



# Washita Battlefield National Historic Site

## *Natural Resource Condition Assessment*

Natural Resource Report NPS/SOPN/NRR—2014/748



**ON THE COVER**

Winter at Washita Battlefield NHS. Photo: Kris Johnson

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Kimberly Struthers  
Utah State University  
Department of Environment and Society  
Logan, Utah

Robert E. Bennetts  
National Park Service  
Southern Plains Inventory and Monitoring Network  
Model, Colorado

Nina Chambers  
Northern Rockies Conservation Cooperative  
Jackson, Wyoming

Tomye Folts-Zettner, Heidi Sosinski  
National Park Service  
Southern Plains Inventory and Monitoring Network  
Johnson City, Texas

Patricia Valentine-Darby  
University of West Florida  
Pensacola, Florida

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# Executive Summary

The Natural Resource Condition Assessment (NRCA) Program, administered by National Park Service's (NPS) Water Resources Division, aims to provide documentation about current conditions of important park natural resources through a spatially explicit, multi-disciplinary synthesis of existing scientific data and knowledge. The NRCA for Washita Battlefield National Historic Site began in 2012, and 11 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.

After being designated a National Historic Landmark in 1965, Washita Battlefield was established as Washita Battlefield National Historic Site on November 12, 1996 (Public Law 104-333). Its purposes are: 1) to recognize the attack by Lt. Col. George Armstrong Custer and the 7th U.S. Cavalry on the Cheyenne encampment of Chief Black Kettle just before dawn on November 27, 1868 as a nationally significant element of the U.S. government Indian policy; 2) to recognize the struggles of the Cheyenne and other Southern Great Plains tribes to maintain control of their traditional homelands; and 3) to protect, preserve, and interpret the cultural and natural resources of the Historic Site through collaborative efforts of the U.S. government and the Cheyenne-Arapaho Tribe.

The landscape scale resources chosen for this assessment included viewshed, night sky, and soundscape. The condition of these resources can influence visitor experience and enjoyment, and is often critical to visitors' understanding of the events that occurred on the site. Overall, viewshed and night sky resources are in moderate condition, and soundscape condition is of significant concern. Human activities/development occurring nearby but outside of Historic Site boundaries (e.g., oil and gas development, wind turbines, and roads) are contributing to views, night-time light pollution, and noise that are not consistent with the park's visitor goal of creating a reflective mood.

The Historic Site's supporting physical environment resource topics included air quality, geology, surface water, and groundwater. Geology, surface water, and groundwater are lacking specific data to provide insight into current condition and trend at the Historic Site. Data exist, however, for air quality. Air quality monitoring is multifaceted and includes visibility, ozone, and wet deposition for total nitrogen and total sulfur; Visibility and Total Nitrogen warranted significant concern, and ozone and Total Sulfur warranted moderate concern. The overall condition of air quality is of significant concern.

The resource topics related to vegetation included riparian habitat, grasslands, and exotic plants. There were three indicators for riparian habitat (hydrology, vegetation, and erosion/deposition), and although the majority of the specific measures indicated a good condition, the overall condition of riparian habitat at the Historic Site is moderate, with an improving trend. Grasslands are in a moderate condition, although the trend is declining. Of the indicators, soil/site stability and hydrologic function, and biotic integrity, the first is in relatively good condition, but the second has several concerns; one of the greatest concerns is the widespread invasion of exotic plants. There were four indicators of condition for exotic plants (presence, ease of control, location, and distribution), all of which are of significant concern. The overall condition is of significant concern with a downward trend. Finally, the wildlife resource topics included only landbirds. There was one indicator for landbirds, with three specific measures of condition (in a temporal, spatial, and conservation context). Each individual measure and the overall condition for landbirds is good.



# Acknowledgements

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## 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;<sup>1</sup>
- employ hierarchical indicator frameworks;<sup>2</sup>

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

- identify or develop reference conditions/values for comparison against current conditions;<sup>3</sup>
- emphasize spatial evaluation of conditions and GIS (map) products;<sup>4</sup>
- summarize key findings by park areas; and<sup>5</sup>
- follow national NRCA guidelines and standards for study design and reporting products.

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

### NRCAs Strive to Provide...

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

### 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

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



HEIDI SOSINSKI

also important. These staff will be asked to assist with the selection of study indicators; recommend data sets, methods, and reference conditions and values; and help provide a multi-disciplinary review of draft study findings and products.

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

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

NRCAs also provide a useful complement to rigorous NPS science support programs, such as the NPS Natural Resources Inventory &

### 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)



KRIS JOHNSON

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

Monitoring (I&M) Program.<sup>8</sup> For example, NRCAs can provide current condition estimates and help establish reference conditions, or baseline values, for some of

<sup>6</sup> 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.

<sup>7</sup> 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.

<sup>8</sup> 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.

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/>.



Washita Battlefield  
NHS.

## Chapter 2: Introduction and Resource Setting

### 2.1. Introduction

#### 2.1.1. Enabling Legislation

The Washita Battlefield was designated a National Historic Landmark in 1965. The site was established as Washita Battlefield National Historic Site on November 12, 1996 to “recognize the importance of the Battle of the Washita as a nationally significant element of frontier military history and as a symbol of the struggles of the Southern Great Plains tribes to maintain control of their traditional use areas” (Public Law 104-333). Three purposes for the Historic site have been identified: 1) to recognize the attack by Lt. Col. George Armstrong Custer and the 7th U.S. Cavalry on the Cheyenne encampment of Chief Black Kettle just before dawn on November 27, 1868 as a nationally significant element of the U.S. government Indian policy; 2) to recognize the struggles of the Cheyenne and other Southern Great Plains tribes to maintain control of their traditional homelands; and 3) to protect, preserve, and interpret the cultural and natural resources of the Historic Site through collaborative efforts of the U.S. government and the Cheyenne-Arapaho Tribe (NPS 2001).

#### 2.1.2. Geographic Setting

Washita Battlefield NHS, 326 acres (132 ha) in size, is located in Roger Mills County in west-central Oklahoma, about a mile northwest of the town of Cheyenne (Figure 2.1.2-1). The Historic Site is surrounded by parcels of the Black Kettle National Grasslands, and about 1.25 miles (2 km) of the Washita River crosses the park. The Historic Site is located in the Rolling Plains, near the western limit of the Redbed Plains physiographic region of the Great Plains Steppe and Shrub Province. At one time, the area was continuous mixed and short-grass prairie among outcroppings of red sandstone and gypsum (USDI NPS 2008a). Land in and around the Historic Site has been used for grazing and farming for the past one hundred years (USDI NPS 2008a).

#### 2.1.3. Visitation Statistics

Visitation data for Washita Battlefield NHS are available for 2002-2012. The total number of visitors each year ranged from 10,527 (in 2009) to 15,467 (in 2003). The number of visitors in 2012 was 10,615. Visitation data by month are available for the same period of time. Although there has been substantial monthly variation by year, the three months



**Figure 2.1.2-1.**  
Setting of Washita  
Battlefield NHS.

receiving the greatest number of visitors over the ten year period were May, June, and July (Figure 2.1.3-1) (NPS Public Use Statistics Office 2013).

## 2.2. Natural Resources

A summary of the natural resources at Washita Battlefield 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 and Watersheds

Washita Battlefield NHS is primarily composed of shortgrass and mixed-grass prairie. This ecosystem supports numerous plant and animal species, including some species of interest. There are no federally or state listed threatened or endangered plant or animal species at the Historic Site, but there are state species of concern. The Texas horned lizard (*Phrynosoma cornutum*), for example, is listed as a Category II species of concern (USDI NPS 2008a). Several bird species are listed as species of greatest conservation need with the state (e.g., Swainson's hawk [*Buteo swainsoni*], Cassin's sparrow [*Peucaea cassinii*] [Oklahoma Department of Wildlife Conservation 2011]).

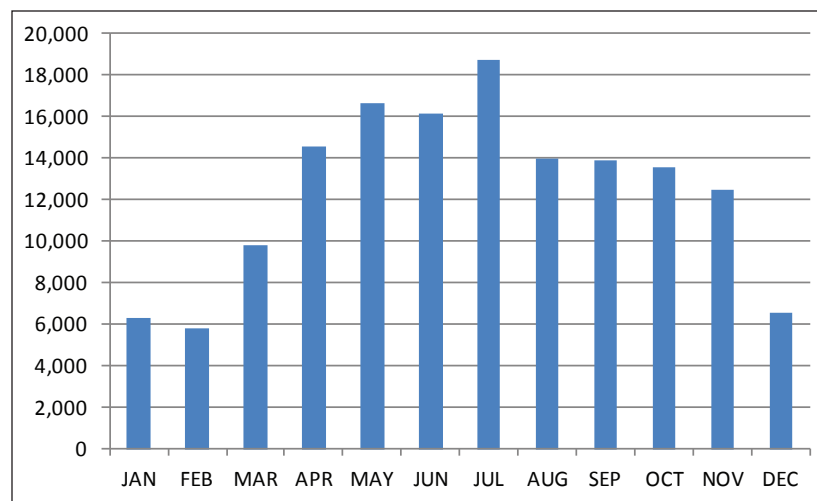


**Figure 2.1.3-1.**  
Total number of  
visitors to Washita  
Battlefield NHS by  
month, 2002-2012.

The Washita River, a tributary to the Red River, is the main hydrologic feature of Washita Battlefield NHS. It crosses the Historic Site west to northeast. Its confluence with Sergeant Major Creek, which also has historic significance to the battle, is to the east (downstream) of the Historic Site (see



Figure 2.2.1-1. Washita Battlefield NHS is within the Sergeant Major Creek sub-drainage of the Washita Headwaters subbasin.

Figure 2.1.2-1). The Historic Site is located within the Sergeant Major Creek sub-drainage of the Washita Headwaters sub-basin (USGS Hydrologic Unit 11130301; Figure 2.2.1-1). The watershed drains an area of about 750 square miles that is dominated by rangeland and irrigated agriculture in suitable areas.

### 2.2.2. Resource Descriptions

(Italicized text in the following section are excerpts from resource backgrounds in USDI NPS 2008a.)

#### Geology and Soils

*Washita Battlefield NHS is near the western limit of the Red Bed Plains physiographic zone, with exposure of the Cloud Chief Formation, which is composed primarily of Permian-aged red sandstones, siltstones, mudstones and impressive white gypsum (Neff 2002; Koch & Santucci 2003). Outcrops of gypsum, or alabaster, protrude from the ridge that divides the southern floodplain from the adjoining uplands. The Cloud Chief Formation has not been known to produce many fossils, although a few have been found just east of the park boundary (Brown 2001). Washita Battlefield NHS lies on the southern flank of the Anadarko Basin, a large, deep, sedimentary basin that is a major source of oil and gas. There is primarily*

*deep gas production from Pennsylvanian age Cherokee, Atoka and Morrow Groups reservoirs near the Historic Site. Six wells within 1-1/2 miles of the site have tested these reservoirs and were unproductive (NPS 2001).*

*The Dust Bowl of the 1930s heavily impacted this part of Oklahoma, to the point that most of the original prairie topsoil is gone (Inglis 2001). The soil survey for Roger Mills County (USDA 1963) identifies 10 principal soil associations within Washita Battlefield NHS. Soils found on uplands and slopes include: Woodward (loam and fine sandy loam), Miles-Springer Complex (somewhat sandy), Miles-Nobscot complex (fine sandy loam to sand), hilly Springer loamy fine sand, and hilly Pratt loamy fine sand. Floodplain soils include: Spur and Port (silty-loam), hummocky Springer loamy fine sand, Yahola fine sandy loam, and Lincoln (NPS 2001).*

#### Hydrology

*Washita Battlefield NHS is located on the Washita River. The “Dust Bowl” of the 1930’s likely resulted in considerable changes to the local hydrology (Inglis 2001) and may be the cause of the stream characteristics that are discordant with its watershed conditions. Currently, the Washita River is considered an*

*undersized stream with a wide valley-bottom floodplain (Inglis 2001). In addition to the drought conditions of the 1930's, dams along the Washita River and irrigation of surface and ground waters have contributed to the current state of the river. Groundwater at the Historic Site is generally hard and may contain excessive dissolved solids. Sulfate concentrations, in particular, are often above the recommended drinking limit. The greatest threats to the water resources at the Historic Site include the silt build-up, dams, regional waste pits, invasive plant establishment in riparian areas, residential development, cattle ranching, and oil well operations. The USGS has gauged the Washita River at a station downstream from the Historic Site for over 60 years. Additionally, they collected water quality data bi-annually from the 1930's to the 1990's. A functional evaluation of the Washita River was performed by the WRD in 2001.*

#### Air Quality

Washita Battlefield NHS is designated as a Class II air quality area (NPS 2001). Air pollution sources in the general region include particulates associated with agriculture, prescribed burning, and vehicle and farm equipment emissions (USDI NPS 2008a). There are no known air pollution point sources in the immediate vicinity of the Historic Site (Washita Battlefield NHS 2001).

#### Wildlife

**Mammals:** A survey was conducted by Oklahoma Natural Heritage Inventory during 2000-2001. Twenty-one mammal species were detected, 10 of which were from

*the small mammal community. The most common mammal trapped was the hispid cotton rat (*Sigmodon hispidus*), only found south of the Washita River, followed by the white-footed mouse (*Peromyscus leucopus*). The most common species detected at tracking plates were raccoon (*Procyon lotor*), striped skunk (*Mephitis mephitis*), opossum (*Didelphis virginiana*) and southern plains woodrat (*Neotoma micropus*) (Lomolino and Smith 2001).*

**Reptiles/Amphibians:** A survey was conducted by Oklahoma Natural Heritage Inventory during 2000-2001, documenting 11 reptiles and 4 amphibians. By far the most common reptile on site was the prairie racerunner (*Cnemidophorus sexlineatus*). Texas horned lizards (*Phrynosoma cornutum*), listed as a Category II species of concern by the state of Oklahoma, were also seen regularly. Along the river, Blanchard's cricket frogs (*Acris crepitans*) were very common (Lomolino and Smith 2001). The northern earless lizard (*Holbrookia maculata maculata*) is another species listed by the state that has been documented at the Historic Site.

**Fish:** Oklahoma Biological Survey conducted an inventory of fish found in the Washita River at the Historic Site. Sampling was conducted three separate times during 2002- 2003 and documented 16 species of fish. Mosquitofish (*Gambusia affinis*) and red shiners (*Cyprinella litrensis*) were extremely abundant. The moderately common fish species found are tolerant of siltation and turbidity (Bergey 2003).

**Invertebrates:** A survey for aquatic invertebrates in the Washita River at the Historic Site was conducted by Oklahoma Biological Survey during 2002-2003. Three sampling visits resulted in 82 taxa of aquatic invertebrates and 26 taxa of aerial insects. Beetles, mayflies and dragonflies/damselflies were especially speciose. The river has a mosaic of different habitats which have characteristic, associated invertebrates, resulting in a high diversity of invertebrate fauna (Bergey 2003).

**Birds:** The Oklahoma Natural Heritage Inventory conducted standard point counts,



Texas horned lizard, one of the reptiles recorded at Washita Battlefield NHS.

and recorded incidental detections, for birds at the Historic Site five times during 2001-2002. The surveys were conducted during spring/summer and fall/winter at 30 stations throughout the park. Fifty-three species were recorded during the surveys (Lomolino and Smith 2007). More recently, annual monitoring of breeding birds has been conducted by the Rocky Mountain Bird Observatory. Seventy-eight individual species, many the same as those recorded by Lomolino and Smith (2007), were observed during the surveys in 2009-2012. A number of the bird species are considered species of conservation concern by the U.S. Fish and Wildlife Service, Partners in Flight, and/or the state of Oklahoma (e.g., Dickcissel [*Spiza americana*], Lark Bunting [*Calamospiza melanocorys*], and Red-headed Woodpecker [*Melanerpes erythrocephalus*]).

### Vegetation

*Washita Battlefield NHS is located at the juncture of several ecoregions. Moisture-loving eastern species overlap the more arid southwestern species, while tallgrass prairie gives way to short-grasses. The site itself can be divided into several clear habitats: upland forest, grasslands, old field, wetlands and riparian areas. It is estimated that historically, riparian areas covered 19 acres (8 ha) of the park, while grassland dominated 316 acres (128 ha) (Hoagland et al. 2005). Baseline vegetation data was collected under drought conditions by Stotts and DuBey (1998). Their analysis suggested that the southern riparian area was the most “pristine,” the upland prairie in the southeast sector was the most ecologically healthy, and that the wooded “bench” to the north, although heavily grazed, had never been plowed (Stotts and DuBey 1998; Milner 2003).*

*The Oklahoma Biological Survey conducted a vascular flora inventory in 2002, collecting over eight months. They documented 272 species of vascular plants, 32 of which were trees, shrubs or vines. Five species tracked by the Oklahoma Natural Heritage Inventory were found: low silverbush (*Argythamnia humilis*), plains beeblossom (*Gaura brachycarpa*), cutleaf nightshade (*Solanum triflorum*), giant dropseed (*Sporobolus giganteus*), and prairie zinnia (*Zinnia grandiflora*) (Hoagland et al. 2005). Thirty-two exotic species were*

*documented, representing 11.8% of the flora collected at Washita Battlefield (Hoagland et al. 2005), several of which are listed by the State of Oklahoma as noxious weeds: Johnson grass (*Sorghum halepense*), white and yellow sweet clover (*Melilotus alba* and *M. officinale*), field bindweed (*Convolvulus arvensis*), bermuda grass (*Cynodon dactylon*), and downy brome (*Bromus mollis*).*

The Southern Plains/Chihuahuan Desert Exotic Plant Management Team has been very active at the Historic Site. They have worked to remove or control several species, and treatment maps are being developed to inform the SOPN of potential impacts to permanent grassland transects (Folts-Zettner and Sosinski 2012).

### Night Sky and Soundscape

No formal studies on the Historic Site’s night sky and soundscape have been conducted to date. Informal studies were conducted on both night sky and soundscape for this NRCA, and results are presented in subsequent chapters. Activities on land surrounding the Historic Site (e.g., highway traffic, oil and gas development and operations, and wind farm operations) have the potential to influence the soundscape and viewsheds.

### **2.2.3. Resource Issues Overview**

(Italicized text in the following section is excerpted from NPS (2009))

*The natural environment and availability of resources has impacted the lifestyles of humans who have used the area for the past 8,000-10,000 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 pronghorn antelope and bison. The landscape is a record of human relationships with the natural environment, the contrasting values of American Indians and Euroamericans, and their competition for limited resources. The continued protection and preservation of these resources contributes to our knowledge of the changing diversity of the Plains ecosystem, its biological communities and its human stories.*

## 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, and the Natural Sounds and Night Skies Program for the soundscape and night sky sections. In addition, NPScape data, developed by the I&M's Natural Resource Program Center, 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;
- 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. Washita Battlefield 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 vascular plants, mammals, reptiles, birds, and geologic resources have been completed, and monitoring on birds, exotic plants and grassland communities is currently underway.

#### Resource Stewardship Strategy

Each national park is directed 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 Washita Battlefield NHS. 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 condition are described in each indicator summary in Chapter 4. Part of SOPN's mission is to collect, manage, analyze, and report long-term ecological data to support each park in determining the status, condition, and trend of important natural resources (USDI NPS 2008b). 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, and air quality also provided a wealth of information for this NRCA.

## 2.4. Literature Cited

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**Riparian habitat  
assessment at  
Washita Battlefield  
NHS.**

## Chapter 3: Study Scoping and Design

This NRCA is a collaborative project between the Washita Battlefield NHS staff and the SOPN, both of the NPS. Stakeholders in this project include the Historic Site's natural resource 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 and agreed upon 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.

### 3.5. Preliminary Scoping

The selection of resources to assess resulted from meetings and subsequent discussions. These meetings and discussions focused on:

1. Confirming the purpose of the Historic Site and its related significance state-ments and related values.
2. Identifying important natural and cultur-al 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 partial) 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 natural resource staff participated in on-site meetings. Historic Site staff reviewed interim and final products. Historic

Site staff, I&M staff, and additional writer/editors data mined information for each assigned resource topic. For a complete list of team members, please refer to Appendix A.

### 3.6. Study Design

#### 3.6.1. 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, 11 key Historic Site 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

**Table 3.2.1-1. Final Washita Battlefield NHS Natural Resource Condition Assessment framework**

| Resource                       | Assessment Level   | Indicators and Measures                                                                                                                                                                                                                                         |
|--------------------------------|--------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| I. Landscape Condition Context |                    |                                                                                                                                                                                                                                                                 |
| Viewshed                       | Full Assessment    | <ul style="list-style-type: none"> <li>Scenic and Historic Integrity               <ul style="list-style-type: none"> <li>Intactness</li> <li>Conspicuousness of noncontributing features</li> <li>Housing density</li> <li>Road density</li> </ul> </li> </ul> |
| Night Sky                      | Full Assessment    | <ul style="list-style-type: none"> <li>Anthropogenic Light Ratio</li> <li>Zenith Sky Brightness</li> <li>Bortle Dark-Sky Scale</li> </ul>                                                                                                                       |
| Soundscape                     | Limited Assessment | <ul style="list-style-type: none"> <li>Types of sounds</li> <li>Characteristics of anthropogenic noise</li> </ul>                                                                                                                                               |
| II. Supporting Environment     |                    |                                                                                                                                                                                                                                                                 |
| Air Quality                    | Full Assessment    | <ul style="list-style-type: none"> <li>Visibility haze index</li> <li>Level of ozone</li> <li>Atmospheric wet deposition in total N and total S</li> </ul>                                                                                                      |
| Geology                        | Full Assessment    | <ul style="list-style-type: none"> <li>No indicators or measures were identified</li> </ul>                                                                                                                                                                     |
| Surface Water                  | Full Assessment    | <ul style="list-style-type: none"> <li>Physiochemistry-Core Water Parameters</li> <li>Physiochemistry-Sediment</li> <li>Biological Communities</li> </ul>                                                                                                       |
| Groundwater                    | Full Assessment    | <ul style="list-style-type: none"> <li>Change in groundwater level</li> </ul>                                                                                                                                                                                   |
| III. Biological Integrity      |                    |                                                                                                                                                                                                                                                                 |
| Vegetation                     |                    |                                                                                                                                                                                                                                                                 |
| Riparian Habitat               | Full Assessment    | <ul style="list-style-type: none"> <li>Hydrology (5 measures)</li> <li>Vegetation (7 measures)</li> <li>Erosion/deposition (5 measures)</li> </ul>                                                                                                              |
| Grasslands                     | Full Assessment    | <ul style="list-style-type: none"> <li>Hydrology Soil/Site Stability and Hydrologic Function (10 measures)</li> <li>Biotic Integrity (4 measures)</li> </ul>                                                                                                    |
| Exotic Plants                  | Full Assessment    | <ul style="list-style-type: none"> <li>Significance of impact</li> <li>Feasibility of control</li> <li>Proportion of high priority blocks infested</li> <li>Proportion of interior plots infested</li> <li>Distribution of high priority species</li> </ul>     |
| Wildlife                       |                    |                                                                                                                                                                                                                                                                 |
| Landbirds                      | Full Assessment    | <ul style="list-style-type: none"> <li>Species occurrence: temporal context</li> <li>Species occurrence: spatial context</li> <li>Species occurrence: conservation context</li> </ul>                                                                           |

to provide some context for interpreting condition.

### 3.6.2. 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 assessed to determine overall condition within the Historic Site (e.g., viewshed, air quality).

### 3.6.3. 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 and their structure, by major heading, is as follows:

The condition/trend graphic provides a visual representation of the condition and trend of the indicator(s)/measure(s). This graphic is intended to give readers a quick interpretation of the authors' assessments of condition. The written statements of condition, located under the "*Condition and Trend*" heading, provides a more in-depth description of an indicator/measure(s)' condition. Figure 3.2.3-1 shows the condition/trend scorecard used to describe each indicator/measure.

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

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

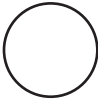
| Condition Status                                                                  |                                                                                                                                                                             | Trend in Condition                                                                |                            | 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 (unfilled) 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 and trend “scorecard”  
used in the Washita  
Battlefield NHS  
NRCA.

reader understand subsequent sections of the document.

#### Data and Methods

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

#### Reference Conditions

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

#### Condition and Trend

This section provides a summary of the condition and trend of the indicator/measure at the 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

#### Condition - Trend - Confidence



Good - Unchanging - Medium

**Figure 3.2.3-2.**  
An example of a  
condition and trend  
graphic used in  
NRCAs.

section. This provides a summary of the unknown information and uncertainties due to lack of data, literature, and expert opinion, as well as our level of confidence about the presented information.

#### Sources of Expertise

Individuals who were consulted for the 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.

### **3.7. 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.



## 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 Washita Battlefield 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/<br>Methods | Condition |
|--------------------------------|-----------------------------------------------------------------------|-------------------------|-----------|
| I. Landscape Condition Context |                                                                       |                         |           |
| Viewshed                       | Scenic and Historic Integrity                                         | 23                      | 31        |
|                                | Intactness                                                            | 24                      | 31        |
|                                | Conspicuousness of noncontributing features                           | 25                      | 32        |
|                                | Housing density                                                       | 28                      | 32        |
|                                | Road density                                                          | 28                      | 32        |
| Night Sky                      | Anthropogenic Light Ratio                                             | 38                      | 41        |
|                                | Zenith Sky Brightness                                                 | 39                      | 41        |
|                                | Bortle Dark Sky Scale                                                 | 39                      | 41        |
| Soundscape                     | Types of sounds                                                       | 49                      | 51        |
|                                | Characteristics of anthropogenic noise                                | 49                      | 52        |
| Air Quality                    | Visibility haze index                                                 | 59                      | 61        |
|                                | Level of ozone                                                        | 60                      | 61        |
|                                | Atmospheric wet deposition in total N and total S                     | 60                      | 61        |
| Geology                        | No indicators or measures were identified                             |                         |           |
| Surface Water Quality          | Physiochemistry-Core Water Parameters                                 | 75                      | 77        |
|                                | Physiochemistry-Sediment                                              | 75                      | 77        |
|                                | Biological Communities                                                | 75                      | 77        |
| Groundwater                    | Change in groundwater level                                           | 83                      | 84        |
| III. Biological Integrity      |                                                                       |                         |           |
| Vegetation                     |                                                                       |                         |           |
| Riparian Habitat               | Hydrology (5 indicators)                                              | 91                      | 95        |
|                                | Vegetation (7 indicators)                                             | 92                      | 98        |
|                                | Erosion/deposition (5 indicators)                                     | 93                      | 99        |
| Grasslands                     | Hydrology Soil/Site Stability and Hydrologic Function (10 Indicators) | 107                     | 112       |
|                                | Biotic Integrity (5 indicators)                                       | 107                     | 112       |

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

| Resource               | Indicator                                   | Description/<br>Methods | Condition |
|------------------------|---------------------------------------------|-------------------------|-----------|
| Vegetation (continued) |                                             |                         |           |
| Exotic Plants          | Significance of impact                      | 120                     | 123       |
|                        | Feasibility of control                      | 120                     | 123       |
|                        | Proportion of high priority blocks infested | 120                     | 126       |
|                        | Proportion of interior plots infested       | 121                     | 126       |
|                        | Distribution of high priority species       | 122                     | 126       |
| Wildlife               |                                             |                         |           |
| Landbirds              | Species occurrence: temporal context        | 138                     | 144       |
|                        | Species occurrence: spatial context         | 138                     | 145       |
|                        | Species occurrence: conservation context    | 138                     | 145       |

## 4.1. Viewshed

### Indicators/Measures

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

### Condition - Trend - Confidence Level



Moderate – Deteriorating - 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 still required to protect scenic and viewshed quality as one of their most fundamental resources. According to Biel (2005), aesthetic conservation, interchangeably used with scenic preservation, has been practiced in the NPS since the early twentieth century. Aesthetic conservation strove to protect scenic beauty for park visitors to better experience the values of the park. The need for scenic preservation management is as relevant today as ever, particularly with the pervasive development pressures that challenge park stewards to conserve scenery today and for future generations.

The site protects and interprets the setting along the Washita River where Lt. Col. George A. Custer led the 7<sup>th</sup> U.S. Cavalry on a surprise dawn attack against the Southern Cheyenne winter camp of Peace Chief Black Kettle on November 27, 1868. Both Black Kettle and his wife, Medicine Woman Later, were killed at the site along with 30-60 Cheyenne. It is also the “pony kill site” where an estimated 800 Cheyenne horses were slaughtered by the Cavalry upon Custer’s command. The Cavalry then burned the Cheyenne lodges with all their winter supply of food and clothing. The attack was an important event in the tragic clash of cultures of the Indian Wars era. Within this context, the cultural landscapes and viewshed have been identified as one of the fundamental resources and values for the site (NPS 2012).

#### 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



PHOTO CREDIT: KRIS JOHNSON

View from near the visitor overlook at Washita Battlefield National Historic Site.

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 the battle on the Washita River. Visualizing the battle as it may have played out on the landscape is a critical part of the visitor experience (Figure 4.1.1-1).

The Washita Battlefield Cultural Landscape Report (John Milner Associates 2003) states regarding views of the village in the floodplain:

“Views into this area are the most significant in the park. The visibility of this area from surrounding high grounds played a strategic role in the historic battle as 7th Cavalry soldiers (including Custer who commanded from a nearby knoll) took positions

here to begin the assault on the village. Views into this area are not only historically significant, they are also a principal focus of the park’s Overlook—a primary point of visitor contact. Views into this area should give visitors a sense of the 1868 landscape.”

#### 4.1.2. Data and Methods

Viewsheds are considered in this assessment within two interrelated contexts: natural scenic integrity and historic integrity. Impacts that degrade one aspect likely degrade the other as well. For example, modern structures or roadways visible on the landscape not only detract from the natural scenic integrity of the viewshed, but also diminish the sense of place that a historically authentic landscape evokes. Depending on the context, scenic and historic integrity may be distinct, or there may be so little practical difference that they are the same. In the case of Washita Battlefield 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.



Figure 4.1.1-1. One of the values of a viewshed, particularly one with such historic significance, is the potential to visualize that site as it once might have been to gain a “sense of place” in that historic context.

## Indicators/Measures

### Scenic and Historic Integrity

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

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

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

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

the assessment by providing the spatial orientation of key features.

### Ground-based Measures of Integrity from Specific Vantage Points

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

#### *Viewshed Vantage Point*

There is one main vantage point within the Historic Site used in this analysis, the Overlook (Figure 4.1.2-1). There are other vantage points throughout the Historic Site that provide views that are important to the story of Washita, but these do not receive the high level of visitation as does the observation point. This does not imply that these alternative views do not warrant management consideration, quite the contrary. It merely implies that for practical reasons, we focused our assessment on the view most likely to be seen by visitors, with recognition that there are other important views.

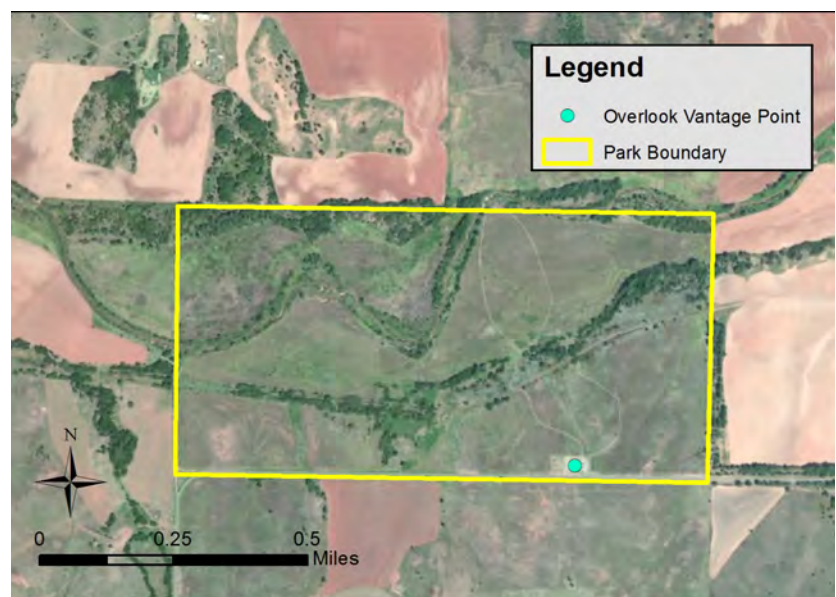


**Figure 4.1.2-1.** The key vantage point (overlook) used in this assessment .

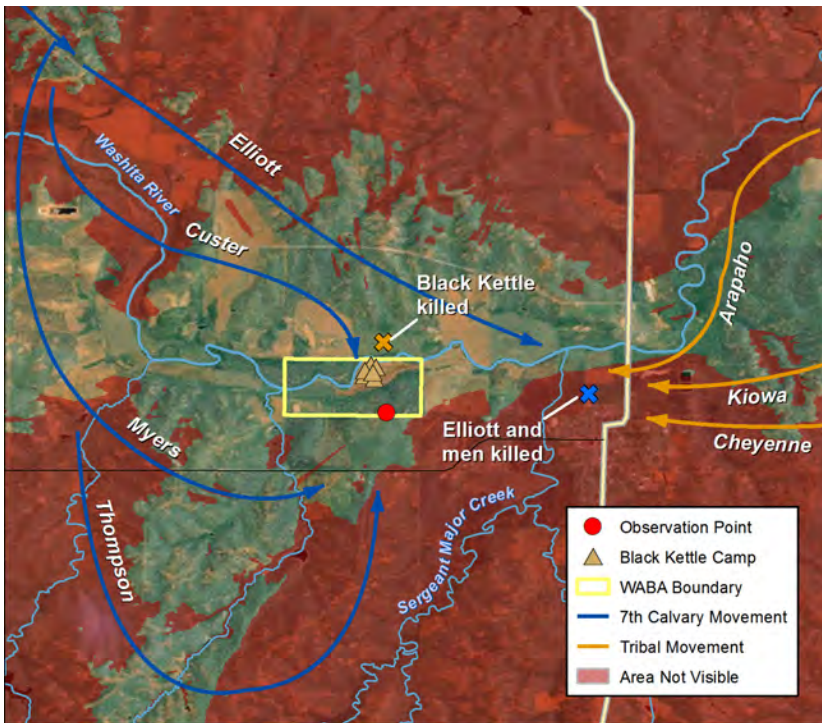


**Figure 4.1.2-2. Prominent contributing historic features within view of one or more key vantage point.**

This site receives high visitation and the views from this point plays a major role in the experience of visitors, both for the scenic quality as well as the historic context.

The Overlook is the most visited location within the site and its views are intended to capture both the scenic and historic quality of the site. This vantage point provides views of the encampment and massacre sites, and the cavalry's approach (Figure 4.1.2-2).

We used a series of panoramic images to portray the viewshed from an observer's perspective from the vantage point. These images were taken using a Canon PowerShot digital camera and the GigaPan Epic 100 system, a robotic camera mount coupled with stitching software (Figure 4.1.2-3). A series

of images are automatically captured and the individual photographs are stitched into a single high-resolution panoramic image.

Normally, panoramic images are shot in all four directions for a 360 degree analysis of the viewshed. In the case of Washita Battlefield NHS, the views to the south and east were too limited (Figure 4.1.2-4), and just the views to the north and west were analyzed. These photographs provided a means of illustrating the indicators related to viewshed integrity.

### Indicators/Measures

#### Intactness

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

We 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 to prefer natural over human-modified landscapes (Zube et al. 1982, Kaplan and Kaplan 1989, Sheppard 2001, Kearny et al. 2008, Han 2010). We believe this is especially true of visitors to national parks. Therefore, natural appearance or a rural setting is considered consistent with the goals of scenic integrity; and obvious, human-altered components of the landscape (e.g., roads, buildings, powerlines, and other features) are considered to detract from the scenic and historic character of the viewshed.



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

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

### Indicators/Measures

#### Conspicuousness of Noncontributing Features

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

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



**Figure 4.1.2-4. Views to the south (top) and east (bottom) had limited value for viewshed analysis.**

assessments using distance zones or classes often define three classes: foreground, middle ground, and background (Figure 4.1.2-5). 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 variation among vegetation patches, or some level of distinguishing clusters of tree boughs.

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

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



Figure 4.1.2-5. An example of approximate distance classes used in this assessment.

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 Washita Battlefield NHS as belonging to one of six size classes (Table 4.1.2-2), which reflect the preference groups reported by studies. Using some categories of perhaps mixed measures, we considered size

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

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

classes within the context of height, volume, and length.

*Color and Shape*—Studies have shown that how people perceive a human-made feature in a rural scene depends greatly on how well it seems to fit or blend in with the environment (Kearney et al. 2008, Ryan 2006). For example, Kearney et al. (2008) found preferences for homes that exhibit lower contrast with their surroundings as a result of color, screening vegetation, or other blending factors (see Figure 4.1.2-6). 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

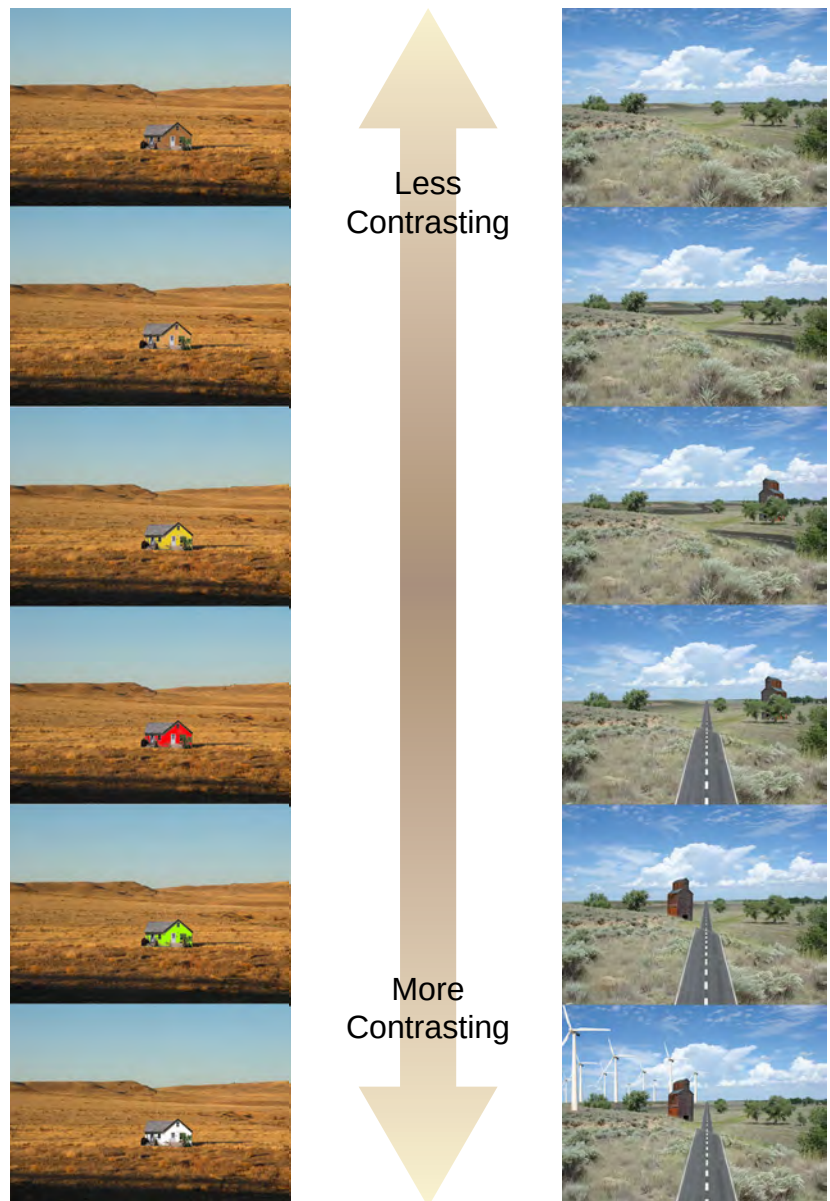


**Figure 4.1.2-6. Graphic illustration of how color (left) and shape (right) can influence whether features are in harmony with the environment, or are in contrast.**

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

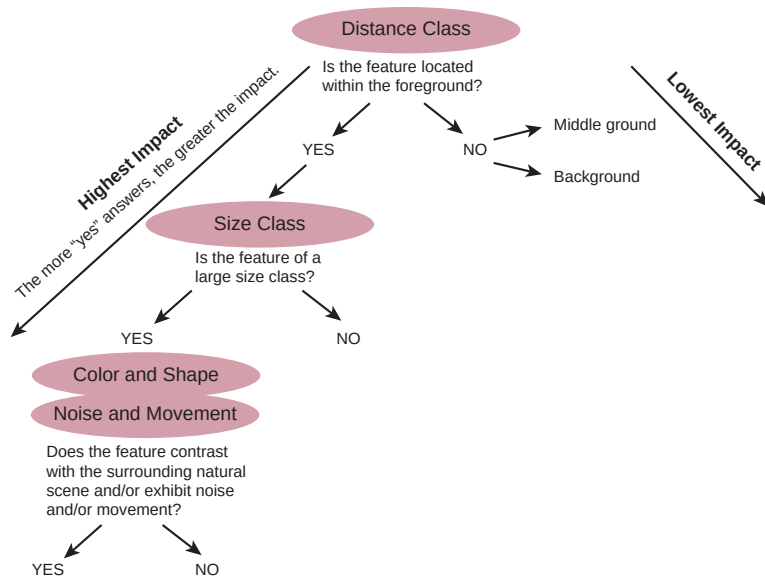


**Figure 4.1.2-7. Conceptual framework for hierarchical relationship of characteristics that influence the conspicuousness of features within a viewshed.**

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 4.1.2-7).

