 2012). These levels of bare soil exceed the desired condition for ground cover in this section of FOUS. In the six plots sampled in 2011 (both within and outside the native prairie community), mean absolute cover of bare ground was 29±16.6% (mean ± SD) (Ashton et al. 2012).

Growth Form Composition

Growth form composition refers to the relative abundance of different plant types, such as grasses vs. forbs vs. shrubs. The goal for growth form composition in the Bodmer Overlook area of FOUS is 5-15% forbs, 2-10% shrubs, with the remainder comprised of grasses and sedges (Symstad 2012). Symstad (2012) measured relative abundance of growth forms found within each vegetation sampling plot. PCM-129 was comprised of 76% grasses, 19% sedges, 12% forbs, and 1% shrubs. PCM-130 contained 97% grasses, 6% sedges, 4% forbs, and 1% shrubs. PCM-129 is near the desired condition goal for growth form composition, and PCM-130 is close, with slightly less forb composition than prescribed by the Vegetation Management Plan.

Threats and Stressor Factors

FOUS identified exotic species, drought, and lack of fire as threats and stressors to the unit's natural prairie community. Only three exotic species were present in the natural prairie plots in 2010 and two in 2011. There are significantly more exotic species present in the reconstructed prairie community of FOUS. Invasion into the native prairie community from this or, more likely from neighboring pastures and hayfields or exotic-dominated areas within the Bodmer unit, could occur (Symstad, pers. comm., 2011).

Data Needs/Gaps

Two NGPN vegetation plots in the natural prairie community of FOUS have not yet been sampled, but will be in coming years: PCM-131 (2013) and PCM-132 (2014). Vegetation monitoring will be ongoing at FOUS, and sampling of these sites will provide a better understanding of the overall prairie community at the park. In addition, reconnaissance-like assessments, such as on-the-ground visual monitoring, of the unit throughout the year would assist exotic plant early detection efforts across the native prairie community.

Overall Condition

Exotic Species Abundance

During initial scoping meetings, the project team assigned the measure of exotic species abundance a *Significance Level* of 3. This indicates that the measure is of high importance in defining the condition of this component. There were a low number of exotic species present in the natural prairie plots during 2010 and 2011 sampling, and these species did not comprise a significant area of most plots. Crested wheatgrass occupied greater than 25% and smooth brome occupied 1-5% of PCM-133. PCM-133 is designated as Crested Wheatgrass Semi-Natural Grassland by Salas and Pucherelli (2003). Given the high prevalence of exotics in PCM-133 the *Condition Level* for this measure is 2, indicating moderate concern.

Native Species Richness
A *Significance Level* of 2, indicating moderate importance in defining the condition of this resource, was assigned to the measure of native species richness. NSR in the two natural prairie plots was comparable to several other mixed-grass prairie sites in the region. PCM-129 had a higher NSR value than PCM-130. Even though the mixed grass prairie sites include data from limited years, no evidence suggests that native species richness is poor in comparison to other similar sites. Therefore, *Condition Level* for this measure is 1, indicating low concern, but more data are needed from other areas of the Bodmer Unit where native species richness may be lower.

Species Composition
A *Significance Level* of 2 was assigned to the measure of species composition. The natural prairie plots sampled in FOUS had a significant number of native species present with very few exotic species. In 2010, PCM-129 was more diverse than PCM-130, which was heavily dominated by blue grama. But, as previously mentioned, limited data is a cause for concern, making a *Condition Level* of 1 appropriate.Nati

Ground Cover
The project team assigned the measure of ground cover a *Significance Level* of 3. Both plots sampled by Symstad (2012) contained more bare soil than prescribed by the desired condition in the Vegetation Management Plan. Similarly, in 2011, mean percent ground cover across six sampled vegetation sites exceeded the desired condition. However, ground cover can vary considerably from year to year (A. Symstad, pers. comm., 2012) and, therefore, describing condition from one year of data is not appropriate (*Condition Level* = unknown).

Growth Form Composition
The project team assigned the measure of growth form composition a *Significance Level* of 3. Growth form composition of both natural prairie plots is close to the desired condition for the Bodmer Overlook area, with a majority composition of grasses and sedges with smaller amounts of forbs and shrubs. However, the limited data are a cause for concern and the *Condition Level* of this measure is 1.

Weighted Condition Score
The *Weighted Condition Score* for this component is 0.433, indicating the condition of this resource is of moderate concern. Although some data were collected in the natural prairie community recently, the lack of long-term data makes it impossible to determine the trend for any of the measures or the component as a whole. As data collection according to the vegetation monitoring protocol continues, condition and trend will become more apparent.

Natural Prairie Community

Measures	SL	CL
• Exotic Species Abundance	3	2
• Native Species Richness	2	1
• Species Composition	2	1
• Ground Cover	3	n/a
• Growth Form Composition	3	1

WCS = 0.433

4.2.6 Sources of Expertise

Amy Symstad, Research Ecologist, USGS/NPS

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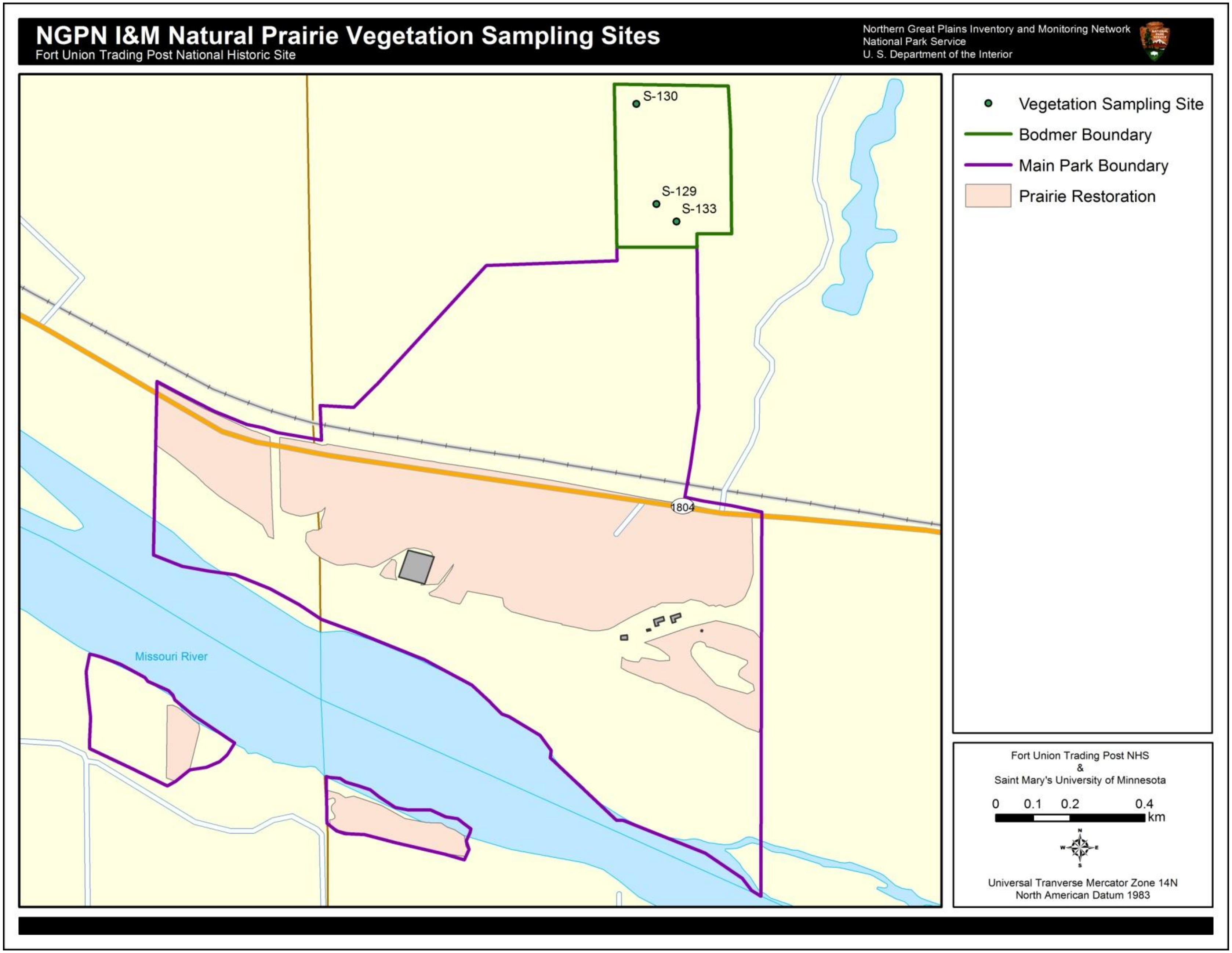


Plate 1. Plots sampled by Symstad in 2010 (PCM-129 and PCM-130) and NGPN I&M program in 2011 (PCM-129 and PCM-133).

4.3 Reconstructed Prairie Community

4.3.1 Description

In 1991, FOUS began a program to reestablish native prairie vegetation in disturbed and previously farmed areas of the unit (Symstad 2012). This program aims to restore the landscape of FOUS to a more natural condition, similar to the mid-1800s when the fort was active. The open, unsettled prairie landscape surrounding the fort is identified in the Vegetation Management Plan as a fundamental resource, making restoration of the prairie community a high priority at FOUS (Symstad 2012). Seed mixtures used to reestablish the prairie consisted primarily of blue grama, western wheatgrass, and green needlegrass (*Nassella viridula*), although many other species are now present (Salas and Pucherelli 2003). Exotic plants exist within prairie restoration sites in FOUS, and they constitute the greatest threat to the plant community.

Photo 6. Native Western Wheatgrass – Blue Grama – Threadleaf Sedge prairie (Salas and Pucherelli 2003).

4.3.2 Measures

- Exotic species abundance
- Native species richness
- Species composition
- Ground cover
- Growth form composition

4.3.3 Reference Conditions/Values

The desired condition at FOUS is to maintain the landscape, including the prairie community, similar to the conditions at the fort circa 1828-1847 as represented in an 1833 painting of the area by Karl Bodmer (Symstad 2012). This reference condition requires that native grasses comprise a large majority of the vegetation at FOUS (Symstad 2012). Prairie restorations at FOUS are an attempt to reconstruct this plant community, which was disturbed and/or replaced by agriculture.

4.3.4 Data and Methods

The reconstructed prairie area is divided into fields. Each field has a unique history of pre-planting preparation and planting (species mix, timing, etc.). Symstad (2012) sampled vegetation in the reconstructed prairie area of FOUS surrounding the fort (i.e., north of the Missouri River) in 2010 using eight plots. These plots were chosen from a Generalized Random Tesselation Stratified (GRTS) sampling design so that no more than one plot occurred in each field and most of the 10 fields in this management unit had one plot. The parameters measured in each plot correspond to the measures used in this document to evaluate condition: relative cover of growth forms, absolute cover of bare soil, species richness and diversity, and proportions of foliar cover and richness of non-native species.

NGPN also completed its first iteration of vegetation sampling according to its established monitoring protocol in 2011. NGPN sampled PCM (Plant Community Monitoring) plots 001, 002, 009, and 010 in 2011. The annual report of the 2011 monitoring work (Ashton et al. 2011) highlights information regarding the measures utilized in this assessment, but does not provide complete data regarding the individual sampled plots for all measures. Since this annual report combines data from natural and reconstructed prairie, data from the 2011 sampling are not included in this assessment.

Data are not available for the south side of the river within FOUS, where reconstructed prairie also occurs.

4.3.5 Current Condition and Trend

Exotic Species Abundance

The FOUS Vegetation Management Plan (2011) specifies that noxious weeds should comprise <1% of total cover in the upland terraces surrounding the fort, where the majority of reconstructed prairie fields are located. Exotic species in general should comprise <10% of total cover in this area (Symstad 2012). Several exotic plant species exist in the FOUS prairie restoration sites, including smooth brome, crested wheatgrass, Canada thistle, *Salsola* spp., and leafy spurge (Salas and Pucherelli 2003). The NPS Certified Plant List for FOUS, developed by the NGPN, identifies 57 exotic plant species in the unit, and vegetation sampling in 2010 identified an additional four species (Symstad 2012). Five state- or county-listed noxious weed species occur in FOUS [common burdock (*Arctium minus*), absinth wormwood (*Artemisia absinthium*), Canada thistle, field bindweed (*Convolvulus arvensis*), and leafy spurge (Symstad 2012)], but not all of these occur in the reconstructed prairie (Godfread 2004). Appendix B lists all 28 exotic plant species identified in the eight plots sampled by Symstad in 2010. Symstad (2012) found exotic species in all examined reconstructed prairie plots, but those species had low absolute and relative cover (Table 9). In 2011, NGPN found relative cover of exotic species to be 18% in four plots examined in the reconstructed prairie community (Ashton et al. 2012).

Table 9. Absolute and relative cover of growth forms (exotic and native species) in eight plots in reconstructed prairie fields in FOUS (Symstad 2012).

	Absolute Cover				Relative Cover			
	Exotic Species		Native Species		Exotic Species		Native Species	
	Grasses (%)	Forbs (%)	Grasses (%)	Forbs (%)	Grasses (%)	Forbs (%)	Grasses (%)	Forbs (%)
VMP-004	10	37	76	4	8	29	60	3
VMP-008	0	1	117	0	0	1	99	0
VMP-011	3	10	130	5	2	7	88	3
VMP-012	1	1	100	0	1	1	98	0
VMP-013	8	10	109	3	6	8	84	2
VMP-015	20	12	43	3	26	15	55	4
VMP-119	11	9	89	4	10	8	79	4
VMP-024	20	7	118	3	14	5	80	2
Mean	9	11	98	3	8	9	80	2

Native Species Richness

NSR measures the number of species present in a given area. Symstad (2012) measured native species richness in 1 m^2 and 10 m^2 plots in FOUS (Table 10). NSR in the reconstructed prairie plots was lower than the NSR of natural prairie plots in the Bodmer Overlook area of FOUS, which had an average NSR of 11.4 in 1 m^2 plots and 18.1 in 10 m^2 plots (Symstad 2012). Table 11 displays NSR values measured in other mixed-grass prairie communities across the Great Plains. It is important to note that these studies may use different sample plot sizes and/or include exotic species in the calculation. However, they still provide an opportunity for comparison, particularly using the number of native species. NSR values measured in FOUS reconstructed prairie plots are towards the lower end of values measured in these studies.

Table 10. Native species richness in 1 m^2 plots, 10 m^2 plots, and total native species in eight plots in reconstructed prairie fields (Symstad 2012).

Plot	Average NSR in 1 m^2 plots	Average NSR in 10 m^2 plots	Total Native Species in all 10 m^2 plots
VMP-004	6.4	7.5	15
VMP-008	3.7	5.6	12
VMP-011	6.9	9.4	16
VMP-012	3	4.8	13
VMP-013	4.2	8.6	15
VMP-015	6.3	9.4	17
VMP-119	6.5	8.2	19
VMP-024	2.6	3.6	9
Mean	5.0	7.1	14.5
Standard Deviation	1.8	2.2	3.1

Table 11. Species richness values measured in mixed-grass prairie communities.

Study	Species Richness	Plot Size	Location
Adler and Levine (2007)	5-12 native species	1 m^2	central Kansas
Butler and Cogan (2004)	18-21 species (native and exotic)	100 m^2	Theodore Roosevelt National Park
Christian and Wilson (1999)	10 species (native and exotic)	0.5 m^2	Grasslands National Park (southwest Saskatchewan)
Stohlgren et al. (1999)	6.5 native species, 3.1 exotic species	1 m^2	Wind Cave National Park
Symstad et al. (2006)	10.1 species (native and exotic)	0.5 m^2	13 NPS units in North Dakota, South Dakota, Nebraska, and eastern Wyoming

Species Composition

The FOUS Vegetation Management Plan (Symstad 2012) states that native grasses should comprise at least 70% of the total cover of upland terraces. Appendix A displays all 46 native plant species present in reconstructed prairie plots and fields sampled by Symstad (2012). 2010 sampling identified 28 exotic species in the reconstructed prairie (Appendix B). Restored prairie plots are notably different from natural prairie plots, containing only 25-38% the number of native species found in the Bodmer Overlook area of FOUS (see Chapter 4.2) (Symstad 2012). Exotic species accounted for 38-62% of overall species richness in restored plots (Symstad 2012).

Ground Cover

Within the upland terrace area of FOUS, bare soil should comprise 5-15% of surface area (Symstad 2012). Symstad (2012) measured the percentage of ground cover that was bare soil, litter, and live vegetation at sample plots and fields within the reconstructed prairie at FOUS. The percentage of bare soil was significantly higher in the majority of plots and fields than the desired conditions identified in the Vegetation Management Plan. However, prescribed fire and recent plantings contribute to low litter accumulation in several of the fields (Symstad 2012). Table 12 shows percentage of ground cover in each category present in plots and fields.

Table 12. Ground cover of plots in reconstructed prairie in 2010 (Symstad 2012).

Plot	Bare Soil (%)	Litter (%)	Live Vegetation (%)
VMP-004	76	23	1
VMP-008	9	72	19
VMP-011[1]	24	71	3
VMP-012	15	80	5
VMP-013	94	1	5
VMP-015	88	6	6
VMP-119	86	13	1
VMP-024	0	96	4
Mean	49	45.3	5.5
Standard Deviation	40.4	38.2	5.8

[1]PCM-011 has 2% moss coverage.

Growth Form Composition

Growth form composition refers to the relative abundance of different plant types, such as grasses vs. forbs vs. shrubs. The desired growth form composition for upland terraces in FOUS is grasses and sedges comprising 55-90% of cover, with 10-20% forbs, and 0-15% shrubs (Symstad 2012). Table 9 shows that the mean relative cover in reconstructed prairie community sites from Symstad (2012)was 88% grasses (8% introduced, 80% native) and 11% forbs (9% introduced, 2% native).

Threats and Stressor Factors

FOUS staff identified drought and human disturbance (foot traffic) as two potential threats to the unit's reconstructed prairie community. Exotic species likely pose the greatest threat to the reconstructed prairie at FOUS, with 28 species identified in 2010 sampling (Symstad 2012). Species posing the greatest threat include Canada thistle, leafy spurge, smooth brome, crested wheatgrass, cheatgrass (*Bromus tectorum*)(NPS 2005).

Data Needs/Gaps

Symstad et al. (2011) provides a protocol for plant monitoring in FOUS. After 5 years of implementation, NGPN will be able to define condition and trend of the park's vegetative resources in order to make more informed management decisions.

Overall Condition

Exotic Species Abundance
During initial scoping meetings, the project team assigned the measure of exotic species abundance a *Significance Level* of 3, indicating this measure is of high importance in defining condition. Although native species generally comprise the majority of vegetation cover in plots and fields sampled by Symstad in 2010, a number of exotic plants are present in the reconstructed prairie community at FOUS and together comprise 17% of total plant cover (Table 9), which is above the 10% target. In addition, the number of exotic species is high in a majority of plots and fields. Therefore, the *Condition Level* for exotic species abundance is a 2, indicating a moderate level of concern.

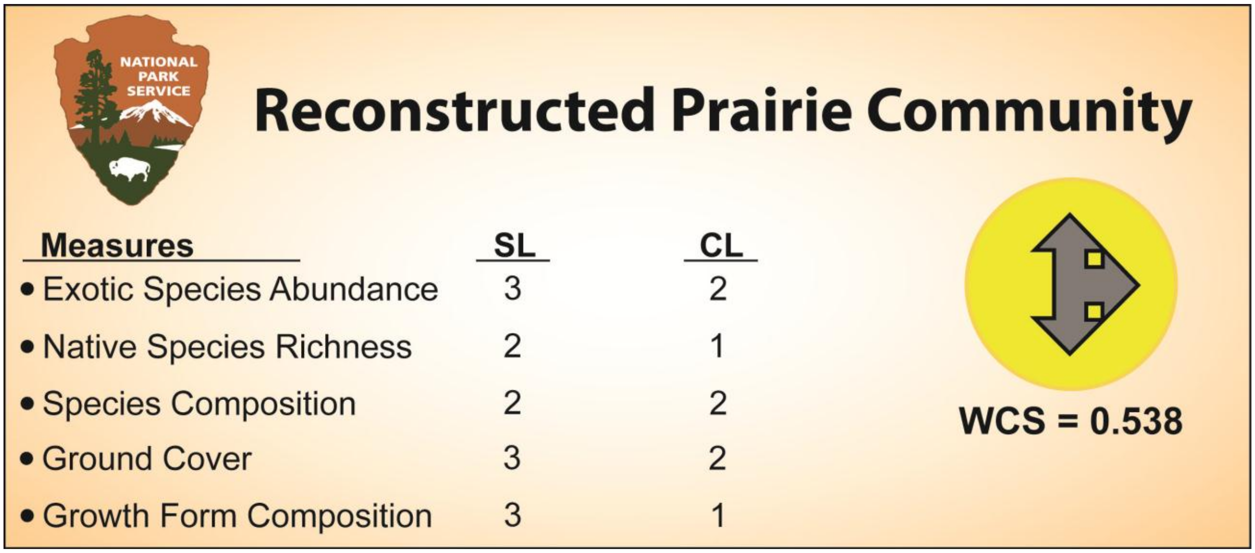
Native Species Richness
A *Significance Level* of 2 was assigned to the measure of native species richness, indicating this measure is of moderate importance in defining condition. Native species richness of the reconstructed prairie in FOUS is lower than that of the natural prairie plots in the unit, but is comparable to the lower NSR range measured in other mixed grass prairie communities. The *Condition Level* for native species richness is a 1, indicating a low level of concern.

Species Composition
A *Significance Level* of 2 was assigned to the measure of species composition. A diverse set of native plants are present in the reconstructed prairie at FOUS, although some fields are heavily dominated by 1-3 native grass species. There are also many exotic plant species in the reconstructed prairie community, which raises concern for the condition of species composition. The *Condition Level* for species composition is a 2.

Ground Cover
A *Significance Level* of 3 was assigned to the measure of ground cover. Bare soil makes up a large portion of overall ground cover within many of the reconstructed plots in FOUS. This could be due in part to recent management activities that have reduced litter cover; however, the high levels of bare soil are of moderate concern since desired conditions call for <15% cover by bare soil. The *Condition Level* for ground cover is a 2.

Growth Form Composition
A *Significance Level* of 3 was assigned to the measure of growth form composition. Overall, the mean relative composition of forbs and grasses is within the desired condition for this community. This measure is assigned a *Condition Level* of 1.

Weighted Condition Score
The *Weighted Condition Score* for the reconstructed prairie community in FOUS is 0.538, indicating a moderate level of concern. Exotic species are the major reason for concern regarding the reconstructed prairie community at FOUS. Since only one sample iteration has been completed for the community, there is not enough information to determine a trend for the condition level.



