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Natural Resource Stewardship and Science

Fort Larned National Historic Site

Natural Resource Condition Assessment

Natural Resource Report NPS/SOPN/NRR—2014/866

ON THE COVER

Wagon at Fort Larned NHS. Photo: Kim Struthers

Fort Larned National Historic Site

Natural Resource Condition Assessment

Natural Resource Report NPS/SOPN/NRR—2014/866

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Executive Summary

The Natural Resource Condition Assessment (NRCA) Program, administered by National Park Service's (NPS) Water Resources Division, aims to provide documentation about current conditions of important park natural resources through a spatially explicit, multi-disciplinary synthesis of existing scientific data and knowledge. The assessment for Fort Larned National Historic Site began in 2013, and 12 focal study natural resources were chosen for the Historic Site's NRCA. These resources were organized into three categories that ranged in contexts from broader to narrower including landscape-scale, supporting environment (i.e., physical resources), and biological integrity, which included wildlife and vegetation topics.

Fort Larned NHS was established in 1964 ([Public Law 85-541]). The Historic Site was set aside to commemorate the historic role this fort played in the opening of the West; to preserve, protect, interpret, and administer the resources at the Historic Site; to preserve areas of archeological and ethnological interest; and to protect scenic, scientific, natural, and historic values (NPS [Fort Larned NHS General Management Plan] 1994).

The landscape scale resources chosen for this assessment included viewshed, night sky, and soundscape. Overall, these resources are in moderate condition. The area surrounding the Historic Site is agricultural land and is moderately developed, contributing to issues impacting these resources, including road and housing developments.

The Historic Site's supporting physical environment resource topics included air quality, geology, groundwater, surface water quality, and groundwater. The condition for each of these resources ranged from moderate to significant concern, and unknown for the surface water quality resource since the Pawnee River was dry in 2013.

The resource topics related to vegetation included grasslands, riparian habitat, and exotic plants. All three resources are considered to be of significant concern.

Finally, the wildlife resource topics included breeding landbirds and prairie dogs. Condition for landbirds is good, however, the condition of the prairie dog population located in the Historic Site's [Santa Fe] Ruts Unit is of moderate concern.

Acknowledgements

We wish to thank Jeff Albright, program lead of the Natural Resource Condition Assessment Program, Water Resources Program Center, National Park Service, who provided programmatic insight and guidance on project development and review. The authors are grateful to the staff at the National Park Service Natural Resource Stewardship and Science Directorate for their technical expertise, guidance, and reviews of their respective subjects, with a special thanks to Michael Martin, NPS Water Resources Division Hydrologist, for researching and writing the groundwater section. We are extremely grateful to all subject matter experts who provided valuable information pertaining to their respective areas of research and expertise. Their input helped to create a relevant, scientifically based document that provided new insights into the communities and processes found and occurring throughout the Historic Site. Finally, we would like to express our gratitude and thanks to Fort Larned NHS staff, whose input and reviews were very informative and helpful. To all those remaining who reviewed and commented on this report, thank you. Your contributions have increased its professional value.

NINA CHAMBERS

Chapter 1: NRCA Background Information

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

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

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

NRCAs Strive to Provide…

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

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

Important NRCA Success Factors

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

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

Due to their modest funding, relatively quick timeframe for completion, and reliance on existing data and information, NRCAs are not intended to be exhaustive. Their methodology typically involves an informal synthesis of scientific data and information from multiple and diverse sources. Level of rigor and statistical repeatability will vary by resource or indicator, reflecting differences in existing data and knowledge bases across the varied study components.

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

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

recommend data sets, methods, and reference conditions and values; and help provide a multi-disciplinary review of draft study findings and products.

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

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

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)

NRCAs also provide a useful complement to rigorous NPS science support programs, such as the NPS Natural Resources Inventory & Monitoring (I&M) Program.[8] For example, NRCAs can provide current condition estimates and help establish reference

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

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

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

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

conditions, or baseline values, for some of a park's vital signs monitoring indicators. They can also draw upon non-NPS data to help evaluate current conditions for those same vital signs. In some cases, I&M data sets are incorporated into NRCA analyses and reporting products.

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

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Nature Trail along grasslands at Fort Larned National Historic Site.

Chapter 2: Introduction and Resource Setting

2.1. Introduction

2.1.1. Enabling Legislation/Executive Orders

Fort Larned National Historic Site was established in 1964 under Public Law 88-541. The purpose of the Historic Site is to "commemorate the historic role Fort Larned played in the opening of the West" (NPS 1994).

Historically, the fort was an area for friendly interaction and conflict between the Plains Indians and non-Indians before and after the Civil War (NPS 1994). It became established in 1859 and operated until 1878. Today, Fort Larned NHS contains nine original sandstone structures and a reconstructed block house along the Pawnee River eight miles above the confluence with the Arkansas River.

A separate tract of land, owned and managed by the National Park Service, is located south of the fort and preserves ruts along the Santa Fe Trail. Fort Larned NHS was one of several forts established to provide protection as a result of hostilities along the Trail (NPS 2013) and served as a guardian for nearly 20 years.

2.1.2. Geographic Setting

Fort Larned National Historic Site contains 718 acres (291 hectares). The Historic Site is located along the Santa Fe Trail and is "one of the finest examples of that bygone era [Santa Fe travel] (Santa Fe Trails n.d.) It is located in Pawnee County in southwestern/south central Kansas. It is on Kansas Highway 156, six miles west of Larned, Kansas and 63 miles northeast of Dodge City, Kansas.(Figure 2.1.2-1). The Pawnee River bisects the Historic Site, and tallgrass prairie and riparian habitat along the river characterize the landscape.

2.1.3. Visitation Statistics

Visitation data for Fort Larned NHS are available for 1979-2012. The total number of visitors each year ranged from 17,500 (in 1974) to 67,292 (in 1984). The number of visitors in 2012 was 33,194. Visitation data by month are available for the same period of time. Although there has been substantial monthly variation by year, the months receiving the greatest average number of visitors over the recording period were May through August (Figure 2.1.3-1) (NPS Public Use Statistics Office 2013).

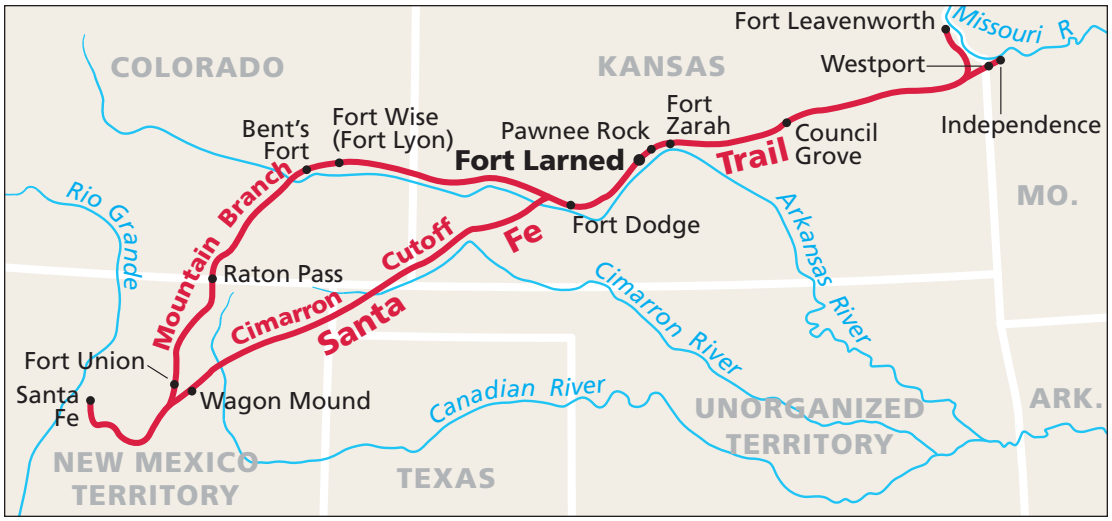

Figure 2.1.2-1. Setting of Fort Larned NHS.

2.2. Natural Resources

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

2.2.1. Ecological Units

Italicized text indicates excerpts taken from studies previously conducted at Fort Larned NHS.

Excerpted from Cogan et al. 2007

Fort Larned is located on the upper floodplain of the Pawnee River. Situated next to a historic oxbow lake and south of the active river channel, this site contains large, flat grasslands common to the Southern Plains region. Until recently these large fields were actively farmed and ranched, heavily influencing the composition of the vegetation. These rural activities resulting in large areas planted with non-native grasses such as smooth brome (Bromus inermis) and patches of weedy, early seral species consisting of annual forbs and grasses.

Bisecting these areas is the Pawnee River that meanders through the site from east to west providing riparian habitat for thick stands of deciduous trees and shrubs lining both banks of the river.

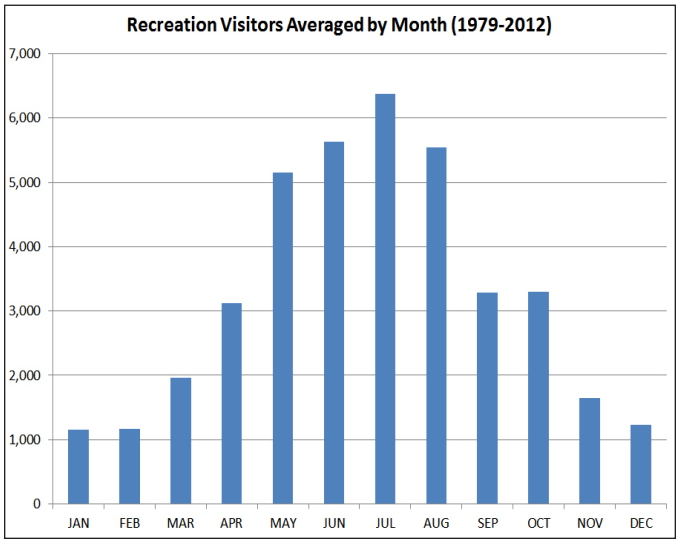

Figure 2.1.3-1. Average number of visitors to Fort Larned NHS by month, 1979-2012.

The Santa Fe Ruts site contains a few remnants of the original tallgrass prairie vegetation and is inhabited by a colony of black-tailed prairie dogs. This site also contains some small drainages that trend from the northeast to the west-central boundary. These low areas are mesic and are often completely saturated most of the year.

The landscape around FOLS is fragmented and primarily rural. Surrounding both sites are extensive agricultural lands that are actively farmed or used for pasture. These

fields are accessed through a network of state, county and private roads.

2.2.2. Resource Descriptions

Italicized text in the following section are excerpts from resource descriptions as cited.

Fluvial Features and Processes (excerpted from KellerLynn 2008).

Geologists characterize the landscape of Fort Larned National Historic Site as an alluvial valley with meandering streams. The fort was built on Pawnee River alluvium. An oxbow feature, probably with historical significance, is part of the landscape and influenced positioning of the fort. This feature was shown in original drawings of the quarter master. Fort Larned National Historic Site lies within the drainage area of the Pawnee River, which empties into the Arkansas River. Today as a result of irrigation practices, the streambeds are dry, and both the Pawnee and Arkansas rivers flow only after significant precipitation events. Flooding is rare, at least in the past decade. Irrigation and other agricultural practices have facilitated soil erosion on the Pawnee River, which in turn has increased turbidity levels and eliminated much of the riparian vegetation. The overall deterioration of water quantity and quality has led to the decline of much of the resident aquatic life (Becker et al. 1986).

Geologic Setting (excerpted from KellerLynn 2008)

Fort Larned bridges the Smoky Hills and Arkansas River physiographic regions. The fort is located on the floodplain of the Pawnee River, specifically a broad flat alluvial plain consisting of Quaternary sand, gravel, silt, and clay. Lower Cretaceous Dakota Formation (shale and sandstone layers), Graneros Shale, and Greenhorn Limestone underlie pasture lands north of the fort. The detached unit containing the Santa Fe Trail Ruts lie on gently rolling uplands of Dakota sandstone. Both units [fort and trail ruts] lie on the western edge of the Kansas mixed-grass prairie region.

Hydrology (excerpted from Martin and Wagner 2013)

The Pawnee River watershed is located in the High Plains Section of the Great Plains Geomorphic Province. This area is characterized by gently rolling, upland plains and broad, low-relief valleys containing relatively flat floodplains and terraces. The Pawnee River, sometimes also referred to as the Pawnee Fork or Pawnee Creek, begins in western Kansas and runs predominantly north-northeast for about 200 miles before joining the Arkansas River. The 2,700 square-mile watershed begins in northwest Gray County, Kansas and contains several tributary streams including Buckner Creek, which joins the Pawnee near Burdett, Kansas upstream of Fort Larned National Historic Site (NHS), and Sawmill Creek which enters the Pawnee about seven river miles downstream of the Site (Figure 2.2.2-1). At the Historic Site, the Pawnee River Valley is about 1,000 feet wide and slopes gently from west to east.

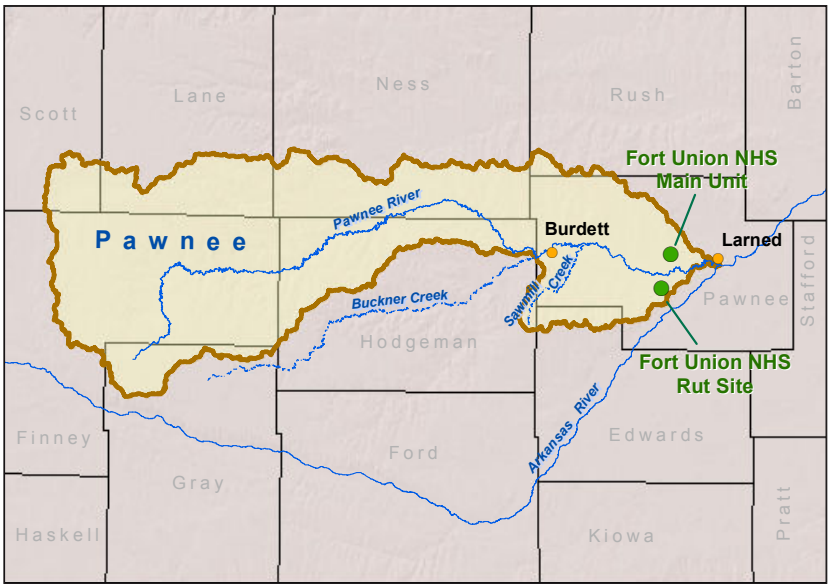

Figure 2.2.2-1. Fort Larned NHS is located along the Pawnee River and is within the Pawnee watershed.

The aquifer that underlies the Historic Site is an alluvial aquifer, meaning that the groundwater fills the interstitial voids of the river alluvium in the valley much like a saturated sand or gravel in a bucket or trough. The water table in the alluvium marks the depth of saturation, below which is the available groundwater. Sometimes this type of aquifer is referred as a "water table" aquifer. The alluvium in the Pawnee River Valley was deposited in channels cut into Cretaceous, Tertiary, and Pleistocene sediments, the latter of which remain in places as terrace deposits on the outer margins of the river valley (McLaughlin 1949). The age of the alluvium,

therefore, is late Pleistocene and Holocene. The thickness of the alluvium ranges from about 65 to 138 feet with an average of about 105 feet (Fishel 1952). The upper part of the alluvium in the Pawnee Valley consists primarily of silt with some clay and sand, and ranges in thickness from about to 50 feet with an average of about 30 feet. Beneath the clay there is, in most places, a thick deposit of sand and gravel that yields large quantities of water to wells in the valley. Most of the domestic and stock wells and all the irrigation wells in the area obtain water from these sand and gravel lenses present variably in the alluvial fill (McLaughlin 1949).

Air Quality

Fort Larned NHS is designated as a Class II air quality area. No on-site monitoring or air quality monitoring stations within the required distances to be representative of park conditions exist, therefore, air quality trends cannot be determined.

Wildlife

Common mammal species at the Historic Site include white-tailed deer (*Odocoileus virginianus*), raccoons (*Procyon lotor*), coyotes (*Canis latrans*), black-tailed prairie dogs (*Cynomys ludovicianus*), and many small mammals (Certified Species List 2013). Also, the Historic Site is home to numerous reptiles, amphibians and fish.

The Historic Site's bird list contains 69 documented species, with 60 of the species observed during 2009-2012 Rocky Mountain Bird Observatory surveys. Common bird species include Red-tailed Hawks (*Buteo jamaicensis*), Warbling Vireos (*Vireo gilvus*), and Great Horned Owls (*Bubo virginianus*), to name a few.

Vegetation (Excerpted from Cogan et al. 2007)

The vegetation of FOLS [Fort Larned NHS] contains a mix of common Southern Plains native plants and agriculture-influenced non-native species. The natural plant communities in the area are not well-described but appear to be separated into two broad groups of tallgrass prairie and riparian forests. The uplands are typically drier and occur on the gentle sloping to flat floodplain terraces and broad plains. These habitats support large expanses of grassland largely being restored to native tallgrass prairie including the seeding of big bluestem (Andropogan gerardii), Indiangrass (Sorghastrum nutans) and switchgrass (Panicum virgatum). At the Santa Fe Ruts site these tallgrass species are also present and are likely remnants from the original pre-settlement tallgrass prairie. In addition, this small site contains a very active black-tailed prairie dog colony that clips the vegetation and keeps it very short. Grazing also influences the species composition favoring plants that are unpalatable and low-growing. Typical plants include species such as yellow foxtail (Setaria pumila), prairie three-awn (Aristida oligantha), horseweed (Conyza ramosissimum), wood sorrel (Oxalis dillenii), and field bindweed (Convolvulus arvensis). Western wheatgrass (Pascopyrum smithii) is also found at FOLS in one small natural area south of the fort.

Unfortunately most of the grasslands in and around FOLS [Fort Larned NHS] have been altered through historical plowing and seeding. Alteration is evidenced by the abundance of smooth brome, Johnsongrass (Sorghum halepense), and other introduced grasses and forbs. On the heavily disturbed sites such as recently flooded areas, non-native, early seral species are present. These include poison hemlock (Conium maculatum), Mexican firebush (Kochia scoparia), Japanese brome (Bromus japonicus), pale dock (Rumex altissimus), western ragweed (Ambrosia psilostachya) and cheatgrass (Bromus tectorum).

Riparian corridors associated with the Pawnee River are typically lush with multi-strata of deciduous vines, shrubs, and trees. Common species include eastern cottonwood (Populus deltoides), green ash (Fraxinus pennsylvanica), black willow (Salix nigra), boxelder (Acer negundo), and elms (Ulmus spp.). Shrubs at FOLS [Fort Larned NHS] are mainly restricted to understory species in the riparian habitats and do not occur as discrete associations. American plum (Prunus americana) is probably the most common shrub at FOLS [Fort Larned NHS]. Along with the riparian trees and shrubs this area also supports seasonal stands of smartweeds (Polygonum lapathifolium and Polygonum bicorne). This unique vegetation

type is dynamic at Fort Larned and is likely a result of the damming and silting of the river below FOLS [Fort Larned NHS]. Smartweeds form nearly homogenous stands in and along the Pawnee River bottom when the water level is low. They are also present as a permanent stand at the Ruts site where a small drainage has been impounded by the roadbed.

Night Sky and Soundscape

No formal night sky or soundscape studies have been conducted at the Historic Site. An informal soundscape study was conducted at the Historic Site for the purposes of this NRCA. Activities on land surrounding the Historic Site (e.g., highway traffic, local development and operations) have the potential to influence the condition of the landscape-scale resources.

2.2.3. Resource Issues Overview

The natural environment and availability of resources has impacted the lifestyles of humans who have used the area for the past thousands of years. The site and surrounding area have been affected by hunting, grazing, cultivation, water diversion, development, introduction of non-native species, and extirpation (local extinction) of native species such as bison. The spread of exotic plant species, alterations in the vegetation community resulting from climate change, changing hydrologic patterns, disease, natural disturbance (e.g., fire and flooding), and succession all are likely to influence the wildlife and vegetation communities of the Historic Site. Fort Larned NHS is a small national park and, even though it is protected, landcover and land use changes around the park and in the region would be expected to influence the various species found in the Historic Site and impact the Historic Site's water resource, the Pawnee River. Water resources also face numerous and varied threats, including impacts from climate change, atmospheric deposition, altered hydrology, agriculture, pollution from boats, non-native species, erosion, improper sewage plant or drain field operations, and storm water runoff, and the Pawnee River is no exception to these potential threats.

2.3. Resource Stewardship

2.3.1. Management Directives and Planning Guidance

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

SOPN Program

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

- inventory the natural resources under NPS stewardship to determine their nature and status;

NPS

Annual grassland monitoring plot at Fort Larned NHS.

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

To facilitate this effort, 270 parks with significant natural resources were organized into 32 regional networks. Fort Larned NHS is part of the SOPN, which also includes ten additional parks. Through a rigorous multi-year, interdisciplinary scoping process, each network selected a number of important physical, chemical, and/or biological elements and processes for long-term monitoring. These ecosystem elements and processes are referred to as 'vital signs', and their respective monitoring programs are intended to provide high-quality, long-term information on the status and trends of those resources. For the SOPN, notable core vital signs were identified. Inventories on a wide variety of natural resource topics have been completed, and long-term monitoring programs are currently underway.

Resource Stewardship Strategy

National Parks are encouraged to develop a Resource Stewardship Strategy (RSS) as part of the park management planning process. Indicators of resource condition, both natural and cultural, are selected by the park. After each indicator is chosen, a target value is determined and the current condition is compared to the desired condition. An RSS has not yet been started for the Historic Site. The NRCA will provide valuable information for the RSS process. Management plans may then be developed based upon information from the RSS and NRCA to outline actions to be taken over the next 15 to 20 years that will help achieve or maintain the desired condition(s) for each indicator.

2.3.2. Status of Supporting Science

Available data and reports varied significantly depending upon the resource topic. The existing data used for each indicator to assess condition or to develop reference conditions are described in each indicator summary in Chapter 4. Part of SOPN's mission is to collect, manage, analyze, and report longterm ecological data to support each park in determining the status, condition, and trend of important natural resources (USDI NPS 2008). In addition to data from the SOPN Program and research by other scientists and programs, subject matter experts provided significant information pertaining to riparian habitat, grassland ecology, and exotic plants. Washington level programs, including night sky, soundscape, riparian habitat, and air quality also provided a wealth of information for this NRCA.

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NPS-JOEL WAGNER

NRCA riparian habitat assessment at Fort Larned NHS.

Chapter 3: Study Scoping and Design

This NRCA is a collaborative project between the Fort Larned NHS staff and the SOPN, both of the NPS. Stakeholders in this project include the Historic Site's division managers and management staff and SOPN staff. The purpose of the condition assessment is to provide a "snapshot-in-time" evaluation of the condition of a select set of Historic Site natural resources that were identified by the project team. Project findings will aid Historic Site staff in the following objectives:

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

The approach we used to select natural resources was to assess the fundamental and important values of the Historic Site as well as to consider broader natural resources as identified by the NPS' Natural Resource Program Center. The resources assessed are limited to natural-based topics, but cultural resources were also taken into consideration within the context of the chosen natural resources.

3.1. Preliminary Scoping

The selection of resources to assess resulted from meetings and subsequent discussions. For a complete list of team members, please refer to Appendix A.

These meetings and discussions focused on:

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

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

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

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

Specific project expectations and outcomes included the following:

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

Historic site staff participated in on-site meetings and staff reviewed interim and final products. Historic site staff, I&M staff, and additional writer/editors data mined information for each assigned resource topic.

3.2. Study Design

3.2.1. Indicator Framework, Focal Study Resources and Indicators

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

Each NRCA project represents a unique assessment of key natural resource components that are important to the specific park that is being assessed. As a result, the project framework is developed by the project participants to reflect the key resources of the park. For the purpose of this NRCA, 12 key Historic Site natural resources were identified and are listed under the "Resource" column in Table 3.2.1-1. This list of focal study resources is not all inclusive of every natural resource at the Historic Site, but it includes natural resources and processes that were of greatest concern at the time of this assessment.

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

Table 3.2.1-1. Fort Larned NHS Natural Resource Condition Assessment Framework

Resource	Assessment Level	Indicators and Measures
I. Landscape Condition Context		
Viewshed	Full Assessment	• Scenic and Historic Integrity (Intactness And Conspicuousness of Noncontributing Features)
Night Sky	Full Assessment	• Sky Brightness (Anthropogenic Light Ratio) • Sky Quality (Bortle Dark-sky Scale)
Soundscape	Full Assessment	• Audibility (Percent Time Audible) • Sound Level (Amplitude - qualitatively and quantitatively)
II. Supporting Environment		
Air Quality	Full Assessment	• Visibility (Visibility Haze Index) • Level of Ozone (Annual 4th-Highest 8-hour Concentration) • Atmospheric Wet Deposition (Total N and Total S in kg/ha/yr)
Geology	Limited Assessment	Geologic Integrity
Surface Water	Limited Assessment	• Core Water Quality Parameters (5 Measures)
Groundwater	Full Assessment	• Groundwater Elevation (Change in Groundwater Elevation)
III. Biological Integrity		
Vegetation		
Riparian Habitat	Full Assessment	Hydrology (5 Indicators) Vegetation (7 Indicators) Erosion/Deposition (5 Indicators)
Grasslands	Full Assessment	Hydrology Soil/Site Stability and Hydrologic Function (10 Indicators) Biotic Integrity (5 Indicators)
Exotic Plants	Full Assessment	• Prevalence of Exotic Plants (2 Measures) • Potential to Alter Native Plant Communities (2 Measures)
Wildlife		
Landbirds	Full Assessment	• Species Occurrence (Temporal. Spatial, and Conservation Context)
Prairie Dog	Limited Assessment	• Prairie Dog Occurrence (Area Occupied and Prairie Dog Density)

3.2.2. Reporting Areas

Since the Historic Site is relatively small, the reporting area was treated as one unit and encompassed the entire acreage within the Historic Site's boundary. Due to the nature of some of the focal study resources, areas outside of the Historic Site's boundary were included in the assessment to determine overall condition within the Historic Site (e.g., viewshed, air quality).

3.2.3. General Approach and Methods

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

Data Mining

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

Subject Matter Experts

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

Data Analyses and Development

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

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

Final Assessments

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

Indicator/Measures Assessment Format

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

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

Circle colors provide indication of condition based upon the chosen indicators/measures and reference conditions. Red circles signify that a resource is of significant concern; yellow circles signify that a resource is in moderate condition; and green circles denote that an indicator is currently in good condition. A circle without any color, (which is almost always associated with the low confidence symbol-dashed line), signifies that there is insufficient information to make a statement about condition of the indicator, therefore, condition is unknown. We include an indicator condition and overall rationale summary table at the end of each resource topic's section.

Arrows inside the circles signify the trend of the indicator/measure condition. Upward pointing arrows signify that the indicator is improving; right pointing arrows signify that the indicator's condition is currently unchanging; downward pointing arrows indicate that the indicator's condition is deteriorating. No arrow denotes that the trend of the indicator's condition is currently unknown. Figure 3.2.3-2 is an example of a final condition graphic used in the indicator assessments.

Background and Importance

This section provides information regarding the relevance of the resource to the Historic Site. This section also explains the characteristics of the resource that help the reader understand subsequent sections of the document.

Data and Methods

This section describes the existing datasets used for evaluating the indicators/measures. Methods used for processing or evaluating

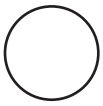
Condition Status		Trend in Condition		Confidence in Assessment	
	Warrants Significant Concern		Condition is Improving		High
	Warrants Moderate Concern		Condition is Unchanging		Medium
	Resource is in Good Condition		Condition is Deteriorating		Low
	An open (uncolored) circle indicates that current condition is unknown or indeterminate; this condition status is typically associated with unknown trend and low confidence				

Figure 3.2.3-1. Condition, trend, and level of confidence key used in the Fort Larned NHS NRCA.

the data are also discussed where applicable. The indicators/measures are listed in this section as well, describing how we measured or qualitatively assessed the natural resource topic.

Reference Conditions

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

Condition and Trend

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

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

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

Sources of Expertise

Individuals who were consulted for the focal study resources are listed in this section. A short paragraph describing their background is also included.

Literature Cited

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

3.3. Literature Cited

The H. John Heinz III Center for Science, Economics and the Environment. 2008. The State of the Nation's Ecosystems 2008: Measuring the Lands, Waters, and Living Resources of the United States. Washington, D.C.

National Park Service. 2012. A Call to Action: Preparing for a Second Century of Stewardship and Engagement. Washington, D.C. 28pp

Chapter 4: Natural Resource Conditions

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

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

Resource	Indicator	Description/ Methods	Condition
I. Landscape Condition Context			
Viewshed	Scenic and Historic Integrity	23	28
Night Sky	Sky Brightness	36	39
	Sky Quality	36	39
Soundscape	Audibility	43	47/48
	Sound Level	43	48
Air Quality	Visibility	55	57
	Level of ozone	56	57
	Atmospheric Wet Deposition	56	57
Geology	Geologic Integrity	64	66
Surface Water	Core Water Quality Parameters	70	72
Groundwater	Groundwater Elevation	77	80
III. Biological Integrity			
Vegetation			
Riparian Habitat	Hydrology (5 indicators)	86	88
	Vegetation (7 indicators)	86	92
	Erosion/Deposition (5 indicators)	87	93
Grasslands	Hydrology Soil/Site Stability and Hydrologic Function (10 Indicators)	99	104
	Biotic Integrity (5 indicators)	101	107
Exotic Plants	Prevalence of Exotic Plants	118	125
	Potential to Alter Native Plant Communities	123	125
Wildlife			
Landbirds	Species Occurrence - Temporal Context	132	137
	Species Occurrence - Spatial Context	132	139
	Species Occurrence - Conservation Context	133	140
Prairie Dog	Prairie Dog Occurrence	151	152

4.1. Viewshed

Indicators/Measures

- Scenic and Historic Integrity (2 Measures)

Condition – Trend - Confidence

Moderate – Unknown - High

4.1.1. Background and Importance

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

Fort Larned National Historic Site (NHS) is located near Larned, Kansas in a prairie/agricultural landscape of the great plains. The Historic Site was established to protect traffic along the Santa Fe Trail in the mid-1800s. The Fort includes restored historic buildings and living history demonstrations (Figure 4.1.1-1); a noncontiguous unit of the Historic Site has a small observation platform from which the ruts created by wagons along the trail are visible.

The Fort was occupied from 1859 to 1878 and was named in honor of U.S. Army paymaster general Col. Benjamin Larned, who never actually came to Kansas. Fort Larned NHS was one of a succession of military posts established to protect and even escort travelers

NPS/HEIDI SOSINSKI

Figure 4.1.1-1. View of several of the historic buildings and surrounding views at Fort Larned National HIstoric Site.

along the Santa Fe Trail which extended from Independence, Missouri along the Missouri River to Santa Fe in New Mexico Territory.

From 1821-1880, the Santa Fe Trail was one of the most important overland routes, carrying millions of dollars a year in commercial traffic. The acquisition of new territory and the gold rushes of 1849 and 1858 further boosted the traffic along the route, and disrupted Native American's way of life.

Believing their existence to be in jeopardy, the Plains Tribes attacked travelers along the trail. The Army counter attacks escalated the Indian Wars. In 1864, after the Sand Creek Massacre and after the War Department forbade travel beyond Fort Larned without armed escort, the post supplied guard detachments for mail stages and wagon trains. In 1868, in violation of the Treaty of Medicine Lodge signed the year before, the Cheyennes attacked several wagon trains along the Santa Fe Trail and raided settlers throughout the southern plains. The U.S. retaliation culminated in the attack on Black Kettle along the Washita River.

During most of the 1860s Fort Larned also served as an agency of the Indian Bureau, which tried to find peaceful solutions to the conflict. Multiple treaties were brokered during this time, however the agency was abolished in 1868 when the tribes were moved to reservations.

Visitor Experience

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

From a cultural and historical perspective, the views are not just about the scenery, but rather an important way to better understand life in a frontier fort.

4.1.2. Data and Methods

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

The overall indicator of viewshed condition we use in this assessment is a combination of scenic and historic integrity. For this overall indictor we used two measures (intactness and conspicuousness) from key vantage points (Table 4.1.2-1). Each of these measures are described in greater detail below.

Table 4.1.2-1. Indicators and measures of viewshed and why these are important to the resource condition.

Indicators of Condition	Measures	Why are these indicators/measures important to resource condition?
Scenic and Historic Integrity	Intactness of View	Intactness represents how much the viewshed has been altered from its reference state, which in turn influences scenic quality as well as the sense of place in an historic context.
	Conspicuousness of non-contributing features	Non-contributing features that are more conspicuous tend to detract more from the scenic quality and/or the sense of place in an historic context.

Indicator

Scenic and Historic Integrity

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

Historic integrity is the authenticity of a site's historic identity, evidenced by the survival of physical characteristics that existed during its historic period. Historic integrity is based on those features of the cultural and natural landscape, from the perspective of an observer, that contribute to the sense of place and enhance the visitor experience. In this assessment, we focus on those features that have a visual impact and contribute to the history of Fort Larned NHS. We evaluate features as contributing, enhancing the scenic and historic features of the landscape, or noncontributing, detracting from the scenic and historic integrity.

Measure

Intactness

We assess scenic and historic integrity by evaluating specific human-made features that can be seen from key vantage points and whether or not those features are contributing or noncontributing to the scenic and/or historic integrity of the view. For noncontributing features, we further assess the characteristics that make them more or less conspicuous; which influences the level of impact that they might have. We then supplement this assessment with a GIS-based map showing areas that are or are not visible from key vantage points. The GIS analysis provides spatial orientation of key features.

Viewshed Vantage Points

The two main vantage points within the Historic Site used in this analysis were near the entrance, looking toward the north, and just outside the Fort buildings looking toward the south (Figure 4.1.2-1). These sites capture what visitors experience, including scenic quality and historic context. We also considered the Ruts Unit as an ancillary view.

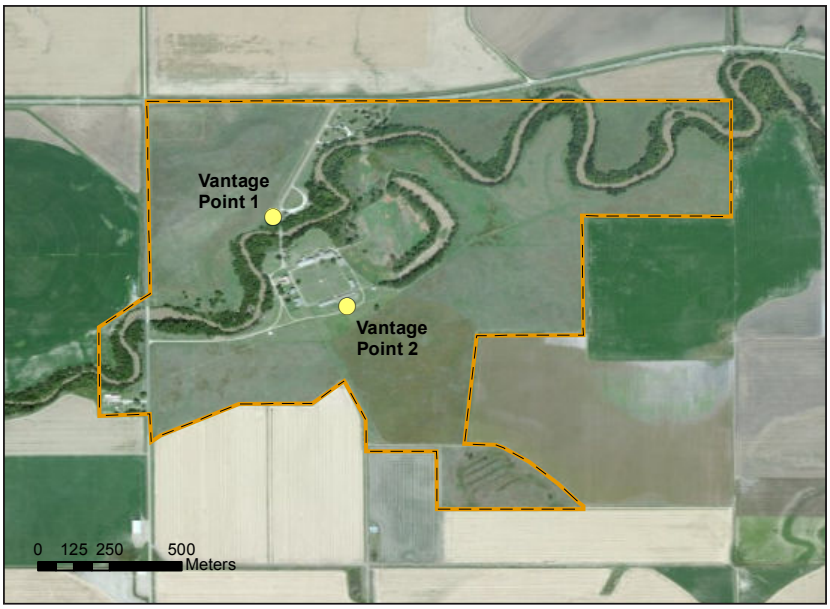


Figure 4.1.2-1. Location of vantage points used in the viewshed assessment; vantage point 1 on the north side of the Historic Site, and vantage point 2 looking south.

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

We used a series of panoramic images to portray the viewshed from an observer's perspective from each vantage point. These images were taken using a Canon PowerShot digital camera and the GigaPan Epic 100 system, a robotic camera mount coupled with stitching software (Figure 4.1.2-2). A series of images are automatically captured and the individual photographs are stitched into a single high-resolution panoramic image. These photographs provide a means of illustrating the indicators related to viewshed integrity.

We recognize that visitor perceptions of an altered landscape are highly subjective, and there is no completely objective way to measure this. Research has shown, however, that there are certain landscape types and characteristics that people tend to prefer over others. In general, there is a wealth of research demonstrating that people tend

Figure 4.1.2-2. The GigaPan system takes a series of images that are stitched together to create a single panoramic image.

to prefer natural over human-modified landscapes (Zube et al. 1982, Kaplan and Kaplan 1989, Sheppard 2001, Kearny et al. 2008, Han 2010). In the case of parks set aside for their historical significance, human-made structures that have historical significance also add value to the historical context and contribute to the sense of place. Therefore, human-made features that are consistent with the historical context of the Historic Site are likewise considered consistent with the goals of scenic and historic integrity. Human-altered components of the landscape (e.g., roads, buildings, powerlines, and other features) that do not contribute to the historic context are often perceived as detracting from the scenic and historic character of the viewshed.

Despite this generalization for natural landscape preferences, studies have shown that not all human-made structures or features have the same impact on visitor preferences. Visitor preferences can be influenced by a variety of factors, including cultural background, familiarity with the landscape, and their environmental values (Kaplan and Kaplan 1989, Virden and Walker 1999, Kaltenborn and Bjerke 2002, Kearney et al. 2008).

Measure

Conspicuousness of Noncontributing Features

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

Distance – The impact that individual human-made features have on perception is substantially influenced by the distance from the observer to the feature(s). Viewshed assessments using distance zones or classes often define three classes: foreground, middle ground, and background. For this assessment, we have used the distance classes that have been recently used by the National Park Service:

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

The foreground is the zone where visitors should be able to distinguish variation in texture and color, such as the relatively subtle

Table 4.1.2-2. Characteristics that influence how less conspicuous human-made features are within a viewshed and the general effect.

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

Table 4.1.2-3. A matrix describing the six size classes used for visible human-made features.

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

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

Size

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

We considered the features on the landscape surrounding Fort Larned NHS as belonging to one of six size classes (Table 4.1.2-3), which reflect the preference groups reported by studies. Using some categories of perhaps mixed measures, we considered size classes within the context of height, volume, and length.

Color and Shape

Studies have shown that how people perceive a human-made feature in a rural scene depends greatly on how well it seems to fit or blend in with the environment (Kearney et al. 2008, Ryan 2006). For example, Kearney et al. (2008) found preferences for homes that exhibit lower contrast with their surroundings as a result of color, screening vegetation, or other

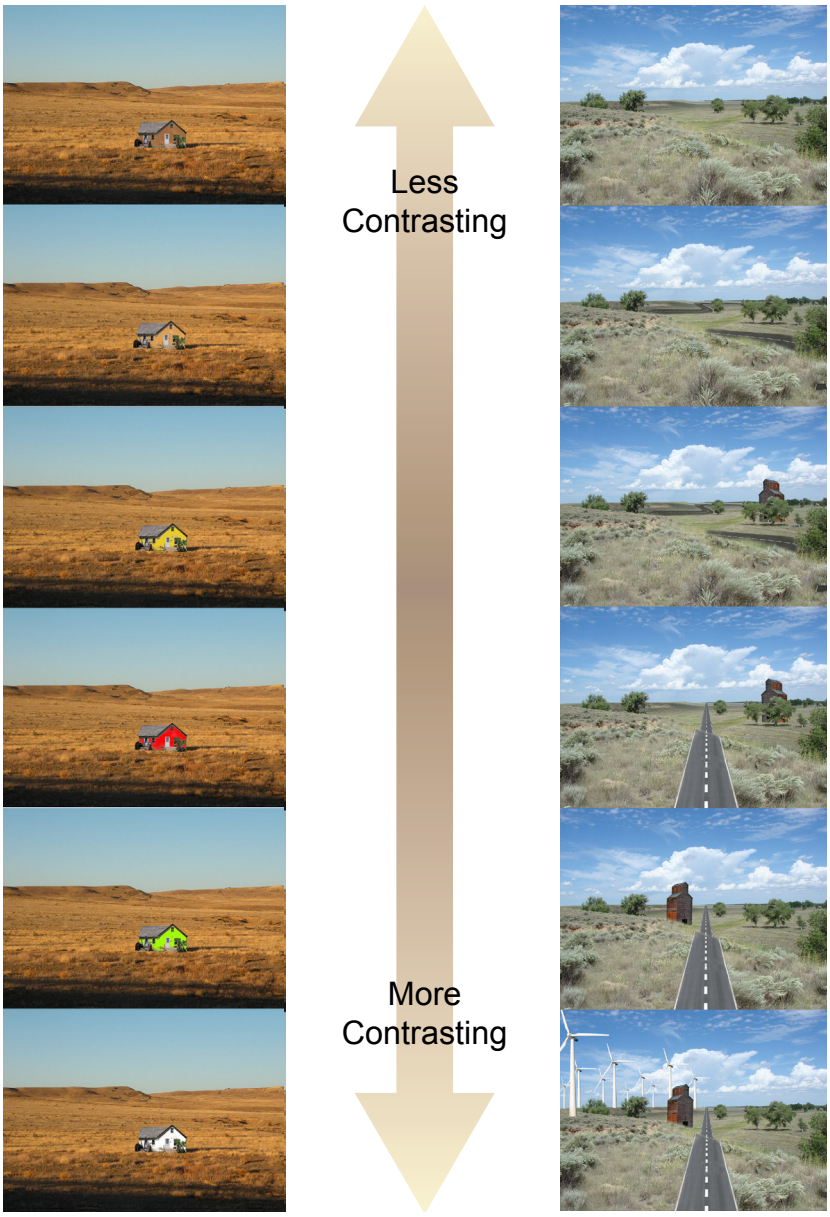


Figure 4.1.2-3. Graphic illustration of how color (left) and shape (right) can influence whether features are in harmony with the environment, or are in contrast.

blending factors (see Figure 4.1.2-3). It has been shown that colors lighter in tone or higher in saturation relative to their surroundings have a tendency to attract attention (contrast with their surroundings), whereas darker colors (relative to their surroundings) tend to fade into the background (Ratcliff 1972), O'Conner 2008). This is consistent with the findings of Kearney et al. (2008) who found that darker color was one of the factors contributing to a feature blending in with its environment and therefore preferred. Some research has indicated that color can be used to offset other factors, such as size, that may evoke a more negative perception (O'Conner 2009). Similarly, shapes of features that contrast sharply with their surroundings may also have an influence on how they are perceived. This has been a dominant focus within visual resource programs of land management agencies (Ribe 2005). In forest management, negative perceptions related to the contrasting shapes of forest harvest with their surroundings (for example, clear cuts) was so strong that it was explicitly addressed in the National Forest Management Act of 1976 calling for "cuts shaped and blended to the extent practicable with the natural terrain" (16 USCA 1604g3Fiii). The Visual Resource Management Program of the BLM (BLM 1980) similarly places considerable focus on design techniques that minimize visual conflicts with features such as roads and power lines by aligning them with the natural contours of the landscape. Based on these characteristics of contrast, we considered the color of a feature in relative harmony with the landscape if it closely matched the surrounding environment, or if the color tended to be darker relative to the environment. We considered the shape of a feature in relative harmony with the landscape if it was not in marked contrast to the environment.

Movement and Noise

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

Hierarchical Relationship among Conspicuousness Measures

The above-described characteristics do not act independently with respect to their influence on the conspicuousness of features; rather, they tend to have a hierarchical effect. For example, the color and shape of a house would not be important to the integrity of the Historic Site's viewshed if the house was located too far away from the vantage point. Thus, distance becomes the primary characteristic that affects the potential conspicuousness. Therefore, we considered potential influences on conspicuousness in the context of a hierarchy based on the distance characteristics having the most impact on the integrity of the viewshed, followed by the size characteristic, then both the color and shape, and movement and noise characteristic (Figure 4.1.2-4).

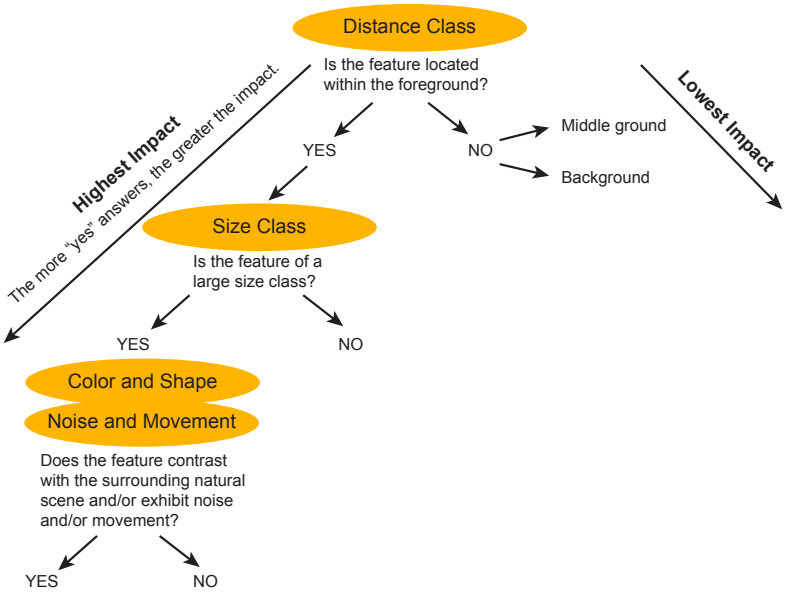


Figure 4.1.2-4. Conceptual framework for hierarchical relationship of characteristics that influence the conspicuousness of features within a viewshed.

GIS Viewshed Analyses

We supplement our assessment with a Geographic Information System (GIS) analysis to provide spatial context for these measures.

Viewshed analyses were conducted to depict the total visible area seen from each of the three key vantage points. Aerial maps of each of the vantage points were generated based on digital elevation models (DEMs) to predict the area visible from a given vantage point taking into account changes in elevation and other obstructions such as tree, mountain, or building heights. We limited this approach to an area of 30 km from Historic Site since features at greater distances have relatively less impact on scenic or historic integrity than those in greater proximity.

Ground verification indicated that the initial viewshed analyses tended to underestimate the visible area. Consequently, we adjusted the analyses by experimenting with different offsets that adjust the height of the observer or the surrounding landscape. After several iterations, we found that a 10 m offset for the surrounding landscape provided the best depiction of the visible area from each vantage point. Complete details of the viewshed analysis process are listed in Appendix B.

4.1.3. Reference Conditions

The indicators and measures of viewshed condition at Fort Larned NHS are all inter-related and are intended to provide information about how well the views maintain their scenic quality and their ability to evoke a sense of place in an historic context. As previously discussed, the scenic and historic integrity at Fort Larned NHS overlap considerably. From the historic perspective, the reference state is based on a particular period relevant to the site—in this case, the time of the Fort's occupation(1859-1878).

The basis for determining condition in an assessment such as this is a comparison between current condition and some reference. For Fort Larned NHS we used a qualitative reference state for the scenic and historic integrity of the viewshed (Table 4.1.3-1). Embedded within these reference conditions is both the intactness and conspicuousness of features that do not contribute to the scenic and historic integrity relative to that period.

4.1.4. Condition and Trend

We considered the views at Fort Larned NHS to be in moderate condition (Table 4.1.4-1). The landscape surrounding the Historic Site

Table 4.1.3-1. Qualitative reference condition classes used for scenic and historic integrity within the viewshed at Fort Larned NHS.

Class	Scenic & Historic Integrity
High Integrity *(Good Condition)*	Some noncontributing features or developments may be visible, but the vast majority of the landscape is dominated by natural or historic features. The integrity of the historic context is well preserved such that an observer can easily visualize the historic aspect of the viewshed. As such, the features that contribute to the historic integrity are well preserved (even as ruins) and the non-contributing features are generally absent or are sufficiently inconspicuous so as to not detract from the historic sense of place.
Moderate Integrity *(Moderate Concern)*	Non-contributing features or developments occupy a moderate portion of the landscape and/or are moderately conspicuous, but sufficient intactness retains much of its integrity. The integrity of the historic context is also largely preserved such that an observer can visualize the historic aspect of the viewshed.
Low Integrity *(Significant Concern)*	The vast majority of the landscape is dominated by non-contributing features or developments that are conspicuous enough that little integrity or "sense of place" remains. The integrity of the historic context is essentially lost either from the contributing factors not being well preserved or the non-contributing features overwhelming the potential to visualize the historic aspect of the viewshed.

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

Vantage Point	Non-contributing Features	Assessment	Condition
Southern View (Figure 4.1.4-1)	Towers, water tower, power lines, agricultural lands, farm buildings, farm equipment, Historic Site facilities building and equipment	The views toward the south show a large expanse of agricultural lands. Some towers and powerlines are evident. Farm buildings, equipment, farming activity (contributing movement and dust), and the Historic Site's facilities building and equipment are conspicuous. Some tree rows, and the riparian vegetation toward the eastern view, provides some screening that helps mitigate non-contributing features.	Moderate
Northern View (Figure 4.1.4-2)	Agricultural lands, farming equipment, farm buildings, powerlines, highways	The northern view is also dominated by an agricultural landscape. This view is what visitors see when they enter the Historic Site, and before they enter the Fort area itself (this is probably a less important view). The movement of vehicles on the highways and agricultural equipment on farms creates movement that is conspicuous. At this point, before you cross the bridge over the Pawnee Fork of the Arkansas River, you don't feel like you are in the Historic Site.	Moderate

Table 4.1.4-2. Indicator and measures of viewshed condition, their corresponding assigned condition class, and the rational for assigning that condition class.

Indicator of Condition	Measures	Condition	Rationale for Condition
Scenic and Historic Integrity	Intactness of View	Moderate	While the views within the immediate Fort area are somewhat protected, the site is surrounded by developed agricultural lands resulting in a view that has only moderate integrity from a natural and cultural perspective.
	Conspicuousness of non-contributing features	Moderate	Non-contributing features related to agriculture, homes and farm buildings, roads, powerlines, and oil and gas development are relatively prevalent and conspicuous throughout the views at Fort Larned NHS.

has some non-contributing features, which are fairly conspicuous on the plains. Once visitors cross the bridge across the river and are within the Fort, there is high scenic and historic integrity focusing on the restored buildings and Fort grounds. The cemetery area to the east feels quite sheltered, and the riparian vegetation provides some screening for the views that keep visitors focused on the Fort itself. Overall, the condition of the viewshed is moderate (Table 4.1.4-2).

The challenge is that the Historic Site is surrounded by developed agricultural lands, which create conspicuous disturbance in the viewsheds. When visitors first enter the site by crossing the bridge, views within the Fort grounds are confined by the riparian vegetation and the buildings themselves. This experience retains a high level of cultural and historic integrity. Views of the landscape directly outside the Historic Site, however, are

Figure 4.1.4-1. Views to the south are dominated by the agricultural landscape, including homes, farm buildings, power lines, and Historic Site facilities.

degraded from the feeling of expansive plains to that of large-scale agriculture.

Views to the south maintain some feeling of the plains in that there are no obvious views of roads. There are tree rows and riparian vegetation that reinforce the natural setting; although towers, power lines, and agricultural equipment and buildings are evident (Figure 4.1.4-1).

The northern view is most disrupted by roads and agriculture (Figure 4.1.4-2); although turning south to enter the Historic Site the view is of the riparian corridor.

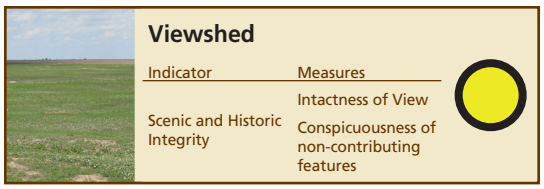
The ruts unit overlook provides a glimpse into the past with evidence of the wagon wheel ruts across the prairie. Now, however, the small area appears in poor condition with extensive weeds and soil disturbance from prairie dogs, and roads, farms and houses,

Figure 4.1.4-2. Views to the north are dominated by the agricultural landscape, roads, and power lines.

BOTH IMAGES: NINA CHAMBERS

Figure 4.1.4-3. From the Ruts Unit, oil/gas development is prominent in the viewshed (left) and the wagon wheel ruts (right) are visible among weeds and soil disturbance from prairie dogs.

and oil/gas development is quite prominent within the viewshed (Figure 4.1.4-3).



Overall Condition

Based on this assessment, the viewshed condition at Fort Larned NHS is considered moderate. While visitors experience a high level of historic and natural integrity within the Fort site, the surrounding landscape is moderately degraded by conspicuous powerlines, agriculture, and roads.

GIS-based Assessment

For our GIS-based analysis, we estimated the areas visible or not visible from the Fort Larned NHS vantage points. The topography allows for expansive views (Figure 4.1.4-4). Within the Fort, the views are more constrained (sheltered) by the Fort buildings and riparian vegetation that do a good job of screening non-contributing factors of the viewsheds surrounding the Fort.

It is important to keep in mind that these estimates of visible area are approximations based on digital evaluation models. Although we have checked them on the ground to verify that they are approximately correct, it should not be assumed that they are exactly correct for the purposes of planning specific projects. Such cases may require further verification, and adjustment if necessary, for the specific context intended.

4.1.5. Sources of Expertise

For assessing the condition of this resource, we relied primary on literature on this topic. Heidi Sosinski, Data Manager with Southern Plains Inventory and Monitoring Network, provided GIS expertise.

Key Uncertainties

How a view is perceived is quite subjective and will always have an element of uncertainty. We have tried to base our assessment on the findings of an extensive body of literature, and have tried to be transparent with our assessment, such that those that disagree can make an argument based on our approach.

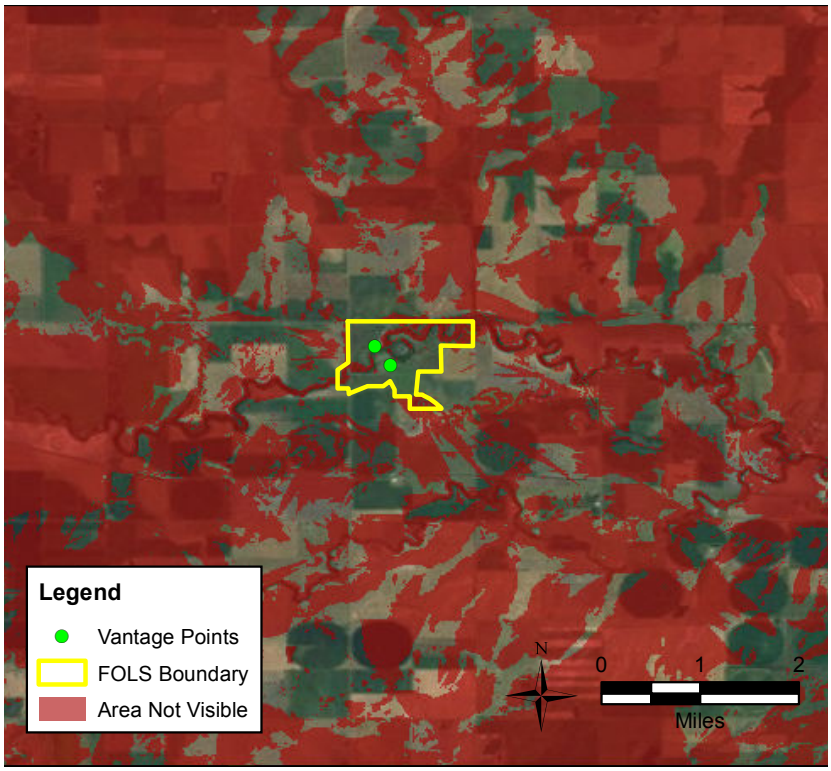


Figure 4.1.4-4. Area visible and not visible from the Fort Larned vantage points based on GIS analysis.

Another element of uncertainty is our GIS analysis. This analysis is based on digital elevation models and does not take into account visibility limitations from vegetation, etc. Also, our field verification of our initial analysis indicated that we were underestimating the visible area, which we accounted for using an offset. Further field checks indicated that our final analysis was closer, but undoubtedly still has some error due to the process. Thus, as stated previously, it should not be assumed that our analysis is exactly correct for the purposes of planning specific projects. Such cases may require further verification, and adjustment if necessary, for the specific context intended.

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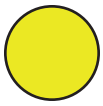
4.2. Night Sky

Indicators/Measures

- Sky Brightness/Anthropogenic Light Ratio
- Sky Quality/Bortle Dark-Sky Scale

Condition – Trend – Confidence Level



Moderate - Unknown - Medium

4.2.1. Background and Importance

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

Lightscapes are an aesthetic and experiential quality that are integral to natural and cultural resources (Moore et al. 2013). A 2007 visitor survey conducted throughout Utah national parks found that 86% of visitors thought the quality of park night skies was "somewhat important" or "very important" to their visit. Additionally, in an estimated 20 national parks, stargazing events are the most popular ranger-led program (NPS 2010).

The values of night skies goes far beyond visitor experience and scenery. The photic environment affects a broad range of species, is integral to ecosystems, and is a natural physical process (Moore et al. 2013). Natural light intensity varies during the day-night (diurnal) cycle, the lunar cycle, and the seasonal cycle. Organisms have evolved to respond to these periodic changes in light levels in ways that control or modulate movement, feeding, mating, emergence, seasonal breeding, migration, hibernation, and dormancy. Plants also respond to light levels by flowering, vegetative growth, and their direction of growth (Royal Commission on Environmental Pollution 2009). Given the effects of light on living organisms, it is likely that the introduction of artificial light into the natural light/darkness regime will disturb the normal routines of many plants and animals (Royal Commission on Environmental Pollution 2009), as well as diminish stargazing recreational opportunities offered to national park visitors.

Fort Larned National Historic Site (NHS) is primarily a cultural resource park, and the cultural significance of dark night skies should be recognized as part of the cultural landscape. The Kansas skies are expansive. As Jean Studebaker writes in Kansas family oral histories:

> Standing in the open, gazing up at the Kansas sky will make you feel small, but not insignificant. ...The Kansas sky is blue, filled at night with the stars of the constellations. They dot the darkness with sparkling points of light, which look as if they are about to burst through from the other side. ... A full moon can seem as close as the tops of the trees across the adjacent forty acres, glowing yellow or red, with the shadows of the moonscape visible to the naked eye (Studebaker 2011:9).

Protecting the night sky resources at Fort Larned NHS benefits the natural resources, is important for visitor experience, has cultural and historical significance, and is important within the cultural context of the Historic Site.

4.2.2. Data and Methods

The NPS Natural Sounds and Night Skies Division goals of measuring night sky brightness are to describe the quality of the lightscape, quantify how much it deviates from natural conditions, and how it changes

Table 4.2.2-1. Indicators and measures of the night sky and why they are important to resource condition.

Indicator	Measure	Description
Sky Brightness	Anthropogenic Light Ratio	The all-sky anthropogenic light ratio describes light due to man-made sources compared to light from a natural dark sky. Understanding the lightscape and sources of light is helpful to managers to maintain dark skies for the benefit of wildlife and people alike.
Sky Quality	Bortle Scale Class	The Bortle Dark Sky classification system describes the quality of the dark night sky by the celestial bodies and night sky features an observer can see. Observing the stars has been an enjoyable human pastime for centuries.

with time due to changes in natural conditions, as well as artificial lighting in areas within and outside of the national parks (Duriscoe et al. 2007).

Based on new guidance (Moore et al. 2013), the NPS Natural Sounds and Night Skies Division recommends that the all-sky Anthropogenic Light Ratio (ALR) as the best single parameter for characterizing the overall sky condition. Additional indicators and measures may be considered in an assessment of night sky condition, but the ALR measure is the primary data source for condition assessment (see Table 4.2.2-1).

We conducted a supplemental rapid assessment of the Historic Site's night sky condition on June 6, 2013 using the Bortle Dark Sky Scale, a qualitative assessment commonly used by amateur astronomers to evaluate the potential quality for star gazing. This rapid assessment is supplementary and is intended only to illustrate the night sky condition.

Indicators/Measures

Sky Brightness /Anthropogenic Light Ratio

The anthropogenic light ratio (ALR) is the average anthropogenic sky luminance presented as a ratio over natural conditions. It is a useful metric to average the light flux over the entire sky (measuring all that is above the horizon and omitting the terrain). Recent advances in modeling of the natural components of the night sky allow the separation of anthropogenic light from natural features, such as the Milky Way. This metric is a convenient and robust measure. It is most accurately obtained from ground-based measurements with the NPS Night Skies Program's photometric system, however, it can also be modeled with moderate confidence when such measurements are not available. No ground-based measures were taken for Fort Davis NHS; modeling data are reported here.

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

Indicators/Measures

Sky Quality /Bortle Dark Sky Scale

The Bortle Dark Sky Scale (Appendix C) was proposed by John Bortle (Bortle 2001) based on 50 years of astronomical observations. Bortle's qualitative approach uses a nine-class scale that requires a basic knowledge of the night sky and no special equipment (Bortle 2001, Moore 2001, White et al. 2012, Table 4.2.2-2). The Bortle scale uses both stellar objects and familiar descriptors to distinguish among the different classes. Another advantage of the Bortle scale is that it is suitable for conditions ranging from the

Table 4.2.2-2. Bortle Dark Sky Scale.*

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

*Table 4.2.2-2 also incorporates the Bortle Dark Sky Scale Key for the Summer Sky for Latitudes 30° to 50° N, White et al. 2012.

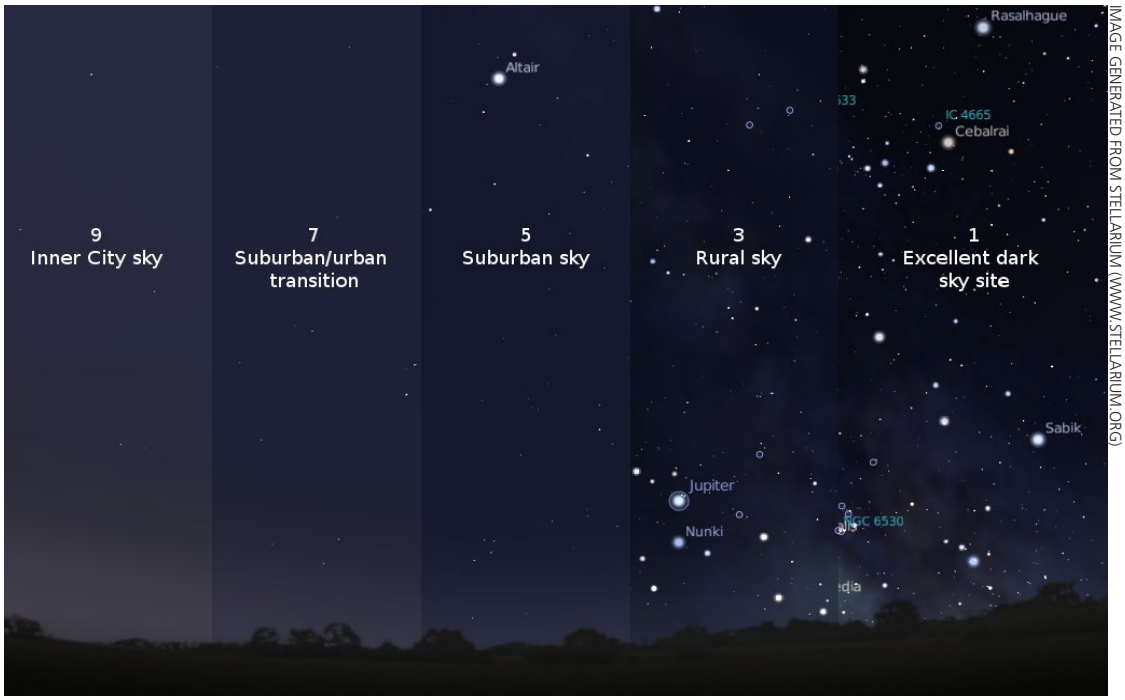


Figure 4.2.2-1. Composite image illustrating the range of night sky conditions based on the Bortle Dark Sky Scale.

darkest skies to the brightest urban areas (Moore 2001, Figure 4.2.2-1).

4.2.3. Reference Conditions

The ideal night sky reference condition, regardless of how it's measured, is one devoid of any light pollution. However, results from night sky data collection throughout more than 90 national parks suggest that a pristine night sky is very rare (NPS 2010). A natural night sky has an average brightness across the entire sky of 80 nL (nanolamberts, a measure of luminance), and includes features such as the Milky Way, Zodiacal light, airglow, and other starlight. This is figured into the ratio, so that an ALR reading of 0.0 would indicate pristine natural conditions where the anthropogenic component was 0 nL. A ratio of 1.0 would indicate that anthropogenic light was 100% brighter than the natural light from the night sky. For a summary of condition assessment categories for all night sky indicators, see Table 4.2.3-1.

Anthropogenic Light Ratio

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

Bortle Dark Sky Scale

A night sky with a Bortle Dark Sky Scale class 1 is considered in the best possible condition (Bortle 2001); unfortunately, a sky that dark is so rare that few observers have ever witnessed it (Moore 2001). Non-urban park skies with a Bortle class 3 or darker are considered to be in good condition, class 4 of moderate condition, and class 5 are considered poor condition. At class 4 and higher, many night-sky features are obscured from view due to artificial lights (either within or outside the park). Skies class 7 and higher have a significantly degraded aesthetic quality that may introduce ecological disruption (Moore et al. 2013). It is important to note that such degraded

Table 4.2.3-1. Night sky condition class summary.

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

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

Table 4.2.4-1. Summary of night sky indicators and measures, and assessment of night sky condition at Fort Larned National Historic Site.

Indicator	Measure	Condition	Description
Sky Brightness	Anthropogenic Light Ratio (0.68)	Moderate	This measure results from modeling data provided by the NPS Night Sky Program. Specific thresholds for condition classes have been set by the NPS. The night sky around Fort Larned NHS is impacted by light domes from nearby cities and towns, resulting in moderate condition.
Sky Quality	Bortle Scale Class (4)	Moderate	Star gazing at Fort Larned NHS is of moderate quality for observing the constellations, Milky Way, and other celestial bodies. Local point sources are somewhat screened by riparian vegetation, but the influence from nearby cities and towns does impact quality..

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

Indicators	Measures	Condition	Condition Rationale
Sky Brightness	Anthropogenic Light Ratio (ALR)	Moderate	Based on modeling conducted by the NPS Night Sky Program, the condition of the night sky at the monument is in moderate condition. This method is the primary consideration for condition.
Sky Quality	Bortle Dark Sky Scale	Moderate	The monument's night sky was assessed to be consistent with rural to suburban skies and is considered to be in moderate condition.

conditions may be restored toward a more natural state by modifying outdoor lighting, depending on the surrounding conditions that exist outside the Fort Larned NHS.

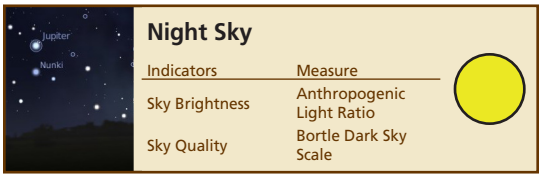
4.2.4. Condition and Trend

Modeling data provided by the NPS Night Skies Program show an ALR of 0.68 indicating moderate condition (the models have an error of ±0.1 ALR).

The qualitative Bortle Scale assessment estimated the night sky quality to class 4, consistent with a rural to suburban sky, which indicates moderate condition (see Table 4.2.4-1). While Fort Larned NHS is in a rural area, the nearby correctional facility, hospital complex, and some areas of Larned (such as the sports fields) have bright outdoor lighting that degrades the quality of the night sky. Trees and other riparian vegetation help shield the lights to the east and toward the highway when you are in the Historic Site.

Local and Regional Context

Fort Larned NHS is located about 6 miles west of Larned, Kansas. Besides the artificial lighting in the Larned area, there are several large Kansas cities that are nearby Fort Larned NHS. Great Bend is about 23 miles to the northeast and has a population of 15,995; Dodge City about 62 miles to the southwest has a population of 27,340; and Wichita is 145 miles to the southeast with a population of 382,368 (U.S. Census Bureau 2010). All of these cities contribute artificial light to the night sky around Fort Larned NHS.



Overall Condition

Quantitative modeling of sky brightness (all-sky anthropogenic light ratio) and a qualitative assessment of sky quality (the Bortle Dark Sky Scale) were used to assess the condition of the night sky. These indicators are summarized and interpreted in Table 4.2.4-2. The overall condition of the Historic Site's night sky is moderate, due to artificial lighting locally and of nearby cities.

Uncertainties

The Bortle Dark Sky Scale estimates have inherent uncertainties and error. The principle drawback of the Bortle Scale is

that it relies upon human visual observers. Differences in visual acuity, experience and knowledge, as well as time and effort expended can influence the estimates (Bortle 2001, Moore 2001). This assessment should be interpreted as interim until ground-based measures of all-sky ALR are taken (C. Moore, NPS, pers. comm.).

4.2.5. Sources of Expertise

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

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4.3. Soundscape

Indicators/Measures

- Audibility (% Time Audible)
- Sound Level (2 measures)

Condition – Trend – Confidence

Moderate - Unknown - Medium

4.3.1. Background and Importance

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

Visitors to national parks often indicate that an important reason for visiting the parks is to enjoy the relative quiet they can offer. In a 1998 survey of the American public, 72% of respondents identified opportunities to experience natural quiet and the sounds of nature as an important reason for having national parks (Haas and Wakefield 1998) (Figure 4.3.1-1). Additionally, 91% of NPS visitors "consider enjoyment of natural quiet and the sounds of nature as compelling reasons for visiting national parks" (McDonald et al. 1995). Despite this desire for quiet environments, noise continues to intrude upon natural areas and has become a source of concern in national parks (Lynch et al. 2011).

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

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

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Figure 4.3.1-1. Natural sounds, such as the Cardinal seen here, as well as Fort Larned NHS cultural sounds contribute to the Historic Site's soundscape.

perception of that acoustical environment is defined as the soundscape. Clarifying this distinction will allow managers to create objectives for safeguarding both the acoustical environment and the visitor experience.

Sound Characteristics

Humans and wildlife perceive sound as an auditory sensation created by pressure variations that move through a medium such as water or air. Sound is measured in terms of frequency (pitch) and amplitude (loudness) (Templeton and Sacre 1997, Harris 1998).