## GIS-based Analyses and Measures

### *GIS Viewshed Analyses*

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

### **Indicators/Measures**

#### *Housing and Road Densities*

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

### *Potential Visibility of Wind, Oil & Gas Facilities*

Because wind farms are rapidly increasing as well as oil and gas developments, we also used the GIS viewshed analysis to estimate the increased visibility of such structures that may stand high on the landscape. The current standard for wind turbine towers is 263 ft (80 m), not including the turbine blades, which add an additional 38.5 m (U.S. Department

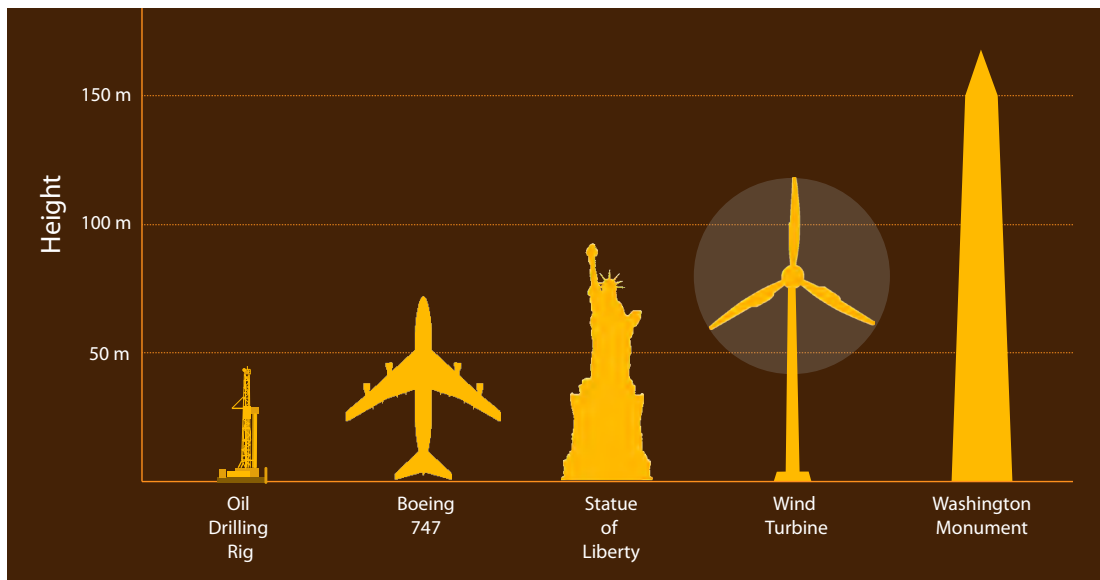


**Figure 4.1.2-8. The relative height of oil and gas drilling rigs and wind towers in relation to familiar objects or structures (adapted from U.S. Department of Energy 2013).**

of Energy 2013) (Figure 4.1.2-8). Thus, we estimated the area that would be visible if structures were 80 or 118.5 m high. For oil and gas development, the drilling structures, although temporary, would typically be 140 ft (43 m) for a 1200 horsepower, triple mast rig likely to be used in this area (Pat O'Dell, NPS Petroleum Engineer, pers. comm.). Thus, we also estimated the area that would be visible if structures were 43 m high.

#### 4.1.3. Reference Conditions

The basis for determining condition in an assessment such as this is a comparison

between current condition and some reference. For Washita Battlefield NHS we used a qualitative reference state for the scenic and historic integrity of the viewshed (Table 4.1.3-1).

As previously discussed, the scenic and historic integrity at Washita Battlefield 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 massacre (1868).

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

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

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

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

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

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

Washita Battlefield NHS was established to “recognize the importance of the Battle of the Washita as a nationally significant element of frontier military history and as a symbol of the struggles of the Southern Great Plains tribes to maintain control of their traditional use areas.” (Public Law 104-333). Three purposes for the site are identified as: (1) to recognize the attack by Lt. Col. George Armstrong Custer and the 7<sup>th</sup> U.S. Cavalry on the Cheyenne encampment of Chief Black Kettle as a nationally significant element of the United States government Indian policy; (2) to recognize the struggles of the Cheyenne and other Southern Great Plains tribes to maintain control of their traditional homelands; and (3) to protect, preserve and interpret the cultural and natural resources of the Historic Site through the collaborative efforts of the United States government and the Cheyenne-Arapaho Tribe (National Park Service 2001).

Natural landforms and ecological communities greatly influenced the tactical aspects and outcome of the battle and are important aspects to the viewshed. These natural features contribute to visitor

understanding and appreciation of the site and historical events.

Intactness is intended to convey something about the proportion of the visible landscape that has preserved its naturalness relative to that 1868 landscape. The four qualitative condition classes we used from intactness are presented in Table 4.1.3-2.

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

**Table 4.1.4-1. Summary of primary noncontributing features and viewshed condition assessed at the vantage point.**

| Vantage Point | Noncontributing Features                                                                                                                                                                                                              | Assessment                                                                                                                                                                                                                                                                                                                                                                                                                            | Condition |
|---------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------|
| Overlook      | <ul style="list-style-type: none"> <li>• Highway spur</li> <li>• Agricultural fields &amp; fences</li> <li>• Wind turbines</li> <li>• Granary</li> <li>• Oil and gas development, rigs</li> <li>• Power poles, cell towers</li> </ul> | The views from the overlook are of moderate scenic and historic integrity. Views toward the north and west are largely natural vegetation in the foreground, agricultural features in the middle ground, and more of the noncontributing features in the background. Views from the south and east are limited, but what is visible are prominent noncontributing features such as roads, wind turbines, and oil and gas development. | Moderate  |

**Figure 4.1.4-1. Panoramic views looking north (above, top two frames) and west (above, lower two frames) from the overlook vantage point.**

#### 4.1.4. Condition and Trend

##### Ground-based Assessment

Overall, the scenic and historic integrity of the viewsheds at Washita Battlefield NHS is in moderate condition. Although the landscape is primarily a rural setting, noncontributing features such as oil and gas development and wind turbines are becoming prominent features within the viewshed.

##### *Assessment from the Overlook Vantage Point*

We considered the condition of the view from the overlook to be moderate (Table 4.1.4-1). Views to the north and west (Figure 4.1.4-1) are dominated by natural features

in the foreground (except for some park infrastructure surrounding the overlook site itself); agricultural influences are evident in the middle ground; and more noncontributing features (towers, for example) intrude somewhat in the middle ground and are visible in the background.

Although views to the south and east are quite limited (due to topography), what is visible is dominated by noncontributing features such as wind turbines, oil and gas development infrastructure, and the main road (Figure 4.1.4-2). As wind farms and oil and gas development expand, the viewshed will continue to deteriorate.



**Figure 4.1.4-2.** Views to the south (upper image) are quite limited, but what is visible from that view is dominated by noncontributing features along with views to the northwest (lower image) that distract from the natural and historical integrity of the site.

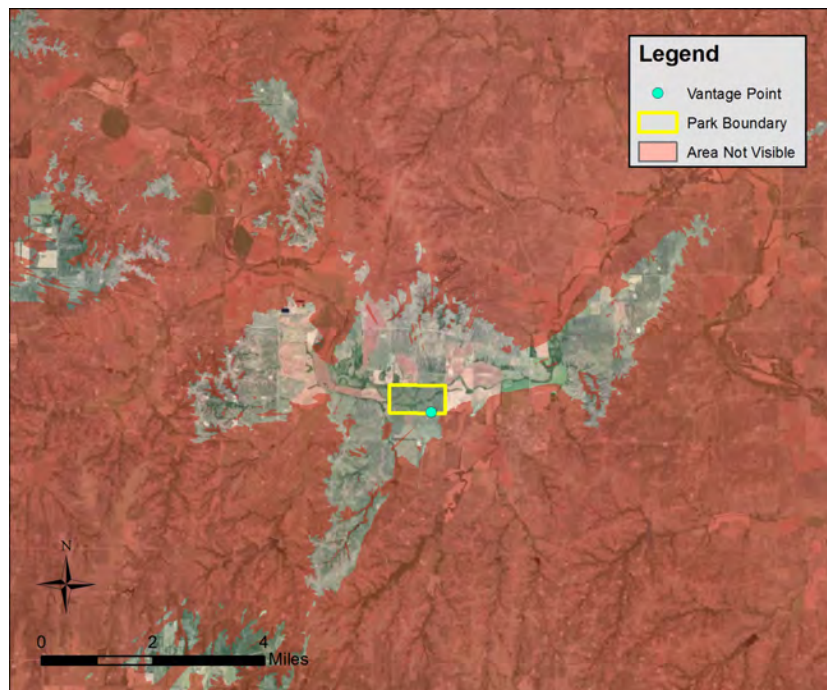


**Figure 4.1.4-3.** Area visible and not visible from the vantage point.

#### GIS-based Assessment

We began our GIS-based assessment by modeling the areas visible or not visible from the vantage point. At the overlook, most of the visible area lies to the northwest looking over the battle site (Figure 4.1.4-3).

**Table 4.1.4-2.** The estimated area visible from the vantage point and the percentage increase of that area due to height of the feature.

| Feature                                | Visible Area (km <sup>2</sup> ) | % Increase in Visible Area |
|----------------------------------------|---------------------------------|----------------------------|
| Base                                   | 87                              | n/a                        |
| Oil - 43 m                             | 472                             | 443%                       |
| Wind Turbine (Tower Only) - 80 m       | 887                             | 920%                       |
| Wind Turbine (Tower + Blade) - 118.5 m | 1300                            | 1394%                      |

It is important to keep in mind that these estimates of visible area are approximations based on Digital elevation 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.

#### *Visibility of Wind Farms or Oil and Gas Development*

Based on our analyses, the height of non-contributing features such as wind turbines and oil and gas drilling rigs (Table 4.1-4-2) (Figure 4.1.4-4) can substantially increase the area from which they are visible. For wind turbines, the height of the tower itself increases the area from which it would be visible by 918%. Taking into account the blades as well as the tower increases the area from which it would be visible by 1391%. The effect of oil and gas drilling rigs was considerably less, but still increases the area from which it would be visible by 441%.

#### *Housing and Road Densities*

Based on the data compiled in NPScape (Budde et al. 2009 and Gross et al. 2009), housing densities surrounding the Historic Site are relatively low, with 44.8% of the square km units being undeveloped and >89% of the area with a housing density less than 1.5 units/square kilometer (Table 4.1.4-3, Figure 4.1.4-5).

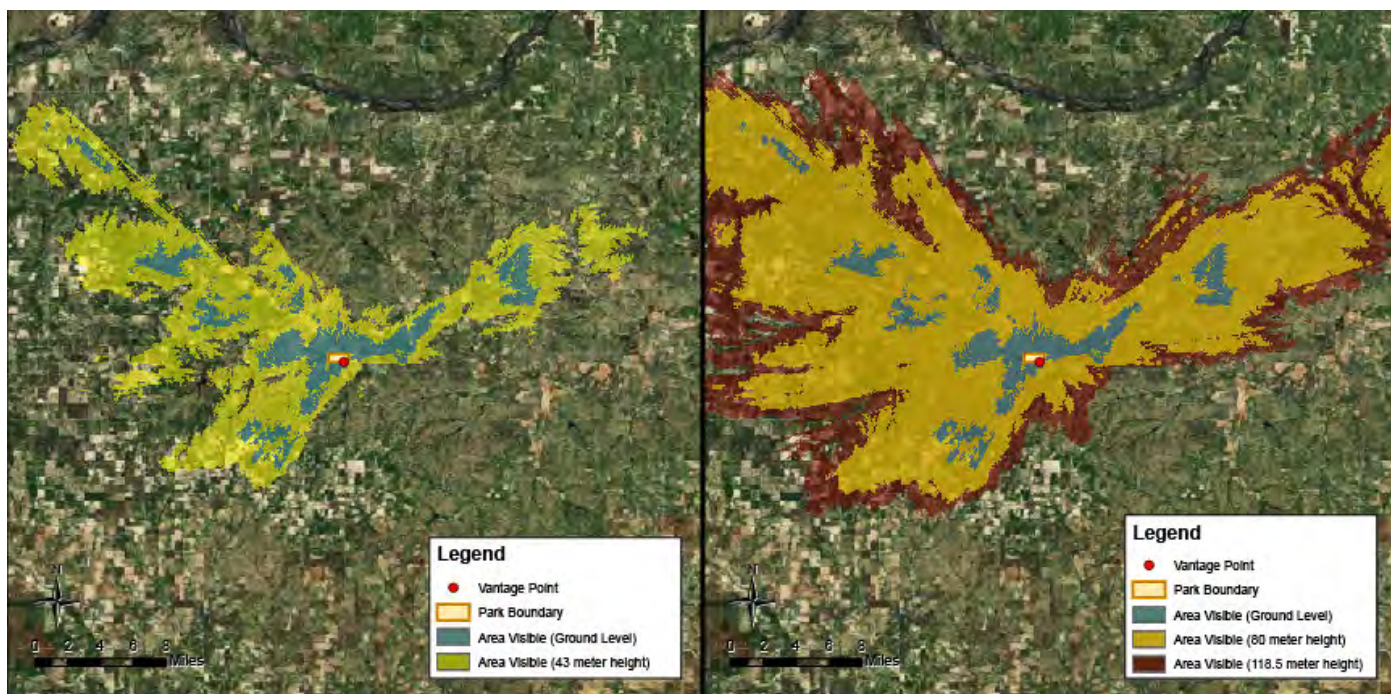


Figure 4.1.4-4. Area visible and not visible from the vantage point. Also shown is the area from which 43 m oil drilling rigs would be visible (left) and from which wind turbines would be visible (right).

Table 4.1.4-3. Housing and road densities within 30 km of Washita Battlefield NHS in 2010 as estimated using NPScape (Budde et al. 2009 and Gross et al. 2009).

| Density Class                        | Area (km <sup>2</sup> ) | Percent |
|--------------------------------------|-------------------------|---------|
| <b>Housing Densities</b>             |                         |         |
| Private undeveloped                  | 1331.56                 | 44.8%   |
| < 1.5 units / km <sup>2</sup>        | 1314.53                 | 44.3%   |
| 1.5 - 6 units / km <sup>2</sup>      | 119.38                  | 4.0%    |
| > 6 units / km <sup>2</sup>          | 13.51                   | 0.5%    |
| Commercial / Industrial              | 0.13                    | 0.0%    |
| No Data                              | 191.19                  | 6.4%    |
| <b>Road Densities</b>                |                         |         |
| 0.015 - 1.125 km / km <sup>2</sup>   | 1145                    | 38.5%   |
| 1.126 - 2.287 km / km <sup>2</sup>   | 1025                    | 34.5%   |
| 2.288 - 4.982 km / km <sup>2</sup>   | 129                     | 4.4%    |
| 4.983 - 13.49 / km / km <sup>2</sup> | 6                       | 0.2%    |
| No Data                              | 670                     | 22.5%   |

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

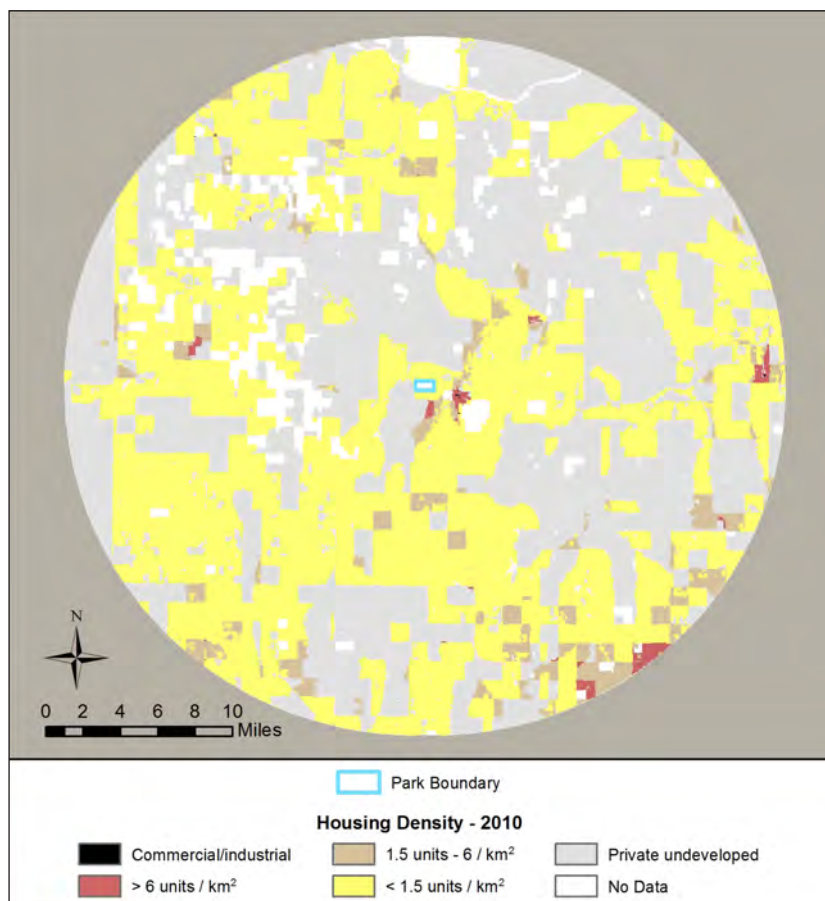


Figure 4.1.4-5. Housing densities (housing units/km<sup>2</sup>) within 30 km of Washita Battlefield NHS based on data compiled in NPScape (Budde et al. 2009 and Gross et al. 2009).

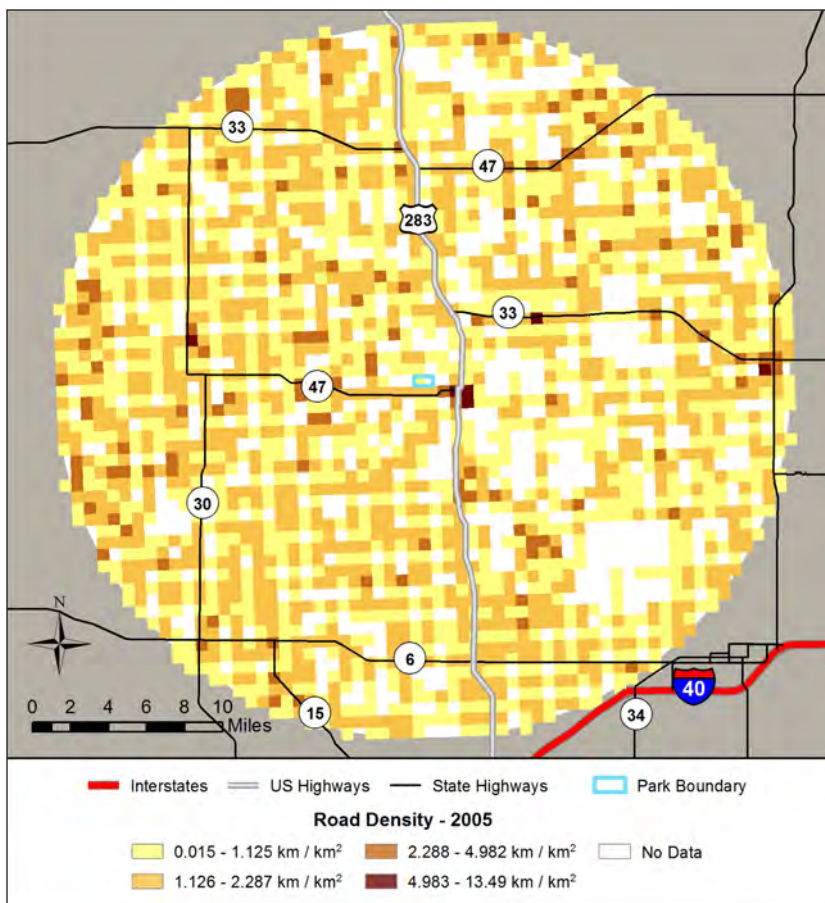


**Figure 4.1.4-6. Road densities (km of roads/km<sup>2</sup>) within 30 km of Washita Battlefield NHS based on data compiled in NPScape (Budde et al. 2009 and Gross et al. 2009).**

Road densities were somewhat higher, but also relatively low (Table 4.1.4-3) (Figure 4.1.4-6), with nearly 73% surrounding the Historic Site having <3 km of roads per square km. Roads surrounding the site are a mixture of highway and state routes.

The low densities of housing supports an assessment of good condition, however, the prominence of noncontributing features and higher road density contributed to an assessment of condition of moderate concern.

#### Overall Condition

Based on this assessment, the viewshed condition at Washita Battlefield NHS is considered moderate (Table 4.1.4-4). The prominent oil rigs and wind turbines dominate the viewshed in several directions and detract significantly from the site's sense of place.

#### **4.1.5. Sources of Expertise**

For assessing the condition of this resource, we relied primarily on literature on this topic.

#### Key Uncertainties

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

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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**Table 4.1.4-4. Summary of the viewshed indicators and their contributions to the overall Natural Resource Condition Assessment.**

| Indicator                     | Measure                                     | Description of How the Indicator Contributes to the Overall Resource Condition                                                                                                                                                                                                                                                                                                    | General Contribution of this Indicator to the Overall Resource Condition                                                                                                                                                                                                                                                                                                                                                                                                |
|-------------------------------|---------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Scenic and Historic Integrity | Intactness                                  | Intactness is measured by ground observation from key vantage points using panoramic images. 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.                                         | Overall, the scenic and historic integrity of the viewsheds at Washita Battlefield National Historic Site is in moderate condition. The landscape surrounding Washita Battlefield NHS is a rural setting, however, noncontributing features such as oil rigs and wind turbines significantly degrade the viewshed. While some views (to the north and west) are in better condition, overall the viewshed is compromised by the prominence of noncontributing features. |
|                               | Conspicuousness of Noncontributing Features | The conspicuousness of noncontributing features is measured by ground observation from key vantage points using panoramic images. For this measure, we focused on four 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. |                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |
|                               | Housing Density                             | Housing density is measured from an aerial perspective using GIS representation. Roads and houses are typically the most common noncontributing features within rural landscapes. Thus, we used data provided by NPScape to provide estimates of road and housing densities within the vicinity (approximately 30 km) of the Historic Site.                                       | Based on the data compiled in NPScape. Housing densities surrounding the Historic Site are relatively low, with >95% of the square km units with known densities being less than 1.5 units/km <sup>2</sup> , indicating good condition.                                                                                                                                                                                                                                 |
|                               | Road Density                                | Road density is measured from an aerial perspective using GIS representation. Roads and houses are typically the most common noncontributing features within rural landscapes. Thus, we used data provided by NPScape to provide estimates of road and housing densities within the vicinity (approximately 30 km) of the Historic Site.                                          | Road road densities were somewhat higher than housing density, but also relatively low, with nearly 73% surrounding the Historic Site having <3 km of roads per square km. Roads surrounding the site are a mixture of highway and state routes.                                                                                                                                                                                                                        |

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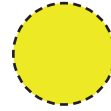
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## 4.2. Night Sky

### Indicators/Measures

- Anthropogenic Light Ratio
- Zenith Sky Brightness
- Bortle Dark-Sky Scale

### Condition - Trend - Confidence Level



Moderate - Insufficient Data - Low

#### 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).

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

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

natural light/darkness regime will disturb the normal routines of many plants and animals (Royal Commission on Environmental Pollution 2009), as well as diminish stargazing recreational opportunities offered to national park visitors.

Washita Battlefield 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 Historic Site is a memorial to the attack by Lt. Col. George Custer and the 7<sup>th</sup> United States Cavalry on the Cheyenne camp of Peace Chief Black Kettle. The Plains Tribes were nomadic and closely followed the seasons, the movement of the sun, and the night sky. Much of their culture was shaped by celestial observation. The cavalry must have also been aware of celestial cycles because during the time of the battle (November 27, 1868) NASA estimates that there was a new moon (NASA 2012). It would have been very dark that night as the cavalry silently crept through the snow for the attack.

For the Cheyenne, winter was the time of the year for storytelling, as families gathered together in the evenings. One Cheyenne story called The Quillwork Girl and her Seven Brothers is about a girl and her brothers who escape a monster buffalo to live in the sky, and become the constellation Pleiades (McHenry 2012). Stories about constellations are often about families or siblings who stay together in the sky (Moroney 2011). Below is another story about the origin of stars that seems relevant to the Washita River and the windy plains of Oklahoma (McHenry 2012):

The Arapaho and the Cheyenne believed that everything came from

the earth, even the stars in the sky. They would travel around underneath the ground until they found the roots of the magical cottonwood tree. They would climb up inside the tree's roots, into the trunk, and out into the branches where they would hide.

One night, the spirit of the night sky looked around and thought, "I don't have enough stars. I want more stars!" So the spirit of the night sky called down to the spirit of the wind and asked for more stars. The spirit of the wind knew that the stars were hiding in the branches of the cottonwood tree, so the spirit of the wind started to blow, and blew harder and harder until the wind blew so hard that the branches of the cottonwood tree broke off right where the stars were hiding. The stars came flying out and up into the night sky.

This is how the Arapaho and Cheyenne believed stars got into the night sky. Find a stick under the cottonwood tree and break it right where the rings are. Look inside to find a five point star shadow right where the stars were hiding!

Protecting the night sky resources at Washita Battlefield NHS benefits the natural resources, is important for visitor experience, and has cultural and historical significance.

#### 4.2.2. Data and Methods

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

Based on new guidance (Moore et al. 2013), the NPS Natural Sounds and Night Skies Division recommends that the all-sky Anthropogenic Light Ratio (ALR) is the best single parameter for characterizing the overall

sky condition. Additional indicators and measures may be considered in an assessment of night sky condition, but the ALR measure is the primary data source for condition assessment.

We conducted a supplemental rapid assessment of the Historic Site's night sky condition on September 10, 2012, using quantitative (Sky Quality Meter) and qualitative (Bortle Dark Sky Scale) assessments commonly used by amateur astronomers to evaluate the potential quality for star gazing. This rapid assessment is supplementary and interim until a more rigorous assessment is completed by the NPS Night Skies Program.

#### Indicators/Measures

- 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 Washita Battlefield 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

- Zenith Sky Brightness

Sky brightness describes the amount of light in the night sky. One method of assessing sky brightness uses a Unihedron Sky Quality Meter (SQM) that samples the night sky in a broad spectrum band roughly corresponding to the entire human visual range. The SQM measures an aggregate average brightness for the entire sky that is skewed to zenith brightness over an 80 degree field of view (Moore 2012). Readings were taken at the Washita Battlefield overlook within Washita Battlefield NHS starting about an hour and fifteen minutes to an hour and a half after sunset.

#### Indicators/Measures

- 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 4.2.2-1). The Bortle scale uses both stellar objects and familiar descriptors to distinguish among the different classes. Another advantage of the Bortle scale is that it is suitable for conditions ranging from the darkest skies to the brightest urban areas (Moore 2001, Figure 4.2.2-1).

#### 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.

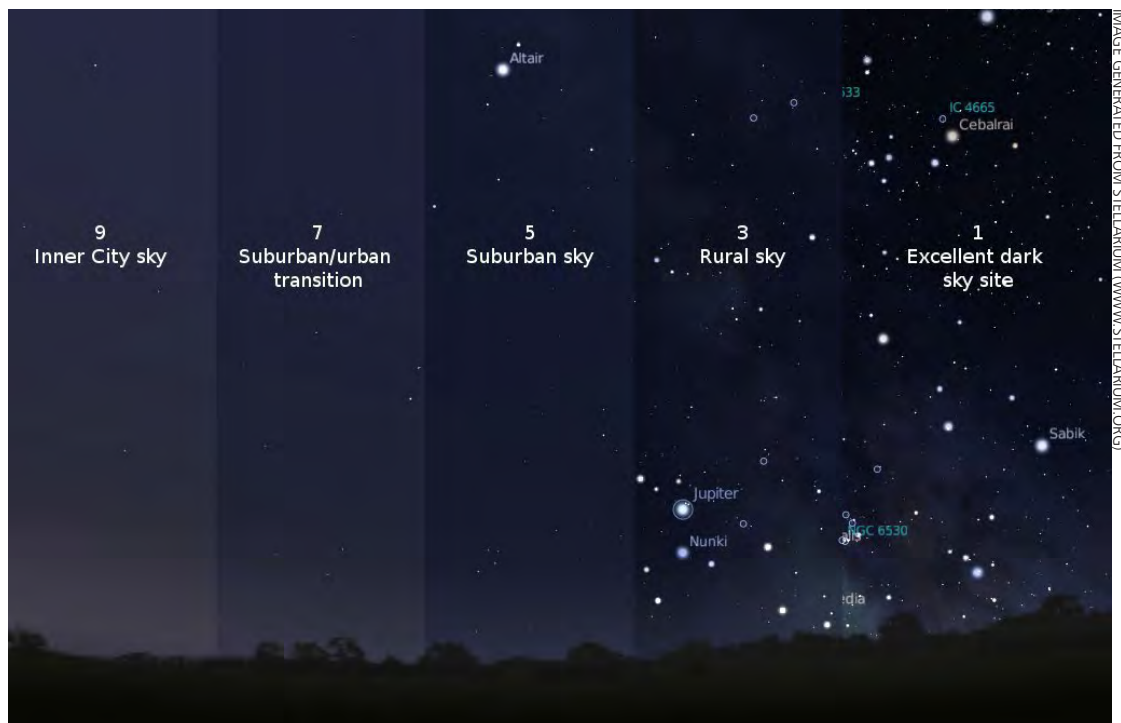


Figure 4.2.2-1. Composite image illustrating the range of night sky conditions based on the Bortle Dark Sky Scale.

**Table 4.2.2-1. Bortle Dark Sky Scale\***

| Bortle Scale                          | Milky Way (MW)                                                                                                 | Astronomical Objects                                                                                                                                         | Zodiacal Constellations                                                                   | Airglow and Clouds                                                                                                                                  | Nighttime Scene                                                                                                      |
|---------------------------------------|----------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------|
| Class 1<br>Excellent<br>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<br>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<br>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<br>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<br>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<br>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<br>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<br>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<br>Inner City Sky             | MW not visible                                                                                                 | Only the Pleiades are visible to all but the most experienced observers                                                                                      | Only the brightest constellations are discernible                                         | Clouds are brilliantly lit                                                                                                                          | Entire sky background has a bright glow, ground is illuminated                                                       |

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

**Table 4.2.3-1. Night sky condition class summary.**

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

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

#### 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).

#### Zenith Sky Brightness

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

The maximum night sky brightness is often found within the Milky Way of a natural sky. A typical measurement from the Sagittarius region of the Milky Way in a natural sky yields 19.2 msa. Other regions of the Milky Way are somewhat dimmer, or around 20.0-21.0 msa. A value brighter than 19.0 msa will result in impairment to human night vision and may

be noticeable by casting faint shadows or causing glare. A value lower (brighter) than 17.0 represents very bright areas of the night sky and would significantly impair human night vision and cast obvious shadows. Values for the brightest portion of the sky are of interest to the NPS because they represent unnatural intrusions on the nightscape, will prevent human dark-adapt vision, and may have effects on wildlife (Duriscoe et al. 2007).

#### 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). 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 conditions may be restored toward a more natural state by modifying outdoor lighting, depending on the surrounding conditions that exist outside the park.

#### **4.2.4. Condition and Trend**

Although no ground-based readings have yet been taken, modeling conducted by the NPS Night Sky Program indicate an ALR of 0.40 for the Historic Site. The models have a somewhat larger error than the ground-based measurement ( $\pm 0.1$  ALR), which indicates the condition of the night sky is right on the edge of good and moderate. For this reason, until further investigation can be made, our

confidence in this condition rating is low and should be considered provisional.

A supplementary rapid assessment was conducted at Washita Battlefield NHS. Bortle class assessments and SQM readings were made at the battlefield overlook within the park. Two SQM readings were taken (about 15 minutes apart) and the middle values were 20.83 and 20.93 msa indicating condition of significant concern, primarily due to the nearby lights (see Table 4.2.4-1). The Bortle Scale assessment was rated a 4 (see Table 4.2.4-1). This indicates moderate condition.

#### Local and Regional Context

Washita Battlefield NHS is located between Amarillo, Texas and Oklahoma City, Oklahoma just outside of the town of Cheyenne, Oklahoma. Cheyenne is a small town with a population of approximately 800 people (U.S. Census Bureau 2010). The park is relatively small, and roads, farm buildings, and oil and gas development are visible from the park and influence the night sky. The proximity of the lighting on the oil and gas rigs probably contributed most to the low-quality sky brightness measures. Being so close to the town of Cheyenne, a light dome is visible at the park (Figure 4.2.4-1).

Cheyenne is about 153 miles from Amarillo, Texas (population of approximately 175,250) and 258 miles from Oklahoma City, Oklahoma (estimated population of 599,199) (U.S. Census Bureau 2012; Figure 4.2.4-2).

#### Overall Condition

For assessing the condition of the night sky, we used a rapid assessment of a qualitative indicator (Bortle Dark Sky Scale) and quantitative measure (sky brightness). These indicators are summarized and interpreted in Table 4.2.4-2. Overall, the Historic Site's night sky is in moderate condition.

#### Uncertainties

The Bortle Dark Sky Scale and sky brightness estimates have inherent uncertainties and error. The principle drawback of the Bortle Scale is that it relies upon human visual observers. Differences in visual acuity, experience and knowledge, as well as time and effort expended can influence the estimates (Bortle 2001, Moore 2001). The sky brightness measures taken with the SQM suffers similar operator bias based on the level of experience in using the SQM and assessing the surrounding conditions. These readings should be interpreted as interim until the CCD camera system and measurement of night sky brightness can be employed. While

**Table 4.2.4-1. Summary of night sky indicators and measures, and assessment of night sky condition at Washita Battlefield National Historic Site.**

| Indicator                 | Location                     | Measure        | Interpretation                                                                                                                                                                                                                                                                                                                                                                                 | Condition              |
|---------------------------|------------------------------|----------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------|
| Anthropogenic Light Ratio | Modeled                      | 0.40           | This measure results from modeling conducted by the NPS Night Sky Program. No ground-based measurement has been collected.                                                                                                                                                                                                                                                                     | Moderate               |
| Zenith Sky Brightness     | Washita Battlefield Overlook | 20.83<br>20.93 | An almost continuous array of faint light domes were visible to the south (probably from Amarillo to the SW extending east to Elk City). One light dome (Cheyenne, OK) was approximately twice the brightness of the Milky Way and extended approximately 15 degrees from the horizon. Additional light pollution was contributed by surrounding oil and gas operations and other development. | Of Significant Concern |
| Bortle Scale Class        | Washita Battlefield Overlook | 4              | Although the Milky Way was visible almost from horizon to horizon (except about 10-15 degrees from the southern horizon), it appeared uniform and lacking detail. The ground was mostly dark with no visible shadow from the Milky Way.                                                                                                                                                        | Moderate               |



ROB BENNETT'S

**Figure 4.2.4-1.**  
Light dome created  
from Cheyenne, OK.

the CCD system is highly precise, it can also be affected by vagaries in the atmosphere and in fluctuations in natural night sky brightness. Research is underway to minimize the influences of these factors upon the quantification of artificial light; and existing data can eventually be post-processed to this new standard (C. Moore, NPS, pers. comm.).

#### 4.2.5. Sources of Expertise

Chad Moore, 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

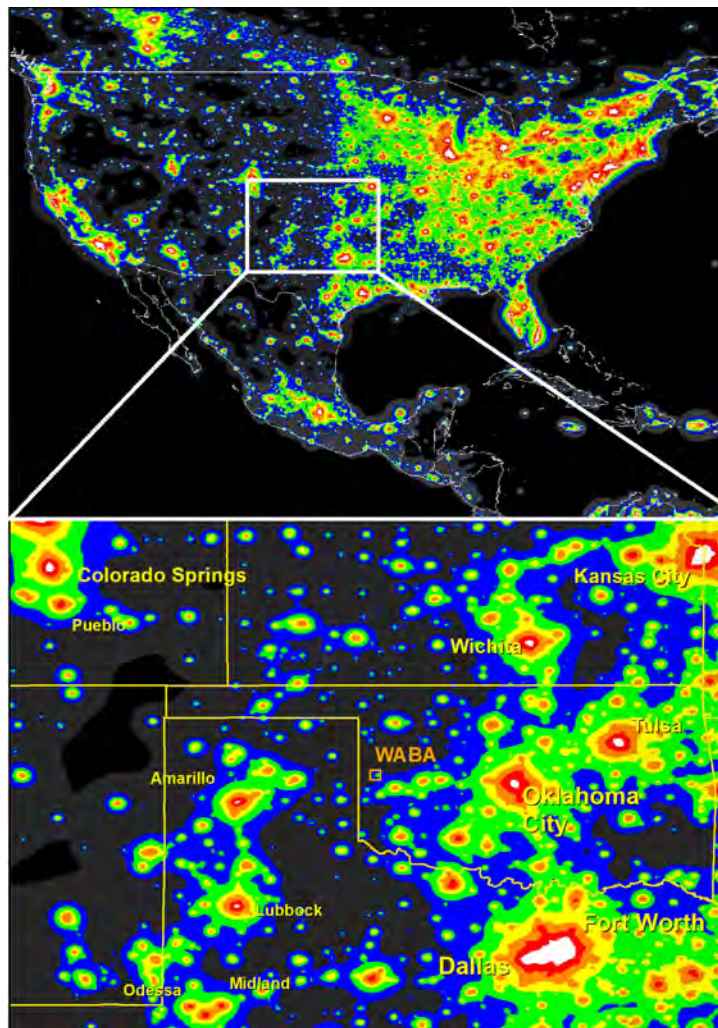


**Figure 4.2.4-2.**  
Artificial brightness  
in North America  
and the location of  
Washita Battlefield  
NHS (Cinzano et al.  
2001).