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Amy Symstad, Research Ecologist, USGS/NPS

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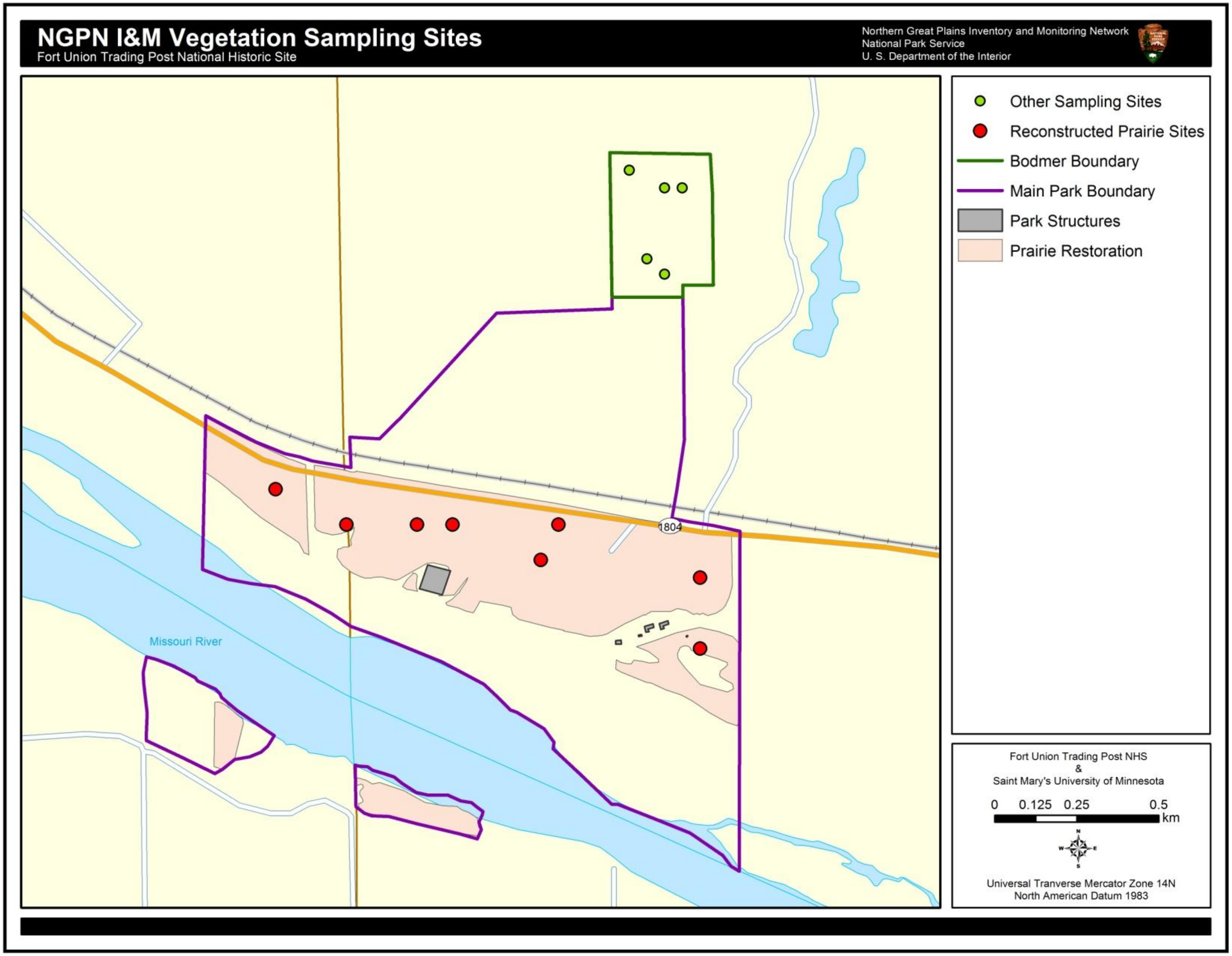


Plate 2. Plots in reconstructed prairie sampled by Symstad in 2010.

4.4 Birds

4.4.1 Description

Bird populations often act as excellent indicators of an ecosystem's health (Morrison 1986, Hutto 1998, NABCI 2009). Birds are typically easy to observe and identify, and bird communities often reflect the abundance and distribution of other organisms with which they co-exist (Blakesley et al. 2010). FOUS is home to diverse habitats that support high numbers of bird species (Panjabi 2005). The generally good condition of these habitats, namely the willow riparian thickets, mixed riparian woodlands, cottonwood stands, emergent wetlands and seasonal ponds, grasslands and meadows, and remnant sage brush shrublands enable this small parcel of land to boast a diversity of bird species. Monitoring avian population health and diversity in these habitats will be important for detecting population and ecosystem changes.

4.4.2 Measures

- Species observed vs. species expected
- Species richness
- Species distribution
- Raptor abundance

4.4.3 Reference Conditions/Values

A reference condition was not assigned for FOUS birds, as limited work has been done in the park. Future studies regarding birds in the park could potentially use Panjabi (2005) as a baseline to compare trends and conditions.

4.4.4 Data and Methods

The Rocky Mountain Bird Observatory (RMBO) inventoried the breeding bird population of FOUS from 2002-2004 (Panjabi 2005). SMUMN GSS used data from this study to estimate species richness for the years surveyed. This assessment also used the NPS Certified Species List for FOUS (NPS 2011).

4.4.5 Current Condition and Trend

<u>Species Richness</u>

RMBO visited FOUS three times during the study, 10-11 June 2002, 3-4 June 2003, and 14-15 June 2004. RMBO staff extensively inventoried all areas of FOUS; the habitats inventoried included:

- The riparian woodlands and wetlands along the north side of the Missouri River;
- The meadows around the housing area;
- The mature cottonwood stand and associated shrublands on the south side of the Missouri River;
- The restored grassland south of ND Highway 1804 and Roosevelt County 327;

- The non-native grasslands north of ND Highway 1804 and Roosevelt County 327 along the trail to the Bodmer Overlook;

The Panjabi (2005) surveys found a large number of bird species during each visit (Figure 2). The unusually high number of breeding bird species detected during these surveys may be attributed to the high diversity and good condition of the habitats in FOUS (Panjabi 2005). The diverse riparian vegetation and other wetland habitats accounted for 90% of the bird species observed during the surveys.

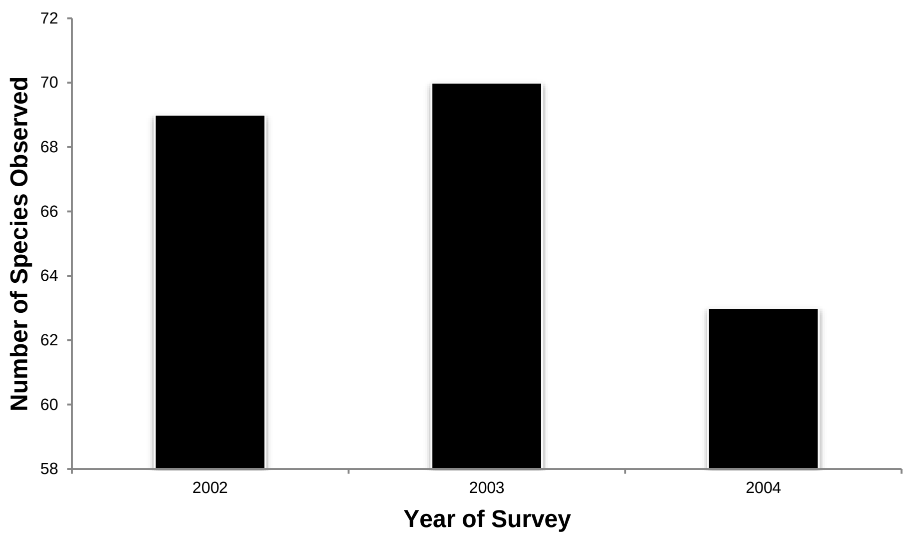


Figure 2. Number of species detected during RMBO breeding bird inventories at FOUS from 2002-2004 (Panjabi 2005).

Panjabi (2005) established species abundance estimates for many of the National Park units surveyed from 2002-2004. FOUS did not have species abundance estimates, as the small size of the park made it impossible to establish enough independent sampling points to yield statistically meaningful results (Panjabi 2005). Because of this, and the absence of long-term species richness trend data, condition for this measure cannot be assessed at this time.

Species of Conservation Concern

The high number of species in FOUS includes several species that are of conservation concern. Four species of birds detected by RMBO (Panjabi 2005) at FOUS are listed as North Dakota Level I Priority Species (Table 13). A Level I Priority Species is one with

> …a high level of conservation priority because of declining status in either North Dakota or across their range; or a high rate of occurrence in North Dakota constituting the core of the species' breeding range, but are at-risk range wide, and non-SWG [State Wildlife Grants] funding is not readily available to them (Dyke et al. 2004).

Table 13. FOUS confirmed bird species that are designated as species of conservation concern.

Common Name	Scientific Name	ND PS[1]	PIF BCR[2] 11	PIF BCR[2] 17
northern harrier	*Circus cyaneus*		X	X
prairie falcon	*Falco mexicanus*		X	
Franklin's gull	*Larus pipixcan*	X		
American white pelican	*Pelecanus erythrorhynchos*	X		
marbled godwit	*Limosa fedoa*	X		
Wilson's phalarope	*Phalaropus tricolor*	X		
horned lark	*Eremophila alpestris*		X	
black-billed magpie	*Pica hudsonia*		X	X
vesper sparrow	*Pooecetes gramineus*			X
clay-colored sparrow	*Spizella pallida*		X	
northern rough-winged swallow	*Stelgidopteryx serripennis*			X
western meadowlark	*Sturnella neglecta*		X	X
loggerhead shrike	*Lanius ludovicianus*		X	X
brown thrasher	*Toxostoma rufum*		X	
northern flicker	*Colaptes auratus*		X	
red-headed woodpecker	*Melanerpes erythrocephalus*		X	X

[1] ND PS = North Dakota Priority Species (Dyke et al. 2004)
[2] PIF BCR= Partners in Flight Bird Conservation Region Species of Regional Importance (http://www.rmbo.org)

Beginning in 1991, Partners in Flight (PIF) began assessing land bird species with the intent of providing consistent, scientific evaluations of conservation status for all land bird species (RMBO 2005). The assessments look at a species' population size, distribution, population trend, threats, and regional abundance in order to generate numerical scores that rank the species in terms of its biological vulnerability and regional status. The RMBO maintains PIF assessment data and organizes the species on a geographic scale using Bird Conservation Regions (BCRs). BCRs are the accepted planning units for updated regional bird conservation assessments under the North American Bird Conservation Initiative (NABCI) (RMBO 2005). FOUS is part of both BCR 11 (Prairie Potholes), and BCR 17 (Badlands and Prairies). PIF lists 10 land bird species from the FOUS Certified Species List as Species of Regional Importance for BCR 11, and seven species for BCR 17 (RMBO 2005) (Table 13). Appendix C shows all of the present and probably present bird species in FOUS.

The North Dakota Priority Species List takes into account all bird species (including waterbirds), while the PIF list only takes into consideration land birds (as defined in Rich et al. 2004). This may partially explain why the North Dakota priority birds identified in Table 13 do not appear in the PIF lists.

<u>Threats and Stressor Factors</u>

One of the major threats facing bird populations across all habitat types is habitat loss driven by land cover change (Morrison 1986). Altered habitat can compromise the reproductive success or survival rates of species adapted to that habitat. Reduction in available stopover habitat along migratory routes has been hypothesized as a potential cause of population decline in some migratory species (Moore et al. 1995, Swanson et al. 2003). Furthermore, human activity in the FOUS region may increase traffic-related disturbances and mortality (Barnhart, pers. comm., 2012). Situated along the Missouri River, FOUS may offer refuge to several habitat-specific species, especially during migration. Land cover change could ultimately alter the species composition of the park.

Data Needs/Gaps

There is a need for long-term trend data for birds in FOUS. Regular monitoring in FOUS would facilitate a more accurate assessment of current observed vs. expected species counts, species richness, species distribution, and abundance. Annual bird surveys, such as breeding bird surveys (BBS), or Christmas bird counts (CBC) are a few ways that this monitoring could occur, although the small size of FOUS would make these types of surveys more difficult. Without monitoring in the park, these measures cannot be accurately assessed. Annual surveys would also help to monitor the abundance of priority species within park boundaries.

Panjabi (2005) suggested that FOUS could sample birds in the park by establishing a line transect in the area. The small size of FOUS makes transects difficult to establish, as appropriate spacing is required to obtain independent observations on the transect. Alternatively, Panjabi (2005) suggests that FOUS staff could use spot mapping to provide a census of all birds in certain regions of the park or potentially the whole park.

Overall Condition

Species Observed vs. Species Expected

This measure was assigned a *Significance Level* of 1 by FOUS staff. Because a significance level of 1 was assigned, SMUMN GSS does not focus on the measure in the text of this component, but rather briefly discusses the condition level of the component here. However, SMUMN GSS was unable to assign a *Condition Level* to the species observed vs. species expected measure due to the lack of available data. While Panjabi (2005) performed a species observed vs. species expected analysis, the data are now several years old and researchers have not repeated this analysis since the 2004 survey.

Species Richness

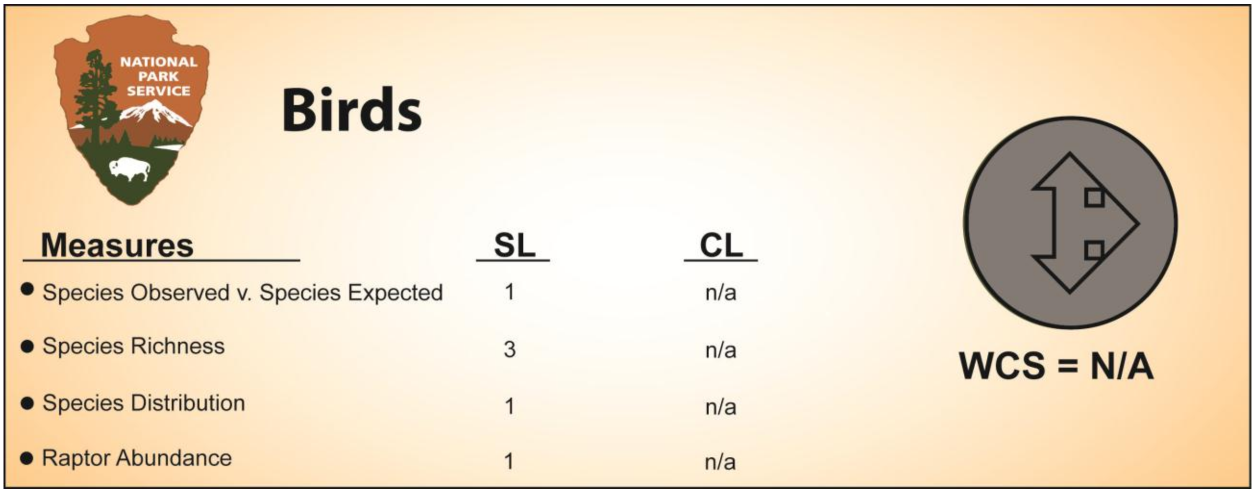
The measure species richness was assigned a *Significance Level* of 3 by FOUS staff. SMUMN GSS did not assign a *Condition Level* to this measure, as there was insufficient data to assign a current condition. While Panjabi (2005) conducted an initial inventory and established baseline abundance levels, no long-term trend data exist. Without long-term data, an assessment of condition for species richness in FOUS is not possible at this time.

Species Distribution

Species distribution was assigned a *Significance Level* of 1 by FOUS staff. No data have been collected in regards to species distribution in FOUS and a *Condition Level* cannot be assigned at this time.

Raptor Abundance
The measure of raptor abundance was also assigned a *Significance Level* of 1. Panjabi (2005) conducted three years of bird surveys and documented the raptors in the park as well. However, the data from these surveys alone are not enough to assign a *Condition Level* for this measure.

Weighted Condition Score
Because SMUMN GSS could not assign condition levels to the component, no *Weighted Condition Score* was assigned.



4.4.6 Sources of Expertise
Andy Banta, FOUS Superintendant
Audrey Barnhart, FOUS Museum Curator

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4.5 Small Mammals

4.5.1 Description

All mammals that reside in FOUS, with the exception of white-tailed deer (*Odocoileus virginianus*), are small mammals. There are two primary habitats available to small mammals at FOUS: the riparian deciduous woodland community and the grasslands (Schmidt et al. 2004). Twenty-two small mammal species are present in FOUS, including a variety of rodents and bats (NPS 2011). Of the small mammal species in the park, deer mice are likely the most abundant (Schmidt et al. 2004; Barnhart, pers. comm., 2012).

Some of the species present in the park are of conservation priority according to the state of North Dakota: Richardson's ground squirrel and the western small-footed myotis (*Myotis ciliolabrum*) (NDGF 2004). Richardson's ground squirrel is a conservation priority because of threats from agriculture and development (NDGF 2004). The western small-footed myotis is a conservation priority because of the perceived loss of critical habitat, hibernation and roosting areas in particular (NDGF 2004).

4.5.2 Measures

- Species richness
- Bat population abundance
- Thirteen-lined ground squirrel abundance

4.5.3 Reference Conditions/Values

The reference condition for small mammals in FOUS is the active period of the Trading Post (1829-1867). Historic descriptions of mammals in FOUS are generally restricted to larger game species, so it is difficult to know the composition of the small mammal community during this period (Weist et al. 1980).

4.5.4 Data and Methods

Schmidt et al. (2004) conducted a mammal inventory at FOUS between 2002 and 2004 in the riparian forest and grassland communities; trapping and wildlife cameras captured terrestrial mammals, and mist nets and acoustical monitoring captured bats.

4.5.5 Current Condition and Trend

Species Richness

Table 14 displays small mammals present in FOUS.

Table 14. Small mammals in FOUS (Schmidt et al. 2004, NPS 2011).

Scientific Name	Common Name
Blarina brevicauda	short-tailed shrew
Canis familiaris	domestic dog (feral)
Clethrionomys gapperi	southern red-backed vole
Eptesicus fuscus	big brown bat
Erethizon dorsatum	porcupine
Microtus pennsylvanicus	meadow vole
Mus musculus	house mouse
Mustela frenata	long-tailed weasel
Myotis ciliolabrum	western small-footed bat
Myotis lucifugus	little brown bat
Myotis volans	long-legged myotis
Onychomys leucogaster	grasshopper mouse
Perognathus fasciatus	olive-backed pocket mouse
Peromyscus leucopus	white-footed mouse
Peromyscus maniculatus	deer mouse
Procyon lotor	raccoon
Reithrodontomys megalotis	harvest mouse
Spermophilus richardsonii	Richardson's ground squirrel
Spermophilus tridecemlineatus	thirteen-lined ground squirrel
Sorex cinereus/haydeni	masked or Hayden's shrew
Thomomys talpoides	northern pocket gopher
Zapus hudsonius	meadow jumping mouse

Schmidt et al. (2004) documented 38% of species expected in FOUS during the 2002-2004 mammal survey. The Schmidt et al. (2004) survey added four new native species to the mammal list for FOUS: northern short-tailed shrew (*Blarina brevicauda*), northern pocket gopher (*Thomomys talpoides*), western small-footed bat, and meadow jumping mouse (*Zapus hudsonius*) (Schmidt et al. 2004). The deer mouse was the most abundant species captured in the survey, followed by the thirteen-lined ground squirrel (Schmidt et al. 2004). Three additional undocumented mammal species may occur in FOUS: western jumping mouse (*Zapus princeps*), badger (*Taxidea taxus*), and snowshoe hare (*Lepus americanus*) (Schmidt et al. 2004).

The domestic dog (*Canis familiaris*) and house mouse (*Mus musculus*) were two non-native mammals identified in the 2002-2004 survey (Schmidt et al. 2004). In addition, park staff have observed domestic or feral cats.

Threats and Stressor Factors

Non-native species (both plant and animal) are potential threats to the native small mammal species in FOUS. Feral dogs, cats and the house mouse are non-native mammals species currently present in FOUS (Schmidt et al. 2004).

Schmidt et al. (2004) identified bats as the primary mammals of concern at FOUS due to their specific habitat requirements. Bats use the riparian forest community in FOUS, and a lack of cottonwood regeneration and habitat loss due to erosion are potential threats to bats and other mammal species in FOUS.

Visitors to FOUS pose a threat to small mammals through vehicular strikes on roads, human-caused wildfires, and the spread of non-native plants (Schmidt et al. 2004). Roads are not thought to hinder the dispersal of mammals in FOUS (Schmidt et al. 2004).

Prescribed fire may have unknown negative impacts on small mammals in FOUS. No data exist on the topic; however, Schmidt et al. (2004) recommends small fires on a rotational basis and avoiding burns in the summer months to protect bat reproduction.

Data Needs/Gaps

Long-term small mammal monitoring is necessary to gain a better understanding of the small mammal community in FOUS (Schmidt et al. 2004).

Overall Condition

Species Richness

A *Significance Level* of 3 was assigned for the measure species richness. FOUS grasslands appear to support a relatively diverse mammal community (Schmidt et al. 2004). However, more data are needed to determine a *Condition Level*.

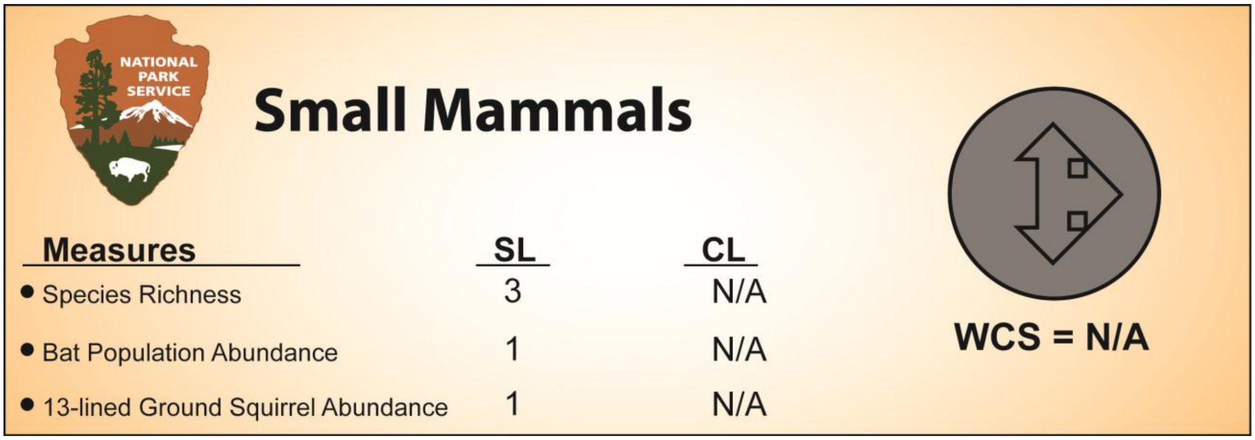
Bat Population Abundance

A *Significance Level* of 1 was assigned for the measure of bat population abundance. Bats are the mammals of greatest concern in FOUS due to their specific habitat requirements (Schmidt et al. 2004). According to an acoustical survey, there are four species of bats present at FOUS: big brown bat, western small-footed bat, little brown myotis, and long-legged myotis (Schmidt et al. 2004). The riparian woodlands provide near optimal habitat for many bat species. However, due to the lack of flooding these forests are not regenerating (Schmidt et al. 2004), and bank erosion is further reducing the riparian habitat in FOUS (Ellis 2006). Due to the lack of quantitative data, *Condition Level* for this measure is currently undetermined.