Frequency, measured in Hertz (Hz), describes the cycles per second of a sound wave, and is perceived by the ear as pitch. Humans with normal hearing can hear sounds between 20 Hz and 20,000 Hz, and are most sensitive to frequencies between 1,000 Hz and 6,000 Hz. High frequency sounds are more readily absorbed by the atmosphere or scattered by obstructions than low frequency sounds. Low frequency sounds diffract more effectively around obstructions. Therefore, low frequency sounds travel farther.

Besides the pitch of a sound, we also perceive the amplitude (or loudness) of a sound, which is measured in decibels (dB). The decibel scale is logarithmic, meaning that every 10 dB increase in sound pressure level (SPL) represents a tenfold increase in sound energy. This also means that small variations in SPL can have significant effects on the acoustical environment. For instance, a 6 dB increase in a noise source will double the distance at which it can be heard, increasing the affected area by a factor of four (Figure 4.3.1-2). SPL is commonly summarized in terms of dBA (A-weighted SPL). This metric significantly discounts sounds below 1,000 Hz and above 6,000 Hz to approximate the variation in human hearing sensitivity.

In addition to loudness (amplitude) and pitch (frequency), the duration of sounds, as well as number of times a particular sound is heard (i.e., rate of occurrence), influences whether sounds contribute or detract from a visitor's park experience or a wildlife species' ability to communicate effectively.

4.3.2. Data and Methods

A formal soundscape assessment has not been conducted by NPS' Natural Sounds and Night Skies Division (NSNSD) for Fort Larned NHS. So for the purposes of this assessment, we conducted on-site listening sessions for the Historic Site at two locations on June 6, 2013 (Figure 4.3.2-1). Table 4.3.2-1 summarizes the time and conditions of the recording sessions at each location.

During these sessions, an observer was situated at the designated listening location with a handheld Personal Digital Assistant (PDA). The observer listened for the designated period of time and identified all sound sources and their durations. This type of monitoring took full advantage of human binaural hearing capabilities but provided the closest match to a park visitor's experience. Several limitations to this method included indirectly measuring amplitude, a short sample period, and a small sample size. Instead, this technique primarily provided a

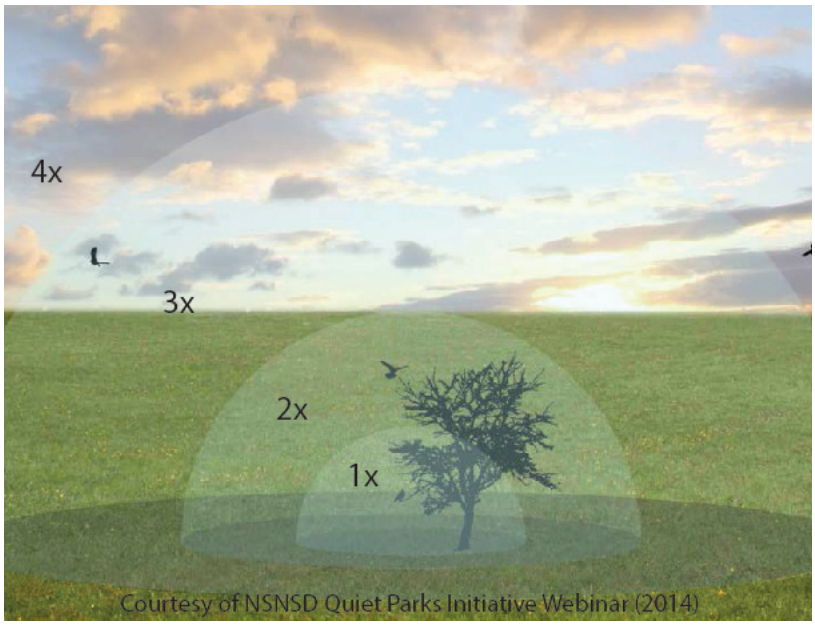


Figure 4.3.1-2. A 6 dBA reduction in sound would produce a 4x increase in listening area (NSNSD 2014).

baseline for future monitoring efforts and a "snapshot" of soundscape condition.

We augmented the on-site listening method by using the NSNSD's sound level model data for the area surrounding the Historic Site to provide an additional indicator. The model provided a quantitative sound level impact that measured the difference between the Historic Site's natural /ambient sound level versus the existing sound level.

The results for each on-site listening session and for NSNSD sound model maps can be found in Appendix D.

On-site Listening Locations

Inside Fort: On-site listening occurred in the center of the Fort's parade grounds by the flagpole. The 1-hour recording session began at 9:03 AM on June 6, 2013.

Nature Trail-Bench: On-site listening occurred along the Nature Trail on June 6, 2013 at 8:01 AM for 30 minutes where the former mail station was located (trail marker #5). A covered bench seating area was at this location within the Pawnee River downslope.

The primary indicators we used to assess the soundscape condition were audibility and sound level, with one and two measures, respectively (Table 4.3.2-2).

Indicators/Measures

Audibility (% Time Audible)

During the on-site listening sessions, we gathered information about the types of sounds that were audible, how long they were audible, and the number of events for each sound that was heard, using the handheld PDA. We discuss the results as percent time audible for each type of sound heard at each on-site listening location.

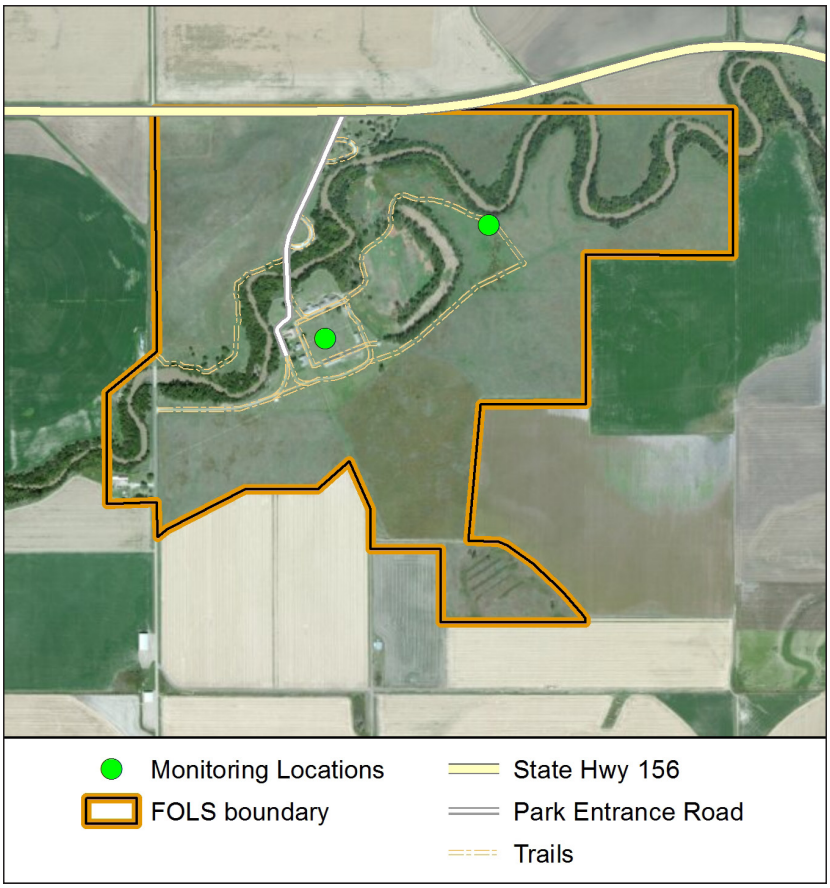


Figure 4.3.2-1. On-site listening locations.

Indicators/Measures

Sound Level (2 measures)

Sound levels were assessed in two ways (1) using sound models created by Mennitt et al. (2013) to provide quantitative parkwide/regional sound levels, and (2) using on-site monitoring information to qualitatively determine sound levels by referencing common sound levels reported in literature.

Mennitt et al. (2013) created sound level models at regional and national scales. The model used spatial, meteorological, and actual sound level measurements from 100s of sites (primarily located in the west) to model sound levels for natural and existing

Table 4.3.2-1. Summary of on-site listening sessions at Fort Larned NHS.

Location	Date	Time	Session Duration	Wind Speed and Direction[1]	Weather
Nature Trail-Bench	June 6, 2013	8:01-8:31 AM	30 minutes	2.1/NW	52° and Sunny
Inside Fort	June 6, 2013	9:03-10:03 AM	60 minutes	2.1/NW	54° and Sunny

[1]Data are from NOAA Satellite and Information Service (2013)-Great Bend, KS monitoring station.

Table 4.3.2-2. Indicators and measures used to assess the soundscape at Fort Larned NHS.

Indicator	Measure	Definition
Audibility	% Time Audible	The percent of time that a particular sound may be detected by the human ear (Lynch 2011) is the measure for audibility. For determining condition, we focused on the percent of time that noise (only) was heard (as opposed to natural or cultural sounds).
Sound Level	Amplitude of Impact Sound Level (regional scale)	"Using long-term sound pressure level measurements from hundreds of sites across the contiguous United States, geospatial models were developed to predict sound levels. These sound models incorporated spatial representations of biological, geophysical, climatic, and anthropogenic factors to assess expected contributions to the existing sound pressure level from both anthropogenic and natural sources, which enable mapping of sound pressure levels at regional and national scales" (cited from Mennitt et al. 2013). This sound level information supplements the qualitative on-site listening results.
	Amplitude (at on-site monitoring locations)	Loudness or amplitude of a sound is typically measured in decibels (dB). The decibel scale is logarithmic, meaning that every 10 dB increase in sound pressure level (SPL) represents a tenfold increase in sound energy. We did not measure amplitude directly; rather we derived inferences from the previously reported amplitude of different sound sources based upon the sounds heard.

conditions, as well as to model the impact of the sound levels based on the difference between the modeled natural and existing sound levels. We used the results from this model to provide a quantitative assessment of sound level at Fort Larned NHS.

For the qualitative sound level assessment, we evaluated the relative levels of sounds heard while monitoring on-site to common sound levels reported throughout the literature. While we are aware of the fact that this qualitative approach did not capture the sound levels in a repeatable way, we believe this method still provided important on-site information that may be influenced more directly.

Context for Evaluating Sounds Heard During On-site Listening

Whether or not a given sound contributes to or detracts from the soundscape depends largely on whether or not that sound is appropriate for the context. Like many other parks, Fort Larned NHS was established because of its historical significance. Its designated purpose includes commemoration, preservation, and interpretation of the Historic Site for the public (NPS 1994b). As such, sounds that contribute to the education and enjoyment of the Historic Site's visitors, even though they are not natural sounds, are considered appropriate for the soundscape.

If this were a wilderness setting, natural verses anthropogenic sounds might be a pertinent distinction for how a sound is perceived. However, the context and setting at Fort Larned NHS is quite different in that there are elements of the historic context as well as an educational context. Thus, in addition to the natural sounds that contribute to the sense of place of a prairie setting, the sounds that might have been heard during the 1859-1878 period the Fort was active also contribute to the soundscape. For example, sounds produced by gatherings of people or by activities typical of a soldier's life contribute to the understanding and appreciation of the historic context and enjoyment of the Historic Site. Thus, for the purposes of this assessment, we considered sounds that were consistent with the historic context to contribute to soundscape condition, if present.

In contrast, some sounds, such as low flying aircraft, vehicles, or excessive human voices may detract from the "sense of place" of the site's historic context and can be perceived negatively as noise, detracting from the soundscape.

Table 4.3.2-3. Types of sounds expected at Fort Larned NHS.

Natural, Cultural, or Recreational Sounds (desireable sounds)	Noises (unwanted sounds)
• Birds • Insects • Wind • Rustling Leaves • Rain/Thunder • Flowing Water • Living history sounds such as blacksmith anvil pounding, people marching along parade grounds, and saddler working • Flag flapping • Interpretive programs • Visitor conversations (normal levels)	• Trains • Planes • Automobiles/Horns • Mowing • Heavy Equipment • Raised voices/yelling

For these reasons, we considered sound types within the context of belonging to two classes: (1) natural, cultural, and recreational-appropriate sounds, and (2) noise (any unwanted sound). The first class was considered as having a neutral or positive influence on soundscape condition; whereas excessive noise, especially in locations where noise is unexpected due to designated use was considered to have a negative effect, contributing to a lower soundscape condition. Some common examples of expected sounds at the Historic Site are listed in Table 4.3.2-3.

Since the Historic Site is relatively small, we assessed the soundscape from along the Nature Trail and at the center of the Fort parade grounds to be representative of the entire Historic Site (Figure 4.3.2-4).

4.3.3. Reference Conditions

Studies identifying effects of noise on human health and well being and effects of noise on wildlife serve as guides for the quality of visitor soundscape experience reference conditions shown in Table 4.3.3-1.

We considered the soundscape to be in good condition if sounds heard were consistent with Historic Site designated activities, if no excessive sound/noise levels were present in any area of the Historic Site, regardless of designated use, and if noise-free intervals were common.

NINA CHAMBERS

Figure 4.3.2-4. One of the on-site listening locations was at the center of the Fort's parade grounds (where this photo was taken from).

Table 4.3.3-1. Reference conditions used to assess soundscape condition at Fort Larned NHS.

Indicator	Measure	Good	Moderate	Significant Concern
Audibility	% Time Audible	Dominant sounds are consistent with Historic Site's designated purpose. Natural ambient sounds such as wind, leaves rustling, birds singing, thunder claps, etc. and sounds related to cultural and visitor activities are expected. Some sources of noise (e.g., automobiles) are acceptable in the developed areas provided they are consistent with the expectations for that location and are audible for a small percentage of the time.	The dominant sounds are generally consistent with Historic Site's designated purpose, but noise occurs more frequently and noise from the developed areas begins to infiltrate into the historic area(s). A historic sense of place is still maintained, but is periodically interrupted by audible noises.	A high percentage of the audible sounds heard are from noise such that the historic and natural sense of place, therefore, the education and enjoyment of visitors is compromised.
Sound Level	Amplitude (loudness)	Natural and historic-context appropriate sounds are consistent with the expected sound levels of the historic Fort. Visitors typically maintain quiet to normal conversation levels (e.g., 40-50 dB), and interpreters talking to larger groups rarely exceed 55-60 dB. There is a sightly higher tolerance for noise levels in the developed areas, but should rarely exceed 60 dB. The natural sound level for the Historic Site modeled for Mennitt et al. (2013) was 33.1-34.8 dBA, which can serve as a reference.	Natural, cultural, and recreational sound levels are generally consistent with the Historic Site's designated purpose, noise > 55 dB is beginning to be heard in many areas so as to cause occasional interference with normal conversation and annoyance among some visitors. Noise greater than approximately 65 dB is still quite rare.	The historic and natural sense of place is compromised due to frequent loud noise(s). Communication among interpreters and visitors is frequently interrupted by loud noise impacting visitor enjoyment and educational experience. Noise levels that might interfere with wildlife behavior and auditory signals, disrupt conversation or evoke annoyance (e.g., exceeding 55-60 dB) may occur.

We considered a moderate condition soundscape to be one where the designated uses for a higher activity area (e.g. parking lot) began to infiltrate into lower use zones (e.g., historic), noise-free intervals became only moderately common, and noise levels began to be heard throughout the Historic Site.

A significant concern soundscape condition was when noises became incongruent with Historic Site designated activities/purpose and/or were disruptive, regardless of the area within the park. Also, noises generated by military overflights, fast moving traffic, etc., were present.

These reference conditions are roughly divided into two main categories: (1) the effects of noise on the quality of visitor experience, and (2) the effect of location where noise is heard, which are described below.

Effects of Noise on Human Health (serves as a guide to help assess visitor soundscape experience)

There have been numerous studies on the effects of noise on human health and probably the most commonly studied effects are cardiovascular from exposure to noise. The World Health Organization (Berglund et al. 1999) suggests that even prolonged exposure to noise levels below 75dB will not result in noise induced hearing loss. They also conclude that prolonged exposure to air and road traffic noises above 65-70 dB are associated with cardiovascular effects, but this is from exposure times that far exceed what is likely to be encountered during a Historic Site visit. The threshold levels for responses such as raising of blood pressure are much lower. However, these human health responses, at the levels of noise exposure at Fort Larned NHS are not likely to cause any physical damage Thus, for the most part, noise levels exceeding thresholds for damage to human

health are not of high concern at Fort Larned NHS. The most likely exception to this is Historic Site staff operating machinery (e.g., mowers, tractors, etc.), although damage to human health is not of high concern, this does not imply that there are no physiological responses to noise.

Effects of Noise on Wildlife (serves as a guide to help assess visitor soundscape experience)

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

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

Effects of Noise on the Quality of Visitor Soundscape Experience

An essential component of the designated purpose of Fort Larned NHS relative to the soundscape is to provide for visitor enjoyment and education. A key element of this is maintaining a sense of place of the Fort such that visitors can visualize being back in time experiencing the sights, smells, and sounds of the 1860s-1870s. Historic Site staff engage in living history activities, depicting the time the Fort was active, which provides a context for the life during that period. From the historic setting of the Fort, with natural sounds of leaves rustling or birds singing, to the historic sounds of the day to day activities of life at Fort Larned, all are part of the education and enjoyment of being transported back in time. However, it is difficult to imagine being in the 1860s while a plane is flying overhead or a car horn is honking. Thus, we consider condition of the soundscape relative to a visitor being able to gain a sense of place in the Fort's setting, which includes natural and cultural sounds, and an enjoyable educational experience at the Fort. Condition is deteriorated when noise interrupts normal conversation and when such noise is frequent enough or loud enough to detract from the sense of place and/or to be annoying to visitors trying to appreciate the historic context of the Historic Site.

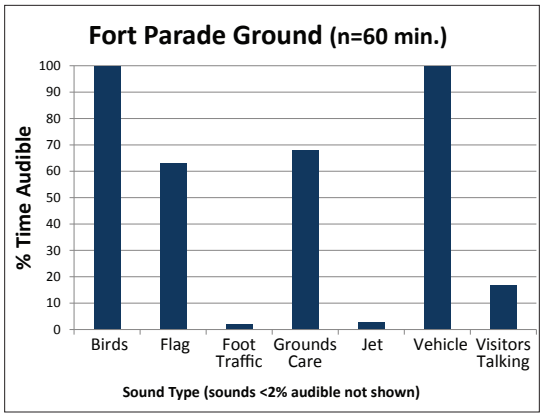
Effect of Location (Management Areas/ Zones) on Soundscape Condition.

Inherent in our condition assessment is how sounds are perceived by visitors and whether or not the sounds contribute or detract from visitor enjoyment. Whether or not sounds are perceived negatively depends not only on the type and amplitude of sound but also where they are heard. For example, a Historic Site visitor is probably going to be less annoyed by noises from vehicles if they are in the parking lot rather than walking along the nature trail.

Since the Historic Site is relatively small, we sampled only within the center of the parade grounds and along the Nature Trail. We did not record sounds within any of the Historic Site's developed areas since sounds heard at the two monitoring locations were likely heard within the developed zone/areas as well.

4.3.4. Condition and Trend

Overall, the most common sounds heard throughout the Historic Site during the on-site listening sessions included bird vocalizations, vehicles traveling along Highway 156, and NPS grounds maintenance,



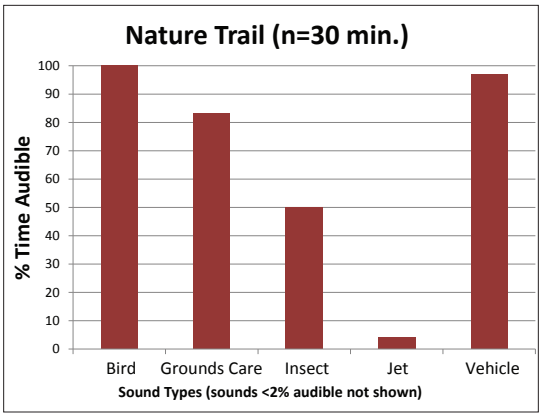


Figure 4.3.4-1. Sound sources heard and percent time audible at on-site monitoring locations.

including mowing, weed trimming, and heavy machinery operation(s) (Figures 4.3.4-1).

Audibility

The majority of sounds heard within the Fort's parade grounds were a mixture of natural and cultural sounds or noise. Bird vocalizations were the primary natural sounds heard during the 1-hour monitoring session. Additionally, vehicles traveling along the highway were also commonly heard. The most common cultural-related sound originated from the flag flapping, which is consistent with what is considered a desirable sound. Many noises generated from Historic Site operations, including mowing, weed trimming, and heavy machinery operations were heard often but not as frequently as either bird vocalizations or vehicles.

One important point worth mentioning is that while conducting the on-site listening in the center of the parade grounds, Historic Site staff were talking, thus it is likely that insect sounds were missed as a result of the conversation. The conversation was recorded as "people voices" and was omitted from our condition assessment. The overall percent time audible of noise heard at the Fort parade grounds was 100% (due to vehicles), warranting significant concern for this measure.

The noises heard along the Nature Trail were relatively similar to those heard within the Fort's parade grounds. Vehicles traveling both along the highway and Historic Site maintenance operations were most frequently heard. Bird vocalizations were heard 100% of the time, and insects were heard more often along the Nature Trail, which was expected due to the naturalized habitat adjacent to the trail. The overall percent time audible of all noise was 99%, warranting significant concern.

Sound Level (on-site listening results)

The Fort's soundscape was periodically punctuated by the louder noises of booming heavy machinery (i.e., crane operations) and mowing operations, but overall did not warrant concern due to the brief noise occurrences and the distance from the monitoring sites where the activities occurred. Also, area noise levels did not require a need to raise voices to continue a normal conversation, indicating a lower level of sound (Figure 4.3.4-2). Vehicle noise was distant at both on-site listening locations (therefore lower decibel level), resulting in a relatively unobtrusive noise level. Overall, we consider this measure to be in good condition at both monitoring locations.

Sound Level (park-wide/regional model results)

The model results for the natural ambient and existing sound levels across the entire Historic Site ranged from 33.1-34.8 dBA and 39.4-43.8 dBA, respectively (Mennitt et al. 2013 and E. Lynch, NSNSD, pers. comm.) (Figure 4.3.4-2). Mennitt et al. (2013) suggested that in a natural environment, the average summertime L_{50}, which is the sound level exceeded half of the time and is a fair representation of expected conditions, is not expected to exceed 41 dBA.

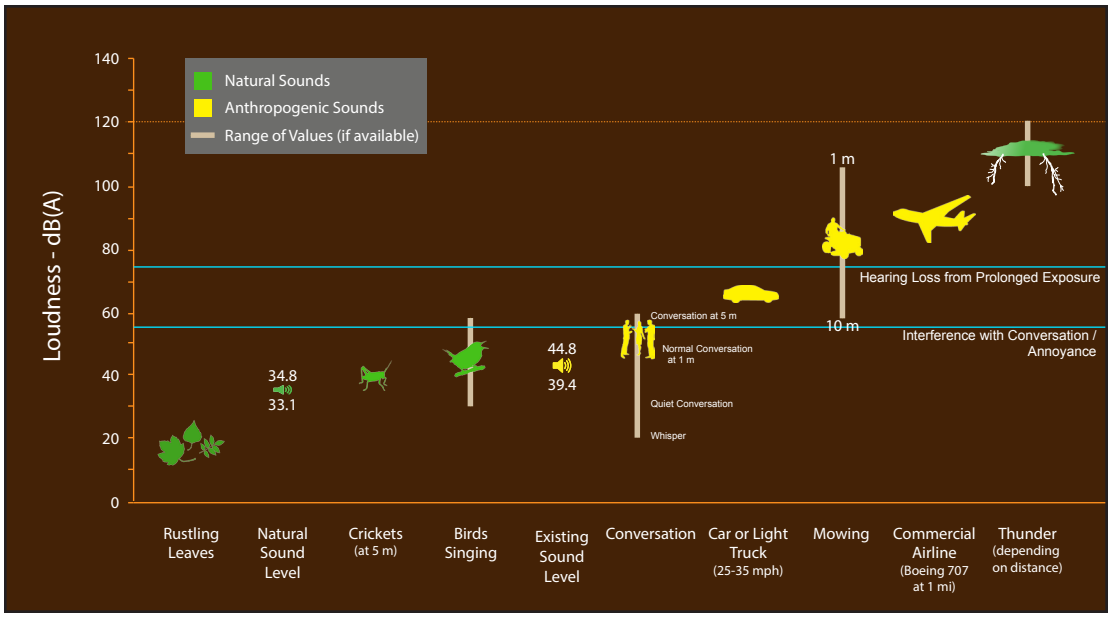


Figure 4.3.4-2. Approximate sound levels for sounds heard at the Historic Site (at specified distances), and modeled sound levels for Fort Larned NHS (Mennitt et al. 2013).

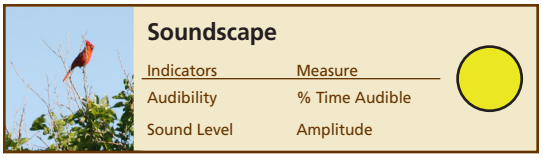
The modeled natural sound level range was 33.1 - 34.8 dBA (located between rustling leaves and crickets) and the modeled existing sound level range was 39.4 - 43.8 dBA (between singing birds and human conversation).

The difference between these two ranges is 6.3-9.0 dBA and is referred to as the impact level. According to Mennitt et al. (2013), "an impact of 3dBA suggests that anthropogenic noise is noticeable at least 50% of the hour or more." NSNSD also provides soundscape reference conditions for the purposes of *The State of the Park* reports, which groups parks into urban versus non-urban. If we consider the Historic Site as a non-urban park, the threshold for significant concern is an impact level that is greater than three. If we consider the Historic Site to be an urban park, the threshold for moderate concern is interpreted to be an impact level between 6-12 dBA. We consider Fort Larned NHS fit somewhere between urban and non-urban, which results in a moderate concern for sound levels based on Mennitt et al. (2013) sound model.

Additional Noises

Agricultural land surrounds the Historic Site's boundary and while noises from farm machinery were not heard during the on-site listening sessions, they most likely contribute to the type of noises periodically heard within the Historic Site (Figure 4.3.4-3).

Additionally, noise from jets was heard during both on-site recording sessions but were quite distant and infrequent. An unknown is whether the number of planes increases by hour and/or day and thereby increases the noise levels heard throughout the Historic Site more often than what our limited assessment captured.



Overall Condition

For assessing the condition of the Historic Site's soundscape, we used two indicators and three measures, which are summarized in Table 4.3.4-1.

In general, the most common sounds heard, with the highest percent time audible at both locations were bird vocalizations and traffic traveling along Highway 156. The wind was calm during the on-site listening sessions but is known for its masking /dampening effect on one's ability to hear other sounds. Moderate to high winds are common in the wide open prairie where Fort Larned NHS is located and most likely plays a role in masking the highway noise that was so prevalent during our on-site listening session.

The percent time audibility of noises accounted for 99-100% of the recording time. As a result of considering this factor, as well as weighing the remaining measures, we consider the overall soundscape condition to be of moderate concern with an unknown trend.

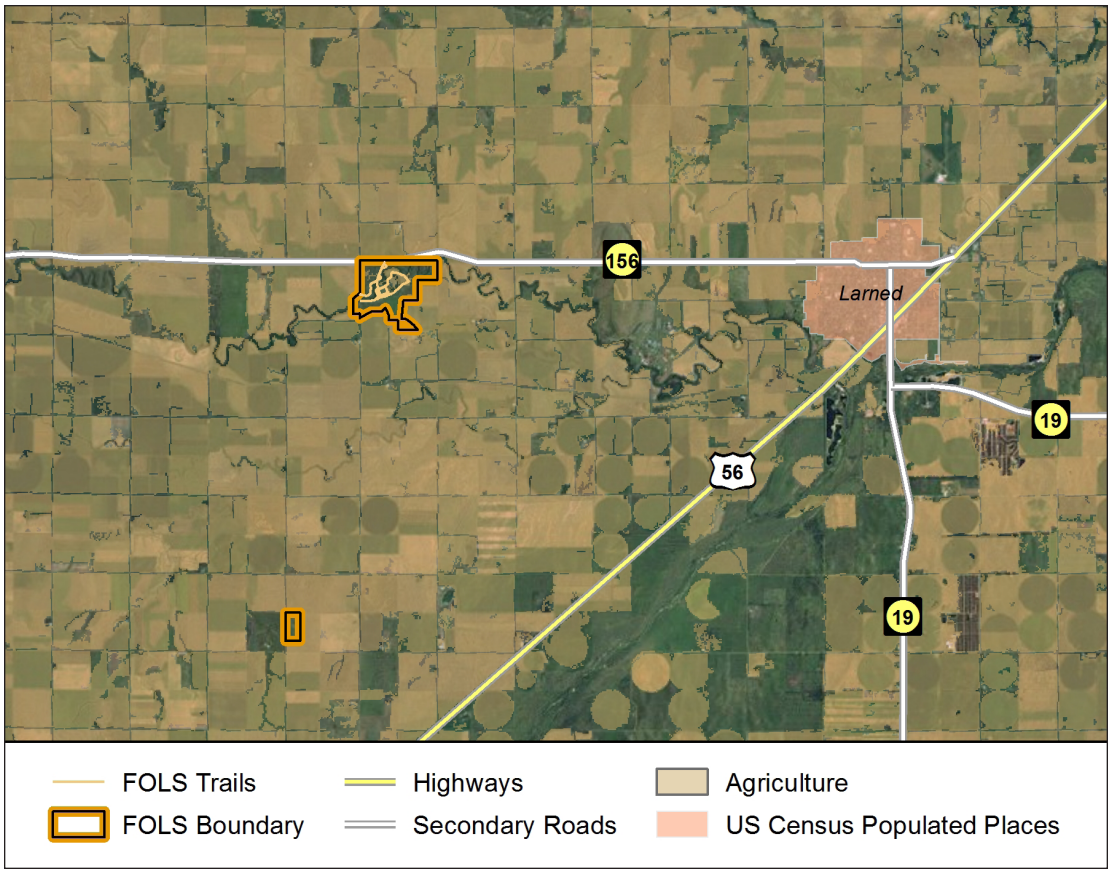


Figure 4.3.4-3. Surrounding developments and land uses that potentially contribute to the noises heard throughout the Historic Site.

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

Indicators of Condition	Measures	Condition	Rationale for Condition
Audibility	% Time Audible	Significant Concern	The percent time audible of all non-natural/cultural sounds was 99-100%, indicating that noises were almost always heard. Due to the presence of continuous noise at both monitoring locations, we consider the percent time audibility of noises to be of significant concern.
Sound Level	Amplitude of sound Level Impact (park-wide/regional model)	Moderate Concern	The modeled impact sound level for the Historic Site ranged between 6.3-9.0 dBA. This range is within a threshold for moderate concern when evaluating a park classified between a non-urban and urban park using NSNSD thresholds.
	Amplitude (of sounds at on-site monitoring locations)	Good	The louder on-site noises originated from Historic Site maintenance operations. Overall, few noises heard were loud enough to warrant concern. Consequently, we considered this measure to be in good condition.

Level of Confidence and Key Uncertainties

This was a very brief, rapid assessment of the Historic Site's soundscape, establishing a relative baseline for a future quantitative assessment or for similar future rapid assessment comparisons. With such a small dataset and short sample period, our confidence is low. But given the sound level model produced by Mennitt et al. (2013), the confidence level in our evaluation of the soundscape condition throughout the Historic Site is of medium confidence.

4.3.5. Sources of Expertise

The NPS Natural Sounds and Night Skies Division scientists help parks manage sounds

in a way that balances the various expectations of park visitors with the protection of park resources. They provide technical assistance to parks in the form of acoustical monitoring, data collection and analysis, and in developing acoustical baselines for planning and reporting purposes.

The NSNSD provided an NRCA soundscape template, which was used to develop Fort Larned NHS' soundscape assessment. They also loaned the PDA for recording sounds at the Historic Site and generated reports from which we based our discussion on. For more information, see http://www.nature.nps.gov/sound/. Finally, they provided the sound model results and maps, which are included in Appendix D.

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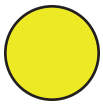
4.4. Air Quality

Indicators/Measures

- Visibility
- Level of Ozone
- Atmospheric Wet Deposition in Total N and Total S

Condition – Trend – Confidence



Moderate - Indicator Specific - Medium

4.4.1. Background and Importance

Under the direction of the NPS' Organic Act, Air Quality Management Policy 4.7.1 (NPS 2006), and the Clean Air Act (CAA) of 1970 (U.S. Federal Register 1970), the NPS has a responsibility to protect air quality and any air quality related values (e.g., scenic, biological, cultural, and recreational resources) that may be impaired from air pollutants.

One of the main purposes of the CAA is "to preserve, protect, and enhance the air quality in national parks" and other areas of special national or regional natural, recreational, scenic or historic value. The CAA includes special programs to prevent significant air quality deterioration in clean air areas and to protect visibility in major national parks and wilderness areas (NPS-ARD 2012a).

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

These classes are allowed different levels of permissible air pollution, with Class I receiving the greatest protection and strictest regulation. The CAA gives federal land managers responsibilities and opportunities to participate in decisions being made by regulatory agencies that might affect air quality in the federally protected areas they administer (NPS-ARD 2012b).

It's important to note that even though the CAA gives Class I areas the greatest protection against air quality deterioration, NPS management policies do not distinguish between the level of protection afforded to any unit of the National Park System (NPS 2006).

Air Quality Standards

Air quality is deteriorated by many forms of pollutants that either occur as primary pollutants, emitted directly from sources such as power plants, vehicles, wildfires, and wind-blown dust, or as secondary pollutants, which result from atmospheric chemical reactions. The CAA requires the Environmental Protection Agency (EPA) to establish National Ambient Air Quality Standards (NAAQS) (40 CFR part 50) to regulate these air pollutants that are considered harmful to human health and the environment (EPA 2012a). The two types of NAAQS are primary and secondary, with the primary standards establishing limits to protect human health, and the secondary standards establishing limits to protect public welfare from air pollution effects, including

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Figure 4.4.1-1. Fort Larned National Historic Site is a Class II airshed.

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Figure 4.4.1-2. A clear morning at Fort Larned National Historic Site.

decreased visibility, damage to animals, crops, vegetation, and buildings (EPA 2012a).

The NPS' Air Resources Division (NPS-ARD) air quality monitoring program uses EPA's NAAQS, natural visibility goals, and ecological thresholds as benchmarks to assess current conditions of visibility, ozone, and atmospheric deposition throughout park service areas.

Visibility affects how well (acuity) and how far (visual range) one can see (NPS-ARD 2002), but air pollution can degrade visibility. Both particulate matter (e.g. soot and dust) and certain gases and particles in the atmosphere, such as sulfate and nitrate particles, can create haze and reduce visibility.

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

Ozone is a gaseous constituent of the atmosphere produced by reactions of nitrogen oxides (NO_x) from vehicles, powerplants, industry, and fire and volatile organic compounds from industry, solvents, and vegetation in the presence of sunlight (Porter and Biel 2011). It is one of the most widespread air pollutants (NPS-ARD 2003), and the major constituent in smog. Ozone can be harmful to human health, and it is also phytotoxic, causing foliar damage to plants (NPS-ARD 2003). The foliar damage requires the interplay of several factors, including the interaction of the plant to the ozone, the level of ozone exposure, and the exposure environment. The highest ozone risk exists when the species of plants are highly sensitive to ozone, the exposure levels of ozone significantly exceed the thresholds for foliar injury, and the environmental conditions, particularly adequate soil moisture, foster gas exchange and the uptake of ozone by plants (Kohut 2007).

Ozone penetrates leaves through stomata (openings) and oxidizes plant tissue, which alters the physiological and biochemical processes (NPS-ARD 2012c). Once the

ozone is inside the plant's cellular system, the chemical reactions can cause cell injury or even death (NPS-ARD 2012c), but more often reduces the plant's resistance to insects and diseases, reduces growth, and reduces reproductive capability (NPS-ARD 2012d).

Air pollutants can be deposited to ecosystems through rain and snow (wet deposition) or dust and gases (dry deposition). Nitrogen and sulfur air pollutants are commonly deposited as nitrate, ammonium, and sulfate ions and can have a variety of effects on ecosystem health, including acidification, fertilization or eutrophication, and accumulation of toxins (NPS-ARD 2010a). Atmospheric deposition can also change soil pH, which in turn, affects microorganisms, understory plants, and trees (NPS-ARD 2010a). Certain ecosystems are more vulnerable to nitrogen or sulfur deposition than others, including high-elevation ecosystems in the western United States, upland areas in the eastern part of the country, areas on granitic bedrock, coastal and estuarine waters, arid ecosystems, and some grasslands (NPS-ARD 2010b). Increases in nitrogen have been found to promote invasions of fast-growing annual grasses (e.g., cheatgrass) and exotic species (e.g., Russian thistle) at the expense of native species (Brooks 2003, Allen et al. 2009, Schwinning et al. 2005). Increased grasses can increase fire risk (Rao et al. 2010), with profound implications for biodiversity in non-fire adapted ecosystems. Nitrogen may also increase water use in plants like big sagebrush (Inouye 2006).

According to the EPA, in the United States, roughly two thirds of all SO_2 and one quarter of all NO_x come from electric power generation that relies on burning fossil fuels. Sulfur dioxide and nitrogen oxides are released from power plants and other sources, and ammonia is released by agricultural activities, feedlots, fires, and catalytic converters. In the atmosphere these transform to sulfate, nitrate, and ammonium and can be transported long distances across state and national borders, impacting resources (EPA 2012b), including at Fort Larned National Historic Site.

4.4.2. Data and Methods

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

Indicators/Measures

Visibility

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

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

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

An IMPROVE monitoring station (ID: CEBL1) is located in Trego County, Kansas and is within the required monitoring distance of 100 km to determine a trend for visibility.

Indicators/Measures

Level of Ozone

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

Indicators/Measures

Atmospheric wet deposition in total N and total S

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

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

4.4.3. Reference Conditions

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

Visibility

A visibility condition estimate of less than 2 dv above estimated natural conditions indicates a "good" condition, estimates ranging from 2-8 dv above natural conditions indicate "moderate" condition, and estimates greater than 8 dv above natural conditions indicate "significant concern." Although the dv ranges of these categories were selected somewhat subjectively, the NPS-ARD chose them to reflect the variation in visibility conditions across the monitoring network as closely as possible.

Ozone

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

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

Wet Deposition

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

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

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

Source: NPS-ARD 2010b

Table 4.4.4-1. Condition results for air quality indicators at Fort Larned NHS.

Data Span	Ozone (ppb)	Visibility (dv)	Total N (kg/ha)	Total S (kg/ha)
2006-2010	Moderate (69.7)	Significant Concern (9.2)	Significant Concern (4.0)	Moderate (1.7)

Source: D. NPS-ARD (2012 e,f,g) Air Quality Estimate Tables

Table 4.4.4-2. Ozone sensitive plants found at Fort Larned NHS (NPS-ARD 2006).

Scientific Name	Common Name	Bioindicator
Apocynum cannabinum	Indianhemp	No
Artemisia ludoviciana	Silver wormwood	Yes
Asclepias syriaca	Common milkweed	Yes
Cercis canadensis	Redbud	Yes
Fraxinus pennsylvanica	Green ash	No

4.4.4. Condition and Trend

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

Visibility

All visibility data used to assess condition were derived from NPS ARD Air Atlas interpolated five-year average values (2006-2010) (NPS-ARD 2012e). The 5-year interpolated values average for the Historic Site's visibility condition fell within the significant concern condition rating, which indicates visibility is degraded from the good reference condition of <2 dv above the natural condition. A visibility trend (2000-2009) was reported for Fort Larned as improving using the Cedar Bluffs IMPROVE monitoring site (NPS-ARD 2013). Visibility improved on the haziest days and showed no trend on the clearest days. Overall, we consider visibility to be improving, as the goal of the Regional Haze Rule is to improve visibility on the haziest days and allow no degradation on the clearest days.

Ozone

Ozone data for the Historic Site were derived from the five-year interpolated values average (2006-2010) (NPS-ARD 2012f), which resulted in a moderate ozone condition ranking for Fort Larned.

A list of ozone sensitive species by park is available at NPSpecies - https://irma.nps.gov/NPSpecies/Report. Five ozone-sensitive plant species found within Fort Larned, three of which are ozone bioindicators (Table 4.4.4-2) (NPS-ARD 2006).

Wet Deposition

The data for atmospheric wet deposition condition were derived from NPS-ARD's 2006-2010 interpolated values (NPS-ARD 2012g). The average value for total nitrogen resulted in a significant concern condition rating and the condition rating was moderate for total sulfur.

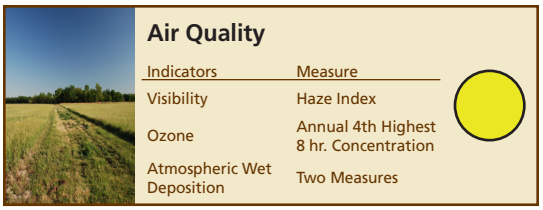
Sullivan et al. (2011a), studied the risk from acidification for acid pollutant exposure and ecosystem sensitivity for Southern Plains parks, including the Historic Site. Pollutant exposure included the type of deposition (i.e., wet, dry, cloud, fog), the oxidized and reduced forms of the chemical, if applicable, and the total quantity deposited. The ecosystem sensitivity considered the type of terrestrial and aquatic ecosystems present at the Historic Site and their inherent sensitivity to the atmospherically deposited chemicals. These risk rankings for Fort Larned NHS were considered moderate for acid pollutant exposure and very low for ecosystem sensitivity to acidification.

Sullivan et al. (2011b), also developed risk rankings for nutrient N pollutant exposure and ecosystem sensitivity to nutrient N enrichment, and were ranked as moderate and high, respectively. Arid ecosystems have been found to be very sensitive to nitrogen deposition, which can promote invasions of annual grasses, with subsequent displacement

of native forbs and shrubs and increased fire risk

In general, nitrate, sulfate, and ammonium deposition levels have changed over the past 20 years throughout the United States (Figure 4.4.4-1). Regulatory programs that mandated a reduction in emissions have proven effective for decreasing both sulfate and nitrate ion deposition primarily through reductions from electric utilities, vehicles, and industrial boilers, although a rise in ammonium ion deposition has occurred in large part due to the agricultural and livestock industries (NPS-ARD 2012h). A new study conducted by Lehmann and Gay (2011), indicated a decrease in sulfate concentrations from 1985-2009 in the area surrounding the Historic Site, and a potential decrease in nitrate concentrations. The observed decrease was statistically significant for sulfate concentrations only.

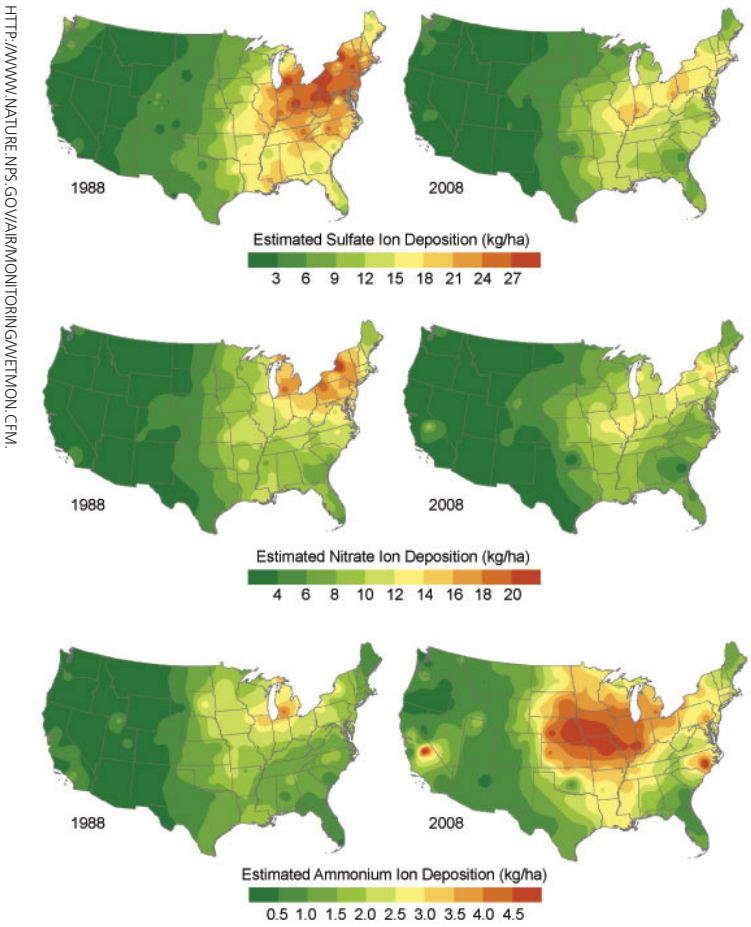
It seems reasonable to expect a continued improvement in sulfate deposition levels because of Clean Air Act requirements, however, at this time, ammonium levels are not regulated by the EPA and may continue to rise as a result (NPS-ARD 2010a).



Overall Condition and Trend

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

We consider the overall condition of air quality at Fort Larned National Historic Site to be of a moderate concern with a medium confidence level due to the interpolated values. Trends for ozone and atmospheric wet depostion could not be derived since air quality monitoring sites are not located near enough to be representative of the conditions at the Historic Site. An ozone monitor is considered representative if it is located within 10 km (6 miles) of a park; a deposition sampler is considered representative if it is within 16 km (10 miles) of a park. A visibility monitor is considered representative if it is within 100 km (60 miles) of a park, so data from the Cedar Bluff IMPROVE monitor can be used to characterize trends at the Historic Site, which is improving.



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

Figure 4.4.4-1. Change in wet deposition levels From 1988-2008 throughout the United States.

Level of Confidence/Key Uncertainties

The key uncertainty of the air quality section is knowing the effect(s) of air

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

Indicator	Measure(s)	Condition	Condition Rationale
Visibility	Haze Index	Significant Concern	For 2006–2010, estimated average visibility in the Historic Site was 9.2 deciviews above natural conditions, therefore, the condition status warrants significant concern based on NPS Air Resource Division benchmarks. From 2000-2009, visibility improved on the haziest days, while visibility on the clearest days showed no trend.
Level of Ozone	Annual 4th-Highest 8-hour Concentration	Moderate	The estimated ozone level for 2006–2010 at the Historic Site was 69.7 parts per billion, therefore, the condition status warrants moderate concern based on NPS Air Resource Division benchmarks. Five ozone-sensitive plants are found in the Historic Site, three of which are bioindicators. No trend information is available because there are not sufficient on-site or nearby ozone monitor stations.
Atmospheric Wet Deposition in Total N and total S	Total N in kg/ha/yr	Significant Concern	For 2006–2010, estimated wet nitrogen deposition was 4.0 kilograms per hectare per year, therefore, the condition status warrants significant concern based on NPS Air Resource Division benchmarks. No trend information is available because there are not sufficient on-site or nearby wet deposition monitor stations.
	Total S in kg/ha/yr	Moderate	For 2006–2010, estimated wet sulfur deposition was 1.7 kilograms per hectare per year, therefore, the resource is in moderate condition based on NPS Air Resource Division benchmarks. No trend information is available because there are not sufficient on-site or nearby wet deposition monitor stations.

pollution, especially nitrogen deposition, on ecosystems at Fort Larned.

4.4.5. Sources of Expertise

The National Park Service's Air Resources Division oversees the national air resource management program for the NPS. Together with parks and NPS regional offices, they monitor air quality in park units; provide air quality analysis and expertise related to all air quality topics.

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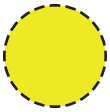
4.5. Geology

Indicators/Measures

- Geologic Integrity

Condition - Trend - Confidence



Moderate - Unknown - Low

This section is extracted from the Geologic Resources Evaluation Scoping Summary (KellerLynn 2008) for Fort Larned National Historic Site. For more information, go to http://www.nature.nps.gov/geology/inventory

4.5.1. Background and Importance

Geologic resources serve as the foundation of ecosystems and yield important information needed for science-based decision making in National Park System units. Geology is a major determinant of topography, water and soil chemistry, fertility of soils, stability of hill slopes, and flow styles of surface water and groundwater. These factors, in turn, influence biology, including the distribution of habitats and the locations of threatened and endangered species. Geology also influences human settlement patterns and how people use natural resources—for farming, ranching, industry, construction, hunting, fishing, and recreation.

Named for Col. Benjamin F. Larned, paymaster general of the District of Kansas and the Territories at the outset of the Civil War, Fort Larned NHS was established in 1859 on the vast prairie in western Kansas near the midpoint of the Santa Fe Trail. For many years Fort Larned NHS was the only post between Fort Leavenworth, Kansas and Fort Lyon, Colorado (Figure 4.5.1-1). Troops stationed there were instrumental in protecting mail coaches, freighters, and other traffic along the trail. As the site of an Indian agency, Fort Larned NHS was also instrumental in maintaining friendly relations with Plains Indians. This area was the hunting grounds for the Comanche, Kiowa, Arapahos, and Southern Cheyenne; some Pawnee, Sioux, and Plains Apache also moved through the area. The "settlers' complex" at the Fort, including a hardware store, mess hall, bar, and residences, was a "melting pot" of culture.

Many historically famous people, such as Buffalo Bill and Kit Carson, were stationed at Fort Larned NHS. Civil War hero George Armstrong Custer was posted in and around

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Figure 4.5.1-1. Fort Larned National Historic Site was the only post between Fort Leavenworth, Kansas and Fort Lyon, Colorado, near the mid-point of the Santa Fe Trail..

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Figure 4.5.1-2. Many of the buildings at Fort Larned NHS have been restored and refurbished.

Fort Larned NHS in the late 1860s. As part of the Hancock expedition in 1867, Custer encountered his first plains Indians and wild buffalo at the site.

After its reign as guardian of the northern portion of the Santa Fe Trail, the Fort became private property and the center of a large ranching operation. Congressman Bob Dole was instrumental in the establishment of Fort Larned National Historic Site (NHS) in 1968. Since that time, the National Park Service has restored the Fort, including 12 historic buildings, to the 1860s period. Restoration returned structures to their original appearance and included period furnishings (Figure 4.5.1-2). Today the 120-ha (300 ac) Historic Site is one of the nation's best-preserved, mid-19th-century western military posts. Visitors have the opportunity to experience military life on the Santa Fe Trail during reenactments on summer holiday weekends (Memorial Day and Labor Day weekends) and selected weekends throughout the year (during "Candlelight Tour" and "Christmas Past"). Cavalry personnel, cooks, and soldiers demonstrate "living history" for the interpretive period 1860–1869.

A separate unit preserves the historic ruts that a constant succession of freight caravans created from 1860 to 1878 along the Santa Fe Trail (Figure 4.5.1-3).

Located 10 km (6 mi) west of Larned, Kansas, Fort Larned NHS bridges the Smoky Hills and Arkansas (pronounced "Ar-Kansas" by Kansans) River physiographic regions. The Fort is located on the floodplain of the Pawnee River; specifically a broad, flat alluvial plain consisting of Quaternary sand, gravel, silt, and clay. Lower Cretaceous Dakota Formation (shale and sandstone layers), Graneros Shale, and Greenhorn Limestone underlie pasture lands north of the Fort. Located 7 km (4 mi) southwest of the Fort unit, the detached Santa Fe Trail Ruts unit lies on gently rolling uplands of Dakota sandstone. Both units lie on the western edge of the Kansas' mixed-grass prairie region.

Fort Larned NHS is situated at the confluence of the Pawnee and Arkansas rivers. Apparently, access to water influenced the decision of where to locate the Fort. The meandering river and related oxbow gave natural protection on three sides of the Fort, leaving only the south side open, which is flat for miles, giving a good view of any approaching intruders. Shallow groundwater in the alluvium provided an additional source of water.

4.5.2. Data and Methods

This limited assessment summarizes the findings from a geologic resource evaluation scoping summary conducted by the National Park Service Geologic Resources Division (KellerLynn 2008). The scoping included

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Figure 4.5.1-3. Ruts made by wagon wheels along the Santa Fe Trail are still seen in the "ruts unit" of Fort Larned National Historic Site.

meetings with park staff and geologic experts to identify geologic issues, features, and processes. For more information about the Geologic Resources Division, visit http://www.nature.nps.gov/geology/.

4.5.3. Reference Conditions

In parks that do not have a geologic resource focus, that is, they do not have significant canyons or volcanoes or other prominent geologic features, no specific indicators or measures have been identified by which to assess geologic condition. In these cases, we use professional judgment and qualitative assessment of general geologic integrity to assign condition class and level of confidence, described in Table 4.5.3-1.

Good condition is assigned to parks where no concerns or issues about geologic resources have been identified. Geologic resources and processes are in a generally natural state and function.

Moderate condition is assigned to parks if there are some areas of moderate concern either inside the park, or outside the park that may impact it. Examples of this could be moderate disturbance due to soil erosion or mining exploration in the region.

Significant concern is assigned to parks that have identified areas of concern in assessments conducted by the NPS Geologic Resources Division or have significant impacts occurring inside or outside the park that have the potential to impact park resources.

Level of confidence is assessed depending on the level of information we have on which to base the condition assessment. A Geologic Resources Inventory Report produced by the NPS Geologic Resources Division, or similar report produced by the U.S. Geological Survey or state geologic survey specifically focused on a park's geology, results in a high confidence level for the assessment.

Table 4.5.3-1. Qualitative description for determining condition of geologic resources.

Class	Description
Good Condition	No concerns or issues about geologic resources have been identified. Geologic resources and processes are in a generally natural state and function.
Moderate Concern	Some areas of moderate concern either inside the park, or outside the park that may impact it. Examples of this could be moderate disturbance due to soil erosion or mining exploration in the region.
Significant Concern	Areas of conern have been identified in assessments conducted by the NPS Geologic Resources Division or significant activities are occurring outside the park that have the potential to impact park resources.

A Geologic Resources Scoping Report (or the equivalent) provides a moderate level of confidence. If a Scoping Summary is all that is available and little is known or available about the geologic resources, then a low confidence level is assigned.

4.5.4. Condition and Trend

Specific indicators and measures related to soil erosion are presented in section 4.9 on grasslands. Based on the level of assessment that has been completed to date, no specific areas of geologic concern have been identified, therefore, the condition is considered moderate until further assessment can be conducted.

The following discussion on geologic issues and geologic processes are excerpts summarized from the geologic scoping summary (KellerLynn 2008).

Geologic Issues

Geologic issues are those that may warant attention from resource managers at Fort Larned NHS as they are relevant for maintenance of facilities, mitigation of hazardous conditions, and protection of resources.

Disturbed Lands

Disturbed lands are those parklands where the natural conditions and processes have been directly impacted by mining, oil and gas production, development (e.g., facilities, roads, dams, abandoned campgrounds, and user trails), agricultural practices (e.g., farming, grazing, timber harvest, and abandoned irrigation ditches), overuse, or inappropriate use.

Modern mining is a management concern for Fort Larned NHS. Northwest of the Fort is an active quarry for fencepost limestone. Dakota sandstone is mined in Larned. Perhaps the greatest concern, however, is sand and gravel extraction in the Arkansas River south of Larned, which could also occur in the Pawnee River valley. All of these operations are outside of the site's boundary.

Another management issue is agricultural activity, which surrounds the Historic Site. No farming or grazing has occurred at Fort Larned NHS since 1968, and much of the landscape is restored prairie. In 2004 a biological inventory estimated that 76% of Fort Larned NHS is formerly cropped grassland that has undergone continuing prairie restoration, where management includes controlled burns.

Energy Development

Fort Larned NHS is surrounded by oil and gas wells, primarily to the north and west. The closest active operation (at the time of writing, KellerLynn 2008) is the Fort Larned Field, 0.8 km (0.5 mi) north of Larned. Most wells were drilled in the 1970s at depths of approximately 610 m (2,000 ft).

Another concern for energy development is wind energy. Kansas already hosts wind farms, with proposed development 5 km (3 mi) north of the Historic Site. The concern is primarily for the preservation of views (see section 4.1).

Fluvial Processes and Surface Water

Geologists characterize the landscape of Fort Larned NHS as an alluvial valley with meandering streams. The Fort was built on Pawnee River alluvium. An oxbow feature, probably with historical significance, is part of the landscape and influenced the positioning of the Fort. This feature was shown in original drawings of the quarter master.

Fort Larned NHS lies within the drainage area of the Pawnee River, which empties into the Arkansas River. Today as a result of irrigation practices, the streambeds are dry, and both the Pawnee and Arkansas rivers flow only after significant precipitation events. Flooding is rare, at least in the past decade. Irrigation and other agricultural practices have facilitated soil erosion on the Pawnee River, which has increased turbidity levels and eliminated much of the riparian vegetation.

Seismic Features and Processes

The risk of a large earthquake in the vicinity of Fort Larned NHS is low, however, historic records document at least 25 earthquakes between 1867 and 1976, and seismographs recorded more than 100 between 1977 and

1989 in Kansas (KellerLynn 2008). Most of these were microearthquakes and too small to be felt. The largest recorded earthquake in Kansas hit the Manhattan area in 1867. It toppled chimneys and cracked foundations and was felt as far away as Dubuque, Iowa. Closer to the Historic Site, a magnitude IV earthquake on the modified Mercalli scale (magnitude 3 or 3.5 on the Richter scale) occurred in Ford County in 1904. In 1929, a magnitude V earthquake on the modified Mercalli scale (magnitude 3.5 or 4 on the Richter scale) was felt in Geary County.

Paleontological Resources

A Paleontological Resource Inventory and Monitoring produced by the Southern Plains Network (Koch and Santucci 2003) states that no discoveries of paleontological resources have been made within the boundaries of Fort Larned NHS; however, there have been suggestions that extinct Pleistocene fauna may occur within and below a 10,000-year-old paleosol within the Historic Site (Rolfe Mandel, University of Kansas and Kansas State University, e-mail, May 19, 2008 in KellerLynn 2008). Mandel's dissertation study area included Fort Larned NHS, and he took deep cores on the property and as a result has interpreted the landscape and underlying valley fills (see Mandel 1994). According to correspondence on May 19, 2008, "Most of the property is on the T-1 terrace of the Pawnee River. There is a prominent buried paleosol about 3.5 m below the T-1 surface, and organic carbon from the upper 10 cm of the paleosol yielded a radiocarbon age of 10,100±130 years B.P. Hence, there is high potential for Paleoindian cultural deposits associated with the buried paleosol, and extinct Pleistocene fauna may occur within and below the paleosol" (KellerLynn 2008).

Although not *in situ*, the Greenhorn Limestone used in the Fort buildings is fossiliferous, and Cretaceous (145 million to 66 million years ago) Inoceramus clams are onsite in the Fort's building stone.

Unique Geologic Resources

Perhaps the most distinctive resource related to geology at the Historic Site is the wagon ruts along the Santa Fe Trail. Some concern has been expressed for preservation as a result of erosion from recently plowed fields and prairie dogs. Filling of the ruts with windblown dust is not a concern.

Geologic Features and Processes

Climate Change

Climate change has the potential to impact park resources such as scenery, environmental quality, and natural and cultural resources. Drought cycles at Fort Larned NHS may change as a result of climate disruption, which would affect the regularity of dust storms..

Eolian Features and Processes

Winds at Fort Larned NHS are constant with only rare periods of calm. Not surprisingly, loess (windblown dust) covers much of the area, including uplands and rolling farmlands (National Park Service 1979). Though not in the Historic Site itself, sand dunes are part of the landscape. Dunes occur in the Arkansas River corridor, primarily south and east of Larned. The source of eolian material is fluvially deposited Rocky Mountain sediments that have been reworked by the wind. Active dunes occur in pasturelands as close as 0.8 km (0.5 mi), but typically within 5 or 6 km (3 or 4 mi) of the river. These are younger and steeper than the dunes farther south, which are stabilized with vegetation or part of croplands.

Building Stone

The location of the Fort provided access to building materials: Cretaceous bedrock, such as Greenhorn Limestone and the Dakota Formation (shale and sandstone layers), are exposed in the uplands and outcrops in the vicinity of the Fort.

Greenhorn Limestone has a distinctive layer known as "fencepost limestone," which was used for that purpose and as building stone. Many window sills and thresholds at the Fort are made of Greenhorn Limestone. Locally, Greenhorn Limestone is referred to as "shell rock" because of the clam fossils it contains.

Another harder, denser (than Greenhorn) limestone was also used in thresholds at the Fort. Described as "Kansas marble," this is

Table 4.5.4-1. Qualitative description for determining condition of geologic resources.

Indicator of Condition	Measure	Condition	Rationale for Condition
Geologic Integrity	None	Moderate	The integrity of the geologic resources at Fort Larned NHS is in moderate condition. The Historic Site is surrounded by agriculture and the potential for soil erosion and disturbance; mining and oil and gas development in the area around the site is also a concern. A geologic resource evaluation scoping summary was completed in 2008.

perhaps Funston Limestone, possibly from near Fort Riley (formerly known as Fort Funston). Smaller blocks of this same stone (perhaps waste material from trimming and the thresholds) were used sporadically in the walls on the backsides of some of the buildings.

Both randomly shaped and cut blocks of Dakota sandstone are used in the buildings at Fort Larned NHS. Walls are generally between 0.6 and 1.2 m (2 and 3 ft) thick. Apparently, older buildings (earlier in the building process) are composed of irregularly shaped blocks; later, blocks were dressed and fitted. Fort builders extracted Dakota sandstone from a quarry at Jenkins Hill, about 0.8 km (0.5 mi) from the Historic Site. Some visitors and inhabitants of the Fort chipped their names and a date into the building stones at the Fort, which add to the historic nature of the buildings.

The red, iron-stained rock of Pawnee Rock is Dakota sandstone. Pawnee Rock was an important landmark along the Santa Fe Trail and the site of Indian battles. Although Pawnee Rock is historically significant and periodically considered for inclusion as part of the Historic Site, it is not currently included in the site.

Overall Condition

Table 4.5.4-1 clearly states how condition is assessed. The condition of the geologic resources at Fort Larned NHS is moderate due to the extent of soil disturbance and extractive industries surrounding the site, with a low level of confidence.

4.5.5. Sources of Expertise

The National Park Service's Geologic Resources Division conducts geologic inventories and resource evaluations, and produces digital geologic maps in close partnership with the Inventory and Monitoring Program, park staff, and partners. This section is based entirely on a scoping summary report (KellerLynn 2008) produced by the Geologic Resources Division, and was reviewed by Bruce Heise, Geologist at the National Park Service Geological Resources Division. Vincent Santucci, Paleontologist for the National Park Service, reviewed the section on Paleontological resources.

4.5.6. Literature Cited

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4.6. Surface Water Quality

Indicators/Measures

- Core Water Quality (5 measures)

Condition – Trend – Confidence

Insufficient Data - Unknown -Low

4.6.1. Background and Importance

Streams and rivers are the integrators within a landscape. They depend upon inputs, such as energy and nutrients, from within their watershed, which in turn, support a wide variety of services including habitat for plants and animals, hydrologic cycling, nutrient processing, recreational opportunities, as well as water supply for public and private uses. Since streams and rivers are generally sensitive to stressors, both locally and at the watershed-level, they are one of the most useful ecosystems to monitor to determine long-term conditions and trends (NPS I&M 2012).

NPS Management Policies (2006) state that parks must work with other governmental agencies to obtain Clean Water Act standards, take necessary action to maintain or restore surface water quality to the standards of the Clean Water Act or to meet federal, state, or local laws and regulations standards, and to create partnerships with other agencies to maximize resources and expertise to maintain or restore park water resources.

Southern Plains Inventory and Monitoring Network (SOPN) has identified two vital signs for monitoring and assessing surface water: water quality and water quantity (Perkins et al. 2005). Fort Larned National Historic Site contains one primary water resource, the Pawnee River (Figure 4.6.1-1). Although once a clear, sandy perennial river, its flow is now intermittent following rainfall events and relatively stagnant. Given the land use changes in the region, it is unlikely that the river will return to its original state. Thus, at the present time, the primary monitoring being considered at the Historic Site is measuring flow and core water quality

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Figure 4.6.1-1
The Pawnee River in Fort Larned NHS was dry during this 2013 assessment.

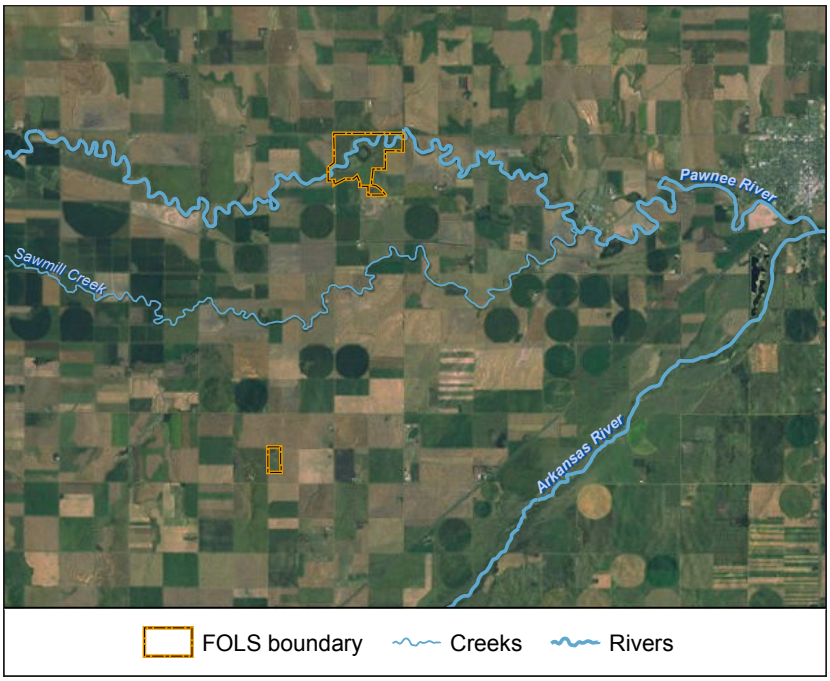


Figure 4.6.1-2 Major surface water features located within and surrounding Fort Larned NHS.

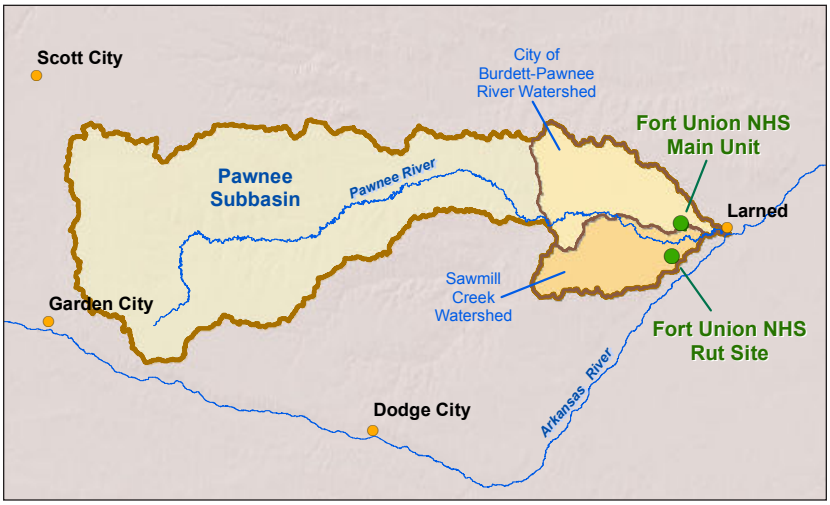


Figure 4.6.1-3 Pawnee River is a tributary of the Arkansas River and part of the City of Burdett-Pawnee River and Sawmill Creek watersheds (USGS 2013).

parameters following rainfall (USDI NPS 2008), however, to date, no formal NPS water quality monitoring program has been implemented at the Historic Site.

The Pawnee River originates in Finney County, Kansas and forms a confluence eight miles downriver from the Historic Site with the Arkansas River in Larned, Kansas. It's approximately 198 miles (319 km) long, with extensive stretches of dry areas, including the 2.0 river-miles stretch within the Historic Site (Kansas Geological Survey 2012) (Figure 4.6.1-2). Its watercourse drains a large watershed in excess of 2,700 square miles (7,000 km^2) through agricultural land, and the Pawnee River within the Historic Site is in the Pawnee subbasin (Figure 4.6.1-3). The overall drainage pattern is dendritic, which is usually indicative of nearly horizontal underlying rocks and lack of structural features such as faults and folds and is true for this area (Kansas Geological Survey 2012).

4.6.2. Data and Methods

Surface Water Quality

According to the U.S. Geological Survey Water Science School, water quality is "a measure of the suitability of water for a particular use based on selected physical, chemical, and biological characteristics" (USGS 2012). Surface water quality is important to maintaining a healthy habitat for many aquatic organisms, wildlife, and humans and can provide insights into overall system productivity, can shift species abundance and distributions, and alter nutrient cycles (USDI NPS 2008).