**Table 4.2.4-2. Summary of the night sky indicators and their contributions to the overall night sky natural resource condition assessment.**

| Indicator                 | Description of How the Indicator Contributes to the Overall Resource Condition                                                                                                                                                                                                                            | General Contribution of this Indicator to the Overall Resource Condition                                                                                                           |
|---------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Anthropogenic Light Ratio | Anthropogenic light ratio (ALR) is a quantitative measure that presents the ratio of the average anthropogenic sky luminance to the average natural sky luminance.                                                                                                                                        | Based on modeling conducted by the NPS Night Sky Program, the condition of the night sky at the Historic Site in moderate condition, though on the edge between moderate and good. |
| Zenith Sky Brightness     | This is a quantitative measure that assesses the sky brightness using readings from a sky quality meter (SQM).                                                                                                                                                                                            | SQM readings were taken as part of an interim, rapid assessment until more rigorous methods can be employed. The readings indicated a condition rating of significant concern.     |
| Bortle Dark Sky Scale     | This is a qualitative measure that uses a scale divided into nine classes. It is a relatively easy measure to use for night sky conditions and requires no special equipment. The scale is based on observing features of the night sky including the Milky Way, constellations, and the nighttime scene. | The Historic Site's night sky was assessed to be typical of rural to suburban transition. This is considered in moderate condition.                                                |

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

- Types of sounds
- Characteristics of anthropogenic noise

#### Condition - Trend - Confidence Level



Significant Concern - Insufficient Data - Low

#### 4.3.1. Background and Importance

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

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

Sound also plays a critical role in intraspecies communication, courtship and mating, predation and predator avoidance, and effective use of habitat. Studies have shown that wildlife can be adversely affected by sounds that intrude on their habitats. While the severity of the impacts varies depending on the species being studied and other conditions, research strongly supports the fact that wildlife can suffer adverse behavioral and physiological changes from intrusive sounds (noise) and other human disturbances. Documented responses of wildlife to noise include increased heart rate, startle responses,

flight, disruption of behavior, and separation of mothers and young (Selye 1956, Clough 1982, USDA 1992, Anderssen et al. 1993, NPS 1994,).

A park’s natural soundscape is an inherent component of “the scenery and the natural and historic objects and the wildlife” protected by the Organic Act of 1916. NPS Management Policies (§ 4.9) (2006) require the NPS to preserve parks’ natural soundscapes and restore degraded soundscapes to natural conditions wherever possible. Additionally, NPS is required to prevent or minimize degradation of the natural soundscapes from noise (i.e., inappropriate/undesirable human-caused sound). Although the management policies currently refer to the term soundscape as the aggregate of all natural sounds that occur in a park, NPS’ Natural Sounds and Night Skies Division (NSNSD) aims to update this terminology. Because the NPS works to protect and enhance park resources and visitor experiences, NSNSD differentiates between the physical sound sources and human perceptions of those sounds. Currently, NSNSD refers to the physical sound resources (i.e., wildlife, waterfalls,



JOHN AND KAREN HOLLINGSWORTH

**Figure 4.3.1-1.** Singing Western meadowlarks are found within Washita Battlefield National Historic Site and contribute to its natural sounds.

wind, rain, and cultural or historical sounds), regardless of their audibility, at a particular location, as the acoustical environment, while the human perception of that acoustical environment is defined as the soundscape. Clarifying this distinction will allow managers to create objectives for safeguarding both the acoustical environment and the visitor experience.

Washita Battlefield NHS preserves the site where Cheyenne Chief Black Kettle of the Southern Cheyenne Tribe and his followers were attacked by the 7th United States Cavalry, led by General Custer along the Washita River in 1868 (NPS 2001a). This tragic event created a sacred ground that is protected by the National Historic Site, and one of their visitor goals is to have them “experience solitude and quiet contemplation” while visiting the park (NPS 2001a).

In general, the types and characteristics of sound as well as park size greatly affects a park visitor’s ability to experience solitude, and unfortunately, areas providing a quiet acoustical environment are becoming increasingly rare.

**4.3.2. Data and Methods**  
**What is Sound? (Sound Science 101)**

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. This metric is decibels (dB). The decibel scale is logarithmic, meaning that every 10 dB increase in sound pressure level (SPL) represents a tenfold increase in sound energy. This also means that small variations in SPL can have significant effects on the acoustical environment. For instance, a 6 dB increase in a noise source will double the distance at which it can be heard, increasing the affected area by a factor of four. SPL is commonly summarized in terms of dBA (A-weighted SPL). This metric significantly discounts sounds below 1,000 Hz and above 6,000 Hz to approximate the variation in human hearing sensitivity. 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. Table 4.3.2-1 lists the various characteristics of sound that influence the quality of a soundscape.

**Table 4.3.2-1. Characteristics of sound.**

| Characteristic              | Low Sounds                                                                                                                                                     | Substantial Sounds                                                                                                                                      |
|-----------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------|
| Loudness (Amplitude in dBA) | Natural quiet, noise-free intervals, breathing, leaves rustling; The more distance between sound source and person/wildlife location, the lower the audibility | Aircraft overflights, high speed traffic, thunder; The closer the distance between sound source and person/wildlife location, the higher the audibility |
| Duration (Minutes/Seconds)  | Sporadic, infrequent, irregular intervals                                                                                                                      | Frequent to constant                                                                                                                                    |
| Rate of Occurrence          | Few                                                                                                                                                            | Many                                                                                                                                                    |
| Pitch (Frequency in Hz)     | Low pitch such as distant transportation                                                                                                                       | High pitch such as lawn mower at 1m                                                                                                                     |

### Noise vs. Natural Sounds

When a sound is evaluated negatively, therefore undesirable, it is defined as noise (Morfeý 2001). Conversely, (and for the purposes of this assessment) when sounds are evaluated from a positive perspective, we define those as “natural sounds” and/or sounds consistent with the designated use of a park area, such as Native American drumming or reenactments that may occur in cultural parks.

Natural sounds include those sounds upon which ecological processes and interactions depend. Examples of natural sounds in parks include:

- Sounds produced by birds, frogs or insects to define territories or attract mates
- Sounds produced by bats to navigate or locate prey
- Sounds produced by physical processes such as wind in trees, flowing water, or thunder.

Some common examples of noise often heard in parks include:

- Aircraft
- Vehicles
- Generators
- Human voices.

### Acoustical Environment

A park’s natural acoustical environment is vital to its function and character, and in many parks, natural sounds often dominate the acoustical environment. However, human-caused noise has the potential to mask these natural sounds, and noise impacts the acoustical environment much like smog impacts the visual environment; obscuring the listening horizon for both wildlife and visitors. But to determine that all natural sounds are good and all human-produced noises are bad would be an overly simplistic approach to a fairly complex issue. Instead, for this assessment, we will identify the types of sounds and their associated loudness and other defining characteristics then evaluate whether those sounds heard, their levels, and characteristics such as duration, rate

of occurrence, etc. are consistent with the designated uses at Washita Battlefield NHS.

To further compound a soundscape assessment, the types of sounds and their characteristics are typically evaluated by the various use areas that are common in parks. These acoustical areas may be characterized by the ambient conditions over the full extent of a park by dividing total area into “acoustic zones” on the basis of different vegetation zones, management zones, visitor use zones, elevations, or climate conditions. Then, the intensity, duration, and distribution of sound sources in each zone can be assessed by collecting SPL measurements and digital audio recordings within each of these zones.

Since the Historic Site is relatively small, 315 acres, and with minimal topographic variation, we are assessing the park’s acoustical environment as one unit despite its four management zone designations. It’s important to note that the Historic Site is part of a larger Natural Historic Landmark that encompasses 12 square miles, but does not afford additional buffering from noises since it is not within NPS jurisdiction except for the Historic Site itself.

### Acoustical Monitoring at the Historic Site

Acoustical monitoring has not been conducted by the NSNSD at the Historic Site, but we have had extensive communication and interviews with Richard Zahm, the Chief of Natural Resources at Washita Battlefield NHS describing the types of sounds frequently heard throughout the park.

#### **Indicators/Measures**

##### *Types of Sounds*

The first indicator used to assess the Historic Site’s soundscape was based on whether the types of sounds heard were expected for the Historic Site.

#### **Indicators/Measures**

##### *Characteristics of Anthropogenic Noise*

The second indicator used to assess the Historic Site’s soundscape was based on whether the characteristics of noises heard,

including sound level, pitch, duration, etc. were appropriate for the designated uses at the Historic Site.

#### 4.3.3. Reference Conditions

In general, human responses to sound can actually serve as a proxy for potential impacts to other vertebrates because humans have more sensitive hearing at low frequencies than most species (Dooling and Popper 2007), so the time that sound pressure levels exceed those mentioned in Table 4.3.3-1. may provide insight to a park's soundscape condition. The first value (35 dBA) is designed to address the health effects of sleep interruption. Recent studies suggest that sound events as low as 35 dB can have adverse effects on blood pressure while sleeping (Haralabidis et al. 2008). The second threshold addresses the World Health Organization's recommendations that noise levels inside bedrooms remain below 45 dBA (Berglund et al. 1999). Park visitors camping in or near a park could experience either of these two effects. The third level (52 dBA) is based on the EPA's speech interference threshold for speaking in a raised voice to an audience at 10 meters. This threshold addresses the effects of noise on interpretive programs in parks. The final threshold (60 dBA) provides a basis for estimating impacts on normal voice communications at 1 meter. Hikers and visitors viewing scenic vistas in the park would likely be conducting such conversations.

Typically, if we are to develop a complete understanding and assessment of a park's soundscape, we must not only consider a variety of sound characteristics but also answer the question of whether a certain sound and its associated characteristics are suitable to the park's purpose.

We consider an ideal soundscape condition to be an area that is dominated by the natural ambient sound level, which refers to the acoustical conditions that exist in the absence of any human-caused noise and represents the base level from which the NPS NSNSD measures impacts to the acoustical environment regardless of park area. However, we realize that while no noise is ideal, it is extremely rare and unrealistic, especially when parks are also mandated to manage for various visitor uses. Instead, we have defined a good soundscape reference condition to be one that is consistent with designated activity-related noises within each management zone or park unit and where no excessive sound sources are present in any area of the park. Additionally, noise-free intervals will be quite common and may exhibit seasonal and temporal fluctuations in sound due to the seasonality of visitation and daily visitor use patterns.

A moderate soundscape condition is one where noises begin to infiltrate into park areas, noise-free intervals become only moderately common, and higher level noises and associated characteristics (i.e., higher pitch, increased occurrence, longer duration, etc.) increase.

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

Meta-analyses of national park monitoring efforts such as those detailed in Lynch et al. 2011 and Mennitt et al. (submitted for review) reveal that aggregated data from 189 sites in 43 national parks reported that

**Table 4.3.3-1. Effects of sound pressure levels (SPL) on humans**

| SPL (dBA) | Relevance                                                                                                                   |
|-----------|-----------------------------------------------------------------------------------------------------------------------------|
| 35        | Blood pressure and heart rate increase in sleeping humans (Haralabidis et al., 2008)                                        |
| 45        | World Health Organization's recommendation for maximum noise levels inside bedrooms (Berglund, Lindvall, and Schwela, 1999) |
| 52        | Speech interference for interpretive programs (U.S. Environmental Protection Agency, 1974)                                  |
| 60        | Speech interruption for normal conversation (U.S. Environmental Protection Agency, 1974)                                    |

the median sound level that is heard 90% of the time (L90) across all sites and hours of the day was 21.8 dBA (between 20 and 800 Hz). A similarly comprehensive geospatial modeling effort (which assimilated data from 291 park monitoring sites across the nation), revealed that the median daytime existing sound level in national parks rests around 31 dBA. In addition, among 89 acoustical monitoring deployments analyzed for audibility, the median percent time audible of anthropogenic noise during daytime hours was found to be 35%. While we do not have park specific acoustical data for the Historic Site, these nationwide results can provide a reference framework for future comparison.

#### 4.3.4. Condition and Trend

##### Types of Sound at the Historic Site

The most common natural sounds that are heard within the Historic Site include weather related sounds (i.e., wind, rain, thunder), wildlife sounds, primarily bird songs or calls, and at rare times complete stillness (i.e. natural quiet). These types of sounds are congruent with the desired visitor experience at the Historic Site, which is to “preserve a reflective mood” (NPS 2001b).

Unfortunately the Historic Site is surrounded by many noise-producing developments including highways where semi trucks travel, oil and gas drilling platforms and associated developments, and an airport 0.6 miles from the Historic Site’s southern boundary. The most common human-produced sounds heard throughout the Historic Site include traffic noise, specifically 18-wheelers, along Highway 47 where the speed limit is 65 mph and traffic noise along Highway bypass 47a, which is adjacent to the Historic Site’s southern boundary, with a 55 mph speed limit (Figure 4.3.4-1) (Richard Zahm, NPS, personal communication). Both of these highways serve as the major travel corridors for the local and regional oil and gas operations (Figure 4.3.4-2).

A “soil building” operation is located directly across Highway 47 from the Historic Site. Heavy equipment transfers and spreads materials from rock tailings, which is a

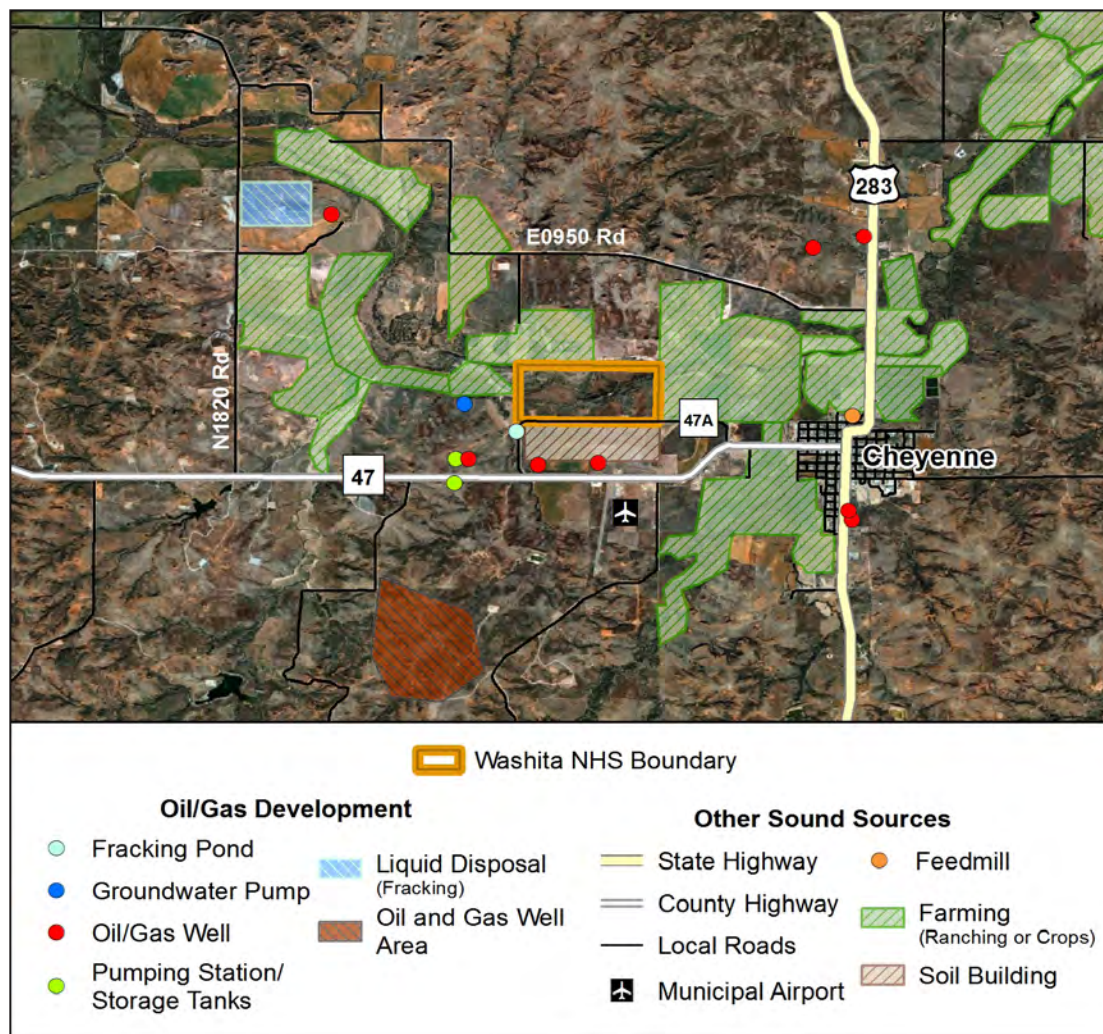
byproduct of well drilling. The tailings are spread with a 2-1/2 ton truck with balloon tires, and throughout 2012, trucks operated daily (Richard Zahm, NPS, pers. comm.). Additionally, a commercial liquid waste disposal facility for the oil and gas industry is located just to the northwest of the Historic Site’s boundary. Even though, the facility itself doesn’t produce any noise, the trucks transferring the waste do. Lastly, a pump station is located on both sides of Highway 47a adjacent to the park’s southwestern boundary. The stations pump the oil to its destination and noise generated from the pump can be heard.

Periodic aircraft sounds from the Mignon Laird Municipal Airport can also be heard, which is located a little over a half mile south of the Historic Site. The airport provides chartered aircraft services that include small passenger planes, executive jets, helicopters, and corporate airliners (International Air Charter 2010).

Agricultural activities, including ranching and farming, surround the Historic Site’s boundary. Ranching operations occur along the northern, eastern, or western boundaries, depending upon the time of year. Ranching operations are quieter than the agricultural operations, which include harvesting alfalfa and wheat crops anywhere from 3-6 times annually. These operations only last for a couple of days per each harvesting period (R. Zahm, NPS, pers. comm.).

If the wind is blowing from the east, which is not the prevailing wind direction (i.e., typically from the south to southwest during the spring and summer months [Oklahoma Climatological Survey. 2013]), one can hear voices and operational activities from the feed mill operation that is located approximately 2 miles to the east in Cheyenne, OK (R. Zahm, NPS, pers. comm.).

For the most part, noise generated from within the Historic Site, including human voices/ conversations and staff operational activities, such as mowing, are kept to a minimum and occur during the daytime hours only.



#### Characteristics of Noises Heard

The decibel levels of some of the common sounds heard throughout the Historic Site, as well as additional sounds for reference purposes only, are shown in Figure 4.3.4-3. In general, most of the anthropogenic noises

likely heard throughout the Historic Site are louder than the majority of the natural sounds.

Some of the noises heard at the Historic Site are shorter in duration, such as traffic traveling

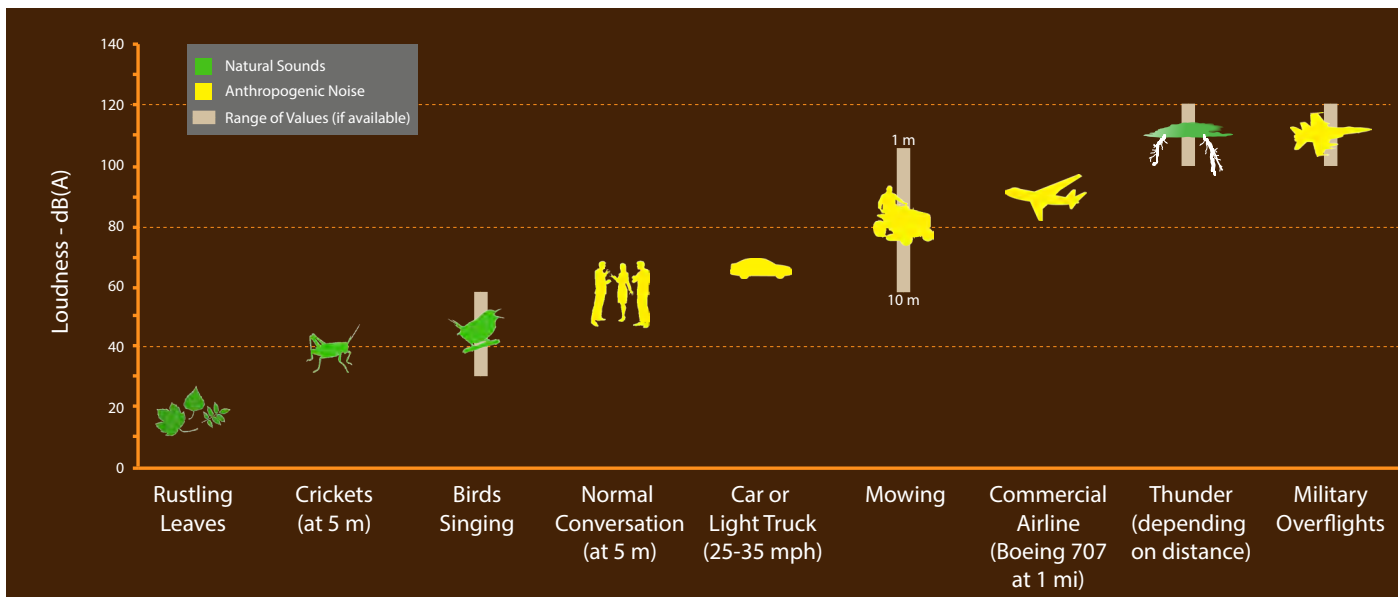


**Figure 4.3.4-3. Approximate sound levels for common natural sounds and noises likely to be heard at Washita Battlefield NHS.**

along the highways compared to local oil/gas operations, including noises from pumps and wells, which typically last longer and sometimes operate both day and night. Even though, the highway noises may be relatively short, they're probably higher pitched.

Humans with normal hearing can hear pitches between 20 Hz and 20,000 Hz, and are most sensitive to frequencies between 1,000 Hz and 6,000 Hz. High frequency (pitched) 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. This is the case with distant traffic noise traveling along Highway 47.

#### Overall Condition

For assessing the condition of the Historic Site's soundscape, we used two indicators/measures, which are summarized in Table 4.3.4-1. The condition of the Historic Site's soundscape is based on both types of noises heard that might be detrimental to park resources (e.g., wildlife), as well as human perception of the acoustical environment, as it relates to a visitor's experience (i.e., Is the site conducive to contemplation?). The types of designated activities within Historic Site include viewing from the overlook, which

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

| Indicator/Measure                      | Description of How the Indicator(s) Contributes to the Overall Resource Condition                                                    | General Contribution of this Indicator or Measure to the Overall Resource Condition.                                                                                                                          |
|----------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Types of sounds                        | Not all sounds are a nuisance and some anthropogenic noises are expected based upon the area of the park in which they are heard.    | The loudest noises that occur in the Historic Site are from traffic, oil/gas operations, and aircraft. The park is small so noises travel throughout the park vs. being contained in specific locations.      |
| Characteristics of Anthropogenic Noise | Noise is comprised of several characteristics including loudness (sound level), duration, pitch (frequency), and rate of occurrence. | Noise levels and other characteristics are intrusive to the soundscape at the Historic Site. The close proximity of large developments contribute to the louder, longer, and more frequent noise occurrences. |

is adjacent to the parking lot, hiking along a designated trail, and restricted use of the contemplative area located along the Historic Site's western boundary. The remaining area of the park is essentially designated as a conservation area where restoration activities, such as exotic plant control and native plant reseeding occurs.

The Historic Site's long-range interpretive plan (NPS 2001a) and General Management Plan (2001b) state that a "reflective mood" will be preserved at the Historic Site. Unfortunately, very little buffering effect from topography or vegetation occurs to dampen the noises generated outside the park, especially given the smaller size of the park.

While natural sounds have the ability to buffer anthropogenic noise characteristics, especially during the windier months, it is likely that the close proximity of developments, including the airport, oil/gas developments, and highways increase the noise levels and negatively impact the Historic Site's soundscape.

Given the amount of development and activity surrounding the Historic Site, it seems likely that the noise levels and rate of noise occurrence is frequent enough to warrant significant concern.

We do not have acoustical monitoring data to support a trend but believe it is deteriorating based upon the amount and frequency of surrounding developments.

#### Level of Confidence and Key Uncertainties

This was a qualitative assessment of the Historic Site's soundscape, establishing the framework for a future quantitative assessment. Although no data were collected, we feel confident to say that the Historic Site's soundscape warrants significant concern due to the current and ongoing developments.

Within the short timeframe of writing this assessment, several new developments were initiated very close to the Historic Site's boundary (Figure 4.3.4-3) (Richard Zahm, NPS, pers. comm.). Several new well developments, with three active drilling oil/gas platforms and one on top of the hill to the south of the park were built less than 2 miles from the park's boundary. Another liquid disposal unit is being proposed on the east side of Highway 283, which depending upon the wind direction, may add to the deterioration of the Historic Site's soundscape. Given the rate of new developments surrounding the park, the condition of the Historic Site's soundscape may be increasingly impacted.

#### **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 also provided a NRCA soundscape template, which we largely used to develop Washita Battlefield NHS' soundscape assessment. For more information, see <http://www.nature.nps.gov/sound/>.

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**Figure 4.3.4-3.**  
A new oil/gas development near the Historic Site that began during the writing of this NRCA.

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## 4.4. Air Quality

### Indicators/Measures

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

### Condition - Trend - Confidence Level



Significant Concern - Insufficient Data-High

### 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, 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 2011a).

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, Washita Battlefield 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 2011b).

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).



**Figure 4.4.1-1.**  
Washita Battlefield  
National Historic Site  
is a Class II airshed.

**Figure 4.4.1-2. A clear day at Washita Battlefield National Historic Site**



#### 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 2011a). The two types of NAAQS are primary and secondary, with the primary standards establishing limits to protect human health, and the secondary standards establishing limits to protect public welfare from air pollution effects, including decreased visibility, damage to animals, crops, vegetation, and buildings (EPA 2011a).

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 ( $\text{NO}_x$ ) 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 2011c). Once the ozone is inside the plant's cellular system, the chemical reactions can cause cell injury or even death (NPS-ARD 2011c), but more often reduces the plant's resistance to insects and diseases, reduces growth, and reduces reproductive capability (NPS-ARD 2011d).

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 nitrate or sulfur deposition than others, including high-elevation ecosystems in the western United States, upland areas in the eastern part of the country, areas on granitic bedrock, coastal and estuarine waters, arid ecosystems, and some grasslands (NPS-ARD 2010b). Increases in N have been found to promote invasions of fast-growing annual grasses (e.g., cheatgrass) and exotic species (e.g., Russian thistle) at the expense of native species (Brooks 2003, Allen et al. 2009, Schwinning et al. 2005). Increased grasses can increase fire risk (Rao et al. 2010), with profound implications for biodiversity in non-fire adapted ecosystems. N may also increase water use in plants like big sagebrush (Inouye 2006).

According to the EPA, in the United States, roughly two thirds of all  $\text{SO}_2$  and one quarter of all  $\text{NO}_x$  come from electric power generation that relies on burning fossil fuels. Sulfur

dioxide and nitrogen oxides are released from power plants and other sources, and ammonia is released by agricultural activities, feedlots, fires, and catalytic converters. In the atmosphere these transform to sulfate, nitrate, and ammonium and can be transported long distances across state and national borders, impacting resources in remote areas, including Washita Battlefield National Historic Site (EPA 2011b).

#### 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.

#### Indicators/Measures

##### Visibility Haze Index

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

**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

the air as light travels a distance of one million meters (NPS-ARD 2003). The haze index for visibility condition is calculated as follows:

$$\text{Visibility Condition/Haze Index (dv)} = \frac{\text{current Group 50 visibility} - \text{estimated Group 50 visibility}}{\text{(under natural conditions)}}$$

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

The IMPROVE visibility monitor at Ellis County, Oklahoma is within the 100 km range of acceptability to represent the air quality for the Historic Site (the monitor is about 64 km away).

#### 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 "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 concentration is between 61 and 75 ppb, and of "significant concern" if the concentration is greater than or equal to 76 ppb.

**Table 4.4.4-1. Condition results for air quality indicators at Washita Battlefield National Historic Site.**

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

**Table 4.4.4-2. Ozone sensitive plants found at Washita Battlefield National Historic Site (NPS-ARD 2006).**

| Scientific Name              | Common Name     | Bioindicator |
|------------------------------|-----------------|--------------|
| <i>Apocynum cannabinum</i>   | Indianhemp      | No           |
| <i>Artemisia ludoviciana</i> | White sagebrush | Yes          |
| <i>Asclepias syriaca</i>     | Common milkweed | Yes          |
| <i>Cercis canadensis</i>     | Redbud          | Yes          |

### Wet Deposition

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

### **4.4.4. Condition and Trend**

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

### Visibility

All visibility data were derived from NPS ARD Air Atlas interpolated five-year average values (2001-2005, 2005-2009) (NPS ARD 2010a). The five-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. No visibility trend was reported specifically for Washita Battlefield.

### Ozone

All ozone data for the Historic Site were derived from the five-year interpolated values average (NPS-ARD 2011f), which resulted in a moderate ozone condition ranking for Washita Battlefield.

Four plant species found within Washita Battlefield are ozone-sensitive (NPS-ARD 2011e), and three of those species are considered bioindicators for ozone (Table

4.4.4-2). “Sensitive” means that they typically exhibit foliar injury at or near ambient ozone concentrations or are species for which ozone foliar injury symptoms have been documented in the field by more than one expert observer. In order to be considered as an ozone bioindicator most of the following criteria must be met:

- species exhibit foliar symptoms in the field at ambient ozone concentrations that can be easily recognized as ozone injury by subject matter experts
- species ozone sensitivity has been confirmed at realistic ozone concentrations in exposure chambers
- species are widely distributed regionally
- species are easily identified in the field (NPS-ARD 2011e).

An example of common milkweed foliar damage from ozone is shown in Figure 4.4.4-1 (NPS-ARD 2011h).

### Wet Deposition

The data for atmospheric wet deposition condition were derived from NPS-ARD’s 2001-2005 and 2005-2009 interpolated values (NPS-ARD 2011g). The average value for total nitrogen resulted in 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

**Figure 4.4.4-1.** Healthy common milkweed plant, left (photo courtesy of USDA PLANTS Database) and milkweed plant exhibiting ozone injury on the leaves, right (photo courtesy of the Ozone Biomonitoring Program).



USDA PLANTS DATABASE

OZONE BIOMONITORING PROGRAM



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 very high, respectively.

In general, nitrate, sulfate, and ammonium deposition levels have changed over the past 20 years throughout the United States (Figure 4.4.4-2). Regulatory programs that mandated a reduction in emissions have proven effective for decreasing both sulfate and nitrate ion deposition primarily through reductions from electric utilities, vehicles, and industrial boilers, although a rise in ammonium ion deposition has occurred in large part due to the agricultural and livestock industries (NPS-ARD 2011g). A new study conducted by Lehmann and Gay (2011), indicated a decrease in both nitrate and sulfate concentrations from 1985-2009 in the area surrounding the Historic Site. The observed decrease in nitrate and sulfate concentrations at Washita Battlefield were not statistically significant.

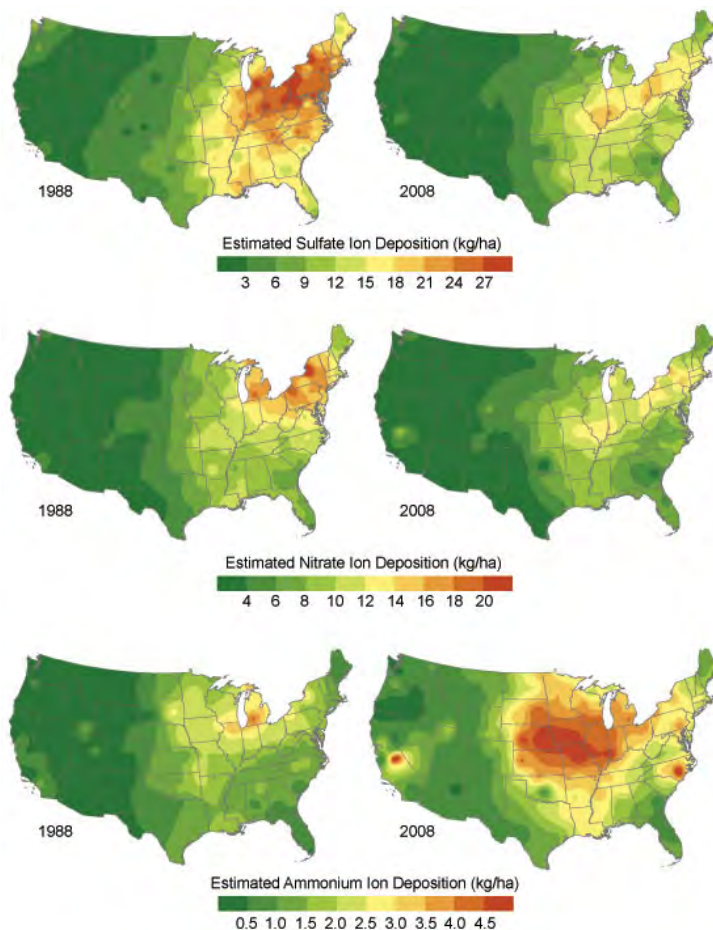
SOURCE: [HTTP://WWW.NATURE.NPS.GOV/AIRMONIT/origins/wetmon.cfm](http://www.nature.nps.gov/airmonit/origins/wetmon.cfm).

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

It seems reasonable to expect a continued improvement in sulfate deposition levels

**Table 4.4.4-3. Summary of the air quality indicators and their contributions to the overall air quality natural resource condition assessment.**

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

because of Clean Air Act requirements, however, at this time, ammonium levels are not regulated by the EPA and may continue to rise as a result (NPS-ARD 2010a).

#### **Overall Condition and Trend**

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

We consider the overall condition of air quality at Washita Battlefield National Historic Site to be of significant concern. Trends cannot be derived for the Historic Site since air quality monitoring sites are not located near enough to be representative of the conditions at the Historic Site (except for visibility) and onsite monitoring does not occur. A monitor is considered representative if it is located within 10 miles for ozone and within 100 km for visibility. There was no statistically significant trend in visibility on

either the clearest or the haziest days from 1999-2008 (NPS-ARD 2010a).

There are several likely contributors to impaired air quality near Washita Battlefield National Historic Site and regional transport of emissions from more distant air pollution sources. One is the amount of oil and gas development around the site; another is a nearby granary and occasional fires that contribute to organic particles in the air.

According to the EPA (2011c), oil and natural gas production facilities emit pollutants such as hazardous air pollutants (HAPs) and volatile organic compounds (VOC). These pollutants contribute to health problems that may affect people working at the production facilities and throughout the community. Existing regulations are designed to limit the amount of emissions from oil and gas production facilities, but dangerous releases of HAPs can occur if an oil and natural gas production facility does not operate in compliance with regulations.

Volatile organic compounds are released during oil and gas production and contribute to ground-level ozone (or smog), which can cause respiratory problems such as coughing, difficulty breathing, inflammation, and exacerbate asthma (CA EPA 2008, EPA 2011c). Those people in the community most affected are the young, elderly, or those who already have a respiratory illness or sensitivity.

Nitrogen oxides (NO<sub>x</sub>) are produced when cars, power plants, and industrial boilers burn fuels, such as gas, coal, or oil. The reddish-brown color you can sometimes see in smog comes from nitrogen oxide (EPA 2012). This is another contributor to degraded visibility near the Historic Site.

Ground-level or “bad” ozone is not emitted directly into the air, but is created by chemical reactions between NO<sub>x</sub> and VOC in the presence of sunlight. Emissions from industrial facilities and electric utilities, motor vehicle exhaust, gasoline vapors, and chemical solvents are some of the major sources of NO<sub>x</sub> and VOC (EPA 2011c).

Ground-level ozone has a characteristic pungent odor that some people can detect at levels as low as 0.05 ppm (CA EPA 2008). It can also have harmful effects on sensitive vegetation, agricultural crops, and ecosystems (EPA 2011c, EPA 2012). Plant species that are sensitive to ozone, and potentially at an increased risk from exposure, include trees such as black cherry, quaking aspen, ponderosa pine, and cottonwood (EPA 2011c). These effects can also have adverse impacts on ecosystems, including loss of species diversity and changes to habitat quality and water and nutrient cycles.

Fine particulates that result from fires or from crushing and grinding operations (such as granaries) contribute to haze that decreases visibility and can also increase respiratory illnesses (EPA 2012).

#### Level of Confidence/Key Uncertainties

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

especially nitrogen deposition, on ecosystems at Washita Battlefield National Historic Site.

#### **4.4.5. Sources of Expertise**

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

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## 4.5. Geology

### Indicators/Measures

- No indicators were identified

*\*\*This section is extracted from the Washita Battlefield National Historic Site Geologic Resources Inventory Scoping Summary (KellerLynn 2011). For more information, go to <http://www.nature.nps.gov/geology/inventory>\*\**

#### 4.5.1. Background and Importance

Geology, and associated soils, are the basis for vegetation communities, the hydrology, and the basic landforms and topography for an area, that then support the biotic communities. Soils, hydrology, and landform also influence human settlement patterns, and how people use the land—for farming, ranching, hunting, fishing, and other basic land uses. The landforms of the Historic Site (the Washita River, bluffs, and knolls) also played key roles in the historical events the park commemorates.

The region of western Oklahoma where Washita Battlefield National Historic Site (NHS) is located is known as “red carpet country,” and is part of the Western Red-Bed Plains physiographic province. It is characterized by gently rolling hills made of nearly flat-lying Permian (299 million to 251 million years ago) red sandstones and shale. The rock units in the area are the Cloud Chief Formation, Doxey Shale, and Elk City Sandstone (Figure 4.5.1-1). These marine, coastal, and fluvial units, respectively, record the withdrawal of a Permian sea from the area (KellerLynn 2011).

Structurally, Washita Battlefield NHS lies on the southern flank of the Anadarko Basin, a deep sedimentary basin that covers approximately 130,000 km<sup>2</sup> (50,000 mi<sup>2</sup>) and contains over 12,190 m (40,000 ft) of sedimentary deposits. The basin subsided and filled with sediment while adjacent areas, such as the Amarillo-Wichita uplift, were folded and thrust upward. (The “Amarillo

### Condition - Trend - Confidence Level



Unknown – Unknown - N/A

uplift” is the portion of the uplift in Texas. The “Wichita uplift” is the portion in western Oklahoma.) Most of the subsidence of the basin and uplift of adjacent strata occurred during the Pennsylvanian Period (318 million to 299 million years ago). There is a hint that uplift started in the latest Mississippian Period (328 million to 318 million years ago) and lasted through the earliest Permian Period (299 million to 270 million years ago), but the vast majority of the action was during the Pennsylvanian Period (KellerLynn 2011).