Thirteen-lined Ground Squirrel Abundance

The project team defined the *Significance Level* for thirteen-lined ground squirrel abundance as a 1. Little data exist regarding thirteen-lined ground squirrel abundance in FOUS. Schmidt et al. (2004) captured 23 individuals during the 2002-2004 survey; only the deer mouse (*Peromyscus maniculatus*) was more abundant in the survey. Andy Banta (pers. comm., 2012) believes there are many more thirteen-lined ground squirrels in FOUS than when the Trading Post was active. In addition, Barnhart (pers. comm., 2012) has noticed a sharp decline in the past 3 years of the thirteen lined ground squirrels. However, no population estimates are currently available for the species. Since no previous data exist for this measure, a *Condition Level* cannot be assigned at this time.

Weighted Condition Score
The *Weighted Condition Score* for small mammals in FOUS cannot be determined due to a lack of data on measures for this component.



4.5.6 Sources of Expertise
Andy Banta, FOUS Superintendent
Audrey Barnhart, FOUS Museum Curator

4.5.7 Literature Cited

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4.6 Herptiles

4.6.1 Description

Herptiles (reptiles and amphibians) are an important ecosystem component in FOUS because they act as key indicator species, as they are especially susceptible to ecological changes, largely because of their permeable skin (Smith and Keinath 2007). In addition, amphibians are often prey species, so the toxins absorbed through their skin quickly spread throughout an entire food web (Smith and Keinath 2007). This assessment focuses specifically on three species of concern in FOUS: the plains spadefoot toad (*Spea bombifrons*), the northern leopard frog (*Rana pipiens*), and the Great Plains toad (*Bufo cognatus*) (NDGFD 2010, USFS 2011).

4.6.2 Measures

- Species of concern – relative abundance

4.6.3 Reference Conditions/Values

The reference condition for herptiles in FOUS is the active period of the Trading Post (1829-1867). Explicit data and information regarding this reference condition are not available.

4.6.4 Data and Methods

Data for this component are limited. Smith et al. (2004) conducted a herpetofauna inventory of FOUS in 2002-2003. The authors, with assistance from volunteers and park staff, performed call surveys, visual encounter surveys, road surveys, and salamander surveys to identify herptile species present in FOUS.

Barnhart (2005) developed a monitoring plan for herptiles in FOUS. This plan included summaries of previous herptile survey work in the park, although most information presented did not help explain current condition.

4.6.5 Current Condition and Trend

Species of Concern – Relative Abundance

Three herptile species of concern exist in and near FOUS. The plains spadefoot toad is listed as a Level I species of concern in North Dakota (NDGFD 2010); North Dakota Level I species are those that “are in decline and receive little or no monetary or conservation efforts” (NDGFD 2012). The northern leopard frog and Great Plains toad are listed as species of concern by the U.S. Forest Service in Region 1, which includes FOUS (USFS 2011); USFS defines sensitive species as species “identified by a Regional Forester for which population viability is a concern, as evidenced by significant current or predicted downward trends in population numbers or density and habitat capability that would reduce a species’ existing distribution” (USFS 2010).

Smith et al. (2004) did not observe plains spadefoots or Great Plains toads during a 2002-2003 herpetofauna survey of FOUS. However, the authors recognized the plains spadefoot as present in the park and the Great Plains toad as possibly present, and park staff captured and photographed individuals of both species in the park following the survey (Barnhart pers. comm., 2012). The NPSpecies database (NPS 2012) identifies both species as present in the park. These rare species are explosive breeders and may not be observed for years at a time (Smith 2003). In Montana, the Great Plains toad only breeds in clear, temporary pools immediately following a rain (Bragg 1940 and Black 1970, as cited by MNHP 2012a); the plains spadefoot exhibits similar reproductive characteristics (Hammerson 1999, as cited by MNHP 2012b).

Smith (2003) did observe northern leopard frogs, but did not estimate abundance. Smith et al. (2004) stated that the species was commonly heard chorusing during the survey and appear to be common in FOUS. Smith and Keinath (2007) list the historical and present abundance of leopard frogs in North Dakota as unknown, and the population trend is also unknown.

Four species of snakes exist in the park (racer [*Coluber constrictor*], bullsnake [*Pituophis catenifer*], plains garter snake [*Thamnophis radix*], and red-sided garter snake [*Thamnophis sirtalis*]) (Barnhart 2005, NPS 2012). Although these snakes are not species of concern according to the state or USFS, Audrey Barnhart (pers. obs., 2011) noticed a decrease in snake abundance over recent years in areas where they were previously observed.

<u>Threats and Stressor Factors</u>
Loss of riparian habitat is the greatest threat to herptiles in FOUS. Bank erosion is reducing the total area of the riparian forest in FOUS (Ellis 2006). Barnhart (2005, p. 7) notes that management should "strive to maintain a natural inflow and outflow within the network of river and floodplain habitats."

Herbicides used to treat non-native plants in FOUS could have negative health implications for herptiles in FOUS (Reylea 2005). Herbicides are used annually to control leafy spurge (*Euphorbia esula*), crested wheatgrass (*Agropyron cristatum*), Canada thistle (*Cirsium arvense*), and smooth brome (*Bromus inermis*)in both upland and bottomland habitats (Barnhart 2005).

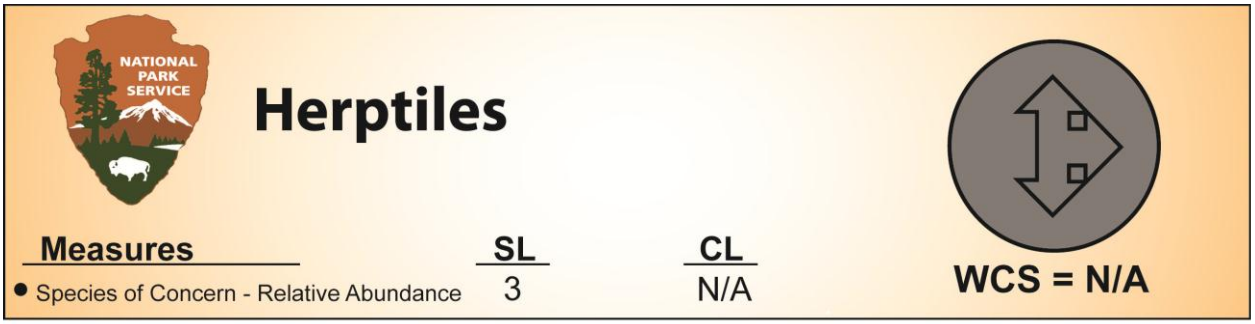
Feral cats (*Felis catus*) do traverse the park on occasion (Barnhart, pers. comm., 2012) and these animals could be preying on herpetofauna in FOUS. The non-native common carp (*Cyprinus carpio*) is common in the Missouri River at FOUS, and could sharply reduce herptile abundance in larger pools during periods of inundation (Barnhart 2005).

<u>Data Needs/Gaps</u>
No relative abundance estimates exist for herptile species within FOUS, including species of concern. Some presence/absence data are available from past surveys, although these studies identified only a few of the species expected to exist in FOUS. A relative abundance survey of herptile species in FOUS would be useful in defining baseline populations of each species.

<u>Overall Condition</u>

Species of Concern – Relative Abundance
A *Significance Level* of 3 was assigned to the measure of species of concern–relative abundance. Due to lack of data regarding this measure within FOUS, *Condition Level* cannot be assigned at this time.

Weighted Condition Score
A *Weighted Condition Score* for herptiles cannot be assigned due to a lack of data on relative abundance of species of concern.



4.6.6 Sources of Expertise

Audrey Barnhart, FOUS Curator

4.6.7 Literature Cited

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4.7 Air Quality

4.7.1 Description

Air pollution can significantly affect natural resources and their associated ecological processes. Consequently, air quality in parks and wilderness areas is protected and regulated through the 1916 Organic Act and the Clean Air Act of 1977 (CAA) and the CAA's subsequent amendments. The Clean Air Act defines two distinct categories of protection for natural areas, Class I and Class II airsheds. Class I airsheds receive the highest level of air quality protection as offered through the CAA; only a small amount of additional air pollution is permitted in the air shed above baseline levels. For Class II airsheds, the increment ceilings for additional air pollution above baseline levels are slightly greater than for Class I areas and allow for moderate development (EPA 2008a). However, new and modified sources of air pollution must be analyzed for potential impacts to ambient air quality and visibility prior to development. FOUS is a Class II airshed (NPS 2011a).

Parks designated as Class I and II airsheds typically use the Environmental Protection Agency's (EPA) National Ambient Air Quality Standards (NAAQS) for criteria air pollutants as the ceiling standards for allowable levels of air pollution. The EPA believes these standards, if not exceeded, protect the health of humans and natural resources (EPA 2008a). The CAA also establishes that current visibility impairment in these areas must be remedied and future impairment prevented (EPA 2008a). However, the EPA acknowledges that the current NAAQS are not necessarily protective of ecosystems and is currently developing secondary NAAQS for ozone, nitrogen, and sulfur compounds to protect sensitive plants, lakes, streams, and soils (EPA 2010a, EPA 2010b). To comply with CAA and NPS Organic Act mandates, the NPS established a monitoring program that measures air quality trends in many park units for key air quality indicators, including atmospheric deposition, ozone, and visibility (NPS 2008).

NPS (2005) and Pohlman and Maniero (2005) suggest the most abundant pollutant emissions affecting the northern Great Plains include nitrogen oxides, ammonia, and sulfur dioxide. Air quality is primarily affected by area sources (e.g., oil and gas development, agriculture, fires, and road dust), stationary sources (e.g., power plants and industry), and mobile sources (e.g., vehicle emissions) (Peterson et al. 1998, NPS 2005). In addition to concerns about increases in nitrate, sulfate, and ammonium, there is also concern throughout the Great Plains Network about increases in ozone levels (Pohlman and Maniero 2005). Emissions from coal-fired power plants in western North Dakota and eastern Montana present a concern for increased mercury deposition in the region as well (Peterson et al. 1998, Pohlman and Maniero 2005).

4.7.2 Measures

- Nitrogen deposition
- Sulfur deposition
- Mercury deposition/concentration
- Ozone concentration
- Particulate matter concentration

Atmospheric Deposition of Sulfur and Nitrogen

Sulfur and nitrogen oxides transmit into the atmosphere primarily through the burning of fossil fuels, industrial processes, and agricultural activities (EPA 2008b). While in the atmosphere, these emissions form compounds that can travel long distances and settle out of the atmosphere in the form of pollutants such as particulate matter (e.g., sulfates, nitrates, ammonium) or gases (e.g., nitrogen dioxide, sulfur dioxide, nitric acid, ammonia) (EPA 2008b, NPS 2008). Atmospheric deposition can be in wet form, in which pollutants are dissolved in atmospheric moisture and deposited in rain, snow, low clouds, or fog, but also occur in dry form, for example as particles or gases that settle on dry surfaces as with windblown dusts (EPA 2008b). Deposition of sulfur and nitrogen can have significant effects on ecosystems including acidification of water and soils, excess fertilization or increased eutrophication, changes in the chemical and physical characteristics of water and soils, and accumulation of toxins in soils, water and vegetation (NPS 2008, reviewed in Sullivan et al. 2011a and 2011b). Grassland prairie and meadow communities are sensitive to increased levels of nitrogen and may be impacted by excess nitrogen enrichment via deposition (reviewed in Sullivan 2011b); the predominant landcover in FOUS is grassland and meadow (Sullivan et al. 2011c). Alternatively, many non-natives, such as the invasive cheatgrass, prefer nitrogen rich environments and may displace native species as nitrogen deposition increases in these sensitive communities (Sullivan et al. 2011a, 2011b, and 2011c).

Mercury

Sources of atmospheric mercury include fuel combustion and evaporation (especially coal-fired power plants), waste disposal, mining, industrial sources, and natural sources such as volcanoes and evaporation from mercury-enriched soils, wetlands, and oceans (EPA 2008b). Mercury deposited into rivers, lakes, and oceans can accumulate in various aquatic species resulting in exposure to wildlife and humans (EPA 2008b).

Ozone

Ozone occurs naturally in the earth's atmosphere where, in the upper atmosphere, it protects the earth's surface against ultraviolet radiation (EPA 2008b). However, it also develops at the ground level (i.e., ground-level ozone) through a chemical reaction between nitrogen oxides and volatile organic compounds (VOCs) in the presence of heat and sunlight (NPS 2008). Ozone is one of the most widespread pollutants affecting vegetation in the U.S. (NPS 2008). Considered phytotoxic, ozone can cause significant foliar injury and growth effects for sensitive plants in natural ecosystems (EPA 2008a, NPS 2008). Specific effects include reduced photosynthesis, premature leaf loss, and reduced biomass; prolonged exposure can increase vulnerability of plants to insects and diseases or other environmental stresses (NPS 2008). At high concentrations, ozone can affect humans by aggravating respiratory and cardiovascular diseases, reducing lung function, causing acute respiratory problems, and increasing susceptibility to respiratory infections (EPA 2008b, EPA 2010c); this would be a concern for visitors and staff engaging in aerobic activities in the park, such as hiking.

Particulate Matter

Particulate matter (PM) is a complex mixture of extremely small particles and liquid droplets that suspend in the atmosphere. PM is categorized as fine particles ($PM_{2.5}$), which are 2.5 micrometers in diameter or smaller, and inhalable coarse particles (PM_{10}), which are smaller than 10 micrometers (the width of a single human hair) (EPA 2009a). Particulate matter largely consists of acids (such as nitrates and sulfates), organic chemicals, metals, and soil or dust particles (EPA 2008a, EPA 2009a). Fine particles are a major cause of reduced visibility (haze) in many national parks and wildernesses (EPA 2010b). $PM_{2.5}$ can be directly emitted from sources such as forest fires or they can form when gases emitted from power plants, industry and/or vehicles react with air (EPA 2009a, EPA 2010d). Sources of coarse particles (PM_{10}) include grinding or crushing operations and windblown or stirred up dust from dirt surfaces (e.g., roads, agricultural fields). Particulate matter either absorbs or scatters light. As a result, the clarity, color, and distance seen by humans decreases, especially during humid conditions when additional moisture is present in the air (EPA 2010d). PM_{10} and $PM_{2.5}$ are also a concern for human health as these particles easily pass through the throat and nose and enter the lungs (EPA 2008b, EPA 2009a, EPA 2010d). Short-term exposure to these particles can cause shortness of breath, fatigue, and lung irritation (EPA 2008b, EPS 2009a).

4.7.3 Reference Conditions/Values

The NPS Air Resources Division (ARD) developed an approach for rating air quality conditions in national parks, based on the current NAAQS, ecosystem thresholds, and visibility improvement goals (Table 15) (NPS 2010a). Assessment of current condition of nitrogen and sulfur atmospheric deposition is based on wet deposition. Visibility conditions are assessed in terms of a Haze Index, a measure of visibility derived from calculated light extinction (NPS 2010a). NPS ARD recommends the following values for determining air quality condition (Table 15). The "good condition" metrics may be considered the reference condition for FOUS. The NAAQS standard for PM_{10} is 150.0 $\mu g/m^3$ over a 24-hour period; this level may not be exceeded more than once per year on average over three years (EPA 2010d). The standard for $PM_{2.5}$ is 15.0 $\mu g/m^3$ weighted annual mean or 35.0 $\mu g/m^3$ in a 24-hour period over an average of three years (EPA 2010d). Currently, there is no standard or threshold established for mercury deposition.

Table 15. National Park Service Air Resources Division air quality index values (NPS 2010a).

Condition	Ozone concentration (ppb)	Wet Deposition of N or S (kg/ha/yr)	Visibility (dv)
Significant Concern	≥76	>3	>8
Moderate Concern	61-75	1-3	2-8
Good Condition	≤60	<1	<2

4.7.4 Data and Methods

<u>NPS Data Resources</u>

Currently, there are no active air quality monitoring stations in FOUS, so data are interpolated or estimated from nearby or regional monitoring stations. NPS ARD provides estimates of ozone, wet deposition of nitrogen and sulfur, and visibility that are based on interpolations of data from all air quality monitoring stations operated by NPS, EPA, various states, and other entities, averaged over five years (2005-2009). These estimates are available from the Explore Air website (NPS 2011b) and are used to evaluate air quality conditions. Note that on-site or nearby data are needed for a statistically valid trends analysis, while a five-year average interpolated estimate is preferred for the condition assessment. NPS ARD (2010b) reports on air quality conditions and trends in an annual report for over 200 park units, including FOUS. This report examines trends in ozone, visibility, and deposition data collected from 1999 to 2008.

NPS (2004) assessed ozone concentrations in the NGPN and the risk of injury to plant species that are sensitive to sustained ozone exposure. Ambient ozone concentrations were estimated through statistical interpolation and estimated hourly concentrations were used to generate annual exposure values for all NGPN parks, including FOUS.

Other Air Quality Data Resources

The National Atmospheric Deposition Program–National Trends Network (NADP) database provided annual average summary data for nitrogen and sulfur concentration and deposition near FOUS. Monitoring site MT96, located in Roosevelt County, Montana, is approximately 80 km (50 mi) NNW of FOUS. This site has been in operation since 1999. The NADP Mercury Deposition Network database provided interpolated average annual deposition and concentration data.

The Clean Air Status and Trends Network (CASTNet) provides summaries of the composition of nitrogen and sulfur deposition in the region around FOUS. Data from the nearest monitoring site (THR422) located at THRO, approximately 160 km (100 mi) south of FOUS was used in this analysis.

The EPA Air Trends database provides annual average summary data for ozone concentrations near FOUS. Monitoring site number 380530002 is located approximately 80 km southeast of FOUS.

Special Air Quality Studies

NPS (2004) reports on the estimated risk of foliar injury from ozone on native vegetation in national parks in the NGPN. Information on ozone sensitive plant species present in the parks, levels of ozone exposure, and relationships between exposure and soil moisture are synthesized into a risk assessment of foliar injury for each park, including FOUS.

Sullivan et al. (2011a) assessed the sensitivity of national parks to the potential effects of acidification caused by acidic atmospheric deposition, including sulfur, oxidized nitrogen, and ammonium nitrate, relative to other parks. The relative risk for each park was assessed by examining three variables: the level of exposure to emissions and deposition of nitrogen and sulfur; inherent sensitivity of park ecosystems to acidifying compounds (N and/or S) from deposition; and level of mandated park protection against air pollution degradation (i.e., Wilderness, Class I and Class II airsheds). The outcome was an overall risk assessment that estimates the risk of acidification impacts to park resources from atmospheric deposition of nitrogen and sulfur relative to all other parks (Sullivan et al. 2011a). Using the same approach as Sullivan et al. (2011a), Sullivan et al. (2011b) assessed the sensitivity of national parks to the effects of nutrient enrichment by atmospheric deposition of nitrogen. The outcome was an overall risk assessment that estimates the risk to park resources of nutrient enrichment from increased nitrogen deposition relative to other parks.

4.7.5 Current Condition and Trend

Nitrogen and Sulfur Deposition

Five-year interpolated averages are used to estimate the condition of most air quality parameters; this offsets annual variations in meteorological conditions, such as heavy precipitation one year versus drought conditions in another. The current 5-year average (2005-2009) estimates total wet deposition of nitrogen in FOUS to be 1.92 kg/ha/yr, while deposition of sulfur is 0.80 kg/ha/yr (NPS 2011b). Based on NPS ratings for air quality conditions, the current estimate for nitrogen deposition falls into the *Moderate Concern* category, while the current estimate for sulfur deposition falls into the *Good Condition* category (see Table 15 for ratings values). However, several factors are considered when rating the condition of atmospheric deposition, including the effects of deposition on different ecosystems (NPS 2010a). Based on the NPS process for rating air quality conditions, ratings for parks with ecosystems considered potentially sensitive to nitrogen or sulfur deposition are typically adjusted up one condition category. In general, native grassland and meadow ecosystems can be sensitive to increased levels of nitrogen, as acidification and nutrient enrichment can cause shifts in native species composition and encroachment of exotic species and grasses (reviewed in Sullivan et al. 2011a and 2011b). FOUS comprises grassland/prairie vegetation communities, which may be at risk from increased nitrogen deposition. Thus, the condition for deposition of nitrogen in FOUS is of *Significant Concern* and *Moderate Concern* for sulfur deposition, based on natural background and current average deposition rates.

Concentrations (mg/L) of nitrogen, sulfur, and ammonium compounds in wet deposition can be used to evaluate trends in deposition of total nitrogen and sulfur. Since atmospheric wet deposition can vary greatly depending on the amount of precipitation that falls in any given year, it can be useful to examine concentrations of pollutants, which factor out the variation introduced by precipitation. The nearest NADP monitoring station to FOUS is located at Poplar River in Roosevelt County, Montana, approximately 130 km north-northwest of FOUS. Despite a slight increase in all concentrations in 2002, annual averages from 2000-2010 indicate that nitrate and sulfate concentrations in FOUS have been decreasing over time; ammonium appears unchanged (NADP 2011) (see Figure 3). This may be an indication of the conditions at FOUS, but given the distance, the data should be viewed with caution.

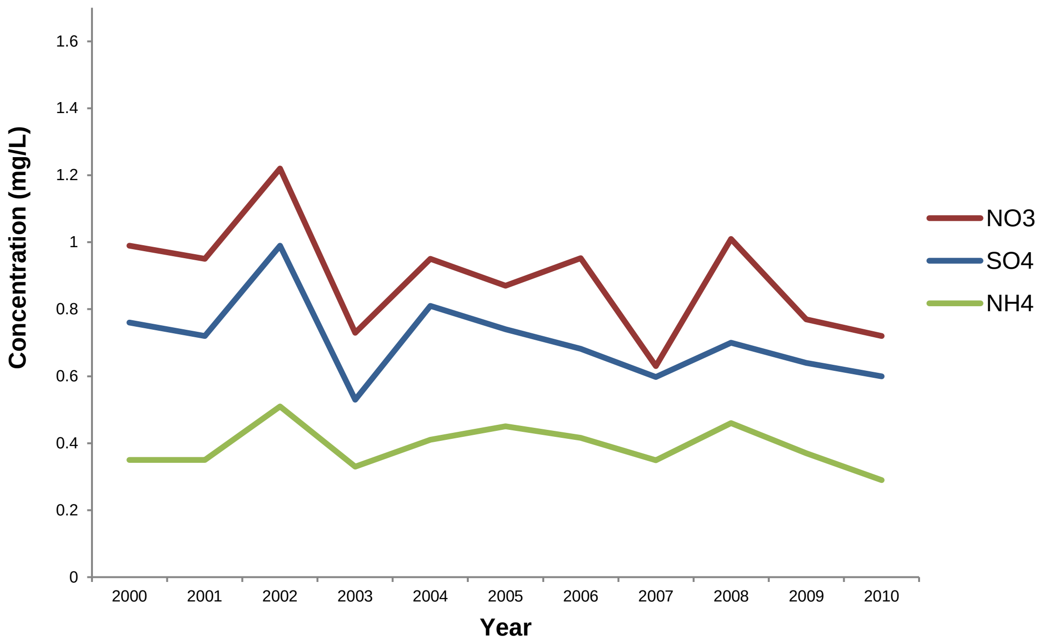

Figure 3. Annual average precipitation-weighted concentrations of nitrate (NO_3), sulfate (SO_4), and ammonium (NH_4) (mg/L) near FOUS, 2000-2010 (NADP Poplar River monitoring site [MT96] is located in Roosevelt County, Montana approximately 130 km [50 mi] NNW of FOUS) (Source: NADP 2011).