Indicators/Measures

Water Quality (temperature, specific conductance, pH, dissolved oxygen, and turbidity)

Typically, parks containing water resources conduct surface water monitoring to determine the trends in core water physiochemistry. Core water quality parameters —temperature, specific conductance (the ability of a solution to conduct an electrical current, [i.e., the lower the conductivity, the "purer" the water]), turbidity, pH, and dissolved oxygen— reflect the function of the physical and biological environment with which water interacts. These indicators are easily measured and constitute a means of characterizing potential stressors to the health of aquatic systems. Monitoring for the parameters dovetails with that of the NPS service-wide Water Quality Monitoring Program, which requires each network to collect all of these parameters (except for turbidity) with any water quality monitoring effort (Gwilliam, in prep). Ideally, multiple water sampling throughout the water year obtains a better understanding of

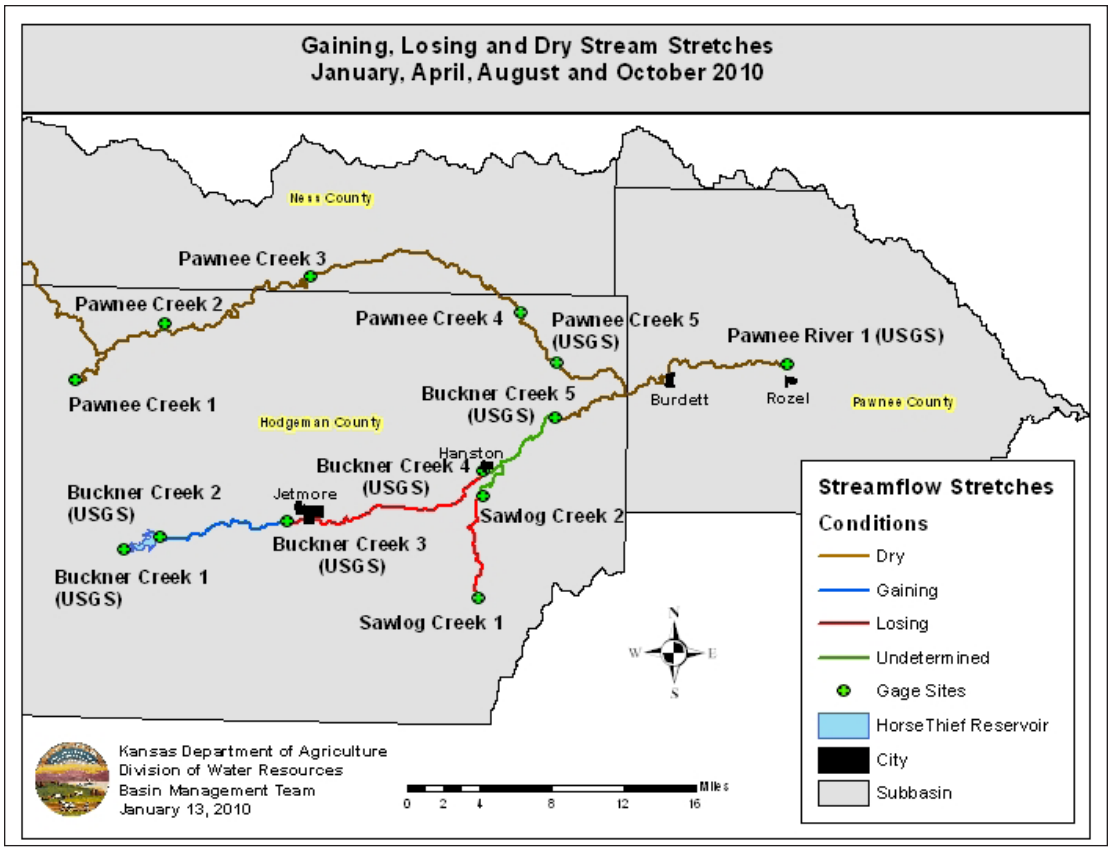


Figure 4.6.2-1 Pawnee Creek and River to the west of Fort Larned NHS were dry during 2010. Currently, in 2013, the stretch of Pawnee River within the Historic Site is dry (Kansas Department of Agriculture 2006).

the range of conditions compared to episodic sampling, which captures information pertaining to that specific date and time only (Schweiger 2012).

Other indicators such as sediment physio-chemistry (presence of nutrients, major ions, and metals) and bioassessments that determine the presence and composition of biological communities (usually stream macroinvertebrates), are common indicators used to assess the condition of surface water bodies. Trace metal contaminants are sampled in the water column as total suspended solids and in sediments deposited from the water column. Many metals bioconcentrate, leading to greater concentrations higher up the food chain.

Water Quality Monitoring at Fort Larned NHS

No formal water quality monitoring program exists at Fort Larned NHS, primarily due to the river being dry the majority of time along this stretch (Figure 4.6.2-1) (Kansas Department of Agriculture 2006). However, the USGS has seven streamflow gage stations along the river within the Pawnee-Buckner subbasin, with the closest stations being the Pawnee at Rozel and Pawnee at Larned from which data can be gathered for comparison during wet years.

In 2000, the National Park Service's Water Resources Division searched water-related data records for the Historic Site and compiled findings into a report titled, *Baseline Water Quality Data Inventory and Analysis*. Since the Pawnee River section, located within the Historic Site is dry, current water quality condition cannot be obtained. Instead, we will discuss water quality from a general watershed perspective versus specifically from on-site.

4.6.3. Reference Conditions

The Kansas Department of Health and Environment establishes water quality standards for the state to maintain and improve the quality of the state's surface waters (Kansas Department of Health and Environment 2008). The regulations are based upon the best available knowledge to insure suitability for public water supply,

domestic, agricultural, industrial and recreational uses, and for the protection and propagation of terrestrial and aquatic life. Since we lack current water quality data for the Pawnee River within the Historic Site, and water quality standards are subject to change, we did not develop any reference conditions for this resource topic.

4.6.4. Condition and Trend

Kansas developed a list of impaired water bodies to comply with Section 303(d) of the Clean Water Act. The 303(d) list for 2012 included the Pawnee River at Larned, Kansas for the following impairments (Table 4.6.4-1).

Table 4.6.4-1. 303(d) 2012 list of impairments at Pawnee River near Larned, Kansas (Kansas Department of Health and Environment 2013).

Impairment	Impaired Use
Copper	Aquatic Life
Dissolved Oxygen	Aquatic Life
Lead	Aquatic Life
Total Phosphorus	Aquatic Life
Fecal Coli	Recreation
Atrazine	Aquatic Life

Copper and Lead

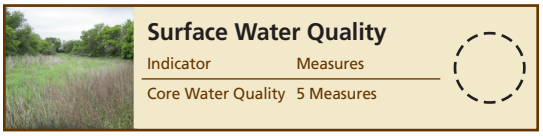
Several bodies of water in Kansas have been listed as impaired by copper and lead for both acute and chronic aquatic life impairments (Kansas Department of Health and Environment 2012). The impairments due to copper and lead are likely a result of the unstable flow conditions when mining operations are absent from the area (Kansas Department of Health and Environment 2012).

Fecal Coliform

Kansas adopted a fecal coliform monitoring method for streams with either existing Total Maximum Daily Loads (TMDL) or previous 303(d) listings for bacteria to be sampled on a rotating basin approach Where none of the intensive sampling events generated violations in two separate years, the stream will be delisted from either the existing TMDL or the 303(d) listing (Kansas Department of Health and Environment 2012).

Summary of Listed Impairment Priority

Kansas Department of Health and Environment (2012) considers all of the listed impairments in Table 4.6.4-1 as low priorities, with the exception of fecal colifom, which is considered to be a high priority.



Overall Condition and Trend

The overall condition and trend of surface water quality within the Pawnee River is unknown at this time due to the lack of water. Table 4.6.4-2 summarizes the indicator and measures used to assess the condition of surface water quality at the Historic Site.

Level of Confidence/Key Uncertainties/ Threats

The level of confidence assessment is not applicable due to the lack of water and relevant surface water quality data. In general though, water quality throughout the Great Plains has been affected by herbicides and other pollutants, and SOPN park water resources are no exception to these threats (Perkins 2005).

Significant changes in the amount and permanency of surface and groundwater since pre-Columbian times is a result of ranching (e.g., stock ponds), irrigation, flood control, and other anthropogenic changes. Few

Table 4.6.4-2. Surface water quality indicator, measures, and rationale for condition rating.

Indicator of Condition	Measure	Condition	Rationale for Condition.
Core Water Quality	5 Measures	Unknown	During 2013, the Pawnee River was dry throughout the Historic Site stretch, therefore, condition and trend are unknown.

major rivers in the Great Plains still exhibit the conditions evident before agricultural development and water management work activities. Altered river hydrographs from dams, irrigation and municipal withdrawals, groundwater depletion, and other land use changes are a significant impact to aquatic systems in the Great Plains (Cross and Moss 1987, Longo and Yoskowitz 2002).

4.6.5. Sources of Expertise

No experts were consulted due to the limited information pertaining to on-site surface water quality data at Fort Larned NHS.

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4.7. Groundwater

Indicators/Measures

- Groundwater Level

Condition - Trend - Confidence

Significant Concern – Stable – High

The majority of the groundwater text is excerpted from Martin and Wagner (2013).

4.7.1. Background and Importance

Groundwater accounts for 1.7% of Earth's total water and 30.1% of Earth's freshwater (USGS 2011). The overall trend in the United States is that as population increases, the amount of groundwater withdrawn also increases (Figure 4.7.1-1).

Long-term water-level declines caused by sustained groundwater pumping are a key issue associated with groundwater use, and many areas of the United States are experiencing groundwater depletion. In 1980, the Kansas Department of Agriculture initiated an intensive groundwater use control area within the Pawnee-Buckner River Subbasin, where Fort Larned National Historic Site is located, due to the gradual decline of groundwater levels since 1943 and diminishing streamflow (Kansas Department of Agriculture 2009; Sophocleous 1980).

One environmental consequence of ground water depletion that may be especially important for the Historic Site is the effect that a lowered water table can have on alluvial rivers and streams. Withdrawals from an alluvial aquifer, the type that underlies all of the park can easily affect flow magnitude and duration of surface water in local drainages. If the water table is lowered enough, a perennial stream can become a predominantly dry channel (Freeze and Cherry 1979).

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

Alluvial Aquifer Characteristics

As mentioned, the aquifer that underlies the Historic Site is an alluvial aquifer, meaning

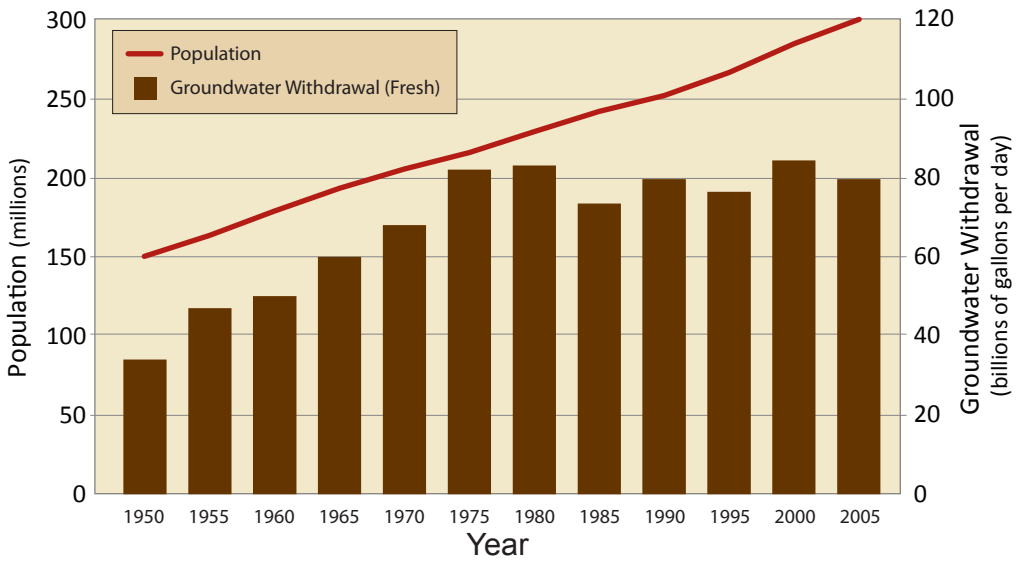


Figure 4.7.1-1. Groundwater withdrawals for the United States, 1950–2005.

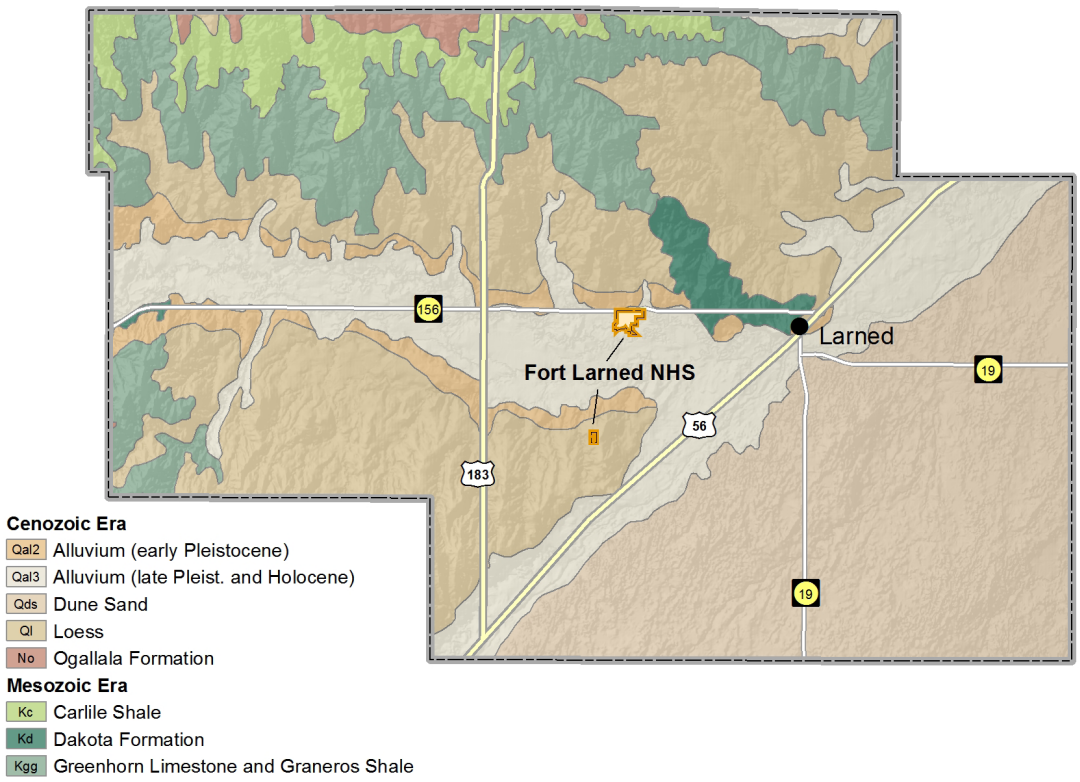


Figure 4.7.1-2. Occurrence of the late Pleistocene and Holocene alluvium at Fort Larned NHS (adapted from McLaughlin 1949).

that the groundwater fills the interstitial voids of the river alluvium in the valley much like a saturated sand or gravel in a bucket or trough. The water table in the alluvium marks the depth of saturation, below which is the available groundwater. Sometimes this type of aquifer is referred as a "water table" aquifer. The alluvium in the Pawnee River Valley was deposited in channels cut into Cretaceous, Tertiary, and Pleistocene sediments, the latter of which remain in places as terrace deposits on the outer margins of the river valley (McLaughlin 1949). The age of the alluvium, therefore, is late Pleistocene and Holocene (Figure 4.7.1-2). The thickness of the alluvium ranges from about 65 to 138 feet with an average of about 105 feet (Fishel 1952). The upper part of the alluvium in the Pawnee Valley consists primarily of silt with some clay and sand, and ranges in thickness from about to 50 feet with an average of about 30 feet. Beneath the clay there is, in most places, a thick deposit of sand and gravel that yields large quantities of water to wells in the valley. Most of the domestic and stock wells and all the irrigation wells in the area obtain water from these sand and gravel lenses present variably in the alluvial fill (McLaughlin 1949).

This watertable/alluvial aquifer that fills the extensive Pawnee River Valley is recharged by direct precipitation (including occasional snowmelt), storm runoff, streamflow or any combination. The climate in Pawnee County and the rest of the western third of the state is similar to other parts of the High Plains, characterized by relatively low precipitation, rapid evaporation, and a wide range of temperatures. The long-term average annual precipitation for this region is in the range of about 22 inches/year with the greatest amount occurring during late spring and summer and the least during the winter months (Kansas Department of Agriculture Division of Water Resources 2010).

Overall, the climate and local meteorological conditions are highly variable, which, in turn, exerts a great deal of variability on the local hydrology. This is significant as the water levels in alluvial aquifers are closely tied to local climate and prevailing meteorological conditions.

Other Local Aquifers

In addition to the alluvial aquifer that underlies all of the Historic Site, there are two

other formations in the area that may serve as aquifers in the Pawnee-Buckner Subbasin- the Tertiary Ogallala and Cretaceous Dakota aquifer. However, because these aquifers have no known connection to the Pawnee River or Fort Larned NHS, they are not included in this discussion.

Groundwater Wells at Fort Larned NHS

There are three wells present on the Fort grounds that range in depth from about 55 to 85 feet and therefore, are likely finished in the lower, sandy layer of the Pawnee River alluvium (Figure 4.7.1-3). Currently, these wells are used for domestic use potable water supply (George Elmore, pers. comm. September 3, 2013). To date, no water level measurements have been taken in these wells. At present, all three well are tested for chloroform twice monthly and annually for nitrates (George Elmore, pers. comm. September 3, 2013).

4.7.2. Data and Methods

The depth of the water table relative to the land surface is determined by a balance between inflows and outflows of the local groundwater system. Inflows result from the amount of water that enters the alluvial aquifer and, as previously mentioned is directly related to prevailing meteorological conditions. On the other side of the equation, groundwater withdrawals may dramatically lower water levels in an alluvial aquifer resulting in decreasing groundwater levels. Groundwater levels are intimately tied to saturated condition in the channel, therefore, we will use groundwater level as the indicator to assess the condition of the groundwater resource at the Historic Site.

Indicators/Measures

Change in Groundwater Level

Comparison of the water table elevation in the wells present at the Historic Site with known channel elevations of the Pawnee River bottom would be the type of data that would allow park managers to evaluate whether groundwater levels are recovering to the extent of supporting wetland riparian vegetation in the channel. Furthermore, long-term monitoring of these local groundwater levels, coupled with a detailed evaluation of the downstream reach of the Pawnee River, would provide the necessary information for evaluating the possible benefits of restoring this reach of the river. At this time, these data have not been collected so we will use data

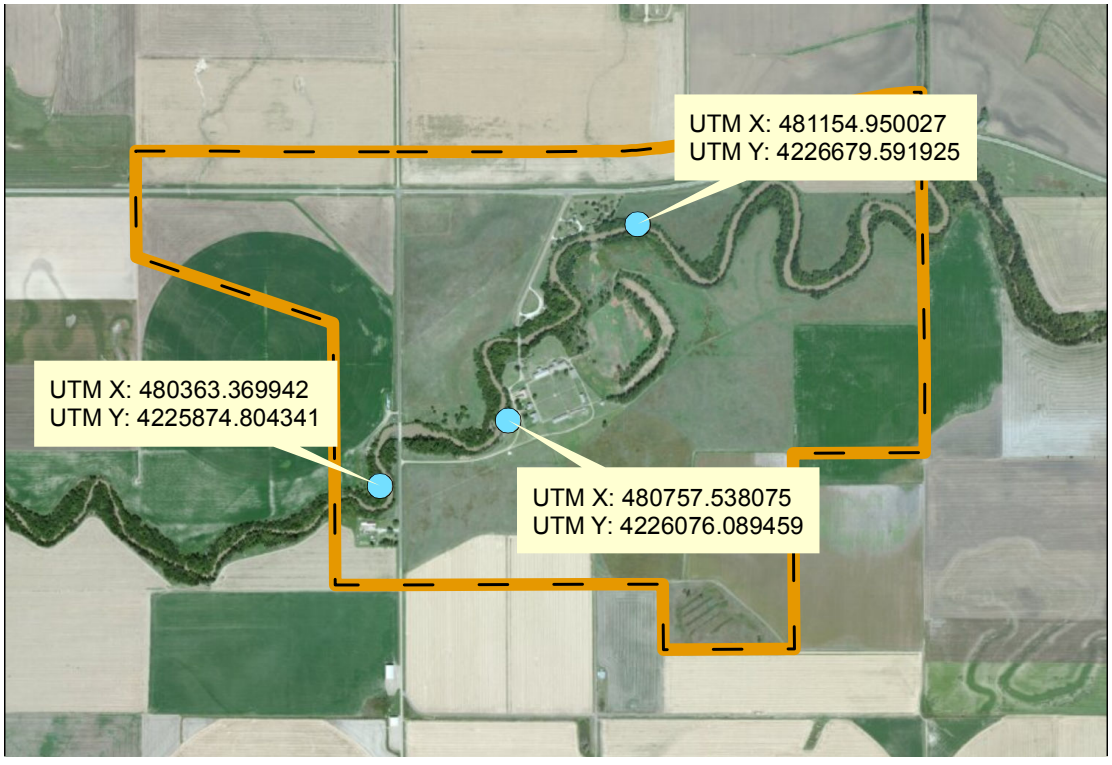


Figure 4.7.1-3. Location of groundwater wells at Fort Larned NHS (Kansas Geological Survey 2013).

gathered from the regional area to assess the condition of groundwater at the Historic Site.

Recognizing human impacts to both local and regional aquifers, the Kansas Department of Agriculture Division of Water Resources created basin management districts in targeted areas throughout the state to analyze aquifer and stream systems. The goals of these management areas are to protect water rights and to improve water resource sustainability (Kansas Department of Agriculture Division of Water Resources 2006a). The Historic Site is located within the Big Bend Groundwater Management District #5 (GMD#5) and also within the Intensive Groundwater Use Control Area (IGUCA) Pawnee-Buckner River Subbasin. The subbasin was established by the Kansas Groundwater Management District Act to "implement additional corrective control provisions in areas where it is determined, through a public hearing process, that groundwater levels are declining excessively, the rate of groundwater withdrawal exceeds the rate of groundwater recharge, unreasonable deterioration of groundwater quality has occurred or may occur, or other conditions exist warranting additional regulation to protect public interest." (Kansas Department of Agriculture Division of Water Resources 2006a).

In 2006, GMD#5 contracted Balleau Groundwater, Inc. to examine hydrologic issues related to groundwater level declines, withdrawals, rates of recharge, operating efficiencies, and GMD#5 boundary delineation (Balleau Groundwater, Inc. 2006).

Balleau Groundwater, Inc. analyzed hydrologic data from several different sources including Oregon State's precipitation data (PRISM), USGS stream gage data, water use information maintained by Kansas' Division of Water Resources (WIMAS and WRIS systems), and Kansas Geological Survey water level database-WIZARD (Balleau Groundwater, Inc. 2006). A summary of the Balleau Groundwater, Inc. (2006) results will be discussed in the condition and trend section of this report.

In addition, NPS Water Resources Division scientists have collected riparian and hydrologic data within the Historic Site (Martin and Wagner 2013; Martin 1992) to provide a riparian habitat assessment and hydrologic analysis of the Pawnee River in the vicinity of the Historic Site, respectively.

4.7.3. Reference Conditions

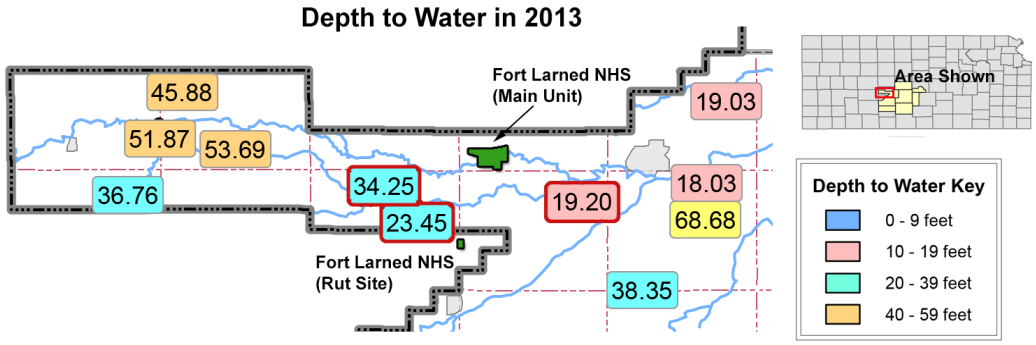
The reference conditions by which groundwater condition is assessed are listed in Table 4.7.3-1.

4.7.4. Condition and Trend

Declining groundwater levels have been a concern throughout the Western United States for some time. The invention of high capacity pumps in the 1950 and '60s allowed the expansion of irrigated agriculture throughout the Great Plains and enormous

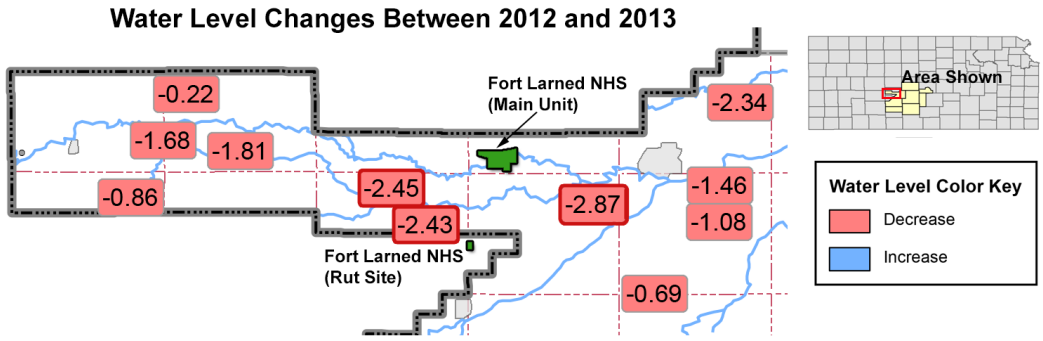
Table 4.7.3-1. Classes for assessing groundwater condition at Fort Larned National Historic Site.

Condition Class	Description
Good	A good reference condition is one of sustainability; where on average, supply meets demand and associated resources, specifically the riparian-wetland system are well supported. When supply meets demand, we expect variability that reflects annual variation in environmental conditions (e.g., rainfall, evapotranspiration, pumping), but lacks an overall long-term declining water level trend. Riparian systems, when well supported by the local water table, are generally resilient enough to maintain viability through natural variations in hydrology, including periods of drought.
Moderate	A moderate condition is when groundwater levels fluctuate around a water table elevation that only provides marginal support for the wetland riparian system. In this scenario prolonged drought or excessive withdrawals could result in loss of the wetland-riparian system.
Significant Concern	A significant concern condition is when water levels are so low in the alluvial aquifer that there is no hydrologic support for the wetland riparian system.



MAP SOURCE: HTTP://WWW.GMD5.ORG/WATER_LEVEL.HTM

Figure 4.7.4-1. The range of groundwater level depths in the wells closet to the Historic Site was 19.20-34.25 feet (GMD #5 2013).



MAP SOURCE: HTTP://WWW.GMD5.ORG/WATER_LEVEL.HTM

Figure 4.7.4-2. The water level changes from 2012-2013 in the wells closest to the Historic Site ranged from -2.43 to -2.87 feet (GMD#5 2013).

quantities of water were removed from local aquifers.

Water levels in the alluvium in the vicinity of the Historic Site have declined anywhere from 10 to 40 feet below historic levels. The overall average decline was about 19 feet from 1947 to 1997 in spite of the large precipitation events that occurred in 1993, 1994, and 1997. Currently, under the sustainable yield policy adopted by GMD#5, additional water appropriations since 2002 have been curtailed and the entire basin is expected to stabilize. While new groundwater withdrawals have stopped, water levels still may fluctuate about plus-or-minus 10 feet from year to year, depending on other hydrologic factors (Balleau Groundwater, Inc. 2006).

Topographic data collected by Martin (1992) indicated that the channel bottom elevation of the Pawnee River within the Historic Site was about nine feet above the local water table elevation measured in three park wells at that time. This disconnect between the channel and the local water table likely persisted through 2013 as evidenced by only rare and short lived flow events through the channel. Additionally, recent groundwater analyses completed for GMD#5 indicated that the local water table was about 30 – 35 feet below valley surface (Balleau Groundwater, Inc. 2006). This lack of a regular water table connection has had a pronounced effect on the type of riparian vegetation that dominates the river channel throughout the Historic Site.

As of May 14, 2013, the depths of groundwater levels in the wells closet to the Historic Site range from 19.20-34.25 feet. The change in groundwater levels range from -2.43 to -2.87 feet (Figures 4.7.4-1, -2) (Big Bend GMD#5 2013). Even though these monitoring wells are not located directly along the Pawnee River, they are representative of the groundwater condition throughout the alluvial aquifer, which is one of overall decline.

The western region of Kansas has been subjected to periods of prolonged drought for multiple years over recent history, and is currently experiencing extreme drought conditions (NOAA 2013) (Figure 4.7.4-3). Water levels can be impacted during extended drought periods, and the alluvial system recharges when significant precipitation

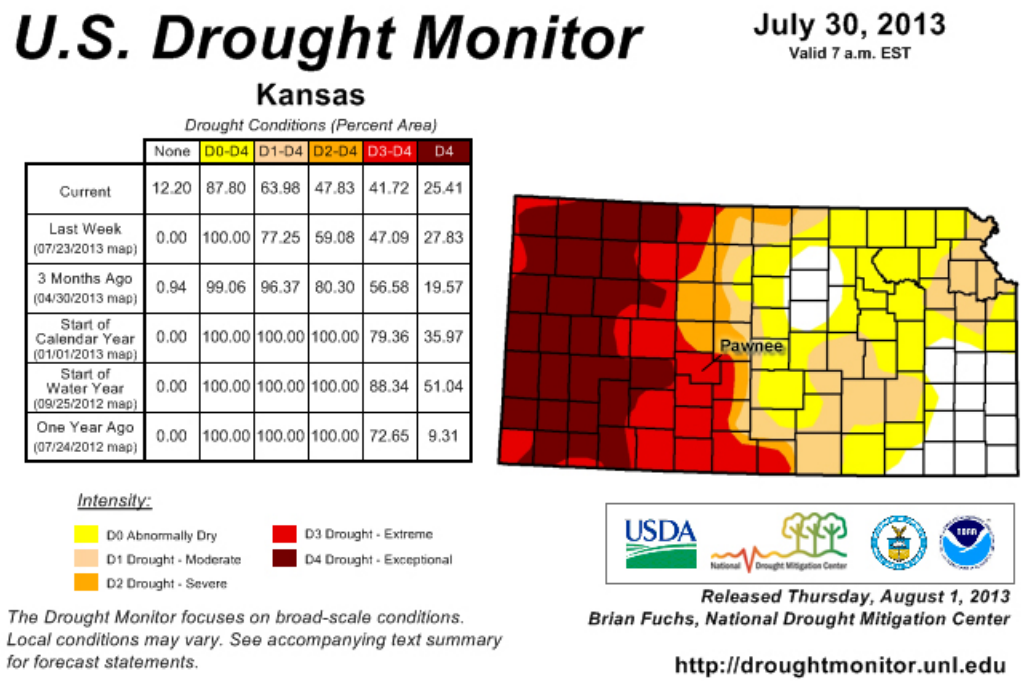
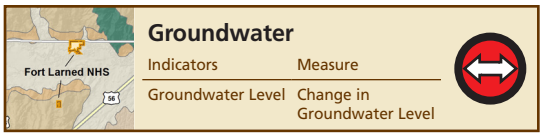


Figure 4.7.4-3. The U.S. Drought Monitor for Kansas shows that Pawnee County is in an extreme drought condition but improving since the start of the water year (9/25/2012) (NOAA 2013).

Table 4.7.4-1. Indicator and measure of groundwater condition, condition class, and rationale for condition rating.

Indicator of Condition	Measure	Condition	Rationale for Condition.
Groundwater Level	Change in Groundwater Level	Significant Concern	The alluvial aquifer and riparian habitat are interconnected and long-term groundwater level decline has resulted in the local aquifer's inability to support the riparian system within the Historic Site as evidenced by lack of surface water and impacts to riparian vegetation.

events occur, such as those that occurred during 1993, 1994, and 1997 (Kansas Department of Agriculture Division of Water Resources n.d.).



Overall Condition/Trend

For assessing the condition of groundwater at the Historic Site, we used one indicator, which is summarized in Table 4.7.4-1. Based upon the data, the alluvial aquifer is not supporting the riparian system within the Historic Site. We consider the overall condition and trend of the alluvial groundwater resource at the Historic Site to be of significant concern, likely with a stable trend, or possibly a slow recovery. Based on regional analyses, it appears that local groundwater levels may have stabilized since about 1991 and possibly shown some minor recovery Balleau Groundwater, Inc. (2006). Since we do not have any kind of continuous record of water levels in the immediate vicinity of the Historic Site, determining the trend specific to the Site and this reach of the Pawnee River, must be based more on regional conditions. In general, groundwater levels have been declining throughout the entire area, which is why we consider the confidence level to be high. After 10 years or so of water level measurements in the park wells, a more reasonable determination of the water level trend, specifically at the Historic Site could be made.

Key Uncertainties

The cause and effect relationship of water management practices throughout the entire basin and their impact to hydrologic condition(s) was unknown during the 2006 water management study conducted

by Balleau Groundwater, Inc. Since then, Balleau Groundwater, Inc. was contracted by GMD#5 in 2010 to develop a hydrologic model of the area, which will most likely further inform water management decisions and assess various alternatives on aquifer and stream management, including the Pawnee-Buckner River IGUCA (Kansas Department of Agriculture Division of Water Resources 2006b). Currently, the hydrologic model report is not for public distribution, which may change pending GMD#5 Board review sometime mid-September 2013 (GMD#5 District Manager, pers. comm. August 19, 2013).

In addition, on-site monitoring would provide the most accurate information to determine groundwater level at the Historic Site. Without these data, park managers need to rely upon more regional information to determine local condition.

4.7.5. Sources of Expertise

The groundwater assessment for the Historic Site was primarily based on information reported by Michael Martin in the riparian habitat assessment conducted at the Site by Martin and Wagner (2013).

Michael Martin is a hydrologist with the NPS Water Resources Division and has his Masters of Science in Watershed Science. Specialty areas include open channel flow, geomorphology, flood analysis, wetlands hydrology, geochemistry, and water quality.

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4.8. Riparian Habitat

Indicators/Measures

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

Condition – Trend– Confidence

Significant Concern - Unknown - High

The majority of this section is extracted from the Proper Functioning Condition (PFC) Assessment for the Pawnee River Within Fort Larned National Historic Site (Martin and Wagner 2013). For more information, go to http://www.nature.nps.gov/publications/nrpm/nrr.cfm

4.8.1. Background and Importance

Riparian wetlands are a type of non-tidal wetland formed along river and stream floodplains. These wetlands serve many functions including water purification, flood control, buffering riverbank erosion, habitat for numerous wildlife, fish, shellfish, and plant species, and also provide many recreational opportunities. In the arid west, riparian habitat is often in marked contrast with the surrounding terrestrial vegetation and is strongly influenced by the presence or absence of water (NPS-WRD 2011).

The National Park Service (NPS) has several wetland protection procedures and policies (Director's Order #77-1: Wetland Protection (2002), Procedural Manual #77-1 (2012), and NPS Management Policies (2006)) to ensure a "no net loss" of wetlands throughout the NPS.

Setting

The Pawnee River watershed is located in the High Plains Section of the Great Plains Geomorphic Province. This area is characterized by gently rolling, upland plains and broad, low-relief valleys containing relatively flat floodplains and terraces. The Pawnee River, sometimes also referred to as the Pawnee Fork or Pawnee Creek, begins in western Kansas and runs predominantly north-northeast for about 200 miles before joining the Arkansas River. The 2,700 square-mile watershed begins in northwest Gray County, Kansas and contains several tributary streams including Buckner Creek, which joins the Pawnee near Burdett, Kansas upstream of Fort Larned National Historic Site (NHS), and Sawmill Creek which enters the Pawnee about seven river miles downstream of the Site (Figure 4.8.1-1). At the Historic Site, the Pawnee River Valley is about 1,000 feet wide and slopes gently from west to east.

Geomorphic History of the Pawnee River

Several studies throughout the last few decades have documented geomorphic changes of high plains streams throughout this area. For example, the Arkansas River has evolved from a wide, braided stream and floodplain system with sparse riparian vegetation to a relatively narrow, single-thread channel with heavily vegetated floodplains (Dunne and Leopold, 1978; Nadler and Schumm 1981). This channelization and encroachment of vegetation was probably accompanied by some degree of incision. These changes have been attributed to the effects of river regulation and associated irrigation followed by changes in water table elevations in the early part of

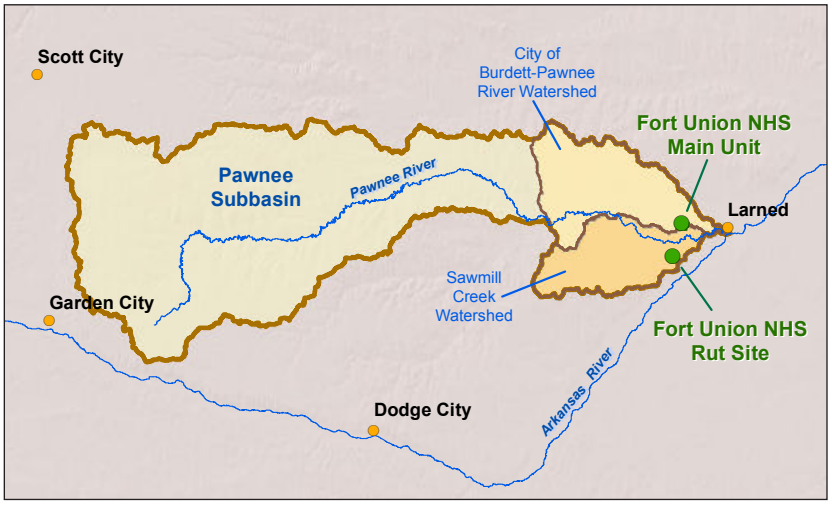


Figure 4.8.1-1. Pawnee River is a tributary of the Arkansas River and part of the City of Burdett-Pawnee River and Sawmill Creek watersheds

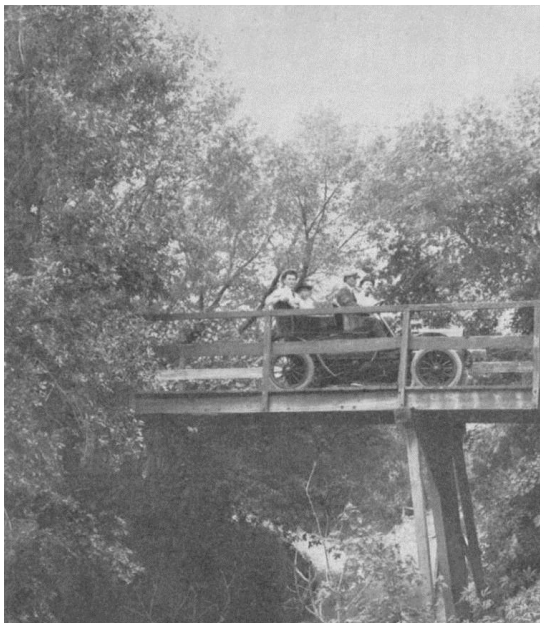

NPS

Figure 4.8.1-2. Bridge that was built soon after the Fort's establishment, spanning a relatively deep channel.

the 20th Century. However, based on both geomorphic evidence and several historic accounts, the Pawnee River channel appears to have been a single-thread, meandering stream with some degree if incision prior to the time of the Fort's establishment in 1860.

The Fort was purposefully sited along the banks of the Pawnee River, indicating that its current alignment existed in the mid-1800s. Additionally, we know that the channel was at least somewhat incised at that time because of a photo taken of a bridge that was built soon after the Fort's establishment, spanning a relatively deep channel (Figure 4.8.1-2).

Also, there are anecdotal reports from the early 1800's of the channel being incised and having a prominent corridor of timber on its upper banks. In September, 1825, George C. Sibley, a contractor with the U.S. Army, noted several species of woody vegetation on the banks of the river and commented that: "I could distinctly trace the course of the Pawnee river for a great distance by the fringe of trees along its banks (Gregg, 1995)." In 1844 James Josiah Webb, an early trader along the Santa Fe Trail, observed that "The east bank must be from twenty to thirty feet above the water and very steep" (Webb, 1995). Consequently, we believe that while the Pawnee River channel may have undergone some 20th Century incision, channel characteristics, including some degree of entrenchment, was well established by the mid-1800's.

Geomorphic History of the Pawnee River

The Pawnee River is a relatively sinuous, meandering stream incised into its gently sloping valley (average valley gradient is approximately 2 feet per mile). The gradient of the river is much less than the valley gradient due to the sinuosity of the channel. Furthermore, any number of grade control structures may be currently in place, locally reducing channel slope even further by retaining sediment.

The river is alluvial, which means that its bed and banks are composed of sediment recently transported (in a geologic sense) by the watercourse. This sediment is mostly fine grained sand with some silts and clays (Fishel, 1953). The channel itself is deeply incised into the landscape, varying in depth from about 15 to 25 feet below the valley surface. Top width, the distance between the tops of the banks, ranges from about 100 to 200 feet. The overall shape of the channel is somewhat trapezoidal with steep banks and a broad, relatively flat bottom about 50 to 80 feet wide.

The watershed of the river does not extend to the high mountains so snowmelt runoff is local and minor at best. Furthermore, most of the watershed soils have high infiltration rates and readily absorb small to moderate precipitation events. Consequently, sustained periods of flow in this reach of the river are rare, usually only driven by intense summer thunderstorms. Historic Site staff report that seasonal flow only occurs about three out of four years, and then, only lasts for a short time. Some reaches of the Pawnee River are likely perennial due to a connection with the water table, but nowhere along the reach within the Historic Site is there perennial flow. There are historical accounts that suggest that the Pawnee near the Fort supported perennial flow, but currently the river is intermittent and only flows in response to rainfall and occasionally from snowmelt

The portion of the river within Historic Site is about 2.5 river-miles long and includes about five prominent meander loops (Figure 4.8.2-1). Additionally, there is at least one relatively recently abandoned meander bend adjacent to the active channel and an oxbow

just east of the Fort grounds. Numerous remnant meander scrolls exist about 200 to 500 feet south of the current channel. Based on their position and sinuosity, these abandoned channel features appear to be a former alignment of the Pawnee River.

At some time in the early 20th Century, a large concrete check dam was installed about 500 feet downstream from the current Historic Site boundary. This dam is about 15 feet high and completely spans the channel. Its presence has had a dramatic effect on the gradient and elevation of the river channel as well as on channel forming processes. The apparent purpose of the structure was grade control, as there are no appurtenant features associated with the dam. No type of spillway is present and there is no indication that it was ever used to capture and redirect water for irrigation. Therefore, it was most likely placed to arrest channel incision and retain sediment, rebuilding the grade of the channel. Currently, there is about 10 feet of sediment and debris that has accumulated on the upstream side of the structure.

4.8.2. Data and Methods

The purpose of our assessment was to determine the overall functional condition or ecological "health" of the river channel and its associated riparian corridor. To complete this assessment, we used "A User Guide to Assessing the Proper Functioning Condition and the Supporting Science for Lotic Areas" (U.S. Department of the Interior, 1998). For this method, "Proper Functioning Condition" (PFC) is the highest rating that can be given to a riparian area based on the perceived stability of the physical system, which in turn is dictated by the interaction of geologic formations, soil, water, and vegetation. This determination was derived by an interdisciplinary team of technical experts from NPS' Water Resources Division, who evaluated 17 hydrology, vegetation and erosion/deposition measures for a single reach, spanning the entire length of the Pawnee River located within the Historic Site (Figure 4.8.2-1). The river was evaluated as a single reach due to an apparent consistency of geomorphic and vegetation characteristics throughout the site.

A riparian area in PFC is in dynamic equilibrium with its stream flow forces and channel processes. The system adjusts to handle larger runoff events with limited change in channel characteristics and associated riparian-wetland plant communities. This limited change, such as some cutbank erosion and point bar expansion in stream meanders, is within the context of natural stream evolution and provides new geomorphic features for riparian-wetland vegetation recruitment. Because of this resiliency, riparian areas in PFC can maintain aquatic habitat, water quality enhancement and other important ecosystem functions, even after moderately large runoff events. In contrast, nonfunctional systems subjected to the same flows might exhibit excessive erosion and sediment loading, loss of aquatic and wetland habitat, and so on.

Both terrestrial and aquatic attributes and processes are important in riparian wetland areas and are used to assess the condition of a given area. This indicators used for this assessment included hydrology, vegetation, and erosion/deposition. The measures within each of these three categories, which included both attributes and processes are listed below.

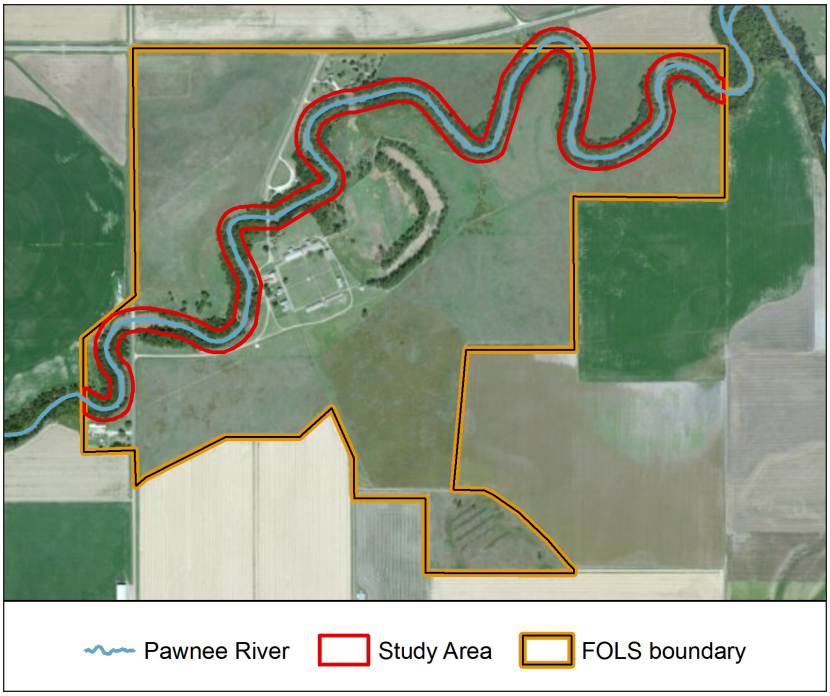


Figure 4.8.2-1 The 2.5-mile stretch of Pawnee River, located within the Historic Site, was treated as one study site for the 2013 riparian assessment.

Indicator

Hydrology (5 measures)

Streamflow forces and channel processes are characteristics of a riparian wetland's hydrologic function, and five measures were assessed for this indicator.

Measure: Floodplain inundated frequently

A floodplain is topographically flat, a landform of unconsolidated sediments originating from the stream, and subject to periodic flooding, usually a recurrence interval between 1 and 3 years (Prichard et al. 1998). The floodplain's role is to handle a basin's discharge and sediment load by spreading out the water and sediment onto a low area adjacent to the stream. This hydrologic function dissipates energy, which keeps a riparian wetland in functioning condition. Periodic flooding also promotes vegetation growth, which contributes to a properly functioning riparian area as well.

Measure: Beaver dams are active and stable

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

Measure: Sinuosity, width/depth ratio, and gradient are in balance

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

Measure: Riparian wetland area is widening or has achieved potential extent

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

Measure: Upland watershed is not contributing to riparian wetland degradation

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

Indicator

Vegetation (7 measures)

Most riparian wetlands require some amount of vegetation to achieve functionality (Prichard et al. 1998). Different factors such as type, amount, and proportion of vegetation contribute to a wetland's condition. In order to accommodate periodic flooding, lateral distribution of vegetation is necessary. In addition, plants must be vigorous and able to maintain or recruit into the plant community to serve their various functions.

Measure: There is a diverse age-class distribution of riparian wetland vegetation

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

Measure: There is diverse composition of riparian wetland vegetation

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

Measure: Species present indicate maintenance of riparian wetland soil moisture characteristics

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

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

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

Measure: Riparian wetland plants exhibit high vigor

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

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

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

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

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

Indicator

Erosion/Deposition (5 measures)

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

Measure: Floodplain and channel characteristics are adequate to dissipate energy

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

Measure: Point bars are revegetating

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

Table 4.8.3-1. The reference conditions used to determine whether the condition of the riparian habitat at Fort Larned NHS is good, moderate, or of significant concern as adapted from Prichard et al. 1998.

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

Measure: Lateral stream movement is associated with natural sinuosity

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

Measure: System is vertically stable

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

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

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

4.8.3. Reference Conditions

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

4.8.4. Condition and Trend

Hydrology

The focus of the hydrology section of the PFC assessment was to determine if the

observed channel morphology was stable and in balance with the landscape setting, given prevailing hydrologic and sediment inputs. This was done by determining the frequency of floodplain inundation, evaluating several channel morphology parameters (sinuosity, slope, and width-to-depth ratio), determining the width and trend (widening or narrowing) of the riparian-wetland area, evaluating the influence of upland watershed conditions on hydrologic and sediment characteristics, and other factors (Table 4.8.4-1).

To evaluate flow conditions of the Pawnee River, we used the long-term record from the USGS gage at Rozel, KS (#07141200). This gage has been operated since 1926 and has a continuous record of 87 years, with only one year (1991) missing. The gage is located about 10 miles upstream of the Historic Site, it has a datum of 2,040.24 feet (NGVD29), and it drains an area of about 2000 square miles (USGS 2013).

The flow in the Pawnee River is highly variable, both from year to year and within any given year. Mean annual flows, a rough measure of the relative "wetness" between years, have varied between five to six cubic feet per second (cfs) in dry years to over 500 cfs in wet years. Annual peaks are also quite variable, ranging from lows less than 100 cfs to extreme flows that approach and sometimes exceed 10,000 cfs (Figure 4.8.4-1). The flood of record for the gage at Rozel occurred on 7/28/1958 with a flow of 16,300 cfs. The second largest flood took place on 5/28/1935, reaching a peak of 14,000 cfs. About 55 percent of the annual peaks were between 1000 and 2000 cfs, and 85 percent were between 1000 and 5000 cfs. Eighteen percent were below the relatively modest flow magnitude of 1000 cfs.

While this reach of the Pawnee River is generally dry, runoff events (usually short-term seasonal flow) do occur periodically, and occasionally there are very large, out-of-channel floods. Historic Site staff report that there is seasonal flow present in the channel about three out of four years, and there have been at least seven flood events that have reached the Fort grounds in the last 36 years (about once every five years). We do not have

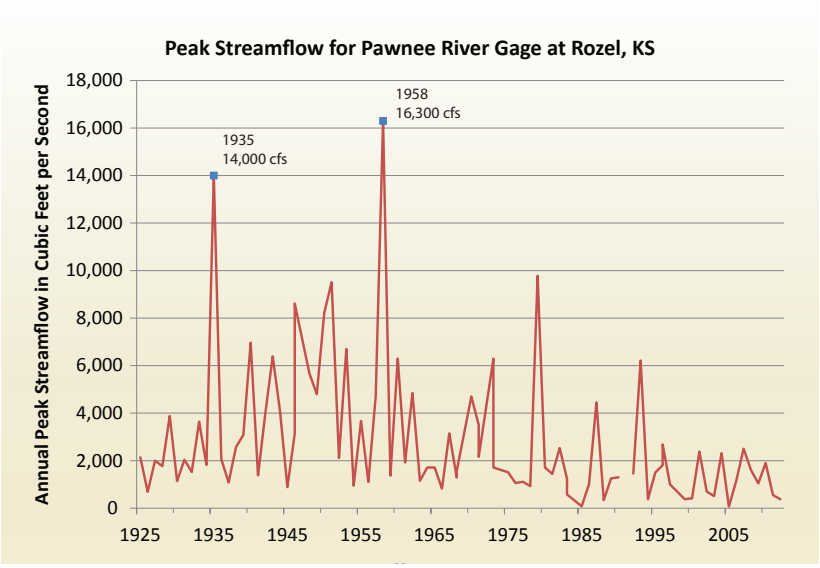


Figure 4.8.4-1 Annual peak flow record from USGS gage #07141200, Pawnee River at Rozel, KS. Note the high variability in magnitude between near zero and over 15,000 cfs (USGS 2013)..

specific dates for these events, but review of the gage record indicates that there have been about five annual peaks that approached or exceeded 5000 cfs in the last 40 years or so.

The flood frequency distribution calculated from a gage record provides a good view of prevailing flow magnitudes for that reach of the stream. The 2-year event is generally accepted as being in the range of a bankfull flow, a flow level that helps drive channel forming and maintenance processes. A USGS analysis from the gage record calculated 2250 cfs for the 2-year flood (Rasmussen and Perry, 2000). This is a sizable flow for a relatively frequent event, suggesting that this watershed is (or was) capable of regularly producing substantial flows under the prevailing climate. Interestingly, this flow magnitude has only been equaled or exceeded twice in the last 20 years at the Rozel gage, much less frequently than would be expected.

The 100-year flood for this gage was calculated to be 15,400 cfs. The two highest discharge events recorded at the gage, 16,300 and 14,000 cfs, were both in the range of a 100-year flood (Rasmussen and Perry, 2000). These floods occurred in 1958 and 1935, respectively, and almost certainly reached the Fort grounds. The Federal Emergency Management Agency (FEMA) map that covers this area, Pawnee County Kansas, 1977 (revised 1990), depicts

Table 4.8.4-1. Results for the riparian wetland condition assessment at Fort Larned NHS (Martin and Wagner 2013 Appendix).

Indicator/ Measure	Reach 1
Hydrology	
Floodplain	Channel is deeply incised. W:D ratio calculated from four of six cross-sections surveyed in 1992 ranges from about 7 to 12.
Beaver dams	n/a
Sinuosity, width/ depth ratio, and gradient	Overall channel sinuosity is a relic of the pre-incision channel form. No lateral migration is taking place due to entrenchment. There is no evidence of new channel/floodplain formation or succession in the bottom of the incised channel as would be expected in a recovering system after an incision event. Instead the channel maintains a trapezoidal shape, likely influenced by pooling and sediment deposition behind the downstream dam.
Riparian wetland area	The channel has maintained a trapezoidal shape after incision and the riparian zone is not widening either through lateral adjustment and aggradation or channel narrowing processes. We observed no perennial riparian-wetland vegetation in the incised channel other than a few cottonwood seedlings/saplings on some lower channel banks. Mature riparian trees persist on the tops of the channel banks.
Upland watershed	Although we didn't see evidence of excessive sediment or water contributions from the uplands, the downstream dam has caused as much as 10 feet of sediment to accumulate in the channel bottom within the Historic Site. The water table may be so far below the accumulated sediment that there is no capability to support perennial herbaceous wetland and riparian species along the channel.
Vegetation	
Age class distribution of riparian wetland vegetation	Scattered mature cottonwoods (*Populus deltoides*) exist on some upper channel banks and we saw seedlings/young saplings in some lower channel bank locations, but middle-aged (replacement) cottonwoods were absent. Ages of seedling/sapling-size cottonwoods could not be estimated because they have been stressed by ponding, herbivory, sediment deposition, and/ or erosion and have re-sprouted from their bases multiple times. Mature black willows (*Salix nigra*) were observed occasionally on upper channel banks, but we saw only one sapling-size plant on a channel bank
Diverse vegetation composition	Perennial herbaceous riparian-wetland vegetation is absent in the channel. Cover is annuals or biennials, many of which are upland species. For woody riparian vegetation, green ash (*Fraxinus pennsylvanica*), American elm (*Ulmus americana*), slippery elm (*Ulmus rubra*), cottonwood and black willow are components of the woods lining the tops of the pre-incision channel banks. But, they are not found on the sides or bottoms of the channel except for the stressed seedling/sapling cottonwoods and the single black willow sapling .
Soil moisture characteristics	See above measures.
Plants have root masses capable of withstanding high streamflow events	Annuals and biennials dominating the channel banks and bottom do not have root masses capable of withstanding high stream flow events. There are no rhizomatous wetland plant species in the channel.
Vigorous plants	Seedling/sapling-size cottonwoods on lower banks are stressed by ponding, herbivory or sediment deposition and have re-sprouted from their bases multiple times. Trees at the tops of channel banks show vigor, but they would only contribute to upper bank stability when flows reach that elevation.
Vegetation cover	Vegetation cover is not adequate to protect banks and dissipate energy during high flows.
Plant communities are coarse and/or large	n/a
Erosion/Deposition	
Floodplain and channel characteristics	The downstream dam pools water in the channel in most of the Pawnee River reach within the Historic Site, and this serves as a primary means of slowing flow and dissipating energy. Natural floodplain and channel characteristics such as overflow channels and riparian vegetation do not come into play for energy dissipation until flows are large enough to access the tops of the relic (pre-incision) channel banks and floodplain.
Point bars	n/a
Lateral stream movement	The pre-incision (relic) channel is no longer migrating laterally and there is no evidence of new channel/floodplain formation or succession in the bottom of the incised channel as would be expected in a recovering system.
Vertical stability	For now the channel is vertically stable (not incising) due to pooling and sediment deposition behind the dam. However, the channel would be expected to incise quickly through the accumulated sediment if the dam fails or is removed without sediment management.
Balance of water and sediment	There is excessive sediment accumulation in the channel due to the downstream dam.

the entire Historic Site as being within the 100-year floodplain. No depth is reported with the FEMA documentation, but a comparison to the USGS topographic map suggests the depth of this Regulatory Flood may be as much as five feet at the Historic Site.

There are historical accounts that this river may have had a more perennial character during the 19th Century, and these accounts are supported with flow analysis from the USGS gage at Rozel. Flow duration curves developed from the 87 year record indicate that discharge has progressively decreased over that period (Balleau Groundwater, Inc., 2006). Thus, the stream flow history of the Pawnee River may be characterized as being in progressive decline. There have been wet periods when stream flow has recovered somewhat, but for the most part there is less water in the river system than in the past.

Our determination of whether the Pawnee River floodplain at the Historic Site was inundated in "relatively frequent" flow events was somewhat problematic due to the unconventional nature of the channel form. For channel/floodplain forms normally expected in this landscape and climate setting, flows would likely overtop stream banks and spread onto the adjacent floodplain about every two years or so. But, as explained previously, the channel at the Historic Site has incised deeply in the past. When an incising channel reaches a new (lower) base level, a new channel and floodplain and associated riparian-wetland community often establish at this lower level, over time. At the Historic Site, however, the hydraulics and channel forming processes have been so affected by the check dam that we did not observe the formation of any substantial channel features (e.g., point bars or cutbanks) or a new floodplain at the lower base level. Only in one short reach (about 300 feet) were we able to identify a distinct thalweg (deepest part of the channel) at all. We concluded that the geomorphic floodplain at the Historic Site is at the level of the top of the river banks, and that floodplain inundation is very infrequent, on the order of every six to 10 years. Therefore, our answer to whether the floodplain inundates frequently was "no."

For the landscape setting and climate in this region, in-balance channel forms would be expected to have sinuosities greater than 1.2, gradients less than two percent and width-to-depth ratios greater than 12 (U.S. Department of the Interior, 1998). For the Pawnee River at the Historic Site, these channel parameters were split between stable and unstable characteristics. The sinuosity of the river, as measured from aerial imagery, was about 1.83. This is well above the expected value of 1.2, and in fact the meander pattern suggested a very robust sinuosity. However, this sinuosity alone does not indicate channel stability, and must be evaluated in the context of the other parameters. We obtained width-to-depth (W:D) ratios from channel cross section survey data collected in 1993. Four of the six cross sections surveyed had W:D ratios below or very close to 12, indicating an incised channel that is out of balance with the landscape setting. This finding was consistent with the first measure, where we concluded that the channel was incised and the floodplain was not inundated on a relatively frequent basis.

The overall channel gradient for this reach of the Pawnee River, taken from the Fort Larned, Kansas (1970) USGS quadrangle map, was about 0.03 percent. Values cited in various documents relating to the Pawnee River report the gradient to be about 2 ft/mile, or again about 0.03 percent. This relatively gentle gradient was even flatter through the Historic Site because of the downstream check dam. Consequently, all indications were that the local channel gradient at the Historic Site was well within the reported "stable" value of less than two percent (U.S. Department of the Interior, 1998). However, the nearly flat channel gradient through the site should be considered temporary. If the check dam were to fail or be removed, the local channel slope would increase substantially, at least for some time.

For the riparian wetland area widening measure, we determined that it was not, nor has it achieved its potential extent. As mentioned previously, channel formation at the current base level was practically non-existent, suggesting that post-incision

channel and floodplain development processes (and associated riparian-wetland vegetation community establishment) have not occurred. In fact, we were unable to locate any perennial wetland vegetation within the channel or on the lower banks, and the limited woody riparian vegetation present in the channel displayed low vigor.

We evaluated whether land use activities in the contributing watershed were degrading the quality of the riparian ecosystem by contributing excess water or sediment. The incised channel at the Historic Site appeared capable of passing the water being delivered by the watershed under most flow conditions without creating excessive erosion or instability. Nowhere in the study reach did we observe isolated deposits of sediment that would suggest excessive upstream erosion and associated deposition along the channel or floodplain. The substantial channel aggradation (up to 10 feet) observed throughout the study reach appears to be the result of long-term trapping of almost the entire sediment load (with the exception of some suspended transport) behind the check dam, as described previously. In view of these findings, we concluded that the upland watershed is not contributing to riparian-wetland degradation.

Vegetation

An integral part of the PFC analysis was evaluation of riparian-wetland vegetation along the channel and floodplain. The species composition, percent cover, age structure, energy dissipation capability and other critical vegetation characteristics for the study reach were evaluated.

A critical finding was that we observed no perennial herbaceous wetland vegetation within the channel. Herbaceous cover was typically 90-100% on most channel bottoms and banks, but it was dominated by annual or biennial herbaceous species including smartweed (*Persicaria pensylvanicum*), poison hemlock (*Conium maculatum*), mapleleaf goosefoot (*Chenopodium simplex*), lambs-quarters (*Chenopodium album*), Canadian horseweed (*Conyza canadensis*), stickywilly (*Galium aparine*) and Venus' looking glass (*Triodanis perfoliata*). Smartweed and poison hemlock are considered wetland plants, but the rest are more typical of uplands. Also represented in various locations (but not dominant) were upland annual species including cheatgrass (*Bromus tectorum*), common wheat (*Triticum aestivum*), little barley (*Hordeum pusillum*) and peppergrass (*Lepidium densiflorum*) and the wetland annual *Veronica peregrina ssp. xalapensis*. This annual/biennial herbaceous cover indicates repeated disturbance (e.g., ponding) and a relatively deep water table. The only perennial herbaceous species we observed in the channel (near the maintenance area) was clammy groundcherry (*Physalis heterophylla*), an upland plant.

Scattered mature cottonwoods (*Populus deltoides*) existed on some upper channel banks and we saw seedlings/young saplings at some lower channel bank locations, but middle-aged (replacement) cottonwoods were absent. Ages of seedling/sapling-size cottonwoods could not be estimated because they have been stressed repeatedly by ponding, herbivory or other stressors and have re-sprouted from their bases multiple times. Mature black willows (*Salix nigra*) were observed occasionally on upper channel banks, but we saw only one sapling-size plant on a lower channel bank. Other riparian woody species present on the upper banks include green ash (*Fraxinus pennsylvanica*), American elm (*Ulmus americana*), slippery elm (*Ulmus rubra*) and black willow. These species, along with cottonwoods, are substantial components of the forest lining the tops of the pre-incision channel banks. They were not found on the sides or bottoms of the channel except for the stressed seedling/sapling cottonwoods and the single black willow sapling mentioned previously.

Based on: 1) the complete absence of perennial wetland vegetation in the channel bottom or lower banks; 2) the general lack of diverse age-class distributions for woody or herbaceous riparian-wetland species; 3) the absence of species with root masses capable of stabilizing streambanks during high flow events; and 4) the poor vigor of the cottonwood seedlings/saplings that have managed to survive in some

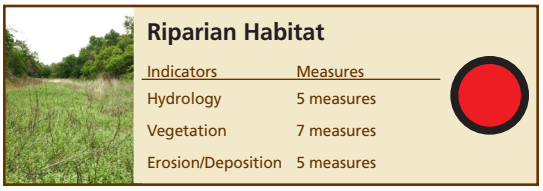
locations, we answered "no" for all vegetation measures. The extensive corridor of riparian trees on the upper banks appeared healthy, but these trees do not contribute substantially to the stability of the channel bottom and lower banks. The check dam downstream and the resulting pool that formed throughout the channel within the Historic Site provided artificial physical stability to what otherwise would be an extremely unstable channel form during flood events.

Erosion/Deposition Condition

The primary focus of this indicator was to determine if there is an apparent balance between flow, sediment, and erosion/deposition processes in the river system. A key element of this balance is energy dissipation that results from resistance to flow from rocks, channel features, and large woody debris, for example.

For the Pawnee River at The Historic Site, channel roughness and channel form did not result in much energy dissipation during frequent to moderately large floods. Characteristics such as floodplains, point bars, or cutoff chutes had not formed within the incised channel to help diminish flow energy, nor were there substantial roughness elements like coarse alluvium or extensive woody debris that systemically reduce flow energy. For these reasons, we rated the floodplain and channel characteristics as inadequate in dissipating energy. There was also no apparent lateral stream movement within the overall channel, and no new channel formation or lateral movement at the new base level created by past incision. Rather, the downstream dam created backwater conditions that resulted in very low velocities, essentially eliminating erosive energies.

Vertical stability is a very important element in evaluating conditions of erosion and deposition in riparian systems. This study reach did not exhibit typical attributes of a vertically unstable riparian system (e.g., v-shaped channel, steep eroding banks, headcuts). Although its U-shaped channel and stable banks suggested vertical stability, processes associated with an incised river that has reached a stable grade, such as an actively forming channel and floodplain morphology at the new base level, were completely absent. We concluded that the aspects of apparent stability are artificially maintained by the check dam. If the structure were to fail catastrophically or be purposefully removed without management of the accumulated sediment, this reach of the Pawnee River would undergo dramatic incision and stream channel evolution, with the release of a great deal of sediment into aquatic habitats downstream.



Overall Condition and Trend

While the Pawnee River at the Historic Site supported a nearly continuous corridor of riparian trees on its upper banks, we found the riparian system to be in "Non-functional" condition as defined by the PFC method and of significant concern. We answered "no" to nearly every measure. Critical findings supporting our conclusion included a channel/floodplain form that is out of balance with the landscape setting, a complete lack of perennial wetland plants in the channel bottom or banks to resist erosion and stabilize soils, a lack of healthy recruitment for riparian tree species, and the absence of channel/floodplain formation at the new base level following past incision (Table 4.8.4-2).

Level of Confidence/Key Uncertainties

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

Threats

According to Prichard et al. (1998), a state of resiliency within a riparian area needs to be maintained to respond to a high-flow event.

Table 4.8.4-2. Summary of the riparian habitat indicators/measures categories and their contributions to the overall riparian habitat resource condition assessment.

Indicators	Measures	Condition	General Contribution of this Indicator or Measure to the Overall Resource Condition.
Hydrology	5 measures	Significant Concern	The channel/floodplain form is out of balance with the landscape setting.
Riparian Vegetation	7 measures	Significant Concern	There is a complete lack of perennial wetland plants in the channel bottom or banks to resist erosion and stabilize soils, a lack of healthy recruitment for riparian tree species
Erosion/ Deposition	5 measures	Significant Concern	There is an absence of channel/floodplain formation at the new base level following past incision.

The downstream check dam has held the riparian ecosystem at the Historic Site in an artificially stabilized, very early successional state. As such, it is unable to develop many of the beneficial aquatic habitat and biodiversity functions found in healthy riparian systems. If the structure were to fail catastrophically, the Pawnee River at the Historic Site would undergo dramatic incision and a great deal of sediment would be released into downstream aquatic habitats. A significant lowering of the channel bed would pose an immediate threat to bridge pier foundations and buried utilities. Significant bed lowering would also increase bank height and bank instability, which may trigger channel widening and further threaten infrastructure. However, controlled dam removal (with careful management of the accumulated sediment) and re-establishment of a natural grade through the site is probably the only possible means of restoring a functional riparian system along this reach of the Pawnee River.

4.8.5. Sources of Expertise

The National Park Service's Water Resources Division scientists, Michael Martin and Joel Wagner, provided the expertise for this assessment.

Michael Martin is a hydrologist with the NPS Water Resources Division and has his Masters of Science in Watershed Science. Specialty areas include open channel flow, geomorphology, flood analysis, wetlands, and hydrology.

Joel Wagner is the Wetlands Program Team Leader with the NPS Water Resources Division and has his Masters of Science in Environmental Science (Water Resources). Specialty areas include wetlands science, hydrology, restoration and regulatory issues.

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4.9. Grasslands

Indicators/Measures

- Hydrology Soil/Site Stability and Hydrologic Function (10 Measures)
- Biotic Integrity (5 measures)

Condition – Trend - Confidence

Significant Concern – Stable - High

Grasslands as a whole are the dominant vegetation type of Fort Larned NHS and an integral part of the cultural landscape. At least 60% of the Historic Site is considered grassland habitat (Becker et al. 1986, as cited in USDI-NPS 2008).

4.9.1. Background and Importance

The central grassland region of North America is one of the largest contiguous grassland environments on earth (Lauenroth et al. 2008), and depending on which classification is used, there are at least three distinct grassland types: tallgrass prairie, mixed grass prairie, and shortgrass steppe (prairie). Fort Larned NHS is located within the region generally classified as mixed grass prairie, a transition zone between the tallgrass prairies to the east and the shortgrass prairies to the west. Mixed grass prairie areas typically have high species diversity, with hundreds of plant species per square mile (USDI-NPS 2008). However, endemic plant species are relatively rare in the Great Plains compared to other biomes. Colorado bursage (*Ambrosia linearis*) and dwarf milkweed (*Asclepias uncialis*) are two endemic plants found in or probably present in the southern plains parks. The species that characterize mixed grasslands in Kansas are grama grasses (*Bouteloua* spp.), buffalograss (*Buchloe dactyloides*), big bluestem (*Andropogon gerardii*), Indian grass (*Sorgastum nutans*), and associated species (Choate et al. 1998, as cited in USDI-NPS 2008).

As with most ecological communities, mixed grass prairie system driver patterns have changed (Figure 4.9.1-1). Early land use consisted primarily of Native Americans hunting the open plains for bison. Historic accounts of the Historic Site area dating back

NPS PHOTO

Figure 4.9.1-1. One of the values of grasslands is the importance they played in the historic context. The ability for visitors to imagine the historic setting, such as from the Santa Fe Trail wagon ruts seen here, can dramatically add to their sense of place in that historic context.

to 1827 described the landscape as having plentiful "good grass" (USDI-NPS 2008). However, by 1867-1868, overgrazed and trampled prairie appeared in photographs. One hundred years later, most of the prairie had been turned into cropland. Although the grasslands at the Trail Ruts unit were never plowed, their original vegetation was heavily impacted by grazing and prairie dogs.