The Washita River runs through the Historic Site and is a tributary of the Red River, one of two drainage basins within the state (the other is the Arkansas River drainage to the north). About one-third of Oklahoma is



NPS, KATIE KELLERLYNN

**4.5.1.1 Washita Battlefield NHS is underlain by the Cloud Chief Formation. The Permian red beds (shown exposed here) give the region its name, “red carpet country.”**

within the Red River drainage basin. The water ultimately flows through Arkansas and Louisiana to the Atchafalaya River near the Mississippi River. The headwaters of the Washita River are in the northeastern part of the Texas Panhandle. The Washita River flows 80 km (50 mi) from its source before entering the Historic Site, immediately upstream of Cheyenne, Oklahoma (KellerLynn 2011) (Figure 4.5.1-2). Black Kettle's winter camp was located on the Washita River floodplain in 1868 before he was attacked by the 7<sup>th</sup> U.S. Cavalry led by Lieutenant Colonel Custer.

#### 4.5.2. Data and Methods

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

#### 4.5.3. Reference Condition

No reference conditions have been defined.

#### 4.5.4. Condition and Trend

Specific indicators and measures related to soil erosion are presented in section 4.9 on grasslands. Based on the level of assessment that has been done to date, no specific areas of geologic concern have been identified. The following discussion on geologic features, issues, and processes are excerpts summarized from the geologic scoping summary (KellerLynn 2011).

#### Fluvial Features and Processes

The primary fluvial feature at Washita Battlefield National Historic Site is the Washita River, which is an integral component of both the natural and cultural landscape. At the time of the battle, the Washita River was a perennial, meandering stream that formed a series of horseshoe bends within and in the vicinity of the Historic Site; Black Kettle's village was situated within one of these meander bends. Because the Washita River is a naturally meandering river, the channel has migrated since 1868 and potentially across the site of Black Kettle's camp.

**4.5.1-2. The Washita River meanders across the entire length of Washita Battlefield NHS.**



Between 1910 and 1930, land owners (farmers) created two artificial meander cutoffs to direct waters to irrigate crops. There is a raised levee on the north side of the river, which was built as part of this water diversion project and also to provide flood control. In addition, disturbances during the Dust Bowl of the 1930s resulted in changes to the channel and flood regime; namely, poor agricultural practices led to excessive sediment supply and frequent floods (KellerLynn 2011).

Although flooding had been a natural and regular process of the Washita River, now controlled by a series of dams, flooding is not a serious issue for infrastructure at the national Historic Site. Under present conditions, the river channel is sometimes dry. Occasionally, flooding does still occur within the Historic Site, but only when check dams upriver fail. Most recently this occurred during the spring of 2007, when deep floodwaters covered the floodplain at the Historic Site, much to the pleasure of park biologists who were hoping for the replenishment of seed banks.

Significant fluvial features at the Historic Site include terrace deposits. Terraces are former floodplains and mark the positions of earlier streams. Previous investigations identified three terrace levels above the present-day floodplain at Washita Battlefield NHS. The highest and oldest terrace level is situated 6 m (20 ft) to 7 m (23 ft) above the riverbed; the youngest terrace level is 2.5 m (8 ft) to 3 m (10 ft) above the riverbed. The youngest/lowest terrace level has been proposed as the surface most likely for the location of Black Kettle's camp, but archaeological evidence has not confirmed this (KellerLynn 2011).

#### *Disturbed Lands*

Land uses and development can disrupt geologic features and processes. Farming, construction, and other ground-disturbing activities can result in increased erosion, runoff, and sedimentation into fluvial systems; exacerbated eolian processes (e.g., dust storms); soil compaction; and the formation of ruts. As the area around the Historic Site was homesteaded and population increased, the trees along the Washita were cut and used for timber, the soil was tilled, fences were

erected, and terraces were cut into slopes to slow runoff during the drought years of the 1930s. In addition, the Panhandle and Santa Fe Railroad constructed a line across the site in 1928–1929. The railroad bed/grade altered the natural hydrology of the site by acting as a dam or constriction to local drainages. During construction, several small drainages were diverted or rerouted.

#### *Oil and Gas Development*

Washita Battlefield NHS is situated in the Anadarko Basin, which is one of the most prolific hydrocarbon producers in the continental United States. The sources of hydrocarbons are the Pennsylvanian (318 million to 299 million years ago) Atoka and Morrow shales. The basin covers 25 counties in southwestern Kansas, 23 counties in northwestern Oklahoma, 13 counties in the northernmost part of the Texas Panhandle, and two counties in southeastern Colorado. Sediments from the Cambrian through Permian periods (542 million to 251 million years ago) are more than 12 km (8 mi) thick in the deepest part of the basin.

A primary issue for the protection of resources at Washita Battlefield NHS is an active pipeline. The pipeline crosses the Historic Site from the west side, just below the Washita River, to the north side, midway along the site's boundary. There also may be an abandoned pipeline within the site boundaries.

#### Eolian Features and Processes

Geologic features, such as sand sheets and dunes, document the wind's impact on the landscape. While no sand dunes are shown within the boundaries of the Historic Site, dunes are prevalent to the north, and dune sand has also been mapped to the south and southeast. Various types of eolian deposits (dune sand, sand sheets, and loess) are likely to occur within the Historic Site's boundaries, and it is suspected that nearby areas of sand sheets may be relicts of the 1930s Dust Bowl.

A distinctive eolian feature across Oklahoma is windblown volcanic ash. Windblown ash is known to occur throughout the Miocene Ogallala Formation in Oklahoma; however,

there is a discrepancy regarding the age of these deposits: the ash occurs in Miocene (23 million to 5.3 million years ago) rocks, but the ash itself is documented as younger, that is, Pleistocene (2.5 million to 11,700 years ago) in age. Further investigation is suggested.

#### Cave and Karst Features and Processes

No caves are known within Washita Battlefield NHS, however, dissolution and collapse—processes related to the formation of caves and karst—are part of the landscape. Because evaporite rocks or “salts”—primarily halite but also gypsum—are components of the Permian red beds, sinkholes are known to form as a result of dissolution. Although sinkholes are not a notable geologic hazard at the Historic Site, caution using fresh water when drilling into Permian strata is warranted. Two giant sinkholes recently (1980 and 2002) brought attention to Winkler County, Texas where collapse was caused by the dissolution of salt in the Permian Salado Formation.

Salt dissolution results in the collapse of overlying strata into the collapse feature. Material that fills the collapse feature, called “collapse breccia,” provides hints to the geologic history of the area that would have otherwise been eroded away. Often, collapse features become inverted topographic forms on the landscape. For instance, erosion stripped away the sediments surrounding the collapse breccia near the entrance of the

Historic Site, leaving a consolidated hillock above the ground surface.

#### Paleontological and Archaeological Studies

An inventory of the paleontological resources for Washita Battlefield NHS was completed (Koch and Santucci 2003 as cited in KellerLynn 2011), documenting that no fossils have been found within the boundaries of the Historic Site. Fossils including cup corals, coiled cephalopods, and trace fossils of worm trails were found from the Cloud Chief Formation just east of the boundary (Brown 2001 as cited in KellerLynn 2011). Not far from the Historic Site is the Ogallala Formation, a well-known fossiliferous area. A multi-disciplinary approach studying the Quaternary sediments at Washita Battlefield National Historic Site may reveal significant finding about various resource types—geological, paleontological, and archaeological.

#### Unique Geologic Features

For Washita Battlefield NHS, “unique geologic features” are directly connected to the events that took place on November 27, 1868. These features are primarily topographic, or from a geologic perspective, they are landforms created through geomorphic processes.

The main geomorphic feature at the Historic Site is fluvial, that is, the floodplain of the Washita River where Black Kettle and his



**Figure 4.5.4-1.**  
Bluffs and knolls are  
landforms that are  
geologic features of  
historic significance.



**Figure 4.5.4-2.**  
Stone markers, such as the red granite (left) and the gray granite interpretive sign (right) are both geologic and historic resources.

people set up their winter camp. Other significant landforms include ridgelines and knolls (Figure 4.5.4-1). During the conflict, U.S. Cavalry forces used the ridgelines in the area to their advantage, completely encircling Black Kettle's camp and effectively reducing escape routes. The low-lying position of Black Kettle's camp with its bordering alluvial terraces had apparently been selected to offer some protection from the winter winds prevalent on the Great Plains; however, the location became a deadly trap during hostile conditions. Furthermore, the cavalry used topographic highs as lookouts, for example, "Custer's Knoll," which served as the starting point for the attack.

Other "unique geologic features" are building stones used to commemorate the events that took place at Washita Battlefield National Historic Site (Figure 4.5.4-2). These stones are both historic and geologic resources. The red granite memorial placed in 1932 that predates the establishment of the Historic Site (in 1996), is suspected to have come from Granite, Oklahoma where Cambrian (542 million to 488 million years ago) granite is exposed at the surface as part of the Wichita uplift. The stone for the gray granite monument/interpretive

sign was prepared by Willis Granite Products in Granite, Oklahoma; however, the gray color suggests that the granite was probably mined elsewhere, probably not from Oklahoma.

#### 4.5.5. Sources of Expertise

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

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## 4.6. Surface Water Quality

### Indicators/Measures

- Physiochemistry-Core Water Parameters
- Physiochemistry-Sediment
- Biological Communities

### Condition – Trend - Confidence Level



Unknown – Unknown - N/A

#### 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 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 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 at Washita Battlefield National Historic Site: water quality and water quantity (Figure 4.6.1-1). Water quality will be used as an indicator for this resource topic, whereas water quantity will be addressed in the riparian habitat section of this NRCA. No formal water quality monitoring program exists at Washita Battlefield NHS but not for lack of trying. Within the last couple of years SOPN has partnered with the Sonoran Desert



NPS - EVAN GWILLIAM

**Figure 4.6.1-1**  
A section of the Washita River located within Washita Battlefield National Historic Site.

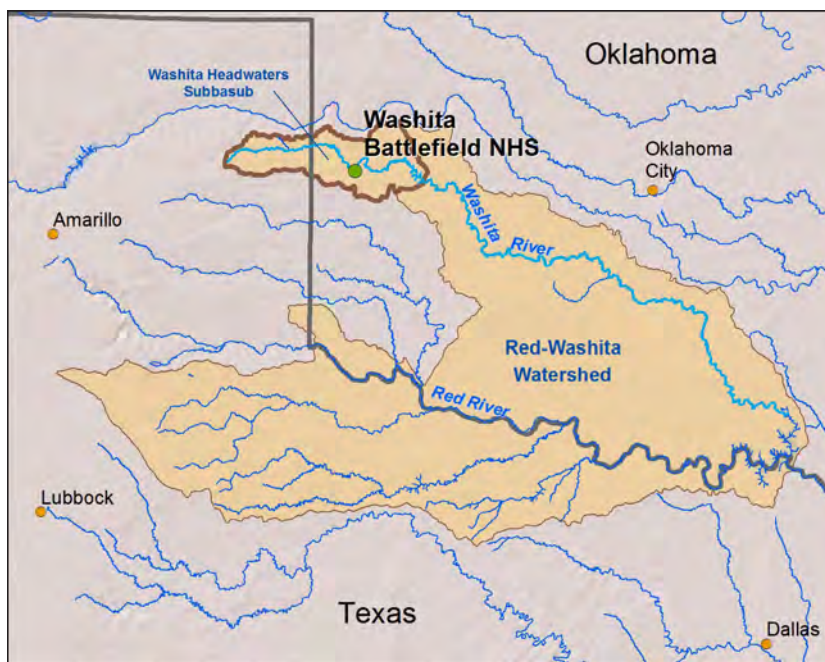


**Figure 4.6.1-2** The Washita Headwaters subwatershed drains an area of approximately 750 square miles.

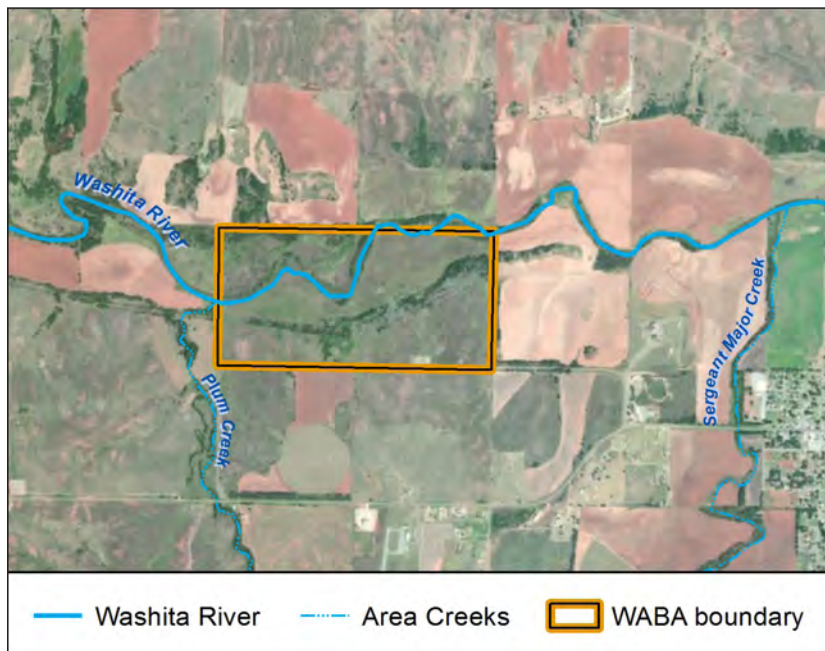


**Figure 4.6.1-3** Washita River runs 0.92 miles along Washita Battlefield NHS' northern boundary.

I&M Network to monitor water quality throughout parks containing water resources in both networks. Hydrologists attempted to collect water quality data at the Historic Site but due to equipment failure and/or lack of water, no data have been collected as part of a long-term water quality monitoring program (E. Gwilliam, NPS, pers. comm. December

2012). However, data pertaining to channel morphology have been collected, but this information is addressed in the riparian habitat section of this NRCA.

Water has long been a scarce resource in the western and central portions of the Great Plains and very important to Native Americans, early European settlers, and present day inhabitants and ecosystems (Perkins 2005). Washita Battlefield NHS commemorates the attack on the Southern Cheyenne village of Chief Black Kettle, along the Washita River, in November, 1868 by the 7th U.S. Cavalry, led by Custer. The site has cultural and historical value for the Cheyenne and other Southern Great Plains tribes, and the river's name is from the Indian tribal name Wichita.

The Washita River is a tributary of the Red River, originating in the eastern Texas Panhandle, flowing 598 miles (949 km), and draining 24,765 square miles (64,140 square km) until it flows into Lake Texoma, formed by the Denison Dam in the Red River (Figure 4.6.1-2). Several dams have been built to create reservoirs along its course, and for most of the year, except for some periods of rainfall in spring and early summer, the stream bed is dry (Reber et al. 1999).

The Washita River is the main hydrologic feature at the Historic Site and runs 0.92 miles along the park's northern boundary, though the confluence with Sergeant Major Creek, which was also of historic significance during the battle, is located just downstream of the Historic Site (Figure 4.6.1-3).

Washita Battlefield National Historic Site is located within the Sergeant Major Creek sub-drainage of the Washita Headwaters watershed (USGS Hydrologic Unit 11130301). The Washita Headwaters watershed encompasses approximately 750 sq mi, is rural in character, and consists primarily of rangeland and irrigated agriculture occurring in suitable areas (Reber et al. 1999) The region is subject to long- and short-term droughts, which it is currently experiencing. The landscape surrounding the Historic Site was drastically affected by the "Dust Bowl" in the 1930's

(Inglis, 2001), which caused changes to the local ecosystems, particularly soil health and water quality/quantity (Perkins et al. 2005). As a result of the severe drought during the Dust Bowl, flooding and eroded sediment flow along the Washita River was historically a very serious problem (Reber et al. 1999).

The watershed contains some of the oldest upstream flood control dams in the nation, totaling more than 70 mostly between 35 and 60 years old, located along the river and its tributaries above Washita Battlefield National Historic Site (Oklahoma Water Resources Board, 1984). Long-term flow records (1937 – present), available from USGS Station 07316500 (Washita River near Cheyenne, OK) located just downstream of the Washita Battlefield indicate that these structures have greatly reduced flooding and significantly modified natural flow patterns on this reach of the Washita River from at least the early 1960s (Tortorelli and Bergman, 1985).

#### 4.6.2. Data and Methods

##### 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 abundances and distributions, and alter nutrient cycles (USDI NPS 2008).

##### Indicators/Measures

##### Physiochemistry-Core Water Parameters

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

##### Indicators/Measures

##### Physiochemistry-Sediment

In addition, sediment physiochemistry, which measures the presence of nutrients, major ions, and metals can be used as an indicator. 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.

##### Indicators/Measures

##### Biological Communities

Bioassessments, which determine the presence and composition of biological communities, usually stream macroinvertebrates, provide valuable information used to assess the condition of surface water bodies.

##### Water Quality Monitoring at the Historic Site

The most comprehensive water quality information for the Washita River in the vicinity of Washita Battlefield National Historic Site comes from long-term water quality monitoring conducted by the US Geological Survey (USGS) at the USGS Station 07316500 (Washita River near Cheyenne, OK) located approximately one mile downstream from the Historic Site. This data set provides information regarding 12 basic physical and chemical water quality

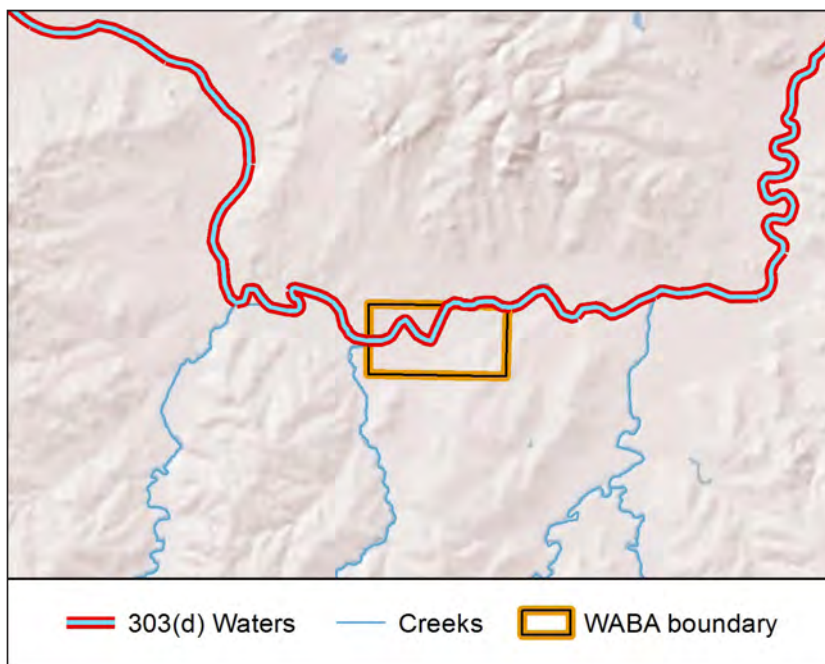


**Figure 4.6.2-1 Washita River is listed on USEPA's 303(d) list of impaired waters due to high turbidity levels.**

constituents including specific conductance, pH, dissolved oxygen, suspended sediments, total hardness, nitrate, phosphorus, sulfate, chloride, sodium, calcium, and magnesium for the period from 1938 through 1990. Unfortunately, water quality monitoring at the site was discontinued in 1991 when budget constraints caused the USGS to significantly realign their national long term water quality monitoring program (Reber et al. 1999).

In 2003, Bergery conducted an aquatic invertebrates and fishes inventory at the Historic Site and also collected core physical water quality data. Unfortunately, the core water quality data are limited and do not reveal anything relative to current water quality condition but are included in the NPS STORET database (USEPA 2012). The river areas sampled for invertebrates had a mosaic of different habitats and these habitats had characteristic associated invertebrates (Bergery 2003). High water and high turbidity during the non-summer sampling period prevented effective habitat-specific sampling, but similar habitat-faunal associations were likely present. This sampling provides a baseline for future water quality monitoring but doesn't provide information relative to the current condition of stream macroinvertebrates.

Instead, information was obtained from the U.S. Environmental Protection Agency's Water Body Reports (2010) for Washita Headwaters (ID: OK310840020010\_00). Section 305(b) of the Clean Water Act requires States to use monitoring data and other information to report bi-annually the status of their waters. Assessed waters are classified as either Fully Supporting, Threatened, or Not Supporting their designated uses (USEPA 2012). Section 303(d) of the Clean Water Act requires States to use monitoring data and other information to develop a list of waters that will not meet water quality standards for a particular pollutant. States must submit this list every two years. States must then develop Total Maximum Daily Loads to restore these waters (USEPA 2012). The Washita River within the Historic Site is on both EPA lists.

The EPA records indicated that Washita Headwaters- a 61.94 mile stretch including the river segment within the Historic Site (Figure 4.6.2-1) is impaired for warm water aquatic communities due to turbidity (Water Body ID: OK310840020010\_00 and Water Body Name: Washita River at Site #384). Sampling began in 2002 and continued biannually through 2010, with all years reporting impairment to the Washita Headwaters (USEPA 2010). The probable sources contributing to the turbidity include agriculture and unknown sources (USEPA 2010). Parsons (2010) prepared a document for Oklahoma Department of Environmental Quality, establishing pollutant load allocations for turbidity in impaired waterbodies including the Washita River, which is the first step toward restoring water quality and protecting public health.

#### **4.6.3. Reference Conditions**

The Oklahoma Water Resources Board (OWRB) establishes Oklahoma's Water Quality Standards (WQS). These standards are a set of rules adopted by Oklahoma in accordance with the federal Clean Water Act, applicable federal regulations, and state pollution control and administrative procedure statutes. The current standards, including all amendments which were effective as of July 1, 2011 are found in OWRD (2011) document. These standards would serve as the water quality reference conditions

but will not be defined since no water quality data for the Historic Site are available.

#### 4.6.4. *Condition and Trend*

Water quality condition could not be assessed, however, we can discuss several threats to the Historic Site's water quality in general terms.

##### Key Uncertainties/Threats

Much of the Washita Headwaters watershed overlies the Anadarko Basin, a region of considerable natural gas exploration and production activity. The impacts of local and regional activities upon the water quality has not been assessed.

A commercial waste pit facility was developed west of the Historic Site, less than two miles upstream of the park's boundary. Previously, this facility consisted of a commercial saltwater disposal well used primarily for the injection of saline waters produced in the oil & gas drilling process into a deep aquifer. However, in 1998, the business received permission from the Oklahoma Corporation Commission to develop this operation into a commercial pit facility (PD No. 970000392) consisting of three 350' x 1150' earthen pits (evaporative ponds) for the disposal of oil field wastes including water-based drilling fluids and/or cuttings and salt-contaminated soils (Reber et al. 1999). The Washita River lies approximately 0.25 miles downgradient from the disposal pits. In 1998, the Washita River and Sergeant Major Creek were listed as "attaining" existing state water quality standards in the vicinity of the Historic Site (State of Oklahoma, 1998). Beginning in 2002, non-attainment of state water quality standards was identified due to turbidity and has not reached attainment since that time (USEPA 2012).

In general, 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). Agricultural use of nitrogen fertilizers is the largest source of nitrates in near-surface aquifers in the midcontinent (Koplin et al. 1994). For example, over 100,000 metric tons of pesticides (herbicides, insecticides, and fungicides) were applied in

the midcontinent in 1991, often to control nonindigenous plants and animals. Effects of these pollutants on the quality of human life and on the integrity of the ecological community are largely unknown. The U.S. Environmental Protection Agency has initiated an effort to develop stressor information to help recognize areas where urban development, agricultural nonpoint pollution (pesticides, toxic chemicals, nutrient pollution), and agricultural development may exacerbate ecological decline. So for example, with high turbidity levels throughout the Washita Headwaters, monitoring for this core water quality parameter may be a high priority within the scope of a surface water monitoring program.

Another threat is the significant changes in the amount and permanency of surface and groundwater since pre-Columbian times as a result of ranching (e.g., stock ponds), irrigation, flood control, and other anthropogenic changes. Few major rivers in the Great Plains still exhibit the conditions evident before agricultural development and water management had occurred. 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).

##### Level of Confidence/

Assessing the level of confidence is irrelevant due to the lack of specific surface water quality data.

#### 4.6.5. *Sources of Expertise*

The U.S. Environmental Protection Agency's MyWATERS Mapper was used to gather site specific information. The mapper dynamically displays snapshots of EPA Office of Water program data, depicts the status of NPDES permits for each State; summary information from the Clean Watershed Needs Survey; and water quality assessments. MyWATERS Mapper also contains water-related geographic themes such as 12-digit watersheds, the national stream network known as the National Hydrography Dataset, and other water-related map layers and

enables you to create customized maps at national and local scales (USEPA 2012).

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## 4.7. Groundwater

### Indicators/Measures

- Change in Groundwater Level

### Condition - Trend - Confidence Level



Unknown - Unknown - N/A

#### 4.7.1. Background and Importance

Groundwater accounts for 1.7% of Earth's total water and 30.1% of Earth's freshwater (USGS 2011a). 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. Oklahoma residents depend on groundwater for their water supply, with 570 million gallons per day being drawn (Tortorelli 2009). The influence from public water supply withdrawal is concentrated in two-thirds of the state (mostly eastern OK), and the demand for irrigation purposes is concentrated in the western third of the state, including the area surrounding Washita Battlefield National Historic Site (Tortorelli 2009).

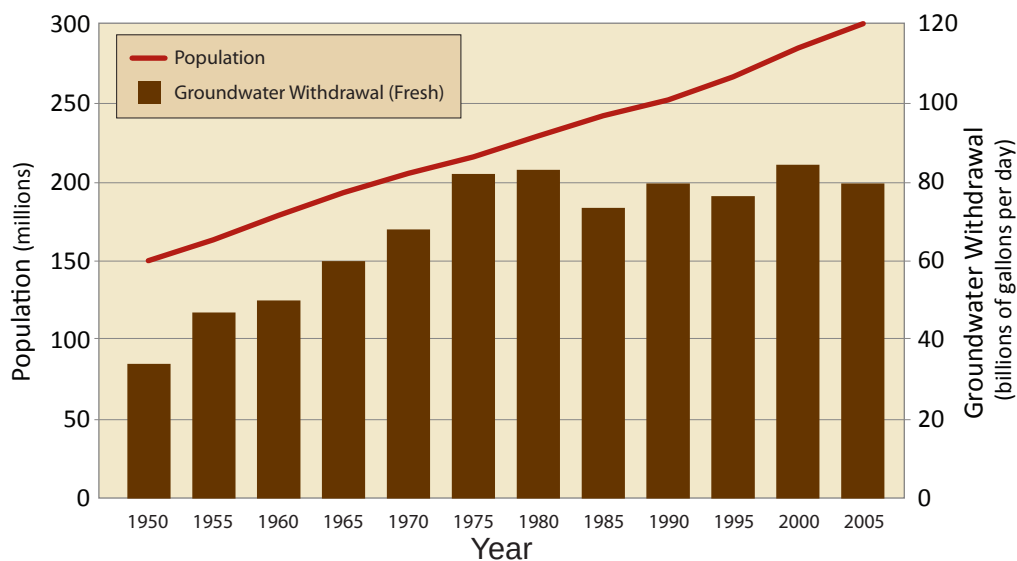
One environmental consequence to groundwater depletion is land subsidence, which is the settling or sinking of the Earth's surface.

The increasing development of land and water resources threatens to exacerbate existing land-subsidence problems and initiate new ones throughout the United States (USGS 2011b).

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

#### Aquifer Characteristics

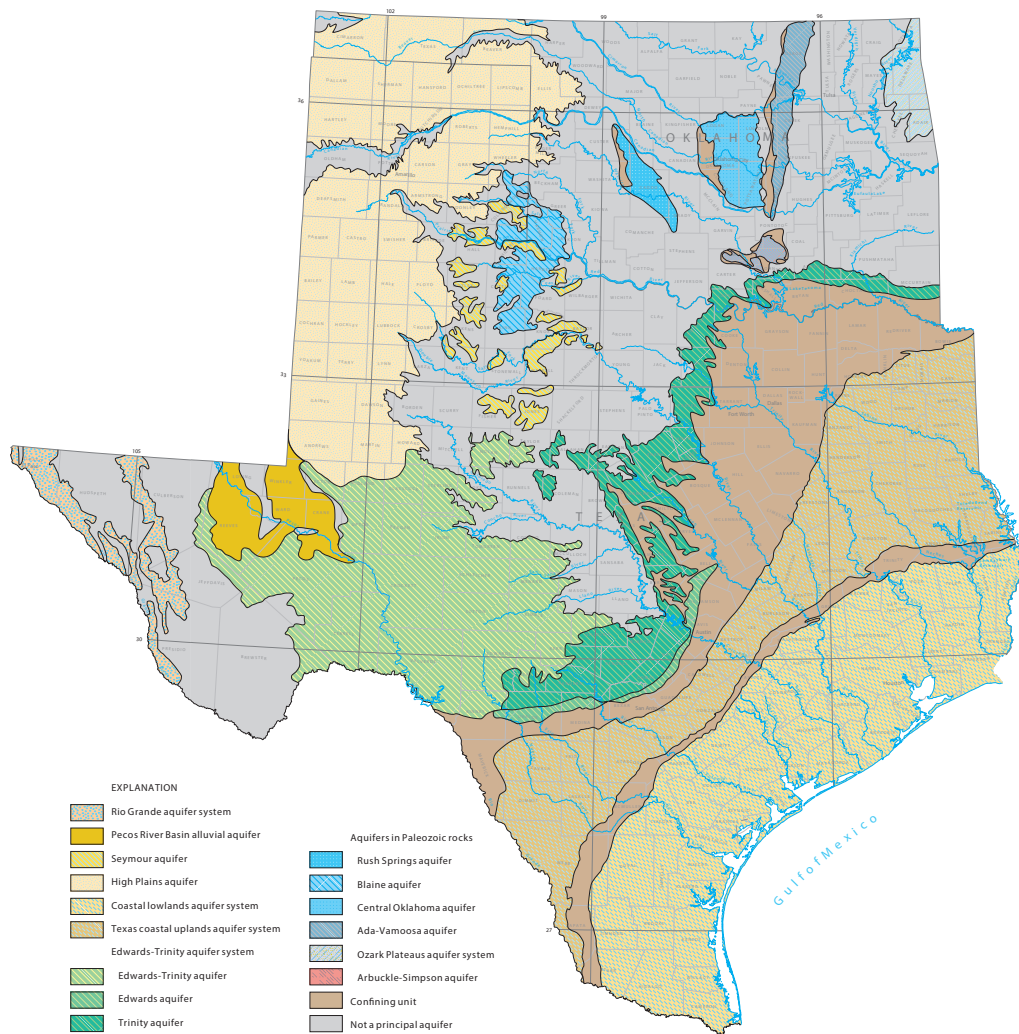
Washita Battlefield NHS' groundwater does not belong to a principal aquifer, such as the High Plains Aquifer, which is located just to the west, but instead is part of an alluvial aquifer located along the Washita River (4.7.1-2). An alluvial aquifer consists of deposits of



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

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

**Figure 4.7.1-2.**  
Sixteen major  
aquifers are  
located throughout  
Oklahoma and  
Texas.



alluvium in and along stream channels, alluvial terraces that are remnants of older alluvium, and overlying windblown deposits. The deposits consist of clay, silt, sand, and gravel, but only the sand and gravel areas yield water. The deposits range in age from Tertiary to Quaternary and are a few feet to more than 100 feet thick. The alluvial aquifers generally contain water under unconfined conditions (USGS 2005). These types of aquifers are good sources for irrigation, although they are shallower and have a lower yield compared to Ogallala Formation groundwater (Reber et al. 1999).

#### Water Use in Roger Mills County Oklahoma

According to the Tortorelli (2009), in Oklahoma, 63% of water use is from surface water withdrawals (989 million gallons/day) compared to 37% from groundwater withdrawals (570 million gallons/day). Public

supply and irrigation accounts for Oklahoma's largest withdrawals and consumptive uses of water (Tortorelli 2009).

Groundwater is used for the majority of freshwater withdrawal (68%) in Roger Mills County. Irrigation accounts for 5 million gallons/day, which represents the tenth highest county in Oklahoma (Tortorelli 2009) and accounts for 86% of total groundwater use. The next highest category of groundwater use in Roger Mills County is for livestock at 0.41 million gallons/day. The remaining categories and amounts of groundwater use in Roger Mills County are shown in Figure (4.7.1-3).

#### **4.7.2. Data and Methods**

The Oklahoma Water Resources Board (OWRB) annually monitors more than 600 groundwater wells throughout Oklahoma to collect data on water levels, which is the attribute we are most interested in to assess

groundwater condition at the Historic Site. The Water Well Level Mass Measurement Program has managed in cooperation with U.S. Geological Survey since the 1950s and is used to predict water use trends and groundwater availability throughout Oklahoma (OWRB 2012).

Each year, primarily during the winter months, data are collected to help determine if there has been any change in groundwater levels and if any areas are experiencing groundwater depletion (OWRB 2012).

### Indicators/Measures

- Change in Groundwater Level

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

One of the Water Well Level Mass Measurement Program's monitoring wells, ID 2687, is located in the Washita River major alluvium aquifer, approximately 3 miles northeast (downstream) of the Historic Site (Figure 4.7.2-1). The water level elevations and depths to water levels have been monitored at the well from 1976-present. Water level

**Total Withdrawals (in millions of gallons per day)**

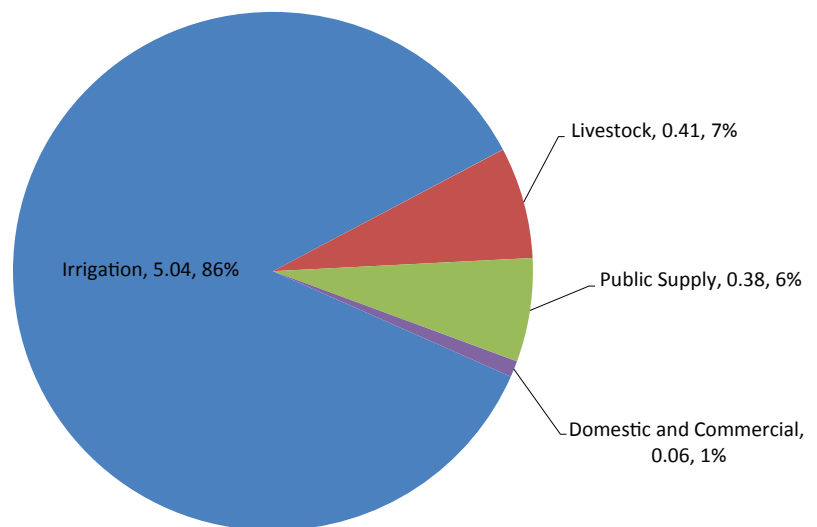


**Figure 4.7.1-3. Total groundwater withdrawals by category of use in Roger Mills County, OK.**

data collected from well 2687 is presented in Figure 4.7.2-2, showing both the depth to water on the y-axis, located on the left, and the water level elevation on the y-axis, located on the right.

The highest depth to water measurement, 10.80 m (35.43 ft), was taken on 2/10/1976, and the shallowest water level was recorded on 3/27/1981 at 7.63 m (25.02 ft) (n=37).

“The USGS annually monitors groundwater levels in thousands of wells in the United States. Groundwater level data are collected and stored as either discrete field-water-level

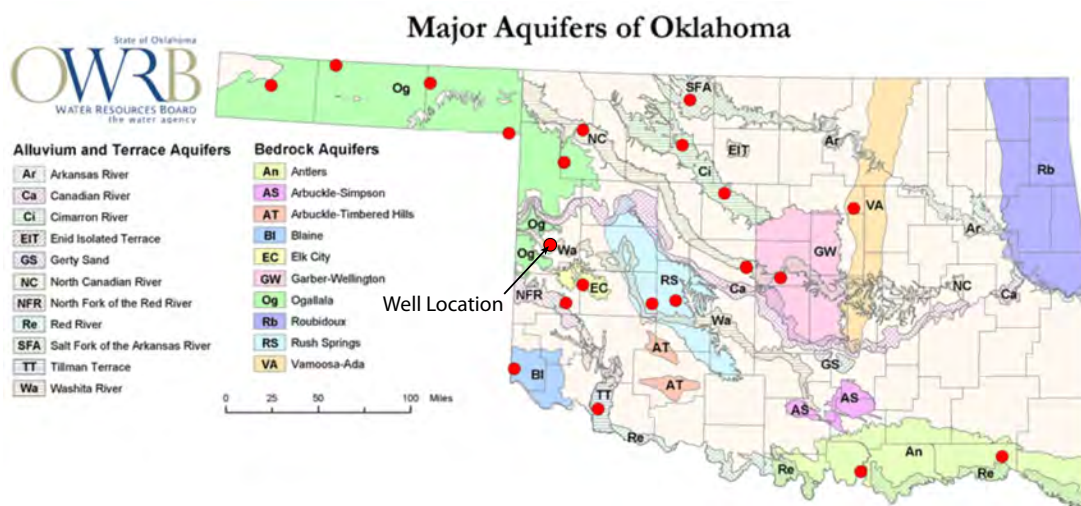


**Figure 4.7.2-1. The Water Well Level Mass Measurement Program well #2687 is located in the Washita River alluvium aquifer.**

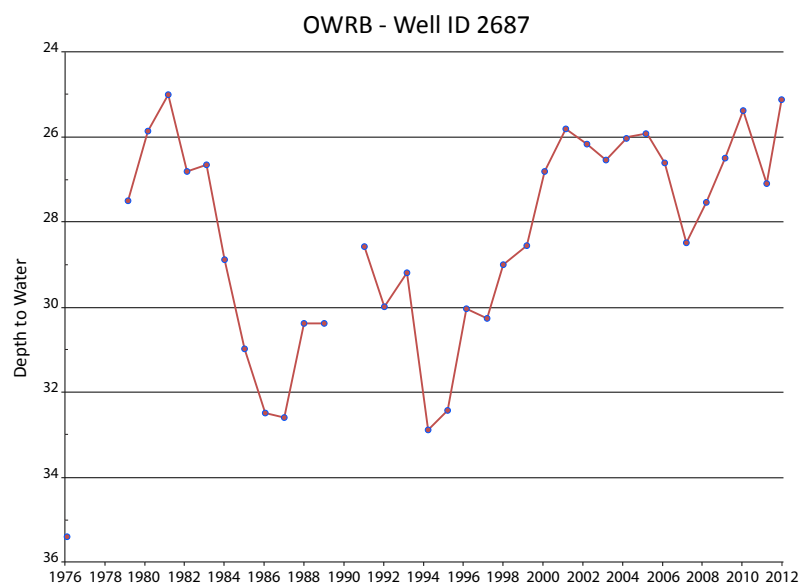


**Figure 4.7.2-2.** Depth to water level and water level elevation for The Water Well Level Mass Measurement Program well #2687 located in the Washita River alluvium aquifer downriver from the Historic Site.