Dry deposition (dust, particles, and aerosols) also contributes significantly to total deposition in the region around FOUS. The nearest CASTNet monitoring station to FOUS is located at THRO, approximately 160 km south of FOUS. CASTNet data indicate that dry forms contribute about one-fourth (26%) to total deposition of nitrogen, and about 30% to total sulfur deposition (EPA 2012) (Figure 4, Figure 5). Figure 4 indicates that reduced forms of nitrogen (i.e., ammonium [NH_4]) contribute approximately 50% of total nitrogen deposition; this is likely an underestimate because ammonia gas is not included in the measurements. Given the distance of the monitor at THRO from FOUS, the data may not be representative of the conditions at FOUS and should be viewed with caution.

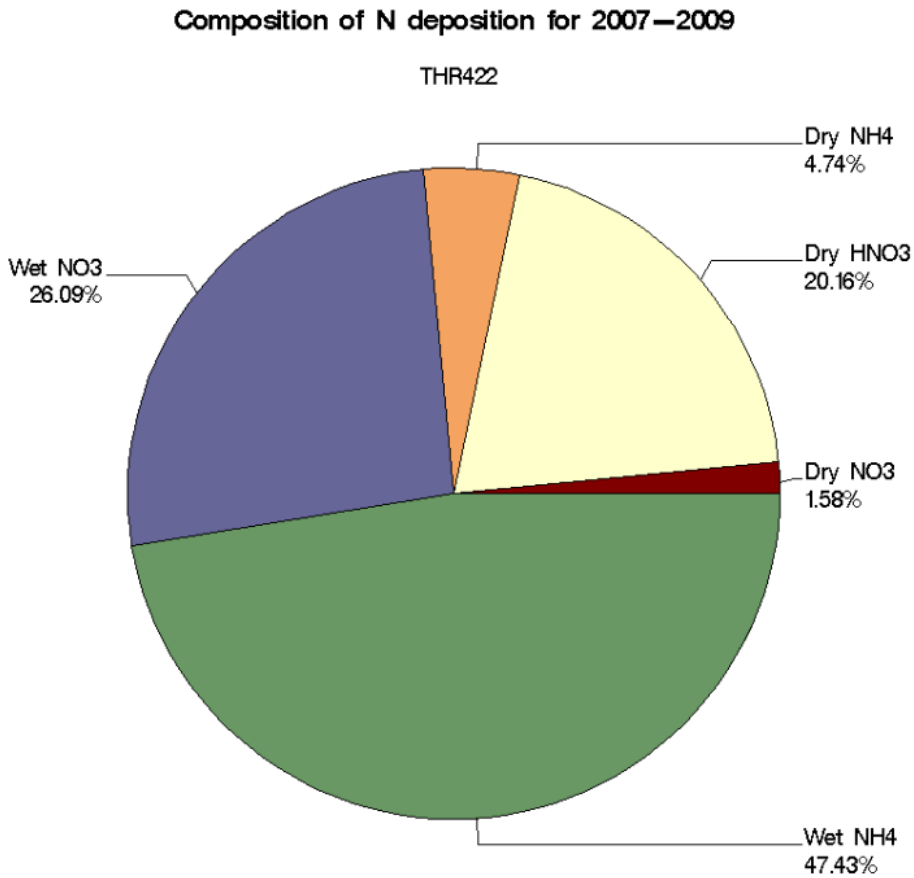

Figure 4. Composition of nitrogen deposition near FOUS, 2007-2009 (EPA 2012). Monitoring station located at THRO, approximately 160 km south of FOUS (site ID number is THRO422).

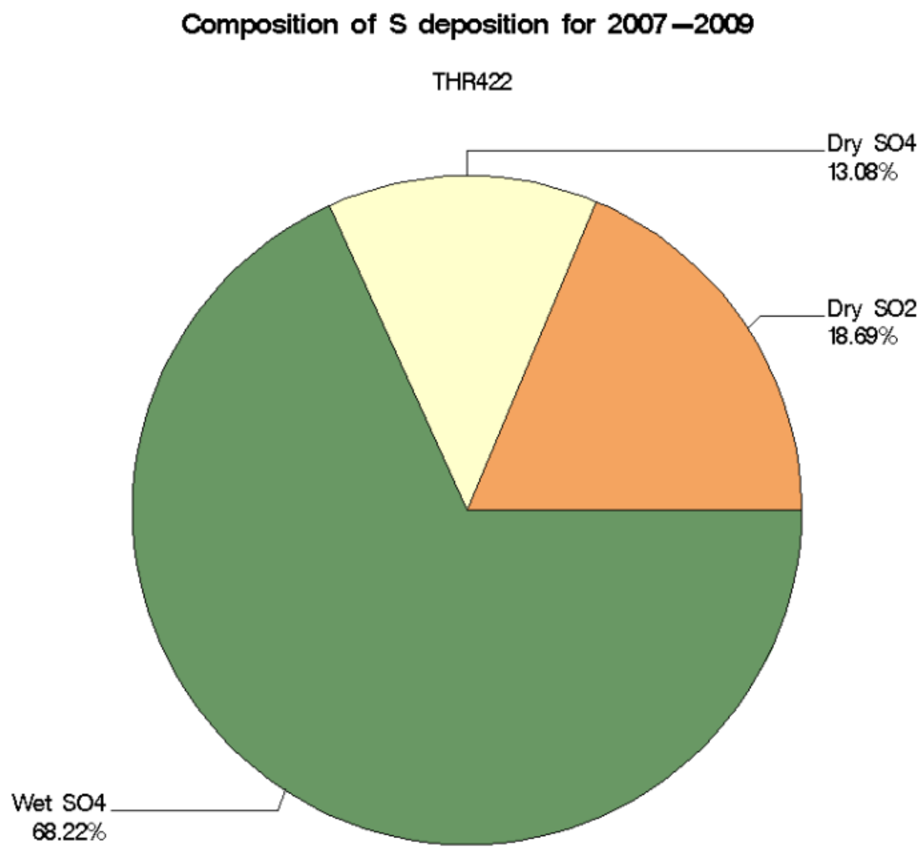

Figure 5. Composition of sulfur deposition near FOUS, 2007-2009 (EPA 2012). Monitoring station located at THRO, approximately 160 km south of FOUS (site ID number is THRO422).

Sullivan et al. (2011a) characterized FOUS as having low acidifying (nitrogen and sulfur) pollutant exposure, very low ecosystem sensitivity to acidification in its grassland ecosystem, and moderate park protection (Class II airshed) against air pollution. Relative to other national parks, the ranking of overall risk from acidification due to acid deposition was low (Sullivan et al. 2011a). In a separate examination, Sullivan et al. (2011b) used the same approach to assess the sensitivity of national parks to nutrient enrichment effects from atmospheric nitrogen deposition relative to other national parks. Risk relative to other parks was assessed by examining exposure to nitrogen deposition, inherent sensitivity of park ecosystems, and mandates for park protection. FOUS was ranked as being at low risk for nitrogen pollutant exposure, moderate ecosystem sensitivity of grasslands and meadows, and moderate park protection mandates (Class II airshed). The overall risk of effects from nutrient enrichment due to atmospheric nitrogen deposition was determined to be very low relative to other parks (Sullivan et al. 2011b).

<u>Mercury Deposition and Concentration</u>

FOUS does not have a monitoring station that records mercury deposition. For locations in the U.S. that do not have active mercury monitoring stations, deposition is interpolated from the nearest sites in areas with sufficient numbers of samplers; this data can be used to estimate conditions in a particular area, but should be used with caution in considering current condition or in determining trends. Figure 6 shows the most recent interpolated average mercury wet deposition for monitoring sites across the U.S. (the approximate location of FOUS is marked with a red star). Recent average deposition data indicate wet deposition of mercury in the region of the park is less than or equal to 4 μg/m^2 (NADP 2012).

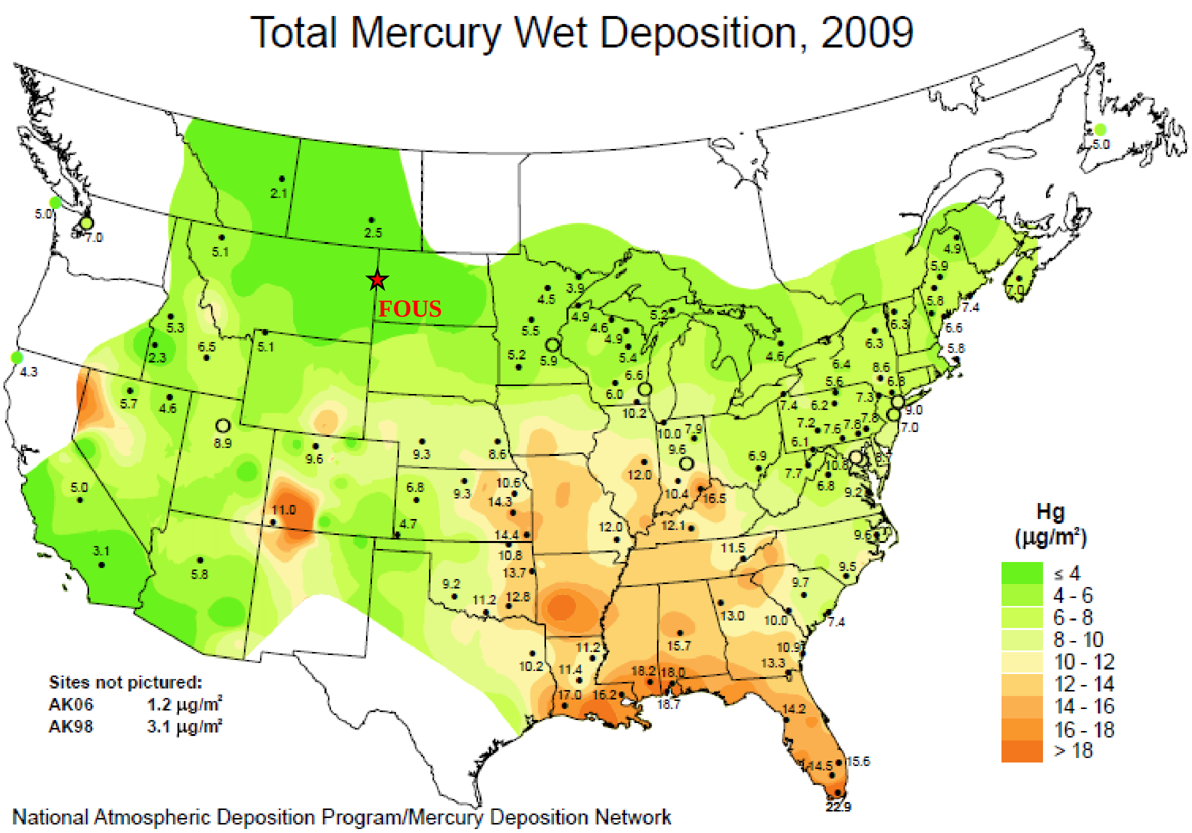

Figure 6. Total mercury deposition near FOUS, 2009 (Source: NADP 2012). Red star indicates the approximate location of FOUS.

Total wet deposition of mercury varies with the amount of precipitation that has fallen in an area across a year or several years. Mercury concentrations more accurately reflect patterns in mercury emissions. Figure 7 shows the most recent interpolated average mercury concentrations for monitoring sites across the U.S. (approximate location of FOUS is marked with a red star). Recent average concentration data indicate mercury concentrations in the region of FOUS are approximately 8-10 ng/L (NADP 2012). Consistent data prior to 2009, aside from the Lostwood National Wildlife Refuge data, are unavailable for both mercury concentration and deposition in the FOUS region.

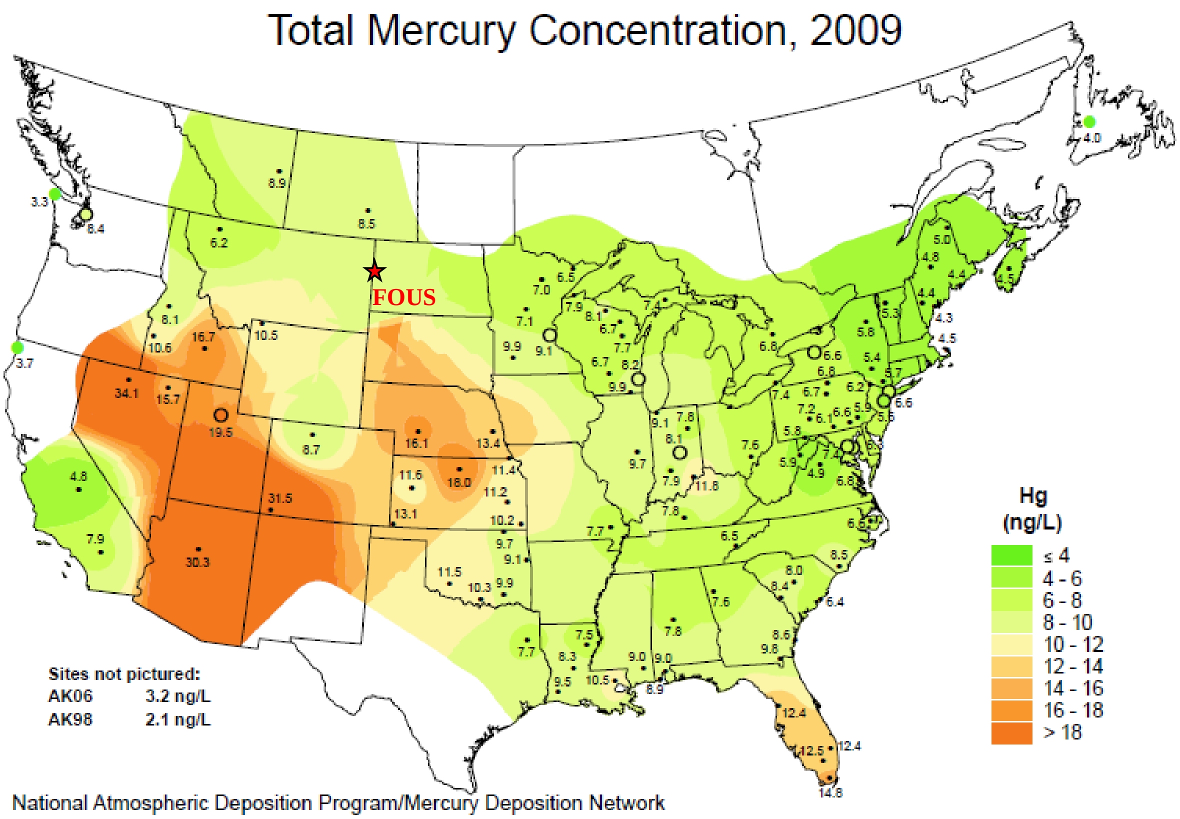

Figure 7. Total mercury concentration near FOUS, 2009 (Source: NADP 2012). Red star indicates the approximate location of FOUS.

The nearest mercury monitoring station is located at Lostwood National Wildlife Refuge (site ND01) in Burke County, North Dakota (approximately 160 km northeast of FOUS). Data were collected intermittently at this site from November 2003 through December 2008; the site no longer actively records data. Table 16 shows the mean mercury concentration (in ng/L) during data collection from 2004 through 2008. During the data collection period, concentrations varied widely between approximately 7-18 ng/L, which may or may not be representative of FOUS given the distance of the monitor to the park.

Table 16. Mean mercury concentrations (in ng/L) recorded near FOUS, 2004-2008 (Source: NADP 2012).

Mercury Monitoring at Lostwood National Wildlife Refuge, North Dakota (Site ND01)		
	Number of samples	**Hg Concentration (ng/L)**
2004	51	7.89
2005	53	8.93
2006	52	10.26
2007	52	17.96
2008	46	6.88

Ozone Concentration

The NAAQS standard for ground-level ozone is the benchmark for rating current ozone conditions within park units. The condition of ozone in NPS park units is determined by calculating the 5-year average of the fourth-highest daily maximum of 8-hour average ozone concentrations measured at each monitor within an area over each year (NPS 2010a). The current 5-year average (from 2005-2009) for FOUS indicates an average ground-level ozone concentration of 60.0 ppb (NPS 2011b), which falls under the *Good Condition* category based on NPS guidelines. Figure 8 shows the trend for average annual ozone concentrations (in ppm) from 1990 to 2010 with respect to the national standard; data originate from a monitoring site approximately 80 km southeast of FOUS (EPA 2009b). Data suggest ozone concentrations vary slightly but, overall, concentrations appear to be stable and within the EPA national standard.

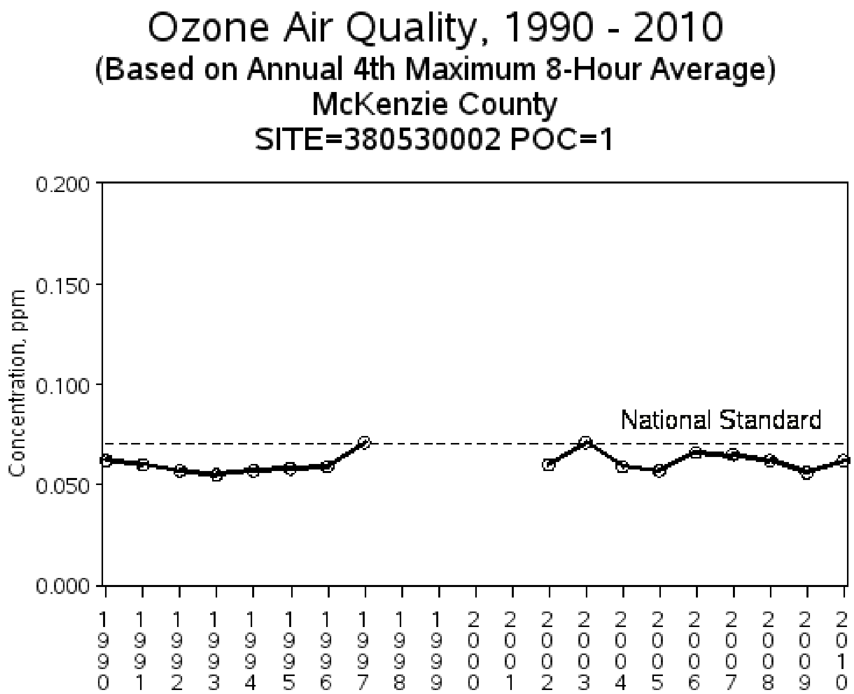

Figure 8. Average annual ozone (O_3) concentration (ppm) near FOUS, 1990-2010 (Source: EPA 2009b). Note: Site 380530002 is the monitor located nearest to FOUS (approximately 80 km southeast of the park).

NPS (2004) assessed ozone concentrations in the NGPN and the risk of injury to plant species that are sensitive to sustained ozone exposure. Data from 1995-1999 indicate ozone concentrations in FOUS frequently exceeded 60 ppb each year but rarely exceeded 80 ppb; ozone concentrations never exceeded 100 ppb. Sensitive plant species begin to experience foliar injury when exposed to ozone concentrations of 80-120 ppb/hour for extended periods of time (8 hours or more) (NPS 2004). Thus, the risk of foliar injury to plants was determined to be low (NPS 2004). However, if ozone concentrations should increase in the future, an on-site monitoring program that assesses foliar injury and growth progress may be necessary (NPS 2004).

Various plant and tree species are monitored to track air pollution impacts. FOUS has six plant species known to be sensitive to excessive or extended concentrations of ozone, including black locust (*Robinia pseudoacacia*), chokecherry, Saskatoon serviceberry (*Amelanchier alnifolia*), Indianhemp (*Apocynum cannabinum*), and white sage (*Artemisia ludoviciana*) (NPS 2004, NPS 2006). None of these species are considered to be bioindicators for ozone.

<u>Concentration of Particulate Matter</u>
Concentrations of particulate matter ($PM_{2.5}$ and PM_{10}) are recorded at a monitoring site approximately 26 km west of FOUS, at the Sidney Oil Field in Montana (site ID 30-083-0001). Measurements recorded at this site represent the most current data on particulate matter concentrations in the area. The NAAQS standard for PM_{10} is 150 µg/m^3 over a 24-hour period; this level may not be exceeded more than once per year on average over three years (EPA 2010d). The standard for $PM_{2.5}$ is a weighted annual mean of 15.0 µg/m^3 or 35 µg/m^3 in a 24-hour period over an average of three years (EPA 2010d). $PM_{2.5}$ concentrations near FOUS have remained stable around 5-7 µg/m^3 since 2009 (Figure 9). Average concentrations of PM_{10} fluctuated between 17-26 µg/m^3. Values for both $PM_{2.5}$ and PM_{10} are well within the EPA standards for levels that are protective of human health and visibility.