Grasslands at Fort Larned NHS are clearly part if its cultural heritage. Today the landscape is being "rehabilitated" to evoke the historic period of the Fort, and at the same time maintaining and restoring vital habitats and their ecological functions.

Grasslands at Fort Larned NHS

While Fort Larned NHS is situated within the broad category of mixed grass prairie, there is also considerable variation in grasslands throughout the Historic Site. The Kansas Natural Heritage Inventory, Cogan Technology, and U.S. Bureau of Reclamation (i.e., Cogan et al. 2007) conducted vegetation classification and mapping at Fort Larned NHS as part of the USGS-NPS Vegetation Characterization Program- a cooperative effort by the U.S. Geological Survey (USGS)

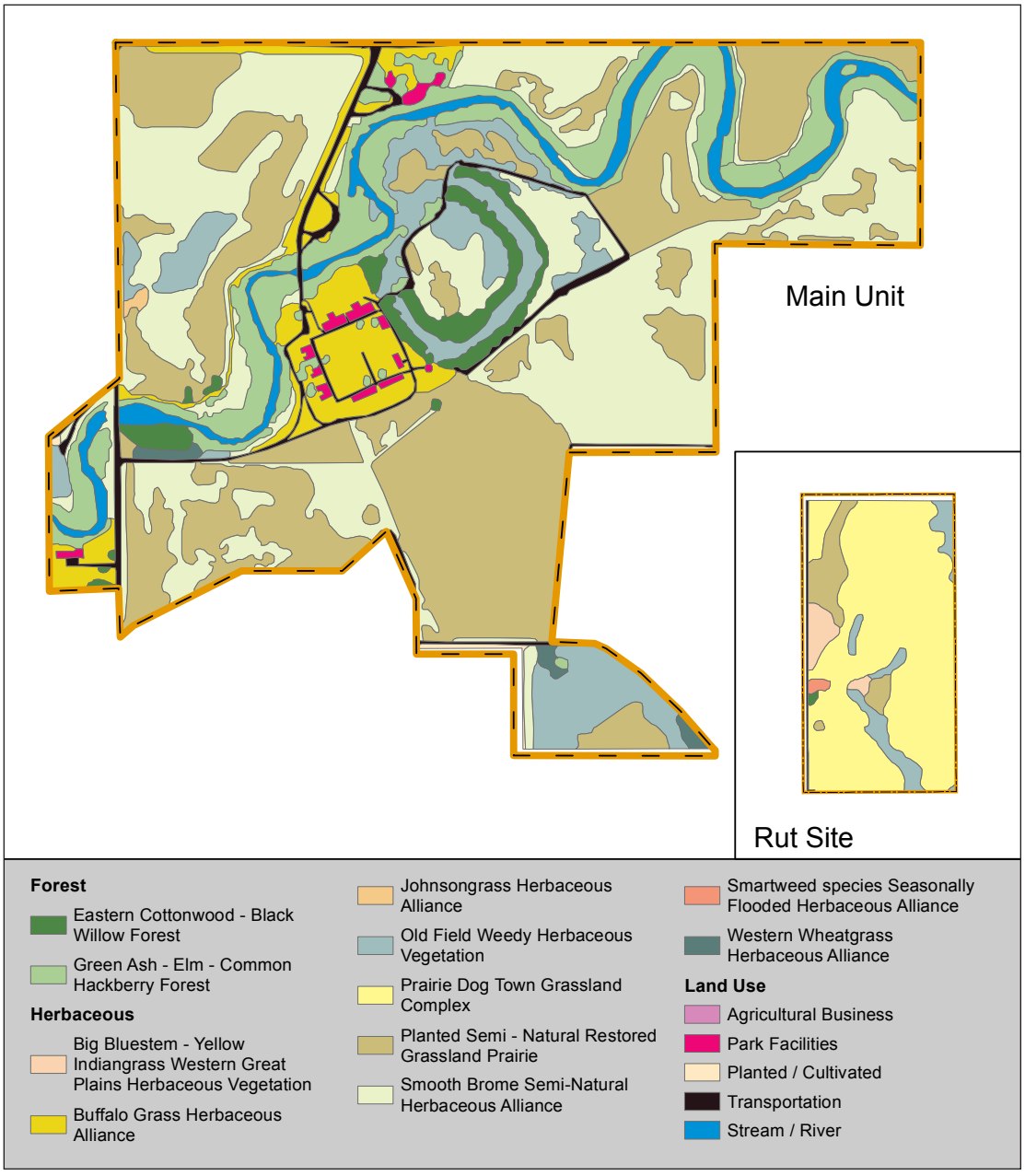


Figure 4.9.1-2. The 16 map units identified by Cogan et al. (2007) including the 11 plant alliances and associations used by the National Vegetation Classification (NVC) system.

Table 4.9.1-1. Eleven different National Vegetation Classification (NVC) plant associations and alliances identified by Cogan et al. (2007) and their corresponding area occupied.

NVC Plant Association / Alliance	Primary Class	Area (hectares acres)	
Populus deltoides - Salix nigra Forest	Forest	4	11
Fraxinus pennsylvanica - Ulmus spp. - Celtis occidentalis Forest	Forest	30	74
Andropogon gerardii - Sorghastrum nutans Western Great Plains Herbaceous Vegetation [1]	Herbaceous	1	2
Buchloe dactyloides Planted/Cultivated Herbaceous Vegetation [1]	Herbaceous	9	23
Prairie Dog Town Grassland Complex	Herbaceous	14	35
Andropogon gerardii - (Sorghastrum nutans) Herbaceous Alliance	Herbaceous	81	200
Old Field Weedy Herbaceous Vegetation	Herbaceous	20	49
Bromus inermis Semi-natural Herbaceous Alliance	Herbaceous	69	170
Hydrologically Disturbed Seasonal *Polygonum* Vegetation [1]	Herbaceous	0.1	0.3
Pascopyrum smithii Herbaceous Alliance [1]	Herbaceous	1	2
Sorghum halepense Herbaceous Alliance [1]	Herbaceous	0.2	0.4

[1] Note from Cogan et al. (2007)- Represents discrete stands of vegetation that were not sampled either due to their small size or they occurred outside of the Historic Site boundary.

and the National Park Service (NPS) to classify, describe, and map vegetation communities in more than 280 national park units across the United States. This program uses a hierarchical classification scheme, the National Vegetation Classification Standard (http://biology.usgs.gov/npsveg/nvcs.html), as a basis for classifying vegetation. Cogan et al. (2007) identified sixteen map units used to describe the landscape at the Historic Site (Figure 4.9.1-2). Among these were four National Vegetation Classification (NVC) plant associations, six alliances, one complex, four non-natural map classes (Agricultural business, Transportation, Park facilities, and Planted/cultivated), and one un-vegetated natural unit (Stream/river) (Cogan et al. 2007). Only 11 of these map units are shown in Table 4.9.1-1; the four non-natural and one un-vegetated units were omitted. Eight map units had a prominent grassland component, although two were not assessed due to their limited extent.

4.9.2. Data and Methods

Conditions During Assessment

Much of the southern Great Plains experienced substantial drought conditions during the past several years, but such extreme conditions were not the case at Fort Larned. According to the Palmer Drought index (NOAA 2013), two of the past four years was considered in the mid-range of variability; whereas, one year (2011) was considered to have experienced moderate drought and one year (2010) was considered as being moderately moist (Figure 4.9.2-1). We have tried to take these conditions into account in our interpretations, but the reader should be aware that the conditions experienced during the past few years have an important impact on our assessment.

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

Indicators/Measures

Soil/Site Stability and Hydrologic Function

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

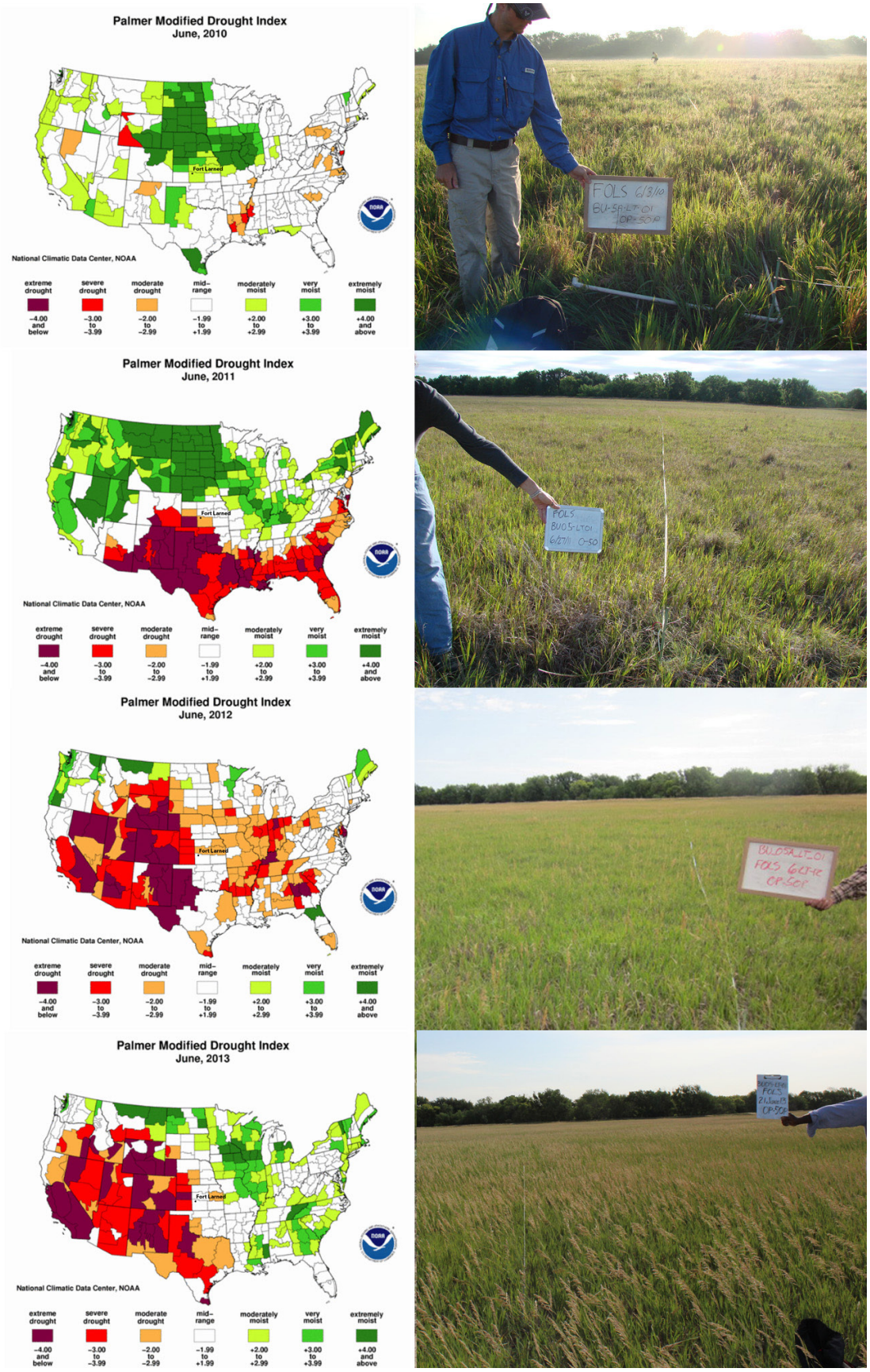


Figure 4.9.2-1. The Palmer Modified Drought Index for each of the four years for which data from Fort Larned NHS were available. Also shown to the right of each map are photos taken from a monitoring transect (BU05-LT01) for the corresponding time period.

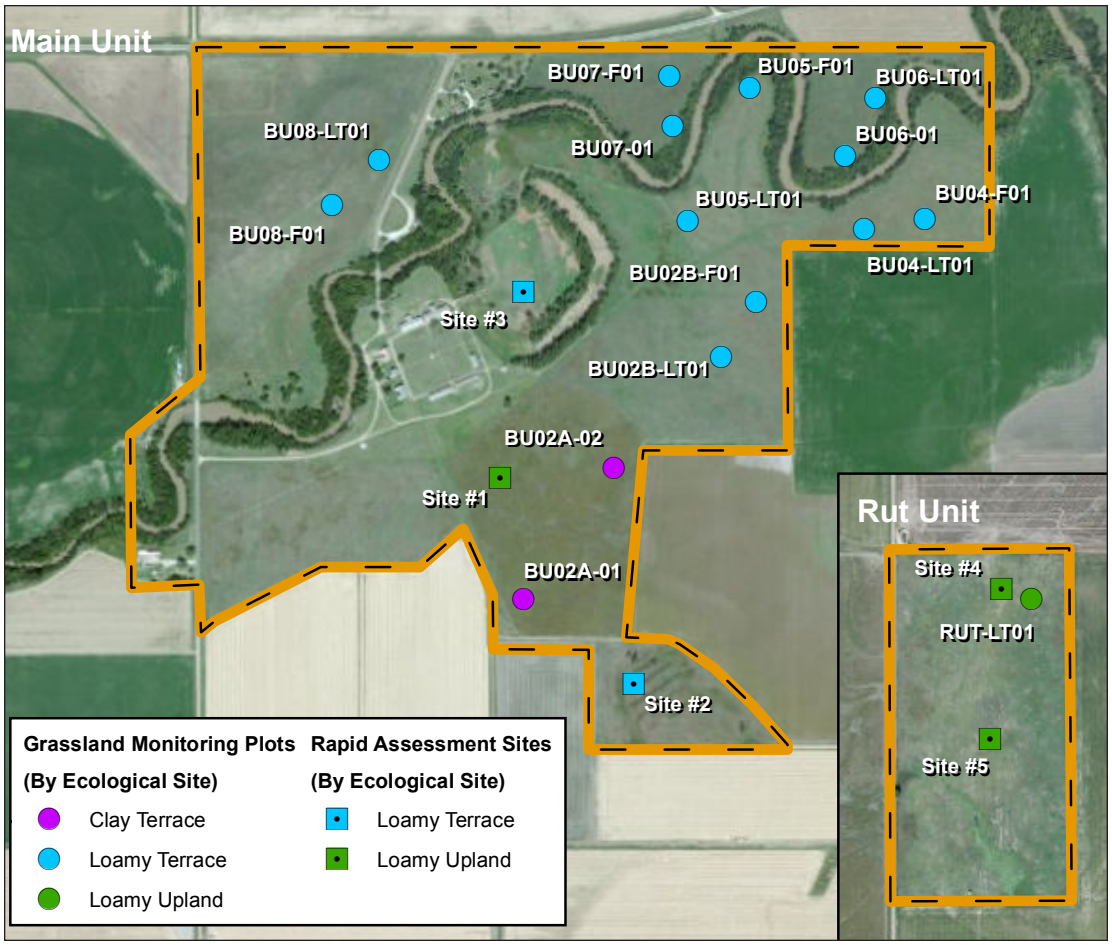


Figure 4.9.2-2. Location of Soil Rapid Assessment points and grassland monitoring plots at Fort Larned NHS.

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

Indicators/Measures

Biotic Integrity

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

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

The soil site stability and hydrologic function measures were assessed primarily through a site visit and rapid assessment in early June 2013 conducted by Tim Seastedt, Pete Biggam, and Tomye Folts-Zettner.

The rapid assessment consisted of evaluating four selected sites at the Historic Site (Figure 4.9.2-2). The methodology for these assessments used an approach based on those described in the qualitative assessment protocol "Interpreting Indicators of Rangeland Health (Version 4.0) (http://usda-ars.nmsu.edu/monit_assess/index.html), in which Soil/Site Stability qualitative measures were used to assess the soil site stability and hydrologic function (Table 4.9.2-1).

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

Table 4.9.2-1. Indicators and measures used to assess grasslands at Fort Larned NHS.

Indicator	Measure	Definition
Soil/Site Stability and Hydrologic Function	Rills	A small, intermittent water course with steep sides, usually only several centimeters deep (SSSA 1997). Rills generally are linear erosion features.
	Water Flow Patterns	Flow patterns are the path that water takes as it moves across the soil surface during overland flow.
	Pedestals and/or terracettes	"Plants or rocks that appear elevated as a result of soil loss by wind or water erosion (does not include plant or rock elevation as a result of non-erosional processes such as frost heaving), and "Benches" of soil deposition behind obstacles caused by water erosion."
	Bare ground	All land surface not covered by vegetation, rock, or litter (SRM 1999). As used in this document, visible biological crusts and standing dead vegetation are included in cover estimates or measurements and therefore are not bare ground (e.g., mineral soil).
	Gullies	A furrow, channel, or miniature valley, usually with steep sides through which water commonly flows during and immediately after rains or snowmelt (SRM 1999). Small channels eroded by concentrated water flow.
	Wind-scoured, blowout and/or depositional areas	Areas, generally in interspaces, where the finer soil particles have blown away sometimes leaving residual gravel, rock, or exposed roots on the soil surface.
	Litter Movement	The uppermost layer of organic debris on the soil surface, essentially the freshly fallen or slightly decomposed vegetal material (SRM 1999). In this document, it includes persistent and non-persistent organic matter that is in contact with the soil surface.
	Soil surface resistance to erosion	The top layer underneath vegetation canopy and characteristics of presence/absence/configuration of debris.
	Soil surface loss or degradation	Intactness of uppermost soil layer.
	Compaction layer	A near surface layer of dense soil caused by the repeated impact on or disturbance of the soil surface. When soil is compacted, soil grains are rearranged to decrease the void space and bring them into closer contact with one another, thereby increasing the bulk density (SSSA 1997).
Biotic Integrity	Landscape-scale Diversity	The extent to which landscape-scale diversity reflects spatial pattern of soils and disturbance.
	Local Species Composition,	The extent to which species composition within a site (e.g., ecological site) deviates substantially from the expected native species compliment either from exotics or native species.
	General Life Cycles Relative to Disturbance	The proportion of annual, biennial and perennial species relative to the time since disturbance.
	Relative proportion of functional groups (e.g., graminoid, forbs, shrubs, etc.)	The relative proportions of functional groups relative to what would be expected based on site characteristics (e.g., lack of forbs, excessive shrub density, etc.).
	Relative proportion of C3 and C4 species.	The relative proportions of C3 and C4 plants relative to what would be expected based on site characteristics.

These measures were used in conjunction with soil survey information and ecological site descriptions for the four selected evaluation areas, each of which were approximately 1/3 acre in size. It is important to note that only the Soil/Site Stability qualitative measures were observed and documented on site and used to perform the rapid soil assessment.

The assessment for the biotic integrity of grasslands was made via a combination of the field rapid assessment and using data collected as part of the Southern Plains Inventory and Monitoring Network's (SOPN) ongoing grassland and fire effects monitoring.

In collaboration with additional SOPN and Historic Site staff, the first task was to determine appropriate measures of grassland biotic integrity. Using the qualitative measures of rangeland health presented in Pellent et al. (2005) as a starting point, the grassland experts, in collaboration with SOPN and Historic Site staff developed a suite of five measures of grassland biotic integrity that was deemed appropriate for this assessment. These measures are summarized in Table 4.9.2-1 and described in greater detail below.

A qualitative rapid field assessment was conducted based on visits to multiple sites at Fort Larned NHS by the grassland and soil experts. We then used monitoring data collected during the past three years to augment the opinions of our experts and to provide a more quantitative baseline for future assessment. These data were collected by SOPN and the Southern Plains Fire Group, following Folts-Zettner et al. (2013). Grassland monitoring data were collected in 2010-2013 along 15 transects, each with five subplots, as part of this monitoring effort (Folts-Zettner et al. 2012; unpublished data) (Figure 4.9.2-2). At each subplot, the percent cover was estimated for each species within a 1x2m quadrat.

Landscape-scale Diversity

The plant communities and alliances are generally expected to reflect local conditions of soil, moisture, disturbance, etc. As such, we would expect the diversity across the Historic Site to generally reflect the variation in these site characteristics. However, it is not reasonable to expect a one to one correspondence between local communities and their corresponding sites because a multitude of factors can influence the local expression of vegetation communities at a given location. Rather, we are trying to determine that some reasonable level of landscape diversity exists and that it generally corresponds to changes in ecological conditions. To assess this, we compared the vegetation communities observed during the Fort Larned NHS vegetation mapping (Cogan et al. 2007) with soil types (NRCS 2012) and ecological sites (NRCS 2013).

Local Species Composition

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

General Life Cycles Relative to Disturbance

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

Relative Proportion of Functional Groups

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

Relative Proportion of C3 and C4 Species

The morphological and physiological characteristics of grassland plants make them highly adaptable to withstand stressors such as drought or grazing by large herbivores such as cattle (Lauenroth et al. 2008). The proportion of C3 and C4 grasses can also dramatically influence how these grassland communities respond to climate change and levels of CO2, although the nature of such response has been much debated (Wand et al. 1999).

4.9.3. Reference Conditions

Soil/Site Stability and Hydrologic Function

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

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

Biotic Integrity

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

Our measure of landscape-scale diversity focuses on whether or not the diversity of plant communities reflects to a reasonable extent the diversity in site characteristics. As such, we used the spatial pattern of soil types (NRCS 2012) and ecological sites (NRCS 2013) as a general reference for the extent and pattern of landscape diversity that might be expected.

For the remaining measures, we used a combination of the NRCS's ecological site descriptions (NRCS 2013) and expert opinion as a general reference for plant community characteristics that might be expected given the soil types and ecological sites that occur at Fort Larned NHS. It is important to note however, the values in the ecological site descriptions are typically only provided for what are considered the historic climax plant communities (HCPCs), and variations in the dynamics of those communities are presented only through qualitative descriptions and/or generalized state and transition models. Consequently we do not strictly adhere to the HCPCs as a reference condition in the sense that departures from that reference necessarily represent a degraded quality; rather as a general guide to be used in conjunction with expert opinion to determine resource condition.

4.9.4. Condition and Trend

Field notes from the grassland assessment are presented in Appendix E.

Soil / Site Stability / Hydrologic Function

The results from the rapid assessment indicated that the overall current condition of the soil/site stability/hydrologic function at Fort Larned NHS was generally good in the Main Unit but with a couple of sites having slight to moderate concern in the Ruts Unit, primarily due to the prairie dogs (Table 4.9.4-1).

Table 4.9.3-1. Reference conditions for soil/site stability/hydrologic function measures.

Measure	Significant Concern		Moderate Concern	Good	
	Extreme to Total	Moderate to Extreme	Moderate	Slight to Moderate	None to Slight
Soil/site Stability and Hydrologic Function					
Rills	Rill formation is severe and well defined throughout most of the site.	Rill formation is moderately active and well defined throughout most of the site.	Active rill formation is slight at infrequent intervals; mostly in exposed areas	No recent formation of rills; old rills have blunted or muted features.	Current or past formation of rills as expected for the site.
Water Flow Patterns	Water flow patterns extensive and numerous; unstable with active erosion; usually connected	Water flow patterns more numerous and extensive than expected; deposition and cut areas common; occasionally connected.	Number and length of water flow patterns nearly match what is expected for the site; erosion is minor with some instability and deposition.	Number and length of water flow patterns match what is expected for the site; some evidence of minor erosion. Flow patterns are stable and short.	Matches what is expected for the site; minimal evidence of current or past soil deposition and erosion.
Pedestals and/or terracettes	Abundant active pedestalling and numerous terracettes. Many rocks and plants are pedestaled; exposed plant roots are common.	Moderate active pedestalling; terracettes common. Some rocks and plants are pedestaled with occasional exposed plant roots.	Slight active pedestalling; Most pedestals are in flow paths and interspaces and/or on exposed slopes. Occasional terracettes present.	Active pedestalling or terracette formation is rare; some evidence of past pedestal formation, especially in flow patterns on exposed slopes.	Current or past evidence of pedestaled plants or rocks as expected for the site. Terracettes uncommon or absent.
Bare ground	Much higher than expected for the site. Bare areas are large and generally connected.	Moderate to much higher than expected for the site. Bare areas are large and occasionally connected.	Moderately higher than expected for the site. Bare areas are of moderate size and sporadically connected.	Slightly to moderately higher than expected for the site. Bare areas are small and rarely connected.	Amount and size of bare areas match that expected for the site.
Gullies	Common with indications of active erosion and downcutting; vegetation is infrequent on slopes and/or bed. Nickpoints and headcuts are numerous and active.	Moderate in number to common with indications of active erosion; vegetation is intermittent on slopes and/or bed. Headcuts are active; downcutting is not apparent.	Moderate in number with indications of active erosion; vegetation is intermittent on slopes and/or bed. Occasional headcuts may be present.	Uncommon, vegetation is stabilizing the bed and slopes; no signs of active headcuts, nickpoints, or bed erosion.	Match what is expected for the site; drainages are represented as natural stable channels; vegetation common and no signs of erosion.
Wind-scoured, blowout, and/or depositional areas	Extensive	Common	Occasionally present	Infrequent and few.	Match what is expected for the site.
Litter movement	Extreme concentrated around obstructions. Most size classes of litter have been displaced.	Moderate to extreme; loosely concentrated near obstructions. Moderate to small size classes of litter have been displaced.	Moderate movement of smaller size classes in scattered concentrations around obstructions and in depressions.	Slightly to moderately more than expected for the site with only small size classes of litter being displaced.	Matches that expected for the site with a fairly uniform distribution of litter.
Soil surface resistance to erosion	Extremely reduced throughout the site. Biological stabilization agents including organic matter and biological crusts virtually absent.	Significantly reduced in most plant canopy interspaces and moderately reduced beneath plant canopies. Stabilizing agents present only in isolated patches.	Significantly reduced in at least half of the plant canopy interspaces or moderately reduced throughout the site.	Some reduction in soil surface stability in plant interspaces or slight reduction throughout the site. Stabilizing agents reduced below expected	Matches that expected for the site. Surface soil is stabilized by organic matter decomposition products and/or a biological crust.

Table 4.9.3-1. Reference conditions for soil/site stability/hydrologic function (continued).

Measure	Significant Concern		Moderate Concern	Good	
	Extreme to Total	Moderate to Extreme	Moderate	Slight to Moderate	None to Slight
Soil surface loss or degradation	Soil surface horizon absent. Soil structure near surface is similar to, or more degraded, than that in subsurface horizons. No distinguishable difference in subsurface organic matter content.	Soil loss or degradation severe throughout site. Minimal differences in soil organic content and structure of surface and subsurface layers.	Moderate soil loss or degradation in plant interspaces with some degradation beneath plant canopies. Soil structure is degraded and soil organic matter is significantly reduced.	Some to no soil loss has occurred and/or soil structure shows signs of degradation, especially in plant interspaces	Soil surface horizon intact. Soil structure and organic matter content match that expected for site.
Compaction layer (below soil surface)	Extensive; severely restricts water movement and root penetration.	Widespread; greatly restricts water movement and root penetration.	Moderately widespread, moderately restricts water movement and root penetration.	Rarely present or is thin and weakly restrictive to water movement and root penetration.	Matches that expected for the site; none to minimal, not restrictive to water movement and root penetration.

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

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

Table 4.9.4-1. The results for measures used to assess soil/site stability/hydrologic function at each of six rapid-assessment points at Fort Larned NHS.

Indicator	Measure	Site Assessment[1]				
		1	2	3	4	5
Soil/Site Stability and Hydrologic Function	Rills	NS	NS	NS	NS	SM
	Water Flow Patterns	NS	NS	NS	NS	M
	Pedestals and/or terracettes	NS	NS	NS	NS	NS
	Bare ground	NS	NS	NS	SM	ME
	Gullies	NS	NS	NS	NS	NS
	Wind-scoured, blowout and/or depositional areas	NS	NS	NS	NS	M
	Litter Movement	NS	NS	NS	NS	M
	Soil surface resistance to erosion	NS	NS	NS	SM	ME
	Soil surface loss or degradation	NS	NS	NS	SM	M
	Compaction layer	NS	NS	NS	SM	SM
	Overall Soil and Site Stability Rating	**NS**	**NS**	**NS**	**SM**	**M**

[1] NS = None to Slight, SM = Slight to Moderate, M = Moderate, ME = Moderate to Extreme, ET = Extreme to Total

Virtually all of the measures of soil and hydrologic function in the Main Unit showed none to slight departure from what would be expected for these ecological sites. In contrast, soil erosion from water and wind in the Ruts Unit ranged from slight to moderate in the northern section of the unit and moderate to extreme at the central rapid assessment site. Some rills were evident and water flow patterns were becoming evident. Soil loss was moderate and bare ground, mostly due to prairie dog activity, was higher than expected.

Biotic Integrity

Landscape-scale Diversity

There remains some correspondence among the ecological sites, soils, and vegetation (Figure 4.9.4-1), although the landscape scale diversity is being lost, primarily as a result of exotic species creating widespread monocultures (Figure 4.9.4-2). This is probably of greater concern regarding the local site diversity, although the overall landscape diversity of native grassland types is being lost. While this is of significant concern from an ecological standpoint (and ranked as such), it is probably of lesser concern for Historic Site visitors who still see prairie habitats, even if they are not the native associations. Attempts at restoring native prairies at the Historic Site have had limited success.

Local Species Composition

There is significant concern from an ecological standpoint regarding local species composition. As previously indicated, a substantial loss of plant species diversity has resulted from monocultures of exotic plants, particularly bromes. Based on the SOPN monitoring data (Folts-Zettner et al. 2012), 67% of the total cover in grasslands of the Main Unit at Fort Larned NHS was made up of smooth brome, an exotic species. Similarly, field bindweed, an exotic forb, had the highest percentage cover (30%) of the plant cover in the Ruts Unit.

We do not have an expectation for species composition to match the species list for historic climax plant communities of the appropriate ecological site descriptions (NRCS 2013), although we did take these descriptions into account along with expert opinion. However, for the condition to be considered good, we do have an expectation for native species appropriate for the site. Given the loss of plant species diversity and the high proportion of exotic species (discussed in greater detail below), we consider the

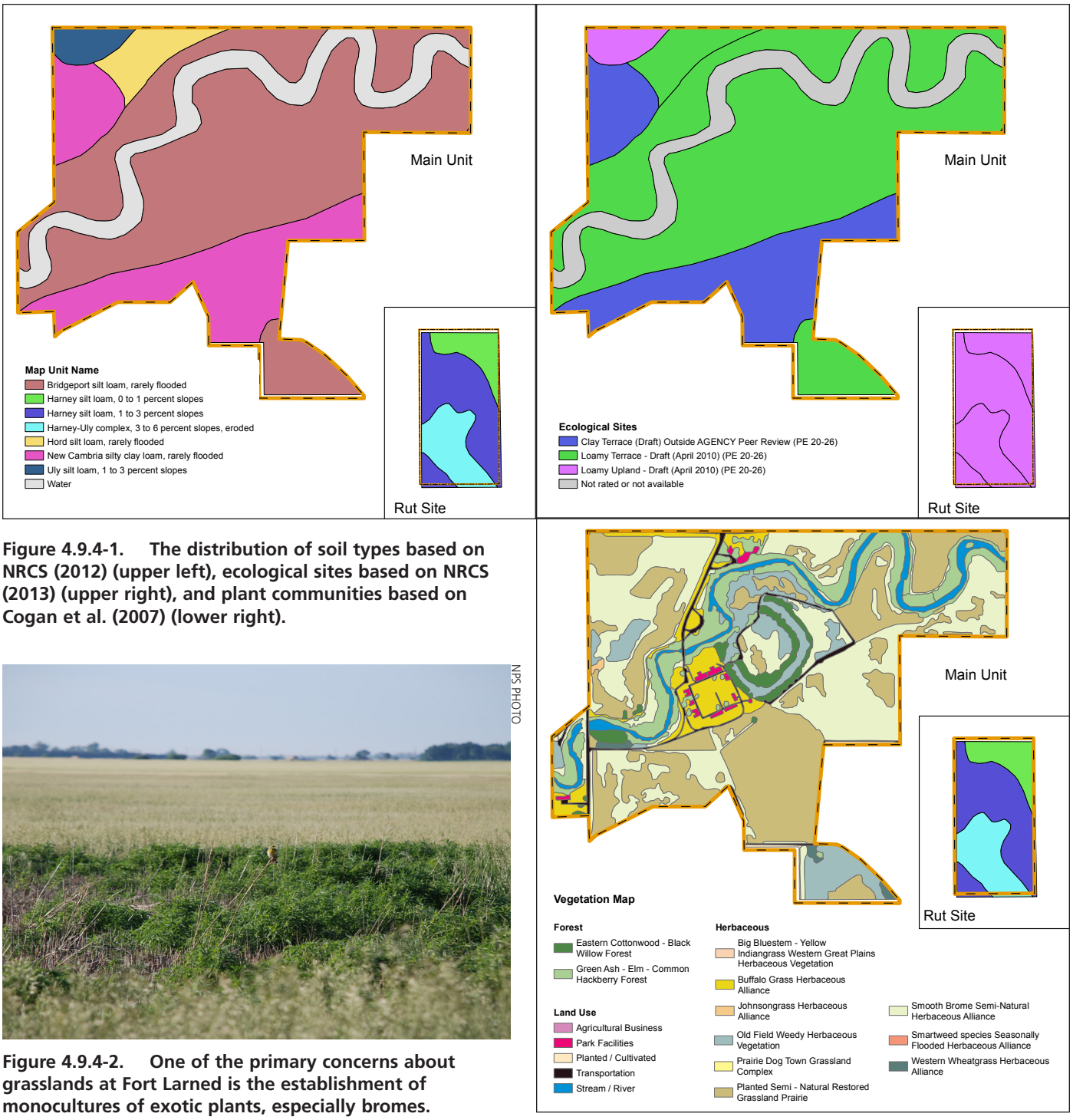


Figure 4.9.4-1. The distribution of soil types based on NRCS (2012) (upper left), ecological sites based on NRCS (2013) (upper right), and plant communities based on Cogan et al. (2007) (lower right).

NPS PHOTO

Figure 4.9.4-2. One of the primary concerns about grasslands at Fort Larned is the establishment of monocultures of exotic plants, especially bromes.

local species composition to be of significant concern from an ecological perspective.

One of the major threats to grasslands and other plant communities is invasive species. Invasive species have been directly linked to the replacement of dominant native species (Tilman 1999), the loss of rare species (King 1985), changes in ecosystem structure, alteration of nutrient cycles and soil chemistry (Ehrenfeld 2003), shifts in community productivity (Vitousek 1990), and changes in water availability (D'Antonio and Mahall 1991).

Based on four years of grassland sampling (2010-2013), 74%, or 52 of 70 (the total number of species observed) were native (Table 4.9.4-2). Of these, the proportion of native species was generally higher for forbs

Table 4.9.4-2. The number and percentage of native and exotic species of each life form found on Fort Larned NHS during the 2010-2013 grassland monitoring sampling.

Life Form	Native	Exotic	Total	Percent Native
Graminoid	12	6	18	67%
Forb	37	12	49	75%
Shrub	2	0	2	100%
Vine	1	0	1	100%

Table 4.9.4-3. The percentage of perennial grass and forb species observed at each ecological site on Fort Larned NHS during the 2010-2013 grassland monitoring sampling.

Ecological Site No.	Ecological Site Name	Life Form	Percent Perennials Observed 2010-2013 [1]
R073XY006KS	Clay Terrace	Graminoid	100%
R073XY006KS	Clay Terrace	Forb	28%
R073XY014KS	Loamy Terrace	Graminoid	100%
R073XY014KS	Loamy Terrace	Forb	67%
R073XY015KS	Loamy Upland	Graminoid	63%
R073XY015KS	Loamy Upland	Forb	67%

[1] For each life form, percent perennial as opposed to annual or biennial.

(75%) than grasses (67%) (Table 4.9.4-3). However, the number of species does not take into account how prevalent those species are on the landscape. Based on the percentage of cover, grasses on our sample plots were almost exclusively native species at one of three primary ecological sites, almost exclusively non-native at one of our sites, and about equal parts native and non-native at the third ecological site (Figure 4.9.4-3). This

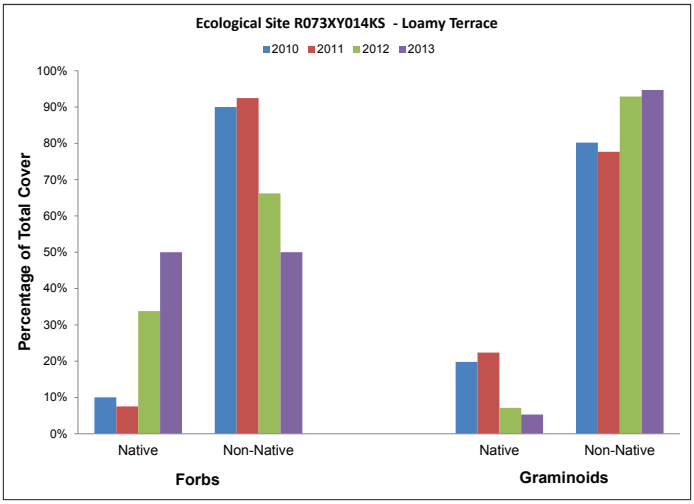
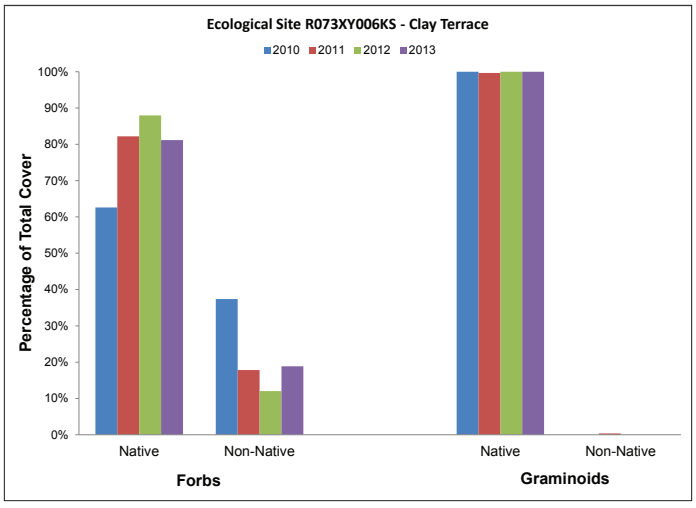
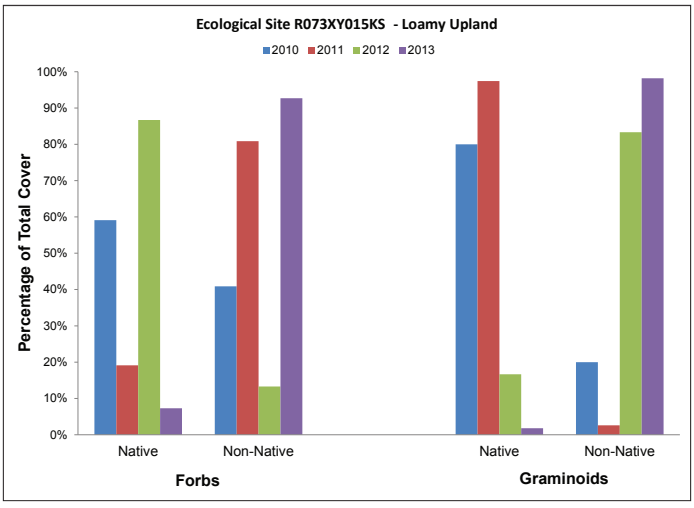


Figure 4.9.4-3. The percentage of native and exotic grasses and forbs for each ecological site sampled in 2010-2013 at Fort Larned NHS.





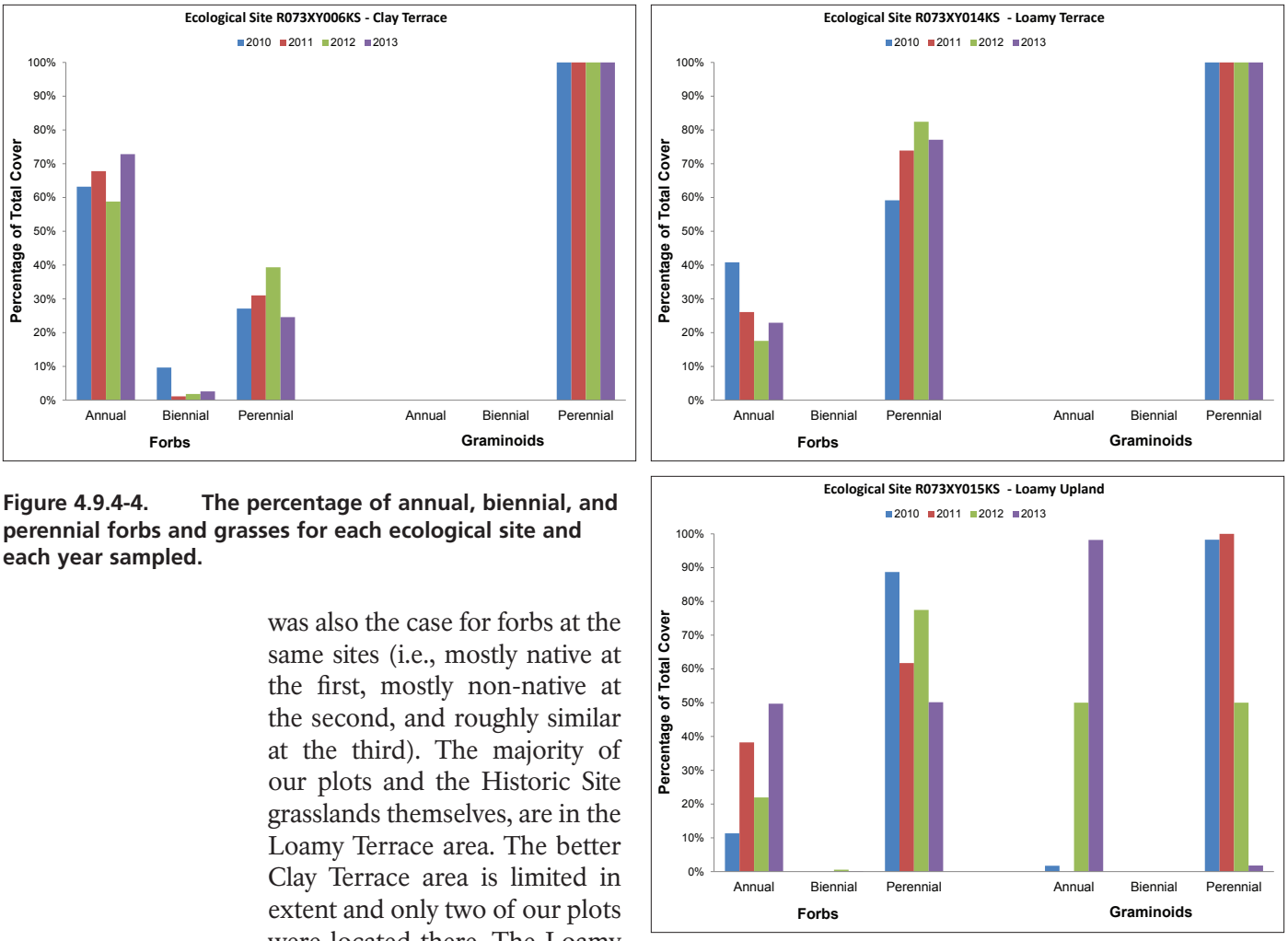


Figure 4.9.4-4. The percentage of annual, biennial, and perennial forbs and grasses for each ecological site and each year sampled.

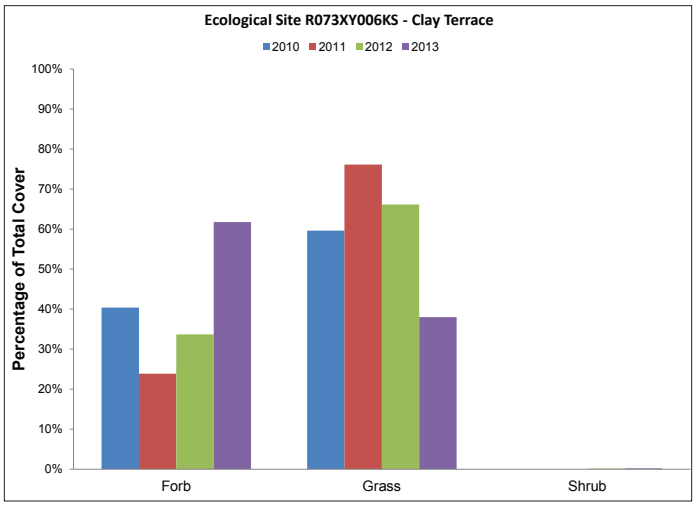
was also the case for forbs at the same sites (i.e., mostly native at the first, mostly non-native at the second, and roughly similar at the third). The majority of our plots and the Historic Site grasslands themselves, are in the Loamy Terrace area. The better Clay Terrace area is limited in extent and only two of our plots were located there. The Loamy Upland is where the prairie dog town is located and has only one monitoring plot. Overall we consider this measure to be of significant concern.

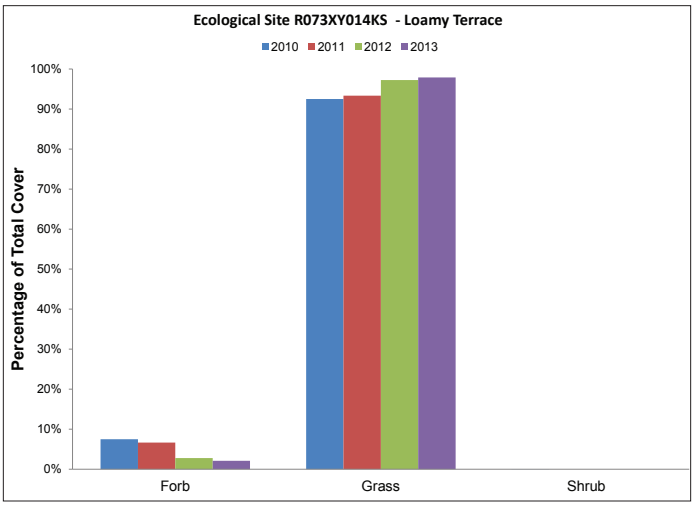
General Life Cycles Relative to Disturbance

The proportion of annual, biennial and perennial species provides an indication of the stability of the site, and it is generally expected that the proportion of annual species at a given site would be higher immediately following a disturbance, but would shift toward an increased proportion of perennials as time passes since a disturbance. Data from our grassland monitoring indicated that grasses were 100% perennial at two of the three sites and predominately perennial (63%) at the third site. Forbs were considerably more variable among sites (Figure 4.9.4-4).

As previously discussed, we did not have any expectation for the proportion of annuals, biennials, and perennials to coincide exactly with historic climax plant communities, in part because of local site variability and not all sites are at a climax stage. However, based on what is considered the historic climax plant communities (NRCS 2013), the proportion of perennial species was generally expected to be high for grasses and more variable for forbs.

The forbs of two areas were dominated by annuals. The Ruts Unit was dominated by exotic annual forbs, which is of some concern. The forbs at the other area (The Clay Terrace Ecosite), were dominated by annual species, but this was of lesser concern. This site is being restored and was probably primarily planted with grass species. Thus, the forbs, while primarily annuals, are also largely native, and are most likely representative of native forbs coming back as part of the restoration process. This area was also noted during the rapid assessment as having annual





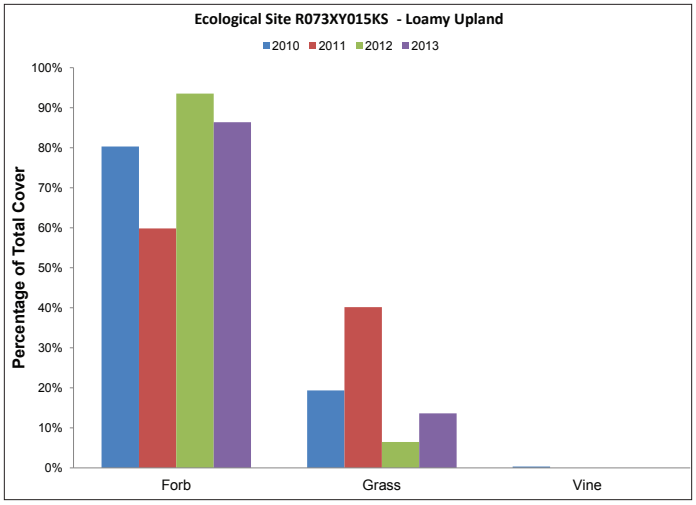


Figure 4.9.4-5. The percentage of life forms for each ecological site sample in 2010-2013 at Fort Larned NHS.

sunflowers, which do not typically persist at undisturbed sites.

Overall, we considered the grasslands at Fort Larned to be in relatively good condition with respect to the proportional plant life cycles, with a notable exception of the Ruts Unit, which was of significant concern with respect to this indicator.

Relative Proportion of Functional Groups - There was considerable variation in the proportions of functional groups observed both during the rapid assessment and in our grassland and fire effects monitoring (Figure 4.9.4-5) (Table 4.9.4-4). In the Main Unit, there was a noticeable absence of forbs, particularly in the loamy terrace ecological sites. This is of some concern, although it may be in part due to a lack of seeding forbs during

Table 4.9.4-4. The percentage cover of each life form observed at each ecological site on Fort Larned NHS during the 2010-2013 grassland monitoring sampling.

Ecological Site No.	Ecological Site Name	Life Form	Percent Observed 2010-2013
R073XY006KS	Clay Terrace	Graminoid	59%
R073XY006KS	Clay Terrace	Forb	41%
R073XY006KS	Clay Terrace	Shrub	0.1%
R073XY014KS	Loamy Terrace	Graminoid	95%
R073XY014KS	Loamy Terrace	Forb	5%
R073XY014KS	Loamy Terrace	Shrub	0.01%
R073XY015KS	Loamy Upland	Graminoid	18%
R073XY015KS	Loamy Upland	Forb	82%
R073XY015KS	Loamy Upland	Vine	0.1%

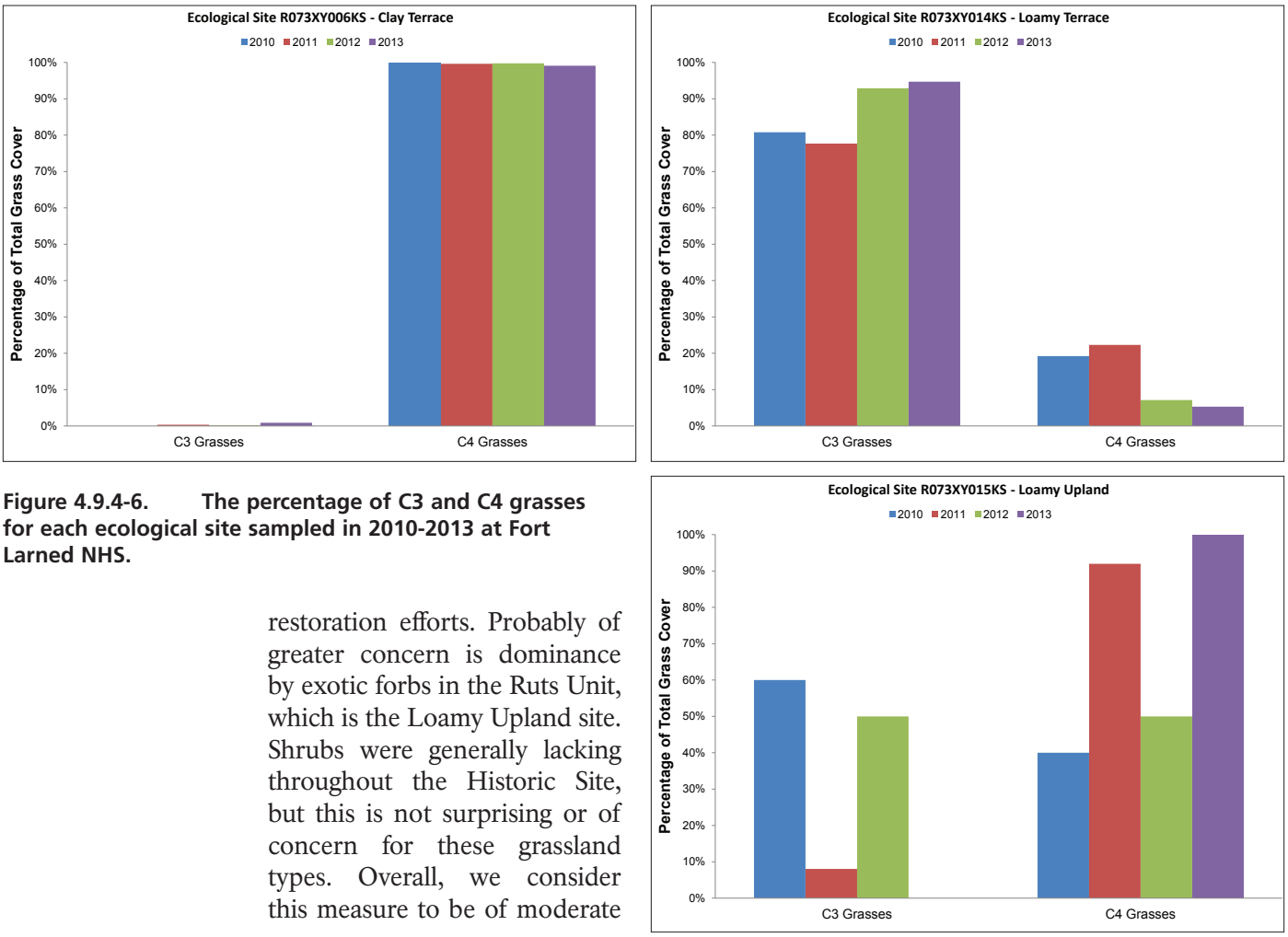


Figure 4.9.4-6. The percentage of C3 and C4 grasses for each ecological site sampled in 2010-2013 at Fort Larned NHS.

restoration efforts. Probably of greater concern is dominance by exotic forbs in the Ruts Unit, which is the Loamy Upland site. Shrubs were generally lacking throughout the Historic Site, but this is not surprising or of concern for these grassland types. Overall, we consider this measure to be of moderate concern.

Relative Proportion of C3 and C4 Species – Based on both the rapid assessment and the grassland monitoring data, there was generally a mix of C3 and C4 grasses, although Stubbendieck et al. (2011) reported a shift from warm season (C4) to cool-season introduced species at Fort Larned NHS since 1980 (Figure 4.9.4-6). As expected, there is some variation of the C3 versus C4 grasses among the ecological sites, which is a reasonable expectation for mixed grass prairie in this region.

The predicted, generalized climate change impacts for this region are drier, hotter, and more severe storms (and more frequent, severe fires). Should these predictions be correct, it may favor shrub invasion and alter the C4 and C3 species composition .

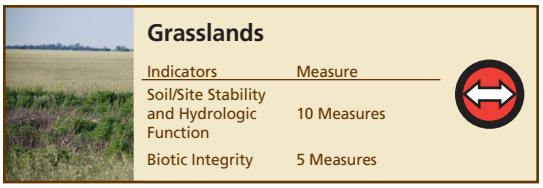
The Role of Fire in Grassland Condition at Fort Larned NHS

Direct evidence of fire frequencies for mixed-grass prairies of the southern Great Plains before settlement is generally lacking due to the absence of trees to carry fire scars from which to estimate fire frequency (e.g., Joern and Keeler 1995). However, fire was reported by travelers through this region during settlement (Joern and Keeler 1995). Although fire is generally reported to play a prominent role in health and functioning of grasslands, this role likely varies substantially among grassland types. In particular, the role of fire as a primary determinant of grassland structure likely decreases strongly from tallgrass prairie to mixed grass and shortgrass steppe as a result of the gradient in productivity and fuel (Kucera 1981, Oesterheld et al. 1999, Scheintaub et al. 2009).

One of the perceived benefits of fire in grassland systems is the reduction of litter. In tallgrass prairie, litter removal increases soil temperature and light leading to increased

productivity (Hulbert, 1988; Knapp and Seastedt, 1986). However, mixed grass probably has less litter accumulation, and Scheintaub et al. (2009) reported a positive relationship between litter and productivity, suggesting that litter may facilitate, or at least not inhibit productivity as it does in tallgrass prairie.

The absence of fire is also generally thought to have contributed to the increase in smooth brome at Fort Larned NHS (Stubbendieck et al. 2011). However, whether this has a positive, neutral or negative benefit on grassland condition will depend on several factors (season, frequency, potential for exotic plant response, etc) that will need to be considered carefully by the Historic Site staff and fire management program. The uncertainty associated with the use of fire as a vegetation management tool might also warrant that such action be undertaken under an adaptive management framework including monitoring of the response.



Overall Condition

For assessing the condition of grasslands, we used a variety of indicators/measures that were not mutually exclusive but were intended to be different ways of capturing the essence of what we thought represented the condition of the Historic Site's grasslands. Grassland condition can be assessed from many different angles, but we chose two main categories for this resource. A summary of how they contributed to the overall grassland condition is summarized in Table 4.9.4-5. Based on the measures, data, and expert opinion, we consider the overall condition of the grasslands at Fort Larned NHS to be of significant concern from an ecological perspective. Although some measures were not of high concern, the native prairie has been almost completely replaced by exotic species. We recognize that the public at large can still see prairie habitat surrounding the Fort, and may not distinguish between native versus exotic grass species. Thus, we emphasize that this condition is based on the NPS policy to "maintain all the components and processes of naturally evolving Historic Site ecosystems, including the natural abundance, diversity, and genetic and ecological integrity of the plant and animal species native to those ecosystems."

Level of Confidence/Key Uncertainties

Overall, our confidence in this assessment is high, although as is generally the case, there are uncertainties. Some of the key uncertainties for the grassland assessment include annual variability, the effect of the moderate drought conditions, and the effect of recovery from disturbance.

Annual variability in rainfall, temperatures, diseases, etc. can have a dramatic effect on some measures (e.g., plant species

Table 4.9.4-5. Summary of the grassland indicators and measures and their contributions to the overall assessment of grassland condition.

Indicator	Measure	Condition	Condition Rationale
Soil/Site Stability and Hydrologic Function	10 measures	Good to Moderate Concern	Departures from expected conditions for most measures of Soil/Site Stability and Hydrologic Function were good among sites, except for the Ruts Unit sites, primarily due to the presence of prairie dogs. The good to moderate condition rating reflects this variability among sites.
Biotic Integrity	5 measures	Significant Concern	The measures of biotic integrity ranged from significant concern to moderate among sites. The overall significant concern rating is due to the fact that there is substantial loss of native plant species diversity resulting from monocultures of exotic plants, particularly the extremely invasive bromes.

composition), which in turn, affects our interpretation of grassland condition. However, this assessment was conducted, at least in part, during moderate drought conditions. The stress from these conditions has likely influenced some of our measures, but this influence would also likely imply our assessment is a bit conservative. That is, conditions may have appeared even better had they been assessed under more typical rainfall period.

Another uncertainty is that parts of the grasslands are changing in response to time since disturbance. These changes are complicated and confounded due to the long history of former agricultural land use and the role of fire, and we do not fully understand the degree to which each mechanism plays a role at modifying these grasslands.

4.9.5. Sources of Expertise

During the course of this assessment, we consulted with the following individuals who provided subject matter expertise as well as an on-site rapid assessment.

Dr. Timothy Seastedt is a Professor at University of Colorado, Boulder, Department of Ecology and Evolutionary Biology. He also has an extensive background of research and publications related to the ecology of grasslands. Dr. Seastedt visited Fort Larned NHS as part of the grasslands rapid assessment team.

Peter Biggam is a soil scientist at the NPS Natural Resources Program Center Geoscience and Restoration Branch, who specializes in and has an extensive background in range science and management. Biggam visited Fort Larned NHS as part of a rapid assessment team and the parts of this assessment related to Soil/Site Stability and Hydrologic Function are based on Biggam's assessment (Biggam 2013 unpublished).

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4.10. Exotic Plants

Indicators/Measures

- Prevalence of Exotic Plant (2 measures)
- Potential to Alter Native Plant Communities (2 measures)

Condition – Trend - Confidence

Significant Concern – Stable - High

4.10.1. Background and Importance

Globalization of commerce, transportation, human migration, and recreation in recent history has introduced invasive exotic species to new areas at an unprecedented rate. Biogeographical barriers that once restricted the location and expansion of species have been circumvented, culminating in the homogenization of Earth's biota. Globalization of commerce, transportation, human migration, and recreation in recent history has introduced invasive exotic species to new areas at an unprecedented rate. Approximately 4-19% of species introduced into the United States may become invasive (USFWS 2012). These invasive species have profound impacts worldwide on the environment, economies, and human health.

Invasive species have been directly linked to displacing several native species of plants (Pimentel et al. 1999) (Figure 4.10.1-1). Approximately 42% of threatened and endangered species are at risk primarily because of alien-invasive species (Pimentel et al. 2005). Changes in ecosystem structure, alteration of nutrient cycles and soil chemistry alter normal successional trajectory of a system ((Ehrenfeld 2003, Emery 2012), negatively impact agriculture (Pimentel 2009), and limit water availability with (USFS 2012).

The spread of invasive species is one of the most environmentally serious global changes, causing economic and environmental damage in the United States and worldwide (UCSUSA 2008). Consequently, the dynamic relationships among plants, animals, soil, and water established over many thousands of years are at risk of being destroyed in a relatively brief period. For the National Park Service (NPS), the consequences of these invasions present a significant challenge to the management of the agency's natural resources "unimpaired for the enjoyment of future generations." National parks, like land managed by other organizations, are deluged by new exotic species arriving through predictable (e.g., road, trail, and riparian

KIM STRUTHERS

Figure 4.10.1-1. Cheatgrass (*Bromus tectorum*) can form dense, nearly single-species communities in grasslands.

corridors), sudden (e.g., long-distance dispersal through cargo containers and air freight), and unexpected anthropogenic pathways (e.g., weed seeds in restoration planting mixes). Nonnative plants claim an estimated 4,600 acres per day on federal lands alone in the Western United States, quadrupling their range from 1985-1995, claiming approximately 17 million acres (BLM 2011) and significantly altering local flora. For example, in Great Smoky Mountains National Park, over ¼ of the plants (27%) are non-native species. On the big island of Hawaii 35% of the plants are non-native (Pimentel et al. 2005). Invasive plants infest an estimated 2.6 million acres of the 83 million acres managed by the NPS. Prevention and early detection are the principal strategies for successful invasive exotic plant management. While there is a need for long-term suppression programs to address high-impact species, management agencies tend to direct resources toward control of weed species that are already major problems, and not much toward the prevention, early detection, and or even early containment of new exotic plants (Radosevich 2007).

4.10.2. Data and Methods

In considering current condition and trend for exotic plants at Fort Larned NHS, two indicators, with two measures each, were used to assess the overall impact an exotic has on the native plant communities throughout Fort Larned NHS.

Indicators/Measures

Prevalence of Exotic Plant (2 measures)

As part of the Southern Plains Inventory and Monitoring Network (SOPN) exotic plants monitoring program, high priority vectors/plots (e.g., roads and trails) were identified based on their potential risk for invasion by exotic plants. Sampling within these high priority plots was conducted from June to July each year. The methodology used in this monitoring is described in detail in Folts-Zettner et al. (2011). The approach is based on a generalized linear model, where 50-meter plots on both sides of the vector (right [R] and left [L]) are surveyed from a transect running along (e.g., trails) or adjacent to (e.g., along the mow strip of roads) the vector (Figure 4.10.2-1). These plots are divided into four distance classes that are 10 meters apart. Distance class one (D1) is immediately adjacent to the road, trail, or boundary that is being surveyed. As the distance class increases so does its proximity from the actual vector.

This effort is part of a sampling scheme that uses a three-year rotating panel design, whereby a new area is surveyed each year (a panel) for three years, after which the areas surveyed are repeated. It is important to emphasize that this sampling approach does not provide a complete survey of exotic plants throughout the Historic Site. Instead, it provides a repeated snapshot for a limited area with high potential (e.g., roads and trails) for

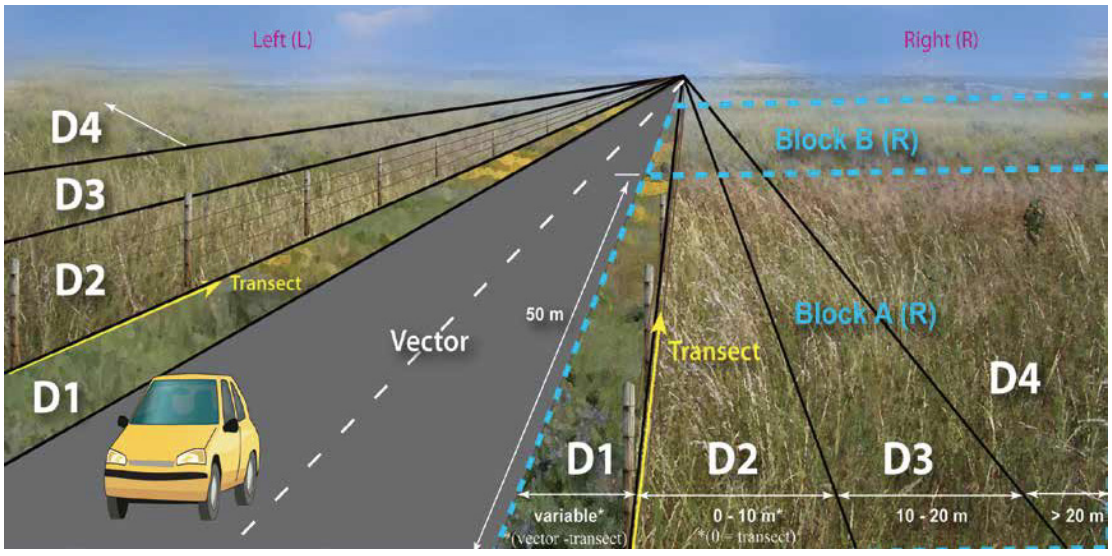


Figure 4.10.2-1. Fifty meter plots, divided into four distance classes, are sampled on each side of a high-risk vector (e.g., roads and trails).

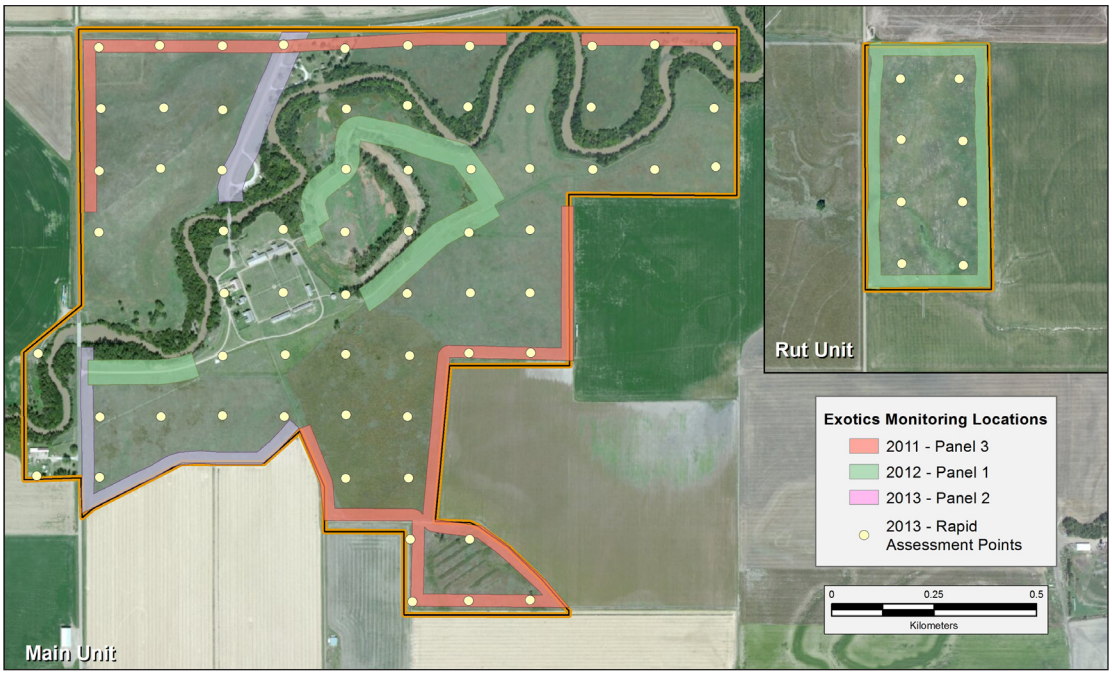


Figure 4.10.2-2. Annual high priority plotss sampled in 2011 -2013 and one time rapid assessment Historic Site grid points sampled in 2013 only.

new invasions. The full protocol also includes estimation of four density classes assigned to each block ranging from scattered plants to a dense matrix.

The data used to assess the measures of proportion of high priority plots infested and plant density were collected in 2011-2013 from plots shown in Figure 4.10.2-2 (Folts-Zettner and Sosinski 2012a,b; 2013). The proportion of plots infested for each exotic species found is shown in Table 4.10.2-1. This measure includes *all* distance classes, whereas the density for each exotic plant, *located within the first distance class (D1) only*, is shown in Figures 4.10.2-3, -4, -5, -6, -7, and -8 and in Appendix F. Within the first distance class each observed exotic

Table 4.10.2-1. Number and percentage of exotic plant species detected in SOPN high priority monitoring plots, including all distance classes sampled in 2011 -2013 at Fort Larned NHS.

Species	No. Plots	% (N=218)
Bromus inermis	180	82.57%
Convolvulus arvensis	132	60.55%
Kochia scoparia	123	56.42%
Bromus tectorum	73	33.49%
Bromus japonicus	70	32.11%
Rumex patientia	60	27.52%
Polygonum arenastrum	57	26.15%
Tragopogon dubius	46	21.10%
Lactuca serriola	45	20.64%
Cynodon dactylon	35	16.06%
Melilotus officinalis	31	14.22%
Conium maculatum	28	12.84%
Taraxacum officinale	25	11.47%
Chenopodium album	20	9.17%
Tribulus terrestris	15	6.88%
Setaria viridis	12	5.50%

Species	No. Plots	% (N=218)
Salsola tragus/kali	10	4.59%
Medicago lupulina	8	3.67%
Medicago sativa	5	2.29%
Sorghum halepense	4	1.83%
Cannabis sativa	3	1.38%
Ulmus pumila	3	1.38%
Amaranthus retroflexus	2	0.92%
Hordeum vulgare	2	0.92%
Lamium amplexicaule	2	0.92%
Verbascum thapsus	2	0.92%
Bothriochloa bladhii	1	0.46%
Lolium perenne	1	0.46%
Poa pratensis	1	0.46%
Rumex crispus	1	0.46%
Triticum aestivum	1	0.46%

Species highlighted are considered to be of highest, high, or moderate concern as shown in Table 4.10.4-1.