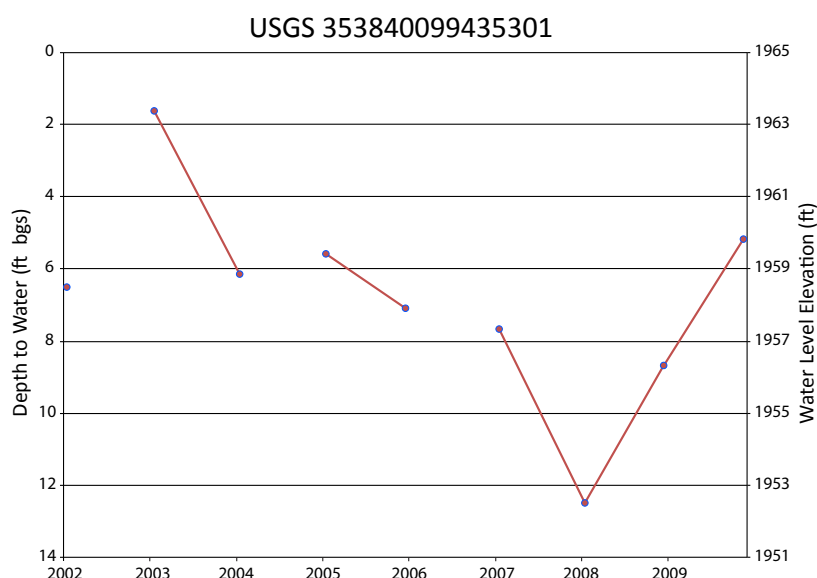


**Figure 4.7.2-3.** The USGS well is located in the Washita River alluvium aquifer upriver from the Historic Site.

measurements or as continuous time-series data from automated recorders. Data from some of the continuous record stations are relayed to USGS offices nationwide through telephone lines or by satellite transmissions providing access to current groundwater data. Once a complete day of readings are received from a site, daily summary data are generated and made available online. Annually, the USGS finalizes and publishes the daily data in a series of water-data reports” (USGS 2013)

A USGS monitoring well is located upriver approximately 1.7 miles from the Historic Site. It has a 9 year record beginning in 2002-2010. The highest depth to water measurement, 3.81 m (12.50 ft), was taken on 3/11/2008, and the shallowest water level was recorded on 3/27/2003 at 0.49 m (1.60 ft) (USGS 2011c). Water level data collected from this well is presented in Figure 4.7.2-3.

Other USGS groundwater monitoring wells are located closer to the Historic Site but have been inactive since the 1950s, with only one record for each well (USGS 2011c).

#### 4.7.3. Reference Conditions

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

#### 4.7.4. Condition and Trend

The water levels for well 2687 have been recorded for 37 years. Most recently, in 2012, the depth to water was the second shallowest on record at 7.67 m (25.16 feet).

Well recordings for the USGS well ceased in 2010, but the shallowest recorded water level depth was 0.49 m (1.60 ft) taken in 2003.

#### Washita River Alluvium and Terrace

The OWRD conducts hydrologic investigations of groundwater basins throughout the state to determine the amounts of water that may be withdrawn (OWRD Fact Sheet). A maximum annual yield amount is determined for each basin, describing the amount of groundwater that can be withdrawn while allowing for a minimum 20-year life of the basin. The amount of water a well permittee is allowed to withdraw is proportionate to the amount of land owned or leased within each basin.

Several factors are considered when establishing maximum annual yield amounts. Area of land overlying the basin, amount of water currently in the basin, rate of recharge,

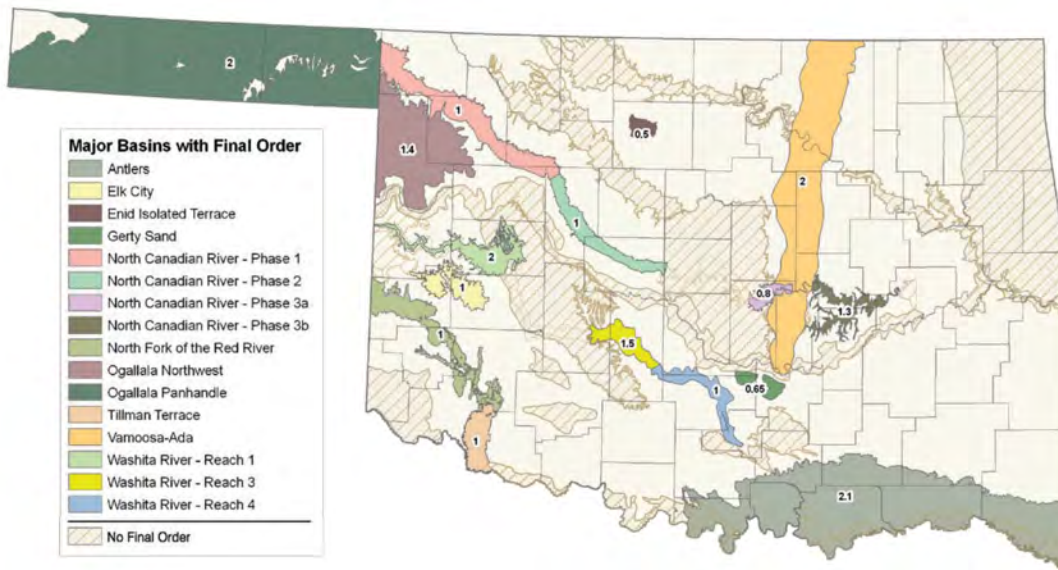


**Figure 4.7.4-1.**  
The Washita River Alluvium and Terrace Basin is divided into three reaches, with the Historic Site located along reach one

total discharge, transmissivity, and pollution potential are the primary considerations. These investigations are usually conducted by an outside expert agency, such as the USGS.

Kent et al (1984) completed the maximum annual yield for the Washita Alluvium and Terrace Basin. They divided the basin into four reaches (only 3 are shown), with reach one including the area of the Historic Site (Figure 4.7.4-1).

Driller's logs throughout reach one showed that the average depth to water was 17 feet and the average saturated thickness was 118 feet (Kent et al. 1984).

The maximum annual yield determined for reach one was 120,320 acre-feet and an equal proportionate share of two acre-feet of water per acre of land per year, one of the highest shares throughout all assessed basins.

#### Overall Condition/Trend

For assessing the condition of groundwater, we used one indicator/measure, which is summarized in Table 4.7.4-1. The wells that draw from the Washita River alluvium aquifer has been monitored by OWRD and USGS, providing information about the groundwater level.

Based on the annual data available, we conclude that we do not have the appropriate

type of data, including an assessment of the local geology and local wells to determine condition for the Historic Site's groundwater resource.

#### Threats

The Washita River alluvial aquifer was rated as being of "very high vulnerability" to contamination by the Oklahoma Water Resources Board (OWRB 1999) (Figure 4.7.4-2). The alluvium and terraces deposits are the most vulnerable to contamination from surface sources of pollution because they are exposed at the surface (OWRB 1999).

Another threat to the groundwater resource is drought. Water year 2006 was the second driest year for statewide annual precipitation and the sixth driest year for statewide annual runoff within an 82-year record (i.e., 1925-2006) (Tortorelli 2008). Although rainfall amounts varied by the National Weather Service Climate Divisions, West Central Oklahoma Division where the Historic Site is located, was only one of two areas with minor rain deficits compared to the remaining areas of Oklahoma that had severe rainfall deficits (Tortorelli 2008). Even though Water Year 2006 represented the 28th driest in 82 years in West Central Oklahoma, only 73% of normal rainfall occurred (Tortorelli 2008). The effects of drought on groundwater resources can eventually lead to increasing depths to water

**Table 4.7.4-1. Summary of the groundwater indicator/measure and its contribution to the overall groundwater natural resource condition assessment.**

| Indicator/Measure           | Description of How the Indicator(s) Contributes to the Overall Resource Condition                                                                                                                                                                                                                                                                                       | General Contribution of this Indicator or Measure to the Overall Resource Condition.                                                                            |
|-----------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Change in groundwater level | Water level can indicate depletion of an aquifer if the level continues to lower. This can be a result of supply exceeding demand and/or from a recharge rate that cannot maintain a degree of sustainability for the aquifer. On the other hand, if water level increase occurs that may be a result of retired wells and/or from recharge rates exceeding extraction. | The well water level recordings within the Washita River Alluvium and Terrace aquifer do not provide sufficient information to determine groundwater condition. |



### Statewide Groundwater Vulnerability Map of Oklahoma

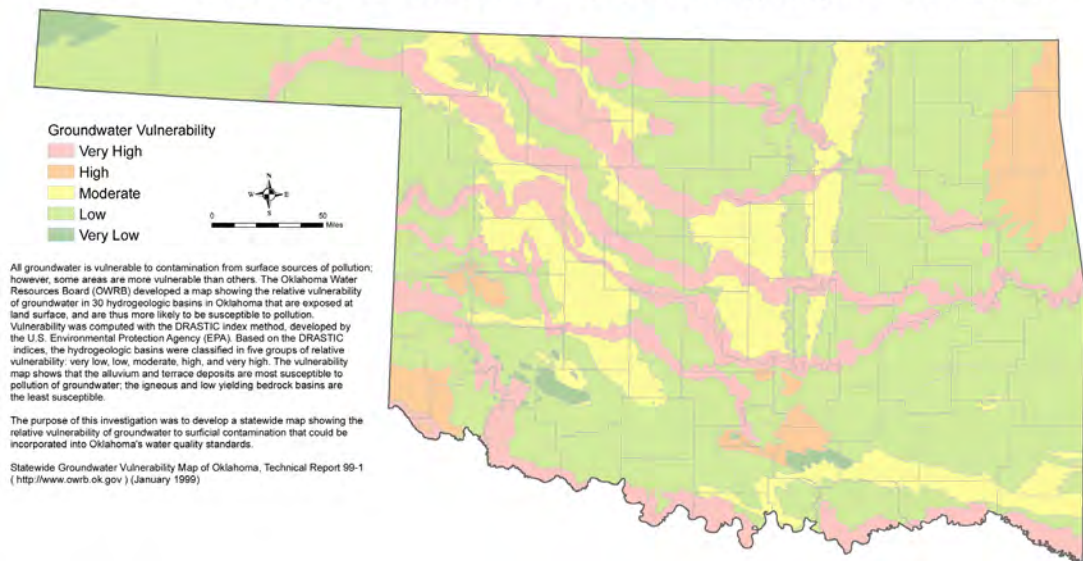


**Figure 4.7.4-2.**  
Groundwater  
vulnerability map  
for Oklahoma,  
specifically Washita  
River..

in wells, which may result in land subsidence and impacts to plants.

#### Key Uncertainties

A key uncertainty of this assessment is data from wells located at least 2-3 miles outside the Historic Site's boundary were used to assess the groundwater level condition. Closer wells were found but only one record for each of the wells was recorded, all taken in the 1950s.

Additionally, we do not know the current supply and demand for groundwater in this area and cannot predict future development throughout the area. However, we are somewhat reassured that withdrawals are being monitored by the OWRB based upon

the maximum annual yield determination for the Washita River Alluvium and Terrace aquifer.

#### **4.7.5. Sources of Expertise**

No experts were available for this resource topic.

#### **4.7.6. Literature Cited**

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## 4.8. Riparian Habitat

### Indicators/Measures

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

### Condition – Trend - Confidence Level



Moderate - Improving - High

#### 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.

The Washita River is a tributary of the Red River. From its source, the Washita River flows in a generally easterly direction approximately 50 miles through sparsely populated areas of the Texas panhandle and west-central Oklahoma before flowing through Washita Battlefield NHS above the confluence of Sergeant Major Creek near Cheyenne, OK.

The Washita River is situated in the High Plains and Western Redbed Plains geomorphic province. This region is characterized by gently rolling hills on flat-lying Permian sandstone and shale. Washita Battlefield NHS is located within

the Sergeant Major Creek sub-drainage of the Washita Headwaters watershed (USGS Hydrologic Unit 11130301) (Figure 4.8.1-1). The Washita Headwaters watershed above the National Historic Site encompasses approximately 1,476 square miles (Heidi Sosinski, data manager, Southern Plains I&M Network, personal communication, September 19, 2012), is rural in character, and consists primarily of rangeland and agriculture. The region is subject to long- and short-term droughts. Historically, flooding and eroded sediment flow along the Washita River was a very serious problem especially during and immediately following the dust bowl years of the 1930s (USDA, 1963 as cited in Reber et al. 1999).

The predominant topography of the region consists of rolling hills, moderate valley slopes, and upland slopes of 2 to 20 percent. Washita Battlefield NHS contains three alluvial terraces, consisting of stream-laid deposits of sand, silt and clay, which rise above the active floodplain and upland areas composed of

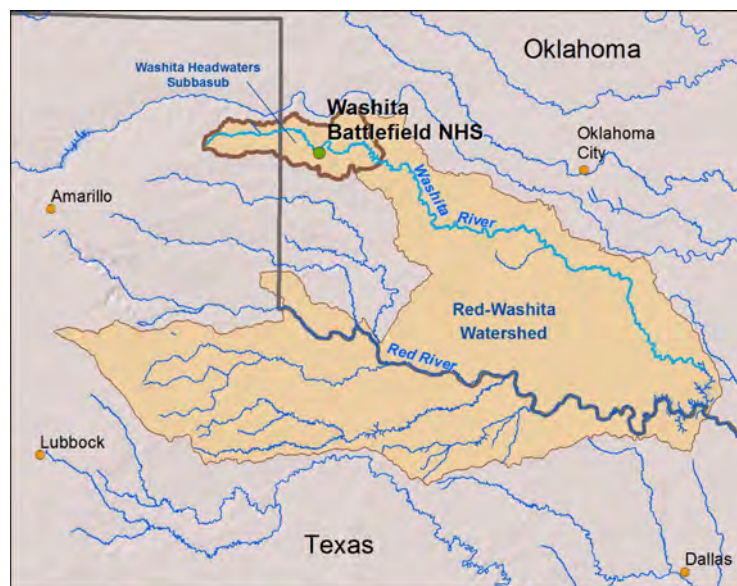


**Figure 4.8.1-1.**  
Washita River is a tributary of the Red River and part of the Washita Headwaters watershed.

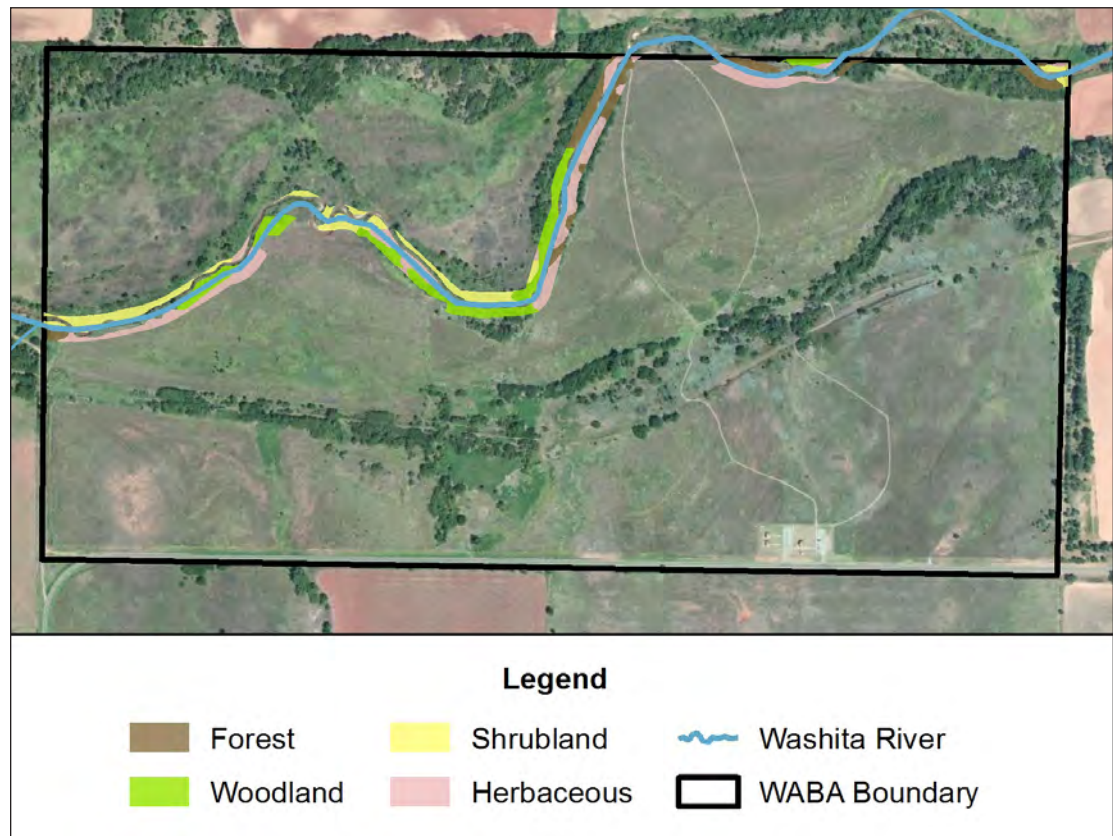


**Figure 4.8.1-2.**  
Riparian habitat  
within the Historic  
Site located along  
the Washita River.

red-bed sandstones, siltstones, mudstones, and gypsum of Permian age (Haynes, 1995 as cited in KellerLynn 2011). In addition, most of the watershed overlies the Anadarko Basin, a region of natural gas exploration and production (Carr and Berman, 1976 as cited in Reber et al. 1999).

The Washita River runs 1,495m within the Historic Site and the riparian habitat is comprised of woody species, including trees and shrubs, and herbaceous vegetation and occupies approximately 4.5 hectares (Heidi Sosinski, data manager, Southern Plains I&M Network, personal communication, September 26, 2012) (Figure 4.8.1-2).

A properly functioning riparian habitat is influenced by several factors and interactions between geologic formations, soil, water, vegetation, and local as well as regional (watershed) land use activities/practices. A river system and associated riparian habitat is always attempting to maintain a dynamic equilibrium between streamflow forces and channel processes. A naturally functioning

system is able to respond to larger waterflow events without excessive change to the riparian habitat plant communities and river channel characteristics. In fact, these larger flow events are a necessary process in the evolution of a river and riparian system, and as a result, aquatic and riparian habitat is maintained and water quality is enhanced. It is when ongoing impacts to the natural river processes occur that riparian habitats can no longer maintain resiliency and proper functioning.

#### **4.8.2. Data and Methods**

An interdisciplinary team of experts from NPS' Water Resources Division and Southern Plains Inventory and Monitoring Network conducted a qualitative riparian habitat assessment at the Historic Site (Cummings and Folts-Zettner 2012) using "A User Guide to Assessing the Proper Functioning Condition and the Supporting Science for Lotic Areas" developed by Prichard et al. (1998). Their assessment methodology was based upon a "Proper Functioning Condition (PFC)", which describes both

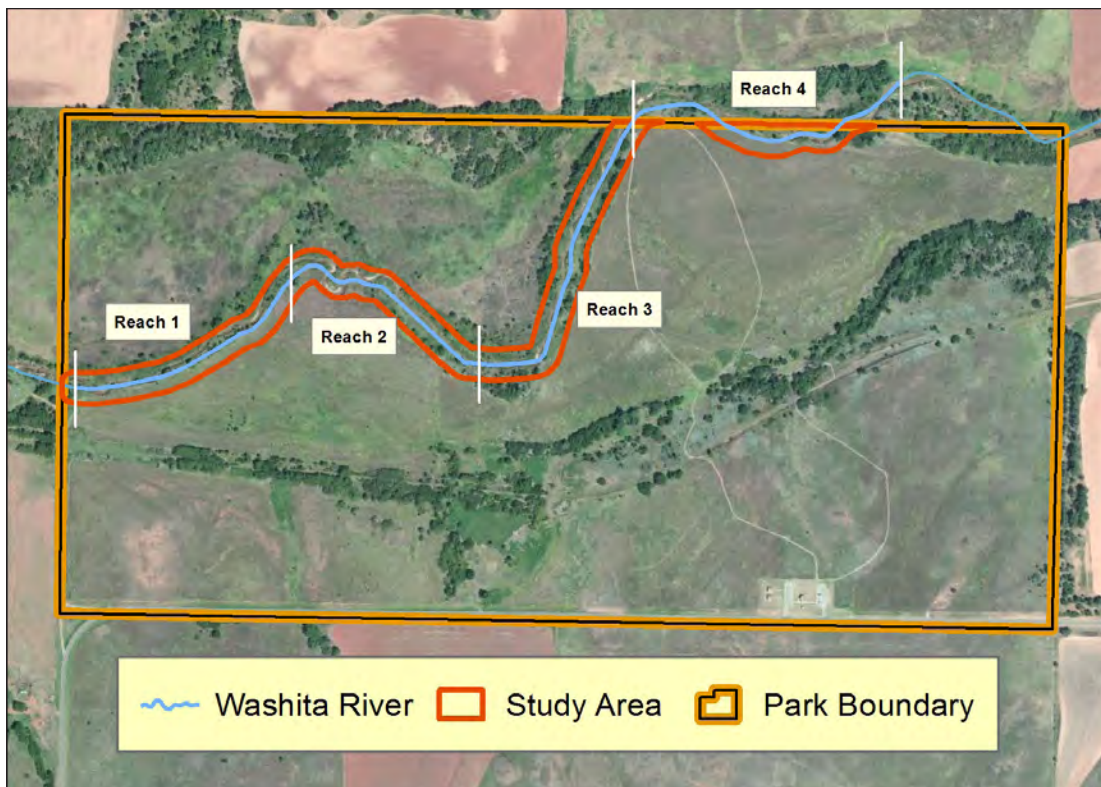


**Figure 4.8.2-1.**  
The Washita River flows approximately 0.93 miles within the Historic Site's boundary.

the condition assessment process as well as a reference condition (Prichard et al. 1998). In 2001, Inglis and Wagner conducted a riparian wetland assessment using the same methodology. They divided the Washita River into four segments for evaluation based upon different attributes and processes throughout these segments. Cummings and Folts-Zettner retained the 2001 study areas (Figure 4.8.2-1) and re-evaluated the Washita River riparian habitat during an 2012 summer on-site visit. This assessment is essentially derived from Cummings and Folts-Zettner (2012) findings; readers seeking additional detail are encouraged to read the full report (<http://www.nature.nps.gov/publications/nrpm/nrr.cfm>).

Both terrestrial and aquatic attributes and processes are important in riparian habitat areas and are used to assess the condition of a given area. This assessment included three main categories including hydrology, vegetation, and erosion/deposition. A total of 17 common attributes and processes within each of these three categories was assessed by the interdisciplinary team (Figure 4.8.2-2) using a standardized checklist/

datasheet developed by Prichard et al (1998). It is the culmination of these indicators, listed below, that determined the overall condition of the Historic Site's riparian habitat.

### Indicators/Measures

#### Hydrology

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

#### Indicator: Floodplain inundated frequently

A floodplain is topographically flat, a landform of unconsolidated sediments originating from the stream, and subject to periodic flooding, 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 habitat in functioning condition. Periodic flooding

**Figure 4.8.2-2.**  
Washita Battlefield  
Natural Resource  
Manager assisting  
with the riparian  
wetland condition  
assessment along  
the Washita River.  
(photo credit: Jalyn  
Cumplings)



also promotes vegetation growth, which contributes to a properly functioning riparian area as well.

**Indicator: Beaver dams are active and stable**

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

**Indicator: 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.

**Indicator: Riparian habitat area is widening or has achieved potential extent**  
Sediment capture develops floodplains, which in turn, aids functionality of a riparian habitat

area. In addition, as sediment is deposited, vegetation can “take root”, increasing certain types of vegetation such as sedges, willows, and rushes.

**Indicator: Upland watershed is not contributing to riparian habitat degradation**

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

**Indicators/Measures**

**Vegetation**

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

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

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

**Indicator: There is diverse composition of riparian habitat vegetation**

Not all plants need to be present within a riparian habitat for the system to maintain itself, but there needs to be enough variety for a 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.

**Indicator: Species present indicate maintenance of riparian habitat 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.

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

Plants that have adapted to riparian habitat conditions, such as cottonwood, aspen, alder, willow, sedge, rush, and some grasses, develop root masses that help stabilize riverbanks, especially during high-flow events. If banks are undercut during storm or high runoff events, many changes can occur to the channel's width/depth ratio, gradient,

and sinuosity, which in turn, may decrease the system's ability to dissipate energy. The presence of obligate and facultative wetland plants is usually a good indication that the streambank will remain stabilized.

**Indicator: Riparian habitat plants exhibit high vigor**

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

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

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

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

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

### Indicators/Measures

#### Erosion/Deposition

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

**Indicator: Floodplain and channel characteristics are adequate to dissipate energy**

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

**Indicator: Point bars are revegetating**

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

**Indicator: Lateral stream movement is associated with natural sinuosity**

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

**Indicator: System is vertically stable**

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

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

Stream channels adjust to water and sediment loads and are classified as either single thread

or braided channels. Most braided channels indicate unnaturally high sediment loads, whereas, excessive erosion indicates an imbalance in water flow.

### ***4.8.3. Reference Conditions***

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

### ***4.8.4. Condition and Trend***

#### **Overall Condition and Trend**

The results for the Historic Site's riparian habitat condition assessment revealed that three of the four reaches during the 2012 assessment were considered to be functional-at risk and one reach was in a non-functional condition. These results are listed in Table 4.8.4-1. However, compared to Inglis and Wagner (2001) riparian habitat assessment, the overall trend for the riparian habitat at the Historic Site is improving.

**Table 4.8.3-1. The reference conditions used to determine whether the condition of the riparian wetlands at Washita Battlefield 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. |

### Hydrology Condition

Washita River's channel morphology and evolution is strongly influenced by the more than 70 flood control dams upriver, which are some of the oldest in the nation (Reber et al. 1999). Prior to the construction of the dams, flooding across the floodplain was a natural river process. The periodic flooding not only helped maintain the natural sinuosity and balance between erosion and deposition of sediments but also provided the necessary seedbanks for replenishing native vegetation such as cottonwoods (KellerLynn 2011). Reach one of the study area was rated non-functional (a.k.a. significant concern) as a result of the "virtually straight channel", lack of point bars, and incising that is occurring along the stretch of river (Cummings and Folts-Zettner 2012). Reaches two, three, and four were rated as a moderate concern relative to the hydrologic characteristics along these sections. Greater stream movement and point bar development were observed. Erosion was also not as evident as what was observed along reach one (Cummings and Folts-Zettner 2012).

USGS installed a water gage along the Washita River near Cheyenne, OK, which has been operational since 1934: : Washita River near Cheyenne, OK gage (#07316500). USGS stream gages record data that describe stream levels, streamflow (discharge rates), and even water quality (USGS 2012a).

Peak streamflow occurred April 1954, with a flow of 69,800 cubic feet per second. The second largest streamflow occurred April

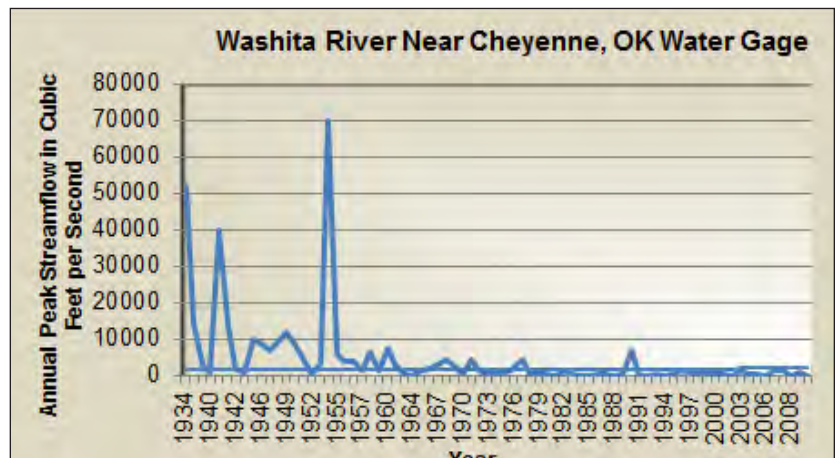


**Figure 4.8.4-1 Peak streamflow at USGS water gage near Ceyenne, OK along the Washita River (USGS 2012b).**

1934, reaching a peak of 52,000 cfs (Figure 4.8.4-1). A marked decrease in streamflow has occurred after the 1954 flood event due to the upstream impoundments constructed in the 1950s and 1960s. These impoundments have significantly reduced peak flows and flooding and have also modified channel movements along the Washita River (Reber et al. 1999).

At the time of the battle, the Washita River was a natural flowing, perennial, meandering stream that formed a series of horseshoe bends within and in the vicinity of the national Historic Site. Black Kettle's camp was located within one of these bends, and since the 1868 battle, the channel has migrated (Haecker 2000 as cited in KellerLynn 2011). According to Marston and Halihan (2007), the location of Black Kettle's camp is now on the north side of the river (Figure 4.8.4-2).

**Table 4.8.4-1. Results for the riparian wetland condition assessment at Washita Battlefield NHS (Cummings and Folts-Zettner 2012).**

| Indicator/Measure                                     | Reach 1                                                                                                                    | Reach 2                                                                                          | Reach 3                                                                                                        | Reach 4                                                                                                          |
|-------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------|
| Hydrology                                             |                                                                                                                            |                                                                                                  |                                                                                                                |                                                                                                                  |
| Floodplain                                            | Evidence of channel incision but small vegetation wracks were observed.                                                    | No incised channel was present and the river has access to the floodplain.                       | A smaller floodplain is beginning to form within channel.                                                      | A smaller floodplain is beginning to form within channel.                                                        |
| Beaver dams                                           | n/a                                                                                                                        | Beaver dams were present and beaver trails to their dens were fresh.                             | The existing beaver dam was actively maintained and trails were fresh.                                         | n/a                                                                                                              |
| Sinuosity, width/depth ratio, and gradient            | This is a straight, shallow reach with a sandy bottom and steep channel banks.                                             | The channel is meandering, with high sinuosity and single threaded with no mid channels forming. | This area has yet to reach its potential but is improving, especially compared to reach #1.                    | More sinuosity and pools of standing water were present compared to reach #3.                                    |
| Riparian wetland area                                 | A positive shift in vegetation from upland species to wetland species was observed but wetland in early development stage. | The in-channel wetland vegetation is in balance with the landscape setting.                      | New vegetated terraces are beginning to form providing some bank and channel stability.                        | Mature wetland vegetation is in the channel, and a riparian buffer exists between the stream and adjacent field. |
| Upland watershed                                      | Upland watershed is not contributing to riparian-wetland degradation                                                       | Upland watershed is not contributing to riparian-wetland degradation                             | Upland watershed is not contributing to riparian-wetland degradation                                           | Upland watershed is not contributing to riparian-wetland degradation                                             |
| Vegetation                                            |                                                                                                                            |                                                                                                  |                                                                                                                |                                                                                                                  |
| Age class distribution of riparian wetland vegetation | Good age class distribution for willows but not for cottonwoods.                                                           | Four age classes of cottonwood were present.                                                     | No woody species larger than willows were present.                                                             | A good vegetation age class distribution was present.                                                            |
| Diverse vegetation composition                        | A wide variety of vegetation was present including willows, herbaceous cover, and rushes.                                  | A variety of woody species and herbaceous plants were present and evidence of good recruitment.  | A diverse assemblage of grasses and shrubs were present; however, larger woody vegetation was absent.          | Grasses, shrubs, and forbs were present but large woody debris was absent.                                       |
| Soil moisture characteristics                         | Soil appeared moist based upon the species present.                                                                        | Species present were indicative of moist conditions.                                             | Species present were indicative of moist conditions and a rising water table possibly due to Tamarisk removal. | Species present were indicative of moist conditions and more standing water was present within this reach.       |

**Table 4.8.4-1. Results for the riparian habitat condition assessment at Washita Battlefield NHS (Cummings and Folts-Zettner 2012) continued.**

| Indicator/Measure                                                      | Reach 1                                                                                               | Reach 2                                                                                                                       | Reach 3                                                                                        | Reach 4                                                                                  |
|------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------|
| Plants have root masses capable of withstanding high streamflow events | Plant composition present, specifically bulrush and switchgrass, can stabilize the streambanks.       | The cottonwoods willows, button bush, switchgrass and lead plants present were assisting with bank stabilization.             | Plants species present were stabilizing streambanks.                                           | Plant species present were stabilizing banks.                                            |
| Vigorous plants                                                        | Native plants appear to be establishing more than non-natives.                                        | Plants appear vigorous and cottonwood recruitment is occurring.                                                               | The plants that are present appear vigorous and are establishing on the newly formed terraces. | Native plants have established and non-natives have decreased due to control efforts.    |
| Vegetation cover                                                       | A variety of herbaceous and shrubs were present, with willows comprising >50% cover along both banks. | A variety of vegetation is growing in channel to provide adequate vegetation cover.                                           | A variety of vegetation was growing, however, larger woody vegetation is absent.               | A variety of plants were growing and more mature vegetation was growing in-channel.      |
| Plant communities are coarse and/or large                              | There was not enough large, woody material present.                                                   | Recruitment of cottonwoods is beginning but the oldest trees are only 10-12 years.                                            | No large woody debris was present.                                                             | No large woody debris was present, however, mature cottonwoods are closest to this area. |
| Erosion/Deposition                                                     |                                                                                                       |                                                                                                                               |                                                                                                |                                                                                          |
| Floodplain and channel characteristics                                 | Rocks, overflow channels, coarse and/or large woody debris are not in this channel.                   | No water flowing during this trip. High sinuosity was observed and river had access to floodplain, but no large woody debris. | The sinuosity, width/depth, and gradient have yet to reach potential.                          | This stretch is sinuous and has several standing pools of water.                         |
| Point bars                                                             | Only one small point bar was beginning to form at the end of the reach.                               | Point bars forming and pools still holding water along this stretch.                                                          | A number of point bars were present within this stretch.                                       | Point bars were present and vegetated, supporting young cottonwood and seedlings.        |
| Lateral stream movement                                                | This stretch is incised, reducing the river's side to side movement                                   | This stretch of river has access to the floodplain and shows terracing.                                                       | The presence of point bars and terraces indicate lateral movement.                             | The presence of point bars and terraces indicate lateral movement.                       |
| Vertical stability                                                     | Channel incising was occurring with 4-5' banks along the river.                                       | No excessive erosion or channel lowering was observed.                                                                        | No excessive erosion or channel lowering was observed.                                         | No excessive erosion or channel lowering was observed.                                   |

**Table 4.8.4-1. Results for the riparian habitat condition assessment at Washita Battlefield NHS (Cummings and Folts-Zettner 2012) continued.**

| Indicator/Measure             | Reach 1                                                                                            | Reach 2                                                                                                                          | Reach 3                                                        | Reach 4                                                        |
|-------------------------------|----------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------|----------------------------------------------------------------|
| Balance of water and sediment | Erosion is occurring but the formation of a point bar implies some channel stability is occurring. | The single thread channel, no formation of mid-channels, and location of vegetation implies balance of water and sediment loads. | No erosion occurring and proper sediment deposition evidenced. | No erosion occurring and proper sediment deposition evidenced. |

**Figure 4.8.4-2. Black Kettle's camp along the Washita River (Source NPS)**

Overall, Washita River's sinuosity, point bar development, decreased erosion, and lateral movement improved along the reaches from west to east but is considered to be in moderate condition (Cummings and Folts-Zettner 2012).

#### Riparian Vegetation Condition

Riparian habitat vegetation serves a variety of functions in a river system including sediment capture, sources for woody debris, which in turn assists with energy dissipation, and creates habitat structure and food sources for several species. The primary concern relative to the vegetation was the lack of larger woody vegetation, however, as a result of active Tamarisk removal a wide variety of native species are becoming established (Cummings and Folts-Zettner 2012). Species composition

has changed from upland invasive species documented by Inglis and Wagner in 2001, such as Tamarisk and other upland species like giant sandreed grass, and black locust to riparian vegetation (Cummings and Folts-Zettner 2012). Common riparian habitat plants included common three square (*Schoenoplectus pungens*), fringleaf paspalum (*Paspalum setaceum*), switchgrass (*Panicum virgatum*), grape (*Vitis acerifolia*), Torrey's rush (*Juncus torreyi*), buttonbush (*Cephalanthus occidentalis*), and lead plant (*Amorpha fruticosa*). These plant communities provide the root stabilization necessary to withstand high streamflow events, if one should occur.

Woody shrubs consisted of black willow (*Salix nigra*) and coyote willow (*Salix exigua*) in enough abundance to hold bank (at least 50%

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

| Indicator/Measure                   | Description of How the Indicator(s) Contributes to the Overall Resource Condition                                                                                                                                                                                                                                                                                                        | General Contribution of this Indicator or Measure to the Overall Resource Condition.                                                                                                                                                                                                                      |
|-------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Hydrology<br>(5 measure)            | The hydrology of a riparian habitat affects how well water flow energy can be dissipated, including erosion and sediment depositional processes. These hydrologic characteristics are also affected by upland watershed activities in addition to on-site activities/changes.                                                                                                            | As evidenced by the river channel's limited sinuosity and limited floodplain development, the hydrologic component of the Historic Site's riparian habitat is considered to be functional but at risk, thus of moderate condition.                                                                        |
| Riparian Vegetation<br>(7 measures) | Riparian vegetation is specialized and controlled by how much water a plant's root system can withstand. Some species are obligate habitat, indicating the need for standing water in order to survive. Several different classes of wetland species also exist, and collectively, provide the necessary cover, debris, and root systems to maintain resiliency during high flow events. | A wide variety of wetland plants were present and growing where expected representing diverse age classes, but the overall lack of large woody material resulted in a moderate condition rating. Active exotic plant removal along the river is resulting in increased recruitment for native vegetation. |
| Erosion/Deposition<br>(5 measures)  | Erosion and sediment deposition is a natural and necessary process for a river and its riparian habitat to maintain dynamic equilibrium. Properly functioning conditions manifest as channel and floodplain "intactness", lack of channel braiding, or streambank failure. Lateral movement also implies erosion and depositional balance.                                               | Evidence of channel incision was observed along reach one., and as a result, lateral movement was also restricted. Erosion and in channel movement improved along the river from west to east, but when considering the river system as a whole, the condition was rated as moderate concern              |

coverage along some of the river stretches), but consistently larger woody debris was lacking (Cummings and Folts-Zettner 2012).

There were a few mature cottonwood trees growing along the banks but not enough to provide channel structure and dissipate energy from potential high flow events. The lack of woody debris was one of the primary reasons the condition was rated as a moderate concern. However, as a result of the active invasive plants removal along the river, a diverse age class distribution and species composition has produced an improving trend in vegetation (Cummings and Folts-Zettner 2012).

In addition, as the assessment progressed from the west to the east reaches, the number of cottonwood seedlings increased, along with soil moisture as evidenced by standing pools of water (Cummings and Folts-Zettner 2012).

#### Erosion/Deposition Condition

Meandering rivers typically migrate through their floodplain, eroding the older terraces and floodplain alluvium along the cutbanks and depositing the sediment onto point bars where they slowly aggrade (Martin at al. 2012). Previous investigations identified three terrace levels above the present-day floodplain at the Historic Site (KellerLynn 2011).

Evidence of excessive erosion was observed along reach one, where the stream geometry was in poorest condition. However, point bar formation and lateral stream movement improved from west to east, decreasing erosion processes.

In summary, the condition of the Historic Site's riparian habitats is a combination of vegetation, hydrology, and erosion and deposition factors and processes. These factors and processes are interconnected, and when evaluated as a whole, provide a

comprehensive assessment of the Historic Site's riparian habitat. Table 4.8.4-2 summarizes the riparian habitat indicator categories and how they contributed overall to the assessment.

#### Historical Context

It is along an area of the Washita River's floodplain, now Washita Battlefield National Historic Site, where Chief Black Kettle established his winter village that was attacked by Custer and his Army in 1868. The low lying floodplain of the Washita River provided the necessary protection from the brutal winter winds, and the river provided a water source for Black Kettle's tribe and horses. The camp included 51 lodges (Lees et al. 2001 as cited in KellerLynn 2011) and covered approximately 10 ha (25 ac) on the south side of the river (Marston and Halihan 2007). Black Kettle's camp was located upstream from Arapaho, Kiowa, and other Cheyenne camps, whose people and horses also needed water. At the time of the attack, the riparian area was enclosed by a canopy of cottonwood trees, which would have provided shelter and fuel for winter fires (Reber et al. 1999).