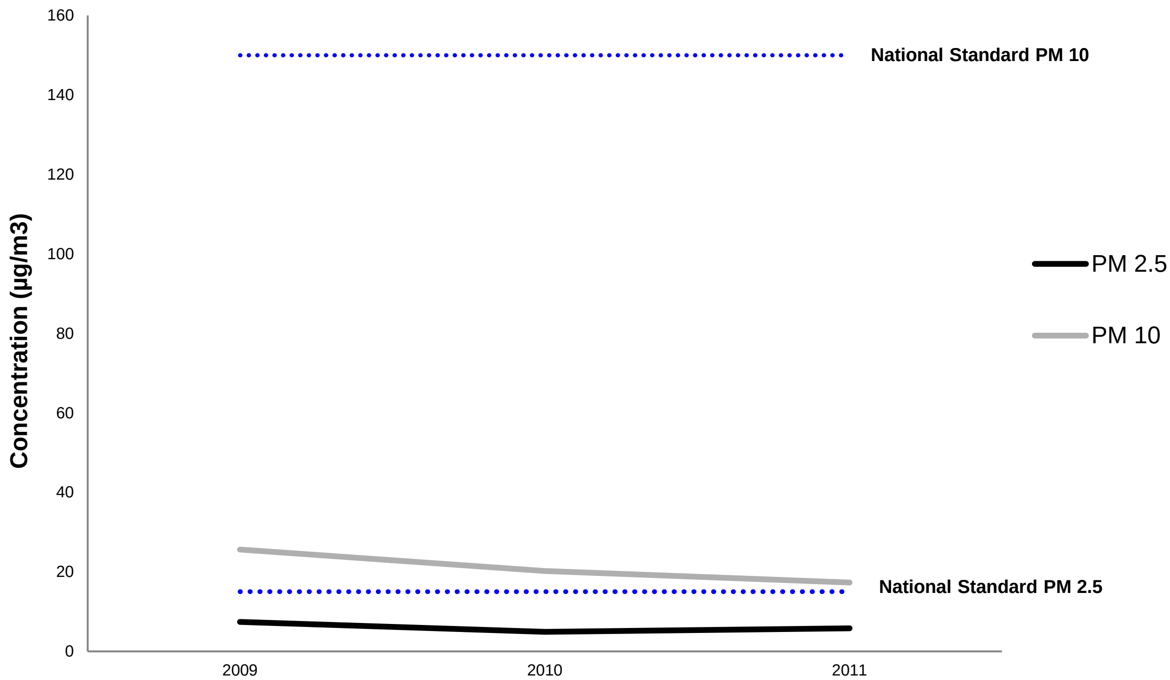

Figure 9. Average annual particulate matter concentration ($PM_{2.5}$ and PM_{10}) near FOUS, 2009-2011 (EPA 2011).

Visibility impairment occurs when airborne particles and gases scatter and absorb light; the net effect is called "light extinction," which is a reduction in the amount of light from a view that is returned to an observer (EPA 2003). In response to the mandates of the CAA of 1977, federal and regional organizations established IMPROVE in 1985 to aid in monitoring of visibility conditions in Class I airsheds. The goals of the program are to 1) establish current visibility conditions in Class I airsheds; 2) identify pollutants and emission sources causing the existing visibility problems; and 3) document long-term trends in visibility (NPS 2009a).

Visibility in parks is examined as the clearest and haziest 20% of days each year (NPS 2009). The nearest visibility monitoring station is located at THRO, approximately 160 km south of FOUS. Figure 10 depicts estimated visibility conditions (in Mm^{-1}) for the 20% haziest and 20% clearest days in THRO. Conditions measured near 0 Mm^{-1} are clear and provide excellent visibility, and as Mm^{-1} measurements increase, visibility conditions become hazier. Estimated visibility conditions appear consistent for both the 20% haziest and clearest days over the last five averaging periods.

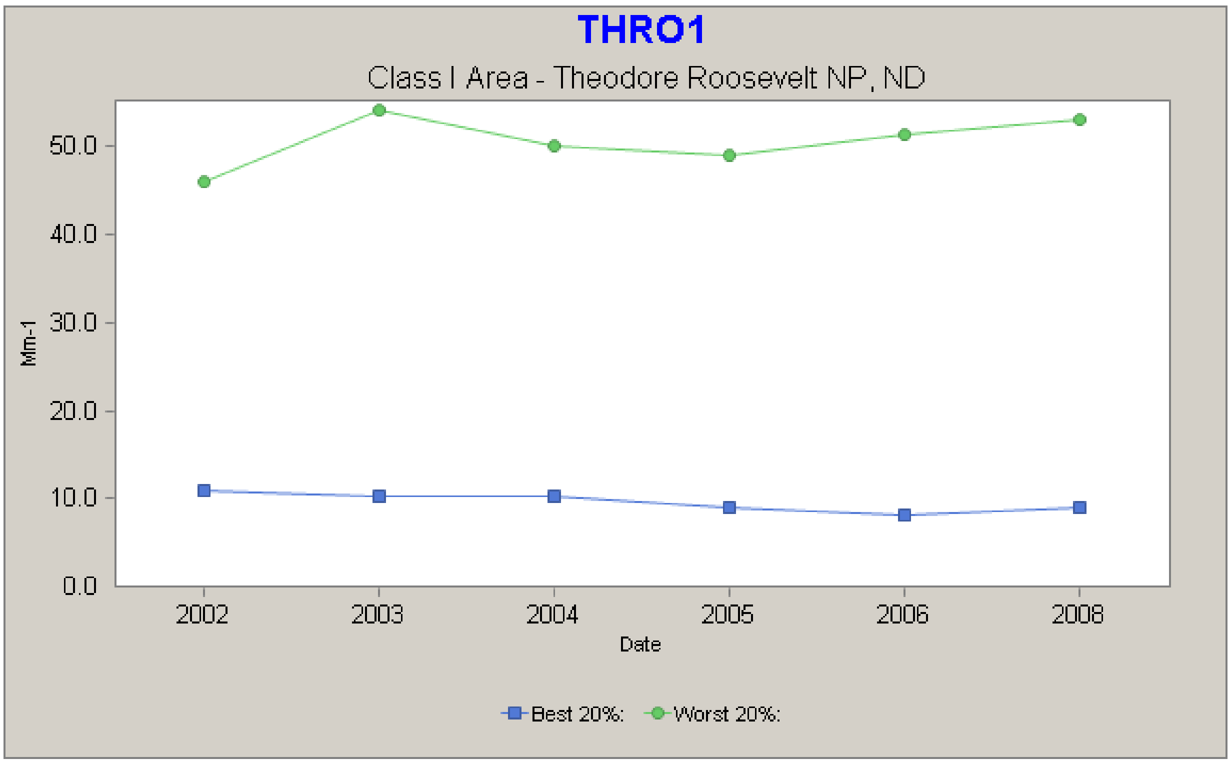

Figure 10. Annual visibility in THRO, 2002-2008 (VIEWS 2010). Note: the IMPROVE monitoring site nearest to FOUS is located at THRO, approximately 160 km south of FOUS.

<u>Threats and Stressor Factors</u>

The most substantial threat to air quality in the northern Great Plains is increased energy development, particularly crude oil and natural gas. Western and central North Dakota have experienced a significant increase in oil and gas development in the last two decades (Peterson et al. 1998), and development is rapidly moving west into eastern Montana. This development has increased exponentially in the last 10 years (park staff, pers. comm., 2012). The major sources of pollution that could affect protected areas in this region include sulfur dioxide and nitrogen oxide emissions, which are added to the air through oil and gas operations, as well as coal-fired power plants (Peterson et al. 1998). The infrastructure needed to support increased vehicle and shipping traffic has added to overall emissions in the region. A small diesel refinery is planned for development just seven miles east of the park, as well as two new rail terminals (located four and seven miles from the park) for transporting oil and materials (park staff, pers. comm., 2012). Several power plants, the largest sources of sulfate dioxide emissions in the region, are located in western North Dakota (Peterson et al. 1998). Although FOUS is unlikely to be affected by acidification from sulfur dioxide and associated sulfate deposition, these coal-burning power plants also release mercury into the atmosphere that, when transformed to toxic methylmercury in wetlands, can bioaccumulate in fish and wildlife. Nitrogen oxides emissions from oil and gas development may increase nitrogen deposition to FOUS grasslands and wetlands, affecting plant communities and promoting growth of annual grasses and invasive species.

Smoke produced by wildfires or human-caused fires has long been a part of the Great Plains ecosystem. Though fires are not considered a long-term source of pollution in the northern Great Plains (including FOUS), if persistent and substantial in extent, they may result in periods of decreased visibility and increased concentrations of particulate matter (Peterson et al. 1998).

Data Needs/Gaps

Currently, there is no monitoring effort in FOUS that tracks impacts to species known to be sensitive to increases in various pollutants. Nitrogen and sulfur deposition can affect plant communities (e.g., promoting invasive species, contributing to loss of biodiversity, or encouraging transition/succession of plant communities), and ozone can cause foliar injury and inhibit growth. Certain plant and tree species can be used to monitor such air pollution impacts. Changes to plant communities over time may reflect changes in nitrogen deposition.

Atmospheric deposition (sulfur, nitrogen, and mercury) is not monitored in or near the park. Thus, managers must rely on estimated interpolated averages from other stations in the region, which are less accurate than measurements recorded on site. An on-site monitoring program would more accurately characterize air quality and atmospheric deposition at FOUS and would enable managers to track trends as oil and gas development in the region increases.

Overall Condition

Atmospheric Deposition of Nitrogen

The project team defined the *Significance Level* for atmospheric deposition of nitrogen as a 3. When factoring in the sensitivity of the grassland ecosystem, current 5-year average estimates of nitrogen deposition fall into the significant concern category. However, concentrations of nitrates near the park appear to be decreasing over the last decade, though it is not clear if this is a significant decrease or if this trend will continue. Therefore, deposition of nitrogen is of significant concern (*Condition Level*=3).

Atmospheric Deposition of Sulfates

The project team defined the *Significance Level* for atmospheric deposition of sulfates as a 3. When factoring in the sensitivity of the grassland ecosystem, current 5-year average estimates of sulfur deposition fall into the moderate concern category. Average concentrations of sulfates near the park appear to be decreasing over the last decade, though it is not clear if this is a significant decrease. Therefore, deposition of sulfates is of moderate concern (*Condition Level*=2) with an improving trend.

Deposition/concentration of Mercury

The project team defined the *Significance Level* for mercury concentration as a 3. Current data suggest mercury deposition and concentration in the northern Great Plains are low relative to other regions of the U.S. However, these data are interpolated from monitoring stations some distance from the park and serve only as estimates for the region. Limited data make it impossible to determine a *Condition Level* for this measure.

Ozone Concentration
The project team defined the *Significance Level* for ozone concentration as a 3. Current average ground-level ozone concentrations fall into the good condition category based on NPS criteria for rating air quality. Both 5-year estimated averages (measured in ppb) and annual averages (measured in ppm) indicate concentrations are stable in the park. Concentrations are within EPA standards. Therefore, the condition of ozone concentration is of no concern (*Condition Level=0*).

Particulate Matter (PM $_{2.5}$ and $_{10}$)
The project team defined the *Significance Level* for concentration of particulate matter as a 3. Values for both $PM_{2.5}$ and PM_{10} measured near FOUS are well within the EPA standards for levels that are protective of human health. The *Condition Level* for particulate matter is of low concern (*Condition Level=1*).

Weighted Condition Score
The *Weighted Condition* Score for the air quality component is 0.500, indicating the condition is of moderate concern with a stable trend.

Air Quality

Measures	SL	CL
• Nitrogen Deposition	3	3
• Sulfur Deposition	3	2
• Mercury Deposition/Concentration	3	N/A
• Ozone Concentration	3	0
• Particulate Matter Concentration	3	1

WCS = 0.500

4.7.6 Sources of Expertise
Ellen Porter, NPS Air Resources Division

4.7.7 Literature Cited

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4.8 Water Quality

4.8.1 Description

Water quality monitoring is important for tracking ecological health in the park, assessing compliance with water quality standards, and detecting threats to human health. Though no formal monitoring program is established for FOUS, the typical core set of measures monitored in national parks to understand water quality includes dissolved oxygen, concentration of fecal coliform bacteria, pH, specific conductance, temperature, and turbidity (NPS 2012).

FOUS is located on the north bank of the Missouri River, which served as the primary transportation corridor in the northern Great Plains during the 1800s. Though the park is small (444 acres), the Missouri River provides habitat for a variety of plants and animals that are observed frequently at FOUS. Additionally, the river provides opportunities for people to recreate, including activities such as boating and fishing near the park. Thus, impaired water quality could substantially affect animals, plants, and people that use the park.

Photo 7. View of the Missouri River from the fort at FOUS (Photo by Barry Drazkowski, SMUMN GSS, 2010).

4.8.2 Measures

- Dissolved oxygen (DO)
- Fecal coliform
- Macroinvertebrates
- pH
- Temperature
- Turbidity

<u>Dissolved Oxygen</u>

Dissolved oxygen (DO) is critical for organisms that live in water. Fish and zooplankton filter out or “breathe” dissolved oxygen from the water to survive (USGS 2010a). Oxygen enters water from the atmosphere or through ground water discharge. As the amount of DO drops, it becomes more difficult for water-based organisms to survive (USGS 2010a). The concentration of DO in a water body is closely related to water temperature; cold water holds more DO than does warm water (USGS 2010a). Thus, DO concentrations are subject to seasonal fluctuations as low temperatures in the winter and spring allow water to hold more oxygen, and warmer temperatures in the summer and fall allow water to hold less oxygen (USGS 2010a).

<u>Fecal coliform</u>

Fecal coliform bacteria are an accurate indicator of fecal contamination in water by warm-blooded animals. It is tested by counting colonies that grow on micron filters placed in an incubator for 22-24 hours. High numbers of fecal coliform can be an indicator of harmful bacteria as well as other disease-causing organisms such as viruses and protozoans (USGS 2011).

Macroinvertebrates

Because they spend most or all of their life cycles in water, aquatic macroinvertebrates are well known as indicators of watershed health and the quality of water in aquatic systems (EPA 2011). 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 species can be an indication of the condition of the water body and water quality (EPA 2011). The life cycles of many macroinvertebrate species are short (sometimes one season in length), though some species live longer, and many have limited mobility; thus, in a discrete area from year to year, it can be easy to detect population fluctuations that may indicate a change (positive or negative) in water quality (EPA 2011).

pH

pH is a measure of the level of acidity or alkalinity of water and is measured on a scale from 0 to 14, with 7 being neutral (USGS 2010a). Water with a pH of less than 7.0 indicates acidity, whereas water with a pH greater than 7.0 indicates alkalinity. Aquatic organisms have a preferred pH range that is ideal for growth and survival (USGS 2010a). Chemicals in water can change the pH and harm animals and plants living in the water; thus, monitoring pH can be useful for detecting natural and human-caused changes in water chemistry (USGS 2010a).

Temperature

Water temperature greatly influences water chemistry and the organisms that live in aquatic systems. Not only can it affect the ability of water to hold oxygen, water temperature also affects biological activity and growth within water systems (USGS 2010a). All aquatic organisms, from fish to insects to zoo- and phytoplankton, have a preferred or ideal temperature range for existence (USGS 2010a). As temperature increases or decreases too far past this range, the number of individuals and species able to live there eventually decreases. In addition, higher temperatures allow some compounds or pollutants to dissolve more easily in water, making them more toxic to aquatic life (USGS 2010a).

Turbidity

Turbidity assesses the amount of fine particle matter (such as clay, silt, plankton, microscopic organisms, or finely divided organic or inorganic matter) that is suspended in water by measuring the scattering effect that solids have on light passing through water (USGS 2010a). For instance, the more light that is scattered, the higher the turbidity measurement will be. The suspended materials that make water turbid can absorb heat from sunlight, increasing the water temperature in waterways and reducing the concentration of DO in the water (USGS 2010a). The scattering of sunlight by suspended particles decreases photosynthesis by plants and algae, which contributes to decreased DO concentrations (USGS 2010a). Suspended particles also irritate and clog the gill structures of many fish or amphibians, making it difficult to thrive (USGS 2010a)

4.8.3 Reference Conditions/Values

The reference condition for FOUS's water quality is the North Dakota Standards of Water Quality for the State for surface waters (NDDH 2001). The Missouri River is classified as a Class I stream by these standards, requiring that water quality be suitable for propagation or protection, or both, of resident species and other aquatic biota and for swimming, boating, and other water recreation (NDDH 2001). When state standards were unavailable, the EPA's water quality criteria for surface waters were used. The water must be safe for freshwater organisms, for human bathing, and must meet drinking water standards. Table 17 displays water quality parameter standards set by the state of North Dakota and EPA.

Table 17. North Dakota water quality standards (North Dakota Department of Health 2001, EPA 2012b).

Parameter	North Dakota standard
Temperature	<85°F or 29.4°C (for Class I streams)
Dissolved oxygen	≥5 mg/L
Turbidity	50 NTU (EPA standard)
pH	≥7.0 – ≤9.0 (up to 10% of representative samples collected during any 3-year period may exceed this range provided that lethal conditions are avoided)
Fecal coliform	≤126 CFU/100 mL (for recreational waters from May 1 – September 30)

4.8.4 Data and Methods

In 1999, the NPS published the results of surface-water quality data retrievals for FOUS using six of the EPA national databases: Storage and Retrieval (STORET) water quality database management system, River Reach File (RF3), Industrial Facilities Discharge (IFD), Drinking Water Supplies (DRINKS), Water Gages (GAGES), and Water Impoundments (DAMS) (NPS 1999). The retrieval located one industrial/municipal discharger, no drinking water intakes, one active and one inactive (since 1975) USGS stream gage, and no water impoundments. Results of the STORET query yielded only 78 observations for various parameters collected in 1974 and 1975 from the Missouri River by the EPA and the Montana Department of Environmental Quality (MDEQ) at two monitoring stations (NPS 1999). The MDEQ monitoring station (FOUS 0001) is located on the Missouri River at Railroad Crossing and Montana State Route 58 Bridge; this site was sampled only once in October 1974 (NPS 1999). The EPA station (FOUS 0002) was also located at the Montana State Route 58 Bridge and collected data during 1974 and 1975. Neither monitoring station is located within park boundaries. No data have been collected at these monitoring sites since 1975.

Rust (2006) collected water quality samples for several parameters on the Missouri River adjacent to FOUS in 2004-2005. The objective of the research was to provide baseline descriptions of macroinvertebrate communities in the aquatic systems of national parks in the NGPN (including FOUS). Chemical, physical, and habitat parameters were assessed for streams, rivers, and springs during the 2004 and 2005 summer seasons. Water quality parameters measured in the study included dissolved oxygen, temperature, turbidity, fecal coliform concentration, pH, and diversity and abundance of macroinvertebrate species as well as other chemical and physical characteristics. These data are also available through the EPA STORET database.

4.8.5 Current Condition and Trend

Dissolved Oxygen

The EPA considers dissolved oxygen levels greater than or equal to 5 mg/L to be protective of freshwater aquatic life (NDDH 2001). NPS (1999) indicated that STORET contains no measurements for DO from either river gage near FOUS.

In 2004 and 2005, Rust (2006) collected a total of 30 DO samples across 10 transects on the Missouri River adjacent to FOUS. During this sampling, DO levels ranged from 8.4 to 9.4 mg/L.

The mean and median DO levels during this time were 8.9 and 9.0 mg/L respectively. These measurements are well within state criteria for protection of freshwater aquatic life.

Fecal Coliform

NPS (1999) indicated fecal coliform concentration was measured one time at the MDEQ monitoring station (FOUS 0001) in October 1974. The sample had a concentration of 250 CFU/100 mL, which exceeded the state screening criterion for safe bathing (126 CFU/100 mL).

Rust (2006) collected three fecal coliform samples in the Missouri River adjacent to FOUS in 2004 and 2005. Concentration of organisms ranged from 10 to 20 CFU/100 mL. The mean concentration was 17 CFU/100 mL. These concentrations were well within the state screening criterion for safe bathing.

pH

The EPA criterion for pH that supports freshwater aquatic life and sustains wildlife is between 6.5 and 9.0 standard units (EPA 2012). There were two pH observations in 1974, one measurement from each of the monitoring stations (NPS 1999). pH levels in the Missouri River near FOUS during this time were measured at 8.4 and 9.0 (NPS 1999). These measurements are at the upper end of the state criteria range for protection of aquatic life.

Rust (2006) collected 30 pH measurements along the Missouri River from 2004 to 2005. Three samples were taken at each of 10 transects along the river. During this sampling, pH levels ranged from 7.7 to 8.4. The mean and median pH levels during this time were 8.2 and 8.3 respectively. All samples fell within the state criteria range for protection of aquatic life.

Macroinvertebrates

In 2004 and 2005, Rust (2006) sampled benthic macroinvertebrates from five randomly chosen transects in the Missouri River adjacent to FOUS. These samples were pooled into one composite sample for the location on each sample date; the reach was sampled on three different dates in total. On average, 52 invertebrates (median=39 invertebrates) were collected per composite sample, representing eight different taxa. The author found that 94% of invertebrates sampled were insects; nearly half (45%) of the total abundance was Ephemeroptera, Plecoptera, and Trichoptera (EPT), three pollution-sensitive orders of macroinvertebrates commonly used to assess water quality. Stonefly sp. (*Isoperla nana*) and mayfly sp. (*Baetis intercalaris*) occurred frequently and in high abundance (Rust 2006), both of which are generally considered benthos that prefer cleaner waters (EPA 2011). Taxa considered intolerant to pollution were more abundant in samples than taxa considered tolerant (Rust 2006).

Temperature

NPS (1999) indicates water temperature was recorded one time in October 1974. The temperature measurement was 3°C (NPS 1999).

Rust (2006) collected 30 temperature measurements at 10 transects along the Missouri River adjacent to FOUS during the summer months of 2004 and 2005. During this sampling, temperature measurements ranged from 16.5° to 23.8°C. Mean and median temperatures during this time were 19.1° and 17.5°C respectively. These measurements are well within North Dakota Department of Health criterion for protection of freshwater aquatic life.

Turbidity
NPS (1999) indicates turbidity was recorded one time in October 1974. The turbidity measurement was 37 NTU, which is within the WRD screening criteria for protection of freshwater aquatic life (NPS 1999).

Rust (2006) collected four turbidity measurements adjacent to FOUS in 2004 and 2005. Sample measurements ranged from 47 NTU to 152 NTU. The mean and median turbidity measurements were 74 NTU and 48 NTU respectively. Rust (2006) suggested this was moderately high turbidity compared to other stretches of the Missouri River that were sampled.

Fluctuations in turbidity may be common due to rain/weather events or increases in activities (agriculture or recreation) that add solid materials into the water along the upper reaches of a watercourse. Without consistent monitoring of water quality parameters, it is difficult to assess the trends in turbidity throughout a single year as well as over the course of many years.

Threats and Stressor Factors
Runoff from agricultural and ranching activities upriver from FOUS can contribute to water quality impairment, increasing the suspended sediment and dissolved solids concentrations in the waterway. Suspended sediment and dissolved solids concentrations were found to be moderately high at several locations in the Missouri River Basin (Apfelbeck 2007). Rust (2006) also noted moderately high turbidity and suspended solids during sampling in 2004 and 2005. Increased concentrations of both parameters can make it difficult for aquatic organisms to thrive (USGS 2010a). Illegal dumping of sewage in the Williams County area has been documented and may contribute to impaired water quality (Barnhart, pers. comm., 2012).

Nutrient enrichment has been identified as the most common stressor of macroinvertebrates in the Missouri River Basin in Montana (Apfelbeck 2007). Total nitrogen concentrations at various gage sites along the Missouri River in Montana, just west of FOUS, ranged from 0.043 to 31.6 mg/L and exceeded the Montana ecoregion guideline of 1.50 mg/L for the prevention of eutrophication at several sites upriver from FOUS (Apfelbeck 2007). Rust (2006) measured nutrients (NH_3, NO_3, and total N) in 2004 and 2005 and reported all levels were within the state thresholds. However, Apfelbeck (2007) reported exceedences in various nutrients occurring in the Missouri River upstream from FOUS. It is not clear if similar stresses are currently affecting water quality and invertebrate assemblages in the Missouri River adjacent to the park.