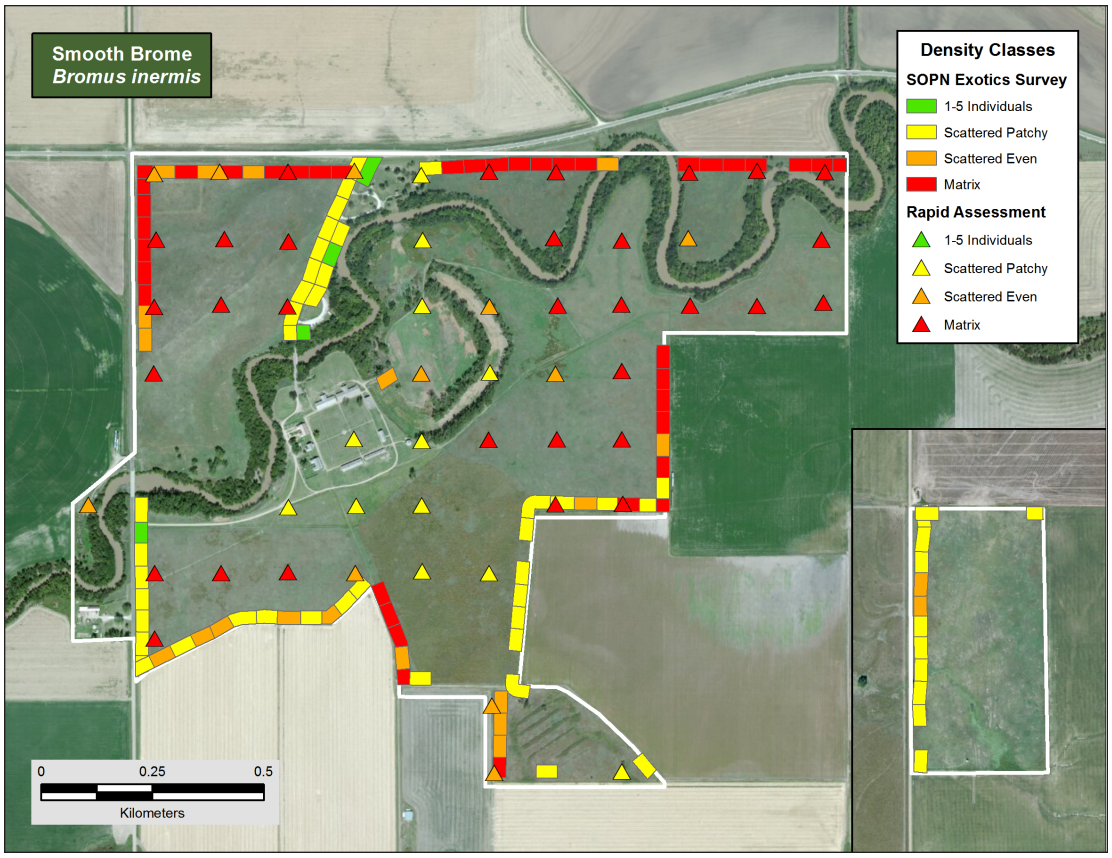


Figure 4.10.2-3. ***Bromus inermis*** **plant density based on distance class one (D1) surveys only, conducted by SOPN monitoring efforts and all 2013 rapid assessment points.**

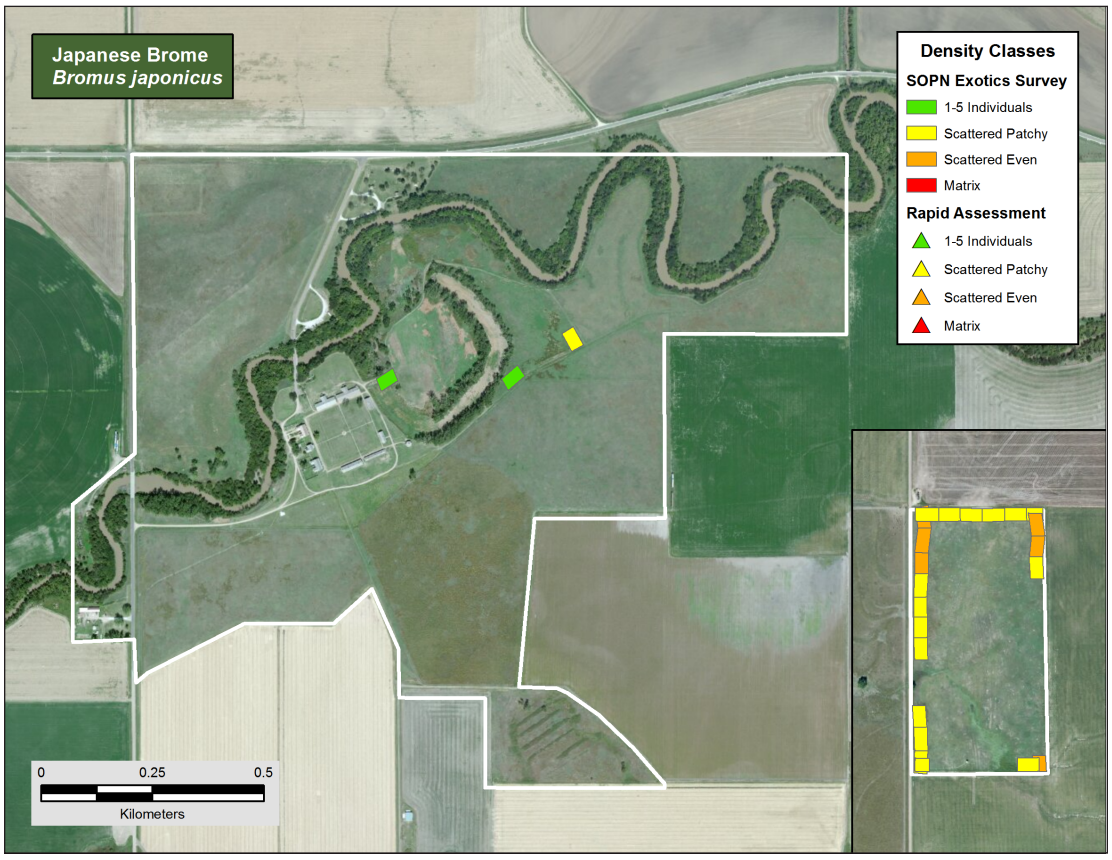


Figure 4.10.2-4. ***Bromus japonicus*** **plant density based on distance class one (D1) surveys only, conducted by SOPN monitoring efforts and all 2013 rapid assessment points. Note: Several additional detections were in the greater distance classes but no plants were detected during the park-wide grid survey.**

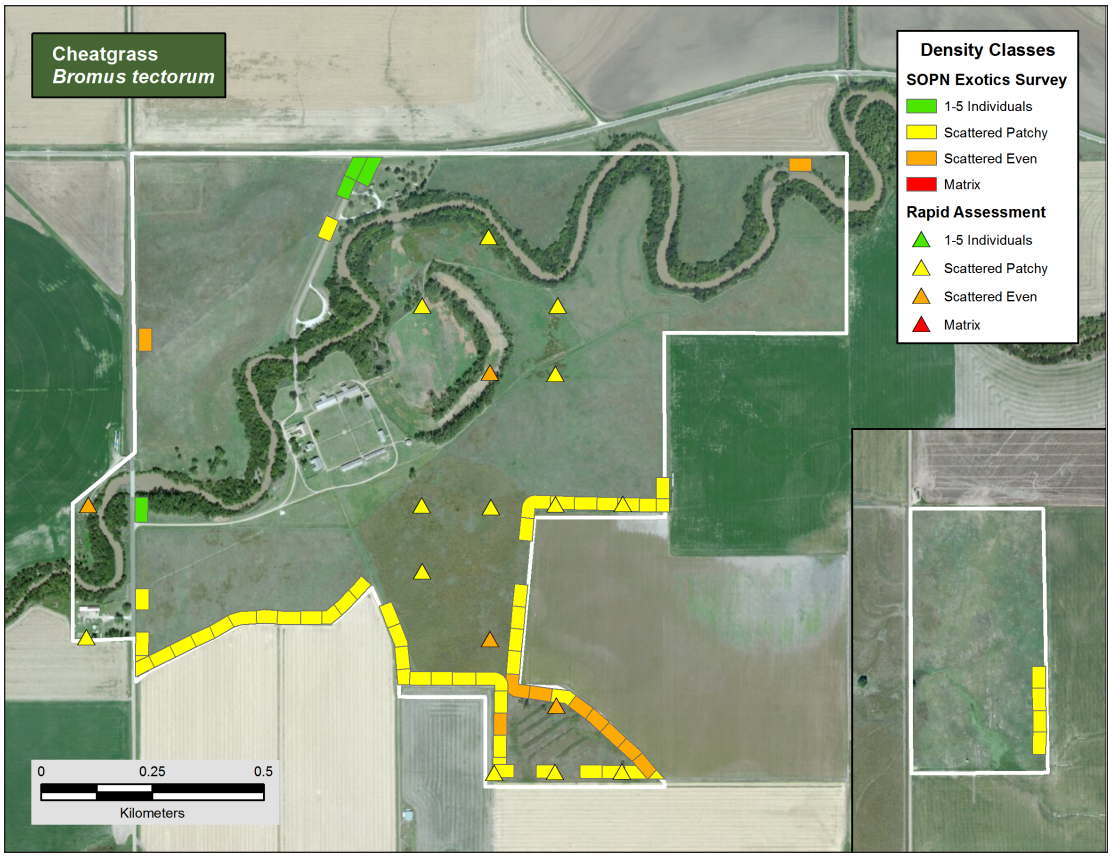


Figure 4.10.2-5. *Bromus tectorum* plant density based on distance class one (D1) surveys only, conducted by SOPN monitoring efforts and all 2013 rapid assessment points.

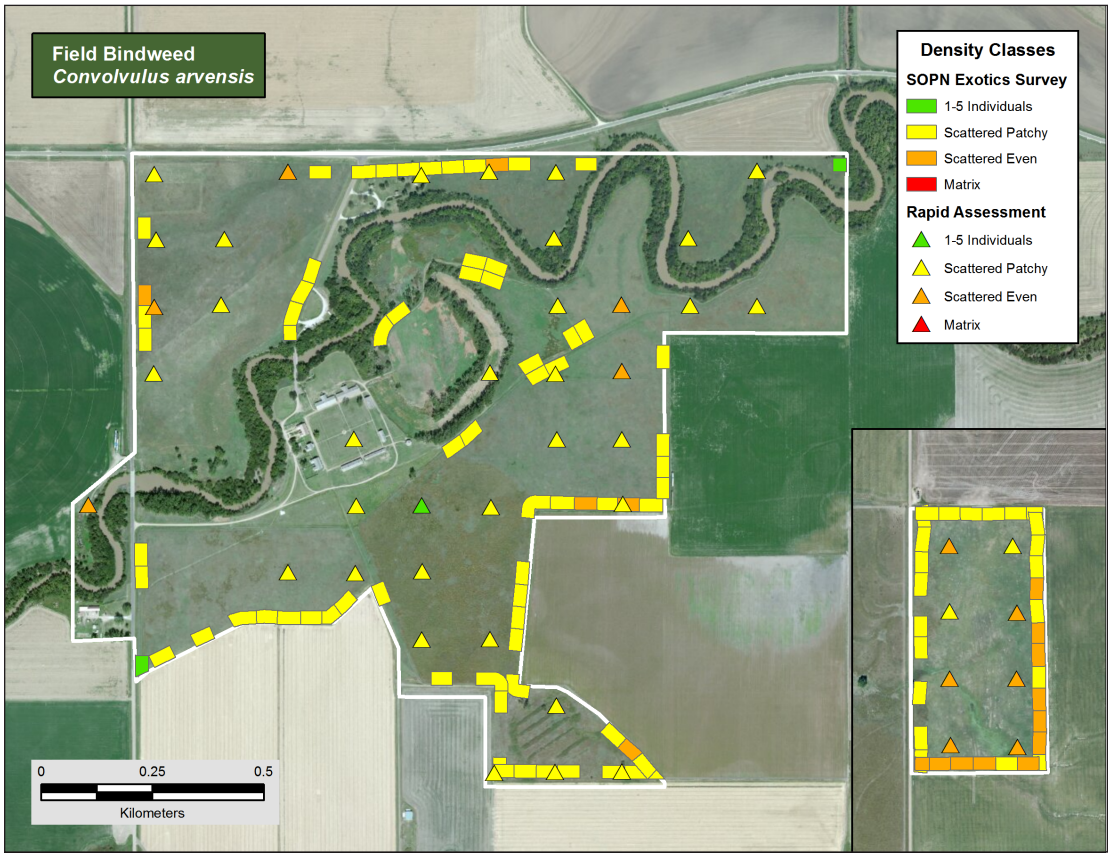


Figure 4.10.2-6. *Convolvulus arvensis* plant density based on distance class one (D1) surveys only, conducted by SOPN monitoring efforts and all 2013 rapid assessment points.

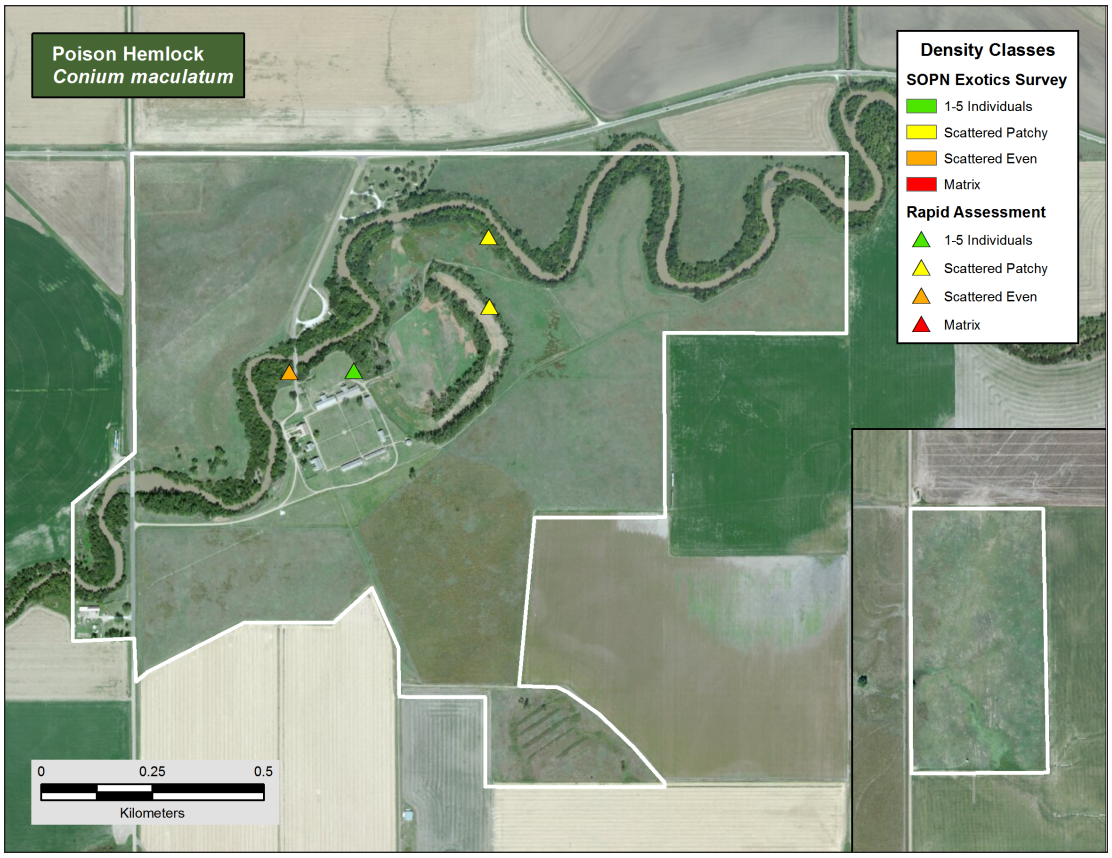


Figure 4.10.2-7. ***Conium maculatum*** **plant density based on distance class one (D1) surveys only, conducted by SOPN monitoring efforts and all 2013 rapid assessment points. Note: This plant was only detected in distance classes greater than D1.**

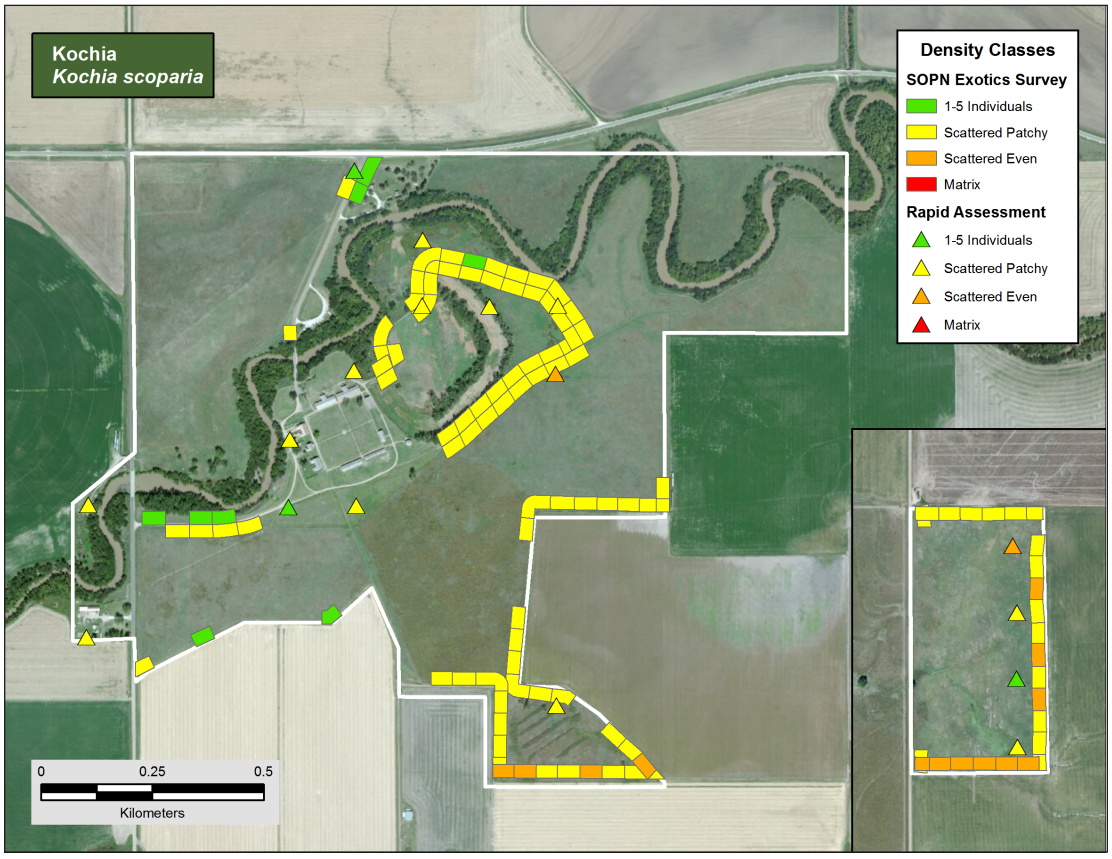


Figure 4.10.2-8. ***Kochia scoparia*** **plant density based on distance class one (D1) surveys only, conducted by SOPN monitoring efforts and all 2013 rapid assessment points.**

species was assigned to one of five density classes (including absent in a given distance class, which is not shown on the maps), which represents a range of occurrence from a small number of individual plants to a continuous matrix within the block for that species. These density classes are as follows:

- 0 = Not observed within that distance class
- 1 = 1-5 plants present within the distance class
- 2 = Scattered in patches within the distance class
- 3 = Scattered fairly evenly throughout a specific distance class
- 4 = Forming a matrix in the distance class (Folts-Zettner et al. 2011).

In addition to the annual SOPN exotic plants monitoring, a rapid assessment was conducted in 2013 as a one time occurrence for this condition assessment to determine the proportion and density of exotics throughout the entire Historic Site (Figure 4.10.2-2). A sample grid of 82 points spaced at 150 m intervals was generated. From this grid, 72 points were sampled, with the remaining 10 points eliminated due to major construction occurring within one section of the Historic Site. Presence and density data for these supplemental points were recorded in the same way as in the standard monitoring plots described above, except that these points will not be included in SOPN's permanent rotating panels. The results for proportion of points occupied by a given exotic plant is shown in Table 4.10.2-2.

Indicators/Measures

Potential to Alter Native Plant Communities (2 measures)

The remaining measures, ecological impact and management difficulty, were derived using NatureServe's invasive species rankings, developed by Morse et al. (2004). The Nature Conservancy and National Park Service developed this ranking system to objectively and systematically evaluate the invasiveness of a plant species based upon four categories: two of which include ecological impact and management difficulty. Each category is reported as either high, medium, low, insignificant, unknown or a combination of two categories (e.g., low/insignificant) and data can be accessed from http://www.natureserve.org/explorer/servlet/NatureServe?init=Species. These rankings for each exotic plant are shown in Table 4.10.2-3.

The ecological impact rank is based on the premise that exotic species with the largest negative impacts on native plant, animal, and other species populations, ecological communities, and ecosystems generally cause the most severe problems, particularly if they change ecosystem processes or harm native species, keystone species, or communities of conservation significance (Morse et al. 2004). NatureServe's management difficulty is based on the premise that a species that is difficult to manage (control or prevent from spreading)

Table 4.10.2-2. Number and percentage of exotic plant species detected throughout the Historic Site grid points sampled in 2013.

Species	No. Points	% (N=72)
Bromus inermis	54	75.00%
Convolvulus arvensis	45	62.50%
Bromus tectorum	17	23.61%
Kochia scoparia	17	23.61%
Lactuca serriola	13	18.06%
Tragopogon dubius	9	12.50%
Melilotus officinalis	8	11.11%
Taraxacum officinale	6	8.33%
Chenopodium album	4	5.56%
Conium maculatum	4	5.56%
Polygonum arenastrum	4	5.56%
Rumex crispus	3	4.17%
Capsella bursa-pastoris	2	2.78%
Salsola kali	2	2.78%
Bromus commutatus	1	1.39%
Cannabis sativa	1	1.39%
Cynodon dactylon	1	1.39%
Lolium perenne	1	1.39%
Medicago lupulina	1	1.39%
Sorghum halepense	1	1.39%

Species highlighted are considered to be of highest, high, or moderate concern as shown in Table 4.10.4-1.

Note: Ten points could not be accessed during this assessment so the number of data points equaled 72 vs. 82 as previously reported.

Table 4.10.2-3. Ecological impact rank and management difficulty rank according to NatureServe (2013).

Species	NatureServe Rank (2013)	
	Ecological Impact	Management Difficulty
Bromus inermis	Medium	Medium
Bromus japonicus	n/a	n/a
Bromus tectorum	High	High/Medium
Cirsium arvense	Medium/Low	High/Medium
Conium maculatum	Low	Low/ Insignificant
Convolvulus arvensis	Low/ Insignificant	High/Medium
Kochia scoparia	Low/ Insignificant	High/Medium
Lactuca serriola	Insignificant	Unknown
Melilotus officinalis	Medium	Medium
Polygonum arenastrum	n/a	n/a
Rumex patientia	n/a	n/a
Salsola kali	n/a	n/a
Setaria viridis	n/a	n/a
Sonchus asper	n/a	n/a
Sorghum halepense	Medium/Low	High/Medium
Taraxacum officinale	n/a	n/a
Tragopogon dubius	Low	Medium
Ulmus pumila	Medium/Low	Medium/Low

All species listed are considered to be of highest, high, or moderate concern as shown in Table 4.10.4-1.

n/a= Not yet ranked by NatureServe

will have a greater chance of causing significant damage because it is more likely to persist and spread (Morse et al. 2004).

Both of these NatureServe rankings were considered when evaluating the overall significance of impact when combining all exotic plant measures. The results of the exotic species considered to be of highest, high, and moderate significance of impact will be discussed in the condition and trend section.

4.10.3. Reference Conditions

The most desirable reference condition is the complete absence of exotic species. However, such a reference condition is probably not a realistic standard to which exotic plant species should be compared. We consider a more realistic reference condition to be the capability for the integrity of the primary communities (e.g., woodlands and grasslands) to be maintained. By this, we mean that the ecological attributes (e.g., species composition, structure, etc.) and natural processes remain within the natural variation for the community type. Therefore, the reference condition of "good" is that species are known to occur regionally or on adjacent lands, but have not yet been confirmed within Historic Site, or if species have been confirmed, distribution is sparse, limited in extent, and may vary from sparse individuals to dense patches (Table 4.10.3-1). A "moderate" condition is when species have been found in the Historic Site in small,

Table 4.10.3-1. Qualitative description for determining condition based on plant community integrity.

Class	Description
Good Condition	Species are known to occur regionally or on adjacent lands, but have not yet been confirmed within Historic Site; or if species have been confirmed, their distribution is sparse and limited in extent; or the species present have low ecological impact and are relatively easy to manage.
Moderate Concern	Species have been found in the Historic Site in localized patches, but distribution is somewhat limited and controlling those patches may likely prevent large-scale invasion, and the species present either pose a low to moderate ecological impact and are moderately to easily managed. If there are species present that pose high risk of ecological impact or are difficult to manage, these species are limited in their extent.
Significant Concern	Exotic plants threaten to alter primary communities within the site to the point where they no longer maintain their ecological attributes or processes. The species present are widely distributed; they pose significant risk of ecological impact, and they are difficult to manage.

localized patches. Finding and controlling patches might prevent large-scale invasion, and distribution is somewhat limited in extent and may vary in intensity from sparse individuals to dense patches. A condition of significant concern is warranted when exotic plants threaten to alter these primary communities to the point where they no longer maintain these attributes or processes. For example, when exotic species dominate a community where key native species are expected for that community type, then the area would be considered as severely degraded. However, significant concern is also warranted when the trend for a community is clearly toward such an degraded outcome rather than it actually having been realized.

4.10.4. Condition and Trend

There are currently a total of 59 exotic species found within Fort Larned NHS (Folts-Zettner and Sosinski 2012a,b; 2013). Eighteen of these species are considered to be the highest, high or of moderate concern based upon the significance of impact and are shown in Table 4.10.4-1. The remaining plants that do not fall into the previous three categories, but are still of concern, are located in Appendix G.

Significance of Impact-Highest Concern

Based on combining the four measures-proportion of plots/points infested, plant densities (based on distance class one only), the ecological impact and the management difficulty, Smooth brome (*Bromus inermis*), Cheatgrass (*Bromus tectorum*), and field bindweed (*Convulvulus arvensis*) are considered to be of highest concern for significance of impact.

Exotic bromes are well known to dramatically change the character of an ecosystem, including such changes as major shifts in community composition and structure (Knapp 1996) as well as substantially altered fire regimes (Whisenant 1990). In many cases these changes have become, for all practical purposes, irreversible (Knapp 1996). From a standpoint of significance of impact to the Historic Site's native grassland community, we consider smooth brome, which was located in 75% and 83% of the park-wide grid points and SOPN monitoring plots, respectively, and cheatgrass, found in almost 24% of the park-wide grid points, to be the greatest exotic plant concerns.

Field bindweed is not as ecologically impactful as the bromes, but it is very difficult to control once established. Currently, field bindweed is located in over 61% of the high priority plots as well as over 62.5% of the park-wide grid points, appearing to spread into native plant communities from the boundary. Field bindweed thrives under drought conditions, which the Historic Site has been experiencing for over the last three years making it that much more significant in potential impact. Field bindweed is most often one of the only green plants observed amidst the brown dead plants (Tomye Folts-Zettner, pers. comm., December 2012).

Significance of Impact-High Concern

Japanese brome (*Bromus japonicus*), Kochia (*Kochia scoparia*), Poison hemlock (*Conium maculatum*), and Siberian elm (*Ulmus pumila*), have a high potential for significance of impact at the Historic Site.

Kochia grows in disturbed areas and is an indicator of changed soil chemistry, especially where organic matter has been added (i.e., barnyards, wood piles, old homestead sites). Kochia self perpetuates and continues to add organic matter into soil. It also sprouts early depending on the amount of rainfall and quickly grows and is persistent, easily out-competing for resources. It is found in over 56% of the high priority plots and in almost 24% of the park-wide points.

Both poison hemlock and Siberian elm are considered to be of high concern. Siberian elm will spread rapidly if allowed to persist (T. Folts-Zettner, Biologist SOPN, pers. comm.).

Poison hemlock is an early seral species and thrives on heavily disturbed sites such as recently flooded areas (Cogan et al. 2007). This is a plant that dominates the understory of the riparian corridor at the Historic Site, so it is abundant in its habitat, but not park-wide. It does not show up well in the SOPN

Table 4.10.4-1. Exotic species found within Fort Larned National Historic Site that are considered to have the most impact to native habitats throughout the Historic Site based upon combined measures.

Scientific Name	Common Name	Noxious[1]	Rationale for Rating[2]
Highest Concern			
Bromus inermis	Smooth Brome		This plant was found in 75% park-wide point and in 83% of the high priority plots. While ranked as medium ecological impact and for the ability to control, this exotic is very established throughout the Historic Site and found growing in very dense patches.
Bromus tectorum (and *var tectorum*)	Cheatgrass		Cheatgrass is one of the highest ranked for both ecological impact and management difficulty. It is also found in 24% of the park-wide points and 33% of the high priority vector plots, indicating that its current distribution is widespread. While relatively scattered and patchy in densities, it is most concentrated along the southern boundary.
Convolvulus arvensis	Field bindweed	N	This plant is found in over 60% of the high vector plots and in over 52% of the park-wide points. This is a difficult plant to manage once established, and even though not ranked as a high ecological risk, it has been observed quickly dominating an area throughout Southern Plains parks (Tomye Folts-Zettner, SOPN Biologist, pers. comm.). Most patches are considered to be scattered patchy throughout the Historic Site.
High Concern			
Bromus japonicus	Japanese Brome		Found in 32% of the high priority plots this plant has yet to be ranked by NatureServe but is similar to smooth brome and cheatgrass and is difficult to manage once established. Most patches found are of low densities.
Conium maculatum	Poison Hemlock		Found in 13% and over 5% of the high priority and park-wide plots, respectively. It is found in persistent, dense monocultures in the riparian understory, an area not currently monitored.
Kochia scoparia	Kochia		Kochia can form monocultures that resist the establishment of preferred natives (Tomye Folts-Zettner, SOPN Biologist, pers. comm.). It is also found in 56% and 23.6% of the high priority and park-wide plots, indicating a fairly wide distribution, although the densest patches are along the trail and southern boundary. Once this plant becomes established, it is difficult to control.
Ulmus pumila	Siberian Elm		This was only found in the SOPN monitoring plots in a distance class that we are not showing. It is moderately difficult to manage, with a moderate ecological impact. This plant as seedlings has the ability to spread rapidly if allowed to persist, changing grassland to shrub/woodland.
Moderate Concern			
Cirsium arvense	Canada Thistle	N	This is designated as a noxious weed in Kansas and has moderate ecological impact. It is also difficult to control. Its rhizomatous roots will eventually exclude all other plants, resulting in dense monocultures.
Lactuca serriola	Prickly Lettuce		This is found in 18% of the park-wide points and in almost 21% of the SOPN plots. It currently occurs in low density patches but can form monocultures.
Melilotus officinalis	Yellow Sweetclover		This plant is of moderate concern for both ecological impact and management difficulty. It is persistent once established, is competitive for resources, is a nitrogen fixer (which is not optimal for short-grass areas) and produces a lot of seed. It is currently found in over 11% of the park-wide points and in 14% of the SOPN plots.
Polygonum arenastrum	Prostrate Knotweed		This plant is in 26% and almost 6% of the SOPN and park-wide monitoring plots, respectively. The density is primarily scattered patchy and has yet to be ranked by NatureServe.
Rumex patientia	Patience Dock		This is found in almost 28% of the SOPN monitoring plots and occurs in relatively low densities. Its large, coarse nature crowds out preferred natives and outcompetes for resources.
Salsola kali	Prickly Russian Thistle		Currently, this plant is not prevalent throughout the Historic Site and is found in only 4% of the SOPN monitoring plots and almost 3% of the park-wide points. Reintroduction of this plant will be a constant maintenance issue due to its tumbling habit of seed dispersal.
Setaria viridis	Green Bristlegrass		This plant is not ranked by NatureServe for ecological impact or management difficulty, but is Impacting the buffalo grass that maintains the cultural landscape at the Historic Site.
Sonchus asper	Spiny Sowthistle		This plant is not ranked by NatureServe for ecological impact or management difficulty, but is has easily dispersed seed, a large taproot and a course nature that degrades the visual aspect of prairie.

Table 4.10.4-1. Exotic species found within Fort Larned National Historic Site that are considered to have the most impact to native habitats throughout the Historic Site based upon combined measures (continued).

Scientific Name	Common Name	Noxious[1]	Rationale for Rating[2]
Sorghum halepense	Johnsongrass	N	This is designated as a noxious weed in Kansas and has moderate ecological impact. It is also difficult to control. Currently, it is not widespread throughout the Historic Site and found in a little over 1% of the park-wide points.
Taraxacum officinale	Dandelion		This plant is not ranked by NatureServe for ecological impact or management difficulty, but is impacting the buffalo grass that naturally surrounds the cultural area and trails, anywhere that receives mowing. Mowing must be carried out to control weed height.
Tragopogon dubius	Western Salsify		This plant is moderately difficult to control and its population is increasing at the Historic Site. It is found in 21% of the SOPN monitoring and in 12.5% of the park-wide points.

[1] Noxious = Kansas state-listed noxious status (NW=appears on the noxious weed list) (USDA NRCS 2013).

[2] The rationale is comprised of the four measures: proportion of high priority plots and park-wide points occupied, density of plants, ecological impact, and management difficulty.

monitoring data because 1) the riparian habitat is not monitored, and 2) not many of the park-wide grid points were within the riparian habitat zone.

Significance of Impact-Moderate Concern

Eleven additional exotic plant species, considered to be of moderate concern for invading the Historic Site's native plant communities, are also listed in Table 4.10.4-1.

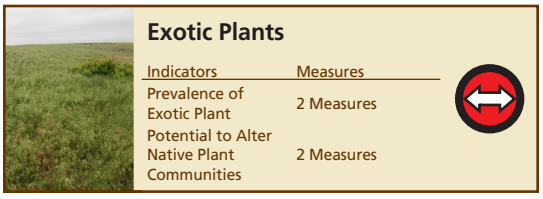
While smooth brome (which is of highest concern) dominates areas of the main Historic Site unit formerly used for agriculture, several additional non-native species are also present in many re-planted and restored fields. Both Johnsongrass (*Sorghum halepense*) and Canada Thistle (*Cirsium arvense*) are listed as noxious in Kansas and of moderate concern throughout the grassland habitat within the Historic Site.

Yellow sweetclover (*Melilotus officinalis*) is an agricultural weed that can quickly form dense stands that successfully compete for resources and degrades grassland. Prickly lettuce (*Lactuca serriola*) is a prolific, easily dispersed seeder that is creeping into grasslands across the southern plains. It is now possible to see monocultures in areas where it is not controlled.

Cirsium arvense spreads primarily vegetatively and secondarily by seed. Its aggressive rhizomes require multi-year treatments to eradicate, and it is a particular threat to both prairie and riparian ecosystems (Folts-Zettner and Sosinski 2012a). The windy environment of Fort Larned NHS favors the dispersal of *Tragopogon dubius*, a deep tap-rooted forb, and its numbers are slowly increasing.

Hydrologically disturbed seasonal Prostrate knotweed (*Polygonum arenastrum*) occurs in and along the Pawnee River bottom in the main unit of the Historic Site and where a small drainage has been impounded by the roadbed on the west side of the remote Santa Fe Trail Ruts Site (Cogan et al. 2007). This is considered to be of moderate concern, and it occupies similar habitat as posion hemlock.

Buffalo grass lawn surrounds the historic Fort and has been planted in the picnic and parking areas. Both Green Bristlegrass (*Setaria viridis*) and Dandelion (T*araxacum officinale*) are impacting buffalo grass foot trails (T. Folts-Zettner, Biologist SOPN, pers. comm.), which are maintained as part of the cultural landscape. Both of these plants have the potential to invade the surrounding grasslands as well.



Overall Condition and Trend

For assessing the condition of exotic plants, we used two indicators and two measures that were not mutually exclusive but were intended to be different ways of capturing the essence of what we thought represented an exotic plant's potential for significance

Table 4.10.4-2. Indicator, measures, and their contributions to the overall exotic plants condition rationale.

Indicator of Condition	Measure	Condition	Rationale for Condition.
Prevalence of Exotic Plant	Proportion of High Priority Plots and Park-wide Points Infested	Significant Concern	Two exotic species, *Bromus inermis* and *Convolvulus arvensis*, were found in greater than 60% of the park-wide sampling points in 2013. In addition *Bromus inermis*, *Convolvulus arvensis*, and *Kochia scoparia* were found in over 50% of the SOPN high priority plots. Three of these species are considered to be of highest concern, and one of high concern. One of the most ecologically impacting plants, *Bromus inermis* was found in three-quarters of the park-wide points, resulting in a significant concern.
	Density of Exotic	Significant Concern	For the most part, most of the species warranting high, highest, or moderate concern occur in relatively low densities throughout the Historic Site, although *Bromus inermis* is forming a matrix resulting in a significant concern rating.
Potential to Alter Native Plant Communities	Ecological Impact	Significant Concern	This measure is based on the premise that species with the largest negative impacts on native plant, animal, and other species populations, and ecosystems generally cause the most severe problems. Exotic species, particularly, the bromes are considered to be extremely impactful to native communities, and these same species are widely distributed throughout the Historic Site, therefore, we consider this measure to be of significant concern.
	Management Difficulty	Significant Concern	Many of the exotic plant species found at the Historic Site are considered to be very difficult to manage, therefore, we consider this measure to be of significant concern.

of impact to the native plant communities throughout the Historic Site.

Several factors contribute to an exotic's ability to threaten the integrity of a native ecosystem including its current abundance, density, and potential for ecological impact and management control based upon its life history. Also, the location where an exotic is found has implications pertaining to its establishment and potential control measures. Thus, our measures for this resource were intended to capture different aspects of these contributing factors, and a summary of how they contributed to the overall exotic plants condition is summarized in Table 4.10.4-2. We consider the overall condition for exotic plants at Fort Larned NHS to be of significant concern with a stable trend.

Level of Confidence/Key Uncertainties

The exotic plants monitoring program is designed to occur during a time of year when early spring plants are still identifiable and rosettes are present for fall blooming plants. This strategic timing ensures the highest degree of detection. In addition with the three year rotation cycle, SOPN staff feel confident that they will identify new plants before they become established even if the plant is introduced right after the rotation cycle has been completed. Overall, we are very confident that at least 85-90% of the exotic plants have been identified throughout the Historic Site.

A key uncertainty is knowing how a given exotic plant species will respond to localized conditions. What may be considered a non-threatening plant in one region may become a nuisance in a different region. But as stated above, annual monitoring of exotic plants helps identify changes to assist with early detection and rapid response.

4.10.5. Sources of Expertise

Surveys for exotic plants at Fort Larned NHS were conducted by the SOPN exotic plants monitoring team well trained in species identification and methods. Our confidence is very high regarding the reliability of their surveys.

Tomye Folts-Zettner is a biologist/botanist with the SOPN and is also the project lead for monitoring exotic plants and grasslands in parks of the SOPN.

Jonathin Horsley is a biological technician for both the Chihuahuan Desert Network and the Southern Plains Network. He is the crew leader for their exotic plant monitoring crews.

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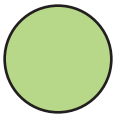
4.11. Breeding Landbirds

Indicators/Measures

- Species Occurrence (3 Measures)

Condition - Trend - Confidence



Good - Unknown - Medium

4.11.1. Background and Importance

The National Park Service's mission is to manage park resources "unimpaired for future generations." Protecting and managing some of our nation's most significant natural resources requires basic knowledge of the condition of ecosystems and species that occur in national parks. Landbirds are a conspicuous component of many ecosystems (Figure 4.11.1-1) and have high body temperatures, rapid metabolisms, and occupy high trophic levels. As such, changes in landbird populations may be indicators of changes in the biotic or abiotic components of the environment upon which they depend (Canterbury et al. 2000; Bryce et al. 2002). Relative to other vertebrates, landbirds are also highly detectable and can be efficiently surveyed with the use of numerous standardized methods (Bibby et al. 2000; Buckland et al. 2001).

Changes in landbird population and community parameters can be an important element of a comprehensive, long-term monitoring program, such as that being implemented for the SOPN parks. Birds select habitat based on the presence of behavioral cues triggered by the environment (Hutto 1985; Alcock 2005). In some environments, however, especially those that vary unpredictably, habitat may not be saturated and changes in resources may not always be tracked by changes in animal populations (Wiens 1985). In these situations, relating changes in bird populations to environmental features can be complex, especially when confounded by time lags that are characteristic of site-tenacious bird species. Additional complications occur if birds respond more sensitively to environmental change than we can detect, and when cyclical environmental changes result in erratic changes in population size that are ultimately inconsequential. However, the utility of monitoring landbirds is strengthened by concurrent monitoring of a broad suite of environmental parameters (Dale and Beyeler 2001) that may assist with elucidating changes in the bird community to other environmental factors. Such a broad-based approach is now being undertaken by the SOPN program (NPS 2008) and other monitoring approaches (e.g., Ringold et al. 1996; Stevens and Gold 2003; Barrows et al. 2005).

Perhaps the most compelling reason to monitor landbird communities in SOPN parks is that birds themselves are inherently valuable. The high aesthetic and spiritual values that humans place on native wildlife is acknowledged in the agency's Organic Act: "to conserve . . . the wildlife therein . . . unimpaired for the enjoyment of future generations." Bird watching, in particular, is a popular, longstanding recreational pastime

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Figure 4.11.1-1 Grasshopper Sparrow, observed in three of the last four years of RMBO surveys at Fort Larned National Historic Site.

in the United States and forms the basis of a large and sustainable industry (Sekercioglu 2002).

4.11.2. Data and Methods

In 2009, Rocky Mountain Bird Observatory (RMBO) began systematic surveys of landbirds at Fort Larned NHS as part of the SOPN Monitoring program. Although these data will enable quantitative evaluation of trends in birds in the future (e.g., in occupancy), it is premature to use them in such a context at the present with only four years of data. Rather, for this assessment, we focus on species occurrence (presence/absence), focusing on what species are, or are not, observed at the Historic Site. The most recent data we have for occurrence of birds at the Historic Site are the RMBO surveys. With the use of additional data sources, we evaluated species occurrence in three contexts: (1) a temporal context (i.e., changes over time), (2) a spatial context (i.e., comparison with surrounding region), and (3) a conservation context (i.e., the occurrence and status of species of conservation concern). We describe each of these below, followed by descriptions of the data sources used to support the comparisons.

Indicators/Measures

Species Occurrence

Temporal Context – Changes over Time

To evaluate breeding landbirds in a temporal context, we compared the occurrence of species detected during 2009-2012 RMBO surveys at Fort Larned NHS (described below) to a 2001 inventory for birds at the Historic Site conducted by the Kansas Natural Heritage Inventory (KNHI; described below). This analysis compares information from 2001 to 2009-2012- a time span of eight to eleven years.

Our analysis is not intended as a rigorous or quantitative comparison given the limitations of the available information; rather, it is intended as a crude qualitative indicator of major changes over time. To do this in the most meaningful way, we needed the sources to be comparable. For example, the recent RMBO surveys were conducted during the breeding season; thus it is not reasonable to compare these results with species that occur at the Historic Site during other seasons. The 2001 KNHI inventory was also conducted during the breeding season (in May and June). The RMBO surveys were conducted in June. Further, we focused our comparisons on those species for which Fort Larned NHS is within their normal breeding range. We made this determination based primarily on the Birds of North America (BNA) species accounts (Cornell Lab of Ornithology 2013). Given the potential for us to have made errors in determining whether the Historic Site was within the normal breeding range from online and hard copy maps (GIS data were not available), we included for consideration species outside of their breeding range but within 100 miles of their breeding range edge. Note that by "normal breeding range" we mean the area designated by the BNA accounts where a species is known to consistently breed. Some birds may breed in small numbers outside of these areas, however.

Unlike field guides that are often written by persons with general knowledge of birds, the BNA accounts for each species are written by persons that have extensive experience and knowledge working with that particular species. Consequently, these accounts constitute a comprehensive summary of our current knowledge for a given species (including range) written by experts for that species.

We further refined our comparisons to species for which reasonably suitable breeding habitat exists at the Historic Site (since comparisons are based on the breeding season). We assigned each species to one of three breeding habitat classes (Table 4.11.2-1) based on the BNA accounts in combination with local knowledge.

Spatial Context – Comparisons with Surrounding Region

We also evaluated species occurrence in a spatial context. Again, this is intended only as a qualitative indicator rather than a rigorous quantitate estimate (which will be possible in the future). For this assessment, we compared

Table 4.11.2-1. Breeding habitat classes assigned to each species that has been reported to occur at Fort Larned NHS and is within or near its reported breeding range.

Breeding Habitat Class	Class Description
Exists	This class was assigned when the habitat at the Historic Site is characteristic of habitats where a given species might be expected to breed.
Possibly Exists	This class was assigned when it was unlikely that the habitat at the Historic Site would support consistent or widespread breeding, but does not preclude some breeding in limited numbers.
Limited to None	This class was assigned when it is unlikely that the habitat at Fort Larned NHS would support breeding by that species. This does not imply that the species would not occur at the Historic Site in limited numbers or during other seasons, but rather that it would be unlikely to breed there.

Table 4.11.2-2. Classes assigned to species of concern regarding the potential for Fort Larned NHS to play a role in their conservation.

Potential for Conservation	Conservation Class Description
High	These are species for which the Historic Site is within the normal breeding range or in proximity to the edge of that range. They are also species for which we considered the Historic Site to have good breeding habitat. We assigned species to this class if we believed, based on the evidence, that the potential for breeding was good, regardless of whether they currently occur at the Historic Site in substantial numbers.
Moderate	These are the species for which the Historic Site is within the normal breeding range or in proximity to the edge of that range, and for which there is some habitat at the Historic Site that might support occurrence or even some breeding in limited numbers.
Low to None	These are the species that are either outside of their normal breeding range and/or for which the habitat at the Historic Site is unlikely to support breeding. This does not preclude limited occurrences of the species, but the potential for the Historic Site to play any significant role in the conservation of that species is very limited.

the results of recent RMBO surveys at the Historic Site to those from Breeding Bird Surveys (BBSs; described below) conducted in similar habitats within the surrounding area; the regional surveys serve as a general spatial reference for species occurrence within the region. As with the temporal comparison, we focused our comparisons on those species for which the Historic Site is within their normal breeding range, but we also considered species outside of but within 100 miles of their normal breeding range. The BBSs were the only available source of regional data for the Fort Larned NHS area.

Conservation Context – The Occurrence and Status of Species of Conservation Concern

Our intent for this context was to determine which species that occur at Fort Larned NHS are considered species of concern at either national or local scales, to assess the current status (occurrence) of those species at the Historic Site, and to evaluate the potential for the Historic Site to play a role in the conservation of those species. For the latter, we assigned each species of conservation concern to a class representing the potential for the Historic Site to play a role in its conservation, at least during the breeding season (Table 4.11.2-2). This was based primarily on whether or not the Historic Site was within the normal breeding range of the species and the availability of breeding habitat at the Historic Site.

To develop a candidate list for species of conservation concern, we used the lists developed by several organizations. There have been a number of such organizations that focus on the conservation of bird species. Such organizations may differ, however,

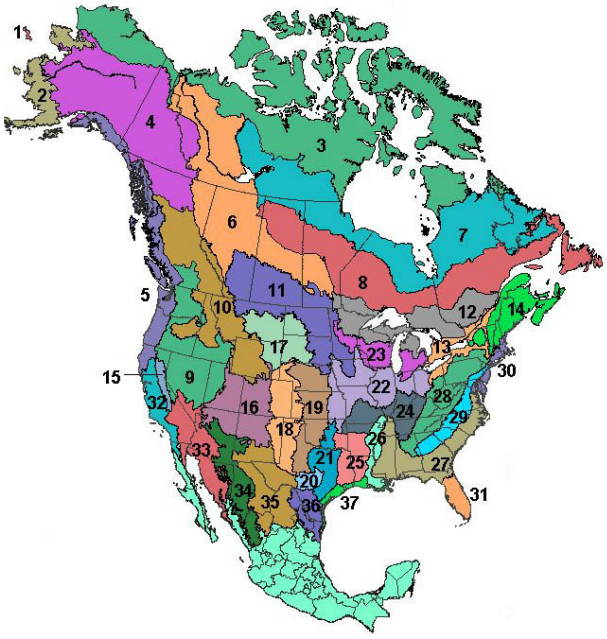

Figure 4.11.2-1. Bird Conservation Regions in North America.

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

One of the developments from the NABCI was the delineation of Bird Conservation Regions (BCRs) (U.S. North American Bird Conservation Initiative 2013). Bird Conservation Regions (BCRs) are ecologically distinct regions in North America with similar bird communities, habitats, and resource management issues (Figure 4.11.2-1). Fort Larned NHS lies within the Central Mixed Grass Prairie Unit (BCR 19) (Figure 4.11.2-2).

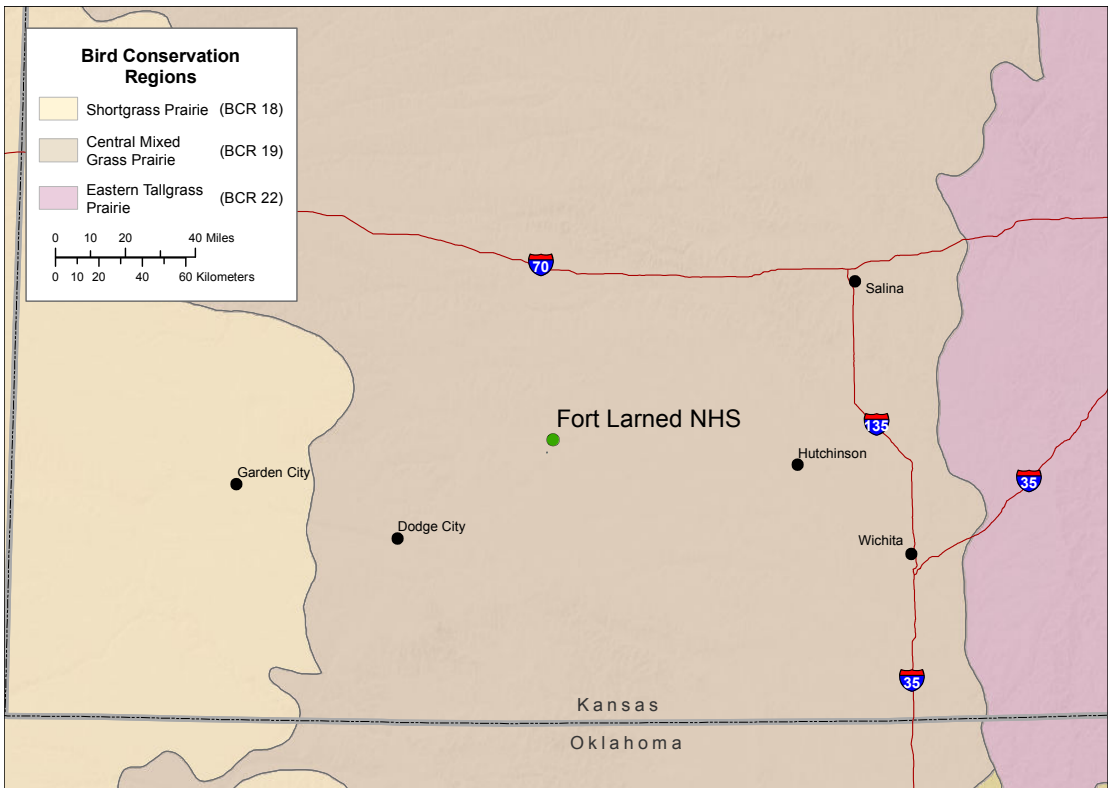

Figure 4.11.2-2. Bird Conservation Regions in the vicinity of Fort Larned NHS.

Conservation Organizations Listing Species of Conservation Concern

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

- U.S. Fish & Wildlife Service: Under the Endangered Species Act, the U.S. Fish and Wildlife Service (USFWS) lists species as threatened, endangered, or candidates for listing.
- State of Kansas: Under the authority of the Kansas Nongame and Endangered Species Conservation Act of 1975, the Kansas Department of Wildlife, Parks, and Tourism identifies and takes conservation measures for State and federally listed species. The Department maintains listings of species considered as threatened or endangered, as well as species in need of conservation (Kansas Department of Wildlife, Parks and Tourism 2013).
- USFWS: This agency also developed lists of birds of conservation concern according to: the Nation, USFWS Region, and BCR.
- The National Audubon Society (NAS) and American Bird Conservancy (ABC): These groups combined efforts to produce a "Watch List," based on, but not identical to, the Partners in Flight approach to species assessment (see below). The 2007 WatchList has two primary levels of concern: a "Red Watchlist," which identifies what these organizations consider as species of highest national concern; and a "Yellow WatchList," which is made up of species that are somewhat less critical.
- Partners in Flight (PIF): This is a cooperative effort among federal, state, and local government agencies, as well as private organizations. PIF has adopted BCRs as the geographic scale for updated regional bird conservation assessments. At the scale of the individual BCRs, there are species of Continental Importance (Continental Concern [CC] and Continental Stewardship [CS]) and Regional Importance (Regional Concern [RC] and Regional Stewardship [RS]).

Primary Data Sources

Data used as part of this condition assessment include: surveys conducted by RMBO at Fort Larned NHS in 2009-2012; a biological inventory for vertebrates, including birds, conducted by the KNHI in 2001 (Delisle and Busby 2004); and data from the Breeding Bird Surveys (BBS). Each of these sources is described below.

RMBO Surveys at the Historic Site in 2009-2012

RMBO used point-transect surveys (Buckland et al. 2001) during the breeding season to estimate and monitor landbird population parameters (Lock et al. 2012). A total of about 43 points in riparian (riparian woodland; n=18) and grassland (upland grassland; n=25) habitats were sampled 3 times each in 2009-2012 (Figure 4.11.2-3) (Lock et al. 2012). All birds detected at a given point were recorded. Observers spent six minutes at each point along the transect or grid and used a rangefinder to estimate the linear distance to each bird or group detected. This protocol of spending six minutes per site is consistent with other efforts being conducted by RMBO. After counts were completed, observers used a handheld GPS (Global Positioning System) unit to locate successive survey points. While walking between points, observers noted only the species that were not recorded during the count period; sometimes these represented species that had not been previously reported for the Historic Site.

KNHI Inventories

In 2001, the KNHI conducted a vertebrate inventory that included birds (Delisle and Busby 2004). Field sampling for breeding birds occurred on May 22-23 and June 6 and 14 between 6:00 and 10:30 am. Birds were inventoried by walking woodland, grasslands, and developed areas over a total of 21.75 hrs. Birds were detected and identified by sight and sound. Nocturnal bird species were recorded on June 5th during surveys for amphibians and reptiles. Migrant bird species were noted, but comprehensive surveys were not conducted for them.

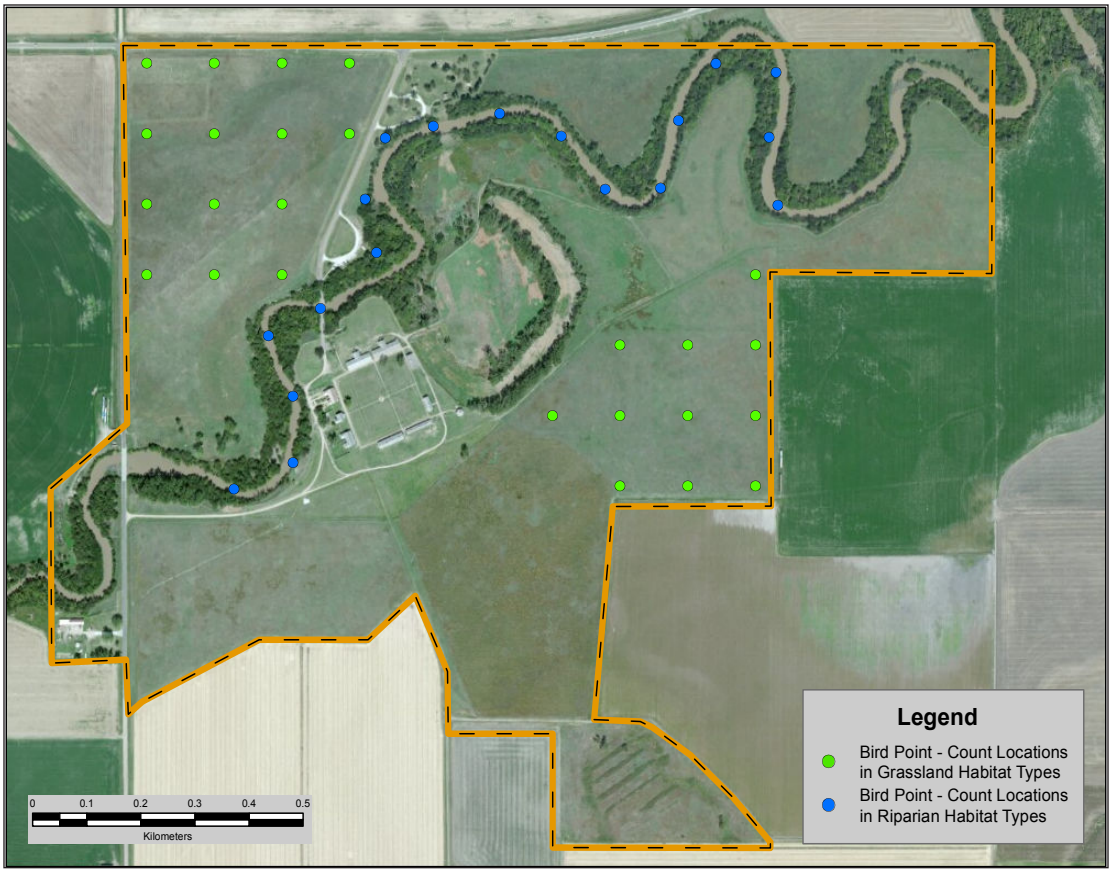

Figure 4.11.2-3. Survey points sampled by the Rocky Mountain Bird Observatory at Fort Larned NHS in 2009-2012.

BBS Routes

Breeding Bird Surveys are conducted on over 4,100 survey routes located across the continental U.S. and Canada (http://www.pwrc.usgs.gov/BBS/). Each year during the height of the avian breeding season, participants skilled in avian identification sample birds along roadside survey routes. Each survey route is 24.5 miles long with stops at 0.5-mile intervals. At each stop, a 3-minute point count is conducted. During the count, every bird seen within a 0.25-mile radius or heard is recorded. Surveys start one-half hour before local sunrise and take about 5 hours to complete. There are three BBS routes in the vicinity of Fort Larned NHS that have similar habitats to those at the Historic Site (Figure 4.11.2-4); measuring from the location on the Historic Site closest to the closest point of each route, distances between the Historic Site and the survey routes range from about 11.5 to 28.5 miles. We used data from BBS routes for the spatial comparison of species occurrence, and this was the only source of regional data available.

4.11.3. Reference Conditions

Temporal Reference Condition for Species Occurrence

The first bird monitoring or inventory effort at Fort Larned NHS was that made by KNHI in 2001 (i.e., Delisle and Busby 2004). During several visits to the Historic Site in May and June, they detected a total of 57 bird species. Delisle and Busby (2004) noted 15 additional species that were not detected during the inventory but were detected in the spring prior to the surveys; only one of these (White-breasted Nuthatch) was also detected by RMBO in 2009-2012.

We compared the species list from the 2001 inventory to the species list from 2009-2012 RMBO surveys to see if there were any differences. Differences in the two lists may represent changes over time. Specifically, we looked at species that were not observed during 2009-2012 RMBO surveys that had been documented in 2001. We "refined" the list of species where there were differences by excluding those species that were outside of their normal breeding range (and more

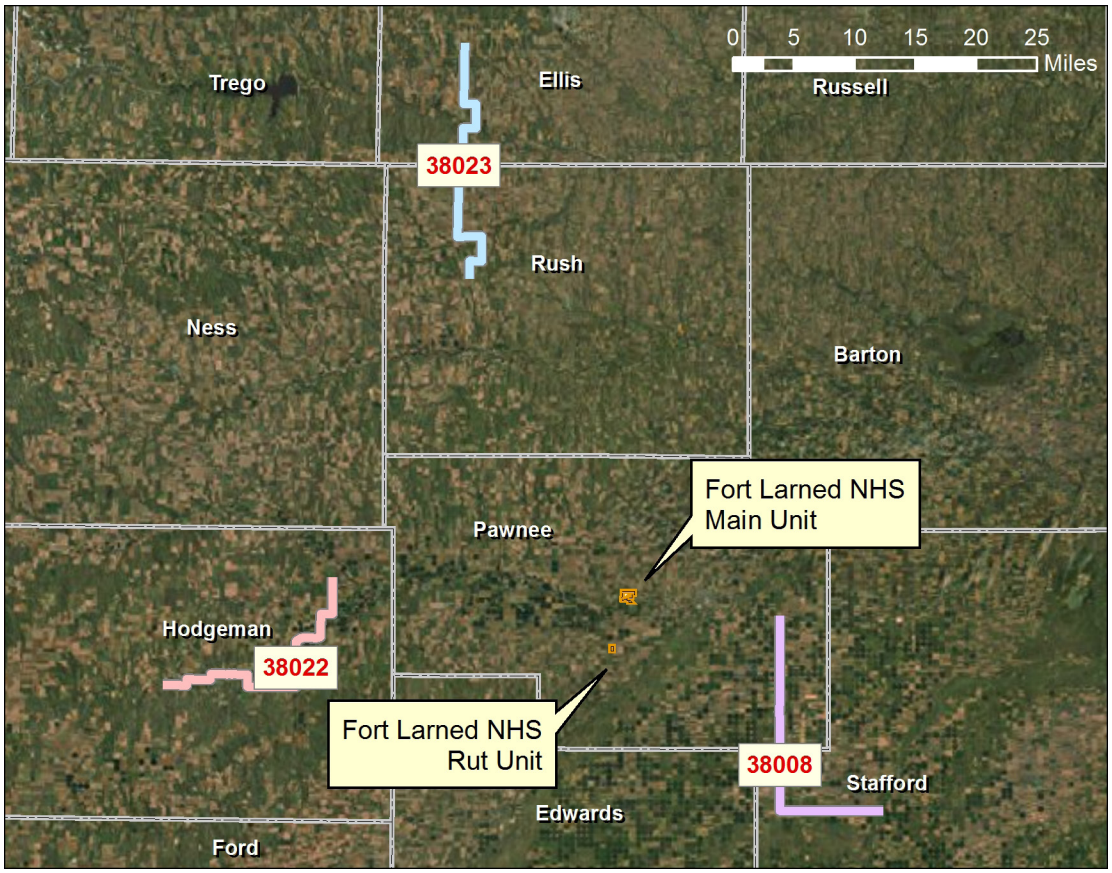

Figure 4.11.2-4. Breeding Bird Survey routes used for the regional breeding landbird species comparison.

than 100 miles from the edge of their normal breeding range). Although this is a crude measure and only spans a relatively short time differential, it does potentially provide some insights as to major shifts that might have occurred at the Historic Site. Table 4.11.3-1 summarizes the qualitative condition classes we assigned for the temporal and spatial indicators.

Spatial Reference Condition for Species Occurrence

In a spatial context, we compared the species observed during recent RMBO surveys (2009-2012) at Fort Larned NHS to those recorded during BBSs in the general vicinity of the Historic Site over the same time period. We used three BBS routes that appeared to have similar habitat (Figure 4.11.2-4). Both surveys were conducted during the breeding season.

Reference Condition for Species of Concern

This aspect of the assessment is somewhat different than the other two in that the focus is on the avian species for which the Historic Site can play a role in their conservation. From the list of species detected at the Historic Site during recent RMBO surveys, we identified the species that occurred on one or more of the lists of species of conservation concern. Those considered as having the greatest potential for conservation at the Historic Site are those within their breeding range and for which breeding habitat exists at the Historic Site.

4.11.4. Condition and Trend

There have been a total of 69 bird species reported at Fort Larned NHS (Appendix I). These species were detected during the 2001 KNHI inventory (same as the 2005 Certified Species List from NPSpecies), and/or the 2009-2012 RMBO point-count surveys. Fifty-seven of the 69 species were observed by KNHI in 2001, and 60 of the species were observed by RMBO in 2009-2012.

Species Comparisons using 2001 KNHI Inventory (Temporal Context)

A total of 57 species of birds were observed at Fort Larned NHS in the 2001 KNHI breeding bird inventory (Appendix I). Of

Table 4.11.3-1. Reference conditions used to assess the current condition of breeding landbird species occurrence in temporal and spatial contexts.

Occurrence Indicator	Significant Concern	Moderate Concern	Good
Temporal Context	We considered condition to be of significant concern if several species of birds that are within their normal breeding range and have existing habitat at the Historic Site were detected in the 2001 inventory but not in recent RMBO surveys, particularly if those species had previously been considered common at the Historic Site.	We considered condition to be of moderate concern if a few bird species that were detected during the 2001 inventory that are within their normal breeding range and have breeding habitat at the Historic Site were not detected during recent RMBO surveys.	We considered condition to be good if all, or nearly all, birds that were detected during the 2001 inventory that are within their normal breeding range and have breeding habitat at the Historic Site were detected during recent RMBO surveys.
Spatial Context	We considered condition to be of significant concern if several species of birds that are within their normal breeding range and have breeding habitat at the Historic Site were detected during regional surveys but not during recent RMBO surveys, particularly if those species had previously been considered common at the Historic Site.	We considered condition to be of moderate concern if a few bird species that were detected during regional surveys and are within their normal breeding range and have breeding habitat at the Historic Site were not detected during recent RMBO surveys.	We considered condition to be good if all, or nearly all, birds that were detected during regional surveys and are within their normal breeding range and have breeding habitat at the Historic Site were detected during recent RMBO surveys.

Table 4.11.4-1 Species reported in 2001 by the Kansas Natural Heritage Inventory (Delisle and Busby 2004) at Fort Larned NHS that were not observed during the 2009-2012 RMBO surveys. Also shown is the range status based on Birds of North America species accounts, and breeding habitat class for birds within (or within 100 miles of) their normal breeding range.

Common Name	Range Status	Breeding Habitat Class
Black-billed Magpie [1]	Year-round (on edge of range)	Possibly Exists
Black-capped Chickadee	Year-round	Limited to None
Chimney Swift	Breeding	Possibly Exists (building chimneys)
Eastern Screech-Owl	Year-round	Possibly Exists
Great Horned Owl [1]	Year-round	Exists
Lark Bunting	Breeding (on edge of range)	Limited to None
Northern Harrier [2]	Year-round	Possibly Exists
Rock Pigeon	Year-round	Possibly Exists
Spotted Towhee	Wintering, and > 100 miles from breeding range edge	Limited to None

[1] Breeding was confirmed during the 2001 inventory.

[2] Delisle and Busby (2004) noted a Northern Harrier was observed flying over the Historic Site and there was no indication of breeding at the site.

these 57 bird species, nine were not observed on recent (2009-2012) RMBO surveys (Table 4.11.4-1). Only one of these nine species (Spotted Towhee) is not within its normal breeding range; further, the species is more than 100 miles from its breeding range edge. The other eight species are within their nomal breeding ranges. However, only one, Great Horned Owl, falls into the "exists" breeding habitat class at the Historic Site. Five fall into the "possibly exists" habitat class, and two fall into the "limited to none" habitat class. Regarding the Great Horned Owl, we are not concerned that it has not yet been detected by RMBO. We expect that the owls occur at the Historic Site, and they may rest during the day (when sampling occurs) in the Historic Site's riparian habitat, which is dense. Great

Table 4.11.4-2 Birds species detected in Breeding Bird Surveys in the vicinity of Fort Larned NHS that were not detected at the Historic Site during the 2009-2012 RMBO point-count surveys.

Common Name	Range Status: Breeding or Outside Range but within 100 miles of Breeding	Breeding Habitat Class: Exists, Probably Exists, Limited to None
American Kestrel	Breeding & Wintering	Possibly Exists
Bank Swallow	Breeding	Limited to None
Barred Owl	Outside Normal Breeding Range [3]	Limited to None
Blue Grosbeak	Breeding	Possibly Exists
Blue-gray Gnatcatcher	Breeding (but near edge)	Limited to None
Blue-winged Teal [2]	Breeding	Limited to None
Cassin's Sparrow	Outside Normal Breeding Range [3] (but close to edge of normal breeding range)	Limited to None
Chimney Swift [1]	Breeding	Possibly Exists
Curve-billed Thrasher	Outside Normal Breeding Range and > 100 mi	Limited to None
Eastern Screech-Owl [1]	Year-round	Possibly Exists
Field Sparrow	Breeding	Possibly Exists
Great Horned Owl [1]	Year-round	Exists
Greater Prairie-Chicken	Outside Normal Breeding Range [3]	Limited to None
Greater Roadrunner	Outside Normal Breeding Range [3]	Limited to None
Green Heron [2]	Breeding	Limited to None
Lark Bunting [1]	Breeding	Limited to None
Lark Sparrow	Breeding	Possibly Exists
Lesser Prairie-Chicken	Breeding	Limited to None
Loggerhead Shrike	Breeding	Limited to None
Mississippi Kite	Outside Normal Breeding Range [3] (just outside of western edge of breeding)	Limited to None
Northern Mockingbird	Year-round	Possibly Exists
Northern Rough-winged Swallow	Breeding	Limited to None
Purple Martin	Breeding	Limited to None
Redhead [2]	Breeding (within a small patch of breeding and wintering habitat)	Limited to None
Rock Pigeon [1]	Year-round	Possibly Exists
Say's Phoebe	Breeding (but close to edge)	Limited to None
Swainson's Hawk	Breeding (but close to edge)	Limited to None

1 = Species detected in the 2001 KNHI survey (Delisle and Busby 2004).
2 = Wetland species.
3 = Species is outside of its normal breeding range, but less than 100 miles from the edge of its breeding range.