On November 27, 1868, General Custer's Army entered the wintering Indian encampment (Milner 2003), attacking in snow and from all four directions. Black Kettle, his wife, Medicine Woman Later, and hundreds of others were killed.

Smaller, intermittent drainages that led down to the Washita River were used by the Cheyenne for retreat and as hiding places during the attack. These same drainages also provided attack routes for pursuing U.S. troops.

The Cheyennes hopes of independently sustaining themselves ended that same day of the attack along the Washita River when they were effectively driven from their homeland-the Plains- into reservations (PBS 2001).

The area along the river where Black Kettle and his people were killed has changed due to the natural meandering of the river prior to the establishments of impoundments but is still preserved to safeguard both the cultural

and natural values that the river's features and processes represent.

#### Level of Confidence/Key Uncertainties

NPS' Water Resources Division and SOPN botanist 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 habitat at the time of the assessment.

#### Threats

According to Prichard et al. (1998), a state of resiliency within a riparian habitat area needs to be maintained to respond to a high-flow event. Different land use practices such as agriculture/farming, located along Washita River's northern bank, may threaten the riparian habitat's ability to maintain this resiliency.

The riparian woody vegetation, specifically cottonwoods are largely absent along the Washita River adjacent to the park. According to Cummings and Folts-Zettner (2012), large woody debris is essential to help dissipate energy and decrease entrenchment. In addition, large woody debris captures sediment, which aids in the development of habitat that provides water depth, duration, and temperature necessary for aquatic life.

Active park and private landowner management of tamarisk has occurred along the riverbanks, which appears to be restoring the native plant community, but additional non-native invasives, including cheatgrass (*Bromus tectorum*), Annual rabbits-foot grass (*Polypogon monspeliensis*), Bermudagrass (*Cynodon dactylon*) and white sweetclover (*Melilotus alba*) are establishing.

#### **4.8.5. Sources of Expertise**

The National Park Service's Water Resources Division scientist, Jalyn Cummings, provides leadership for the preservation, protection, and management of the water and aquatic resources in the NPS.

Tomye Folts-Zettner, Southern Plains Inventory and Monitoring Network Botanist, also assisted with the riparian assessment, providing plant identification expertise.

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## 4.9. Grasslands

### Indicators/Measures

- Hydrology Soil/Site Stability and Hydrologic Function (10 measures)
- Biotic Integrity (4 measures)

### Condition – Trend - Confidence Level



Moderate – Deteriorating - High

Washita Battlefield National Historic Site (NHS) is located on the banks of the Washita River. The surrounding landscape is classified as dry plains, steppe with moderate valley slopes (2–20%), and a gently rolling topography (Bergey 2003). The 1930s Dust Bowl (Inglis and Wagner 2001) drastically changed local ecosystems, particularly soil health and water quality and quantity. Restoring natural environmental conditions is the primary concern of land managers at the Historic Site.

#### 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).

Washita Battlefield NHS is located at the juncture of several ecoregions. Moisture-loving eastern species overlap the more arid southwestern species, while tall-grass prairie gives way to short-grasses. The site itself can be divided into several clear habitats: upland forest, grasslands, old field, wetlands and riparian areas (Figure 4.9.1-1). It is estimated that historically, riparian areas covered 19 acres (8 ha) of park, while grassland dominated 316 acres (128 ha) (Hoagland et al. 2005). Baseline vegetation data were collected under drought conditions by Stotts and DuBey (1998). Their analysis suggested that the southern riparian area was the most “pristine,” the upland prairie in the southeast sector was the most ecologically healthy, and that the wooded “bench” to the north, although heavily grazed, had never been plowed (Stotts and DuBey 1998; Milner 2003). The Oklahoma



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**Figure 4.9.1-1 .**  
**Grassland at Washita**  
**Battlefield NHS.**

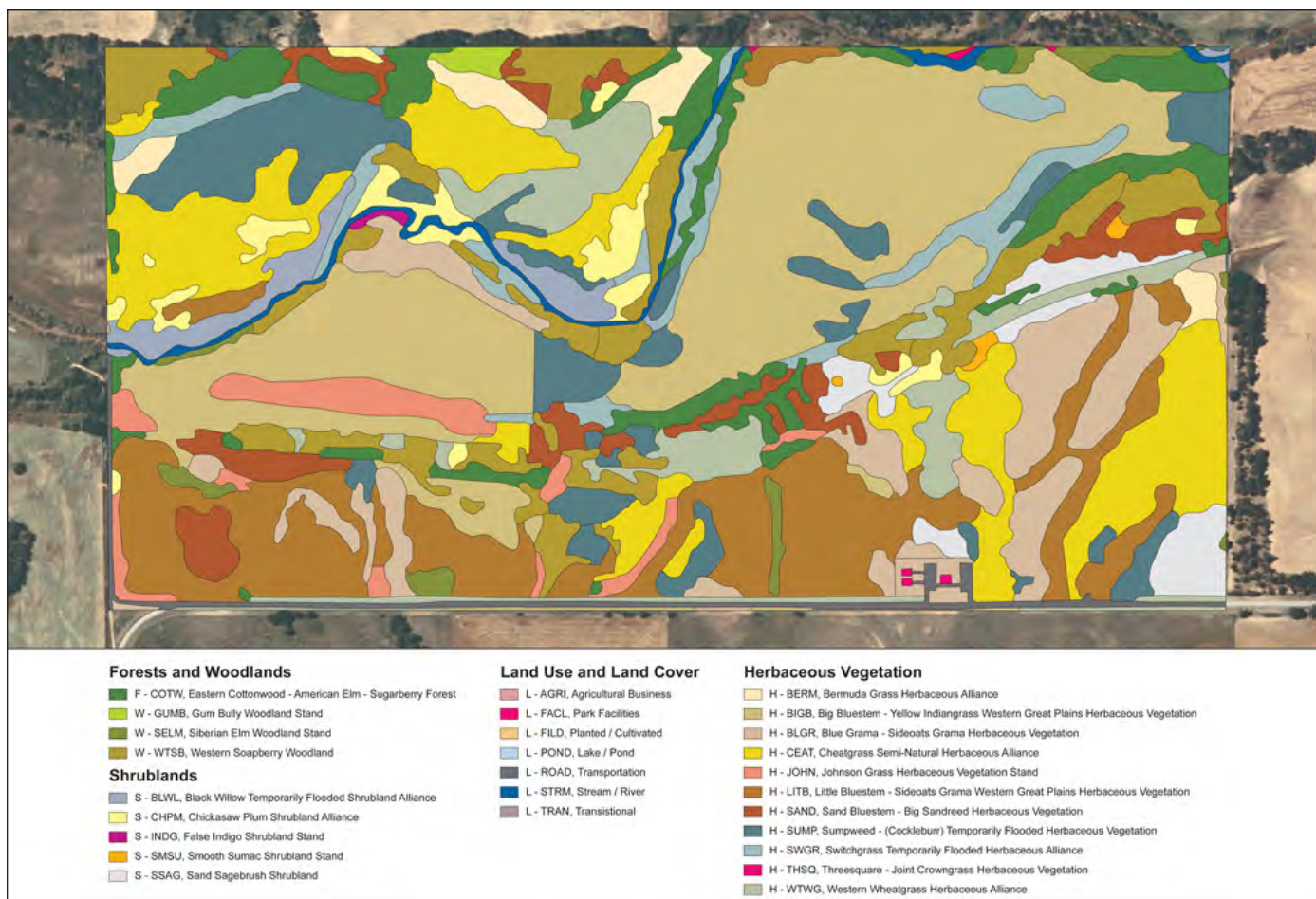


Figure 4.9.1-2. The map classes identified by Cogan (2007) used by the National Vegetation Classification (NVC) system.

Biological Survey conducted a vascular flora inventory in 2002, collecting over eight months. They documented 272 species of vascular plants, 32 of which were trees, shrubs or vines. Five species tracked by the Oklahoma Natural Heritage Inventory were found: low silverbush (*Argythamnia humilis*), plains beeblossom (*Gaura brachycarpa*), cutleaf nightshade (*Solanum triflorum*), giant dropseed (*Sporobolus giganteus*), and prairie zinnina (*Zinnia grandiflora*) (Hoagland et al. 2005).

For the past one hundred years, land both in and around the Washita Battlefield NHS has been used for farming and grazing. Land was cleared, fields were terraced and the Washita River was impounded and straightened in sections. A now-abandoned rail line was laid across the southern section of the Historic Site in the 1920s, involving cuts at the eastern end of the park and fill on the west end.

#### Grasslands at Washita Battlefiled NHS

Cogan Technology, Inc. (2007) conducted vegetation classification and mapping at Washita Battlefield NHS as part of the USGS-NPS Vegetation Characterization Program; a cooperative effort by the U.S. Geological Survey (USGS) 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. Sixteen different National Vegetation Classification (NVC) plant associations and alliances were identified within 27 mapping units. The sixteen associations and alliances consisted of two woodlands, three shrublands, and eleven herbaceous vegetation dominated (Cogan 2007) (Figure 4.9.1-2)(Table 4.9.1-1).

**Table 4.9.1-1. The 16 National Vegetation Classification (NVC) plant associations and alliances identified at Washita Battlefield NHS by Cogen (2007) and their corresponding area occupied.**

| NVC Plant Association                                                | Area (hectares / acres) |
|----------------------------------------------------------------------|-------------------------|
| <b>FOREST AND WOODLANDS</b>                                          |                         |
| Populus deltoides Temporarily Flooded Forest Alliance <sup>1</sup>   | 8/21                    |
| Sapindus saponaria Woodland Alliance                                 | 10/24                   |
| <b>SHRUBLANDS</b>                                                    |                         |
| Prunus angustifolia Shrubland Alliance                               | 3/7                     |
| Artemisia filifolia Shrubland Alliance                               | 3/7                     |
| Salix nigra Temporarily Flooded Shrubland Alliance <sup>1</sup>      | 2/5                     |
| <b>HERBACEOUS VEGETATION</b>                                         |                         |
| Andropogon gerardii - (Sorghastrum nutans) Herbaceous Alliance       | 27/68                   |
| Andropogon hallii Herbaceous Alliance                                | 5/12                    |
| Bouteloua gracilis Herbaceous Alliance                               | 9/23                    |
| Bromus tectorum Semi-Natural Herbaceous Alliance                     | 14/36                   |
| Cynodon dactylon Herbaceous Alliance                                 | 2/5                     |
| Iva annua - (Xanthium strumarium) Temporarily Flooded Herbaceous     | 10/25                   |
| Panicum virgatum Temporarily Flooded Herbaceous Alliance             | 4/11                    |
| Pascopyrum smithii Herbaceous Alliance                               | 7/17                    |
| Schizachyrium scoparium - Bouteloua curtipendula Herbaceous Alliance | 16/40                   |
| Schoenoplectus pungens Semipermanently Flooded Herbaceous Alliance   | 0/0.12                  |
| Sorghum halepense Herbaceous Alliance                                | 3/8                     |

<sup>1</sup>Includes a prominent grass component

### Historic Context

Grasslands at Washita Battlefield NHS are clearly part of its cultural heritage. For centuries the Cheyenne and Arapahoe tribes used native plants for food, medicine, and ceremonies. The grasslands were also home to the native animals that were essential to the way of life for the Plains Tribes (Figure 4.9.1-3).

### Conditions During Assessment

It is important to recognize that a major drought occurred during the time period of this assessment. During the summers of 2010 and 2012, Washita Battlefield NHS was experiencing conditions that were in the midrange of variability. However, in 2011 the site was experiencing extreme drought conditions (Figure 4.9.1-4). We have tried to take these conditions into account in



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

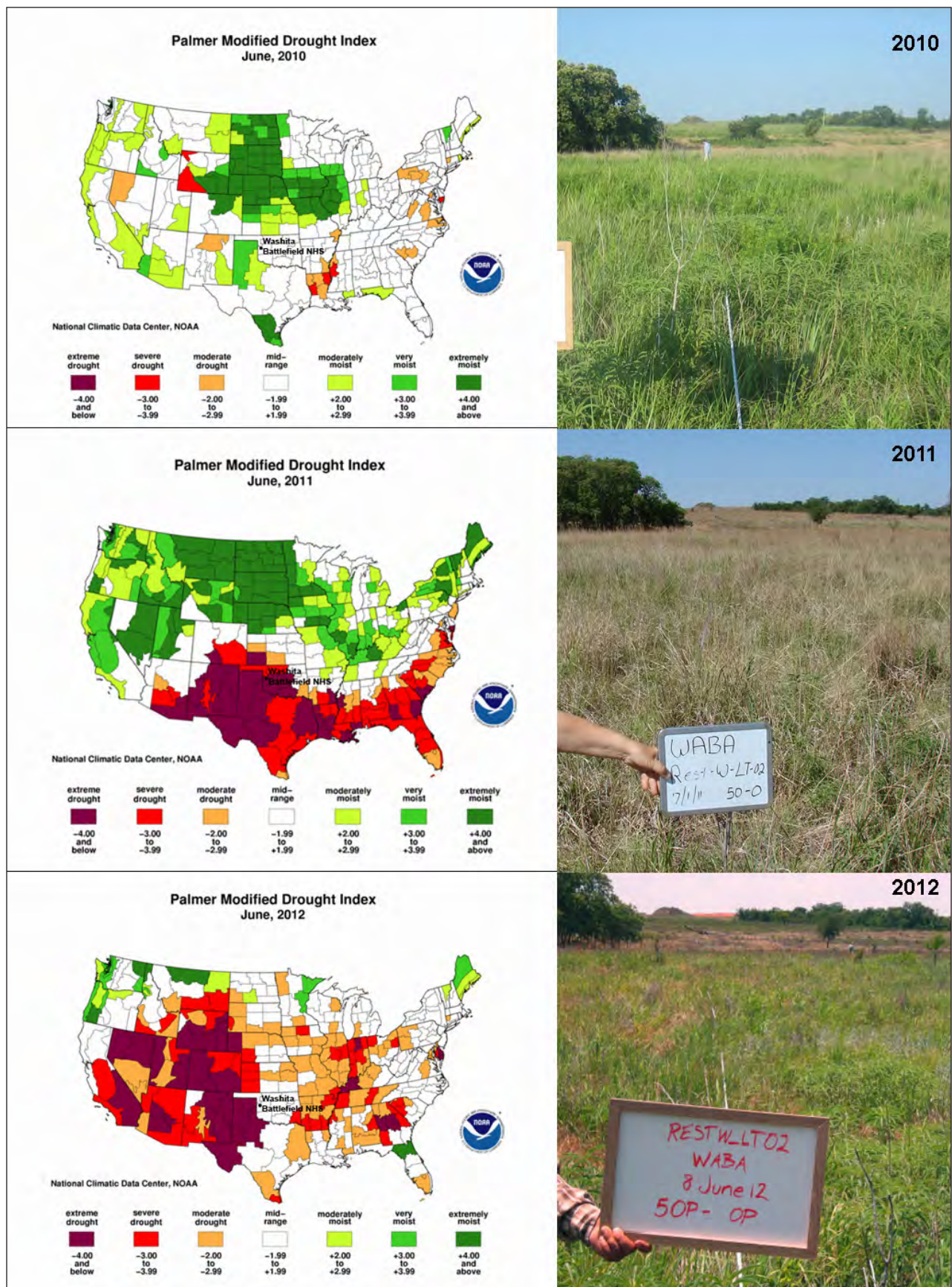


Figure 4.9.1-4. The Palmer Drought Index for each of the three years for which data from Washita Battlefield were available. Also shown to the right of each map are photos taken from a monitoring transect (RESTW-LT02) for the corresponding time period.

our interpretations, but the reader should be aware that such conditions may have an important impact on our assessment.

#### 4.9.2. Data and Methods

Qualitative indicators 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.

We considered three categories of measures/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:

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

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

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

The methodology used for these assessments used an approach based on those described in the qualitative assessment protocol “Interpreting Indicators of Rangeland Health (Pellant et al. 2005)([http://usda-ars.nmsu.edu/monit\\_assess/index.html](http://usda-ars.nmsu.edu/monit_assess/index.html)), in which Soil/ Site Stability qualitative indicators (Table 4.9.2-1) were used to assess the ability of an area to limit redistribution and loss of soil resources by wind and water.

#### Indicators/Measures

##### Soil/Site Stability and Hydrologic Function

The soil/ site stability/hydrologic function indicators and measures were grouped together and assessed as a supplement to ongoing grassland monitoring by the Southern Plains Inventory and Monitoring Network (SOPN).

#### Indicators/Measures

##### Biotic Integrity

The assessment for the biotic integrity of grasslands was made via a combination of a field assessment by grassland experts Alan Knapp (Colorado State University) and Tim Seastedt (University of Colorado at Boulder) and data collected as part of SOPN’s ongoing grassland monitoring.

Using the qualitative indicators of rangeland health presented in (Pellant et al. 2005) as a starting point, the grassland experts, in collaboration with SOPN and park staff developed a suite of four measures for grassland biotic integrity that were deemed appropriate for this assessment. These indicators are summarized in Table 4.9.2-2 and described in greater detail below.

A rapid field assessment was conducted at multiple sites throughout the Historic Site. Each site was qualitatively evaluated by the experts based on the indicators/measures developed. In addition, we used data collected during the past three years of monitoring to provide a more quantitative baseline for future assessment and to supplement the opinions of the experts during their field visit.

These additional data were collected by the SOPN and the Southern Plains Fire Group, following Folts-Zettner et al.(2013). Grassland monitoring data were collected in 2010-2012 along 13 transects, each with five subplots, as part of this monitoring effort Folts-Zettner et al (2012)(Figure 4.9.2-1). At each subplot, the percent cover was estimated for each species within a 1x2m<sup>2</sup> quadrat.

**Table 4.9.2-1. Indicators/measures used to assess the soil/site stability and hydrologic function of grasslands at Washita Battlefield NHS.**

| Indicator/Measure                               | Definition                                                                                                                                                                                                                                                                                  |
|-------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 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). |

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

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

#### Species Composition, Landscape-scale Diversity

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

Rather, we are trying to determine that some reasonable level of landscape diversity exists and that it generally corresponds to changes in ecological conditions.

#### Local-scale Species Composition

The intent behind this indicator is to see if the species composition is generally consistent with what might be expected for the site, given the local conditions (soils, disturbance, moisture, etc). We considered this using two measures. First, was the degree to which the local species consisted of native versus exotic

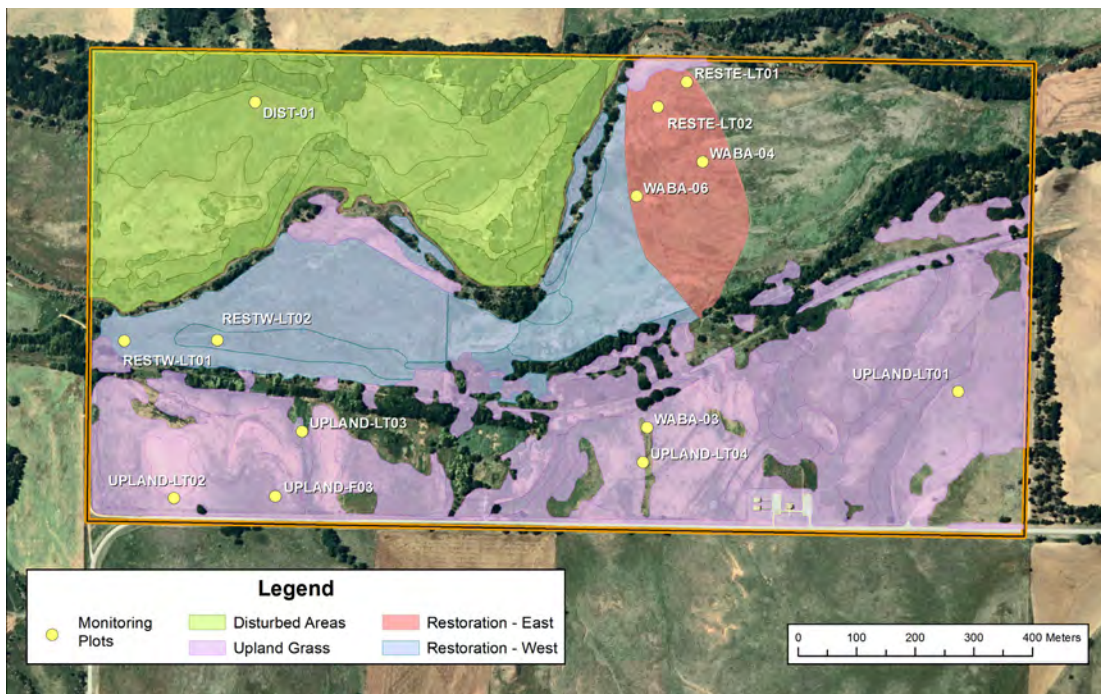


**Figure 4.9.2-1.**  
Location of  
grassland  
monitoring plots at  
Washita Battlefield  
NHS.

species. Details about which exotic species are present and their effect on the site are presented in greater detail in Chapter 4.10. Here we just provide an initial indicator of the extent of invasion by exotic species by looking at the proportion of native and exotic species. Second, we looked at the species composition of the native species relative to what might be expected for that site, given the local site characteristics. This was conducted separately for areas that have been disturbed and are mostly undergoing restoration and areas of upland grasslands that have not been extensively disturbed. An exception to this is the northwest corner of the Historic Site that has been disturbed but is not yet undergoing any restoration. As we have done for other indicators, this assessment is based primarily on percent cover, rather than the number of individual species because most species are quite rare and cover provides a more realistic assessment of the impact of exotic invasion.

#### Response of Annual Species to Disturbance

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

and unnaturally disturbed might be expected to have a greater persistence of annual species compared to interior sites.

#### Relative Proportion of Functional Groups

The composition of functional groups can have a dramatic effect 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.

#### **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.

**Table 4.9.3-1. Reference conditions for soil/site stability/hydrologic function and biotic integrity indicators.**

| Indicator                                        | 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 and biotic integrity indicators (continued).**

| Indicator                             | 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. |

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

#### Biotic Integrity

Part of our consideration in choosing the indicators 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 Washita Battlefield 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 indicator of Landscape-scale diversity focuses on whether or not the diversity of

plant communities reflects to a reasonable extent the diversity in site characteristics. As such, we used the spatial pattern of soil types (Soil Survey Staff NRCS n.d.) and ecological sites (NRCS 2011) as a general reference for the extent and pattern of landscape diversity that might be expected.

For the remaining indicators, we used a combination of the Natural Resources Conservation Service’s ecological site descriptions (NRCS 2011) 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 Washita Battlefield NHS. It is important to note however, the values in the NRCS 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 and literature on grassland communities.

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

| Indicator                                                                        | Significant Concern                                                                                                                                                                           | Moderate Concern                                                                                                                                                                                                             | Good                                                                                                                                                                                                                                                                                            |
|----------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Landscape- scale diversity                                                       | Significant lack of spatial landscape heterogeneity that does not reflect the expected diversity for the soil types and sites                                                                 | Moderate lack of spatial landscape heterogeneity that does not fully reflect the spatial pattern of soils and disturbance                                                                                                    | Landscape-scale diversity reflects spatial pattern of soils and disturbance                                                                                                                                                                                                                     |
| Local scale species composition                                                  | Species composition deviates substantially from the native species compliment that would typically occur at such sites. Such a deviation could also be either from exotics or native species. | Species composition moderately deviates from the expected native species compliment either from exotics or native species in such a way that does reflect typical types of natural disturbance (e.g., fire or prairie dogs). | Species composition reflects expected native species compliment consistent with the site characteristics (e.g., from ESDs). Species composition need not reflect expected climax communities if their current state reflects typical types of natural disturbance (e.g., fire or prairie dogs). |
| Annual, biennial and perennial species relative to Disturbance                   | Substantially higher proportion of annual species than expected in sites not recently disturbed.                                                                                              | Proportion of perennial species is moderately lower than 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.                                                                                                                                                  |

#### 4.9.4. Condition and Trend

##### Soil/Site Stability / Hydrologic Function

Our assessment indicated that the overall current condition of the soil/site stability/hydrologic function at Washita Battlefield NHS was good, with departures from expected generally being not more than slight to moderate (Table 4.9.4-1). Although not part of our sample plots, there are some localized departures from expected associated with an old railroad grade, but these were not of substantial concern for interior grasslands. The *Artemesia* alliance areas have some potential for future erosion should drought conditions persist, but are not currently a significant problem. Erosion in the riparian zone is addressed in chapter 4.8.

##### Biotic Integrity

##### *Species Composition, Landscape-scale Diversity*

The patterns of plant community distribution generally match that of the ecological sites and soils (Figure 4.9.4-1); although there is more detail in the breakdown of vegetation communities. This difference in scale of diversity patterns may merely reflect the

classification process of plant communities rather than real difference in expected diversity. There is some concern regarding landscape diversity in that during 2012, non-native bromes were quite widespread. It is not known at this time whether this is a short term response to drought and subsequent conditions, or whether these bromes will persist long term. At the present time, native species are still present, but should non-native bromes persist or become dominant, this would constitute a loss of landscape diversity toward in increasing monoculture of bromes. Given the uncertainty of the future, we considered landscape scale diversity as warranting moderate concern, where the trend in condition is unknown at this time.

##### *Local Scale Species Composition*

As previously indicated, we do not have an expectation for species composition to exactly match the species list for historic climax plant communities, in part because of local variability of micro sites as well as temporal variability such as seasonal or annual variation in rainfall etc. In addition, not all sites at Washita are in a climax state given their history of disturbance. When considering the

**Table 4.9.4-1. Indicators/measures used to assess the soil/site stability and hydrologic function of grasslands at Washita Battlefield NHS.**

| Indicator/Measure                               | Departure from Expected | Comments                                                                                                                                                                                                                                                                                                                                                                                                          |
|-------------------------------------------------|-------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Rills                                           | None to Slight          | None evident                                                                                                                                                                                                                                                                                                                                                                                                      |
| Water Flow Patterns                             | Slight to moderate      | Past minor erosion and deposition, but none evident now except occasionally off top of railbed.                                                                                                                                                                                                                                                                                                                   |
| Pedestals and/or terracettes                    | None to Slight          | No sign anywhere                                                                                                                                                                                                                                                                                                                                                                                                  |
| Bare ground                                     | Slight to moderate      | 2011 had bare ground increasing (drought effect), more so in the Upland community but some in the Restoration community. Bare ground dropped in all communities in 2012, due primarily to the biomass increase in bromes. One upland transect in the SW corner had an increase in bare ground, likely due to EPMT and park treatment of Johnsongrass and Siberian elm. The soil in this area IS a bit more sandy. |
| Gullies                                         | Slight to moderate      | Past history of minor gullies but now stabilized.                                                                                                                                                                                                                                                                                                                                                                 |
| Wind-scoured, blowout and/or depositional areas | None to Slight          | Only seen in Artemisia community. If drought continues this area could be threatened.                                                                                                                                                                                                                                                                                                                             |
| Litter Movement                                 | None to Slight          | None evident                                                                                                                                                                                                                                                                                                                                                                                                      |
| Soil surface resistance to erosion              | None to Slight          | None evident                                                                                                                                                                                                                                                                                                                                                                                                      |
| Soil surface loss or degradation                | None to Slight          | None evident                                                                                                                                                                                                                                                                                                                                                                                                      |
| Compaction layer                                | None to Slight          | Only on railroad bed and two-tracks                                                                                                                                                                                                                                                                                                                                                                               |

condition of Washita's grasslands, we tried to take into account not only the ecological site, but also the other factors discussed above that influence species composition.

We consider local species composition to be of moderate concern for the Historic Site's grasslands. One concern is the widespread invasion of exotic species, which is discussed in greater detail below and in chapter 4.10. There also some concern about local species composition in the restoration areas. Our assessment indicated a lack of diversity of forb species that would be expected in these grasslands. This is particularly true for perennial forb species, although there are some annual forb species associated with disturbed areas. This may be a result of the seeding process of the restoration process, which may change over time as restoration continues. A more detailed treatment of species diversity at the Historic Site is presented in Folts-Zettner et al. (2013).

The concern about species compositions is the widespread invasion of exotic species

at Washita Battlefield NHS. 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 three years (2010-2012) of grassland sampling 86 of 103 (83%) of the species we observed were native (Table 4.9.4-2). However, the number of species does not take into account how prevalent those species are on the landscape or the variation among years. Based on the percentage of cover from our grassland monitoring plots, the proportion of natives to exotics has changed over the three years of sampling. For example, approximately 10% of the grass cover on our upland grassland samples were from exotic

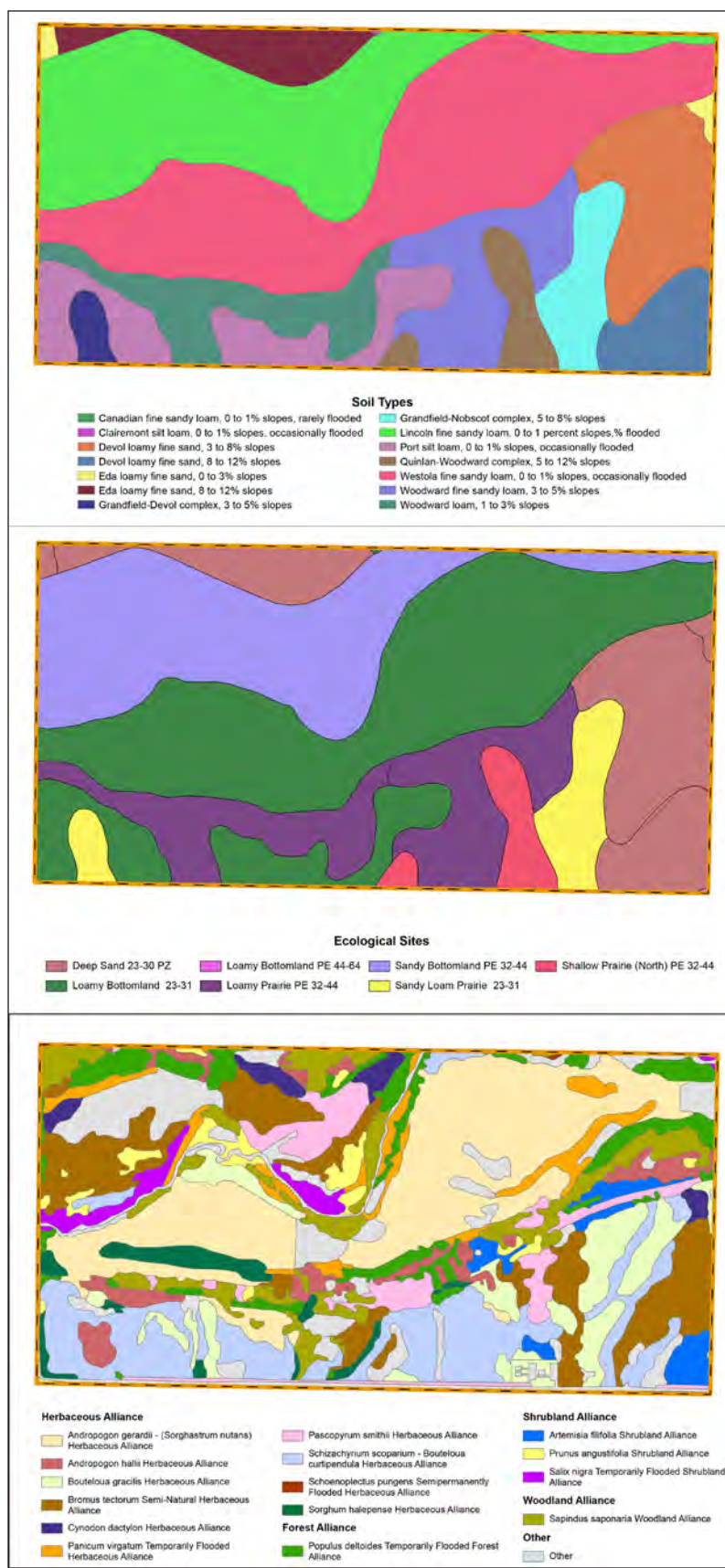


Figure 4.9.4-1. The distribution of soil types based on NRCS (n.d.), ecological sites based on NRCS (2011) and plant communities based on Cogan (2007)

Table 4.9.4-2. The number and percentage of native and exotic species of each life form found at Washita Battlefield NHS during the 2010-2012 grassland monitoring sampling.

| Lifeform  | Native | Exotic | Total | % Native |
|-----------|--------|--------|-------|----------|
| Forb      | 53     | 11     | 64    | 83%      |
| Graminoid | 25     | 5      | 30    | 83%      |
| Subshrub  | 1      | 0      | 1     | 100%     |
| Vine      | 3      | 0      | 3     | 100%     |
| Tree      | 4      | 1      | 5     | 80%      |

species in 2010. That increased to nearly 50% in 2012 (Figure 4.9.4-2).

These results are based on grassland monitoring plots, which are located throughout the park unit. Two additional sources of information about exotics are the SOPN exotic monitoring transects and a supplementary rapid assessment grid that was sampled in 2011. Both of these sources of information are presented in depth in Chapter 4.10. However, both of these sources of data focused explicitly and exclusively on exotic species in order to gain a better understanding of their distribution and density; thus they do not consider how prevalent these exotics are relative to native species. The SOPN exotic monitoring transects focus explicitly on areas considered as high risk for invasion of exotics; thus are not representative of grasslands in general. The supplementary rapid assessment grid covers the entirety of the park unit at 65 m intervals; thus it does represent the overall park, but does not take into account native species.

#### Response of Annual Species 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 samples indicated that most of the cover was comprised of perennial grasses (Figure 4.9.4-3), but this proportion tended to decrease over the

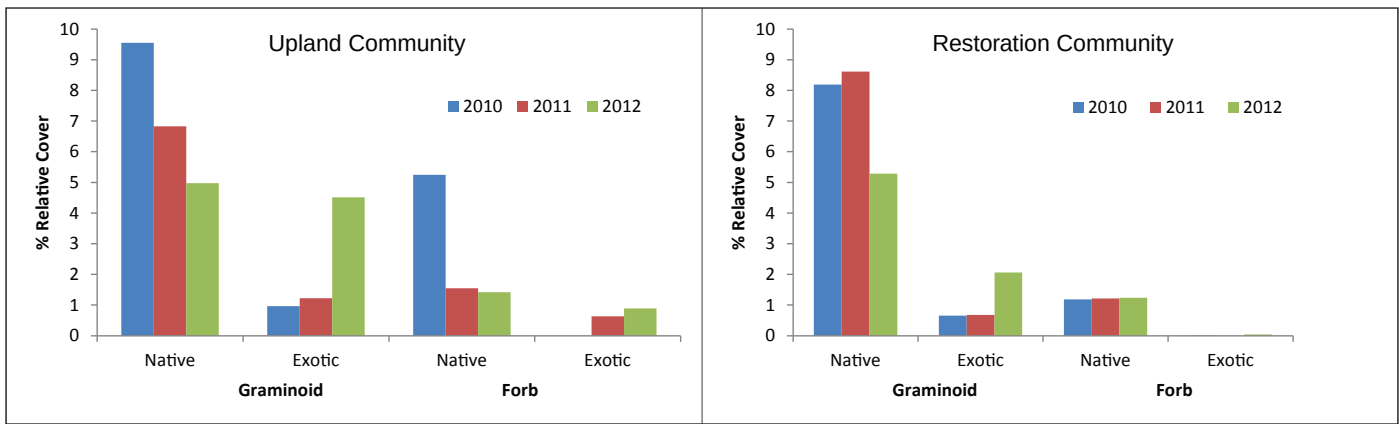


**Figure 4.9.4-2.** The percentage of native and exotic grasses and forbs for upland grassland and upland restoration areas at Washita Battlefield NHS each year from 2010-2012.

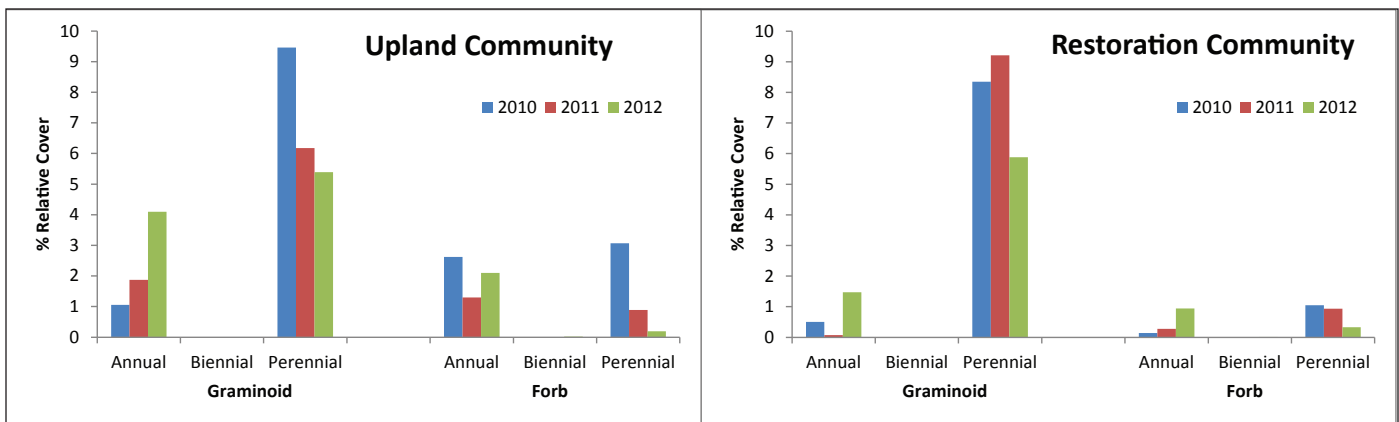


**Figure 4.9.4-3.** The percentage of annual, biennial, and perennial grasses and forbs for upland grassland and upland restoration areas at Washita Battlefield NHS each year from 2010-2012.

three-year sampling period. This is not what would have been expected given the general lack of disturbance.

#### *Relative Proportion of Functional Groups -*

The relative proportions of functional groups observed in our grassland monitoring did not differ dramatically from what was expected and showed some annual variability among years (Figure 4.9.4-4). As previously discussed, one exception to this was the low proportion of forbs on the restoration sites. During the rapid assessment, the subject experts did not express any additional major concerns regarding the proportion of the various life forms.

#### The Role of Fire in Grassland Condition at Washita Battlefield NHS

In general, recurring fire in what is broadly considered the southern mixed prairie tends to maintain the integrity of that grassland by containing woodland and forest species to the

more mesic parts of the landscape. Direct evidence of the natural historic fire regime is lacking, but it is believed that fires in this type of prairie did not occur more frequently than every 5 to 10 years (Joern and Keeler 1995).