Data Needs/Gaps
The most recent data collected for water quality parameters are nearly 10 years old. Consistent, long-term monitoring of such parameters as DO, pH, temperature, turbidity, suspended solids, and dissolved solids, is needed in order to determine trends in water quality. Basic water quality parameters should be monitored to allow for future detection of trends and to determine if park water quality adheres to state criteria considered safe and healthy for aquatic life and human health.

The presence and composition of macroinvertebrate species in waterways can be useful in determining water quality and the overall health of water bodies (USGS 2011). To date, there has been only one baseline survey of the benthic macroinvertebrate community in the Missouri River adjacent to FOUS (conducted by Rust 2006).

Overall Condition

A few considerations should be made in examining these data. There is very limited data collected on the stretch of the Missouri River adjacent to FOUS. Those samples collected at USGS and EPA gages for the parameters of interest to this assessment were obtained at one time in October 1974. Other available data, collected by Rust (2006) in 2004 and 2005, are nearly a decade old and represent the ranges that occur in the summer months of the year; they do not reflect any variation that may be occurring through the influence of seasonal changes. A significant lack of available data makes it inappropriate to assign condition levels for each measure.

Dissolved Oxygen

The project team defined the *Significance Level* for dissolved oxygen as a 3. Rust collected 30 measurements on the Missouri River, which ranged from 8.9 to 9.0 mg/L. The available data represents only DO ranges in the summer months and is not current. Because of this data gap, a *Condition Level* was not assigned.

Fecal Coliform

The project team defined the *Significance Level* for fecal coliform as a 3. Rust (2006) measured fecal coliform three times from 2004 – 2005. Measurements were low, approximately 10-20 CFU/100mL. Available data are limited for this measure and may not reflect current conditions. Therefore, a *Condition Level* for fecal coliform was not assigned.

pH

The project team defined the *Significance Level* for pH as a 3. Rust (2006) collected 30 measurements on the Missouri River adjacent to FOUS. pH ranged from 7.7 to 8.4. However, available data are limited for pH and may not reflect current conditions. Therefore, a *Condition Level* for pH was not assigned.

Macroinvertebrates

The project team defined the *Significance Level* for macroinvertebrates as a 3. Rust (2006) compiled three different composite samples from 2004 - 2005. It was determined that nearly half of the total invertebrates sampled were species considered to be intolerant of impaired or polluted waters, suggesting the stretch of the Missouri River adjacent to FOUS has good water quality. However, this is the first survey of the macroinvertebrate community for the park. The data are nearly 10 years old and may not reflect current conditions in this stretch of river. Therefore, a *Condition Level* for macroinvertebrates was not assigned.

Temperature

The project team defined the *Significance Level* for temperature as a 3. Rust (2006) collected 30 measurements over two summers (2004 – 2005). The available data represents only temperature ranges for the summer months and is not current. For these reasons, a *Condition Level* was not assigned to temperature.

Turbidity

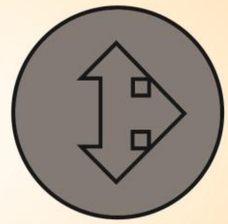
The project team defined the *Significance Level* for turbidity as a 3. Rust’s (2006) study collected a total of four observations on the Missouri River adjacent to FOUS. Data are limited for turbidity and are not current. For these reasons, a *Condition Level* for turbidity was not assigned.

Weighted Condition Score

A *Weighted Condition Score* for water quality in FOUS was not assigned due to a lack of available data for all measures.

Water Quality

Measures	SL	CL
• Dissolved Oxygen	3	N/A
• Fecal Coliform	3	N/A
• pH	3	N/A
• Macroinvertebrates	3	N/A
• Temperature	3	N/A
• Turbidity	3	N/A



WCS = N/A

4.8.6 Sources of Expertise

N/A

4.8.7 Literature Cited

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4.9 Soundscape

4.9.1 Description

The National Park Service's mission is to preserve natural resources, including natural soundscapes, associated with the national park units. The definition of soundscape in a national park is the total ambient sound level of the park, comprised of both natural ambient sound and human-made sounds (NPS 2000). According to a survey conducted by the NPS, many visitors come to national parks to enjoy, equally, the natural soundscape and natural scenery (NPS 2000).

Many factors affect how visitors and wildlife perceive and respond to noise. Primary acoustical factors include the level, duration, and spectral properties of the noise, as well as the rate of occurrence and its diurnal or seasonal schedule. Non-acoustical factors, such as experience, expectations, and adaptability, play a role in how visitors and wildlife respond to noise. Intrusive sounds are of concern to park visitors, as they detract from their natural and cultural resource experiences in different ways (NPS 2000). Perceived noises can alter the quality of the soundscape and alter the behavior of visitors and wildlife. Noise also elevates ambient sound levels above the natural condition, and thereby reduces opportunities to hear the sounds of nature or cultural sounds.

<u>Characteristics of Sound</u>

Sound pressure level is proportional to the sound power and is measured in decibels (dB). The decibel is a logarithmic scale unit commonly used to relate sound pressures to some common reference level, thus producing a smaller, more manageable range of numbers. The loudness of a sound as heard by the human ear is estimated by an A-weighted decibel scale, where the A-weighting provides a formula for discounting sounds at low (<1 kHz) and high (>6 kHz) frequencies. This adjustment for human hearing is expressed as dB(A). For this discussion, the A-weighted values are used to describe potential effects on the park's acoustic environment and soundscape (Table 18).

Table 18. Common noise levels and their effects on the human ear (Kormanoff and Shaw 2000, American Speech-Language Hearing Association 2012, McCusker, pers. comm. 2007).

Source	Decibel Level (dBA)	Effect
Normal breathing	10	
Leaves rustling at Canyonlands National Park	20	
Soft whisper, quiet library (15 feet), Snake River (at 300 feet)	30	Very quiet
Crickets at Zion National Park (at 16 feet), Snake River (at 100 feet)	40	Moderate
Light auto traffic (100 feet)	50	Moderate
Conversational speech (3 feet), 4-stroke snowmobile (30 mph at 50 feet), automobile (45 mph at 100 feet)	60	Sound levels above 60 dB begin to interfere with close range conversational speech
Personal watercraft (82 feet)	68-76	Very loud
Vacuum cleaner, 2-stroke snowmobile (30 mph at 50 feet)	70	Intrusive
Off-road Recreational vehicles	70-90	85 dB is the level at which hearing damage begins
V8 "muscle" boat (82 feet)	85-86	
Heavy truck or motorcycle (25 feet)	90	Extremely loud No more than 15 minutes of unprotected exposure recommended for sounds between 90-100 dB
Thunder	100	
Military jet at Yukon-Charley Rivers National Preserve (328 feet above ground level)	120	Threshold of sensation begins around 120 dB
Shotgun firing	130	Threshold of pain begins around 125 dB

4.9.2 Measures

- Occurrence of human-caused sound
- Natural ambient sound level
- Visitors' natural experience

4.9.3 Reference Conditions/Values

The reference condition for soundscape at FOUS is the active period of the Trading Post (1829-1867).

4.9.4 Data and Methods

Littlejohn et al. (2008) conducted a survey of FOUS visitors in 2007. The survey asked a question pertaining to the importance of "natural quiet/sounds of nature" at the Trading Post. These results provide some information about visitors' experience of soundscape at FOUS.

4.9.5 Current Condition and Trend

<u>Occurrence of Human-caused Sound</u>

There are no quantitative data available regarding the occurrence of human-caused sound in FOUS. Trains travel near FOUS several times per day, producing the greatest amount of human-caused sound within the Trading Post (Banta, pers. comm., 2011). Truck traffic passing to the north of FOUS creates additional noise, and is expected to increase in the future (Banta, pers. comm., 2011). Crop-dusters operate in agricultural areas surrounding FOUS several times per year as well, causing noise for brief periods of time (Banta, pers. comm., 2011). Cultural sounds appropriate to the reference condition would include a blacksmith forge, pounding iron, and black-powder firing.

<u>Natural Ambient Sound Level</u>
There are no baseline data available regarding the natural ambient sound level in FOUS. Natural ambient sounds at FOUS include wind, birdsongs, rustling leaves, insects, amphibians and coyotes.

<u>Threats and Stressor Factors</u>
FOUS staff identified road and train traffic and oil development as threats to the soundscape at the Trading Post, specifically a diesel refinery is planned to operate 7 miles from the park and could affect the soundscape. Trains are the greatest threat to the soundscape, as they pass by the Trading Post several times per day (Banta, pers. comm., 2011). Crop-dusting planes operating over agricultural areas near FOUS create additional noise several times per year (Banta, pers. comm., 2011). Noise associated with oil development in the surrounding area is a threat to FOUS' soundscape (Banta, pers. comm., 2011). Since late 2010 and early 2011, oil exploration and truck traffic around the park has increased exponentially.

<u>Data Needs/Gaps</u>
Baseline data are needed on the natural ambient sound level in FOUS, as well as the occurrence of human-caused sound.

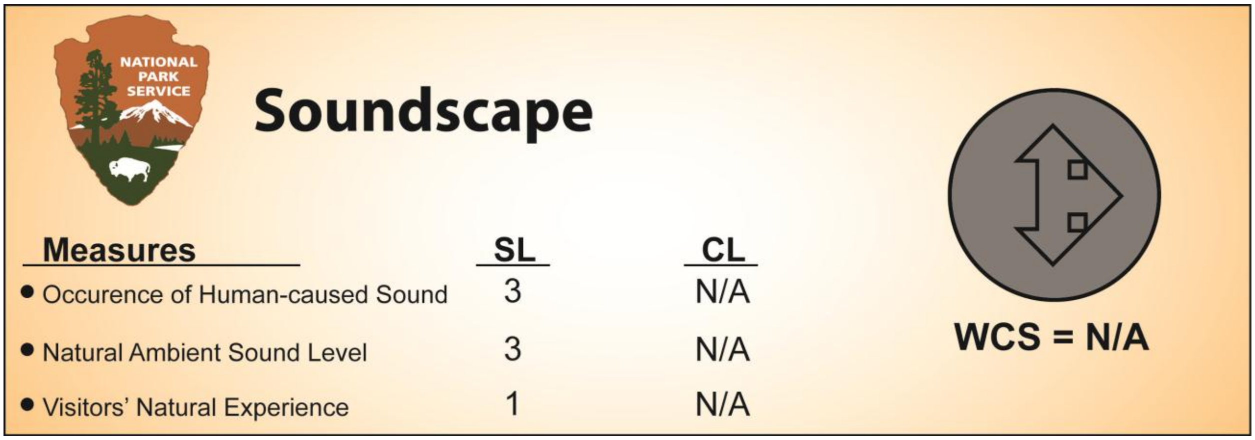
<u>Overall Condition</u>

Occurrence of Human-caused Sound
During initial scoping meetings, the project team assigned the measure of occurrence of human-caused sound a *Significance Level* of 3. Several sources of human-caused noise such as train and truck traffic have been identified; however, no quantitative data have been collected. A *Condition Level* cannot be assigned at this time.

Natural Ambient Sound Level
A *Significance Level* of 3 was assigned to the measure of natural ambient sound level. There are no data on this measure; therefore, a *Condition Level* cannot be assigned.

Visitors' Natural Experience
A *Significance Level* of 1 was assigned to the measure of visitors' natural experience. The 2007 visitor survey at FOUS asked respondents about the importance of natural quiet and sounds of nature at the Trading Post. Eighty-two percent of general visitors surveyed listed natural quiet/sounds of nature as "extremely important" or "very important"; less than one percent of visitors responded to this question as "not important" (Littlejohn et al. 2008). The study did not ask visitors how they would rate their experience of the soundscape during their visit. Therefore, a *Condition Level* cannot be assigned at this time.

Weighted Condition Score
A *Weighted Condition Score* could not be assigned due to a lack of data on the component measures.



4.9.6 Sources of Expertise
Andy Banta, FOUS Superintendent
Vicky McCusker, NPS Natural Sounds & Night Sky Division

4.9.7 Literature Cited

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4.10 Viewshed

4.10.1 Description

A viewshed is the area that can be "seen" from a particular location. The National Park Service Organic Act (16 U.S.C. l) implies the need to protect the viewsheds of National Parks, Monuments, and Reservations. At FOUS, viewsheds are of particular importance because the primary reason for visitation to the historical site is to immerse oneself in the cultural history of the fort. The remoteness of the park has helped preserve the viewshed and invokes a sense of what the fort would have looked like 200 years ago (NPCA 2006). The park intends to preserve the historical aura, as described in FOUS's long-range interpretive plan, which indicates that visitors will have the opportunity to "discover the landscape - views, wildlife, fort, and river - the same way and in the same condition to the extent possible that Lewis and Clark, Catlin, and Bodmer did" (NPS 2010).

The Bodmer Overlook is the primary viewing area in the park (Photo 8); at that location, Karl Bodmer painted "Assiniboine at Fort Union", which portrays the Fort and Native Americans interacting with European fur traders. To access the overlook, visitors hike a one-mile trail that traverses the Mondak ghost town and mixed-grass prairie (NPS 2010). From the overlook, visible features include the Fort, prairie within the park, and the confluence of the Yellowstone and Missouri Rivers.

Photo 8. View of Fort Union Trading Post from Bodmer Overlook (SMUMN GSS photo).

4.10.2 Measures

- Developed areas within viewshed

4.10.3 Reference Conditions/Values

The reference condition for viewsheds in the park is the time while the fort was active. Audrey Barnhart (pers. comm., 2012) noted that many visitors appreciate the archaic feeling experienced while visiting FOUS. In addition, the park's long-range interpretative plan includes reference to maintaining opportunities for visitors to observe and experience the historical atmosphere of the fort (NPS 2010).

Achieving conditions for viewsheds that closely match the time of the fort's operation is unrealistic though. For example, most of the visible area from the Bodmer Overlook is not within the park (Plate 3). Therefore, maintaining a point-in-time representation of the landscape as a whole is difficult.

4.10.4 Data and Methods

A viewshed layer was developed for this assessment using a mosaicked digital elevation model (DEM) comprised of 1/3-arc second USGS DEMs and a polyline shapefile (Plate 4). The polyline shapefile was created within and in close proximity to (<15 m) the boundaries of the Bodmer Overlook and includes 17 vertices that correspond to higher elevations, in order to provide a realistic representation of visible area (Plate 5). Each vertex in the polyline is used to calculate an individual viewshed and those viewsheds combined provide a composite viewshed for Bodmer Overlook (Plate 3); the composite viewshed represents the theoretically visible area, not taking into account visibility or the curvature of the earth.

Within the Bodmer Overlook viewshed layer, National Land Cover Dataset (NLCD) (Fry et al. 2011) data were used to provide insight regarding the land cover, development, and recent change within the viewshed of Bodmer Overlook facing south towards the Fort. Three NLCD products were used in this analysis:

- NLCD 2006 Land Cover - Describes general land cover classes developed using Landsat imagery.

- NLCD 2006 Change Pixels - Data describing pixels within the NLCD 2006 Land Cover dataset that changed since the development of the NLCD 2001 Land Cover dataset. Pixels defined within this dataset show the 2006 classification of the data.

- NLCD 2006 From-To Change Pixels - Describes the change from the 2001 to 2006 with 2001 classification and 2006 classification defined.

4.10.5 Current Condition and Trend

<u>Developed Areas within Viewshed</u>

Within the Bodmer Overlook viewshed, cultivated crops and grassland/herbaceous are the primary cover classes from 2006 NLCD land cover data: 46% and 21% of the viewshed, respectively (Table 19, Plate 6). In total, all NLCD developed area cover classes (developed, low intensity; developed, medium intensity; developed, high intensity) constitute less than 5% of the area within the viewshed. Forested areas comprise a low percentage of the viewshed (less than 10% of the total area). Overall, based on NLCD land cover data, the viewshed from Bodmer Overlook is agriculture-rich with interspersed wetland classes.

Table 19. NLCD land cover classes and area occupied within Bodmer Overlook viewshed, 2006.

	Area		
Class	**Acres**	**Hectares**	**Percent Area**
Cultivated Crops	25,994	10,519	46.0%
Grassland/Herbaceous	12,340	4,994	21.9%
Woody Wetlands	4,985	2,017	8.8%
Pasture/Hay	3,936	1,593	7.0%
Emergent Herbaceous Wetlands	2,149	869	3.8%
Open Water	1,981	801	3.5%
Developed, Open Space	1,807	731	3.2%
Shrub/Scrub	1,115	451	2.0%
Deciduous Forest	632	255	1.1%
Developed, Low Intensity	578	234	1.0%
Barren Land	475	192	0.8%
Mixed Forest	283	114	0.5%
Evergreen Forest	172	69	0.3%
Developed, Medium Intensity	11	5	0.0%
Developed, High Intensity	2	1	0.0%

In addition to 2006 NLCD land cover data, a change dataset (Fry et al. 2011) is available that describes the transition of land cover classes over time. Within the Bodmer Overlook viewshed, the woody wetlands NLCD class was the most converted-to class from 2001 to 2006, with 231 ha (571 ac) converted (Table 20). Cultivated crops was the next most prevalent converted-to class (100 ha [248 ac]). Emergent herbaceous and open water classes were the most converted-from NLCD classes from 2001 to 2006: 133.5 ha (330.0 ac) and 171.0 ha (422.7 ac), respectively. Most of the conversion of both the emergent herbaceous and open water classes was to woody wetlands: 101.5 ha (250.8 ac) and 59.5 ha (147.2 ac), respectively (Table 21). Interpretation of this conversion is not available.

Table 20. Area converted to various NLCD Land Cover classes within Bodmer Overlook's viewshed from 2001 to 2006.

	Area	
Class changed to	**Acres**	**Hectares**
Woody Wetlands	571	231
Cultivated Crops	248	100
Emergent Herbaceous Wetlands	87	35
Barren Land	86	35
Open Water	77	31
Herbaceous	46	19
Deciduous Forest	11	4
Evergreen Forest	9	3
Hay/Pasture	2	1

Table 21. Areas converted from various NLCD Land Cover classes, 2001 to 2006, within Bodmer Overlook's viewshed according to NLCD change product.

		Area	
2001 Class	**2006 Converted Class**	**Acres**	**Hectares**
Open Water			
	to Woody Wetlands	147.2	59.5
	to Barren Land	80.0	32.4
	to Cultivated Crops	36.4	14.7
	to Emergent Herbaceous Wetlands	32.6	13.2
	to Grassland/Herbaceous	10.8	4.4
	to Deciduous Forest	10.6	4.3
	to Evergreen Forest	10.2	4.1
	to Pasture/Hay	2.2	0.9
	Total	330.0	133.5
Barren Land			
	to Open Water	1.7	0.7
	to Emergent Herbaceous Wetlands	1.5	0.6
	to Woody Wetlands	1.3	0.5
	Total	4.5	1.8
Deciduous Forest			
	to Woody Wetlands	7.5	3.0
	to Emergent Herbaceous Wetlands	0.4	0.1
	to Cultivated Crops	0.2	0.0
	Total	8.1	3.1
Mixed Forest			
	to Emergent Herbaceous Wetlands	1.3	0.5
	to Woody Wetlands	1.1	0.4
	to Grassland/Herbaceous	0.2	0.0
	Total	2.6	1.0
Shrub/Scrub			
	to Cultivated Crops	2.4	0.9
	to Grassland/Herbaceous	2.2	0.9
	to Woody Wetlands	0.8	0.3
	to Emergent Herbaceous Wetlands	0.8	0.3
	Total	6.2	2.5

Table 21. Areas converted from various NLCD Land Cover classes, 2001 to 2006, within Bodmer Overlook's viewshed according to NLCD change product. (continued)

		Area	
2001 Class	**2006 Converted Class**	**Acres**	**Hectares**
Grassland/Herbaceous			
	to Cultivated Crops	110.0	44.5
	to Woody Wetlands	32.0	12.9
	to Emergent Herbaceous Wetlands	12.0	4.8
	to Open Water	2.0	0.8
	to Deciduous Forest	0.8	0.3
	Total	156.8	63.4
Pasture/Hay			
	to Woody Wetlands	23.5	9.5
	to Cultivated Crops	12.0	4.8
	to Emergent Herbaceous Wetlands	1.3	0.5
	Total	36.8	14.8
Cultivated Crops			
	to Woody Wetlands	113.4	45.9
	to Emergent Herbaceous Wetlands	29.8	12.0
	to Open Water	3.1	1.2
	to Grassland/Herbaceous	2.0	0.8
	Total	148.3	60.0
Woody Wetlands			
	to Cultivated Crops	18.6	7.5
	to Emergent Herbaceous Wetlands	5.3	2.1
	to Grassland/Herbaceous	3.3	1.3
	to Barren Land	2.2	0.9
	to Open Water	0.4	0.1
	Total	29.8	12.0
Emergent Herbaceous			
	to Woody Wetlands	250.8	101.5
	to Open Water	70.7	28.6
	to Cultivated Crops	70.0	28.3
	to Grassland/Herbaceous	27.5	11.1
	to Barren Land	3.7	1.5
	Total	422.7	171.0

Park staff identified three other visual resources of interest within the park: Fort Union Trading Post, Garden Coulee, and MonDak Township. These are smaller sites in comparison to the viewshed from Bodmer Overlook and do not lend themselves to GIS analysis of viewshed integrity because of the lack of small-scale data that are applicable at the scale of the viewshed. Rather, photopoint analysis could provide an index for change into the future; some historic photos may be available that would assist the development of a photopoint analysis protocol (Barnhart, pers. comm., 2012). At all of these sites within FOUS, park staff can manage the visual resources actively, whereas they cannot across the Bodmer Overlook viewshed.

Threats and Stressor Factors
Development is the primary threat to viewsheds at FOUS. Management has little influence over the development in surrounding areas, making maintenance of high-integrity viewsheds difficult. However, park management manages resources within the park to maintain a historic sense as dictated by the park's enabling legislation.

Data Needs/Gaps
FOUS staff identified many different parameters and aspects of FOUS's visual resources that could assist with a thorough viewshed analysis in the future. Future analyses of visual resources could include many different viewing frames, both from within and outside of the park. Some measures that could describe degradation from different views include the number of non-natural features, the number of non-historic features, percent land developed, and brightness of non-natural or non-historic features. In addition, photopoint analysis (either using terrestrial imagery or oblique, aerial imagery) could be valuable for analysis of smaller viewsheds, such as the view from the river looking at the fort. Finally, FOUS recently acquired another parcel of land and future analyses should utilize appropriate GIS data.

Overall Condition
While some data help explain the integrity of Bodmer Overlook viewshed with respect to development over time, a standard method for analyzing and assessing the condition of the visual resources in the park does not exist. Therefore, condition of this resource is currently unknown.