Horned Owls are probably going undetected during RMBO surveys due to the habitat.

From the comparison of species detected in 2001 to 2009-2012, we do not have any particular concerns for species occurrence.

A different set of species (12) was detected in the 2009-2012 surveys but not observed in the 2001 inventory (e.g., Carolina Wren, Eastern Phoebe, Great-tailed Grackle, Scissor-tailed Flycatcher, and Summer Tanager; (see Appendix I).

Species Comparisons to Surrounding Region (Spatial Context)

Twenty-seven bird species were recorded during BBSs in 2009-2012 in the vicinity of Fort Larned NHS but not during RMBO surveys at the Historic Site (Table 4.11.4.2). Of these 27 species, five were observed during 2001 surveys at the Historic Site (noted in

table) and were discussed in the temporal analysis. Three of the 27 species are wetland species and would not be expected to be detected during RMBO surveys (and have limited to no breeding habitat at the Historic Site). Of the remaining 19 species, none are in the "exists" habitat class at the Historic Site. Five are in the "possibly exists" habitat class (and are within their normal breeding ranges), and the majority, 14, are in the "limited to none" breeding habitat class (with eight of these within their normal breeding ranges; see Table 4.11.4-2).

The five species in the "possibly exists" class are the American Kestrel, Blue Grosbeak, Field Sparrow, Lark Sparrow, and Northern Mockingbird. A review of the BBS data indicated that from 2009-2012, few American Kestrels, Blue Grosbeaks, and Field Sparrows were observed on the routes. Larger numbers of Lark Sparrow and Northern Mockingbird were observed (3 routes and 75 individuals total, and 3 routes and 41 individuals total, respectively).

In summary, based on the comparison of species found in the surrounding region during BBSs to those reported from recent RMBO surveys at Fort Larned NHS, a concern for bird species occurrence is not justified at this time.

Species of Conservation Concern

There are 14 species that have been detected at Fort Larned NHS during 2009-2012 RMBO surveys that are listed as species of conservation concern on one or more of the lists described in Section 4.11.2 and Appendix H (Table 4.11.4-3). Additionally, there are two species that were detected in the 2001 inventory that are considered species of conservation concern, which we will also address in this section. Note that the Horned Lark, which appears in Table 4.11.4-3, is excluded because it appeared on only the USFWS National List, and the entry was for a subspecies that does not occur in Kansas.

- USFWS / Listed Species: There are no bird species listed by the USFWS as endangered or threatened that are known to occur at Fort Larned NHS (USFWS 2013). Although there is one bird species considered a candidate for listing (i.e., Yellow-billed Cuckoo), the listing applies only to birds in other parts of the western U.S. (Table 4.11.4-3).
- State of Kansas / Listed Species and Species in Need of Conservation: There are no bird species that occur at the Historic Site that are listed as endangered or threatened by the state of Kansas. There are also no species listed as Species in Need of Conservation that occur at Fort Larned NHS.
- USFWS / Birds of Conservation Concern: There are seven species that have been detected at the Historic Site that have been identified by the USFWS as having the greatest conservation need at a National, USFWS Regional, or BCR geographic scale (U.S. Fish and Wildlife Service 2008). This includes one species that was not detected during recent RMBO surveys but during the 2001 inventory at the Historic Site (Lark Bunting).
- NAS / ABC: There are three species that occur or have occurred at Fort Larned NHS that have been listed on the NAS/ABC 2007 WatchList. One species, Bell's Vireo, is on their Red List. The other two species are on the Yellow List, both due to population declines.
- PIF: All of the birds in Table 4.11.4-3 (excluding Horned Lark) are listed by PIF in one or more of its categories (i.e., CC, RC, CS, RS). This includes two species that were detected in the 2001 inventory but not in recent RMBO surveys at the Historic Site.

Summary of Species Listed as Birds of Conservation Concern (Conservation Context)

For this summary, we emphasize species for which Fort Larned NHS has the greatest potential to positively impact their conservation during the breeding season, based on their habitat and range. We do not mean to imply that other seasons are not important for the conservation of birds, they are. Rather, we have limited this assessment to the breeding season because that is the only season for which we have current

Table 4.11.4-3. Summary of species detected during 2009-2012 RMBO surveys at Fort Larned NHS (or 2001 inventories only [5]) of conservation concern, as listed by government agencies and non-governmental organizations.

Common Name	Listed Species		Species of Conservation Concern Lists								Comments
	Federal [1]	State [2]	US Fish & Wildlife Service			NAS/ ABC [3]	Partners in Flight				
							National Conservation Strategy [4]				
	USFWS	KDWP&T	National	Region 6	BCR 19	2007 Watch List	BCR 19 (2012 List)				
							CC	RC	CS	RS	
Baltimore Oriole								•		•	
Bell's Vireo			•	•	•	•	•	•			
Black-billed Cuckoo				•			•				
Brown Thrasher									•	•	
Carolina Wren									•		
Dickcissel			•					•	•	•	
Eastern Meadowlark								•		•	
Grasshopper Sparrow				•				•	•	•	
Horned Lark			A								[A] Listings with "A" are only for a subspecies that does not occur in KS (species excluded from analysis because this was the only entry for Horned Lark).
Indigo Bunting									•		
Lark Bunting [5]					•	•		•	•		
Northern Harrier [5]								•			
Red-bellied Woodpecker									•		
Red-headed Woodpecker			•	•	•	•	•			•	
Scissor-tailed Flycatcher					•			•		•	
Western Meadowlark								•		•	
Yellow-billed Cuckoo	C [B]		B					•			[B] Listings with "B" are for a sub-population that does not occur in KS.

[1] Federal Listed Species Codes
T = Threatened C= Candidate
E = Endangered

[2] State Listed Species Codes
ST = Threatened
SE = Endangered

[3] NAS/ABC - 2007 Watchlist
• = Red List
• = Declining or Rare

[4] PIF NCS Categories
CC = Continental Concern RC = Regional Concern
CS = Continental Stewardship RS = Regional Stewardship

[5] Species observed in 2001 KNHI inventory (Delisle and Busby 2004) only.

Table 4.11.4-4. Species detected at Fort Larned NHS during 2009-2012 surveys (and 2001 KNHP inventory) that have also been identified as species of concern on one or more watch list. Species are organized by whether they have high, moderate, or low potential for the Historic Site to contribute to their conservation.

Common Name	Detected During		Range Status	Breeding Habitat Class
	2001 Inventory (Delisle & Busby (2004)	2009-2012 RMBO Surveys		
High Potential				
Baltimore Oriole	•	•	Breeding	Exists
Brown Thrasher	•	•	Breeding	Exists
Dickcissel	•	•	Breeding (Core range)	Exists
Eastern Meadowlark	•	•	Year-round	Exists
Grasshopper Sparrow	•	•	Breeding	Exists
Indigo Bunting	•	•	Breeding	Exists
Red-headed Woodpecker	•	•	Breeding	Exists
Western Meadowlark	•	•	Year-round	Exists
Yellow-billed Cuckoo	•	•	Breeding	Exists
Moderate Potential				
Northern Harrier [2]	•		Year-round	Possibly Exists
Red-bellied Woodpecker	•	•	Year-round	Possibly Exists
Scissor-tailed Flycatcher		•	Breeding	Possibly Exists
Low to No Potential				
Bell's Vireo	•	•	Breeding	Limited to None
Black-billed Cuckoo	•	•	Breeding	Limited to None
Carolina Wren		•	Outside Normal Breeding Range [1]	Possibly Exists
Lark Bunting [3]	•		Breeding	Limited to None

[1] Outside Normal Breeding Range, but <100 miles from breeding range (year-round) edge.

[2] Delisle and Busby (2004) noted a Northern Harrier was observed flying over the Historic Site and there was no indication of breeding at the site.

[3] Species observed once by Delisle and Busby (2004).

information. We also recognize that there is considerable uncertainty and subjectivity in our assessment. Thus, we do not mean to imply that the classes we assigned are the only "correct" categories. Rather, this represents our interpretation from the available evidence, but we fully expect that other interpretations might be appropriate.

Of the 16 species listed by one or more organization as being of conservation concern, we believe that nine have sufficient habitat at the Historic Site to be considered as having high conservation potential (Table 4.11.4-4). These are the species that are within or on the edge of their normal breeding range and sufficient habitat exists at the Historic Site to support breeding. All of these nine species have been observed on recent (2009-2012) RMBO surveys. Furthermore, all but two of the species have been observed during all four years of surveys (Table 4.11.4-5). Some of the species, such as Baltimore Oriole, Dickcissel, and Eastern Meadowlark, have been observed in relatively high numbers. Dickcissel was observed in the highest number of any species in two of the years (2009, 2010), and Baltimore Oriole was in the first, second, or third place for three of the four years.

In summary, all species of conservation concern that are within their normal breeding range and have "existing" breeding habitat at the Historic Site have been observed during

Table 4.11.4-5. The number of individuals of species with highest conservation potential detected at Fort Larned NHS during recent RMBO surveys.

Species	2009 Survey	2010 Survey	2011 Survey	2012 Survey	Total
Baltimore Oriole [1]	47 (3rd; 8%)	66 (2nd; 9%)	83 (1st; 10%)	89 (6th; 7%)	285
Brown Thrasher	22	20	24	19	85
Dickcissel [1]	106 (1st; 18%)	99 (1st; 14%)	65 (3rd; 8%)	92 (5th; 7%)	362
Eastern Meadowlark [1]	39 (6th; 7%)	56 (3rd; 8%)	52 (5th; 6%)	110 (3; 8%)	257
Grasshopper Sparrow	2	0	10	4	16
Indigo Bunting	0	0	1	43	44
Red-headed Woodpecker	14	11	12	1	38
Western Meadowlark	22	29	32	35	118
Yellow-billed Cuckoo	11	9	17	2	39

[1] For these species, additional information is provided in parentheses on 1) the order in which the species occurred on the list of birds counted in the highest numbers, and 2) the proportion of birds counted of that species relative to the total.

recent (2009-2012) RMBO surveys. Based on this, we consider the condition for species of conservation concern to be good.

Overall Condition

For assessing the condition of breeding landbirds, we used one indicator/measure that assessed landbird occurrence. This indicator is summarized in Table 4.11.4-6. Although our assessment is based on limited data, we found no justification for concern at this time for landbird occurrence at Fort Larned NHS.

From the comparison of species detected in 2001 to 2009-2012, we do not have any particular concerns for species occurrence. The temporal comparison found only nine species that were not detected during recent RMBO surveys. Of these, one was outside and more than 100 miles from its normal breeding range, and two do not have breeding habitat at the Historic Site. Of the remaining six species, only one has characteristic breeding habitat at the Historic Site. Further, as described previously, this one species (Great Horned Owl) may occur at the Historic Site but go undetected because of the dense habitat it may use during the day (when sampling occurs). Additionally, 12 species have been detected in the recent RMBO surveys that were not detected in 2001.

Similarly, there was nothing particularly surprising when comparing species observed during recent RMBO surveys to the species observed during 2009-2012 BBS in the surrounding region. After dismissing several species already addressed in the temporal comparison, 19 species were on the list of those not detected at the Historic Site. Of these, none are in the "exists" breeding habitat class; five are in the "possibly exists" class, and 14 are in the "limited to none" habitat class. Most of the five species in the "possibly exists" habitat class were counted in low numbers during the BBSs.

We found nine species that we believe have high conservation potential at Fort Larned NHS, all of which have been observed numerous times at the Historic Site during recent years. Some of the species have been observed in relatively high numbers.

Based on the information presented here, we consider the condition of birds at the Historic Site to be good. Unfortunately, we do not have sufficient data to justify a trend in that condition, although ongoing monitoring should provide such an estimate for future assessments.

Level of Confidence/Key Uncertainties

The key uncertainties related to this assessment are the overall lack of data and subjectivity with respect to assigning individual species to range, habitat, or conservation classes.

Table 4.11.4-6. Summary of the breeding landbirds indicator/measures and their contributions to the overall landbirds condition.

Indicator	Measure	Condition	Condition Rationale
Species Occurrence	Temporal Context	Good	Eighty-four percent of 57 species observed in the 2001 bird inventory were observed in 2009-2012 RMBO bird surveys at the Historic Site. Only one of the nine species not observed in 2009-2012 is within its normal breeding range and has characteristic breeding habitat at the Historic Site; it is believed that this species occurs at the Historic Site but has gone undetected due to its dense, daytime resting habitat (it is a nocturnal owl species). Additionally, 12 species were observed in the 2009-2012 RMBO surveys that were not observed in 2001. In a temporal context, the condition of breeding landbirds at the Historic Site is good. Data are available for a relatively small number of years, so no trend information is available at this time.
	Spatial Context	Good	In a comparison of Breeding Bird Surveys (BBSs) in the vicinity of the Historic Site to RMBO surveys within the Historic Site, there were 27 species that were not observed at the Historic Site from 2009-2012. However, the majority of the species are outside of their normal breeding ranges or fall within the "limited to none" breeding habitat class at the park; only one (the owl species discussed above) is thought to have existing breeding habitat at the Historic Site. Based on this comparison, the condition of breeding landbirds is good. Because data are available for a relatively small number of years, no trend information is available at this time.
	Conservation Context	Good	There are 16 species that have been observed during 2009-2012 and/or 2001 surveys that are listed by one or more organization as being of conservation concern. We believe that nine of these species have high conservation potential at the Historic Site. These are species that are within their normal breeding ranges and sufficient habitat exists at the park to support breeding. All of these species have been observed on recent RMBO surveys, and all but two of the species were observed during all four years of the surveys. Therefore, we consider the condition of species of conservation concern at the Historic Site to be good. We do not have sufficient data to justify a trend in the condition at this time.

Although we are currently collecting data that will provide for a quantitatively rigorous analysis in the future, at the present time we relied primarily on qualitative indicators to assess the condition of breeding landbirds. We had four years of data from recent RMBO surveys at the Historic Site (similar to other SOPN parks), but the older data for the temporal comparison was limited to only a one-year inventory.

We determined the breeding ranges primarily from the BNA species accounts and had to judge from online and hard copies whether or not the Historic Site was within those ranges. We tried to account for this uncertainty by also including species that were on the edge of their ranges (i.e., less than 100 miles from the breeding range edge). Similarly, there is considerable subjectivity in our assignment of habitat classes. We based this assignment on a combination of the BNA accounts, as well as our own and local knowledge of the species in question.

4.11.5. Sources of Expertise

Ross Lock, a wildlife biologist with RMBO, provided consultation and reviewed the information in Tables 4.11.4-1, 4.11.4-2, and 4.11.4-4.

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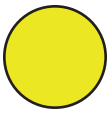
4.12. Black-tailed Prairie Dog (*Cynomys ludovicianus*)

Indicators/Measures

- Prairie Dog Occurrence (Area occupied and Density)

Condition – Trend - Confidence



Moderate – Unknown - Medium

4.12.1. Background and Importance

Prairie dogs, which occur only in North America, are burrowing rodents that belong to the squirrel family. Prairie dogs are diurnal and live in colonies, or towns, which sometimes contain thousands of individuals and extend for miles. There are five species of prairie dogs, all of which may be considered rare (Hoogland 2006a). The black-tailed prairie dog (*Cynomys ludovicianus*) (Figure 4.12.1-1), the most abundant, widespread, and conspicuous of the five species, occurs at Fort Larned NHS in the detached, 44-acre Santa Fe Trail Ruts area ("Ruts" area). The area contains ruts from wagons travelling along the historic Santa Fe Trail. The area is five miles southwest of the Fort and consists of gently rolling uplands of native mixed-grass prairie.

Prairie dogs are an important component of the ecosystems they inhabit. They directly and indirectly influence grasslands through their grazing and burrowing and as prey (Kotliar et al. 2006). Through their foraging and clipping of vegetation to maintain their habitat, as well as the mixing of subsoil and topsoil during excavations, prairie dogs affect the redistribution of minerals and nutrients, encourage penetration and retention of moisture, and affect plant species composition (Kotliar et al. 2006). Although they reduce the biomass of vegetation, they often also enhance the digestibility, protein content, and productivity of grasses and forbs at colony-sites (especially young colony-sites) that are preferred by large herbivores. On the other hand, a new study also suggests that in some areas prairie dogs are causing conservation problems (denuding the landscape, causing a shift from grasslands to shrublands and landscapes dominated by exotic forbs) when their activities interact with fragmentation,

PHOTO: J AND K HOLLINGSWORTH, USFWS

Figure 4.12.1-1 Black-tailed Prairie Dog (*Cynomys ludovicianus*), the most abundant and widespread of the prairie dog species.

climate change, and invasive plant species (Seastedt et al. 2013).

Prairie dog colony-sites may extend for miles and contain hundreds of mounds that surround their burrow entrances. Black-tailed prairie dog mounds may be as high as 2.5 feet (0.75 meters), with a diameter up to 7 feet (2 meters; Hoogland 2006b). Because black-tailed prairie dogs eat or clip grasses and other plants that grow taller than about 12 inches (30 centimeters), vegetation at colony-sites is relatively short (Hoogland 2006b). Prairie dog burrows and colony-sites provide shelter and nesting habitat for a variety of animals (only some of which have been reported at Fort Larned NHS), including insect and arachnid species, Burrowing Owls (*Athene cunicularia*), Mountain Plovers (*Charadrius montanus*), Horned Larks (*Eremophila alpestris*), and federally-endangered black-footed ferrets (*Mustela nigripes;* which do not occur at the Historic Site). Among the animals that consume prairie dogs are black-footed ferrets, American badgers (*Taxidea taxus*), long-tailed weasels (*Mustela frenata*), bobcats (*Felis rufus*), coyotes (*Canis latrans*), Ferruginous Hawks (*Buteo regalis*), Golden Eagles (*Aquila chrysaetoes*), Prairie Falcons (*Falco mexicanus*), bull snakes (*Pituophis melanoleucus*), and prairie rattlesnakes (*Crotalus viridis*) (see Figure 4.12.1-2 for some of these species). Additional species use prairie dog towns (see Sovell et al. 2008).

Within colonies, prairie dogs live in family groups called coteries. The size of a coterie ranges from 1 to 26 individuals, but a coterie generally consists of 1 breeding male, 2-3 adult females, and 1-2 yearling offspring of each gender (Hoogland 2006a). Most black-tailed prairie dogs reach sexual maturity and mate in the second February-March following their birth. Female prairie dogs have one litter of young per year, with the most common litter size being three. Breeding takes place in late January through early March, and gestation length is typically 34-35 days. On average, young emerge from the natal burrow 41 days after birth.

Black-tailed prairie dogs are thought to have once occupied 74 million acres from Canada to Mexico (Proctor et al. 2006), including parts of eleven states (Hoogland 2006b). However, after 200 years of shootings, poisonings, conversion of habitat, and more recently sylvatic plague, prairie dog numbers are a fraction of what they once were (Hoogland 2006b). Sylvatic plague, caused by the bacterium *Yersinia pestis*, is a disease transmitted by fleas; it can be contracted by various mammals and may kill nearly

PHOTO: ROBERT SHANTZ

PHOTO: BRYAN HARRY

PHOTO: BRYAN HARRY

PHOTO: ROBERT SHANTZ

Figure 4.12.1-2 Species that benefit from black-tailed prairie dogs, clockwise from top left: Horned Lark (*Eremophila alpestris*); Coyote (*Canis latrans*); Bobcat (*Lynx rufus*); and American badger (*Taxidea taxus*).

all prairie dogs in an infected colony (U.S. Geological Survey [USGS] 2008). Today, the black-tailed prairie dog's overall range is similar to its historic range, but it occupies only about 1.2 to 2.1 million acres (Proctor et al. 2006). An estimate for 2003 for Kansas was 130,620 acres (52,861 ha) occupied (Luce et al. 2006). In 2004, it was estimated that black-tailed prairie dogs inhabited about 6,900 acres of land managed by the NPS in the western United States (including Fort Larned NHS; Sidle et al. 2006).

As previously noted, prairie dogs inhabit the Trail Ruts tract, and have done so at least since the Historic Site was established in 1966 (Cully and Willson no date) (Figure 4.12.1-3, Figure 4.12.1-4). Delisle and Busby (2004) provided, in their *Biological Inventory for Vertebrates at Fort Larned National Historic Site*, some information on the species at the Historic Site. They reported that prairie dogs were "abundant" at the site, citing their observations in 2001 and Choate et al. (1998). They also noted in their management recommendations that most of the trail ruts tract did not require grassland restoration, because prairie dogs clip the vegetation and maintain it in an early successional stage. They further stated that in areas without prairie dogs, there were high levels of thatch that should be managed with fire, mowing, or grazing (Delisle and Busby 2004). The report did not provide any estimates of prairie dog numbers or acreage inhabited.

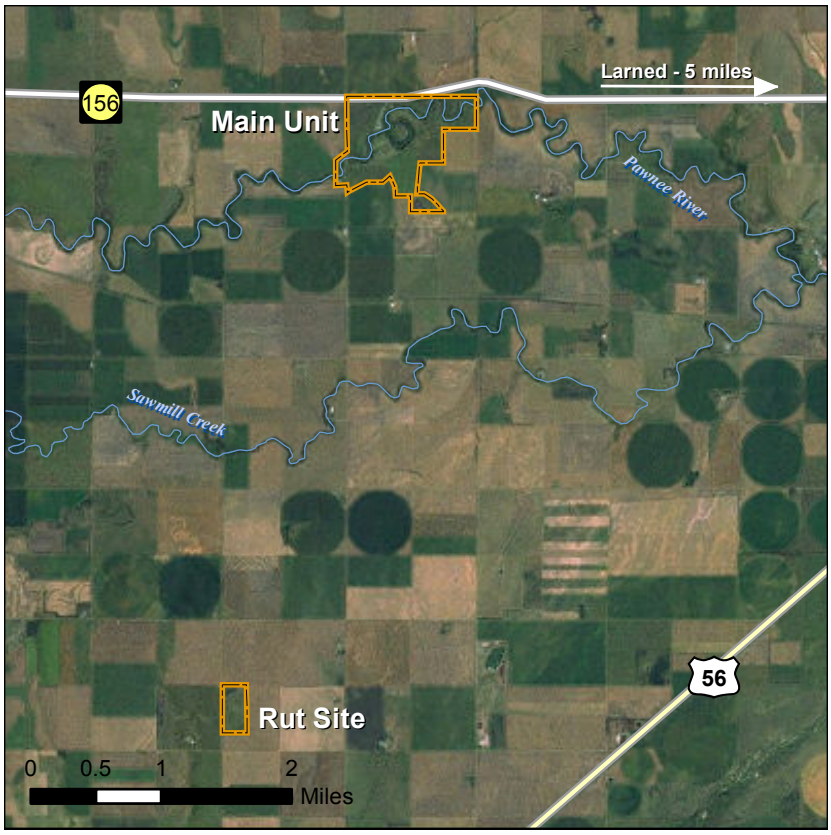


Figure 4.12.1-3 Main Unit and Santa Fe Trail Ruts Site at Fort Larned NHS. Prairie dogs occur only at the Ruts Site.

Goldberg (2012) reported that the area inhabited by prairie dogs at Fort Larned NHS contained native grasses (western wheatgrass [*Pascopyrum smithii*], blue grama [*Bouteloua gracilis*], big bluestem [*Andropogon gerardii*], three-awn [*Aristida oligantha*], and buffalo grass [*Buchloe dactyloides*]), as well as some exotics (bindweed [*Convolvulus arvensis*] and summer cypress [*Kochia scoparia*]). The 2009-2011 study of prairie dogs on four national parks (Pigg and Cully 2010 and Goldberg 2012), reported on the status and size of the prairie dog population at Fort Larned NHS. They provided estimates of prairie dog abundance in April/May and July/August using visual counts, and abundance estimates for the same periods using mark-recapture or mark-resight methods (more information on the estimates is provided later). Other than these data, there is little available on prairie dogs at the Historic Site. The vegetation map for the Historic Site includes a layer called Prairie Dog Town/Grassland Complex. It shows conditions in 2007 and is discussed below under "Condition and Trend."

Animal species associated with prairie dog towns that have been recorded at Fort Larned NHS include Horned Larks (see Section 4.11 on Breeding Landbirds), coyotes (Delisle and Busby 2004), and bobcats (observed by Historic Site staff and reported in Delisle and Busby 2004). The American badger and the prairie rattlesnake were not observed in the 2001 survey, but they may occur at the Historic Site (Delisle and Busby 2004).

Management of the black-tailed prairie dog varies substantially across its range; some states consider it a species of special concern, other states consider it a small game species, and still others consider it a vertebrate pest. Because prairie dogs are both an important

component of the ecosystem and, in some cases, damaging to other resources within and adjacent to parks, their management is important and complex. The policy of the National Park Service is to conserve and recover the black-tailed prairie dog wherever possible (Sovell 2008). The NPS can control prairie dogs on its property only to protect human health and safety, for good neighbor relations, and to manage conflicts with other park objectives, such as the preservation of cultural resources.

Out of concerns for the preservation of the Santa Fe Trail ruts, managers have, on occasion, removed prairie dogs from the site (e.g., by poisoning) (Cully and Willson no date, NPS 1999).

4.12.2. Data and Methods

This assessment is based on all of the information on black-tailed prairie dogs at Fort Larned NHS that is available. The assessment is qualitative in nature, as there is not much quantitative data available for prairie dog occurrence at the Historic Site. The primary information sources used for the assessment are described immediately below and consist of: 1) Kansas Natural Heritage Inventory (KNHI) vertebrate inventories (Delisle and Busby 2004); 2) a study on the prairie dog population at Fort Larned NHS (and three other small NPS units) (Pigg and Cully 2010); and 3) a continuation of the study reported in Pigg and Cully (2010) that is presented in Goldberg (2012). This description of primary information sources is followed by a discussion of the indicators/measures we used to determine the condition of prairie dogs at Fort Larned NHS.

Primary Data Sources

KNHI Inventories

In 2001, the KNHI conducted a vertebrate inventory at the Historic Site (Delisle and Busby 2004). In April and May, surveys for mammals included use of driving and walking surveys and trapping using Sherman live traps and pitfall traps. Prairie dogs were observed and recorded, but little additional information was provided on the species.

Study of Prairie Dogs at Fort Larned NHS (Pigg and Cully 2010, and Goldberg 2012)

Because additional information was needed on the prairie dog populations at Fort Larned NHS and other parks, such as on their dispersal to adjacent lands, a project (*Status and Management of Black-tailed Prairie Dogs on Small Cultural National Parks of the Western Great Plains*) was devised to collect information over multiple years. At Fort

NPS PHOTO

Figure 4.12.1-4 Prairie dog burrows visible amongst Santa Fe Trail ruts at Fort Larned NHS.

Larned NHS, trapping was conducted from April 16-28 and from July 7-13, 2009 (but April data were not presented in the report due to unforeseen field problems). The report contains density estimates based on the sampling, a report on the number and type of burrows counted, and some information on movements from radio telemetry work. They used two methods to estimate prairie dog density. One method used the protocol of Plumb et al. (2001), and the other used capture data and models in program CAPTURE. We mention both density estimates in our assessment because varying methods have been used to sample prairie dogs in different years at the Historic Site.

The study continued in 2010 and 2011, and relevant information was collected on prairie dog dispersal and estimating abundance (Goldberg 2012). The researchers estimated prairie dog abundance using visual counts and mark-recapture and mark-resight methodologies.

Except for the Historic Site's vegetation map mentioned previously, which contains a layer for the prairie dog town/grassland complex, and the density estimates from 2009-2011, no annual monitoring or digital occurrence data are available. One exception to this is a population estimate made in the mid-1990s (presented in Table 4.12.4-1).

Indicators/Measures

Prairie dog occurrence:
Density of prairie dogs

In the past, estimates of prairie dog populations have usually been based on the amount of occupied habitat, rather than on the number of individual animals (U.S. Fish and Wildlife Service [USFWS] 2013). However, densities of prairie dogs (the number of animals per unit of area) may also be estimated, and their use appears to be on the rise (e.g., Godlberg 2012). Because we have little information on the area occupied at Fort Larned NHS, we relied primarily on density of prairie dogs for our assessment. We assessed the occurrence of prairie dogs by looking at their estimated densities over time according to the data sources described above. We also considered other information, such as the areal coverage of the prairie dog town/grassland complex layer from the Historic Site's vegetation map and descriptive accounts of the abundance of the population.

4.12.3. Reference Conditions

Reference conditions for prairie dogs are complex and highly dependent on the perspective from which they are taken. For example, a landowner that makes his or her living from production needs to consider the decreased plant biomass associated with prairie dog colonies, as well as the potential for injury of stock animals. Thus, from their perspective the condition of the resource may be best when prairie dogs are in very low numbers or entirely absent. In contrast, from an ecological perspective, prairie dogs have a pronounced impact on their ecosystem (Kotliar et al. 2006). As discussed in Section 4.12.1, prairie dogs increase habitat diversity and contribute to grassland ecosystem processes. Prairie dogs clip the vegetation and maintain open habitats preferred by some animals, such as the Horned Lark and Burrowing Owl. Many species, such as the American badger, prairie rattlesnake, Burrowing Owl, and the federally endangered black-footed ferret, prey on prairie dogs or use their burrows for shelter. Thus, from an ecological standpoint, having a healthy population of prairie dogs may be viewed positively, especially when considering the suite of other species that may benefit from their presence. Even from an ecological perspective, however, having an overabundance of prairie dogs may have detrimental consequences to the vegetation.

In this NRCA, we focus on the prairie dog's ecological role in the grassland ecosystem, while also acknowledging that prairie dogs in a national park may pose difficulties to management, particularly with regard to the damage that prairie dog excavations can cause to important cultural resources that the park must protect, and with adjacent land owners who do not value prairie dogs on their property.

Table 4.12.4-1. Number of burrows and estimated densities of black-tailed prairie dogs at Fort Larned NHS from various studies and surveys.

Year	No. of Burrows Counted	Density of prairie dogs in Hectares (and Acres)	Other Information	Source
mid-1990s	No Data	No Data	260 prairie dogs in the colony	NPS (1999)[3]
2009	active burrows in 4-ha (9.9-acre) study area = 182	43 prairie dogs per ha (17.4 per acre) in July; measured with visual counts	50.7 prairie dogs per ha (20.5 per acre) in July using CAPTURE analysis (mark-recapture method)	Pigg and Cully (2010)
2010	No Data	31 per ha (12.5 per acre) in April/May; 28 per ha (11.3 per acre) in July/Aug; measured with visual counts[1]	36 per ha (14.6 per acre) in April/May; 55 per ha (22.3 per acre) in July/Aug; measured by mark-resight[1,2]	Goldberg (2012)
2011	No Data	37 per ha (15 per acre) in April/May; 99 per ha (40.1 per acre) in July/Aug; measured with visual counts[1]	38 per ha (15.4 per acre) in April/May; 56 per ha (22.7 per acre) in July/Aug); measured by mark-resight[1,2]	Goldberg (2012)

[1] Goldberg (2012) presented abundance estimates, for 4-ha study sites, rather than density estimates. We converted abundance estimates (taken from Figure 3.1 of Goldberg [2012]) to densities by dividing by 4 ha.

[2] We presented mark-resight estimates from Goldberg (2012) (which also presented estimates using other methods), because the author reported the method usually produced the most precise estimates.

[3] Original source is G. Plumb and G. Willson, "Black-tailed Prairie Dog Inventory and Monitoring in the NPS," draft report, 2/28/97 as cited in NPS 1999.

4.12.4. Condition and Trend

Density of Prairie Dogs

As previously noted, prairie dogs have inhabited the Trail Ruts unit at least since the Historic Site was established in 1966 (Cully and Willson no date). We did not discover an individual report that summarized recent and past prairie dog numbers or areal coverage of prairie dogs at Fort Larned NHS. The vegetation map from 2007 (Cogan et al. 2007) indicates that the prairie dog town/grassland complex makes up 35 acres (14 hectares), or 79% of the 44-acre unit (Figure 4.12.4-1). The 2004 report by Delisle and Busby reported, based on their work and that of Choate et al. (1998), that black-tailed prairie dogs were "abundant at the Santa Fe Trail ruts site." However, they did not provide any additional data on the prairie dog colony. We found no information that described changes in the areal coverage of the colony(ies) over time. However, prairie dog density estimates are available for prairie dogs at the 44-acre Trail Ruts site for 2009, 2010, and 2011 (Pigg and Cully 2010, Goldberg 2012) (Table 4.12.4-1).

Figure 4.12.4-1 Prairie dog town/grassland complex at the Trail Ruts unit. Figure adapted from vegetation map for the park (Cogan et al. 2007).

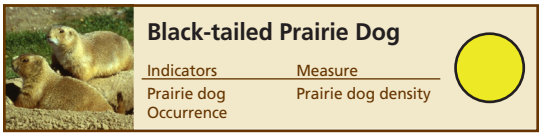
Two estimates are presented for each year (except 2009, due to a field issue) because estimates are made for the period before juveniles emerge from the burrows (sampling period of April/May), and after juveniles emerge (sampling period of July/August; Goldberg 2012). For all three years, the table

shows density estimates using visual counts (and estimates using other methods in the adjacent column). Although Goldberg (2012) reported that other methods of estimation are more precise (mark-resight), or may be preferable when certain types of information are needed (mark-recapture), we present the data from visual counts (protocol of Plumb et al. 2001) because it is available for all three years, and it is the method that has been used for sampling at national parks (e.g., at Bent's Old Fort NHS). Additionally, Goldberg (2012) pointed out that under certain conditions (e.g., prairie dog colony is on level ground with good visibility), visual counts using the Plumb et al. (2001) protocol may be the most cost-effective, quickest, and easiest method.

In a very crude comparison of the density estimates from 2009 to 2011 (i.e., July 2009 to July/August 2010 and 2011), the prairie dog density appears to have varied substantially (43 per hectare [17.4 per acre] in 2009, 28 per hectare [11.3 per acre] in 2010, and 99 per hectare [40.1 per acre] in 2011). However, the comparison from July/August 2010 to July/August 2011 using mark-resight numbers (there were no mark-resight estimates in 2009), indicates that there was no increase from summer 2010 to summer 2011 (i.e., 55 per hectare [22.2 per acre] in 2010 and 56 per hectare [22.7 per acre] in 2011).

There is not enough information to determine whether prairie dog densities at Fort Larned NHS are increasing or remaining the same. It does not appear, based on only three years of data, that prairie dog numbers are decreasing, as they have in some other parks in the SOPN (Sand Creek Massacre NHS and Bent's Old Fort NHS, where populations crashed due to sylvatic plague). Fort Larned NHS is outside of the known range of plague (Cully et al. 2006, Goldberg (2012).

Several studies have provided precise determinations of prairie dog colony densities at various locations (Hoogland 2006a), and these densities ranged from 3 to 27 individuals per acre (8 to 68 per hectare). Prairie dog densities vary over time and space due to factors such as forage, climate, predation, and disease. Given that such variations occur, a crude estimate of colony density before juveniles first emerge from their natal burrows is 10 adults and yearlings per acre (25 adults and yearlings per hectare) (Hoogland 2006a). A crude estimate for after juveniles first emerge (in May and June) is 20 adults, yearlings, and juveniles per acre (or 50 per hectare). Most of the post emergence estimates from Fort Larned NHS (those from visual counts and mark-recapture or mark-resight) are in the range of those from Hoogland (2006a), except for one that was lower (28 per hectare [11.3 per acre] in 2010) and one that was higher (99 per hectare [40.1 per acre] in 2011); note that both of these estimates are from visual counts. The numbers for pre-emergence at the Historic Site are somewhat higher than those suggested in Hoogland (2006a).



Overall Condition and Trend

Based on the information available at this time, and using the reference conditions stated in Section 4.12.3, we believe the overall condition of the black-tailed prairie dog at Fort Larned NHS warrants moderate concern. We reached this conclusion because, from an ecological standpoint, the population appears to be in good condition. Prairie dogs have occurred at the Historic Site for many years, and based on recent data and earlier reports (e.g., 2004 report) their numbers appear to be relatively stable. Prairie dogs provide numerous ecological benefits. However, from the perspective of protecting Historic Site cultural resources, there is cause for concern. Prairie dogs have caused damage to the historic Santa Fe Trail ruts at the Historic Site. According to George Elmore, Chief of Interpretation at the Historic Site, prairie dogs are causing damage by causing erosion of the trail ruts and by causing material from their burrows to fall into and fill the ruts. In consideration of both of these situations (positive [ecological standpoint] and negative [trail ruts protection]) at the same time, the overall condition warrants moderate concern. This indicator is summarized in Table 4.12.4-2. The trend is uncertain, because of the small

Table 4.12.4-2. Indicators and measures of black-tailed prairie dog condition, their corresponding assigned condition class(es), and the rationale for assigning the condition class(es).

Indicator	Measure	Condition	Rationale for Condition
Prairie dog occurrence	Prairie dog density	Moderate Concern	Even though indications are that the prairie dog population at the Historic Site is in good condition, there are concerns for the damage that prairie dog burrowing and foraging activities can cause to the historic Santa Fe Trail ruts. Protection of the trail ruts is a priority because the trail ruts represent the primary historic resource on that unit of the Historic Site (NPS 1999).

amount of specific information available (e.g., prairie dog density data for only three years).

Level of Confidence/Key Uncertainties

According to the best available information, which consists of only three years of prairie dog density data and evidence of damage to the trail ruts (George Elmore of the Historic Site and NPS 1999), the condition of prairie dogs at Fort Larned NHS is of moderate concern. Although the condition of prairie dogs appears to be good from an ecological perspective, data for a longer period of time are required to assess the trend in the condition. The sylvatic plague, caused by fleas carrying the *Yersinia pestis* bacterium, has caused complete mortality of the prairie dog colonies at Bent's Old Fort NHS and Sand Creek Massacre NHS in Colorado (in 2011/2012 and 2010/2011, respectively). No plague event has occurred at Fort Larned NHS, and the Historic Site is outside of the known range of plague (Cully et al. 2006). Additionally, Delisle and Busby (2004) reported that black-tailed prairie dogs were "abundant" at the Historic Site at the time of their work, but they provided no specific numbers.

4.12.5. Sources of Expertise

For this assessment, we relied on previous reports and publications about the black-tailed prairie dog at the Historic Site and elsewhere in the western U.S.

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Grassland and soil rapid assessments for Fort Larned NHS' NRCA.

Chapter 5: Discussion of Natural Resource Condition Assessment Findings and Considerations for Park Planning

5.1. Introduction

The primary purpose of the Natural Resource Condition Assessment (NRCA) Chapter 5 is to provide a "big picture" - broader application of resource condition findings (Albright 2010). We will fulfill this purpose by:

- creating a framework that connects the natural resource findings to Fort Larned National Historic Site's purpose, and significance statements
- delivering completed State of the Park natural resource condition summary tables and resource briefs for each of the topics assessed; and
- providing resource narratives for each assessed topic.

These Chapter 5 reporting pieces are *value added* products that can be used by park managers for a variety of resource planning and comprehensive park management purposes (Jeff Albright, NRCA Program Coordinator, pers. comm. August 23, 2013). Additionally, efficiencies are gained by providing these "ready to use products" because they deliver information to park staff that directly meet other reporting requirements, such as those for the *State of the Park* report, or by providing information that can be easily modified as needed (re: resource management discussions) to be used for PMIS proposals as background information and problem statements, for other funding proposals, priority setting, or for interpretive purposes.

5.2. Connecting Natural Resource Condition Assessment Findings to Park Purpose and Significance

Managing the natural resources at Fort Larned NHS is inextricably tied to its historic purpose and significance. It is most often within this interdisciplinary perspective that managers consider potential actions and alternatives when addressing resource issues or needs. As such, we have created a table (Table 5.2-1) where natural resource topic

Table 5.2-1. Summary of natural resource topic relevance (denoted by black dots) as it relates to Fort Larned National Historic Site's purpose and significance statements as identified in NPS (1994, 2011).

Natural Resource Condition Assessment Topics	Viewshed	Night Sky	Sound-scape	Air Quality	Geology	Surface Water Quality	Ground-water	Riparian Habitat	Grassland	Exotic Plants	Landbirds	Prairie Dog
I. Park Purpose												
Commemorate the historic role Fort Larned played in the opening of the West									●			
Preserve, protect, interpret, and administer the resources of Fort Larned as a National Historic Site.			●			●		●	●			
Preserve areas of archeological and ethnological interest									●			●
Protect scenic, scientific, natural, and historic values	●	●	●	●	●	●	●	●	●	●	●	●
II. Park Significance												
Fort Larned played an important role in protecting the Santa Fe Trail in the 1860s and the Atchison, Topeka, and Santa Fe Railroad in the 1870s.	●											
Fort Larned was a focal point for conflicts and peaceful interactions with plains Indians in the 1860s.												
The Historic Site contains nine structures dating from the historic period and is listed on the National Register of Historic Places (NRHP or national register). Because of its large number of authentically restored and furnished buildings and surrounding grasslands, Fort Larned is the finest example of an Indian Wars military post on the Santa Fe Trail.					●				●			
A separate unit of the Historic Site (the 44-acre Trail Ruts Unit) preserves deep worn wagon ruts that still mark the Santa Fe Trail route.	●								●			●

Literature Cited: National Park Service 1994 and National Park Service 2011.

relevance is presented within a framework of the Historic Site's purpose and significance statements (NPS 1994, 2011). This provides a "snapshot" look at how each natural resource condition ties into the Historic Site's primary reasons for establishment.

All of the natural resource topics shown in Table 5.2-1 relate to Fort Larned NHS' purpose statement of "protect scenic, scientific, natural, and historic values". These resources comprise not only the current Historic Site setting but were also integral to the site during the Fort's establishment and active period. The viewshed and soundscape are both important to interpreting life within the military fort. The historic views provided safety and defense and the current views provide visitors with an opportunity to "step back in time" and imagine what traveling across the expansive prairie along the Santa Fe Trail, with very little protection except that provided by military posts such as Fort Larned, must have been like. The sounds emanating from the various fort buildings and areas during living history events, including the blacksmith shop, saddler's shop, and

parade grounds, create experiences that engage all senses.

The geology, Pawnee River, and grasslands surrounding the Historic Site provided the necessary resources required for living in such a remote environment. The Historic Site was situated at a strategic bend in the Pawnee River and selected for its natural characteristics and location along the Santa Fe Trail (Quinn Evans Architects 1999). The meandering Pawnee River and related oxbow gave natural protection on three sides of the Fort, leaving only the south side open, which is flat and historically grasslands for as far as the eye can see, providing views of any approaching friend or foe. Shallow groundwater in the alluvium provided an additional source of water. The area's surrounding geology and riparian woodlands provided a variety of building materials, including local sandstones and limestones and wood for constructing the Fort's structures. To this day, the sandstone blocks have preserved the signatures of those who have been a part of the site's past.

These resources supported life on the prairie and provided the backdrop from which Fort Larned came into existence and is still preserved for visitor enjoyment to this day.

The resource condition highlights for each resource topic, if applicable, will be presented in the *State of the Park* resource brief (section 5.3). Condition findings relative to potential resource issues/data gaps, opportunities and management considerations will be presented in the resource narratives section 5.4.

5.3. State of the Park Reporting

As part of the stewardship of national parks for the American people, the NPS has begun to develop *State of the Park* reports to assess the overall status of each park's resources. The NPS will use the *State of the Park* report information to improve park priority setting and to synthesize and communicate complex park condition information to the public in a clear and simple way (NPS 2012).

The key purposes of each *State of the Park* report are to:

- Provide to visitors and the American public a snapshot of the status and trend in the condition of a park's priority resources and values.
- Summarize and communicate complex scientific, scholarly, and park operations factual information and expert opinion using non-technical language and a visual format.

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Both randomly shaped and cut blocks of Dakota sandstone were used to construct the buildings at Fort Larned National Historic Site.

- Highlight park stewardship activities and accomplishments to maintain or improve the state of the park.
- Identify key issues and challenges facing the park to help inform park management planning.

The format for relevant *State of the Park* content in sections 5.4-5.16 will integrate resource condition findings into the required format for the Historic Site's *State of the Park* report, such that relevant pieces can easily be used for such reports. This includes an overall natural resource summary table showing the resource topic condition and rationale for overall condition ratings (Note: A summary of the Status and Trend symbols for condition ratings can be found in Chapter 3, Table 3.2.3-1). We then present each natural resource topic individually, including all indicators and/or measures by which resource topics were assessed. Finally, a resource brief summarizing the condition rationale, will follow the condition table and include any significant condition highlights.

Table 5.3-1 *State of the Park* Natural Resource Summary Table

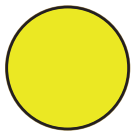
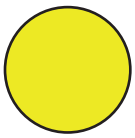
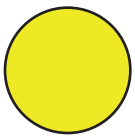
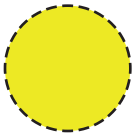
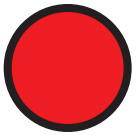
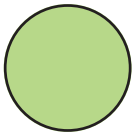
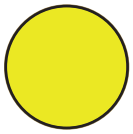
Priority Resource or Value	Condition Status/Trend	Summary of Overall Condition Rating
Natural Resources		
Viewshed		The challenge is that the Historic Site is surrounded by developed agricultural lands, which create conspicuous disturbance in the viewsheds. When visitors first enter the site by crossing the bridge, views within the Fort grounds are confined by the riparian vegetation and the buildings themselves. This experience retains a high level of cultural and historic integrity. Views of the landscape directly outside the Historic Site, however, are degraded from the feeling of expansive plains to that of large-scale agriculture. Overall, the condition of the viewshed is moderate.
Night Sky		Quantitative modeling of sky brightness (all-sky anthropogenic light ratio) and a qualitative assessment of sky quality (the Bortle Dark Sky Scale) were used to assess the condition of the night sky. The overall condition of the Historic Site's night sky is moderate, based on the more reliable ALR modeling results.
Soundscape		Sound audibility and sound level (amplitude) were assessed at two locations to determine soundscape condition. While cultural and natural sounds were heard, noise audibility from vehicles and Historic Site maintenance activities were pervasive. In addition, noises could be heard at both monitoring sites >99% of the time. Sound levels were relatively low at both on-site listening locations, but estimating the impact sound level using Mennitt et al. (2013) sound model results, we consider the soundscape condition to be of moderate concern.
Air Quality		Air quality monitoring is multifaceted and includes visibility, ozone, and wet deposition for total nitrogen and total sulfur. Both ozone and total S indicators warranted moderate concern and visibility and total N warranted significant concern. The visibility trend for 2000-2009 was reported as improving. Additional trends for remaining air quality indicators could not be determined due to lack of nearby monitoring stations.
Geology		A geologic resource evaluation scoping summary was completed in 2008. There were several geologic concerns raised, therefore, geology at the Historic Site is considered to be in moderate condition.
Surface Water		The Pawnee River throughout the Historic Site was dry in 2013, therefore, current condition is unknown.

Table 5.3-1 State of the Park Natural Resource Summary Table (continued)

Priority Resource or Value	Condition Status/Trend	Summary of Overall Condition Rating
Groundwater		The alluvial aquifer and riparian habitat are interconnected and long-term groundwater level decline has resulted in the local aquifer's inability to support the riparian system within the Historic Site as evidenced by lack of surface water and impacts to riparian vegetation. As a result we consider the groundwater level condition to be of significant concern with a stable or possibly slow recovery trend.
Riparian Habitat		While the Pawnee River at the Historic Site supported a nearly continuous corridor of riparian trees on its upper banks, we found the riparian system to be in "Non-functional" condition and of significant concern. Critical findings supporting our conclusion included a channel/floodplain form that is out of balance with the landscape setting, a complete lack of perennial wetland plants in the channel bottom or banks to resist erosion and stabilize soils, a lack of healthy recruitment for riparian tree species, and the absence of channel/floodplain formation at the new base level following past incision.
Grasslands		Grasslands at Fort Larned NHS are within the region generally characterized as mixed grass prairie. The grasses themselves are largely non-native species, and various land uses, including agriculture, prairie dogs, and moderate drought conditions have all contributed to significant concerns about grassland condition.
Exotic Plants		In 2013, 59 exotic plant species were found throughout the Historic Site, with 18 (30.5%) of these considered to be of the highest, high, or moderate concern due to their management difficulty, ecological impact, prevalence, and/or density. Three of the exotic species were found in >50% of the high priority monitoring plots and two species, >60%, were found throughout the entire Historic Site. Based upon the relative number of high ecological impact species present, and their wide distribution throughout the Historic Site, we consider the overall condition of exotic plants to warrant significant concern, with a stable trend.
Breeding Landbirds		We used one indicator, species occurrence (presence/absence), in three separate contexts (or measures; temporal, spatial, and conservation), to assess the condition of breeding landbirds at the Historic Site. For each measure, we found the current condition of breeding landbirds to be good. We do not have sufficient data to justify a trend in the condition at this time.
Prairie Dog		Density (prairie dogs per unit area) was estimated in three years from 2009-2011. Although it is unclear whether or how much the densities have varied over the three years, overall the numbers are comparable to those reported for prairie dogs in other areas. If the prairie dog reference condition was based solely from an ecological perspective, we would consider the condition of prairie dogs to be good. However, our reference condition includes the damage that prairie dog burrowing activities can cause to cultural resources such as the Santa Fe Trail ruts. Therefore, we consider the overall condition to be one of moderate concern.

5.4. Viewshed Resource Brief and Narrative

5.4.1. Noteworthy Highlights

From a cultural and historical perspective, the views are not just about the scenery, but an important way to better understand life in a frontier fort. Fort Larned NHS has an important place in history along the Santa Fe Trail. Visitors can explore the restored and refurnished buildings to get a sense of what life was like and experience the Fort similar to the way it was when it was occupied.

5.4.2. Condition Rationale

Based on this assessment, the viewshed condition at Fort Larned NHS is considered moderate (Table 5.4.2-1). While visitors experience a high level of historic and natural integrity within the Fort site, the surrounding landscape is moderately degraded by conspicuous powerlines, agriculture, and roads.

Table 5.4.2-1. Summary of overall viewshed condition, indicators and measures, and rationale for assigning condition ratings at Fort Larned National Historic Site.

Viewshed			
Indicators of Condition	Specific Measures	Condition Status/Trend	Rationale
Scenic and Historic Integrity	Intactness of View		While the views within the immediate Fort area are somewhat protected, the site is surrounded by developed agricultural lands resulting in a view that has only moderate integrity from a natural and cultural perspective.
	Conspicuousness of Noncontributing Features		Non-contributing features related to agriculture, homes and farm buildings, roads, powerlines, and oil and gas development are relatively prevalent and conspicuous throughout the views at Fort Larned NHS.

5.5. Night Sky Resource Brief and Narrative

5.5.1. Noteworthy Highlights

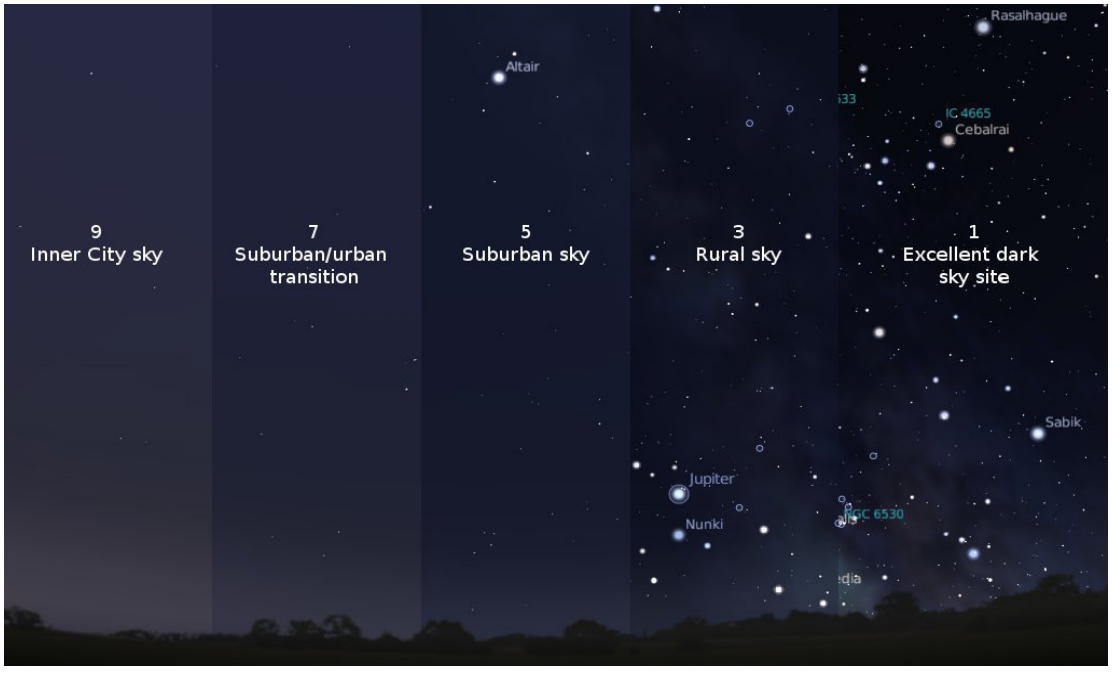
Natural dark skies are a valued resource for many reasons; they are an important factor for maintaining healthy biological systems and have an aesthetic appeal for recreational value. Night skies, and the objects that can be seen, also have strong cultural connections. For thousands of years, people have watched the night sky and told stories connected to the stars, planets, and constellations that they observe.

5.5.2. Condition Rationale

Night skies are part of the cultural landscape, and the Kansas night sky is expansive. Although the riparian vegetation can screen the influence of some local light sources, the light from nearby cities also impacts the quality of the night sky at the Historic Site.

Table 5.5.2-1. Summary of overall night sky condition, indicators and measures, and rationale for assigning condition ratings at Fort Larned National Historic Site.

Night Sky			
Indicators of Condition	Specific Measures	Condition Status/ Trend	Rationale
Sky Brightness	All-sky Anthropogenic Light Ratio		This measure results from modeling data provided by the NPS Night Sky Program. Specific thresholds for condition classes have been set by the NPS; condition at Fort Larned NHS is moderate (0.68). No ground-based measurement has been collected, therefore, the confidence level in this assessment is medium.
Sky Quality	Bortle Dark-Sky Scale		Star gazing at Fort Larned NHS is of moderate condition for observing constellations, the Milky Way, and other celestial bodies. The qualitative assessment of moderate condition (Bortle class 4) reflects the influence of local lighting and the lights from nearby cities.



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

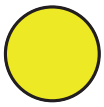
5.6. Soundscape Resource Brief and Narrative

5.6.1. Condition Rationale

Soundscape condition was assessed using audibility and sound level (amplitude) within the Fort's parade grounds and along the Nature Trail within Fort Larned NHS. The percent time audibility of noise was greater than 99% of the time at both locations, warranting significant concern.

The on-site monitoring decibel levels were relatively low, but of moderate concern when using the sound impact level modeled by Mennitt et al. (2013). When combining all three soundscape condition measures, we consider the Historic Site's soundscape to be of moderate concern.

Table 5.6.1-1. Summary of overall soundscape condition, indicators and measures, and rationale for assigning condition ratings at Fort Larned National Historic Site.

Soundscape			
Indicators of Condition	Specific Measures	Condition Status/Trend	Rationale
Audibility	% Time Audible		The percent time audible of all non-natural/cultural sounds was 99-100%, indicating that noises were almost always heard. Due to the presence of continuous noise at both monitoring locations, we consider the percent time audibility of noises to be of significant concern.
Sound Level	Amplitude of sound Level Impact (park-wide/regional model)		The modeled impact sound level for the Historic Site ranged between 6.3-9.0 dBA. This range is within a threshold for moderate concern when evaluating a park classified between a non-urban and urban park using NSNSD thresholds.
	Amplitude (of sounds at on-site monitoring locations)		The louder on-site noises originated from Historic Site maintenance operations. Overall, few noises heard were loud enough to warrant concern. Consequently, we considered this measure to be in good condition.

NPS PHOTO

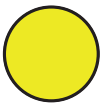
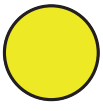
Sounds originating from cultural activities, such as those heard in the blacksmith shop at Fort Larned NHS, contribute to the soundscape quality.

5.7. Air Quality Resource Brief and Narrative

5.7.1. Condition Rationale

Air quality doesn't just affect the air we breathe, it also affects many air quality related values such as visibility and cultural and natural resources. There are different facets to air quality monitoring including measuring ozone levels, visibility conditions, and wet deposition levels. Currently, the level of ozone and total sulfur warrant a moderate concern condition at the Historic Site, whereas visibility and total nitrogen warrant significant concern (Table 5.7.1-1). The Historic Site contains five ozone-sensitive plant species, three of which are bioindicators. A visibility trend (2000-2009) was reported for Fort Larned NHS as improving (NPS-ARD 2013). The Historic Site's air quality is largely influenced by activities and operations that occur outside its boundary, and the future of its air quality condition is ultimately dependent on local, regional, and national planning.

Table 5.7.1-1. Summary of overall air quality condition, indicators and measures, and rationale for assigning condition ratings at Fort Larned National Historic Site.

Air Quality			
Indicators of Condition	Specific Measures	Condition Status/Trend	Rationale
Visibility	Haze Index		For 2006–2010, estimated average visibility in the Historic Site was 9.2 deciviews above natural conditions, therefore, the condition status warrants significant concern based on NPS Air Resource Division benchmarks. From 2000-2009, visibility improved on the haziest days, while visibility on the clearest days showed no trend.
Ozone	Annual 4th-Highest 8-hour Concentration		The estimated ozone level for 2006–2010 at the Historic Site was 69.7 parts per billion, therefore, the condition status warrants moderate concern based on NPS Air Resource Division benchmarks. Five ozone-sensitive plants are found in the Historic Site, three of which are bioindicators. No trend information is available because there are not sufficient on-site or nearby ozone monitoring stations.
Atmospheric Wet Deposition in Total N and total S	Total N in kg/ha/yr		For 2006–2010, estimated wet nitrogen deposition was 4.0 kilograms per hectare per year, therefore, the condition status warrants significant concern based on NPS Air Resource Division benchmarks. No trend information is available because there are not sufficient on-site or nearby wet deposition monitoring stations.
	Total S in kg/ha/yr		For 2006–2010, estimated wet sulfur deposition was 1.7 kilograms per hectare per year, therefore, the resource is in moderate condition based on NPS Air Resource Division benchmarks. No trend information is available because there are not sufficient on-site or nearby wet deposition monitoring stations.

5.8. Geology Resource Brief and Narrative

5.8.1. Noteworthy Highlights

Located 10 km (6 mi) west of Larned, Kansas, Fort Larned NHS bridges the Smoky Hills and Arkansas (pronounced "Ar-Kansas" by Kansans) River physiographic regions. The Fort is located on the floodplain of the Pawnee River; specifically a broad, flat alluvial plain consisting of Quaternary sand, gravel, silt, and clay. Lower Cretaceous Dakota Formation (shale and sandstone layers), Graneros Shale, and Greenhorn Limestone underlie pasture lands north of the Fort. Located 7 km (4 mi) southwest of the Fort unit, the detached Santa Fe Trail Ruts unit lies on gently rolling uplands of Dakota sandstone. Both units lie on the western edge of the Kansas mixed-grass prairie region (KellerLynn 2008).

5.8.2. Condition Rationale

Geologic resources serve as the foundation of ecosystems and yield important information needed for science-based decision making in National Parks. Geology is a major determinant of topography, water and soil chemistry, fertility of soils, stability of hill slopes, and flow styles of surface water and groundwater. These factors, in turn, influence biology, including the distribution of habitats and the locations of threatened and endangered species. Geology also influences human settlement patterns and how people use natural resources—for farming, ranching, industry, construction, hunting, fishing, and recreation. Fort Larned NHS is situated at the confluence of the Pawnee and Arkansas rivers. Apparently, access to water influenced the decision of where to locate the Fort. The meandering river and related oxbow gave natural protection on three sides of the Fort, leaving only the south side open, which is flat for miles, giving a good view of any approaching intruders. Shallow groundwater in the alluvium provided an additional source of water.

A geologic resource evaluation scoping summary was completed in 2008. There were several geologic concerns raised (see below), therefore, the Historic Site is considered in moderate condition (Table 5.8.12-1).

Table 5.8.2-1. Summary of overall geology condition, indicators and measures, and rationale for assigning condition ratings at Fort Larned National Historic Site.

Geology			
Indicators of Condition	Specific Measures	Condition Status/Trend	Rationale
Geologic Integrity	None		The integrity of the geologic resources at Fort Larned NHS is in moderate condition. The Historic Site is surrounded by agriculture and has the potential for soil erosion and disturbance. Mining and oil and gas development in the area around the Historic Site is also a concern.

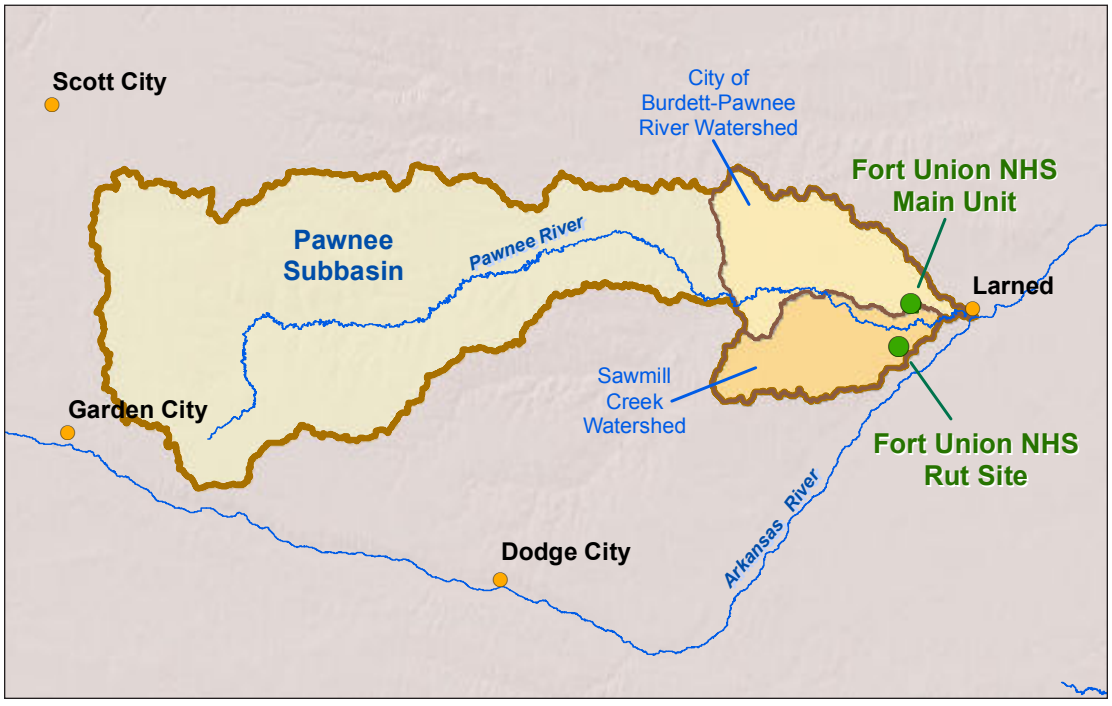
5.9. Surface Water Quality Resource Brief and Narrative

5.9.1. Condition Rationale

Pawnee River originates in Finney County, Kansas and forms a confluence eight miles downriver from the Historic Site with the Arkansas River in Larned, Kansas. It's approximately 198 miles (319 km) long, with extensive stretches of dry areas, including the 2.0 river-miles stretch within the Historic Site (Kansas Geological Survey 2012). Its watercourse drains a large watershed in excess of 2,700 square miles (7,000 km^2) through agricultural land, and the Pawnee River within the Historic Site is in the Pawnee subbasin. The overall drainage pattern is dendritic, which is usually indicative of nearly horizontal underlying rocks and lack of structural features such as faults and folds and is true for this area (Kansas Geological Survey 2012). No formal water quality monitoring program exists at Fort Larned NHS, and this stretch of river was dry in 2013 during this assessment, therefore, condition and trend are unknown.

Table 5.9.1-1. Summary of overall surface water quality condition, indicators and measures, and rationale for assigning condition ratings at Fort Larned National Historic Site.

Surface Water			
Indicators of Condition	Specific Measures	Condition Status/Trend	Rationale
Core Water Quality Parameters	Temperature, Specific Conductance, pH, Dissolved Oxygen, and Turbidity		During 2013, the Pawnee River was dry throughout the Historic Site river stretch, therefore, current condition and trend are unknown.



Fort Larned NHS is located within the Pawnee Subbasin watershed.

5.10. Groundwater Resource Brief and Narrative

5.10.1. Condition Rationale

Declining groundwater levels have been a concern throughout the Western United States for some time. The invention of high capacity pumps in the 1950 and '60s allowed the expansion of irrigated agriculture throughout the Great Plains and enormous quantities of water were removed from local aquifers.

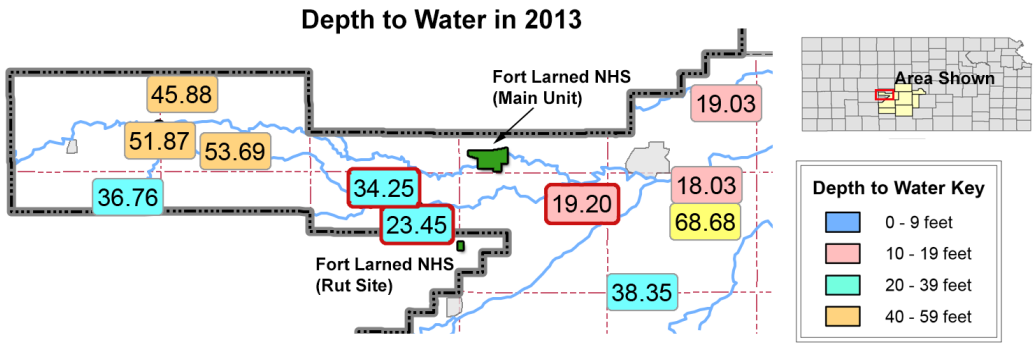
Water levels in the alluvium in the vicinity of the Historic Site have declined anywhere from 10 to 40 feet below historic levels. The overall average decline was about 19 feet from 1947 to 1997 in spite of the large precipitation events that occurred in 1993, 1994, and 1997. Currently, under the sustainable yield policy adopted by Big Bend Groundwater Management District #5 (GMD#5) in Kansas, additional water appropriations since 2002 have been curtailed, and the entire basin is expected to stabilize. While new groundwater withdrawals have stopped, water levels still may fluctuate plus-or-minus 10 feet from year to year, depending on other hydrologic factors (Balleau Groundwater, Inc. 2006).

Topographic data collected by Martin (1992) indicated that the channel bottom elevation of the Pawnee River within the Historic Site was about nine feet above the local water table elevation measured in three Historic Site wells at that time. This disconnect between the channel and the local water table likely persisted through 2013 as evidenced by only rare and short lived flow events through the channel. Additionally, recent groundwater analyses completed for GMD#5 indicated that the local water table was about 30 – 35 feet below valley surface (Balleau Groundwater, Inc. 2006). This lack of a regular water table connection has had a pronounced effect on the type of riparian vegetation that dominates the river channel throughout the Historic Site.

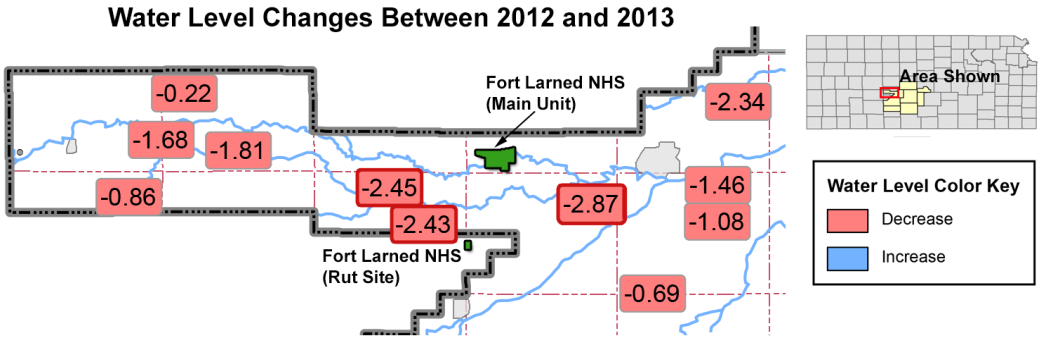
As of May 14, 2013, the depths of groundwater levels in the wells closet to the Historic Site ranged from 19.20-34.25 feet. The change in groundwater levels ranged from -2.43 to -2.87 feet (Big Bend GMD#5 2013). Even though these monitoring wells are not located directly along the Pawnee River, they are representative of the groundwater condition throughout the alluvial aquifer, which is one of overall decline. We consider the groundwater resource at the Historic Site to be of significant concern, with either a stable or possibly improving trend.

Table 5.10.1-1. Summary of overall groundwater condition, indicators and measures, and rationale for assigning condition ratings at Fort Larned National Historic Site.

Groundwater			
Indicators of Condition	Specific Measures	Condition Status/Trend	Rationale
Groundwater	Change in Groundwater Level		The alluvial aquifer and riparian habitat are interconnected and long-term groundwater level decline has resulted in the local aquifer's inability to support the riparian system within the Historic Site as evidenced by lack of surface water and impacts to riparian vegetation. This warrants significant concern.



The range of groundwater level depths in the wells closet to the Historic Site was 19.20-34.25 feet (GMD #5 2013).