As the current vegetation at the Historic Site is far removed from the vegetation present at time of settlement, the current role of naturally recurring fire as an ecological process can only be surmised. This is particularly true in regard to the succession currently underway in the absence of grazing, cultivation or fire disturbance. With the highly fragmented nature of the surrounding landscape due to roads, grazing and cultivation and the relatively small size of the park, frequently recurring fire has been effectively eliminated as a naturally occurring phenomena from Washita Battlefield NHS. Thus the absence of recurring fire and grazing has contributed to the accumulation of litter that may prove to be adverse to some native species and

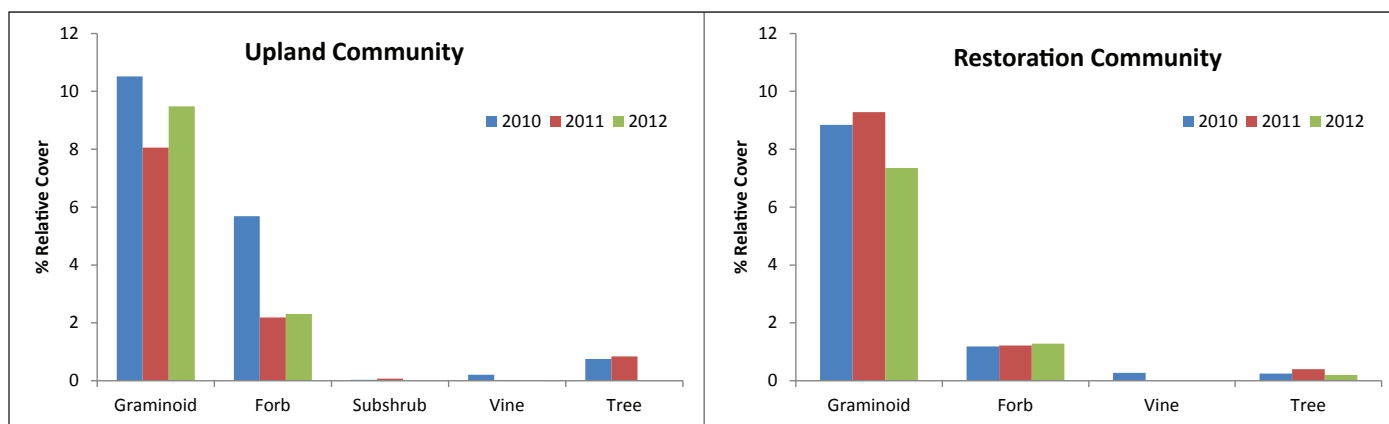


**Figure 4.9.4-4. The percentage of life forms for upland grassland and upland restoration areas at Washita Battlefield NHS each year from 2010-2012.**

favorable to others (Nagel 1994) and facilitate the expansion of woody plants into what was historically grasslands. When fires do occur it is possible that the fuelloading is such that fires burn at a greater severity than they did historically, especially where shrubs or trees have encroached. The effect this may have is largely unknown, however it is a concern that these events could facilitate the expansion of exotic plants already present such as Johnsongrass, Japanese brome, cheatgrass, or bermuda grass. Thus the uncertainty associated with the use of fire as a vegetation management tool should be undertaken under an adaptive management framework.

#### 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 4.9.4-3. Based on our assessment, the condition of soil stability and hydrologic function is in relatively good condition, but the biotic integrity has several concerns. Most notably is the widespread invasion of exotic species, but there is also some concern about the diversity of forbs in the restoration areas.

We consider the overall condition of the grasslands at Washita Battlefield NHS to be of moderate concern with a deteriorating trend.

#### Level of Confidence/Key Uncertainties

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

Annual variability in rainfall, temperatures, diseases, etc. can have a dramatic effect on some indicators (e.g., plant species composition), which in turn, affects our interpretation of grassland condition. However, this assessment was conducted, at least in part, during drought conditions. The stress from drought conditions has likely influenced some of our indicators, 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.

**Figure 4.9.4-5. The widespread invasion of exotic species at Washita Battlefield NHS is going to require careful consideration and monitoring of management options, including the relative roles of different treatments such as fire, grazing, mowing, and chemicals.**



**Table 4.9.4-3. Summary of the grassland indicators/measures categories and their contributions to the overall assessment of grassland condition.**

| Indicator/Measure                                         | Description of How the Indicator(s) Contributes to the Overall Resource Condition                                                                                                                                                                                           | General Contribution of this Indicator or Measure to the Overall Resource Condition.                                                                                                                                                                                                                                                                                                                                                             |
|-----------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Soil/Site Stability and Hydrologic Function (10 measures) | Soil/Site Stability and Hydrologic Function addresses capacity of an area to limit excessive loss and/or redistribution of soil resources by wind and water.                                                                                                                | Cumulative departures from expected conditions for most measures of Soil/Site Stability and Hydrologic Function general ranged from none to slight or from slight to moderate. With the exception of a few very localized concerns (e.g., the railroad grade), there was no significant concern regarding these indicators.                                                                                                                      |
| Biotic Integrity (4 measures)                             | The biotic integrity addresses the capacity for the composition and functioning of the grassland communities to remain within normal range of variability expected for the site and to resist a loss in this capacity and/or to recover this capacity when losses do occur. | In contrast to Soil/Site Stability and Hydrologic Function, we did have concerns about the biotic integrity that were significant enough for us to consider the overall condition of grasslands at Washita Battlefield NHS to be of moderate concern. Most notable is the widespread invasion of exotic species. For example in the park-wide grid sampled in 2011, > 97% of the sample points had <i>cheatgrass</i> present (see chapter 4.10). |

The Washita Battlefield NHS is a southern mixed prairie site whose grassland structure should be strongly influenced by the historical “summer wet” rainfall pattern and recurrent fire. The small size of the site and the surrounding agricultural areas make this an ‘island site’ with management issues strongly confounded by fragmentation, roads, and historical legacies. The 2012 increase in annual bromes was identified as a concern, but whether or not this marks a potential tipping point or transformation to a grassland influenced by the annuals or a short-lived pulse in annuals due to unusual weather remains unknown. Continued monitoring will resolve that, but the fact that this system evolved with fire, which likely was most common in late spring or early fall, might suggest that the use of late spring fires will provide the management tool needed to maintain and/or restore the site (T. Seastedt, Professor at University of Colorado, pers. comm.).

#### 4.9.5. Sources of Expertise

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

Dr. Alan K. Knapp is a Professor at Colorado State University, Department of Biology. Dr. Knapp has an extensive background

of research and publications related to the ecology of grasslands.

Dr. Timothy Seastedt is a Professor at University of Colorado, Boulder, Department of Ecology and Evolutionary Biology. He also has an extensive background of research and publications related to the ecology of grasslands.

#### 4.9.6. Literature Cited

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## 4.10. Exotic Plants

### Indicators/Measures

- Significance of impact
- Feasibility of control
- Proportion of high priority blocks infested
- Proportion of interior plots infested
- Distribution of high priority species

### Condition – Trend - Confidence Level



Significant Concern – Deteriorating - High

#### 4.10.1. Background and Importance

Globalization of commerce, transportation, human migration, and recreation in recent history has introduced invasive exotic species to new areas at an unprecedented rate. Biogeographical barriers that once restricted the location and expansion of species have been circumvented, culminating in the homogenization of Earth's biota. Although only 10% of introduced species become established and only 1% become problematic (Williamson 1993; Williamson and Fitter 1996) or invasive, nonnative species have profound impacts worldwide on the environment, economies, and human health.

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),

reduced agricultural productivity, and changes in water availability (D'Antonio and Mahall 1991). The damage caused by these species to natural resources is often irreparable, and our understanding of the consequences incomplete. Invasive species are second only to habitat destruction as a threat to wildland biodiversity (Wilcove et al. 1998). Consequently, the dynamic relationships among plants, animals, soil, and water established over many thousands of years are at risk of being destroyed in a relatively brief period. For the NPS, the consequences of these invasions present a significant challenge to the management of the agency's natural resources "unimpaired for the enjoyment of future generations." National parks, like land managed by other organizations, are deluged by new exotic species arriving through predictable (e.g., road, trail, and riparian corridors), sudden (e.g., long-distance dispersal through cargo containers and air freight), and unexpected



**Figure 4.10.1-1.**  
Brome grasses (*Bromus japonicus* and *B. tectorum*), are invasive exotic plants found at Washita Battlefield NHS..

anthropogenic pathways (e.g., weed seeds in restoration planting mixes) (Figure 4.10.1-1). Nonnative plants claim an estimated 4,600 acres of public land each year in the United States (Asher and Harmon 1995), significantly altering local flora. For example, exotic plants comprise an estimated 43% and 36% of the flora of the states of Hawaii and New York, respectively (Rejmanek and Randall 1994). 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, eradication efforts are most successful for infestations of less than one hectare in size (Rejmanek and Pitcairn 2002).

#### 4.10.2. Data and Methods

In evaluating current condition and trend for exotic plants at Washita Battlefield NHS, five indicators/measures were considered.

##### Indicators/Measures

Significance of impact  
Feasibility of control

One of our first indicators for exotic plants was to determine which species pose the greatest risk to the historic site. As a foundation for evaluating potential risk, we used the Exotic Species Ranking System presented by Hiebert and Stubbendieck (1993) (Appendix D). This ranking system has been applied in parks throughout the Midwest (Stubbendieck et al. 1992; Stumpf et al. 1994) as well as at Washita Battlefield, Capulin Volcano, Sand Creek Massacre, and Fort Union National Monument (Willson et al. 2008). Ranking is based on two primary components of the potential risk: *significance of impact* and *feasibility of control/management*. Each component has several subcomponents and is ranked on a scale from 0–100 points.

*Significance of impact* is subdivided into the current level of impact and the potential for the species to become a pest. The current level of impact takes into account such things as abundance, distribution relative to

disturbance, effects on natural processes and community character, potential threat to park resources, and visual impact. The potential for a species to become a pest considers life history traits that might preadapt a given species to become a problem as well as its known impacts in other areas. Important life history characteristics include potential rate of increase, adaptations for long-distance dispersal, and the breadth of habitats in which the species can colonize and thrive.

*Feasibility of control/management* focuses on such things as its abundance within the historic site, the ease to which it is controlled, its reproductive capability, proximity of other populations, potential side effects of control measures, and the potential for biological control.

##### Indicators/Measures

Proportion of High Priority Blocks Infested

As part of the Southern Plains Inventory and Monitoring Network (SOPN) exotic plants monitoring program, high priority vectors (e.g., roads and trails) were identified based on their potential risk for invasion by exotic plants. The highest priority vectors were surveyed in 2009–2012 (Figure 4.10.2-1), and the data are used to assess this indicator. 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; rather, it provides a repeated snapshot for a limited area with high potential (e.g., roads and trails) for new invasions.

Sampling was conducted from June to July. The methodology used in this monitoring is described in detail in Folts-Zettner et al. (2010). The approach is based on a generalized linear model, where 50-meter blocks 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 4.10.2-2).

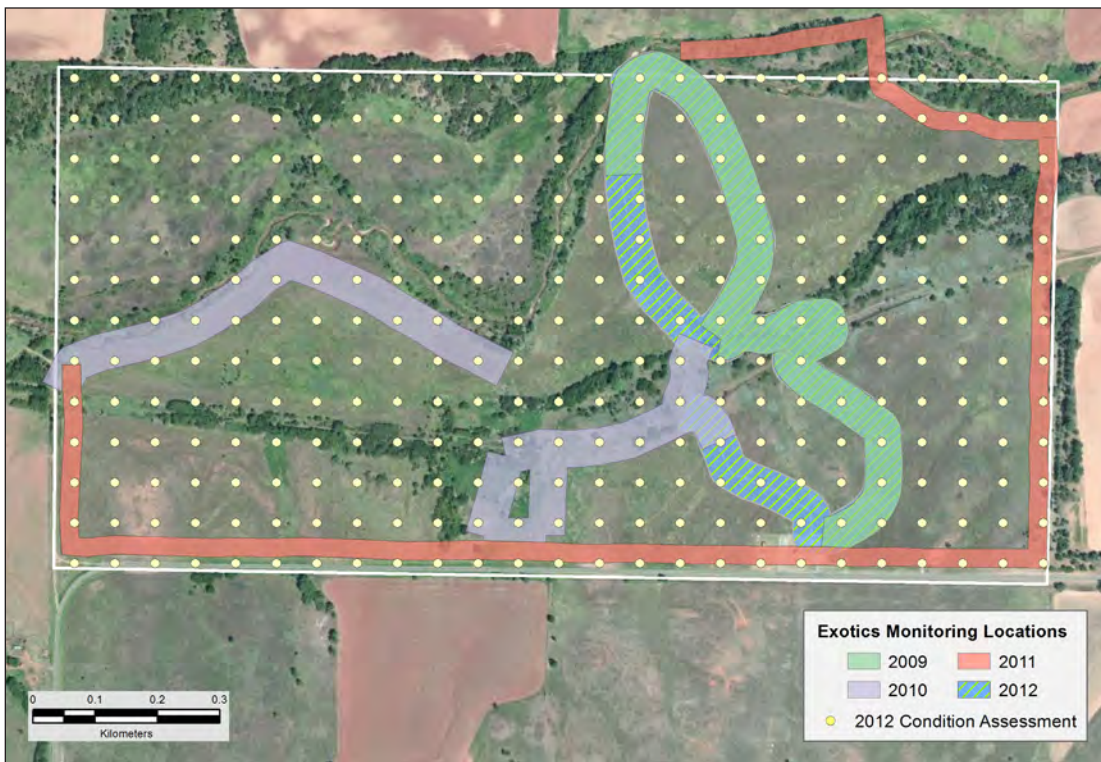


Figure 4.10.2-1. High priority blocks sampled in 2009-2012 and rapid assessment plots sampled in 2012.

The full protocol also includes estimation of four density classes assigned to each block ranging from scattered plants to a dense matrix, as well as four distance classes used to determine the extent to which exotic plants are limited to the zone immediately adjacent to the vector. These measures provide more specific detail for the historic site than is warranted for this assessment, therefore, are provided along with other information in SOPN's annual reports (Folts-Zettner et al. 2012a; Folts-Zettner and Sosinski 2012b).

#### Indicators/Measures

##### Proportion of Grid Plots Infested

A sample grid of points spaced 65 meters apart was laid out across the park as an additional part of this condition assessment. These points were intended as a rapid assessment supplement to our standard monitoring blocks for the purposes of this condition assessment.

Presence and density data for these supplemental points were recorded in the

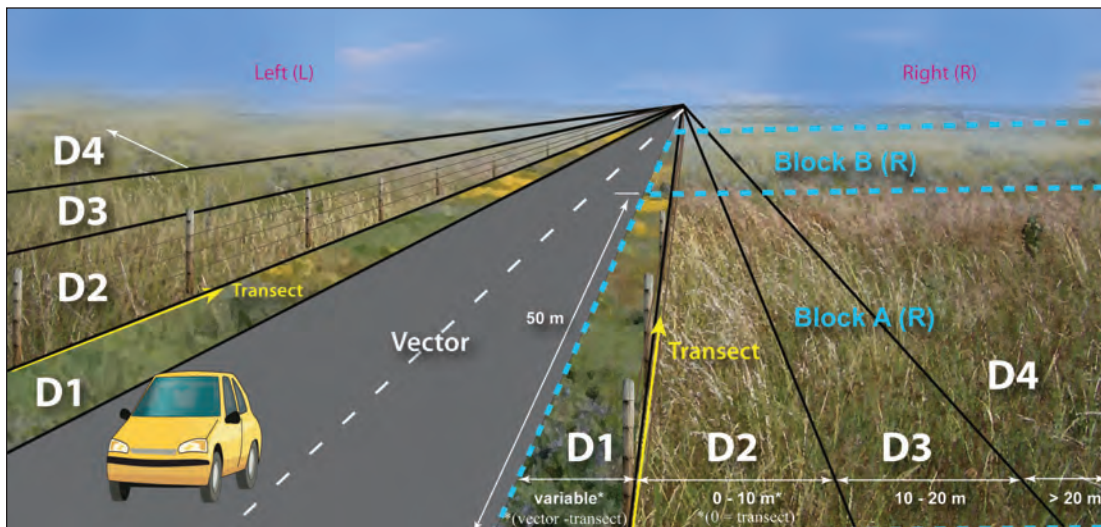


Figure 4.10.2-2. Fifty meter blocks are sampled on each side of a high-risk vector (e.g., roads and trails).

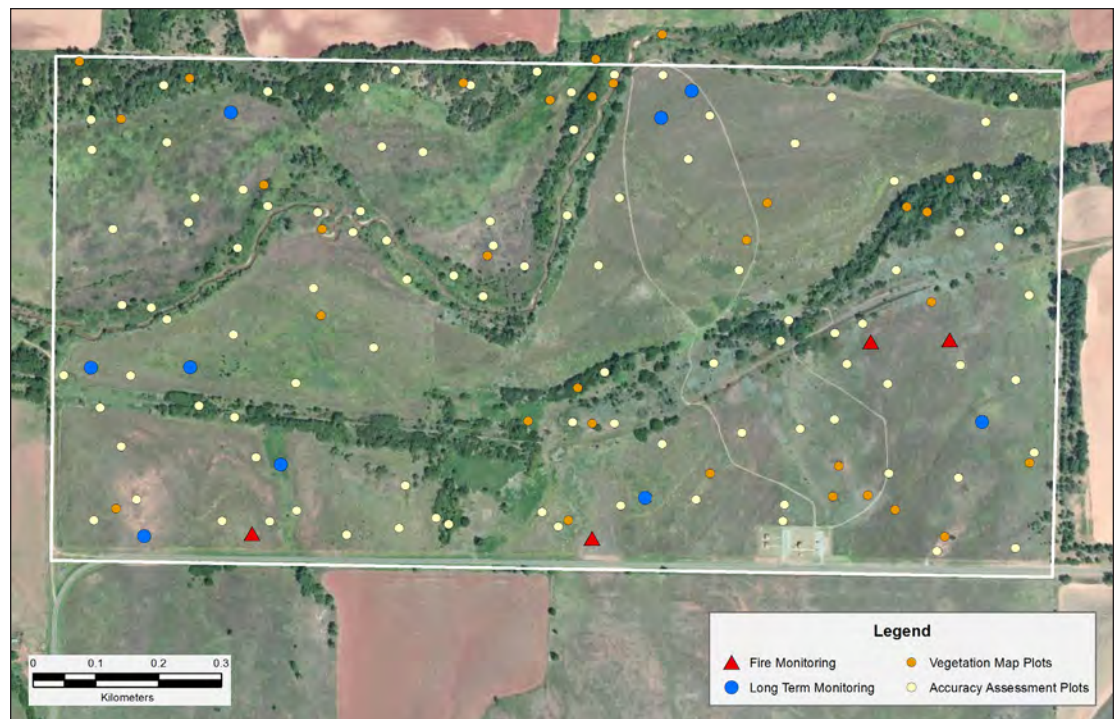


**Figure 4.10.2-3.** The location of interior plots that were sampled from 2005 to 2010.

same way as in our standard blocks described above, except that these units will not be included in SOPN's rotating panel.

We used two data sources for estimating the proportion of interior plots occupied by a given exotic species. First, we used the secondary exotic-plant monitoring that was conducted in 2009 -2012 in grassland areas within the interior landscape in as part of SOPN's grassland/fire effects monitoring efforts (Figure 4.10.2-3). This monitoring consists of collecting plant occurrence and cover data from five 2 x 1-m nested quadrats along a 50 m permanent transect.

The second data source used for assessing interior sites were the standard vegetation plots sampled in 2005 as part of the vegetation mapping effort conducted by Cogan (2007) for the historic site. Vegetation structure and species composition were sampled using plots that varied in size depending on the dominant physiognomy of the vegetation. Forest and woodland plots were 400 m<sup>2</sup>, while shrubland, dwarfshrubland, and herbaceous vegetation plots were 100 m<sup>2</sup>. Plot dimensions were recorded on the forms and the plot shape usually was square, but was modified to best represent the vegetation (e.g. narrow, linear rectangles for riparian vegetation

(Cogan 2007). A list of all vascular plant species occurring in these plots was recorded.

#### Indicators/Measures

##### Distribution of High Priority Species

For this measure, we used data sources gathered by SOPN exotic plants monitoring efforts (Folts-Zettner and Sosinski 2012a and 2012b) and from SOPN and Southern Plains Fire Group grassland monitoring efforts (Folts-Zettner et al. 2012 and 2013).

#### 4.10.3. Reference Conditions

The most desirable reference condition for a natural resource park is the complete absence of exotic species. However, such a reference condition is probably not a realistic standard to which exotic plant species should be compared. We consider a more realistic reference condition to be the capability for the integrity of the primary communities (e.g., woodlands, shrublands, and Great Plains prairie) to be maintained. By this, we mean that the ecological attributes (e.g., species composition, structure, etc.) and natural processes remain within the natural variation for the community type. Therefore, the reference condition of "good" is that species are known to occur regionally or on adjacent

lands, but have not yet been confirmed within historic site, or if species have been confirmed, distribution is sparse, limited in extent, and may vary from sparse individuals to dense patches. A “moderate” condition is when species have been found in the historic site in small, localized patches. Finding and controlling patches might prevent large-scale invasion, and distribution is somewhat limited in extent and may vary in intensity from sparse individuals to dense patches. A condition of significant concern is warranted when exotic plants threaten to alter these primary communities to the point where they no longer maintain 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 49 exotic species found within Washita Battlefield NHS (Table 4.10.4-1). Several additional non-native species have been cited as occurring at the historic site but for a variety of reasons most likely are not present. These species are listed in Appendix E.

#### Significance of Impact

Based on the ranking system of Hiebert and Stubbendiek (1993), several species have the potential for significant impact at Washita Battlefield NHS (Table 4.10.4-2). *Tamarix ramosissima* ranked the highest with *Sorghum halpense*, *Bothriochloa ischaemum*, *Bromus tectorum*, *Bromus japonicus*, *Convolvulus arvensis*, *Melilotus alba/officinalis*, and *Cynodon dactylon* closely following in highest ranked for significance of impact.

According to Folts-Zettner et al. (2012), the Historic Site has consistently suffered from a persistent low-level invasion of a suite of exotic grasses and forbs. Unique weather conditions leading up to the 2012 growing season resulted in a mass explosion of these exotic populations that overwhelmed all plant

communities. The most dramatic increases occurred with two grasses, Japanese brome (*Bromus japonicus*) and cheatgrass (*Bromus tectorum*), both early season annuals that produced a smothering amount of biomass in some areas.

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). Thus, from a standpoint of significance of impact to the historic site’s ecosystem, we would consider the exotic bromes to be a significant concern.

#### Feasibility of Control

Based on Hiebert and Stubbendiek’s (1993) ranking system *Ulmus pumila* ranked lowest in feasibility of control followed by *Convolvulus arvensis*, *Medicago minima*, *Cynodon dactylon*, and *Bromus tectorum* (Table 4.10.4-3). Several traits of the species add to the difficulty of control: extensive tap root and ability to re-sprout, especially field bindweed, prodigious seed production, a long-lived seed bank (seeds remain viable in soil for many years), and limited methods of control.

Seven of the most difficult to control species are also in the top ten list of highest significance of impact, which is of concern. Plants that have the ability to cause major damage and are very difficult to control are the worst. Unfortunately, there are several of these types of exotics found at the Historic Site.

While not ranked as high as the others, several additional species should be watched closely. *Salsola tragus*, *Tragopogon dubius*, *Lactuca serriola*, and *Sonchus asper* are windborne seeders and produce a lot of seed, but are not as competitive resource users. Overall, condition relative to feasibility of control is of significant concern.

Table 4.10.4-1. Exotic species found within Washita Battlefield National Historic Site

| Scientific Name                                         | Common Name                          | Life Form <sup>1</sup> | Type <sup>2</sup> | Noxious <sup>3</sup> | Stotts and Dubey 1998 | Inglis and Wagner 2001 | Hoagland et al. 2005 | Milner et al. 2003 | Cogan 2007 | NPS 2011 | Folts-Zettner and Sosinski 2012a | Folts-Zettner and Sosinski 2012b | Folts-Zettner et al. 2012 | Folts-Zettner et al. 2013 | Cummings and Folts-Zettner 2012 |
|---------------------------------------------------------|--------------------------------------|------------------------|-------------------|----------------------|-----------------------|------------------------|----------------------|--------------------|------------|----------|----------------------------------|----------------------------------|---------------------------|---------------------------|---------------------------------|
| <i>Alyssum alyssoides</i>                               | Field pennycress <sup>4</sup>        | F                      | A                 |                      | •                     |                        |                      |                    |            |          |                                  |                                  |                           |                           |                                 |
| <i>Amaranthus retroflexus</i>                           | Redroot amaranth                     | F                      | A                 |                      |                       |                        |                      |                    |            |          |                                  |                                  |                           | •                         |                                 |
| <i>Arenaria serpyllifolia</i>                           | Thymeleaf sandwort                   | F                      | A                 |                      |                       |                        | •                    |                    |            | •        |                                  |                                  |                           |                           |                                 |
| <i>Bothriochloa ischaemum</i> var. <i>songarica</i> ler | King ranch bluestem; Yellow bluestem | G                      | P                 |                      | •                     |                        | •                    |                    | •          | •        | •                                | •                                |                           | •                         |                                 |
| <i>Bromus catharticus</i>                               | Rescuegrass                          | G                      | A/P               |                      |                       |                        |                      |                    |            |          |                                  | •                                |                           | •                         |                                 |
| <i>Bromus japonicus</i>                                 | Japanese brome                       | G                      | A                 |                      |                       |                        | •                    |                    | •          | •        | •                                | •                                |                           | •                         |                                 |
| <i>Bromus tectorum</i>                                  | Cheatgrass                           | G                      | A                 |                      | •                     | •                      |                      | •                  | •          | •        | •                                | •                                |                           | •                         |                                 |
| <i>Capsella bursa-pastoris</i>                          | Shepherd's purse                     | F                      | A                 |                      |                       |                        |                      |                    |            | •        |                                  |                                  |                           |                           |                                 |
| <i>Chenopodium album</i>                                | Common lambsquarters                 | F                      | A                 |                      |                       |                        | •                    |                    | •          | •        | •                                | •                                |                           | •                         |                                 |
| <i>Cirsium arvense</i>                                  | Canada thistle                       | F                      | P                 | N                    |                       |                        |                      |                    |            |          | •                                |                                  |                           | •                         |                                 |
| <i>Cirsium vulgare</i>                                  | Bull thistle                         | F                      | B                 | n                    | •                     |                        | •                    |                    |            |          | •                                |                                  |                           |                           |                                 |
| <i>Convolvulus avensis</i>                              | Field Bindweed                       | V                      | P                 | n                    |                       |                        | •                    |                    |            | •        | •                                | •                                |                           |                           |                                 |
| <i>Cynodon dactylon</i>                                 | Bermudagrass                         | G                      | P                 |                      | •                     |                        | •                    | •                  | •          | •        | •                                | •                                |                           | •                         | •                               |
| <i>Echinochloa crus-galli</i>                           | Barnyardgrass                        | G                      | A                 |                      |                       |                        | •                    |                    | •          | •        |                                  |                                  |                           | •                         |                                 |
| <i>Eragrostis barrelieri</i>                            | Mediterranean lovegrass              | G                      | P                 |                      |                       |                        | •                    |                    |            | •        |                                  |                                  |                           |                           |                                 |
| <i>Eragrostis cilianensis</i>                           | Stinkgrass                           | G                      | P                 |                      |                       |                        | •                    |                    |            | •        |                                  |                                  |                           |                           |                                 |
| <i>Eragrostis curvula</i>                               | Weeping lovegrass                    | G                      | P                 |                      |                       |                        | •                    |                    | •          | •        |                                  |                                  |                           |                           |                                 |
| <i>Erodium cicutarium</i>                               | Alfilarie                            | F                      | A/B               |                      |                       |                        | •                    |                    |            | •        | •                                | •                                |                           | •                         |                                 |
| <i>Euphorbia dentata</i>                                | Toothed spurge                       | F                      | A                 |                      |                       |                        |                      |                    | •          |          | •                                |                                  | •                         |                           |                                 |
| <i>Geranium pusillum</i>                                | Small geranium                       | F                      | A/B               |                      |                       |                        | •                    |                    |            | •        |                                  |                                  |                           |                           |                                 |
| <i>Hibiscus trionum</i>                                 | Flower of an hour                    | F                      | A                 |                      |                       |                        |                      |                    |            | •        |                                  |                                  |                           |                           |                                 |
| <i>Kochia scoparia</i>                                  | Kochia                               | F                      | A                 |                      | •                     |                        | •                    | •                  | •          | •        | •                                | •                                | •                         | •                         |                                 |
| <i>Lactuca serriola</i>                                 | Prickly lettuce                      | F                      | A/B               |                      |                       |                        | •                    |                    | •          | •        | •                                | •                                | •                         | •                         |                                 |
| <i>Lamium amplexicaule</i>                              | Henbit                               | F                      | A/B               |                      |                       |                        | •                    |                    |            | •        |                                  | •                                | •                         | •                         |                                 |
| <i>Lolium perenne</i>                                   | Italian ryegrass                     | G                      | A/P               |                      |                       |                        | •                    |                    |            | •        | •                                |                                  |                           |                           |                                 |
| <i>Medicago lupulina</i>                                | Black medic clover                   | F                      | A/P               |                      |                       |                        |                      |                    |            |          | •                                | •                                |                           | •                         |                                 |
| <i>Medicago minima</i>                                  | Burr medic                           | F                      | A                 |                      |                       |                        | •                    |                    |            | •        | •                                | •                                | •                         | •                         |                                 |
| <i>Mellilotus alba</i>                                  | White sweetclover                    | F                      | A/P               |                      |                       |                        |                      | •                  |            |          | •                                | •                                |                           |                           | •                               |

**Table 4.10.4-1. Exotic species found within Washita Battlefield National Historic Site (continued)**

| Scientific Name                         | Common Name               | Life Form <sup>1</sup> | Type <sup>2</sup> | Noxious <sup>3</sup> | Stotts and Dubey 1998 | Inglis and Wagner 2001 | Hoagland et al. 2005 | Miner et al. 2003 | Cogan 2007 | NPS 2011 | Folts-Zettner and Sosinski 2012a | Folts-Zettner et al. 2012 | Folts-Zettner et al. 2013 | Cummings and Fols-Zettner 2012 |
|-----------------------------------------|---------------------------|------------------------|-------------------|----------------------|-----------------------|------------------------|----------------------|-------------------|------------|----------|----------------------------------|---------------------------|---------------------------|--------------------------------|
| <i>Mellilotus officinalis</i>           | Yellow SweetClover        | F                      | A/P               |                      | •                     |                        | •                    | •                 | •          | •        | •                                |                           | •                         |                                |
| <i>Onopordum acanthium</i>              | Scotch thistle            | F                      | B                 | N                    |                       |                        |                      |                   |            |          |                                  |                           | •                         |                                |
| <i>Plantago purshii</i>                 | Plantago                  | F                      | A                 |                      | •                     |                        |                      |                   |            |          |                                  |                           |                           |                                |
| <i>Polygonum aviculare</i>              | Prostrate knotweed        | F                      | A/P               |                      |                       |                        | •                    |                   |            | •        |                                  |                           |                           |                                |
| <i>Polygonum convolvulus</i>            | Annual wild buckwheat     | F/V                    | A                 |                      | •                     |                        |                      |                   |            |          |                                  |                           |                           |                                |
| <i>Polygonum monspeliensis</i>          | Annual rabbits-foot grass | G                      | A                 |                      |                       |                        |                      |                   |            |          |                                  |                           |                           | •                              |
| <i>Rumex crispus</i>                    | Curley dock               | F                      | P                 |                      |                       |                        | •                    |                   |            | •        | •                                |                           |                           |                                |
| <i>Rumex patientia</i>                  | Patience dock             | F                      | P                 |                      |                       |                        |                      |                   |            |          | •                                |                           | •                         |                                |
| <i>Salsola tragus</i>                   | Prickly Russian thistle   | F                      | A                 |                      |                       |                        |                      |                   |            |          | •                                | •                         | •                         | •                              |
| <i>Setaria viridis</i>                  | Green Bristlegrass        | G                      | A                 |                      |                       |                        | •                    |                   |            | •        |                                  |                           |                           |                                |
| <i>Sonchus asper</i>                    | Spiny sowthistle          | F                      | A                 |                      |                       |                        |                      | •                 |            |          | •                                | •                         |                           |                                |
| <i>Solanum nigrum</i>                   | Black nightshade          | F                      | A/P               |                      | •                     |                        |                      |                   |            |          |                                  |                           |                           |                                |
| <i>Sorghum halepense</i>                | Johnsongrass              | G                      | P                 | n                    | •                     |                        | •                    | •                 | •          | •        | •                                | •                         | •                         | •                              |
| <i>Stellaria media</i>                  | Common chickweed          | F                      | A/P               |                      |                       |                        | •                    |                   |            | •        |                                  |                           |                           |                                |
| <i>Tamarix ramosissima</i> <sup>5</sup> | Saltcedar                 | T                      | P                 | n                    | •                     | •                      | •                    | •                 | •          | •        | •                                |                           | •                         |                                |
| <i>Taraxacum officinale</i>             | Dandelion                 | F                      | P                 |                      |                       |                        | •                    |                   |            | •        | •                                | •                         | •                         |                                |
| <i>Tragopogon dubius</i>                | Western salsify           | F                      | P                 |                      |                       |                        | •                    |                   |            | •        | •                                |                           | •                         |                                |
| <i>Tribulus terrestris</i>              | Puncturevine              | F                      | A                 |                      |                       |                        | •                    |                   |            | •        | •                                |                           |                           |                                |
| <i>Triticum aestivum</i>                | Common wheat              | G                      | A                 |                      |                       |                        | •                    |                   |            | •        |                                  |                           |                           |                                |
| <i>Ulmus pumila</i>                     | Siberian elm              | T                      | P                 | n                    | •                     |                        | •                    | •                 | •          | •        | •                                |                           | •                         |                                |
| <i>Veronica arvensis</i>                | Common speedwell          | F                      | A                 |                      |                       |                        | •                    |                   |            | •        |                                  |                           |                           |                                |

<sup>1</sup> Life form: G = Graminoid, F = Forb/Herb, V = Vine, T = Tree<sup>2</sup> Type: A = Annual, P = Perennial, B = Biennial<sup>3</sup> Noxious: N = Listed as noxious in Oklahoma, n = Listed as noxious in Texas, New Mexico, and/or Kansas (USDA 2012)<sup>4</sup> Stotts and Dubey (1998) list *Alyssum alyssoides* as field pennycress, but the scientific and common names do not match. We're uncertain as to which one is correct.<sup>5</sup> Both *Tamarix ramosissima* and *Tamarix chinensis* are reported to occur at the historic site, but it is very difficult to differentiate between these very similar species. *T. ramosissima* will be the plant listed for both species.

**Table 4.10.4-2. Exotic species ranking for significance of impact at Washita Battlefield NHS, based on Hiebert and Stubbendieck (2003) ranking system.**

| Species                           | Significance of Impact |                |       |
|-----------------------------------|------------------------|----------------|-------|
|                                   | Level of Impact        | Pest Potential | Total |
| <i>Tamarix ramosissima</i>        | 36                     | 48             | 84    |
| <i>Sorghum halepense</i>          | 32                     | 45             | 77    |
| <i>Bothriochloa ischaemum</i>     | 35                     | 41             | 76    |
| <i>Bromus tectorum</i>            | 35                     | 41             | 76    |
| <i>Ulmus pumila</i>               | 41                     | 32             | 73    |
| <i>Bromus japonicus</i>           | 31                     | 29             | 60    |
| <i>Convolvulus arvensis</i>       | 12                     | 46             | 58    |
| <i>Melilotus alba/officinalis</i> | 28                     | 29             | 57    |
| <i>Cynodon dactylon</i>           | 26                     | 29             | 55    |
| <i>Polypogon monspeliensis</i>    | 12                     | 36             | 48    |
| <i>Salsola kali</i>               | 10                     | 38             | 48    |
| <i>Kochia scoparia</i>            | 15                     | 32             | 47    |
| <i>Cirsium vulgare</i>            | 10                     | 34             | 44    |
| <i>Lactuca serriola</i>           | 10                     | 34             | 44    |
| <i>Sonchus asper</i>              | 10                     | 33             | 43    |
| <i>Tragopogon dubius</i>          | 18                     | 25             | 43    |
| <i>Salsola tragus</i>             | 13                     | 29             | 42    |
| <i>Cirsium arvense</i>            | -8                     | 48             | 40    |
| <i>Eragrostis curvula</i>         | -8                     | 46             | 38    |
| <i>Taraxacum officinale</i>       | 3                      | 34             | 37    |
| <i>Lolium perenne</i>             | 10                     | 24             | 34    |
| <i>Medicago minima</i>            | 1                      | 32             | 33    |
| <i>Chenopodium album</i>          | 5                      | 27             | 32    |
| <i>Eragrostis barrelieri</i>      | -8                     | 40             | 32    |
| <i>Rumex crispus</i>              | -1                     | 32             | 31    |

| Species                        | Significance of Impact |                |       |
|--------------------------------|------------------------|----------------|-------|
|                                | Level of Impact        | Pest Potential | Total |
| <i>Rumex patientia</i>         | -1                     | 32             | 31    |
| <i>Medicago lupulina</i>       | -1                     | 30             | 29    |
| <i>Echinochloa crus-galli</i>  | -8                     | 36             | 28    |
| <i>Tribulus terrestris</i>     | -4                     | 32             | 28    |
| <i>Descurainia sophia</i>      | -4                     | 31             | 27    |
| <i>Polygonum convolvulus</i>   | -6                     | 31             | 25    |
| <i>Lamium amplexicaule</i>     | -8                     | 32             | 24    |
| <i>Erodium cicutarium</i>      | -9                     | 31             | 23    |
| <i>Onopordum acanthium</i>     | -4                     | 27             | 23    |
| <i>Stellaria media</i>         | -8                     | 30             | 22    |
| <i>Amaranthus retroflexus</i>  | -8                     | 29             | 21    |
| <i>Bromus catharticus</i>      | -4                     | 25             | 21    |
| <i>Euphorbia dentata</i>       | -8                     | 28             | 20    |
| <i>Setaria viridis</i>         | -8                     | 28             | 20    |
| <i>Eragrostis cilianensis</i>  | -8                     | 27             | 19    |
| <i>Plantago purshii</i>        | -8                     | 26             | 18    |
| <i>Polygonum aviculare</i>     | -8                     | 26             | 18    |
| <i>Capsella bursa-pastoris</i> | -8                     | 24             | 16    |
| <i>Veronica arvensis</i>       | -8                     | 22             | 14    |
| <i>Alyssum alyssoides</i>      | -8                     | 21             | 13    |
| <i>Arenaria serpyllifolia</i>  | -8                     | 19             | 11    |
| <i>Geranium pusillum</i>       | -8                     | 16             | 8     |
| <i>Hibiscus trionum</i>        | -8                     | 16             | 8     |
| <i>Triticum aestivum</i>       | -8                     | 16             | 8     |

Species ranking was conducted by Tomye Folts-Zettner of the SOPN and Kim Struthers of USU.

#### Proportion of High Priority Blocks Infested

Not only did *Bromus tectorum*, *B. japonicus*, *Sorghum halepense*, and *Ulmus pumila* rank in the top ten highest for their significance of impact, but they also were the most widespread within high-risk areas. *Bromus tectorum* was observed in 89% of the high-risk blocks surveyed in 2010-2012. (Table 4.10.4-4).

#### Proportion of Grid Plots Infested

The relative order of proportion of plots infested were similar to the high priority blocks. Once again *Bromus tectorum* was the most detected and found within 97% of the grid plots, which encompassed the entire

park. *B. japonicus* was only detected in 2% of the grid plots, but was most likely identified as *B. tectorum* (Table 4.10.4-5), however, it is just as problematic and may hybridize with *B. tectorum* (T. Folts-Zettner, SOPN Biologist, pers. comm.). *Sorghum halepense* and *Ulmus pumila* are also widespread throughout the grid plots.