Viewshed

Measures	SL	CL
• Developed Areas within Viewshed	3	N/A

WCS = N/A

4.10.6 Sources of Expertise
Andy Banta, FOUS Superintendent
Audrey Barnhart, FOUS Museum Curator
Stephen K. Wilson, NGPN Data Manager

4.10.1 Literature Cited

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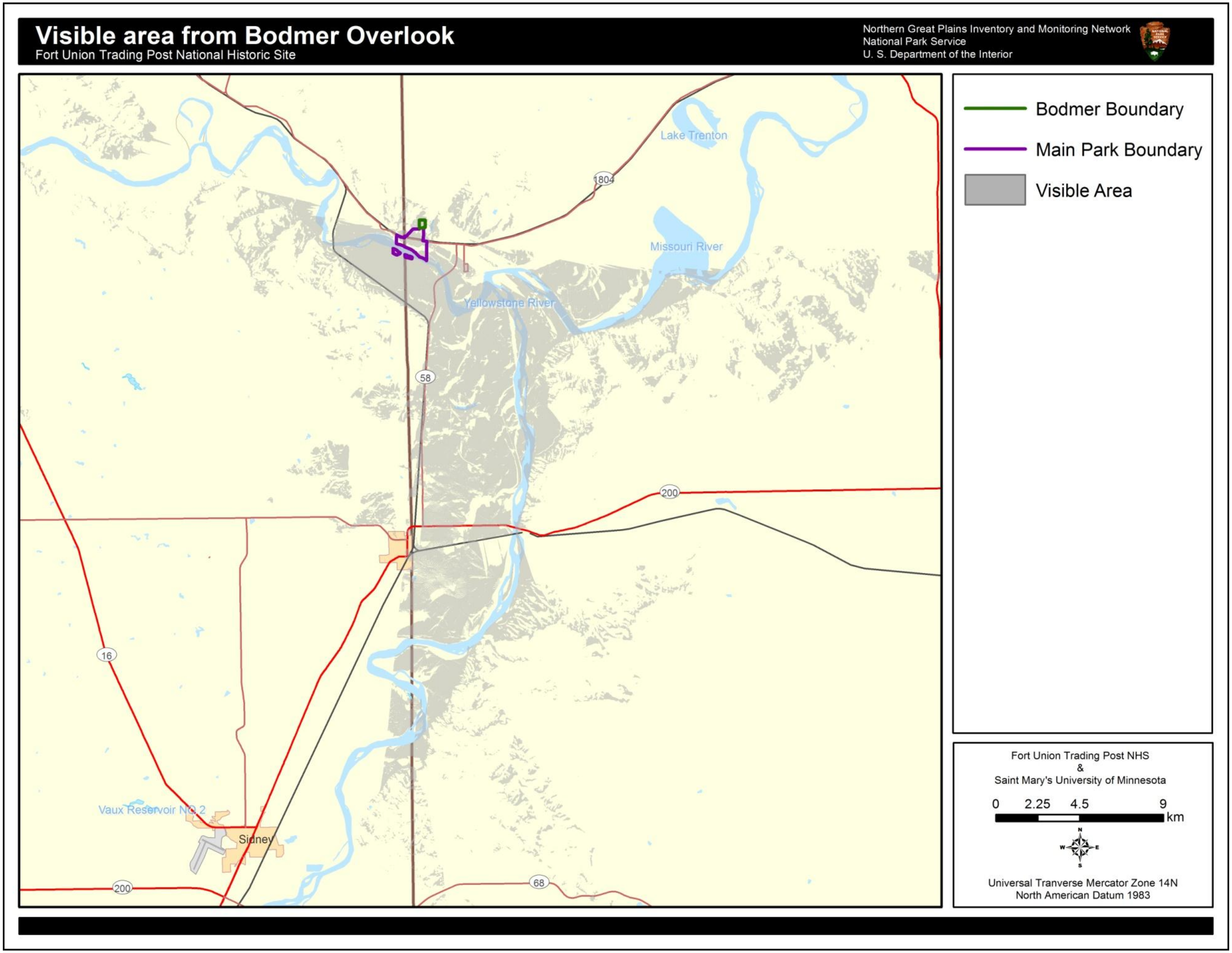

Plate 3. Visible area from Bodmer Overlook.

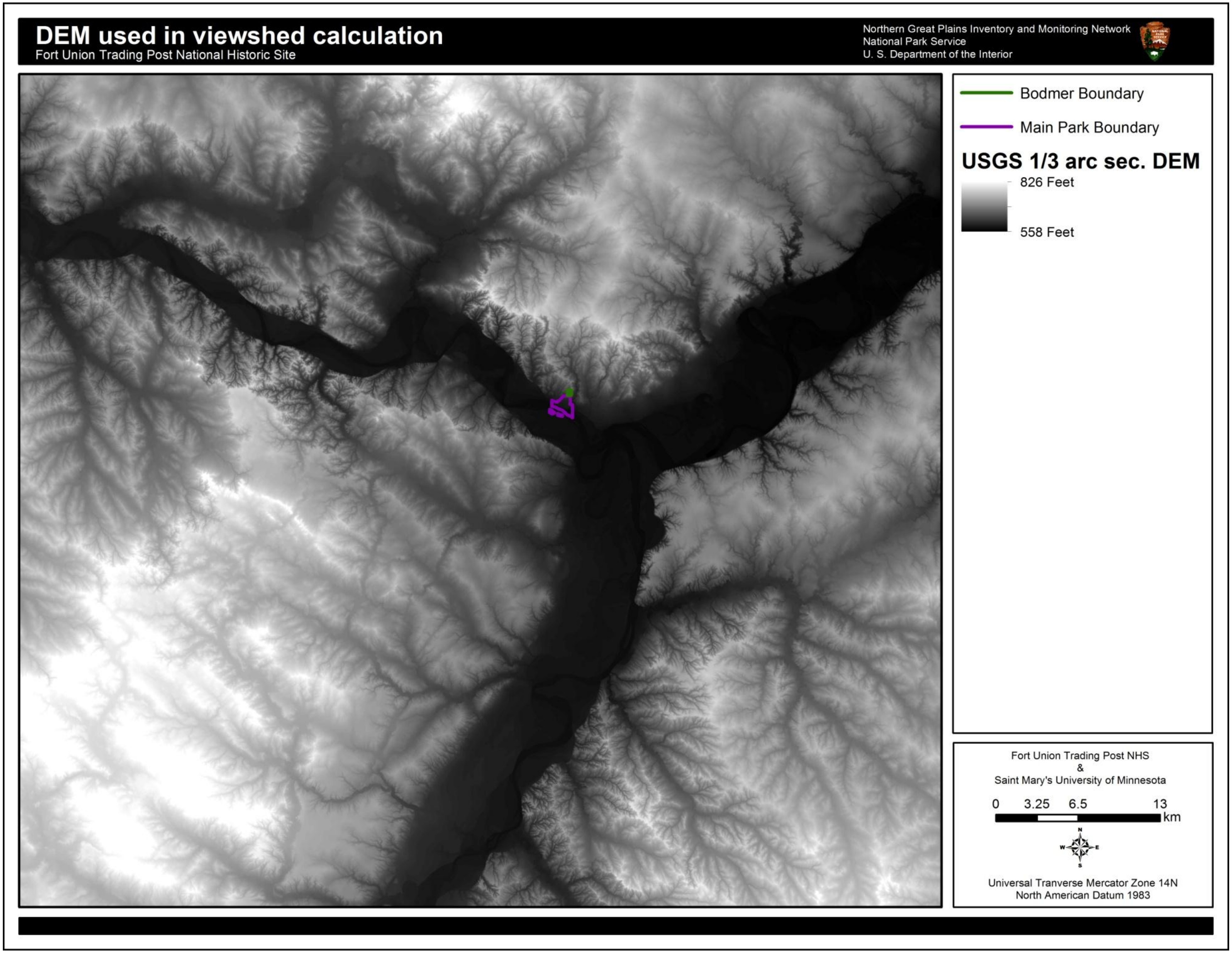

Plate 4. DEM used in the viewshed calculation.

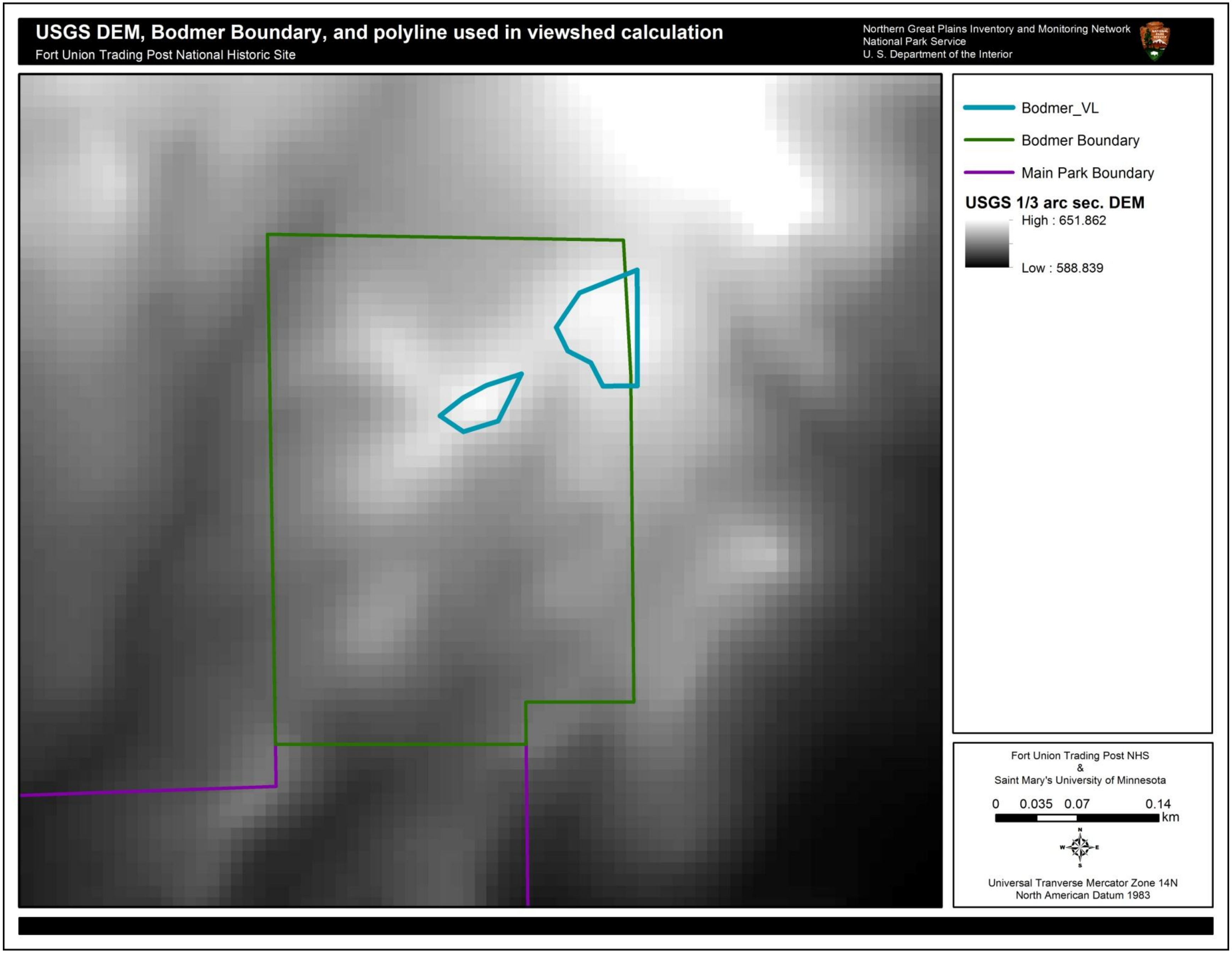

Plate 5. USGS DEM, Bodmer boundary, and polyline used in viewshed calculation.

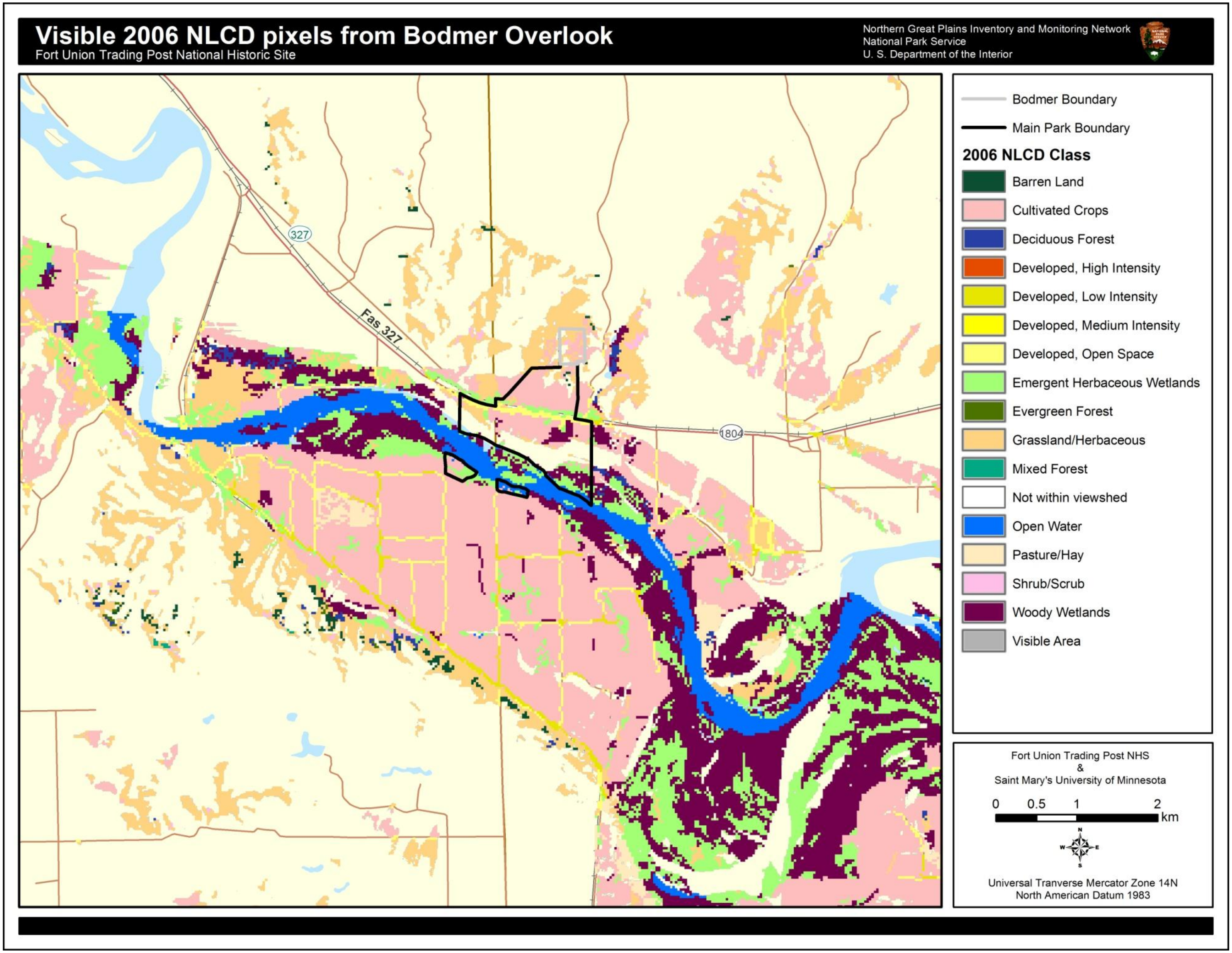

Plate 6. Visible 2006 NLCD pixels from Bodmer Overlook.

4.11 River and Stream Geomorphology

4.11.1 Description

The segment of the Missouri River passing through FOUS is a relatively straight reach, located approximately 6 km upstream of the confluence of the Yellowstone and Missouri Rivers. The river remains state property from within the banks of normal high water. The closure of the Fort Peck and Garrison Dams has had extensive effects on the Missouri River, changing natural sediment loads and altering natural hydrology (Ellis 2006). Recently, the southern bank of the segment near FOUS has experienced significant erosion and bank failures, largely due to the changes caused by dam construction (Ellis 2008). According to Ellis (2008), the eroding bank does not pose any immediate risks to FOUS infrastructure, people, or property, but it is approaching an irrigation ditch (approximately 39 m from the ditch in the spring of 2007). This bank is moving approximately 6 m annually, suggesting the eroding bank could reach the irrigation ditch by 2014, assuming all patterns stay the same. The significant and long duration of high water in 2011 accelerated the erosion significantly. As much as 15.24 meters (50 feet) was lost at several points along the bank. It would appear that the main river channel has moved further to the south, which will continue to impact the southern bank.

4.11.2 Measures

- Flooding events
- Discharge patterns
- Erosion rates

4.11.3 Reference Conditions/Values

The reference condition for Missouri River geomorphology is pre-dam conditions. The morphology of a river channel is largely dependent on how flow and bank material interact with each other (Ellis 2006). Impoundment affects both of these factors, and will likely change the morphology of the river channel.

Prior to dam construction, the Missouri River was “typical of large rivers in a cold, semi-arid climate” (Ellis 2006, p. 16). Natural sediment load was high and discharge was extremely variable, resulting in a sinuous channel (Ellis 2006). Planform change was rapid, as sediment was eroded from beds, bars, and banks, and re-deposited into new areas once the floods retreated (Ellis 2006). The constant re-depositing of sediment resulted in meander migration, as well as a constant bar pattern change; spring flows from ice melt, precipitation, and ice jams caused much of the morphological change of the Missouri River (Ellis 2006). Ellis (2006) noted that bank erosion, specifically, increased dramatically when discharge exceeded 18,000 cfs, which typically occurred around 12% of the time. The segment of river near FOUS has experienced significant changes since the closure of the Fort Peck and Garrison Dams. Ellis (2006) suggested that the Fort Peck Dam decreased the sediment load of the Missouri River near FOUS, which has increased the stream power and caused the flows to be much more erosive. The closure of the Fort Peck Dam also caused many changes in the hydrology of the Missouri River, disrupting the magnitude and frequency of peak flows (Ellis 2006). Ellis (2006) noted that these hydrological changes have caused meander wavelength to decrease and, subsequently, the location of erosion near FOUS has changed.

4.11.4 Data and Methods
Ellis (2006, 2008) was the main sources of information for this assessment. Ellis (2006, 2008) conducted geomorphological assessments of bank erosion along the Missouri River at FOUS, North Dakota.

Several investigations analyzing Missouri River bank erosion within FOUS have taken place (Inglis 1999, Cummings 2011). NPS/MWR hydrologists and archeologists visited FOUS in July 2010 in order to "assess the condition implications of bank erosion on the Missouri River at FOUS and provide recommendations for potential treatment" (Cummings 2011, p.1).

4.11.5 Current Condition and Trend

<u>Flooding Events</u>

The closure of the Fort Peck Dam has regulated high flow events, nearly eliminating all large floods, lowering the magnitude of peak flows, and disrupting the seasonality of flood flows (Ellis 2006). Ellis (2006) stated that, historically, flood flows occurred between April and June, as a result of ice thaw, ice jams, and increased precipitation; however, since the closure of Fort Peck Dam, winter discharge has increased and flood flows occur between February and March. This increase in discharge during the winter months further compounds the problems of river ice, causing more high flows, resulting in heavily saturated and weak river banks (Ellis 2006).

The confluence of the Missouri and Yellowstone Rivers is approximately 6 km downstream of FOUS. Though impoundment has eliminated nearly all large floods in the Missouri River, the Yellowstone River still experiences large floods, as it is the largest unregulated river in the United States (Ellis 2006). Ellis (2006) suggested that these floods likely back up the Missouri River in the spring, and could impact the morphology of the Missouri River near FOUS.

<u>Discharge Patterns</u>

The Missouri River has experienced significant changes in discharge (both daily and peak discharge) since dam closure. For average daily trends, Ellis (2006) indicated that there is a significant reduction in variability of flow and an increase in the overall average daily discharge. Prior to dam closure, the average daily discharge of the Missouri River near Wolf Point, Montana (downstream of Fort Peck Dam and approximately 120 km east of FOUS) was approximately 6,660 cfs; after dam closure, average daily discharge increased to approximately 9,700 cfs (Ellis 2006). For comparison, the unregulated Yellowstone River showed consistent daily discharge averages for the same periods (Ellis 2006).

Dam closure not only affected daily discharge averages, but average annual peak discharge and average annual flow as well. Prior to the closure of Fort Peck Dam, average annual peak discharge was 26,860 cfs; after dam closure, average annual peak discharge dropped to 18,110 cfs, although average annual flow increased (Ellis 2006). In juxtaposition with the Missouri River trends, the Yellowstone River saw an average decrease in average annual flow, further demonstrating the effects of impoundment on discharge patterns (Ellis 2006). During June of 2011 both the Missouri and the Yellowstone River reached abnormally high flows that caused the parking lot at FOUS to flood. The Missouri River reached 104,000 cfs on 16 June 2011 and the Yellowstone reached 124,000 cfs on 24 May 2011.

Erosion Rates

The stability of a river bank depends on the strength of the bank and the amount of stress acting upon the bank (Ellis 2005). Ellis (2005) also noted that bank failure occurs when the base of the bank is eroded to the point that it surpasses its critical value, and gravity exceeds the strength of the bank material. Other factors that impact bank stability include bank material makeup, degree of bank material saturation, the presence of failed material, the presence of vegetation, and the presence of tension cracks (Ellis 2006). Ellis (2006) points out that the most important factors for bank failure in the Missouri River near FOUS appear to be degree of bank material saturation and gouging from river ice, not discharge magnitude. The impacts of high flows in the winter are extensive because river ice can gouge out higher layers of the bank. In addition, more over bank flows are likely to occur. When overbank flows occur with river ice present, the banks become very saturated once the ice melts. This results in a weaker bank that is more susceptible to bank failure once drawdown occurs.

The conclusion by Ellis (2006) that bank erosion near FOUS is not dependent on discharge magnitude but rather bank saturation and river ice is also supported by a NPS bank erosion study that started in 2000. Inglis (1999) noted that approximately 10% of the FOUS parcel was lost to erosion in the two years prior to a 1999 investigation. The study by Ellis (2006) found over 18 meters of bank failure and erosion between 2001 and 2006. In addition, a correlation between erosion and discharge magnitude was apparent at some stakes, but not all of them (Ellis 2006). This inconsistency in correlation implied that there were factors other than discharge magnitude that resulted in extensive bank erosion.