The water level changes from 2012-2013 in the wells closest to the Historic Site ranged from -2.43 to -2.87 feet (GMD#5 2013).

5.11. Riparian Habitat Resource Brief and Narrative

5.11.1. Condition Rationale

Riparian wetlands are a type of non-tidal wetland formed along river and stream floodplains. These wetlands serve many functions including water purification, flood control, buffering riverbank erosion, habitat for numerous wildlife, fish, shellfish, and plant species, and also provide many recreational opportunities. In the arid west, riparian habitat is often in marked contrast with the surrounding terrestrial vegetation and is strongly influenced by the presence or absence of water (NPS-WRD 2011).

An interdisciplinary team of experts from NPS' Water Resources Division conducted a qualitative riparian habitat assessment at the Historic Site along the Pawnee River (Martin and Wagner 2013), using "A User Guide to Assessing the Proper Functioning Condition and the Supporting Science for Lotic Areas" developed by Prichard et al. (1998). This assessment included three main indicators including hydrology, vegetation, and erosion/deposition. A total of 17 common attributes and processes (measures) within each of these three categories was assessed.

The Pawnee River was assessed as one study unit throughout the Historic Site, and based upon nearly all the measures, the riparian system was considered to be of significant concern.

Table 5.11.1-1. Summary of overall riparian habitat condition, indicators and measures, and rationale for assigning condition ratings at Fort Larned National Historic Site.

Riparian Habitat			
Indicators of Condition	Specific Measures	Condition Status/Trend	Rationale
Hydrology	5 measures		The channel/floodplain form is out of balance with the landscape setting.
Riparian Vegetation	7 measures		There is a complete lack of perennial wetland plants in the channel bottom or banks to resist erosion and stabilize soils. There is also a lack of healthy recruitment for riparian tree species.
Erosion/Deposition	5 measures		There is an absence of channel/floodplain formation at the new base level following past incision.

5.12. Grasslands Resource Brief and Narrative

5.12.1. Condition Rationale

For several of the measures of grassland condition at Fort Larned NHS, there was variability among sites, especially between the Main Unit and Ruts Unit. Overall grassland condition was generally good for the soil/site stability and hydrologic function measures throughout the Main Unit, while being of moderate concern within the Ruts Unit, primarily due to the soil disturbance caused by the prairie dogs. The condition of good to moderate concern represents a balance of this variability between the units (Table 5.12.2-1). Historic Site staff have been actively engaged in prairie restoration in an attempt to counter a long history of intensive use of grasslands surrounding the Fort, but very invasive exotic species, such as the bromes, have formed monotypic stands. As a result, many of the native prairie species have been displaced, resulting in a significant concern rating for the overall grassland condition at the Historic Site.

Table 5.12.2-1. Summary of overall grasslands condition, indicators and measures, and rationale for assigning condition ratings at Fort Larned National Historic Site.

Grasslands			
Indicators of Condition	Specific Measures	Condition Status/Trend	Rationale
Hydrology Soil/Site Stability and Hydrologic Function	Rills		None observed except at one site that was rated slight to moderate within the Ruts Unit.
	Water Flow Patterns		One site within the Ruts Unit showed flow pattern evidence.
	Pedestals and/or terracettes		None were observed.
	Bare ground		Both sites within the Ruts Unit had bare ground due to prairie dog activity.
	Gullies		None were observed.
	Wind-scoured, blowout and/or depositional areas		One site within the Ruts Unit showed evidence of this measure.
	Litter Movement		One site within the Ruts Unit showed evidence of this measure.
	Soil surface resistance to erosion		Both sites within the Ruts Unit had soil erosion due to prairie dog activity.

Table 5.12.2-1. Summary of overall grasslands condition, indicators and measures, and rationale for assigning condition ratings at Fort Larned National Historic Site. (continued)

Grasslands			
Indicators of Condition	Specific Measures	Condition Status/Trend	Rationale
Hydrology Soil/Site Stability and Hydrologic Function (continued)	Soil surface loss or degradation		Both sites within the Ruts Unit had soil loss due to prairie dog activity.
	Compaction layer		Both sites within the Ruts Unit exhibited soil compaction.
Biotic Integrity	Landscape-scale Diversity		There remains some correspondence among the ecological sites, soils, and vegetation, although the landscape scale diversity is being lost, primarily as a result of exotic species creating widespread monocultures.
	Local Species Composition		There is significant concern from an ecological standpoint regarding local species composition. As previously indicated, a substantial loss of plant species diversity has resulted from monocultures of exotic plants, particularly bromes.
	General Life Cycles Relative to Disturbance		We considered the grasslands at Fort Larned NHS to be in relatively good condition with respect to the proportional plant life cycles, with a notable exception of the Ruts Unit, which was of significant concern with respect to this indicator.
	Relative Proportion of Functional Groups		In the Main Unit, there was a noticeable absence of forbs, particularly in the loamy terrace ecological sites. This is of some concern, although it may be in part due to a lack of seeding forbs during restoration efforts. Probably of greater concern is dominance by exotic forbs in the Ruts Unit, which is the Loamy Upland site. Overall, we rated this measure as moderate.
	Relative Proportion of C3 and C4 species		Based on both the rapid assessment and the grassland monitoring data, there was generally a mix of C3 and C4 grasses, although Stubbendieck et al. (2011) reported a shift from warm season (C4) to cool-season introduced species at Fort Larned NHS since 1980. Overall we consider this measure to be of moderate concern.

Grassland at Fort Larned National Historic Site.

5.13. Exotic Plants Resource Brief and Narrative

5.13.1. Condition Rationale

Globalization of commerce, transportation, human migration, and recreation in recent history has introduced invasive exotic species to new areas at an unprecedented rate. Approximately 4-19% of species introduced into the United States may become invasive (USFWS 2012). Nonnative species can have profound impacts to native plant communities, and currently at Fort Larned NHS, 59 exotic plant species are found. Many are very difficult to manage once established, and a few notable exotic plants are known for their ability to dramatically alter primary plant communities to the point where they no longer maintain their attributes or processes, including cheatgrass and smooth brome. Several species like Kochia and field bindweed are widespread along both the high priority plots and park-wide. Smooth brome and cheatgrass are rapidly forming monocultures throughout the Historic Site's grasslands, warranting significant concern.

Table 5.13.1-1. Summary of overall exotic plants condition, indicators and measures, and rationale for assigning condition ratings at Fort Larned National Historic Site.

Exotic Plants			
Indicators of Condition	Specific Measures	Condition Status/Trend	Rationale
Prevalence of Exotic Plant	Proportion of High Priority Plots and Park-wide Points Infested		Two exotic species, *Bromus inermis* and *Convolvulus arvensis*, were found in greater than 60% of the park-wide sampling points in 2013. In addition *Bromus inermis*, *Convolvulus arvensis*, and *Kochia scoparia* were found in over 50% of the SOPN high priority plots. Three of these species are considered to be of highest concern, and one of high concern. One of the most ecologically impacting plants, *Bromus inermis* was found in three-quarters of the park-wide points, resulting in a significant concern.
	Density of Exotic		For the most part, most of the species warranting high, highest, or moderate concern occur in relatively low densities throughout the Historic Site, although *Bromus inermis* is forming a matrix resulting in a significant concern rating.
Ability to Damage Native Plant Communities	Ecological Impact		This measure is based on the premise that species with the largest negative impacts on native plant, animal, and other species populations, and ecosystems generally cause the most severe problems. Exotic species, particularly, the bromes are considered to be extremely damaging to native communities, and these same species are widely distributed throughout the Historic Site, therefore, we consider this measure to be of significant concern.
	Management Difficulty		Many of the exotic plant species found at the Historic Site are considered to be very difficult to manage, therefore, we consider this measure to be of significant concern.

5.14. Breeding Landbirds Resource Brief and Narrative

5.14.1. Noteworthy Highlights

A total of 69 bird species have been reported to occur at the Historic Site (see Appendix I), with 60 of the species observed during 2009-2012 RMBO surveys. Sixteen species (including two species observed in 2001 only) are considered species of conservation concern by one or more organization. Nine of these 16 species have high conservation potential at the Historic Site, because they are within their normal breeding ranges (or on the edge) and breeding habitat exists for them at the Historic Site. Additionally, seven of the nine species have been observed in all of the RMBO survey years (2009-2012) at the Historic Site, and the other two species were observed in most of the individual survey years.

Table 5.14.2-1. Summary of overall landbirds condition, indicators and measures, and rationale for assigning condition ratings at Fort Larned National Historic Site.

Breeding Landbirds			
Indicators of Condition	Specific Measures	Condition Status/Trend	Rationale
Species Occurrence	Temporal Context		Eighty-four percent of 57 species observed in the 2001 bird inventory were observed in 2009-2012 RMBO bird surveys at the Historic Site. Only one of the nine species not observed in 2009-2012 is within its normal breeding range and has characteristic breeding habitat at the Historic Site; it is believed that this species occurs at the Historic Site but has gone undetected due to its dense, daytime resting habitat (it is a nocturnal owl species). Additionally, 12 species were observed in the 2009-2012 RMBO surveys that were not observed in 2001. In a temporal context, the condition of breeding landbirds at the Historic Site is good. Data are available only for a relatively small number of years, so no trend information is available at this time.
	Spatial Context		In a comparison of Breeding Bird Surveys (BBSs) in the vicinity of the Historic Site to RMBO surveys within the Historic Site, there were 27 species that were not observed at the Historic Site from 2009-2012. However, the majority of the species are outside of their normal breeding ranges or fall within the "limited to none" breeding habitat class at the Historic Site; only one (the owl species discussed above) is thought to have existing breeding habitat at the Historic Site. Based on this comparison, the condition of breeding landbirds is good. Because data are available only for a relatively small number of years, no trend information is available at this time.
	Conservation Context		There are 16 species that have been observed during 2009-2012 and/or 2001 surveys that are listed by one or more organization as being of conservation concern. We believe that nine of these species have high conservation potential at the Historic Site. These are species that are within their normal breeding ranges and sufficient habitat exists at the Historic Site to support breeding. All of these species have been observed on recent RMBO surveys, and all but two of the species were observed during all four years of the surveys. Therefore, we consider the condition of species of conservation concern at the NHS to be good. We do not have sufficient data to justify a trend in the condition at this time.

5.14.2. Condition Rationale

USFWS, DAVE MENKE

The Red-headed woodpecker (*Melanerpes erythrocephalus*) has high conservation potential at the Historic Site.

The condition of breeding landbirds at the Historic Site, assessed using one indicator, species occurrence (presence/absence), is good (Table 5.14.2-1). We evaluated species occurrence using three measures/in three contexts (temporal, spatial, and conservation), all of which were determined to be in good condition. The temporal species occurrence comparison found that, of 57 bird species detected at the Historic Site in 2001, 48 were detected in recent surveys. Nine were not detected in recent surveys. However, only one of the nine species is within its normal breeding range and has breeding habitat at the Historic Site; it is believed that this species occurs at the Historic Site but has gone undetected due to its dense, daytime resting habitat (it is a nocturnal owl species). Also, 12 additional species were observed only on recent RMBO surveys. The spatial comparison found that 27 species were observed during nearby Breeding Bird Surveys but not at the Historic Site during RMBO surveys. However, the majority of the species are outside of their normal breeding ranges or fall within the "limited to none" breeding habitat class at the Historic Site; only one (the owl species discussed above) is thought to have existing breeding habitat at the Historic Site. Sixteen species that have been reported to occur at the Historic Site are listed by one or more organization as being of conservation concern. Of these, nine species are considered to have high conservation potential; these are species that are within their normal breeding ranges, and sufficient habitat exists at the Historic Site to support their breeding. All of these nine species have been observed during recent RMBO surveys, and all but two of the species were observed during all four years of the surveys. Overall, the condition of breeding landbirds at the Historic Site is good. Adequate information does not exist at this time to evaluate trends in the condition.

5.15. Prairie Dog Resource Brief and Narrative

5.15.1. Noteworthy Highlights

A prairie dog colony has been present at the Historic Site (at the Ruts Unit) at least since the site was established in 1966. This prairie dog colony represents one of the few colonies on NPS land where the sylvatic plague appears not to be a threat. Prairie dogs have caused damage to the historic Santa Fe Trail ruts through their burrowing activities.

5.15.2. Condition Rationale

Prairie dogs have inhabited the Trail Ruts Unit at least since the Historic Site was established in 1966, and in 2004, Delisle and Busby (2004) reported that prairie dogs were abundant at the Ruts Unit. Prairie dogs are an important component of the ecosystems they inhabit. They directly and indirectly influence grasslands through their grazing and burrowing and as prey (Kotliar et al. 2006). They affect the redistribution of minerals and nutrients, encourage penetration and retention of moisture, and affect plant species composition (Kotliar et al. 2006). Prairie dog burrows and colony-sites provide shelter and nesting habitat for a variety of animals, and many animals prey on prairie dogs. From this ecological standpoint, having a thriving population of prairie dogs would be viewed positively. However, we also acknowledge that prairie dogs may cause difficulties to management in a national park. They may damage important cultural resources due to their burrowing activities, as well as cause other issues. It is from this dual reference perspective that we assessed the condition of prairie dogs at the Historic Site. We used one indicator, prairie dog occurrence, with one measure, density, to assess condition. Density of prairie dogs per unit area was estimated in three years from 2009-2011 using visual counts (and mark-resight/mark-recapture). Comparing the July/August estimates using visual counts, the prairie dog density appears to have varied substantially (43 per hectare [17.4 per acre] in 2009, 28 per hectare [11.3 per acre] in 2010, and 99 per hectare [40.1 per acre] in 2011). However, a comparison of the July/August estimates using mark-resight methods for 2010 and 2011 (none available for 2009) indicates that there was no increase from 2010 to 2011 (i.e., 55 per hectare [22.2 per acre] in 2010 and 56 per hectare [22.7 per acre] in 2011). Although it is unclear whether or how much the densities have actually varied over the three years,

Table 5.15.2-1. Summary of overall landbirds condition, indicators and measures, and rationale for assigning condition ratings at Fort Larned National Historic Site.

Prairie Dog			
Indicators of Condition	Specific Measures	Condition Status/Trend	Rationale
Prairie Dog Occurrence	Density		Density of prairie dogs per unit area was estimated in three years from 2009-2011. In a comparison of the July/August estimates using visual counts, the prairie dog density appears to have varied substantially (43 per hectare [17.4 per acre] in 2009, 28 per hectare [11.3 per acre] in 2010, and 99 per hectare [40.1 per acre] in 2011). However, a comparison of the July/August estimates using mark-resight methods for 2010 and 2011 (none available for 2009) indicates that there was no increase from 2010 to 2011 (i.e., 55 per hectare [22.2 per acre] in 2010 and 56 per hectare [22.7 per acre] in 2011). Although it is unclear whether or how much the densities have varied over the three years, overall the numbers are comparable to those reported for prairie dogs in other areas. If the prairie dog reference condition was based solely from an ecological perspective, we would consider the condition of prairie dogs to be good. However, our reference condition includes the damage that prairie dog burrowing activities can cause to cultural resources such as the Santa Fe Trail ruts. Therefore, we consider the overall condition to be one of moderate concern.

overall the numbers are comparable to those reported by Hoogland (2006) for prairie dogs in other areas. If we were judging the condition only on the ecological merits of prairie dogs, the current condition would be good. However, taking into account the potential for prairie dogs to damage the historic Santa Fe Trail ruts, the primary historic resource at the Ruts Unit and part of the significance of the Historic Site, the overall condition is one of moderate concern. The trend is uncertain at this time.

PHOTO: RON SINGER

Black-tailed Prairie Dog (*Cynomys ludovicianus*) is named for its characteristic, black-tipped tail.

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Appendix A: Team Members and Subject Matter Experts

Table A.1. Fort Larned National Historic Site NRCA Project Team Members

Fort Larned NHS NRCA Project Team
Jeff Albright, NPS Water Resources Division's Coordinator of the NRCA Series
Rob Bennetts, NPS Southern Plains Inventory and Monitoring Network Program Manager
Nina Chambers, Northern Rockies Conservation Cooperative, Writer/Editor
George Elmore, NPS Fort Larned NHS, Chief Ranger
Tomye Folts-Zettner, NPS Southern Plains Inventory and Monitoring Network Biologist
Kevin McMurry, NPS, Fort Larned NHS, Superintendent
Heidi Sosinski, NPS Southern Plains Inventory and Monitoring Network Data Manager
Kim Struthers, Utah State University, Writer/Editor
Carmen Thomson, NPS Midwest Region Inventory and Monitoring Network Program Manager/NRCA Coordinator
Patty Valentine-Darby, University of West Florida, Biologist and Writer/Editor

Table A.2. Fort Larned NHS NRCA Subject Matter Experts

Subject Matter Expert	Topic	Project Deliverables
Jeff Albright, National Park Service Water Resources Division, Natural Resource Condition Assessment Series Coordinator	All	Program Level Review
Mark Brunson, Professor & Department Head, Environment and Society; Utah State University	Viewshed	Reviewed viewshed and soundscape sections
Chad Moore, National Park Service Natural Sounds and Night Skies Division Night Sky Program Manager	Night Sky	NPS guidance on night sky monitoring and reviewed of night sky section
Emma Lynch National Park Service Natural Sounds and Night Skies Division Acoustical Research Specialist	Soundscape	Reviewed soundscape section
Ellen Porter, National Park Service Air Resources Division	Air Quality	Reviewed air quality section
Bruce Heise, National Park Service Geologic Resources Division Geologist	Geology	Reviewed geology section
Katie KellerLynn, Colorado State University, Research Associate	Geology	Reviewed geology section
Evan Gwilliam, National Park Service Sonoran Desert Network Ecologist	Surface Water	Wrote annual water quality reports and reviewed surface water section.
Pete Biggam, National Park Service Geologic Resources Division Soil Scientist	Soils	Provided NPS guidance on soils, site visit to conduct soils rapid assessment June 2013
Michael Martin, National Park Service Water Resources Division Hydrologist	Groundwater and Riparian Wetlands	Wrote groundwater section and provided expert opinion and report on riparian wetland assessment during June 2013 field visit
Joel Wagner, National Park Service Water Resources Division, Wetlands Program Leader	Riparian Wetlands	Provided expert opinion and report on riparian wetlands during June 2013 field visit
Tim Seastedt, University of Colorado, Department of Ecology and Evolutionary Biology Professor	Grasslands	Provided grasslands expert opinion during June 2013 field visit

Table A.2. Fort Larned NHS NRCA Subject Matter Experts (cont.)

Subject Matter Expert	Topic	Project Deliverables
Jonathin Horsley, National Park Service Chihuahuan Desert I&M Network and Southern Plains I&M Network Exotic/Invasive Plant Monitoring Crew Leader	Exotic Plants	Provided exotic plants section review
Ross Lock Rocky Mountain Bird Observatory Wildlife Biologist	Landbirds	Provided expert opinion on landbird table information
Authors Who Served as Subject Matter Experts	**Topic**	**Project Deliverables**
Tomye Folts-Zettner National Park Service Southern Plains Inventory and Monitoring Network Biologist/ Botanist	All	Provided expert opinion and assistance on grasslands and exotic plants and reviewed all sections
Heidi Sosinski, National Park Service Southern Plains Inventory and Monitoring Network Data Manager	All	Viewshed analyses, maps, graphs, and remaining graphics

Appendix B: Viewshed Analysis Steps

The process Heidi Sosinski used to complete the Fort Larned NHS's viewshed analyses is listed below.

Downloaded 1/3 arc second national elevation dataset (NED) grid (roughly equivalent to a 30 m digital elevation model [DEM]) from The National Map Seamless Server (http://seamless.usgs.gov/). The x and y values for the NED are in arc seconds while the z data are in meters. Projected NED into NAD83 UTM 13 to get all data in meters.

Adjustments were made to the elevation grid to compensate for areas obcured due to large areas of tree cover. Tree groves were on-screen digitized from basemap aerial imagery provided by ESRI. A height value of 30 meters was assigned to each record of the attribute table. This value represents an average height of trees in the area. A height value of 0 was set to the remaining analysis area. Using the conversion tool in ArcGIS 10.1, the polygon shapfile was converted to raster format with the cell value set to the height attribute. The tree value raster was added to the NED using the Weighted Sum tool in Spatial Analyst Toolbox, with the weighted value of each input set to 1. The resulting raster was used in the following viewshed analysis.

Downloaded Fort Larned National Historic Site boundary, roads, and trails layers from NPS Integrated Resource Management Applications (IRMA) portal (https://irma.nps.gov).

Prepared Observation Point layers for Viewshed Analyses.

Created point layers for bastion towers at the fort.

Used Edit > Create New Feature tool to create 2 observation points (Vantage Point 1 and Vantage Point 2). Saved file as obs_point.shp

Added field named "OFFSETA" (type = double) to shapefile and set value to 1.68 for both records in the attribute table. The value in the field "OFFSETA" represents an observer height of 1.68m (~5'6").

Ran Viewshed Analysis using ESRI Spatial Analyst Viewshed Tool.

Using the Viewshed Tool in ESRI's ArcGIS 10, Spatial Analyst Toolbox, ran viewsheds using the following inputs.

- Input raster = 1/3 arc second NED modified to include area tree cover.
- Input point observer feature = obs_point.shp.

Appendix C: Bortle Dark-Sky Scale

Key for the Summer Sky— Latitudes 30° to 50° N

The Milky Way is not visible and sky glow extends above 35 degrees. Little to no dark adaptation is possible. Ground texture is easily seen, and artificial light dominates the landscape. Visible constellations are limited to the very brightest if any. The sky has a uniform washed out appearance.[1]

If this describes your nighttime environment, continue below

If the nighttime environment appears darker than this description, jump to the next section

Sky appears nearly completely washed out, and is luminous. Dark adaptation is not possible, ground is brightly illuminated and fewer than 200 stars are visible. Only the most major constellations are identifiable. For instance, the entire keystone of Hercules or the five stars of Delphinus are not completely visible.

this is accurate **Bortle Class 9** if darker—proceed below

Constellations are visible but may be missing key stars, sky background has a uniform washed out glow with light domes reaching 60 degrees above the horizon. Stars such as the tip of Sagitta or epsilon Lyrae are not visible. If clouds are present they are brilliantly lit.

this is accurate **Bortle Class 8** if darker—proceed below

Brighter constellations are easily seen in full, yet sky background has greyish or yellow background. Milky Way may be just barely seen near the zenith. The Scutum and Cygnus star clouds are not visible.If clouds are present they are brilliantly lit. Ground texture is still visible.

this is accurate **Bortle Class 7**

The Milky Way is visible but discontinuous, and lost to light domes near the horizon. Fine details and structure are not easily visible, if at all. Ground texture is still visible, and shadows are cast from light pollution. Light domes are clearly visible along the horizon and appear brighter than any portion of the visible Milky Way.[2]

If this describes your nighttime environment, continue below

If the nighttime environment appears darker than this description, jump to the next section

The Milky Way is just visible overhead, but is not continuous and is diminished to obvious skyglow. Cygnus ,Scutum, and Sagittarius star fields just visible. If clouds present they are illuminated and reflecting light. Ground texture is seen with difficulty.

this is accurate **Bortle Class 6** if darker—proceed below

Milky Way is faintly present, but may have occasional gaps and is lost to skyglow near the horizon. Great rift in Cygnus is just visible. Any clouds present are brighter than the background sky and reflect light back. Zodiacal light may be glimpsed, but is difficult to see amidst the light pollution. Ground texture is not visible but forms are easily seen.

this is accurate **Bortle Class 5** if darker—proceed below

Milky Way is evident from horizon to horizon, but fine details are lost. Clouds are just brighter than background sky, but appear dark at zenith. Light domes are much brighter than brightest part of Milky Way and extend to up to 15 degrees above the horizon. Zodiacal light is evident in west after sunset or in east before dawn. Deep sky objects such as the M13 globular cluster and Northern Coal Sac are visible.

this is accurate **Bortle Class 4**

The Milky Way has a defined outline with visible structure and detail. Very few light domes are visible just along the horizon and do not cast shadows. You may see color in the Zodical light when compared to bluish-white color of the Milky Way. Scattered clouds appear dark against the night sky except those clouds just above light domes.[3]

If this describes your nighttime environment, continue below

Milky Way appears complex with visible outline, however some light pollution is still evident along the horizon. Light domes only slightly brighter than brightest part of the Milky Way. Zodiacal light easily seen, but band and gegenschein difficult or absent. Many summer globular clusters and emission nebulae are visible with the naked eye despite distracting light domes along the horizon. Venus casts an obvious shadow.

this is accurate **Bortle Class 3** if darker—proceed below

Very few light domes are visible; with none extending above 5 degrees and fainter than the Milky Way. Airglow is often visible, and character in its brightness may be seen. Ground is mostly dark. The Zodiacal band (away from the Milky Way and at least 45 degrees above the horizon) and gegenschein are visible. The rift in the Cygnus star cloud is visible. The Prancing Horse in Sagittarius and Fingers of Ophiuchus dark nebulae are visible, extending to Antares. Jupiter and Milky Way cast barely visible shadows.

this is accurate **Bortle Class 2** if darker—proceed below

The Milky Way is intricate, marbled, and veined with Sagittarius region of the Milky Way casting obvious shadows. Milky Way appears 40 degrees wide in some parts with a convoluted outline. The horizon completely free of light domes, though some distant light domes may be visible from mountain tops. Transparency and seeing are excellent (among the best of the year) with very low airglow. Many objects such as M81 or the Helix nebula are visible with the naked eye. Zodical light is striking as a complete band. Any clouds are very difficult to see.

this is accurate **Bortle Class 1**

The Bortle Dark-Sky Scale is a qualitative scale developed by John Bortle and published in Sky & Telescope Magaine in 2001. It provides a useful complement to quantitative measures. The National Park Service is testing this dichotomous key for use by professional and citizen scientists. Some knowledge of the night sky and visual observational techniques are required to properly implement this assessment.

note 1) At least 5 minutes of dark adaptation is required to properly differentiate Class 7,8 & 9 skies.

note 2) At least 10 minutes of dark adaptation is required to properly differentiate Class 4, 5 & 6 skies.

note 3) 20 to 120 minutes of dark adaptation is required to properly differentiate Class 1, 2 & 3 skies.

Developed by Jeremy White, Dan Duriscoe, and Chad Moore of the NPS Natural Sounds & Night Skies Division, www.nature.nps.gov/night

August 2, 2012

Appendix D: Listening Session Reports and NSNSD Sound Model Maps

D.1. Fort Parade Ground - June 6, 2013

Soundscape Audibility Report

No description entered.

Sessions: Duration as seconds: 3,600 Duration as minutes: 60.00 AudRpt ID: 72

Session ID:	9097606	Date:	6/6/2013	Name:	Struthers, Kimberly		
Site:	002	Start Time:	9:03 AM	Address:			
SubSite ID:	Endt Time:	10:03 AM		Phone:		Wind:	
Park:	FOLS	Time Group:	0	Palm ID:	PN70UCM7V2	Weather:	
Comments:							

Sound Source Audibility (PA: Percentage of period audible, Events reported as seconds)

Sound ID	Sound Source Description	PA	Max Event	Mean Event	Min Event	SD Event	Count
1.1	Jet	3.0	57	49	41	11	2
2	Vehicle	100.0	2,668	1,799	930	1,229	2
7	Grounds Care	68.0	436	81	2	102	30
8.1	People, Voices	17.0	625	625	625	1	
8.11	Interpretive Talk	63.0	476	53	1	108	43
8.2	People, Walking	2.0	69	44	18	36	2
20	Non-natural Unknown	2.0	35	12	1	13	6
25	Bird	100.0	3,596	3,596	3,596	1	
28	Insect	1.0	8	3	1	2	12
G0100	All Aircraft	2.7					
G0200	All Road Vehicles	99.9					
G2000	All Non-natural Sources	99.9					
G4000	All Natural Sources	99.9					
NFI	Noise Free Interval	0.1	2	2	2	1	

D.2. Nature Trail - June 6, 2013

Soundscape Audibility Report

No description entered.

Sessions:	Duration as seconds:		1,800	Duration as minutes:	30.00	AudRpt ID:	71
Session ID:	9097605	Date:	6/6/2013	Name:	Struthers, Kimberly		
Site:	001	Start Time:	8:01 AM	Address:			
SubSite ID:	trail #5	Endt Time:	8:31 AM	Phone:	Wind: <5		
Park:	FOLS	Time Group:	0	Palm ID:	PN70UCM7V2	Weather:	Sunny
Comments:	half hour only						

Sound Source Audibility (PA: Percentage of period audible, Events reported as seconds)

Sound ID	Sound Source Description	PA	Max Event	Mean Event	Min Event	SD Event	Count
1.1	Jet	4.0	76	76	76	1	
2	Vehicle	97.0	1,157	438	163	480	4
7	Grounds Care	83.0	1,044	149	3	318	10
9	Domestic Animal	0.0	4	4	4	1	
25	Bird	99.0	1,785	1,785	1,785	1	
28	Insect	50.0	611	150	33	227	6
29	Animal (Natural)	1.0	17	6	1	7	4
40	Natural Unknown	0.0	2	2	1	1	2
G0100	All Aircraft	4.2					
G0200	All Road Vehicles	97.4					
G2000	All Non-natural Sources	99.2					
G4000	All Natural Sources	99.2					
NFI	Noise Free Interval	0.8	13	7	1	8	2

D.3. NSNSD Sound Models Maps

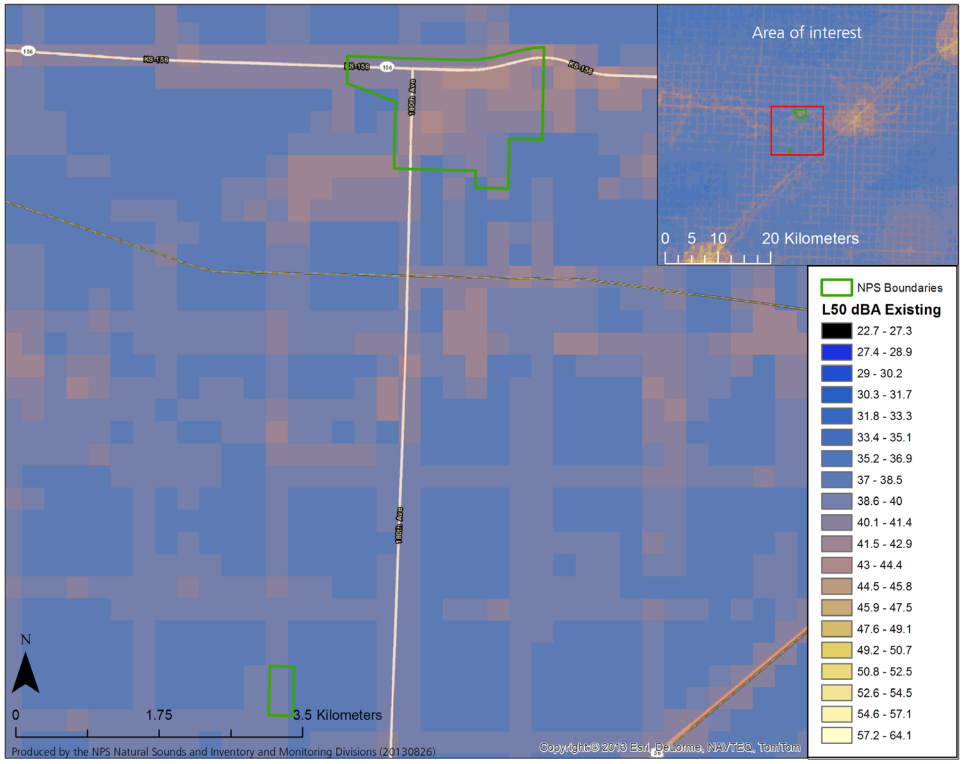

Figure D-1. Existing CONUS soundscape model zoomed to Fort Larned NHS.

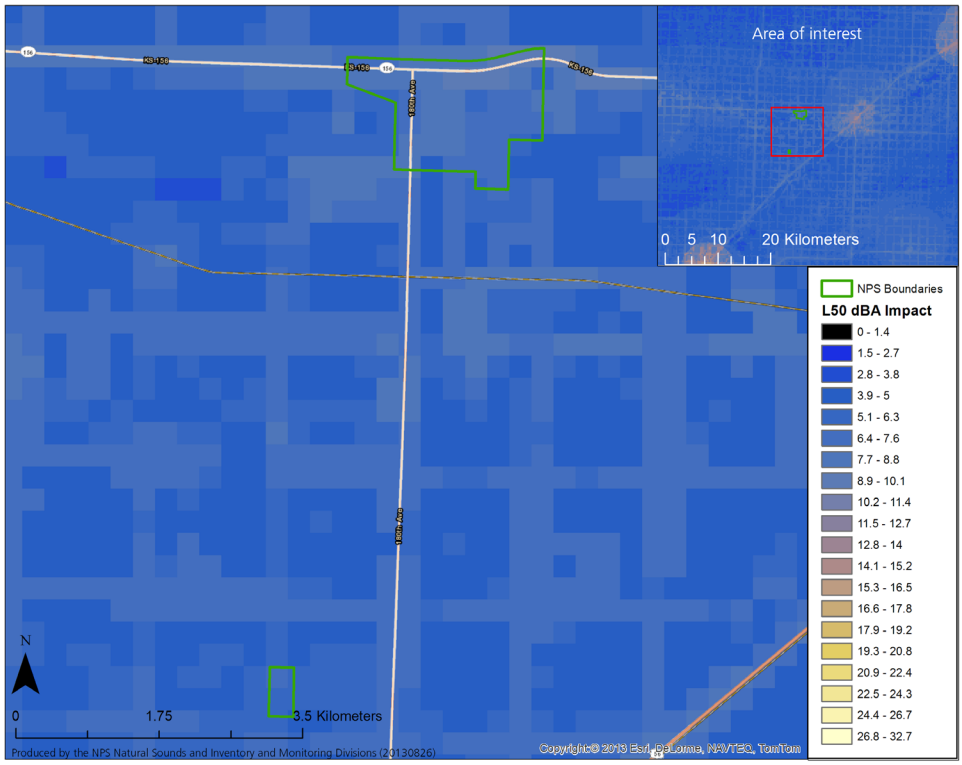

Figure D-2. Impact between existing and natural CONUS soundscape models zoomed to Fort Larned NHS.

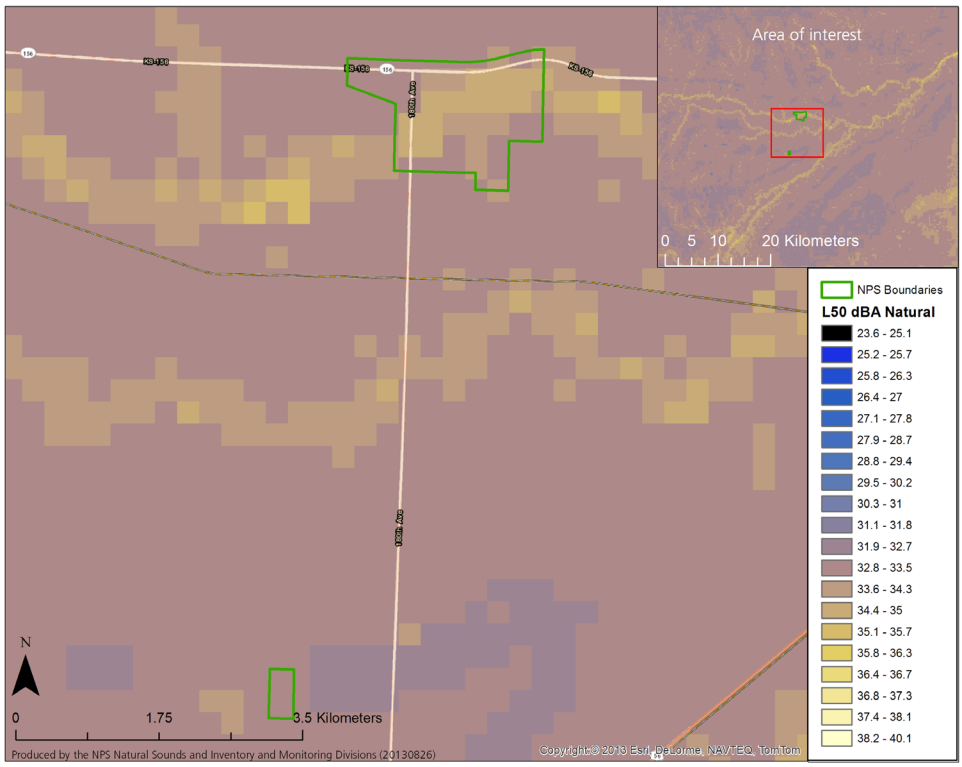

Figure D-3. Natural CONUS soundscape model zoomed to Fort Larned NHS.

Appendix E: Grassland and Soil Assessment Notes - June 5, 2013

The assessment was performed by Tim Seastedt and Pete Biggam.

Site #1

Mark #6 - Tomye I marked this site either 2 or 3 times with the gps

Species Composition Landscape-scale Diversity: Historic or climax plant assemblage is a mixed grass prairie that includes Big bluestem (*Andropogon gerardii)*, little bluestem (*Schizachyrium scoparium)*, and sideoats grama (*Bouteloua curtipendula)*. Clay Terrace Ecological Site

Species Composition Local-scale: 30 year reseeding program was implemented (check this in Stubbendieck's reports). Some serious plant litter (a mat of litter), no bare soil anywhere; this is not healthy for a C4 grassland. Not much western wheatgrass or buffalograss present. No sideoats grama was present. Big bluestem, Indian grass, and switchgrass was scattered throughout the site. Switchgrass is a #4 ranking for Kansas. Tallgrasses were more dominant than shortgrasses with a low diversity of forbs.

This site was highly disturbed with annual sunflowers, although native, are indicative of some sort of disturbance. Maybe a heavily cultivated field? Bindweed, yellow sweet clover, and a few monocultures of smooth brome present.

There is potential for tallgrass prairie restoration with some management effort. The farther east we walked within the site, more native species were present. Tim suggested fencing a couple of buffalo (introduce grazing) and intensive fire every year in late May for at least 10 years, and the tallgrass prairie would return, however, most forbs would be negatively affected by that activity

Further thoughts: Why didn't the 30-yr restoration effort work (or, is only half-done)? The restoration needs annual hands-on attention, and this probably has not been possible to date. One would need 'a champion' to lead this activity. Using NPS protocols, a staffer would have to become a volunteer coordinator to guarantee the volunteer leader would have the opportunity to succeed. If that was possible, annual late spring (May) burning would definitely favor the warm season grasses and their expansion. Repeated annual burning for a number of years without grazing would generate the matrix of warm season tallgrass species. Grazers would then be brought in for late spring-early summer grazing at the same time native forbs and the shortgrass species known to have been present could be seeded or planted into the system. Such an activity, if given this level of attention, would likely be successful and would create an island of restored prairie for the site.

The soils are very fertile and rich. Site occurs within soil map unit 2365 - New Cambria silty clay loam, rarely flooded.These are deep, nearly level, moderately well drained, very slowly permeable soils on stream terraces. These soils are subject to rare flooding. These soils have a calcareous silty clay loam surface layer and a very firm silty clay subsoil.

This area receives 16-33" of precipitation/year.

Biggam comments: Due to the dense vegetation cover, the soil indicators at this site are all rated None-Slight.

Annual Species Response to Disturbance: The annual sunflowers are opportunists and indicative of some sort of heavy disturbance. These plants usually do not persist over multiple

years in the densities observed here. The smooth brome was setting seed. The yellow sweet clover is a nitrogen fixer and was widely dispersed.

Relative Proportion of Functional Groups: Very low presence of forbs and virtually no shrubs, which aren't expected anyway. A few plants of lead plant, bee blossom, aster, and cumin (rag??). Mainly tallgrasses present when nonnatives are not found.

Relative proportion of C3:C4 species: 60/40 annual:perennial or 50:50 at best.

Site #2 (waste site with terraces)

Mark #8/9- 38 degrees 10.628' and 099 degrees 12.805'

Species Composition Landscape-scale Diversity: same as site #1

Species Composition Local-scale: This site was reseeded into a monoculture of western wheatgrass (*Agropyron smithii),* dispersed patches of little bluestem. Monocultures of smooth brome. Only one lead plant observed. Kochia quite prevalent.

Response to Annual Species Disturbance: Cheatgrass was common at field edges and kochia are present throughout the site (even more so as we continued walking towards oxbow). Jointed goatgrass was identified on the road, (which is a nitrogen fixer and making its way east) don't think that's correct. There is a linear disturbance (terraced) when looking at the aerial image but not evident on the ground. It looks like the site was possibly restored in strips. The soils are fine (2310 map unit).

Relative Proportion of Functional Groups: Site dominated by grasses, including invasive grass. The only shrub present was snowberry and only one lead plant was observed within the site.

C3:C4 Proportion: 50/50 (in hindsight, I would say 90:10)

Soils: Site occurs within soil map unit 2310 – Bridgeport silt loam, rarely flooded, and is correlated to the R073XY014KS – Loamy Terrace Ecological Site. These are deep, nearly level, well drained, moderately permeable soils on stream terrace. These soils are subject to rare flooding. They have a calcareous silt loam surface layer and a friable, calcareous silt loam subsoil.

Biggam comments: Due to the dense vegetation cover, the soil indicators at this site are all rated None-Slight.

Site #3 (behind cemetery)

Mark #9/10 (11)- 38 degrees 11.057' and 099 degrees 12.960'

Species Composition Landscape-scale Diversity: same as site #1

Species Composition Local-scale: This site was a lowland area with higher moisture retention and a pocket of native plants. Plants present included switchgrass, Indiangrass, Ambrosia, little bluestem, a small patch of western wheatgrass, and one native forb (did not know the species).

Response of Annual Species to Disturbance: Near 0% for the presence of annual species. Only 1 annual present: cheatgrass

Relative Proportion of Functional Groups: Grass dominated, including 3 non-native bromes: smooth, cheatgrass, Japanese.

C3:C4: Dominated by C3 species.

Soils: Site occurs within soil map unit 2310 – Bridgeport silt loam, rarely flooded, and is correlated to the R073XY014KS – Loamy Terrace Ecological Site. These are deep, nearly level, well drained, moderately permeable soils on stream terrace. These soils are subject to rare flooding. They have a calcareous silt loam surface layer and a friable, calcareous silt loam subsoil.

Biggam comments: Due to the dense vegetation cover, the soil indicators at this site are all rated None-Slight.

Site #4A (prairie dog town) north ridge

Mark #14

General comments on Ruts site as a whole: Bad shape for unplowed ground. Land form suggests that this was a drainage before the trail period and that the trail just followed the point of least resistance. Evidence of wide trailing likely to occur during wet periods to avoid mud. It is not known if previous landowner never plowed because it was a drainage or because of the trail ruts. There is no obvious water channel formation, possibly because prairie dog mounds can intercept runoff.

Landscape-scale diversity: Unique site in surrounding landscape.

Local-scale diversity: Diversity of grass and forbs, but most species are exotic.

Annuals response to disturbance: Great diversity of exotic annuals, mainly forbs, a few annual grasses.

Proportion of functional groups: Predominately forbs with minimal grass. A couple of species of mature cactus. No shrubs. Small grove of trees on west fenceline.

C3 vs. C4: C3 dominated except for small patch of native perennial C4 grasses on western fenceline.

Soils: Site occurs within soil map unit 2612 – Harney silt loam, 0 to 1 percent slopes, and is correlated to the R073XY015KS – Loamy Upland Ecological site. These soils are very deep, nearly level, well drained, moderately slowly permeable soils on uplands. These soils have a silt loam surface layer and a very firm silty clay loam and silty clay subsoil.

Biggam comments : Harney soil – silty clay loam. Low wind erodability, even on dog mounds. No rills, water flow or pedestals. Most bare ground from prairie dog and gopher disturbance. Bare areas are quickly colonized; areas of moderate size are mounds. Bare areas rarely connected, so condition is slight to moderate. No gullies, wind scour or deposition. Litter movement none to slight. Soil erosion and soil loss slight to moderate. Infiltration and compaction slight to moderate.

Site #4B (prairie dog town) south-facing slope

Mark #15

Overall vegetation more sparse, but everything basically the same as above.

Soils: Site occurs within soil map unit 2630 – Harney Uly complex, 3 to 6 percent sloipes, eroded, and is occurring on the Euly eroded component of the map unit, which is correlated to the R073XY015KS – Loamy Upland Ecological site. Euly soils The Euly soils have a silt loam surface layer and a friable, calcareous silt loam subsoil.

Biggam comments:Euly eroded phase. “A” horizon not intact, and has been lost thru water and wind erosion.. Some rilling from sheet flow. Water flow patterns becoming evident. No pedestals or terracettes. Litter movement moderate. Soil erosion moderate to extreme. Soil loss moderate. Plant community (or lack of it) has a major influence on the amount of bare ground present, which is much greater than expected for the site. Compaction is slight to moderate.

Some general thoughts from Seastadt:

This site cannot be managed in its historical condition. The Pawnee river is now only a storm channel and the traditional riparian zone is gone. The channel probably should remain tree-free to provide flood control, and the riparian forest can and should remain to provide substantial wildlife habitat. The fort can be viewed as an island surrounded by a sea of agricultural landscapes. Maintaining natural areas that once got their characteristics from their landscape-level linkages is problematic and would likely require non-traditional proactive management efforts. Recreating the dominants and common species associated with native upland landscapes is feasible (see above), but would demand a level of stakeholder activity above what’s currently available.

General Recommendations from Seastadt:

1. Brome fields...keep them there
2. Partially restored prairie.

   Something’s not right...no way you get monoculture patches of annual sunflowers in sites that have not been physically disturbed for decades. Tallgrasses (mostly switch plus Indian grass...big blue abundance is very modest) are present and would greatly benefit from late spring fires.

   To get it there will require
   a) Repeated annual burning, preferably in very late spring when brome can be harmed.
   b) After multiple burned years, infrequent grazing and forb introduction possible.

Requires a major effort and resource commitment unlikely to be available from federal sources, but this could be a long-term volunteer effort that would succeed provided the amount of NPS off-site staff required for fires could be minimized.

3. Wagon wheel site.
   While this was an upland site that might have had the tracks visible during a portion of the year, prairie dogs now allow year-around viewing of the trail legacy. This can be viewed as an ecological service provided by the prairie dogs. The vegetation, however, is almost totally nonnative and likely to remain so. However, if the goal is to preserve and show off the wagon trail, then maintain the current management (which includes carefully removing non-native thistles).

Appendix F: Maps of the Known Distribution of Exotic Plant Species At Fort Larned NHS

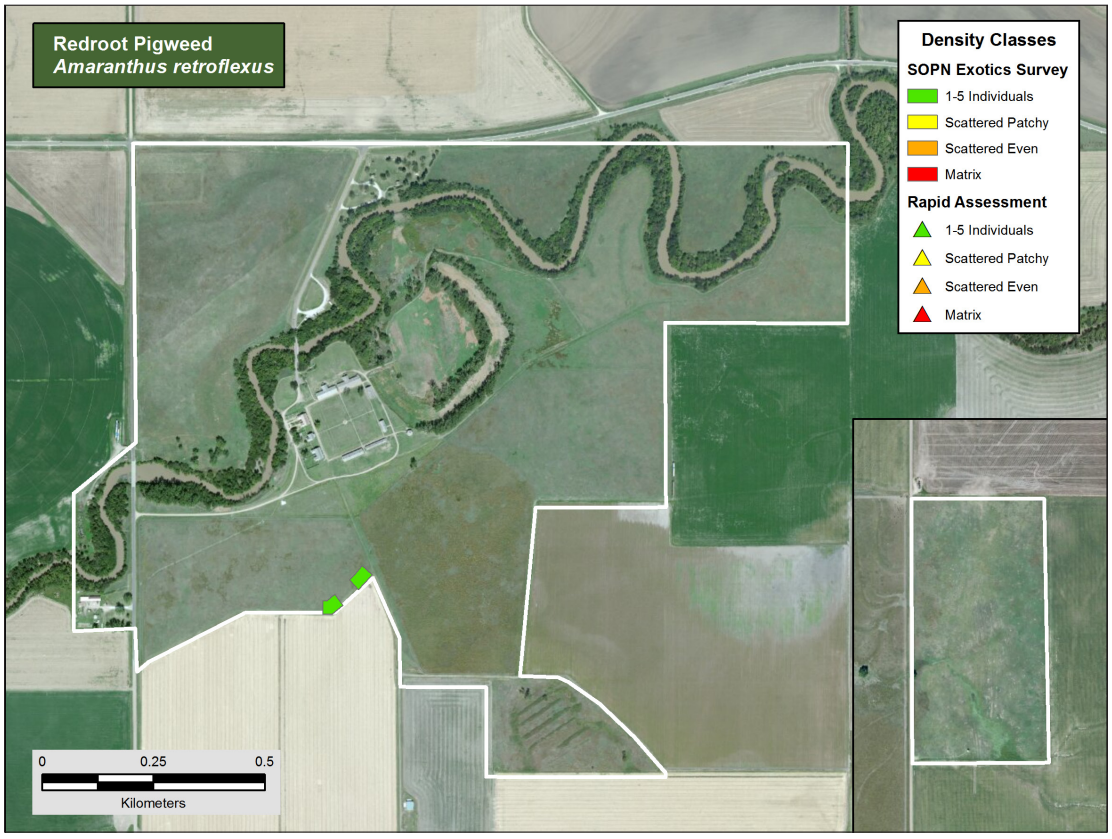

Figure F-1. Redroot Pigweed (*Amaranthus retroflexus*)

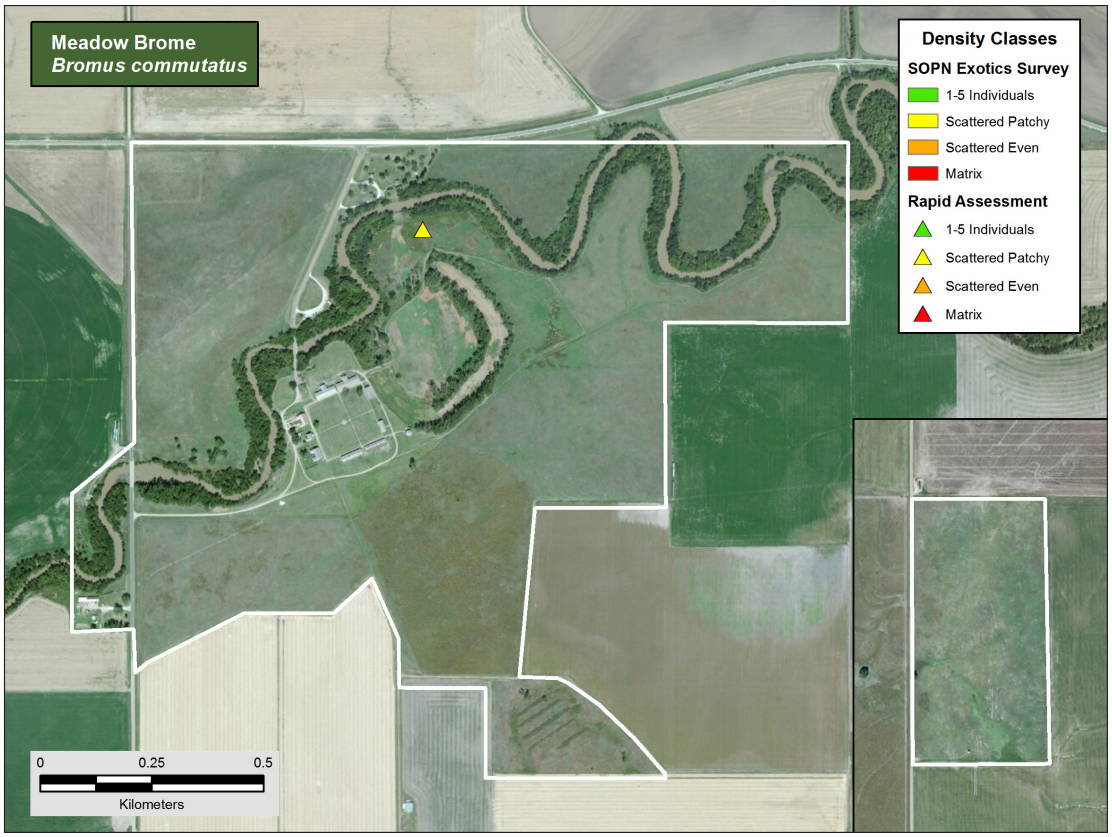

Figure F-2. Meadow Brome (*Bromus commutatus*)

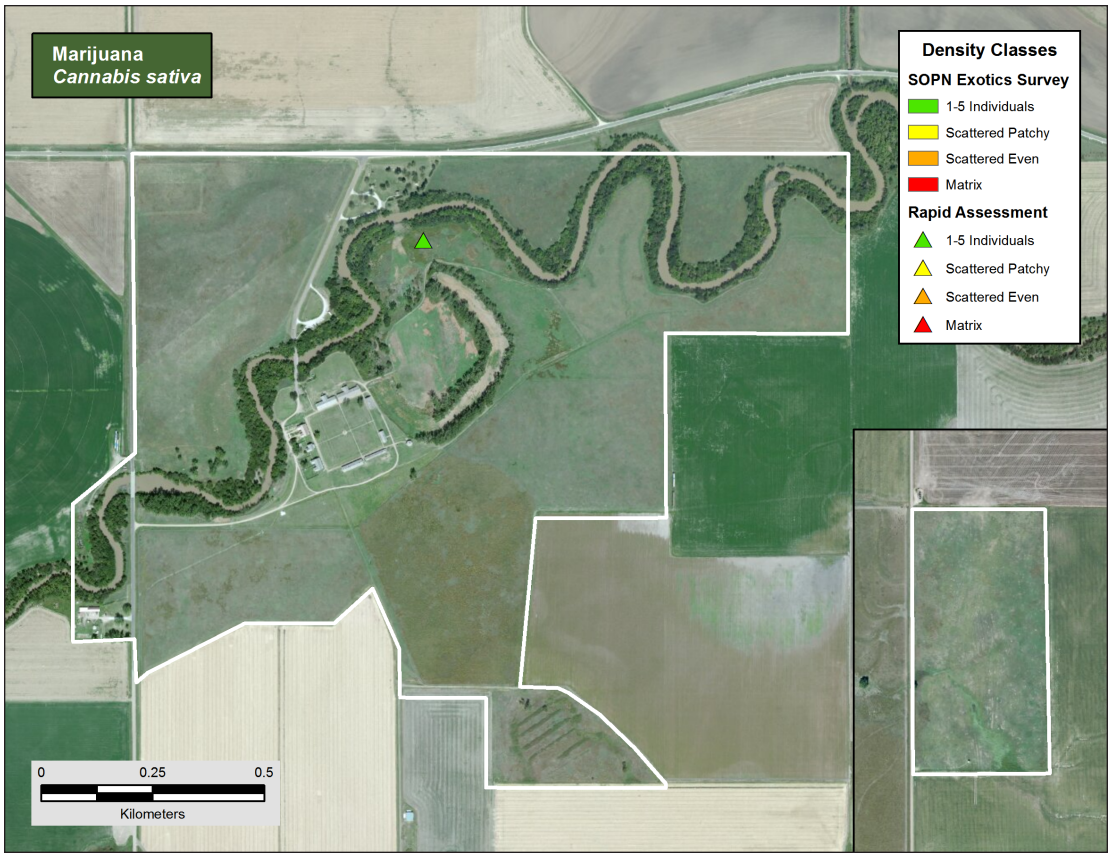

Figure F-3. Marijuana (*Cannabis sativa)*

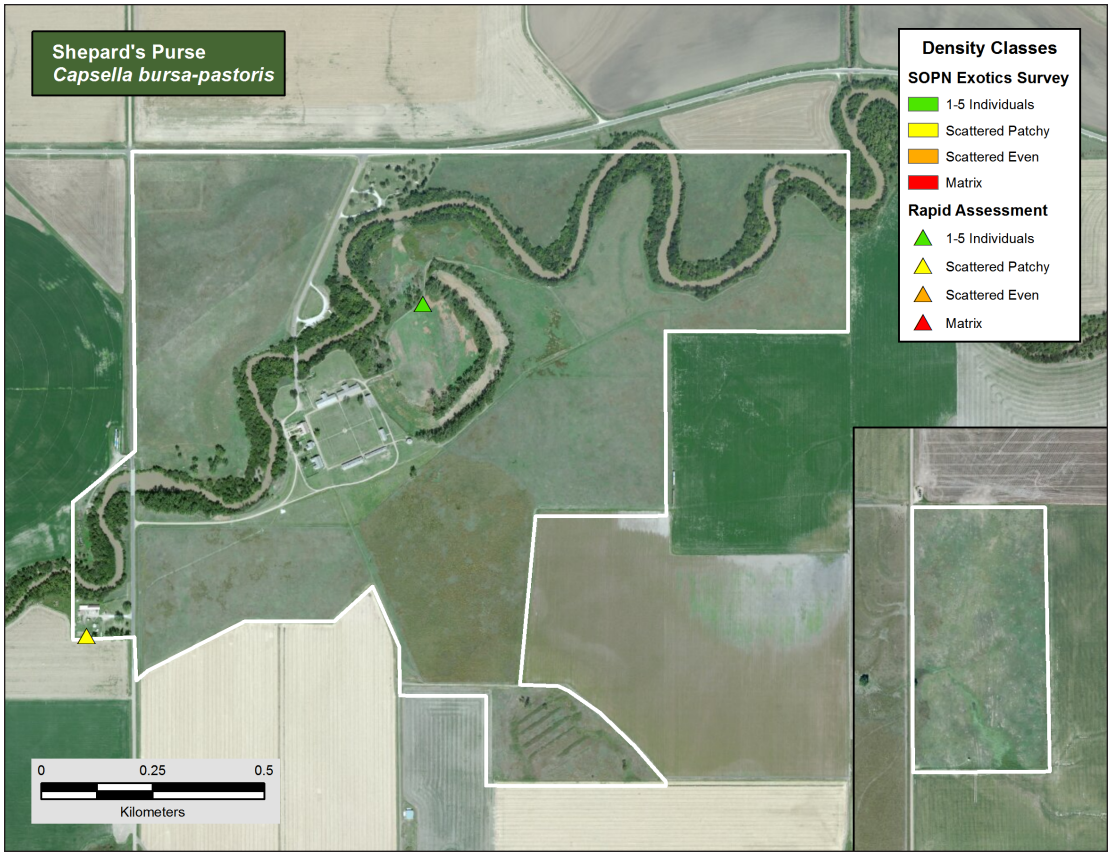

Figure F-4. Shepard's Purse (*Capsella bursa-pastoris)*

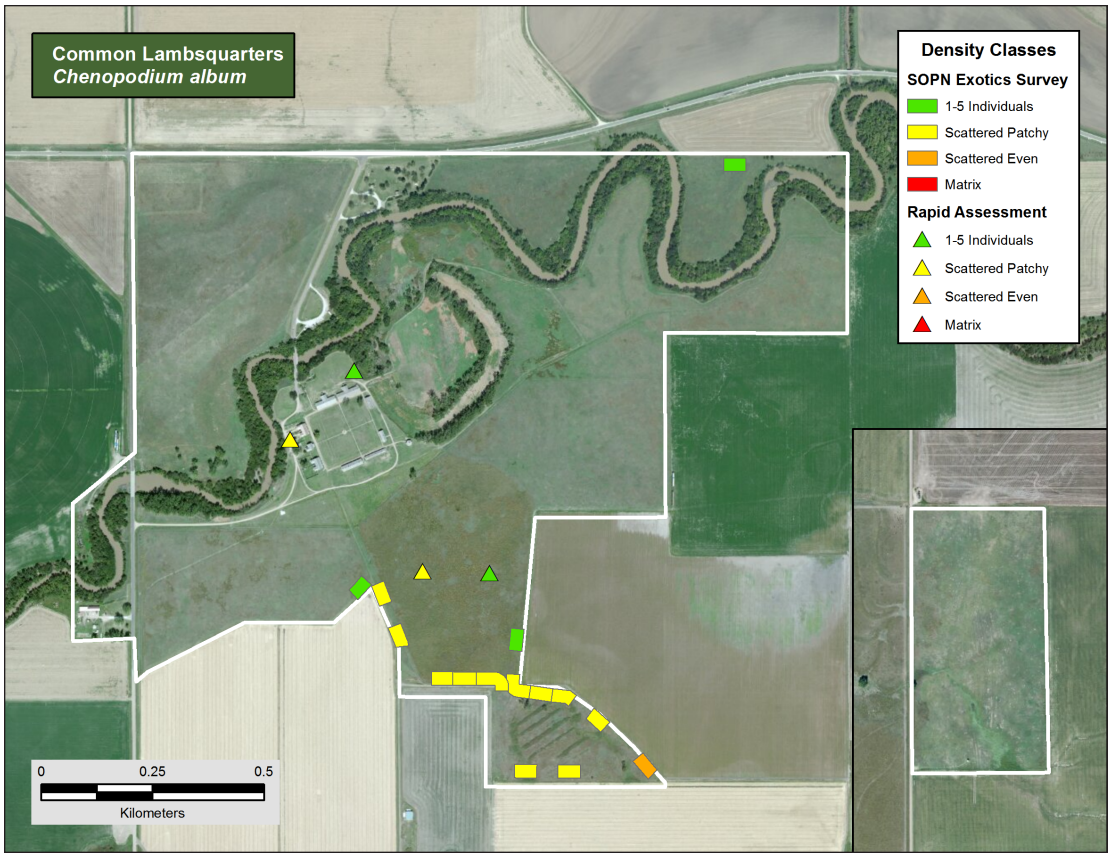

Figure F-5. Common lambsquarters (*Chenopodium album*)

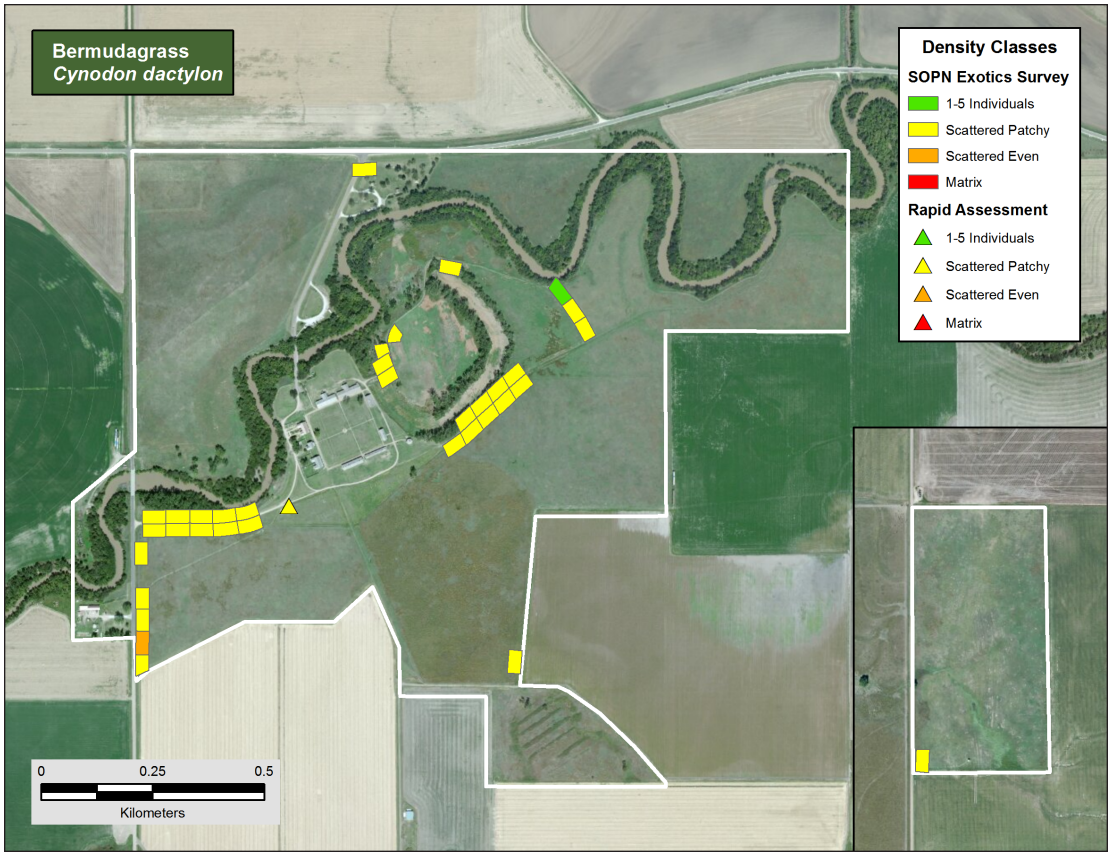

Figure F-6. Bermudagrass (*Cynodon dactylon*)

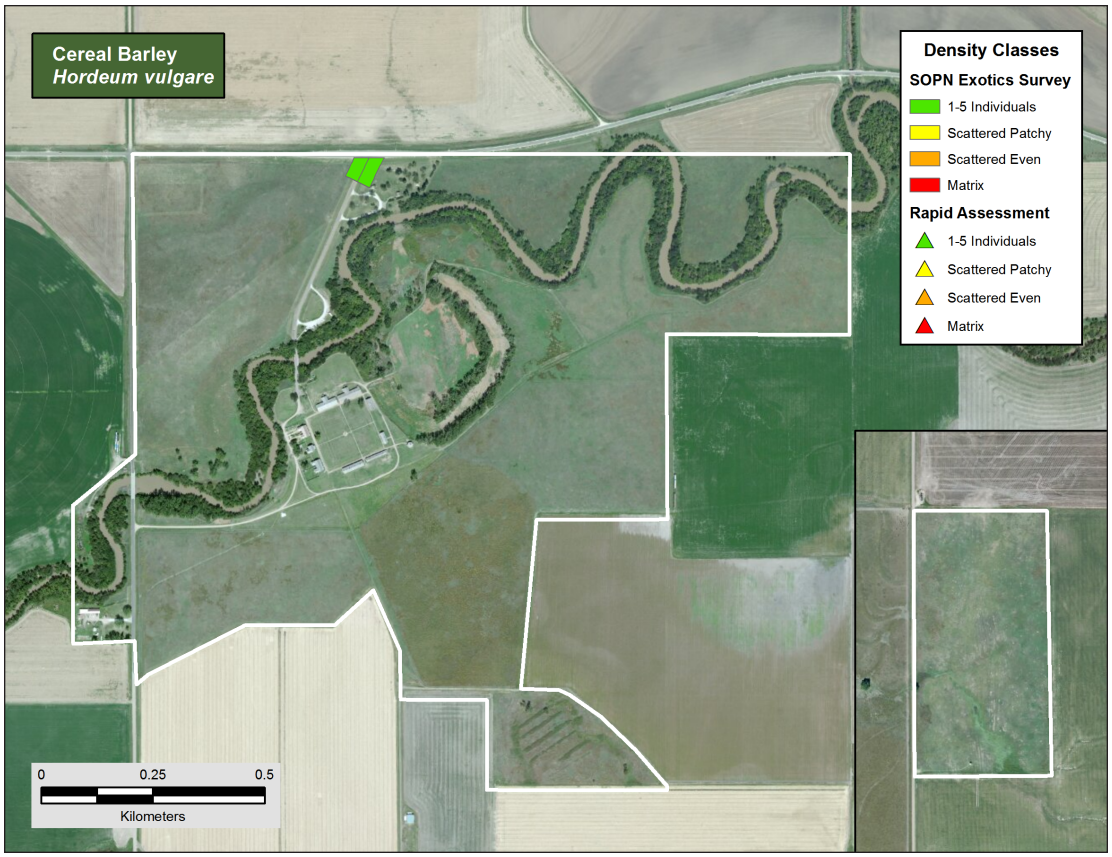

Figure F-7.
Cereal Barley
(*Hordeum vulgare*)

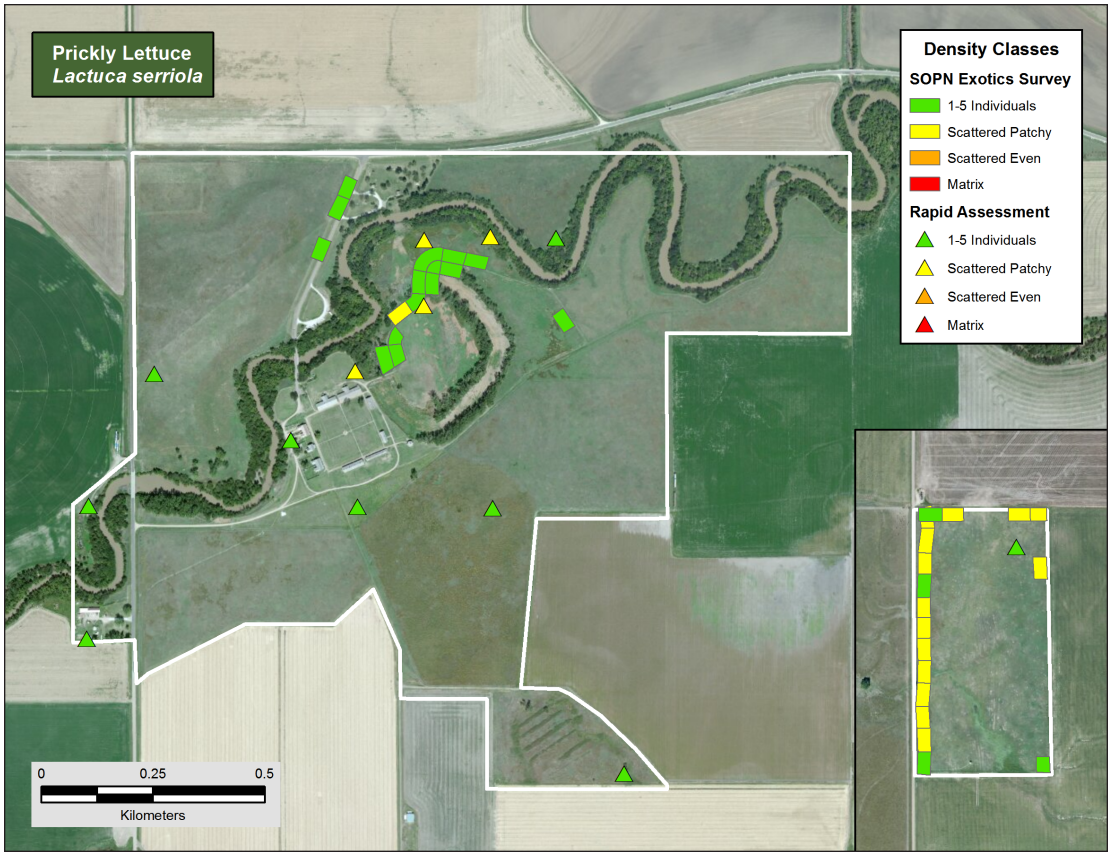

Figure F-8.
Prickly lettuce
(*Lactuca serriola*)