The southern bank of the Missouri River near FOUS is experiencing the bulk of erosion; the 18 m of erosion that was found in the NPS study was located on the southern bank (Ellis 2006). Erosion is more extensive on the southern bank because the thalweg (deepest channel) near FOUS has moved from the north bank to the south bank, due to mid-stream bars that have been deposited near the north bank (Ellis 2006, Cummings 2011). Vegetation has stabilized these bars, resulting in the main channel pushing towards the southern bank. This erosion has rapidly increased in the last decade, due to the formation of a new island near the south bank, further pushing the thalweg towards the southern bank (Ellis 2006). When NPS revisited the southern bank in July 2005, there were many recent failure blocks, suggesting a planar slip (slipping of a failure block downwards along a straight line) as the main mechanism of failure (Ellis 2006, Cummings 2011). Ellis (2006) noted that planar slips were a likely explanation due to an extended rainfall that occurred in June 2005. In the fall of 2005, NPS observed a new bar that was forming between the southern bank and the newer island. The forming of a new bar beyond the island exemplifies the southerly evolution of the channel (Ellis 2006).

FOUS has been actively monitoring and documenting changes in erosion, and using implementation of groundwater wells and cottonwood tree plantings to stem the erosion process (Cummings 2011). Several recommendations regarding bank stabilization and erosion management have been made (Inglis 1999, Patterson 2010, Cummings 2011), including: planting of native deep-rooted vegetation and de-watering of banks using tile drains or wells.

Threats and Stressor Factors

The closure of the Fort Peck Dam has had extensive effects on the FOUS reach of the Missouri River. Ellis (2006) suggested that this impoundment altered the natural hydrograph of the

Missouri River, disrupted natural sediment loads, and changed the timing of high flow events. These changes have led to bank erosion and failure on the southern bank near FOUS, but are currently not affecting the park's cultural resources (Ellis 2006, Ellis 2008). However, Ellis (2008) noted that if current bank erosion rates continue, an irrigation ditch in FOUS could fail as early as 2014. According to Cummings (2011), the irrigation district, as well as NPS-owned land could be threatened due to erosion along the banks. However, Cummings (2011, p. 1) also suggested that "observed erosion and channel migration is predominantly a natural process consistent with meandering river evolution."

Data Needs/Gaps

Ellis (2008) predicted that some of the factors controlling the rate and location of erosion would most likely change by 2014, but suggested that rates should be monitored to avoid any damage to park property. Continued groundwater and erosion monitoring would provide for annual data analysis. No updated GIS analysis of erosion in FOUS has taken place (Cummings 2011). The use of GIS technologies to spatially display edges of river cutbanks and analyze historical imagery over time would help in the development of a "standardized monitoring strategy" helping display river changes, erosion degradation, and archeological area impacts (Cummings 2011, p. 6).

Overall Condition

Flooding Events

The project team defined the *Significance Level* for flooding events as a 3. The timing of peak flows have moved from spring to winter, which can have considerable effects on geomorphology because of the presence of river ice in the winter months. Because of this shift in timing, the project team defined *Condition Level* for flooding events as a 2 (moderate concern).

Discharge Patterns

The project team defined the *Significance Level* for discharge patterns as a 3. Daily and peak discharge have changed since flow regulation, and subsequently, the project team defined the *Condition Level* as a 2 (moderate concern).

Erosion Rates

The project team defined the *Significance Level* for erosion rates as a 3. Cummings (2011) indicated that channel migration due to observed erosion was a natural process, prominent in the evolution of meandering rivers. However, due to changes in sediment levels and stream power, considerable amounts of erosion have shifted to the southern bank near FOUS (Ellis 2006). Because of these changes, the *Condition Level* for erosion rates is 2 (moderate concern).

Weighted Condition Score
The overall *Weighted Condition Score* for the geomorphology of the Missouri River in FOUS is 0.667, meaning it is of moderate concern. Though no park infrastructure is at immediate risk of damage, the FOUS reach of the Missouri River has endured significant changes since the closure of the Fort Peck Dam. These changes not only pose a risk for property damage, but they also have many ecological implications as they alter natural habitats for both terrestrial and aquatic species.

River and Stream Geomorphology

Measures	SL	CL
• Flooding Events	3	2
• Discharge Patterns	3	2
• Erosion Rates	3	2

WCS = 0.667

4.11.6 Sources of Expertise
Jalyn Cummings, IMR/MWR Hydrologist

4.11.7 Literature Cited

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Chapter 5

5.1 Component Data Gaps

The identification of key data and information gaps is an important objective of the NRCA process. Data gaps or needs are those pieces of information that are currently unavailable, but would help to inform the status of the overall condition of a key resource component. Data gaps/needs exist for all key resource components assessed in this NRCA, and are summarized in Table 22.

Table 22. Data gaps/needs for components analyzed for the FOUS NRCA.

Component	Data Gaps/Needs
Riparian Forest Community	-Thorough, quantitative survey of riparian forest composition in the park.
Natural Prairie Community	-5 years of monitoring under the new vegetation monitoring protocol to enhance understanding of condition. -Examination into alternative methods for defining condition using available data collected according to vegetation monitoring protocol.
Reconstructed Prairie Community	-5 years of monitoring under the new vegetation monitoring protocol to enhance understanding of condition.
Birds	-Long-term trend data, such as annual bird surveys specific to the park, possibly utilizing a line-transect method (Panjabi 2005).
Small Mammals	-Long-term mammal monitoring.
Herptiles	-Surveys to determine trends in relative abundance.
Air Quality	-Identification and monitoring of species sensitive to pollutants. -Monitoring of atmospheric deposition in the park (sulfur, nitrogen, and mercury).
Water Quality	-Updated water quality data for the park; data are nearly 10 years old. -Macroinvertebrate surveys to determine presence and composition.
Soundscape	-Baseline data to determine ambient sound levels within the park.
Viewshed	-Examination of potential methods for future viewshed analyses and monitoring.
River and Stream Geomorphology	-Continued groundwater and erosion monitoring. -GIS analysis of erosion impacts using available imagery and collected field data, similar to Sexton's analysis at KNRI.

5.2 Component Condition Designations

The condition of seven of the resources examined in this assessment is currently unknown (Table 23); as identified in the data gaps highlighted in Table 22 (Figure 11 provides definitions of condition graphics), many components lack baseline data for evaluating condition.

Condition for the ecological community resources will continue to become clearer with continued monitoring by NGPN according to the new monitoring protocol. Currently, condition is determined for the Natural Prairie Community and Reconstructed Prairie Community, but not the Riparian Forest Community. Trend is unknown for all ecological community components because of the lack of long-term monitoring data at this time.

The condition of all other biological components (i.e., birds, small mammals, and herptiles) is unknown. Data exists for these components, but mostly in the form of anecdotal knowledge possessed by park staff. While personal knowledge is valuable and, therefore, documented in this report, it rarely provides enough information to make an authoritative determination of condition.

The condition of all environmental quality components is unknown, except for the air quality component, which is of moderate concern. Water quality data are minimal for the park and when available, are dated. Baseline data and reference conditions to compare against current data are lacking for the Soundscape and Viewshed components.

The condition of the one physical characteristic component, river and stream geomorphology, was of significant concern. Continued erosion was the primary reason for this condition and available evidence suggests that erosion will continue to be a problem. NPS will continue to monitor erosion, because of the threat to park lands and resources.

Table 23. Summary of current condition and condition trend for featured NRCA components.

Component	WCS	Condition
Biological Composition		
Ecological Communities		
Riparian Forest Community	N/A	
Natural Prairie Community	0.433	
Reconstructed Prairie Community	0.538	
Birds		
Birds	N/A	
Mammals		
Small Mammals	N/A	
Herptiles		
Herptiles	N/A	
Environmental Quality		
Air Quality	0.500	
Water Quality	N/A	
Soundscape	N/A	
Viewshed	N/A	
Physical Characteristics		
Geologic and Hydrologic		
River and Stream Geomorphology	.667	

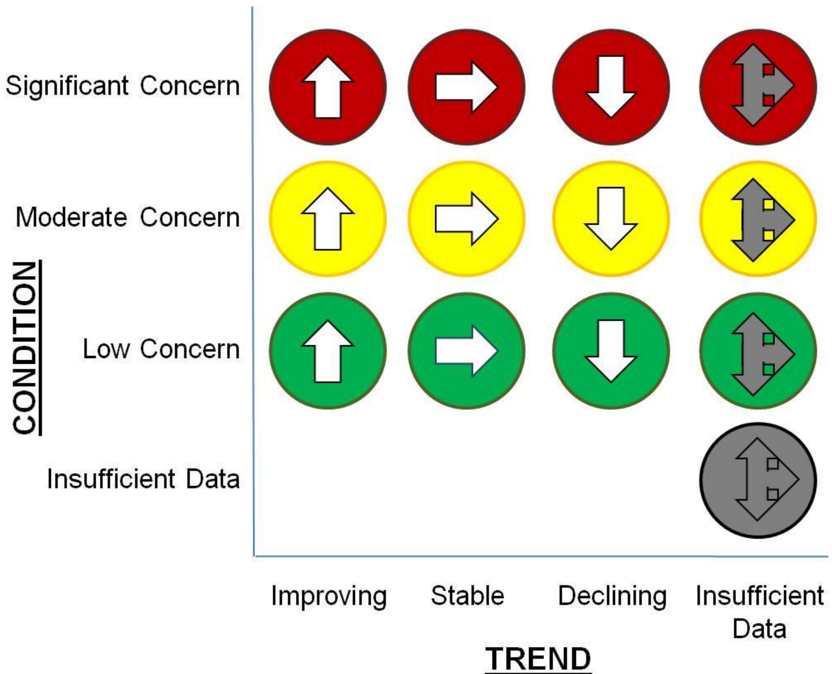

Figure 11. Symbols used for individual component assessments with condition or concern designations along the vertical axis and trend designations along the horizontal.

5.3 Park-wide condition observations

Data and information available for most components assessed in this NRCA are minimal and, with the exception of the plant community components, formal data collection regarding the measures for identified components does not occur. In the future, the data gaps identified in the component sections and in Table 22 need to be resolved in order to define condition. As displayed in Table 22, many of the data gaps focus on baseline data acquisition and development of protocols to monitor resources in the future.

In addition, the obscure reference conditions for many of the resources analyzed make assessing condition difficult. A common reference condition for analyzed components is the active period of the Trading Post, because the park's enabling legislation directs management to preserve the visual and historical characteristics of the Trading Post at its time of operation. However, this reference condition is difficult to translate into quantitative metrics that can be compared to modern data and literature; modification of reference condition for future assessments or agreement on what the active period of the Trading Post likely entailed for certain resources would benefit future efforts similar to the NRCA.

Threats and stressors to park resources identified during this assessment are typically anthropogenic, and often relate directly to development associated with energy production. The recent onset of new natural gas and oil production is a cause of concern for many of the resources in the park, especially components relating to environmental quality. In addition, flow regulation and dam operations on the Missouri River are factors that influence multiple components in the park. Unfortunately, park management possesses minimal control or influence over most of the threats and stressor factors.

In conclusion, multiple factors contribute to the limited ability to determine the condition of natural resources at FOUS. Primarily, the park's purpose focuses on providing a historical experience through exposure to the fort and historic artifacts, rather than the natural resources at the park. In addition, the small size of the park factors into the designations of significant and moderate concern for components that are defined, because many of the landscape-level effects on resources are not and cannot be managed for effectively at FOUS's scale.

Appendices

Appendix A. Native plant species identified in reconstructed prairie plots and fields in 2010 (Symstad 2012).

Scientific Name	Common Name	VMP-004	VMP-008	VMP-011	VMP-012	VMP-013	VMP-119	VMP-015	VMP-024
Achillea millefolium	common yarrow		X	X			X		X
Agastache foeniculum	lavender hyssop						X		
Amaranthus blitoides	prostrate pigweed	X	X			X	X	X	X
Amaranthus retroflexus	rough pigweed	X				X	X	X	
Andropogon gerardii	big bluestem					X		X	
Artemisia cana	dwarf sagebrush			X			X		
Artemisia frigida	fringed sage, prairie sagewort			X					
Asclepias verticillata	whorled milkweed						X		
Atriplex nuttallii	moundscale						X		
Bouteloua curtipendula	side-oats grama	X	X	X	X	X	X	X	X
Bouteloua gracilis	blue grama	X	X	X	X	X	X	X	
Bouteloua hirsuta	hairy grama		X						
Carex spp.	sedge species			X					
Chamaesyce glyptosperma	ridgeseed spurge			X					
Chamaesyce spp.	spurge species	X	X	X	X	X	X	X	X
Conyza canadensis	horseweed			X	X		X	X	
Dalea candida	white prairie clover				X				
Dalea purpurea	purple prairie clover	X	X	X	X	X	X	X	X
Echinacea angustifolia	purple coneflower		X	X	X		X	X	
Ellisia nyctelea	waterpod								X
Elymus canadensis	Canada wildrye					X			
Fraxinus pennsylvanica	green ash			X		X	X		
Gaillardia aristata	blanket flower, Mexican hat							X	
Grindelia squarrosa	curly-cup gumweed			X					
Hedeoma hispida	rough false pennyroyal			X					
Helianthus annuus	common sunflower							X	

Appendix A. Native plant species identified in reconstructed prairie plots and fields in 2010 (Symstad 2012). (continued)

Scientific Name	Common Name	VMP-004	VMP-008	VMP-011	VMP-012	VMP-013	VMP-119	VMP-015	VMP-024
Helianthus maximilianii	Maximilian sunflower	X		X		X	X	X	
Koeleria macrantha	prairie junegrass			X		X	X		
Linum lewisii	blue flax	X		X	X			X	X
Nassella viridula	green needlegrass	X	X	X	X	X	X	X	X
Panicum capillare	common witchgrass	X			X	X	X	X	
Panicum virgatum	switchgrass			X		X	X	X	
Pascopyrum smithii	western wheatgrass	X	X	X	X	X	X	X	X
Penstemon grandiflorus	large beardtongue	X	X	X	X		X		X
Potentilla pensylvanica	Pennsylvania cinquefoil			X					
Ratibida columnifera	prairie coneflower	X		X			X	X	
Rudbeckia hirta	blackeyed Susan						X		
Schizachyrium scoparium	little bluestem	X				X	X	X	
Solanum rostratum	buffalo bur							X	
Sorghastrum nutans	Indiangrass					X			
Sphaeralcea coccinea	scarlet globemallow		X	X	X				
Sporobolus cryptandrus	sand dropseed			X				X	
Symphoricarpos occidentalis	western snowberry, buckbrush			X					
Verbena bracteata	prostrate vervain					X	X		
Verbena stricta	hoary vervain	X	X				X	X	
Vicia americana	American vetch	X	X	X			X	X	X

Appendix B. Exotic plant species identified in eight plots in reconstructed prairie in 2010 (Symstad 2012).

Scientific Name	Common Name	VMP-004	VMP-008	VMP-011	VMP-012	VMP-013	VMP-119	VMP-015	VMP-024
Agropyron cristatum	crested wheatgrass	X		X	X		X	X	X
Alyssum alyssoides	pale alyssum			X					
Bromus arvensis	Japanese brome, field brome	X		X					X
Bromus inermis	smooth brome	X		X		X	X	X	X
Bromus tectorum	downy brome								X
Camelina macrocarpa	small-seeded false flax		X	X			X		
Camelina microcarpa	small-seeded flax								X
Cirsium arvense	Canada thistle	X		X		X		X	
Convolvulus arvensis	field bindweed	X					X		X
Coronilla varia	crown vetch		X						
Descurainia sophia	flixweed	X	X	X	X		X	X	X
Elymus repens	quackgrass					X			
Euphorbia esula	leafy spurge					X			
Kochia scoparia	kochia	X	X		X	X	X	X	X
Lactuca serriola	prickly lettuce	X		X	X	X	X	X	X
Malva neglecta	common mallow							X	
Medicago lupulina	black medick		X						X
Medicago sativa	alfalfa		X	X	X	X		X	
Melilotus officinalis	sweetclover	X	X	X	X		X	X	X
Phalaris arundinacea	reed canary grass					X			
Poa pratensis	Kentucky bluegrass			X		X	X	X	
Polygonum convolvulus	wild buckwheat			X			X	X	
Salsola spp.	Russian thistle species	X	X	X	X	X	X	X	X
Setaria viridis	green foxtail	X				X	X	X	
Sisymbrium loeselli	tall hedge mustard			X					X
Taraxacum officinale	common dandelion	X	X	X	X	X	X	X	X

Appendix B. Exotic plant species identified in five reconstructed prairie plots in 2010 (Symstad 2012). (continued)

Scientific Name	Common Name	VMP-004	VMP-008	VMP-011	VMP-012	VMP-013	VMP-119	VMP-015	VMP-024
Thlaspi arvense	field pennycress	X		X		X	X		X
Tragopogon dubius	goat's beard, salsify	X	X	X	X		X	X	X

Appendix C. Species of birds in FOUS. Lists used include the NPS Certified Species List (present and probably present) and the RMBO Surveys (2002-2004) (Panjabi 2005).

Common Name	Scientific Name	NPS (2012): Species Present or Probably Present	RMBO Confirmed
wood duck	*Aix sponsa*	X	X
northern pintail	*Anas acuta*	X	
American wigeon	*Anas americana*	X	
northern shoveler	*Anas clypeata*	X	X
green-winged teal	*Anas crecca*	X	
blue-winged teal	*Anas discors*	X	X
mallard	*Anas platyrhynchos*	X	X
gadwall	*Anas strepera*	X	X
Canada goose	*Branta canadensis*	X	X
common goldeneye	*Bucephala clangula*	X	
common merganser	*Mergus merganser*	X	
Cooper's hawk	*Accipiter cooperii*	X	
sharp-shinned hawk	*Accipiter striatus*	X	
red-tailed hawk	*Buteo jamaicensis*	X	X
northern harrier	*Circus cyaneus*	X	X
bald eagle	*Haliaeetus leucocephalus*	X	
great blue heron	*Ardea herodias*	X	X
killdeer	*Charadrius vociferus*	X	X
turkey vulture	*Cathartes aura*	X	X
prairie falcon	*Falco mexicanus*	X	X
American kestrel	*Falco sparverius*	X	X
California gull	*Larus californicus*	X	X
ring-billed gull	*Larus delawarensis*	X	X
Franklin's gull	*Leucophaeus pipixcan*	X	X
least tern	*Sternula antillarum*	X	X
Caspian tern	*Hydroprogne caspia*	X	X
Forster's tern	*Sterna forsteri*	X	X
common tern	*Sterna hirundo*	X	X
American white pelican	*Pelecanus erythrorhynchos*	X	X
double-crested cormorant	*Phalacrocorax auritus*	X	X
western grebe	*Aechmophorus occidentalis*	X	X
spotted sandpiper	*Actitis macularius*	X	X
Wilson's snipe	*Gallinago delicata*	X	
marbled godwit	*Limosa fedoa*	X	X
Wilson's phalarope	*Phalaropus tricolor*	X	X
rock pigeon	*Columba livia*	X	X
mourning dove	*Zenaida macroura*	X	X

Appendix C. Species of birds that have been detected in FOUS. Lists used include the NPS Certified Species List and the RMBO Surveys (2002-2004) (Panjabi 2005). (continued)

Common Name	Scientific Name	NPS (2012): Species Present or Probably Present	RMBO Confirmed
belted kingfisher	*Megaceryle alcyon*	X	X
wild turkey	*Meleagris gallopavo*	X	X
ring-necked pheasant	*Phasianus colchicus*	X	X
sora	*Porzana carolina*	X	X
horned lark	*Eremophila alpestris*	X	
cedar waxwing	*Bombycilla cedrorum*	X	X
lazuli bunting	*Passerina amoena*	X	X
indigo bunting	*Passerina cyanea*	X	X
rose-breasted grosbeak	*Pheucticus ludovicianus*	X	
black-headed grosbeak	*Pheucticus melanocephalus*	X	X
American crow	*Corvus brachyrhynchos*	X	X
blue jay	*Cyanocitta cristata*	X	X
black-billed magpie	*Pica hudsonia*	X	X
lark sparrow	*Chondestes grammacus*	X	X
song sparrow	*Melospiza melodia*	X	X
spotted towhee	*Pipilo maculatus*	X	X
vesper sparrow	*Pooecetes gramineus*	X	X
clay-colored sparrow	*Spizella pallida*	X	X
chipping sparrow	*Spizella passerina*	X	X
field sparrow	*Spizella pusilla*	X	X
white-crowned sparrow	*Zonotrichia leucophrys*	X	
American goldfinch	*Carduelis tristis*	X	X
barn swallow	*Hirundo rustica*	X	X
cliff swallow	*Petrochelidon pyrrhonota*	X	X
bank swallow	*Riparia riparia*	X	X
northern rough-winged swallow	*Stelgidopteryx serripennis*	X	X
tree swallow	*Tachycineta bicolor*	X	X
red-winged blackbird	*Agelaius phoeniceus*	X	X
bobolink	*Dolichonyx oryzivorus*	X	X
Brewer's blackbird	*Euphagus cyanocephalus*	X	X
Bullock's oriole	*Icterus bullockii*	X	X
Baltimore oriole	*Icterus galbula*	X	X
orchard oriole	*Icterus spurius*	X	X
brown-headed cowbird	*Molothrus ater*	X	X
common grackle	*Quiscalus quiscula*	X	X
western meadowlark	*Sturnella neglecta*	X	X
yellow-headed blackbird	*Xanthocephalus xanthocephalus*	X	X

Appendix C. Species of birds that have been detected in FOUS. Lists used include the NPS Certified Species List and the RMBO Surveys (2002-2004) (Panjabi 2005). (continued)

Common Name	Scientific Name	NPS (2012): Species Present or Probably Present	RMBO Confirmed
loggerhead shrike	*Lanius ludovicianus*	X	
gray catbird	*Dumetella carolinensis*	X	X
brown thrasher	*Toxostoma rufum*	X	X
black-capped chickadee	*Poecile atricapillus*	X	X
yellow warbler	*Dendroica petechia*	X	X
common yellowthroat	*Geothlypis trichas*	X	X
yellow-breasted chat	*Icteria virens*	X	X
black-and-white warbler	*Mniotilta varia*	X	X
ovenbird	*Seiurus aurocapilla*	X	X
northern waterthrush	*Seiurus noveboracensis*	X	X
American redstart	*Setophaga ruticilla*	X	X
white-breasted nuthatch	*Sitta carolinensis*	X	X
European starling	*Sturnus vulgaris*	X	X
house wren	*Troglodytes aedon*	X	X
veery	*Catharus fuscescens*	X	X
American robin	*Turdus migratorius*	X	X
western wood-pewee	*Contopus sordidulus*	X	X
least flycatcher	*Empidonax minimus*	X	X
eastern kingbird	*Tyrannus tyrannus*	X	X
western kingbird	*Tyrannus verticalis*	X	X
warbling vireo	*Vireo gilvus*	X	X
red-eyed vireo	*Vireo olivaceus*	X	X
northern flicker	*Colaptes auratus*	X	X
red-headed woodpecker	*Melanerpes erythrocephalus*	X	X
downy woodpecker	*Picoides pubescens*	X	X
hairy woodpecker	*Picoides villosus*	X	X
common nighthawk	*Chordeiles minor*	X	X
great horned owl	*Bubo virginianus*	X	X
eastern screech-owl	*Megascops asio*	X	X

NPS 436/123908, February 2014

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