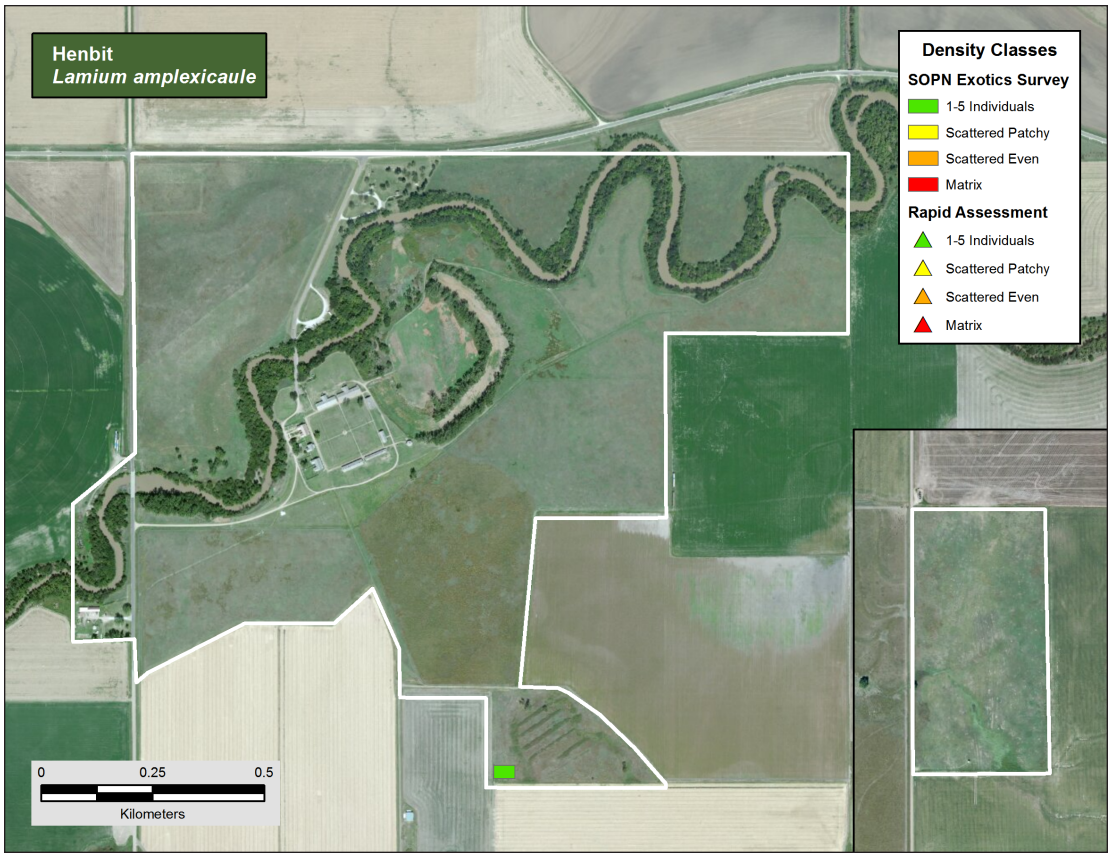

Figure F-9. Henbit (*Lamium amplexicaule)*

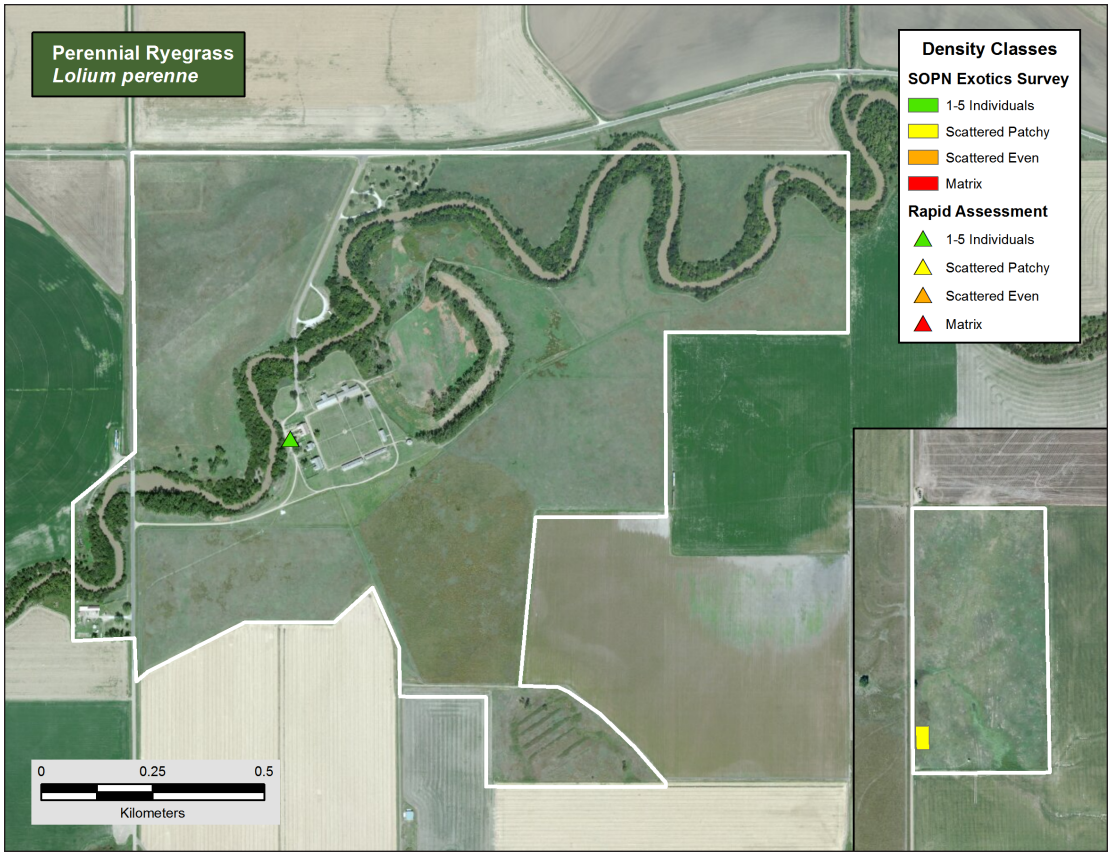

Figure F-10. Perennial Ryegrass (*Lolium perenne)*

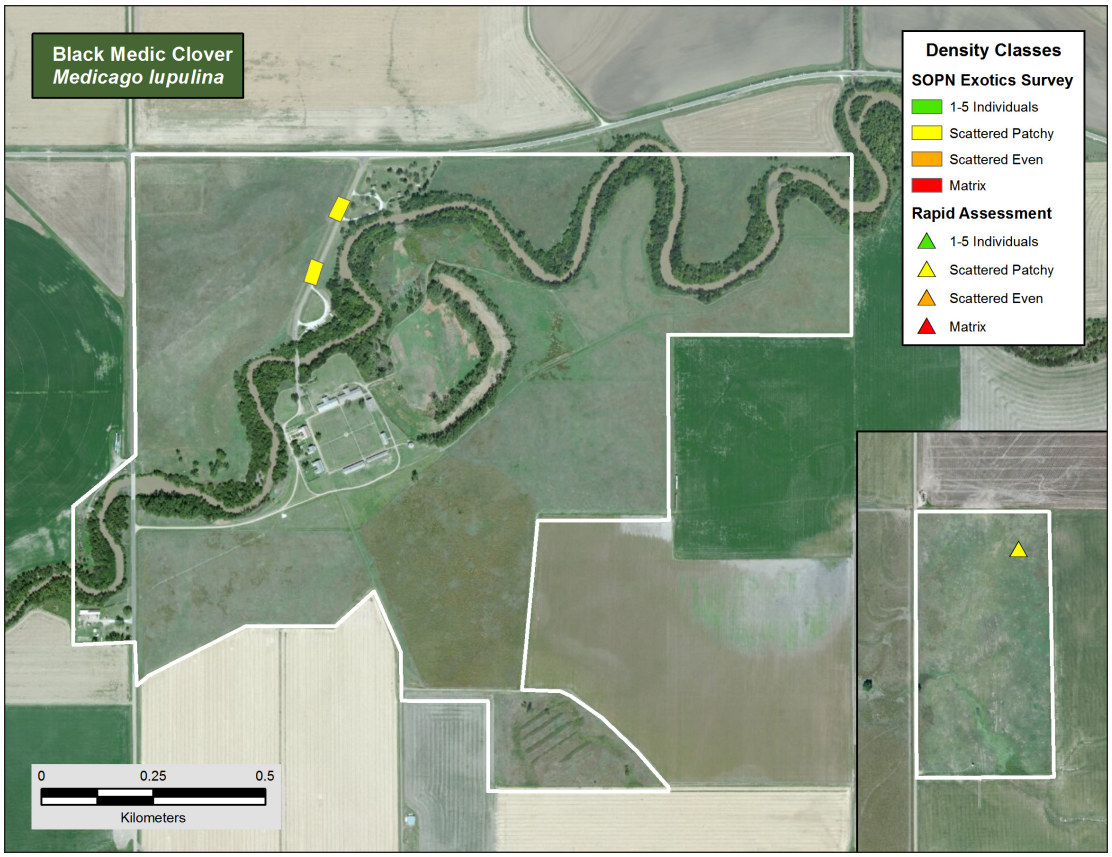

Figure F-11.
Black Medic Clover (*Medicago lupulina)*

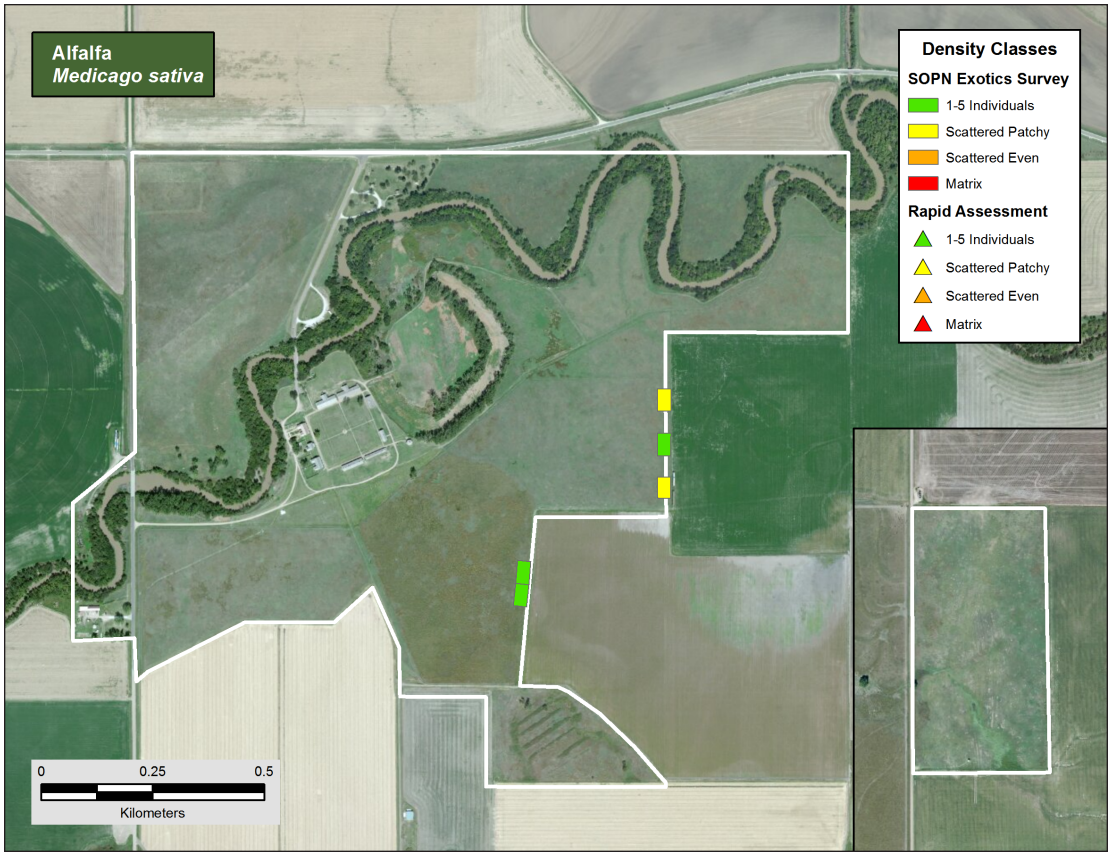

Figure F-12.
Alfalfa (*Medicago sativa)*

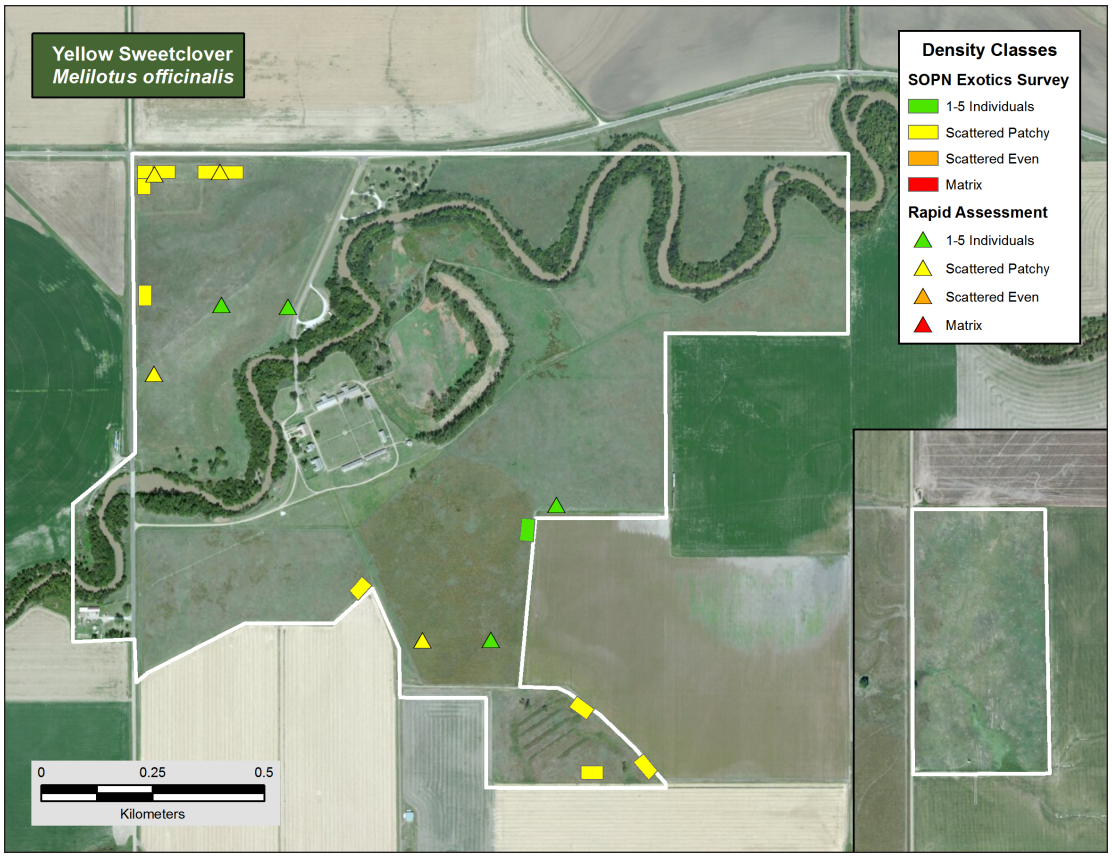

Figure F-13.
Yellow Sweetclover
(*Melilotus officinalis*)

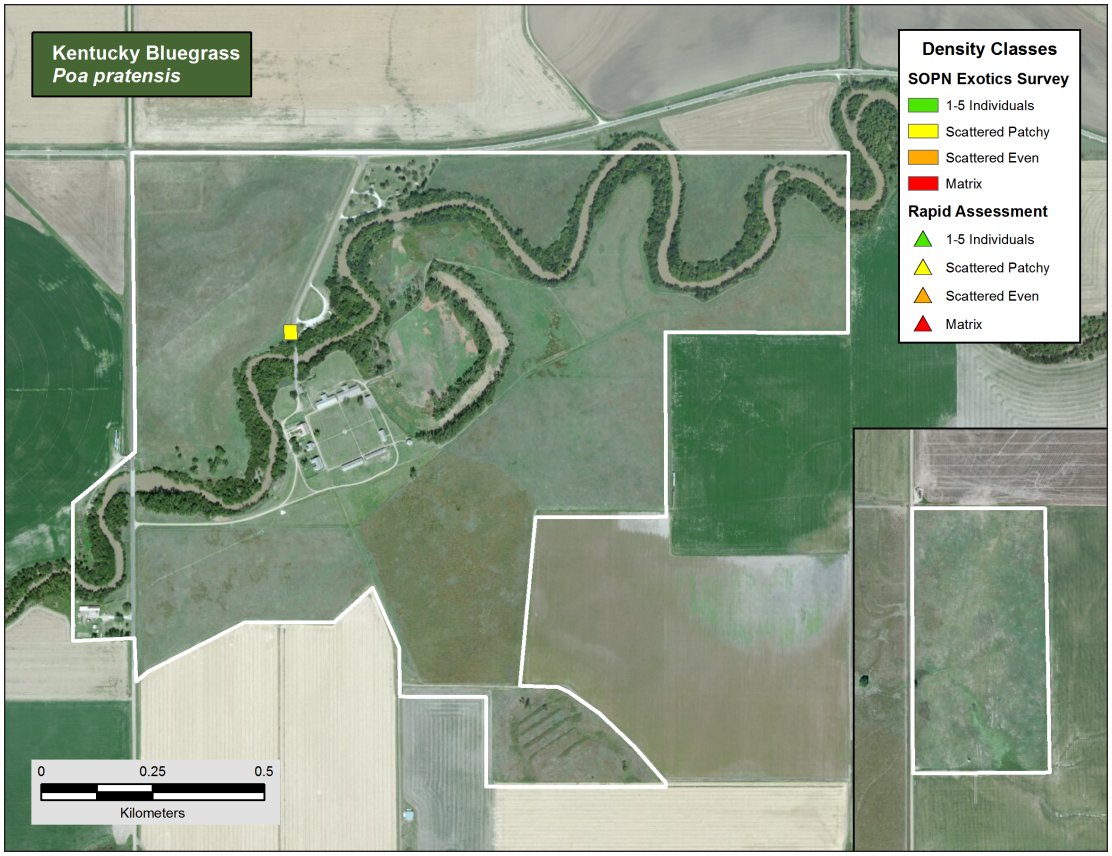

Figure F-14.
Kentucky Bluegrass
(*Poa pratensis*)

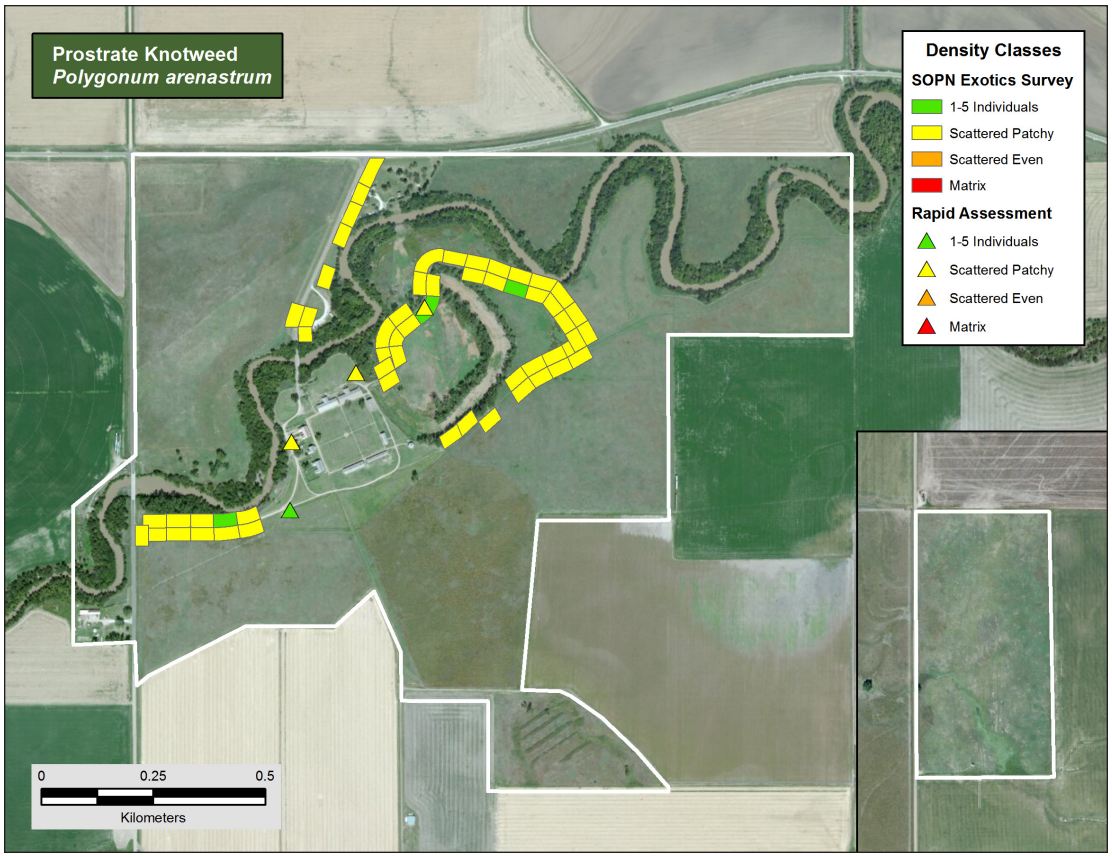

Figure F-15. Prostrate Knotweed (*Polygonum arenastrum*)

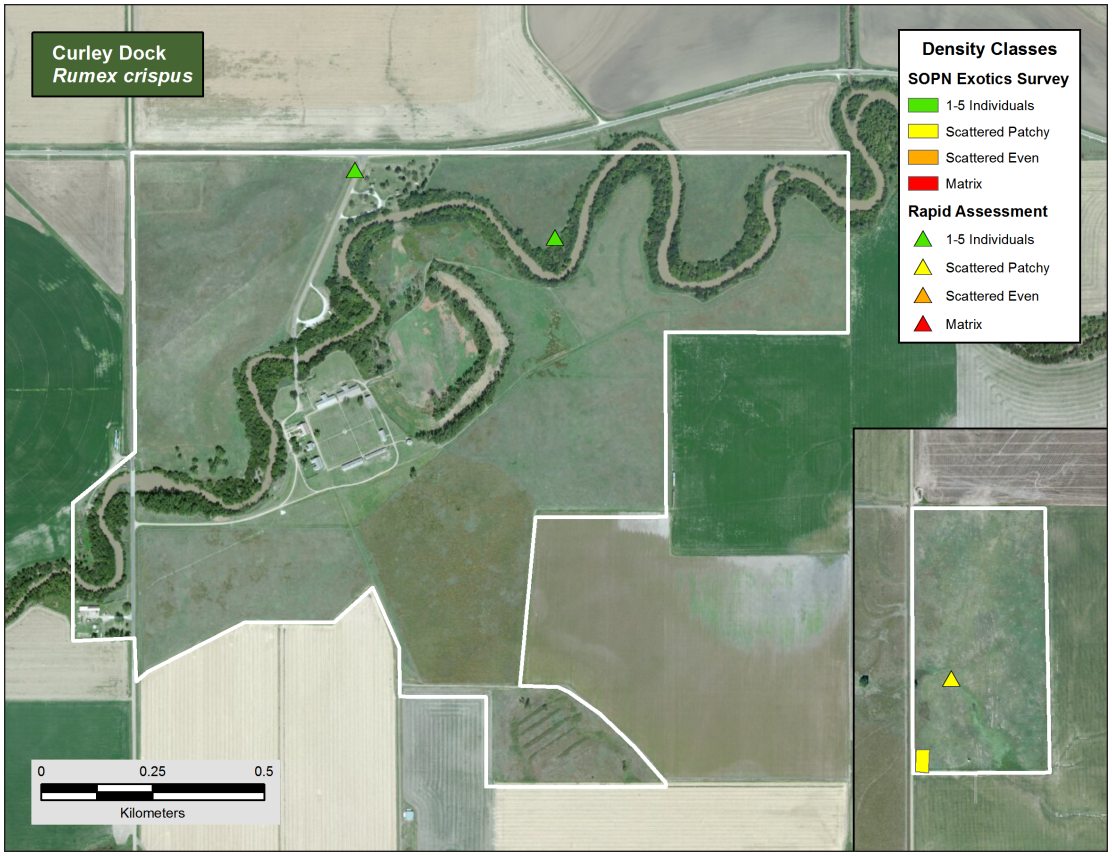

Figure F-16. Curly dock (*Rumex crispus*)

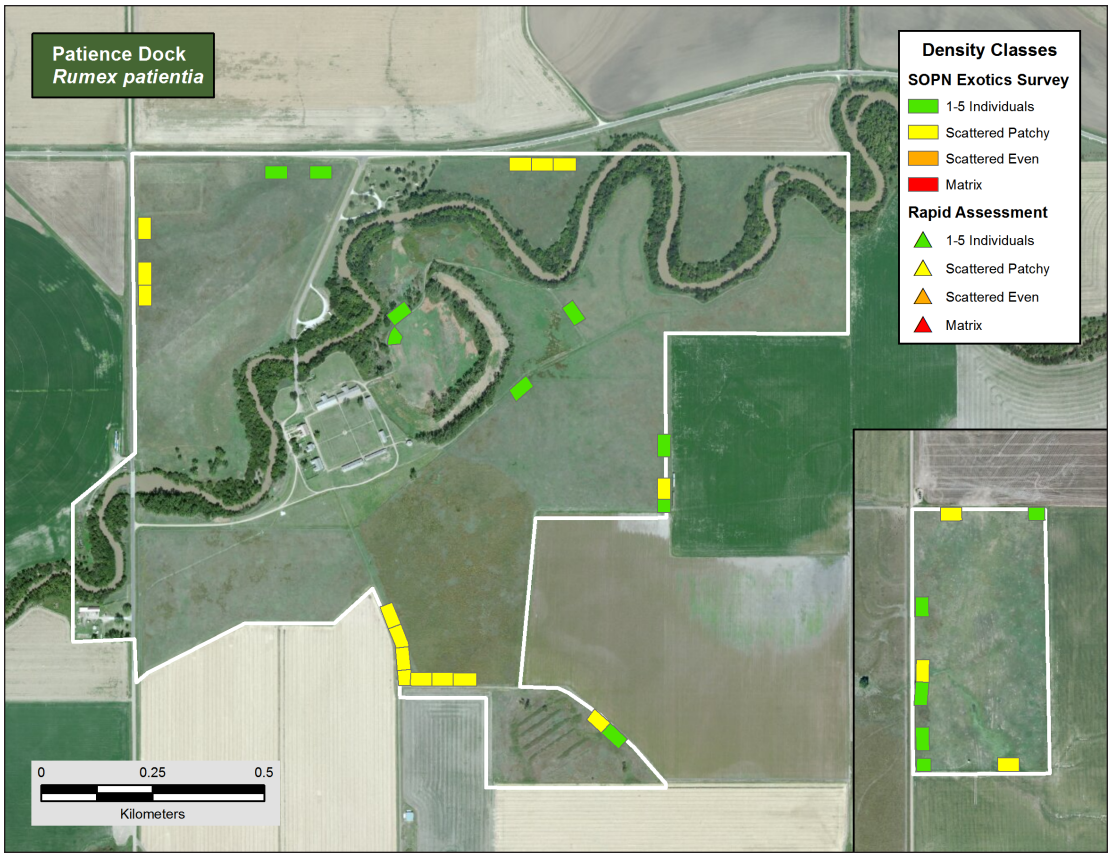

Figure F-17. Patience Dock (*Rumex patientia)*

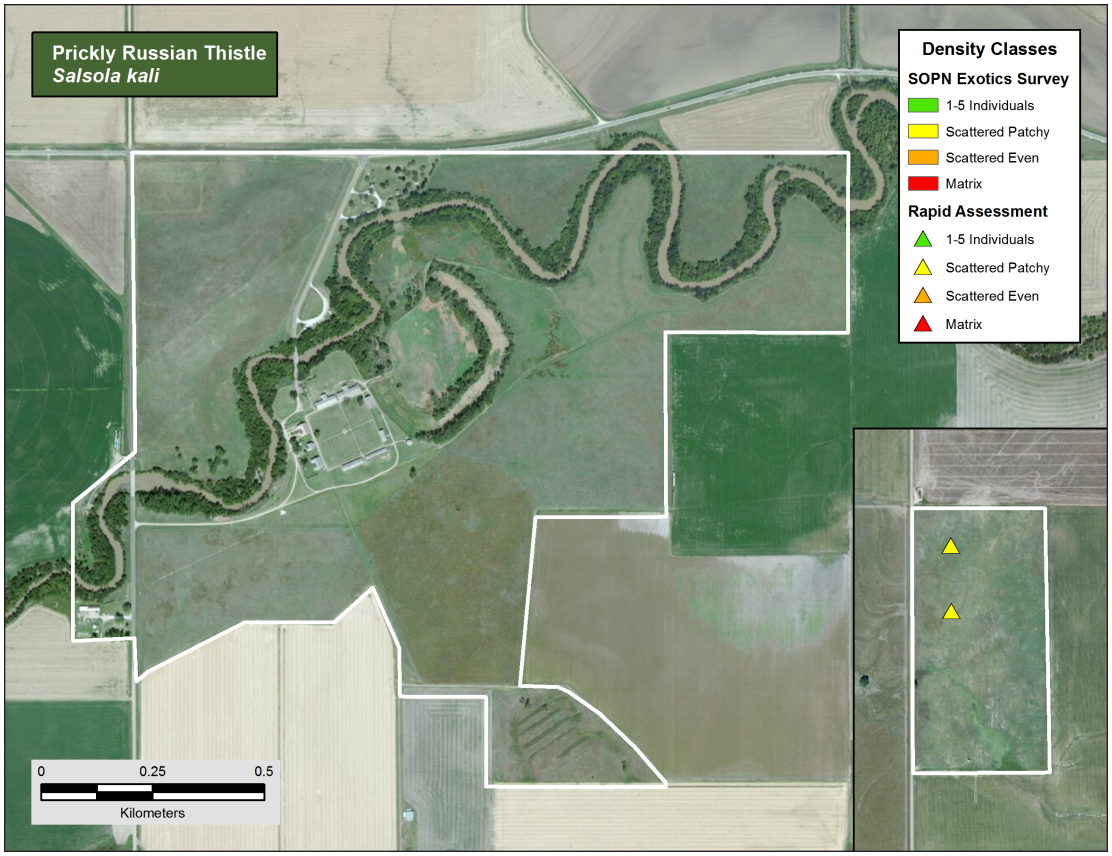

Figure F-18. Prickly Russian thistle (*Salsola kali)*

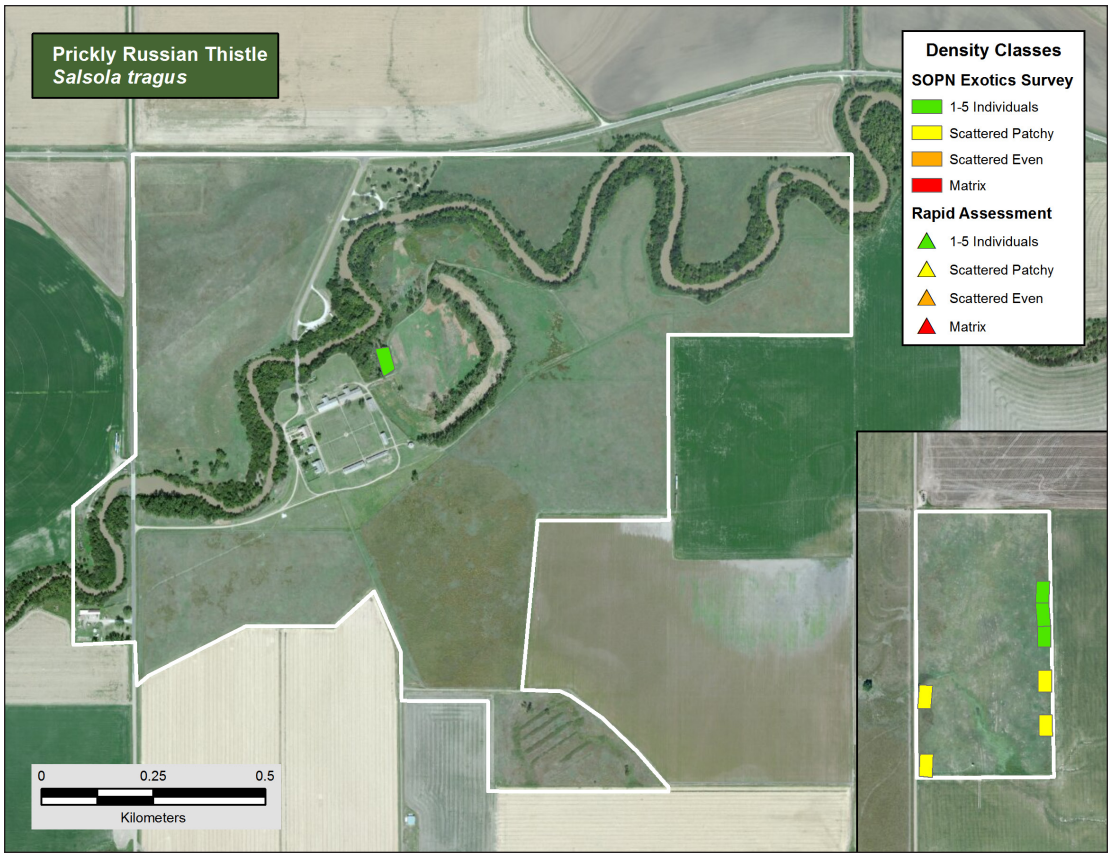

Figure F-19. Prickly Russian thistle (*Salsola tragus*)

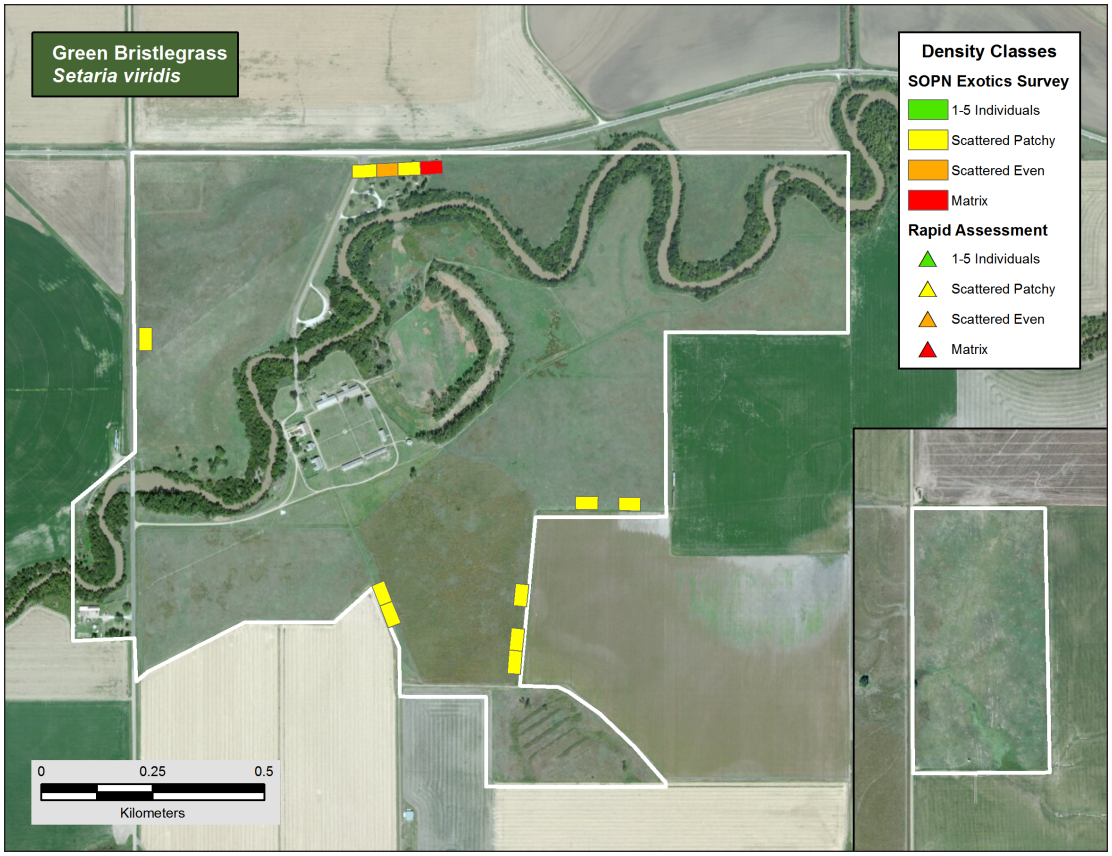

Figure F-20. Green Bristlegrass (*Setaria viridis*)

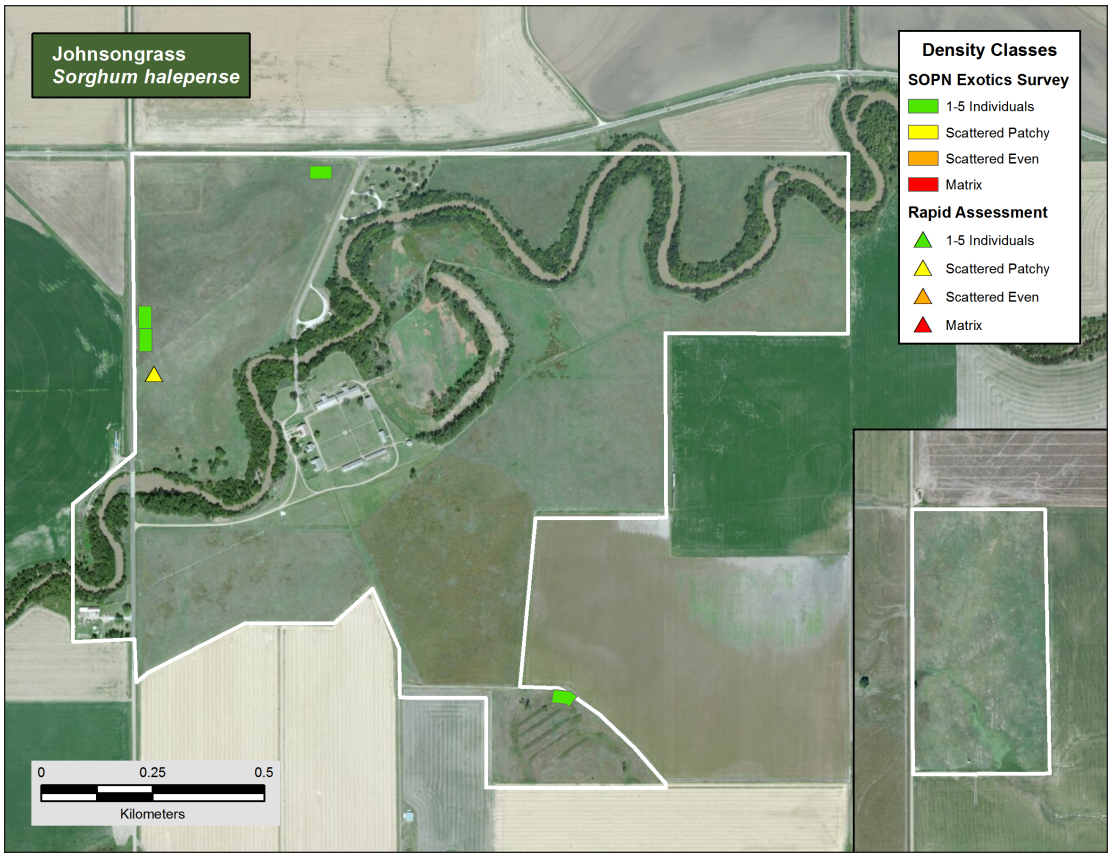

Figure F-21. Johnsongrass (*Sorghum halapense)*

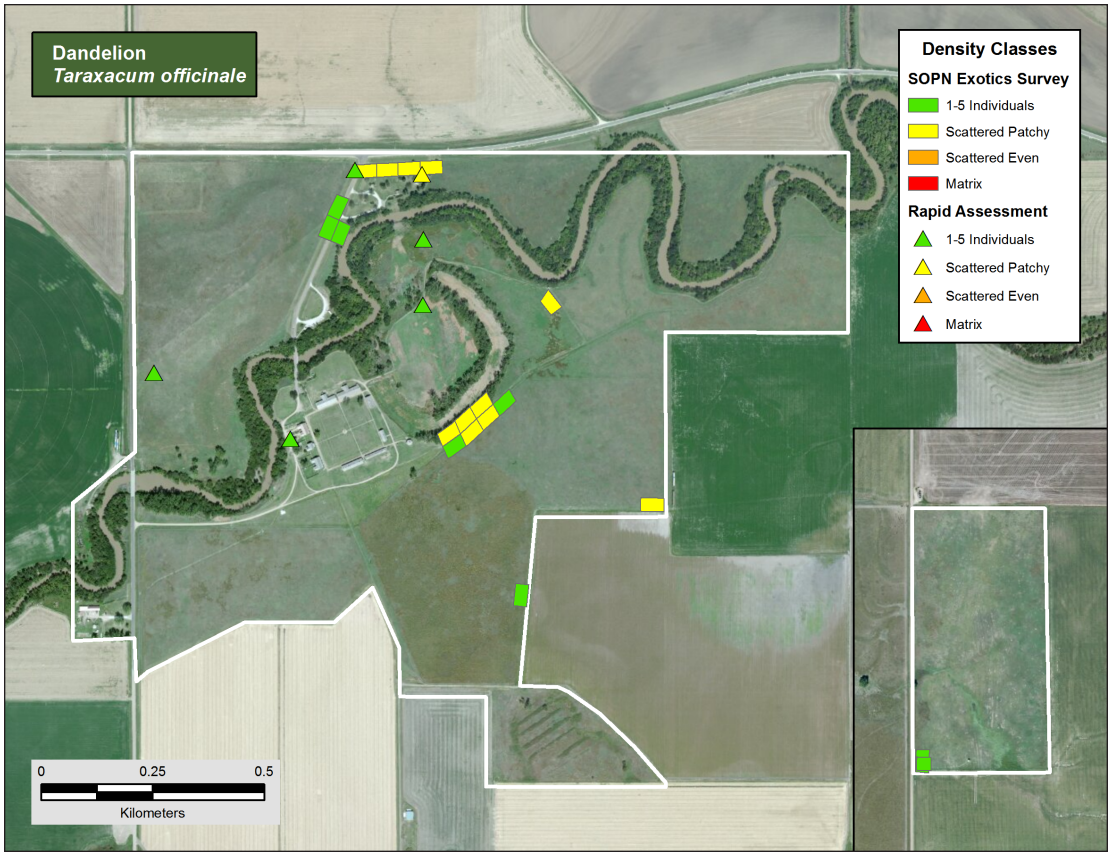

Figure F-22. Dandelion (*Taraxacum officinale)*

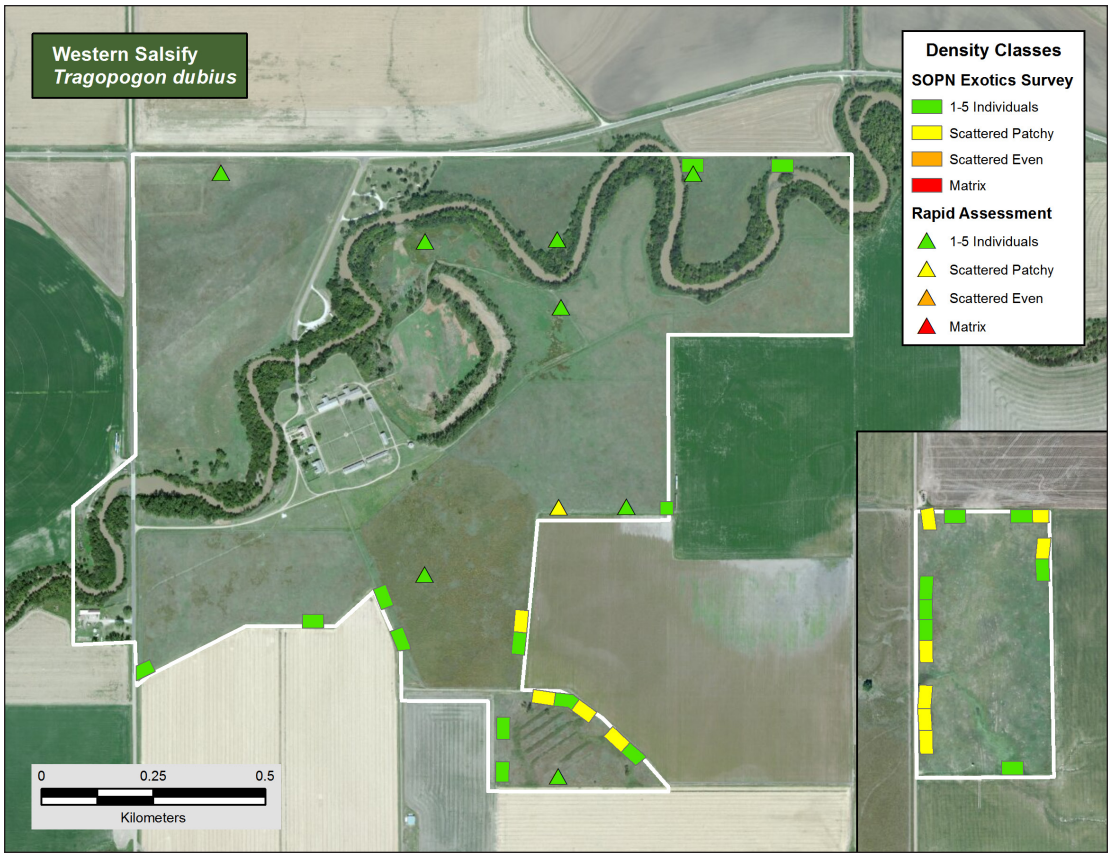

Figure F-23. Western Salsify (*Tragopogon dubius*)

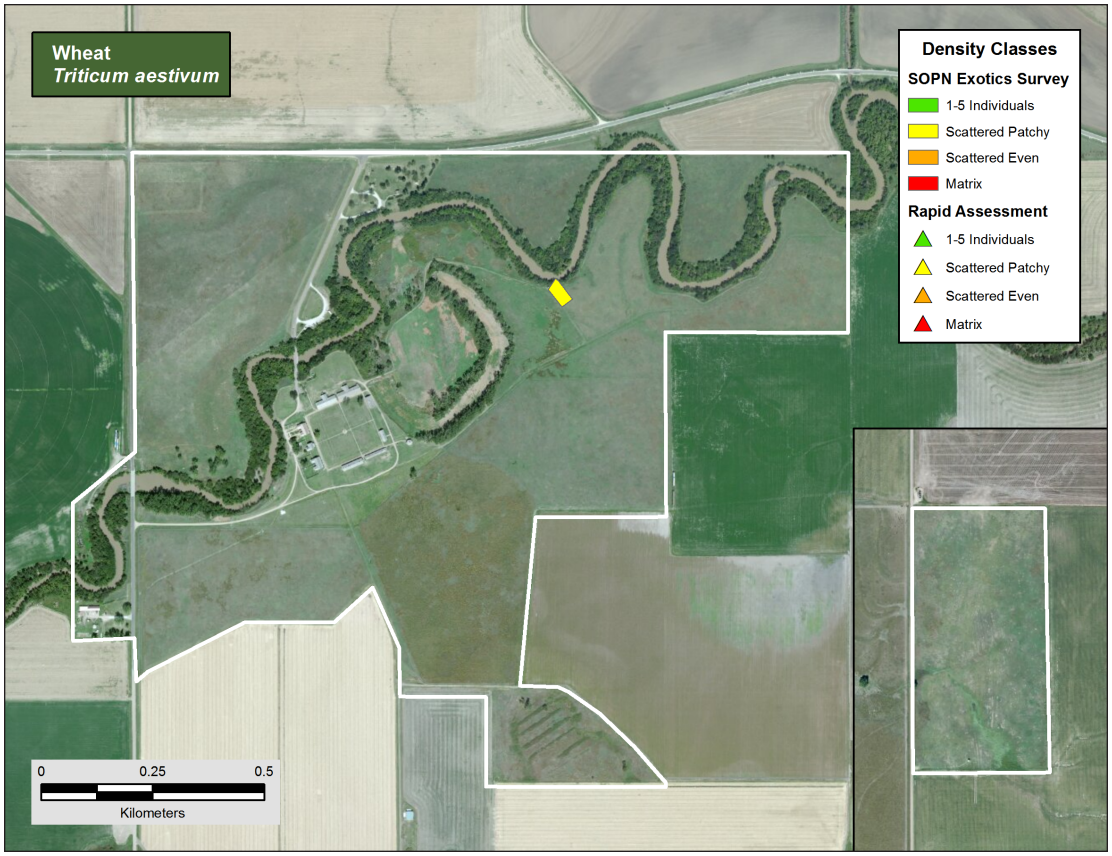

Figure F-24. Wheat (*Triticum aestivum*)

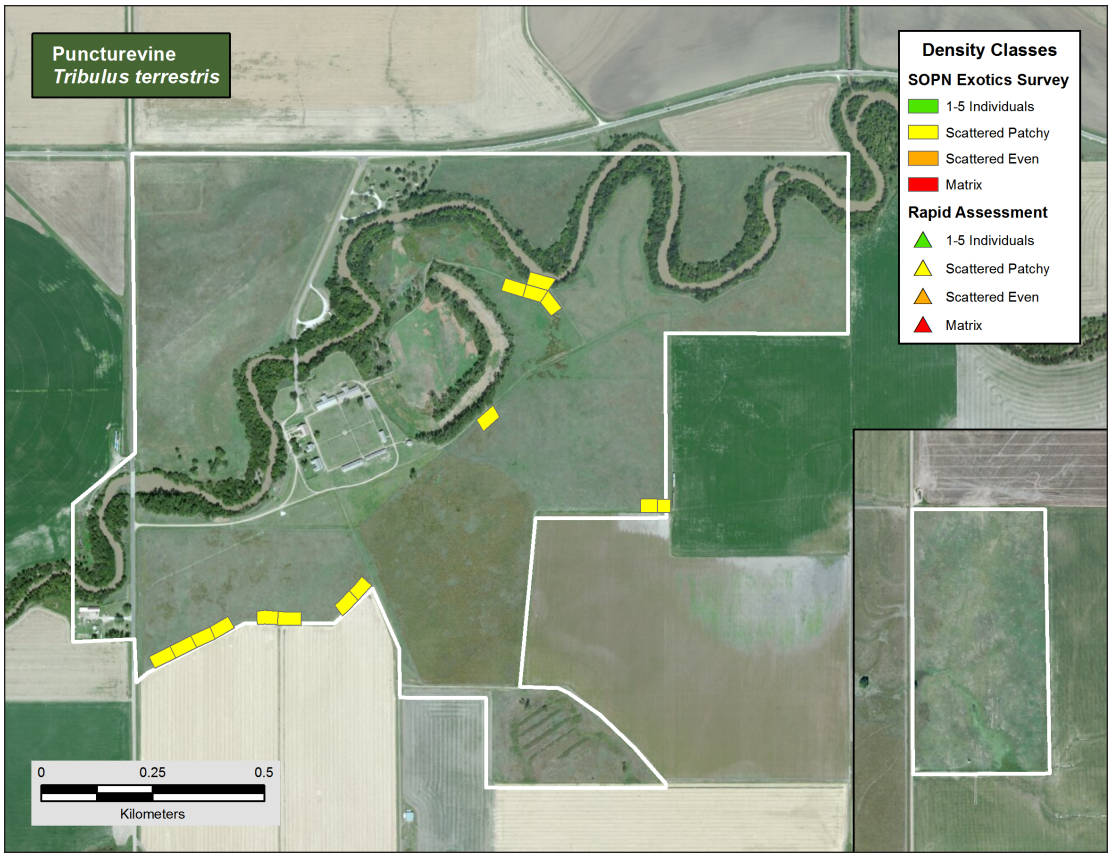

Figure F-25. Puncturevine (*Tribulus terrestris*)

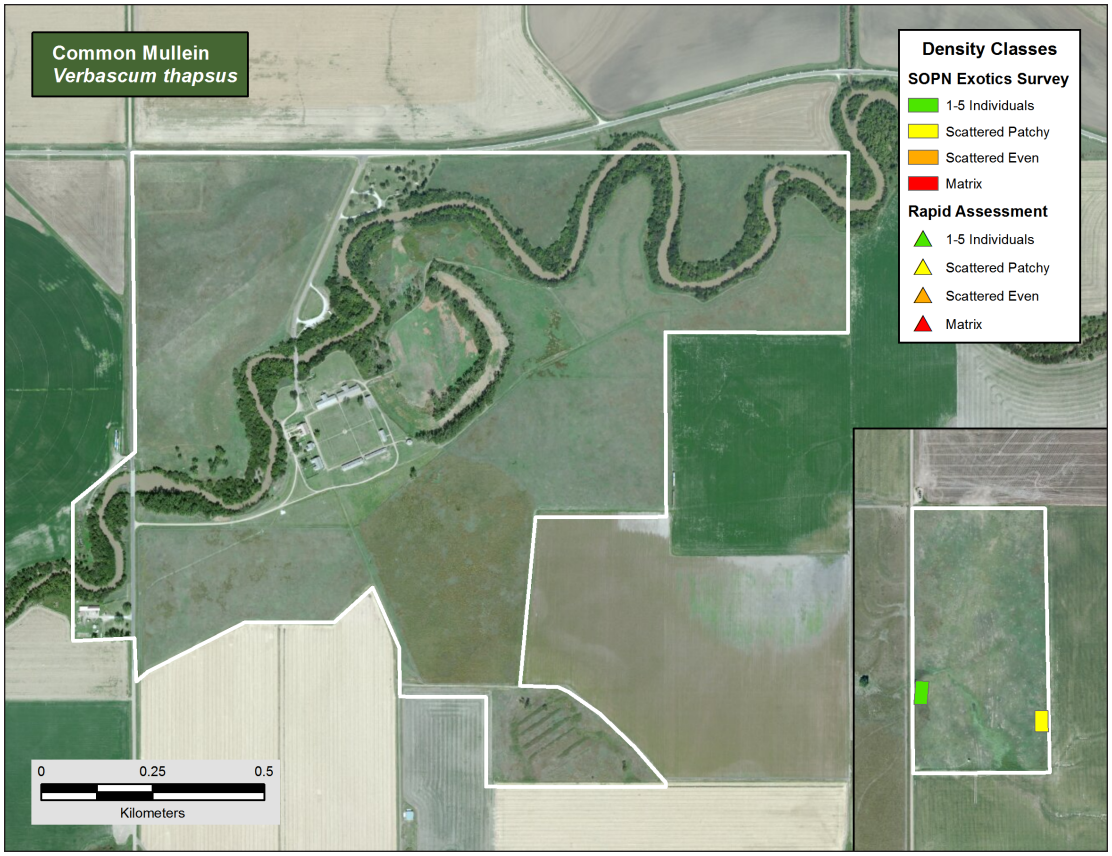

Figure F-26. Common Mullein (*Verbascum thapsus*)

Appendix G: Additional Exotic Plant Species at Fort Larned NHS

The following table lists exotic species that are and have been found within Fort Larned NHS. None of the species above were listed on Kansas state-listed noxious status. Source: USDA-NRCS. 2013. Kansas state listed noxious weeds. Available at http://plants.usda.gov/java/noxious?rptType=State&statefips=20 (accessed June 13, 2013).

Scientific Name	Common Name	Ecological Impact	Management Difficulty
Abutilon theophrasti	velvetleaf	LOW/INSIG	HIGH/LOW
Aegilops cylindrica	jointed goat grass	MED/INSIG	HIGH/LOW
Alliaria petiolata	Garlic Mustard	MED/LOW	MED
Amaranthus blitoides	Prostrate Pigweed		
Amaranthus retroflexus	Redroot Pigweed		
Bothriochloa bladhii	Australian Beardgrass		
Bromus commutatus	Meadow Brome	MED/INSIG	UNK
Calystegia sepium	Hedge Bindweed		
Cannabis sativa	Marijuana	LOW/INSIG	MED
Capsella bursa-pastoris	Shepard'S Purse	INSIG	HIGH/LOW
Chenopodium album	Common Lambsquarters		
Cirsium vulgare	Bull Thistle	MED/LOW	MED/LOW
Cynodon dactylon	Bermudagrass	MED/LOW	HIGH/MED
Dactylus glomerata	orchard grass	LOW/INSIG	MED/LOW
Descurainia sophia	Flixweed	MED/LOW	MED/LOW
Digitaria sanguinalis	Hairy Crabgrass	LOW/INSIG	LOW/INSIG
Echinochloa crus-galli	barnyard grass	LOW/INSIG	UNK
Elaeagnus angustifolia	Russian Olive	HIGH/MED	HIGH
Eragrostis cilianensis	Stinkgrass	LOW/INSIG	UNK
Euphorbia dentata	Toothed Spurge		
Hibiscus trionum	flower-of-an-hour	MED/INSIG	MED/INSIG
Hordeum vulgare	Cereal Barley		
Lamium amplexicaule	Henbit		
Lolium arundinaceum	Tall fescue	MED	HIGH/MED
Lolium perenne	Perennial Ryegrass	MED	MED/INSIG
Medicago lupulina	Black Medic Clover	MED/INSIG	UNK
Medicago polymorpha	burr clover		
Medicago sativa	Alfalfa		
Morus alba	white mulberry	MED/LOW	MED/LOW

Scientific Name	Common Name	Ecological Impact	Management Difficulty
Nepeta cataria	catnip		
Pennisetum glaucum	yellow foxtail		
Poa pratensis	Kentucky Bluegrass	MED	MED/LOW
Rumex crispus	Curley Dock	LOW/INSIG	MED/LOW
Rumex stenophylla	narrow-leaf dock		
Setaria pumila	yellow bristlegrass	LOW/INSIG	UNK
Stellaria media	common chickweed	LOW/INSIG	MED/LOW
Thlaspi arvense	field pennycress	LOW/INSIG	MED/LOW
Tribulus terrestris	Puncturevine		
Trifolium repens	Ladino Clover	MED/LOW	MED/INSIG
Triticum aestivum	Wheat		
Verbascum thapsus	Common mullein		

Appendix H: Background on Bird Species of Conservation Concern Lists

This appendix provides background information on the organizations and efforts to determine species of birds that are in need of conservation. The information preseneted here supports Section 4.11.2, Data and Methods, of the breeding landbirds chapter. This appendix contains some of the same, but additional, information as that section of the report.

One component of the landbird condition assessment was to assess species occurrence in a conservation context. We compared the list of species that occur at Fort Larned National Historic Site (NHS) (i.e., those detected during Rocky Mountain Bird Observatory [RMBO] surveys at the NHS during 2009-2012) to lists of species of conservation concern developed by several organizations. There have been a number of such organizations that focus on the conservation of bird species. Such organizations may differ, however, in the criteria they use to identify and/or prioritize species of concern based on the mission and goals of their organization. They also range in geographic scale from global organizations such as the International Union for Conservation of Nature (IUCN), who maintains a "Red List of Threatened Species," to local organizations or chapters of larger organizations. This has been, and continues to be, a source of confusion and perhaps frustration for managers that need to make sense of and apply the applicable information. In recognition of this, the U.S. North American Bird Conservation Initiative (NABCI) was started in 1999; it represents a coalition of government agencies, private organizations, and bird initiatives in the United States working to ensure the conservation of North America's native bird populations. Although there remain a number of sources at multiple geographic and administrative scales for information on species of concern, the NABCI has made great progress in developing a common biological framework for conservation planning and design.

One of the developments from the NABCI was the delineation of Bird Conservation Regions (BCRs) (U.S. North American Bird Conservation Initiative 2013). Bird Conservation Regions (BCRs) are ecologically distinct regions in North America with similar bird communities, habitats, and resource management issues.

The purpose of delineating these BCRs was to:

- facilitate communication among the bird conservation initiatives;
- systematically and scientifically apportion the U.S. into conservation units;
- facilitate a regional approach to bird conservation;
- promote new, expanded, or restructured partnerships; and
- identify overlapping or conflicting conservation priorities.

H.1. Conservation Organizations Listing Species of Conservation Concern

Below we present a snapshot of some of the organizations that list species of conservation concern and briefly discuss the different purposes or goals of each organization.

U.S. Fish & Wildlife Service

The Endangered Species Act, passed in 1973, is intended to protect and recover imperiled species and the ecosystems upon which they depend. It is administered by the U.S. Fish and Wildlife Service (USFWS) and the Commerce Department's National Marine Fisheries Service (NMFS). USFWS has primary responsibility for terrestrial and freshwater organisms, while the responsibilities of NMFS are mainly marine wildlife, such as whales, and anadromous fish.

State of Kansas

Under the authority of the Kansas Nongame and Endangered Species Conservation Act

of 1975, the Kansas Department of Wildlife, Parks, and Tourism identifies and takes conservation measures for State and federally listed species. The Department maintains listings of species considered as threatened or endangered, as well as species in need of conservation (Kansas Department of Wildlife, Parks and Tourism 2013).

USFWS Birds of Conservation Concern

The USFWS has responsibilities for wildlife, including birds, in addition to endangered and threatened species. The Fish and Wildlife Conservation Act, as amended in 1988, further mandates that the USFWS "identify species, subspecies, and populations of all migratory nongame birds (i.e., Birds of Conservation Concern) that, without additional conservation actions, are likely to become candidates for listing under the Endangered Species Act" (USFWS 2008). The agency's 2008 effort, *Birds of Conservation Concern*, is one effort to fulfill the Act's requirements. The report includes both migratory and non-migratory bird species (beyond those federally-listed as threatened or endangered) that USFWS considers the highest conservtion priorities. Three geographic scales are included-- National, USFWS Regional, and the NABCI BCRs. The information used to compile the lists came primarily from the following three bird conservation plans: the Partners in Flight North American Landbird Conservation Plan, the U.S. Shorebird Conservation Plan, and the North American Waterbird Conservation Plan. The scores used to assess the species are based on factors such as population trends, distribution, threats, and abundance.

National Audubon Society/American Bird Conservancy

The National Audubon Society and American Bird Conservancy each formerly published their own lists of bird species of concern, but have recently combined efforts into a single "Watch List". This collaborative effort was based on a concern by these organizations that there were too many lists with similar purposes (Butcher et al. 2007). Their 2007 WatchList is based on, but not identical to, the Partners in Flight (PIF) approach to species assessment (see below).

The 2007 WatchList has two primary levels of concern: a "Red Watchlist" and a "Yellow WatchList", although the latter is subdivided into two categories. The Red WatchList identifies what these organizations consider as species of highest national concern. This list overlaps considerably with the IUCNs "Red List" (not presented here), thus, can essentially be considered as a list of globally threatened birds that occur in the United States (Butcher et al. 2007). The Yellow WatchList is made up of species that are somewhat less critical, but serves as an early warning list of birds that have the potential of being elevated to the Red WatchList. Species on this list can be there either because their populations are declining or because they are considered rare.

Partners in Flight

Partners in Flight is a cooperative effort among federal, state, and local government agencies, as well as private organizations. One of its primary goals, relative to listing species of conservation concern, is to develop a scientifically based process for identifying and finding solutions to risks and threats to landbird populations. Their approach to identifying and assessing species of conservation concern is based on biological criteria to evaluate different components of vulnerability (Panjabi et al. 2005). Each species is evaluated for six components of vulnerability: population size, breeding distribution, non-breeding distribution, threats to breeding, threats to non-breeding, and population trend. The specific process is presented in detail in the species assessment handbook (Panjabi et al. 2005).

Their assessments are conducted at multiple scales. At the broadest scale, the North American Landbird Conservation Plan (Rich et al. 2004) identifies what PIF considers "Continental Watch List Species" and "Continental Stewardship Species." Continental Watch List Species are those that are most vulnerable at the continental scale, due to a combination of small and declining

populations, limited distributions, and high threats throughout their ranges (Panjabi et al. 2005). Continental Stewardship Species are defined as those species that have a disproportionately high percentage of their world population within a single Avifaunal Biome during either the breeding season or the non-migratory portion of the non-breeding season.

More recently, PIF has adopted BCRs, the common planning unit under the NABCI, as the geographic scale for updated regional bird conservation assessments. These assessments are available via an online database (http://www.rmbo.org/pif/pifdb.html) maintained by RMBO. At the scale of the individual BCRs, these same principles of concern (sensu Continental Watch List Species) or stewardship (sensu Continental Stewardship Species) are applied at the BCR scale. The intention of this approach is to emphasize conservation of species where it is most relevant, as well as the recognition that some species may be experiencing dramatic declines locally even if they are not of high concern nationally, etc. There are two categories (concern and stewardship) each for Continental and Regional levels. The details of the criteria for inclusion in each can be found in Panjabi et al. (2005), and a general summary is as follows:

Criteria for Species of Continental Importance

A. Continental Concern (CC)

- Species is listed on the Continental Watch List (Rich et al. 2004).
- Species occurs in significant numbers in the BCR.
- Future conditions are not enhanced by human activities.

B. Continental Stewardship (CS)

- Species is listed as Continental Stewardship Species (Rich et al. 2004).
- Relatively high density (compared to highest density regions) and/or a high proportion of the species occurs in the BCR.
- Future conditions are not enhanced by human activities.

Criteria for Species of Regional Importance

Regional scores are calculated for each species according to which season(s) they are present in the BCR. The formulae include a mix of global and regional scores pertinent to each season (see Panjabi et al. 2005 for details). The criteria for each category are:

A. Regional Concern (RC)

- Regional Combined Score > 13 (see Panjabi et al. 2005 for details).
- High regional threats or moderate regional threat combined with significant population decline.
- Occurs regularly in significant numbers in the BCR.

B. Regional Stewardship (RS)

- Regional Combined Score > 13 (see Panjabi et al. 2005 for details).
- High importance of the BCR to the species.
- Future conditions are not enhanced by human activities.

H.2. Literature Cited

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Appendix I: Fort Larned NHS Bird List

Listed below is the full list of species reported to occur or that have occurred at Fort Larned NHS. The most recent Certified List for Birds at Fort Larned NHS from NPSpecies was certified on September 29, 2005; the list is identical to the list from the 2001 Kansas Natural Heritage Inventory (KNHI) survey (i.e., Delisle and Busby 2004), except that some of the abundance descriptions are different.

Common Name	2009-2012 Surveys (RMBO)	Delisle and Busby (2004) [1, 2]
American Crow	X	c
American Goldfinch	X	c
American Robin	X	c
Baltimore Oriole	X	c
Barn Swallow	X	c
Bell's Vireo	X	r
Black-billed Cuckoo	X	r
Black-billed Magpie		c
Black-capped Chickadee		c
Blue Jay	X	c
Brown Thrasher	X	c
Brown-headed Cowbird	X	c
Carolina Wren	X	
Chimney Swift		u
Cliff Swallow	X	
Common Grackle	X	c
Common Nighthawk	X	c
Common Yellowthroat	X	c
Dickcissel	X	c
Downy Woodpecker	X	c
Eastern Bluebird	X	r
Eastern Kingbird	X	c
Eastern Meadowlark	X	c
Eastern Phoebe	X	
Eastern Screech-Owl		u
Eastern Wood-Pewee	X	u
Eurasian Collared-Dove	X	
European Starling	X	c
Grasshopper Sparrow	X	u
Gray Catbird	X	c
Great Blue Heron	X	r (fly over)
Great Crested Flycatcher	X	u

1= Codes used: c (common in suitable habitat), u (uncommon in suitable habitat), r (observed once).

2= The Delisle and Busby (2004) inventory was conducted in the 2001 breeding season.

Common Name	2009-2012 Surveys (RMBO)	Delisle and Busby (2004) [1, 2]
Great Horned Owl		c
Great-tailed Grackle	X	
Hairy Woodpecker	X	
Horned Lark	X	
House Finch	X	u
House Sparrow	X	c
House Wren	X	c
Indigo Bunting	X	u
Killdeer	X	u
Lark Bunting		r
Mallard	X	u
Mourning Dove	X	c
Northern Bobwhite	X	u
Northern Cardinal	X	c
Northern Flicker	X	u
Northern Harrier		r (fly over)
Orchard Oriole	X	u
Red-bellied Woodpecker	X	r
Red-headed Woodpecker	X	u
Red-tailed Hawk	X	c
Red-winged Blackbird	X	c
Ring-necked Pheasant	X	c
Rock Pigeon		c
Rose-breasted Grosbeak	X	
Scissor-tailed Flycatcher	X	
Spotted Towhee		u
Summer Tanager	X	
Turkey Vulture	X	u
Warbling Vireo	X	c
Western Kingbird	X	u
Western Meadowlark	X	c
White-breasted Nuthatch	X	
Wild Turkey	X	u
Wood Duck	X	u
Yellow Warbler	X	u
Yellow-billed Cuckoo	X	c
Yellow-breasted Chat	X	

1= Codes used: c (common in suitable habitat), u (uncommon in suitable habitat), r (observed once).

2= The Delisle and Busby (2004) inventory was conducted in the 2001 breeding season.

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