#### Distribution of High Priority Species

The known distribution of the nine highest ranked exotic plant species are shown below (Figures 4.10.4-1 to 4.10.4-9). The most widespread species include cheatgrass, Johnsongrass, and Siberian elm. Distributions of the remaining species that have been mapped are presented in Appendix F. The

**Table 4.10.4-3. Exotic species ranking for feasibility of control, from least to most feasible, at Washita Battlefield NHS, based on Hiebert and Stubbendieck (2003) ranking system.**

| Species                           | Feasibility of Control | Species                        | Feasibility of Control |
|-----------------------------------|------------------------|--------------------------------|------------------------|
| <i>Ulmus pumila</i>               | 8                      | <i>Polypogon monspeliensis</i> | 38                     |
| <i>Convolvulus arvensis</i>       | 14                     | <i>Onopordum acanthium</i>     | 40                     |
| <i>Medicago minima</i>            | 14                     | <i>Salsola kali</i>            | 41                     |
| <i>Cynodon dactylon</i>           | 17                     | <i>Tamarix ramosissima</i>     | 42                     |
| <i>Bromus tectorum</i>            | 18                     | <i>Amaranthus retroflexus</i>  | 45                     |
| <i>Lamium amplexicaule</i>        | 20                     | <i>Bromus catharticus</i>      | 45                     |
| <i>Veronica arvensis</i>          | 21                     | <i>Echinochloa crus-galli</i>  | 45                     |
| <i>Sorghum halepense</i>          | 23                     | <i>Eragrostis barrelieri</i>   | 45                     |
| <i>Erodium cicutarium</i>         | 25                     | <i>Eragrostis cilianensis</i>  | 45                     |
| <i>Melilotus alba/officinalis</i> | 25                     | <i>Lactuca serriola</i>        | 45                     |
| <i>Rumex crispus</i>              | 25                     | <i>Sonchus asper</i>           | 45                     |
| <i>Rumex patientia</i>            | 25                     | <i>Stellaria media</i>         | 45                     |
| <i>Eragrostis curvula</i>         | 26                     | <i>Taraxacum officinale</i>    | 45                     |
| <i>Euphorbia dentata</i>          | 26                     | <i>Tribulus terrestris</i>     | 45                     |
| <i>Polygonum convolvulus</i>      | 26                     | <i>Capsella bursa-pastoris</i> | 50                     |
| <i>Salsola tragus</i>             | 26                     | <i>Descurainia sophia</i>      | 50                     |
| <i>Bothriochloa ischaemum</i>     | 27                     | <i>Lolium perenne</i>          | 50                     |
| <i>Bromus japonicus</i>           | 28                     | <i>Polygonum aviculare</i>     | 50                     |
| <i>Plantago purshii</i>           | 30                     | <i>Arenaria serpyllifolia</i>  | 55                     |
| <i>Setaria viridis</i>            | 30                     | <i>Triticum aestivum</i>       | 55                     |
| <i>Cirsium vulgare</i>            | 31                     | <i>Chenopodium album</i>       | 60                     |
| <i>Kochia scoparia</i>            | 33                     | <i>Geranium pusillum</i>       | 60                     |
| <i>Tragopogon dubius</i>          | 34                     | <i>Hibiscus trionum</i>        | 70                     |
| <i>Medicago lupulina</i>          | 35                     | <i>Alyssum alyssoides</i>      | 75                     |
| <i>Cirsium arvense</i>            | 36                     |                                |                        |

Note: The nine species ranked highest for significance of impact are shown by shaded cells for reference.

Species ranking was conducted by Tomye Folts-Zettner of the SOPN and Kim Struthers of USU.

exotic brome species are of high concern not only because of their potential ecological impact, but also because their distribution is widespread and they are continuing to spread.

According to Folts-Zettner and Sosinski (2012), the majority of the land at the Historic Site is reclaimed agricultural field that still contains terracing and the scars of a one-time homestead. The hydrological regime is further altered by an abandoned railroad grade that effectively divides the uplands from the bottom-lands across the park. These long-term disturbances provide ample microhabitats for the establishment and proliferation of exotic species. The

surrounding agricultural lands and shelterbelts provide propagule sources for continuous re-infestation of park lands. The presence of the Washita River enables additional propagules to enter the park from up-stream populations of exotics and the altered flow, due to agricultural draw-downs and impoundments provide ideal conditions for exotic establishment.

#### Overall Condition

For assessing the condition of exotic plants, we used five 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

**Table 4.10.4-4. Number and percentage of exotic plant species detected in high priority blocks sampled in 2010 -2012 at Washita Battlefield NHS.**

| Species                       | Standardized Blocks |           |
|-------------------------------|---------------------|-----------|
|                               | No. Blocks          | % (N=212) |
| <i>Bromus tectorum</i>        | 188                 | 88.68     |
| <i>Sorghum halepense</i>      | 123                 | 58.02     |
| <i>Ulmus pumila</i>           | 93                  | 43.87     |
| <i>Bromus japonicus</i>       | 80                  | 37.74     |
| <i>Kochia scoparia</i>        | 78                  | 36.79     |
| <i>Tragopogon dubius</i>      | 69                  | 32.55     |
| <i>Melilotus officinalis</i>  | 47                  | 22.17     |
| <i>Cynodon dactylon</i>       | 35                  | 16.51     |
| <i>Cirsium vulgare</i>        | 33                  | 15.57     |
| <i>Lactuca serriola</i>       | 25                  | 11.79     |
| <i>Bothriochloa ischaemum</i> | 17                  | 8.02      |
| <i>Medicago minima</i>        | 17                  | 8.02      |
| <i>Bromus catharticus</i>     | 12                  | 5.66      |
| <i>Euphorbia dentata</i>      | 11                  | 5.19      |
| <i>Salsola tragus</i>         | 11                  | 5.19      |
| <i>Melilotus alba</i>         | 8                   | 3.77      |
| <i>Erodium cicutarium</i>     | 7                   | 3.30      |
| <i>Chenopodium album</i>      | 6                   | 2.83      |
| <i>Rumex patientia</i>        | 6                   | 2.83      |
| <i>Lolium perenne</i>         | 3                   | 1.42      |
| <i>Tamarix chinensis</i>      | 3                   | 1.42      |
| <i>Taraxacum officinale</i>   | 3                   | 1.42      |
| <i>Tribulus terrestris</i>    | 3                   | 1.42      |
| <i>Medicago lupulina</i>      | 2                   | 0.94      |
| <i>Convolvulus arvensis</i>   | 1                   | 0.47      |
| <i>Lamium amplexicaule</i>    | 1                   | 0.47      |

Notes: Ten of the species ranked highest for significance of impact are shown by shaded cells for reference.

of the Historic Site's exotic plants. Several factors contribute to an exotic's threat to the integrity of a native ecosystem including its current status and potential for invasion 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 indicators/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

**Table 4.10.4-5. Number and percentage of exotic plant species detected throughout the park grid plots sampled in 2011 only at Washita Battlefield NHS.**

| Species                       | No. Blocks | % (N=302) |
|-------------------------------|------------|-----------|
| <i>Bromus tectorum</i>        | 294        | 97.35     |
| <i>Sorghum halepense</i>      | 130        | 43.05     |
| <i>Ulmus pumila</i>           | 111        | 36.75     |
| <i>Tragopogon dubius</i>      | 22         | 7.28      |
| <i>Bothriochloa ischaemum</i> | 21         | 6.95      |
| <i>Melilotus officinalis</i>  | 17         | 5.63      |
| <i>Kochia scoparia</i>        | 15         | 4.97      |
| <i>Amaranthus retroflexus</i> | 9          | 2.98      |
| <i>Cynodon dactylon</i>       | 8          | 2.65      |
| <i>Bromus japonicus</i>       | 6          | 1.99      |
| <i>Chenopodium album</i>      | 6          | 1.99      |
| <i>Tamarix chinensis</i>      | 6          | 1.99      |
| <i>Salsola tragus</i>         | 5          | 1.66      |
| <i>Lactuca serriola</i>       | 4          | 1.32      |
| <i>Rumex patientia</i>        | 3          | 0.99      |
| <i>Medicago minima</i>        | 2          | 0.66      |
| <i>Erodium cicutarium</i>     | 2          | 0.66      |
| <i>Bromus catharticus</i>     | 2          | 0.66      |
| <i>Medicago lupulina</i>      | 1          | 0.33      |
| <i>Taraxacum officinale</i>   | 1          | 0.33      |
| <i>Cirsium arvense</i>        | 1          | 0.33      |
| <i>Echinochloa crus-galli</i> | 1          | 0.33      |
| <i>Lamium amplexicaule</i>    | 1          | 0.33      |
| <i>Onopordum acanthium</i>    | 1          | 0.33      |

Notes: Eight of the ten species ranked highest for significance of impact are shown by shaded cells for reference.

in Table 4.10.4-6. Based on a qualitative evaluation of condition findings across the five indicators/measures, we consider the overall conditions for exotic plants at Washita Battlefield NHS as a significant concern with a declining 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

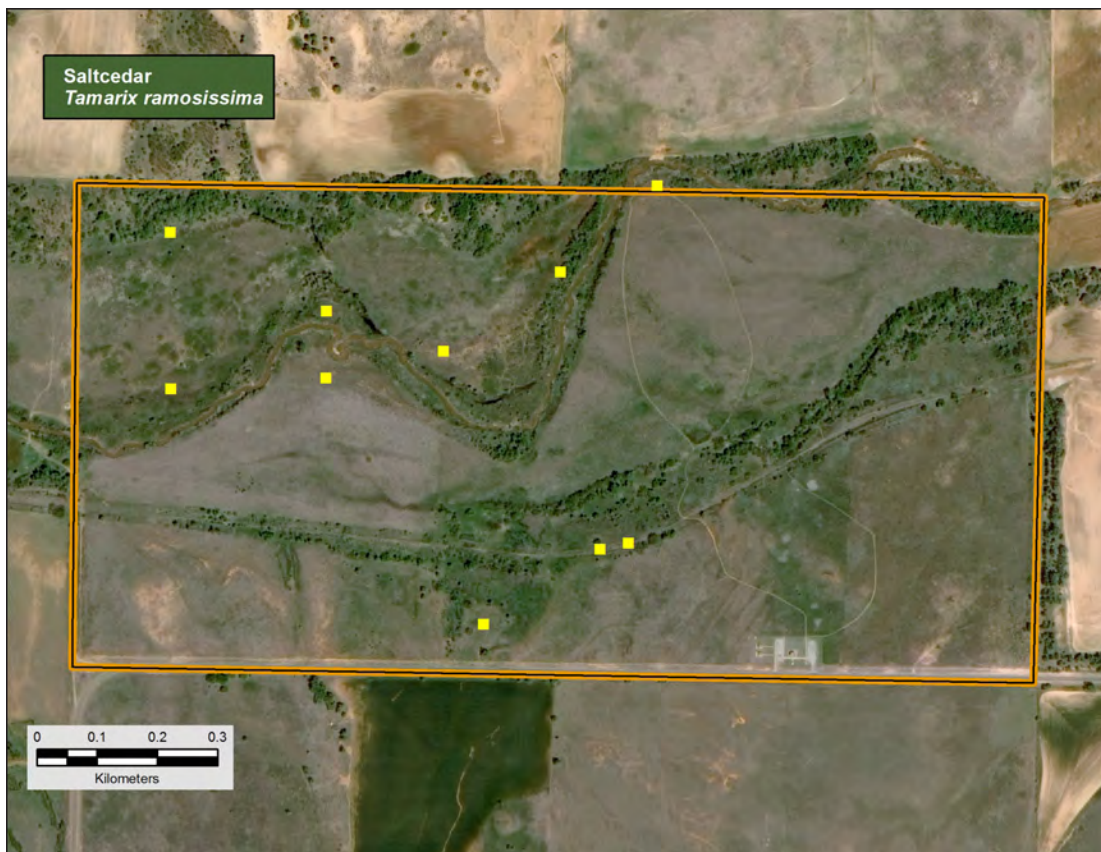


Figure 4.10.4-1.  
Known distribution  
of *Tamarix  
ramosissima*  
based on surveys  
conducted by SOPN  
and grassland  
monitoring efforts.

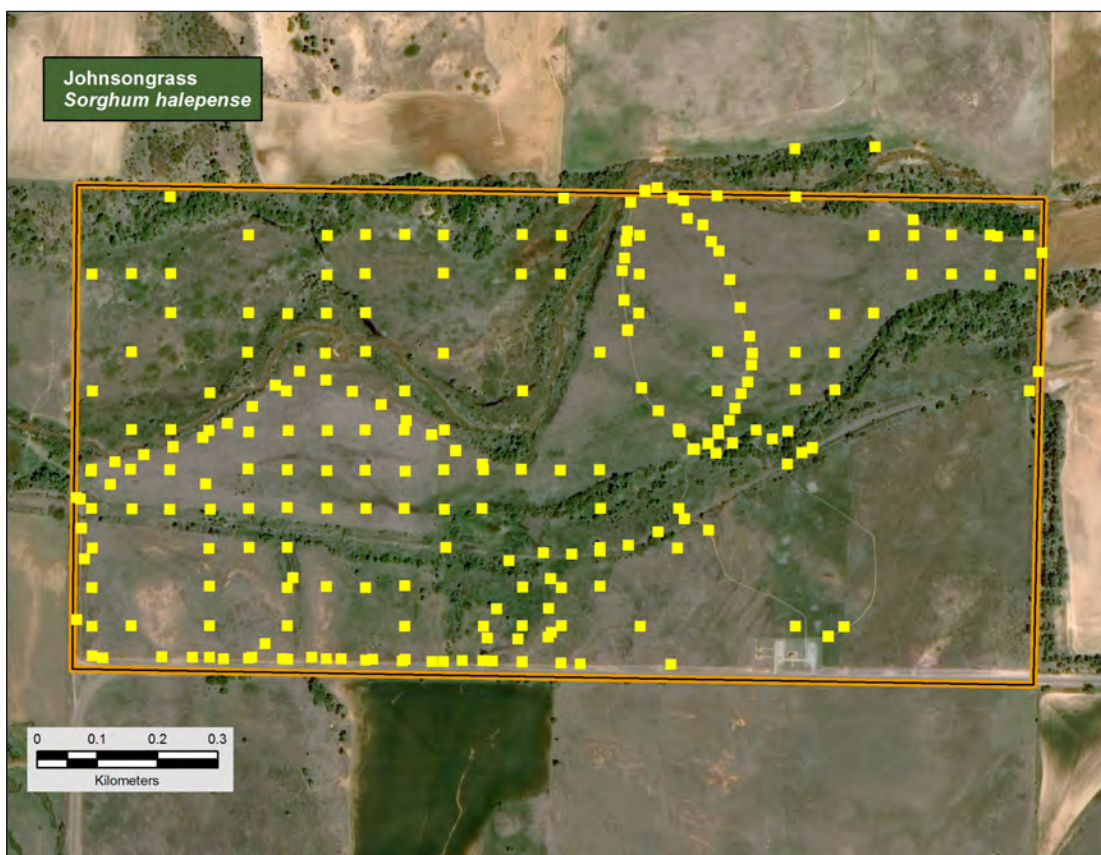


Figure 4.10.4-2.  
Known distribution  
of *Sorghum  
halepense* based  
on surveys  
conducted by SOPN  
and grassland  
monitoring efforts.

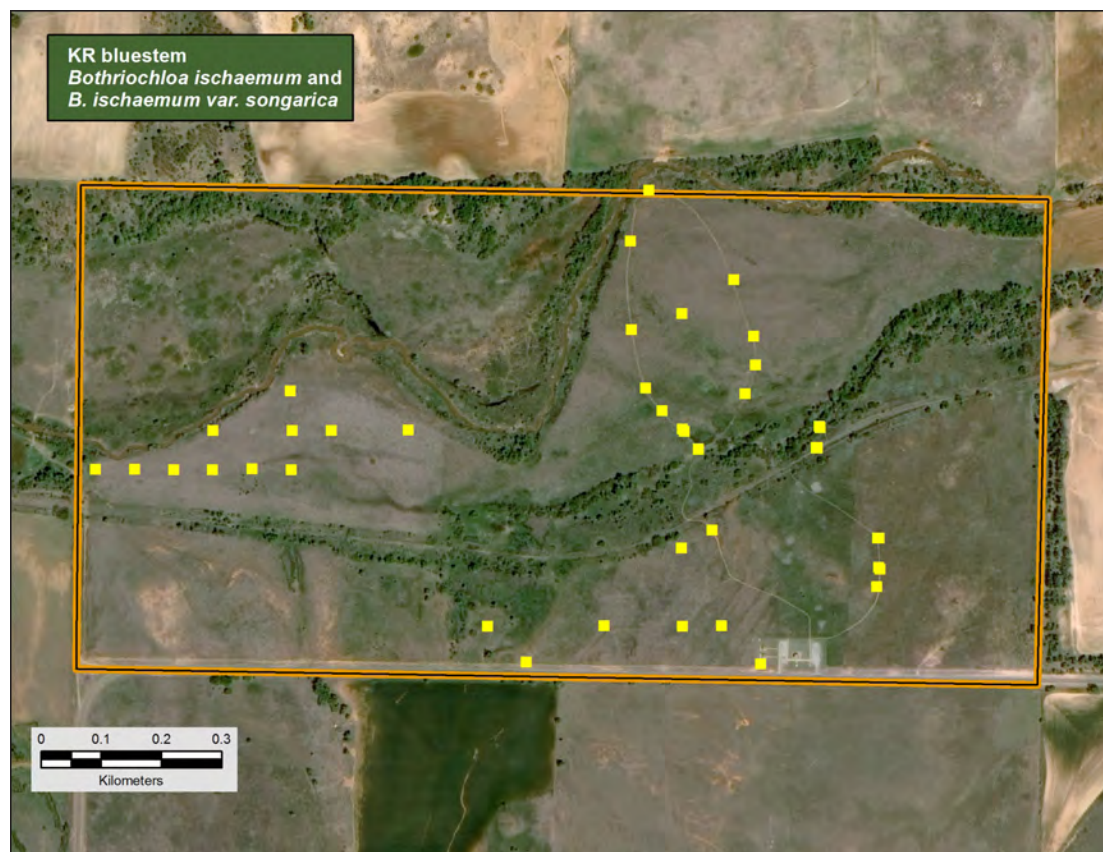


Figure 4.10.4-3.  
Known distribution  
of *Bothriochloa*  
*ischaemum*  
based on surveys  
conducted by SOPN  
and grassland  
monitoring efforts.

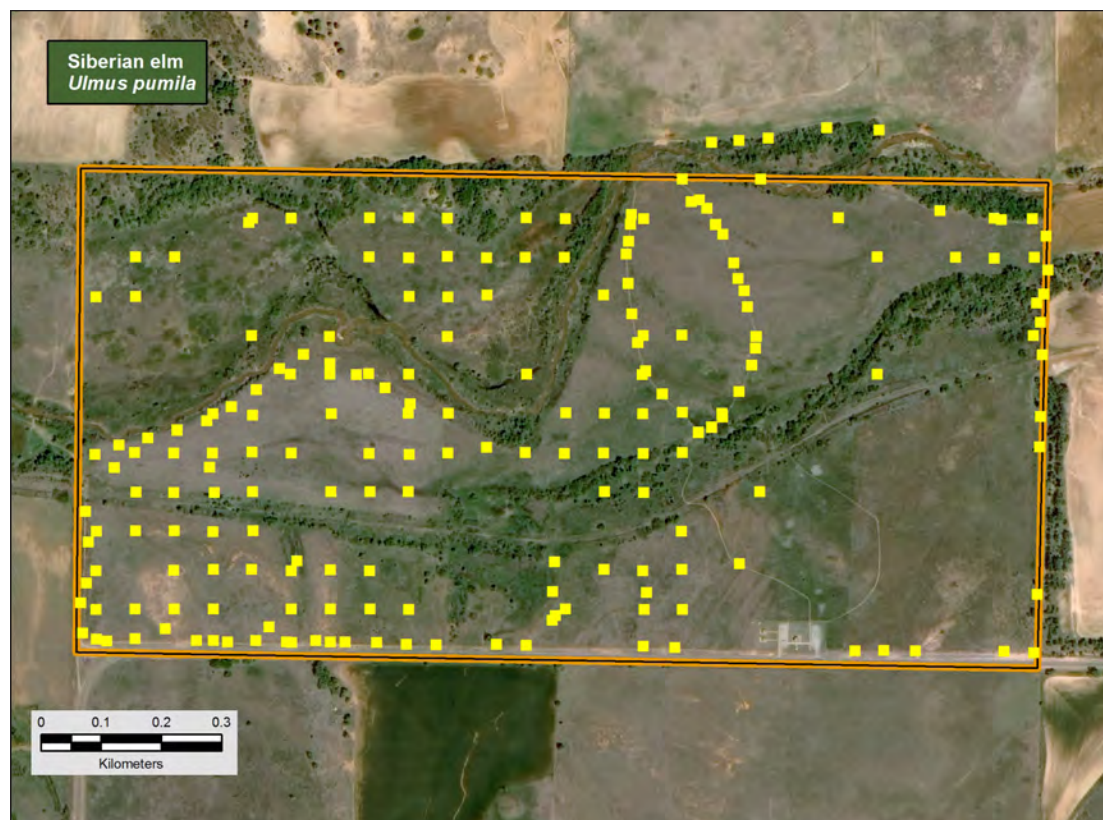


Figure 4.10.4-4.  
Known distribution  
of *Ulmus pumila*  
based on surveys  
conducted by SOPN  
and grassland  
monitoring efforts.

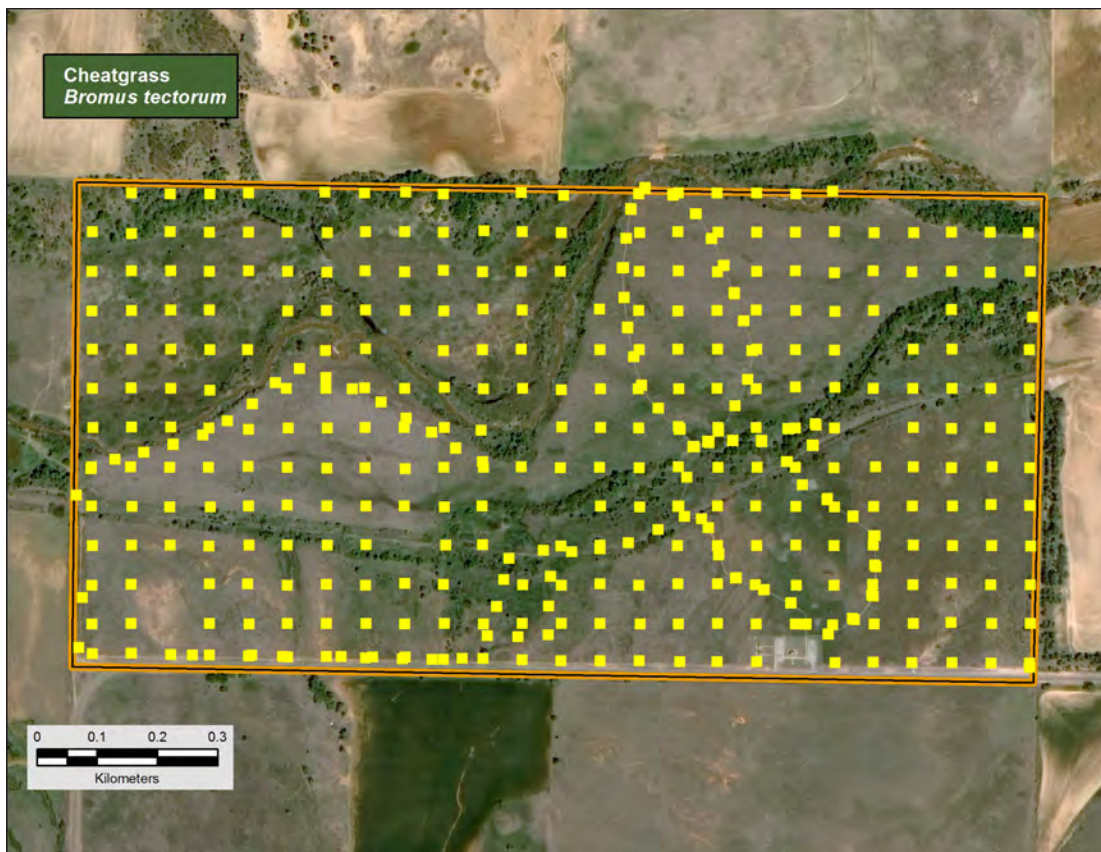


Figure 4.10.4-5. Known distribution of ecologically similar *Bromus tectorum* based on surveys conducted by SOPN and grassland monitoring efforts. *B. japonicus* may have been identified as *B. tectorum*.

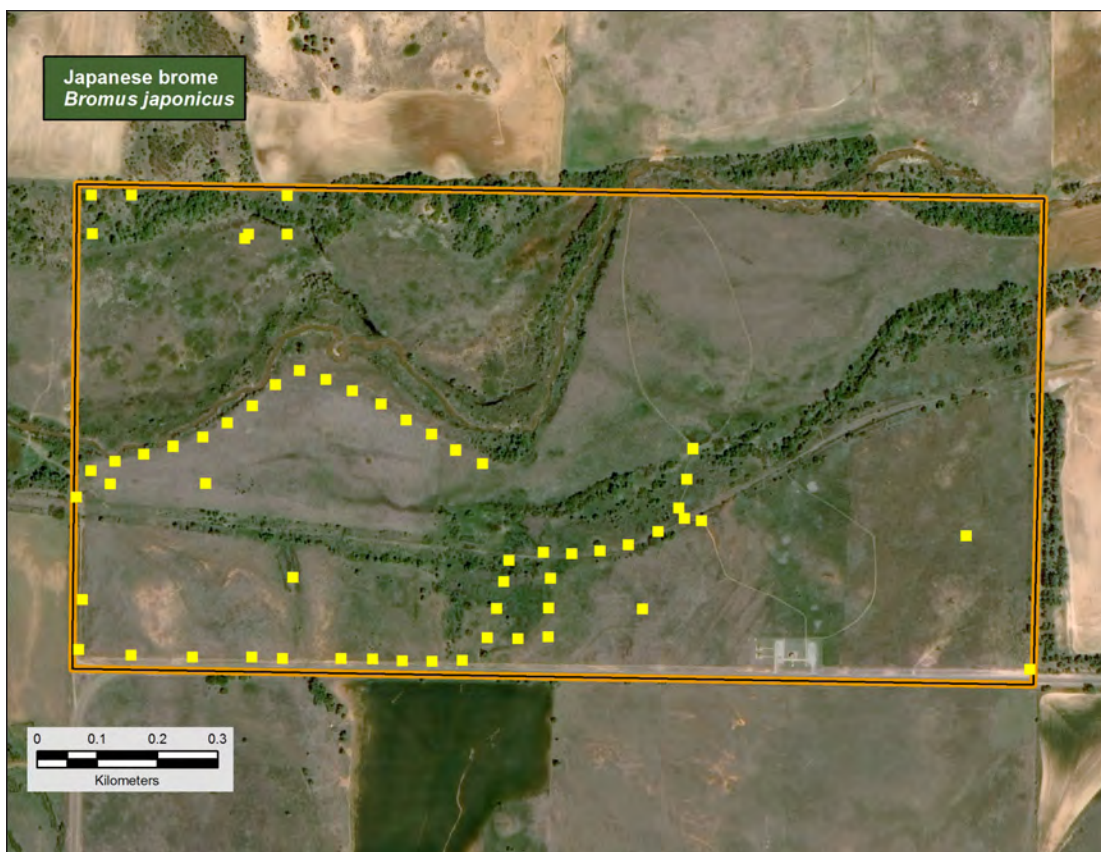


Figure 4.10.4-6. Known distribution of *Bromus japonicus* based on surveys conducted by SOPN and grassland monitoring efforts. *B. japonicus* may have been identified as *B. tectorum*.

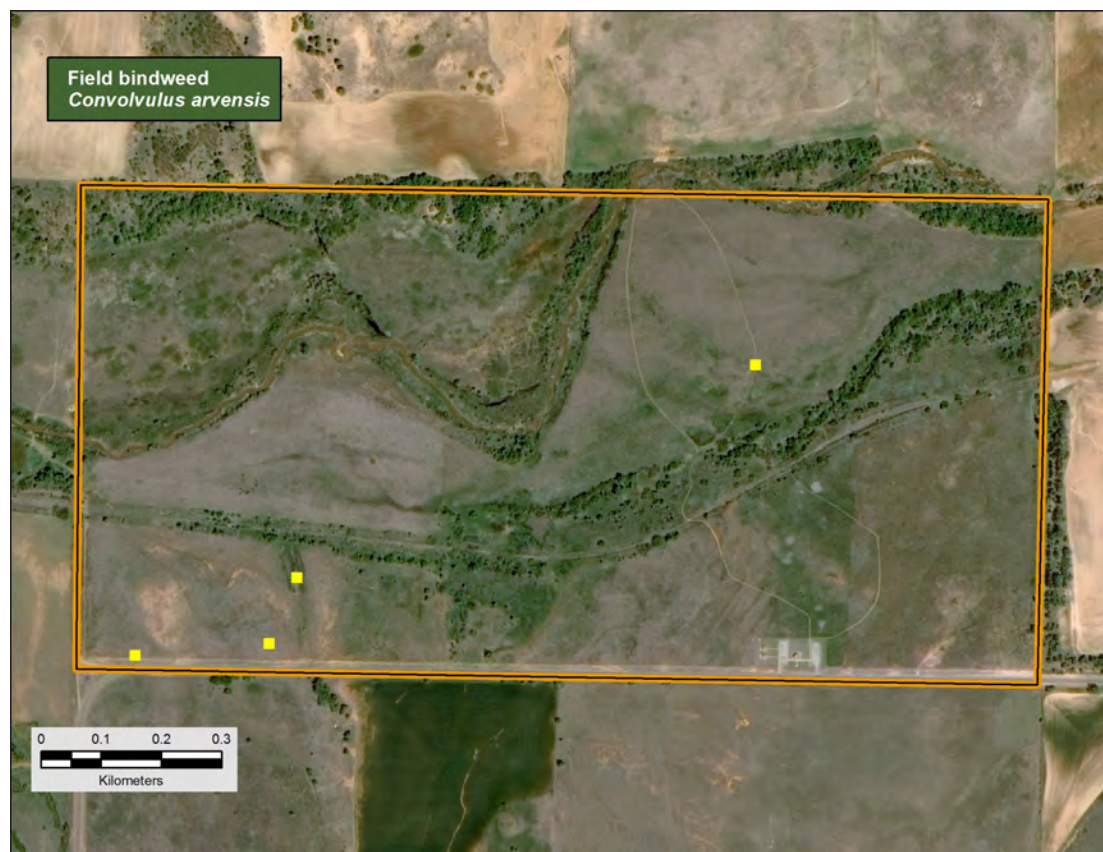


Figure 4.10.4-7.  
Known distribution  
of *Convolvulus  
arvensis* based  
on surveys  
conducted by SOPN  
and grassland  
monitoring efforts.

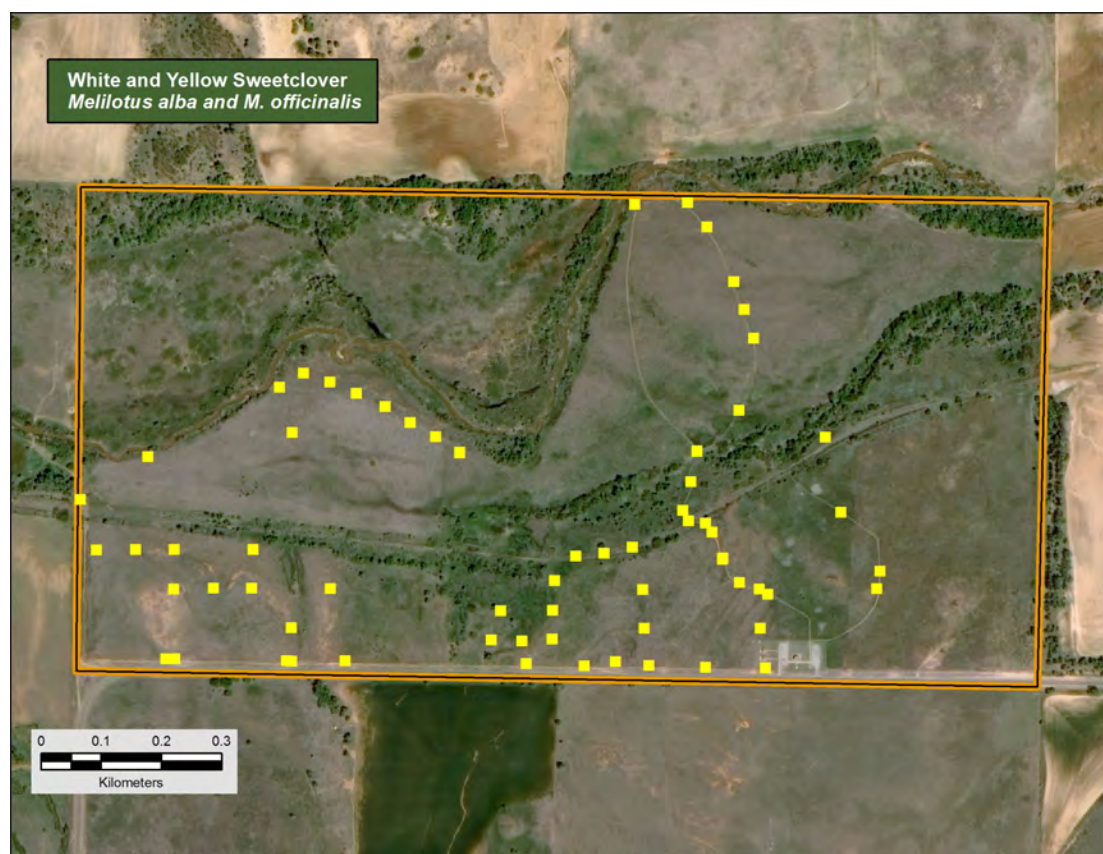


Figure 4.10.4-8.  
Known distribution  
of ecologically  
similar *Melilotus  
alba/officinalis*  
based on surveys  
conducted by SOPN  
and grassland  
monitoring efforts.

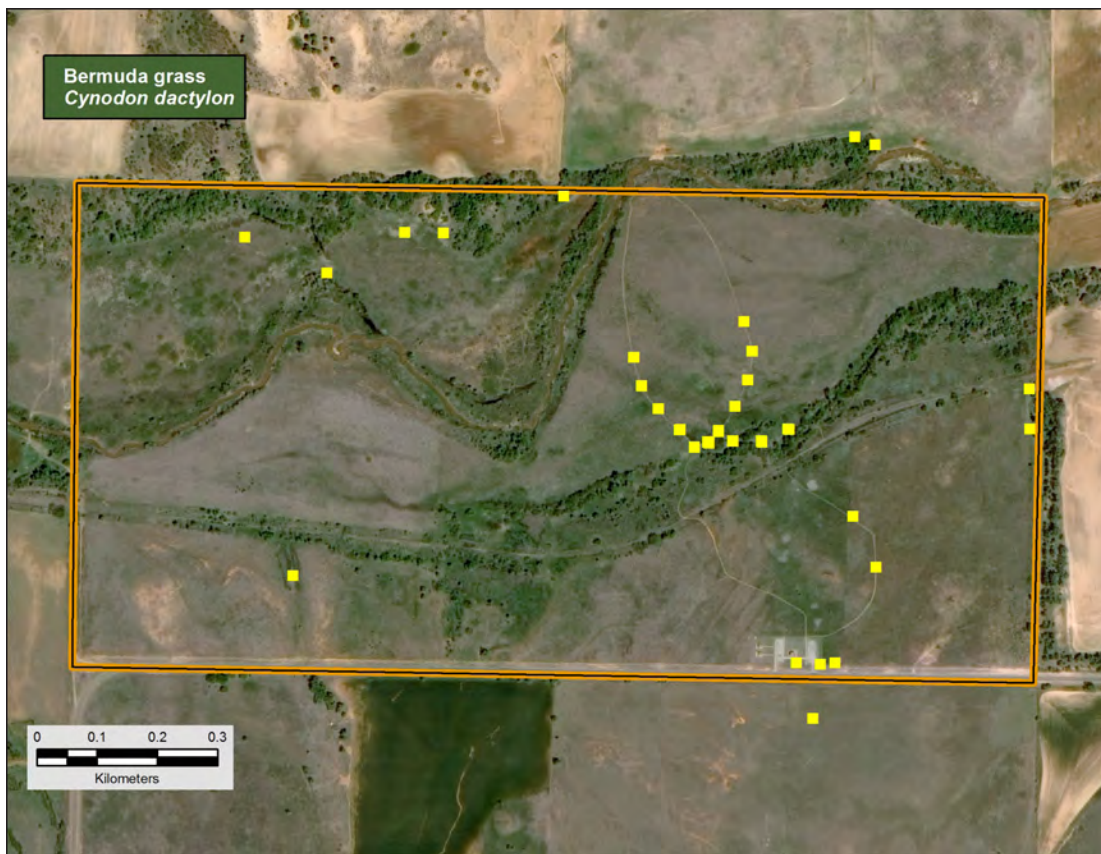


**Figure 4.10.4-9.**  
Known distribution  
of *Cynodon dactylon*  
based on surveys  
conducted by SOPN  
and grassland  
monitoring efforts.

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.

The species ranking approach developed by Hiebert and Stubbendieck (1993) does an excellent job of defining the criteria by which individual species are ranked in terms of the significance of impact and feasibility of control. However, as for any ranking system, there is also a certain degree of subjectivity that goes into any such system. Despite this potential for subjectivity, we believe that the overall ranking did reflect at least the top species of concern.

We are very confident that at least 85-90% of the exotics have been identified throughout the Historic Site.

#### 4.10.5. Sources of Expertise

Surveys for exotic plants at Washita Battlefield 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 in parks of the SOPN.

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**Table 4.10.4-6. Summary of the exotic plants indicators/measures and their contributions to the overall exotic plants natural resource condition assessment.**

| Indicator/Measure                           | Description of How the Indicator(s) Contributes to the Overall Resource Condition                                                                                                                                                                                                                                                                                                                                                                | General Contribution of this Indicator or Measure to the Overall Resource Condition.                                                                                                                                                                                 |
|---------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Significance of impact                      | Not all exotics are the same and as such need to be assessed individually from the perspective of which ones pose the greatest risk to a given ecosystem. Significance of impact is divided into two categories, with one assessing the current status of a given exotic relative to abundance and current level of distribution and the other category assessing the potential of impact given the exotic plant's life history characteristics. | Ranking the highest in significance of impact were several grass species and woody species, including Saltcedar and Siberian elm. The exotic bromes, which ranked high, are well known for their ability to dramatically change an ecosystem sometimes irreversibly. |
| Feasibility of control                      | Given the fact that exotic plants vary in their life histories, the feasibility of controlling a particular exotic plant depends upon factors such as its current abundance, ease of control, proximity to other known populations, side effects of control measures, and response(s) to biological control.                                                                                                                                     | A variety of species ranked highly infeasible to control including Siberian elm, field bindweed, exotic bromes, Bermudagrass, and Burr medic.                                                                                                                        |
| Proportion of high priority blocks infested | High priority blocks were established by SOPN as the "well traveled vectors" where the potential for plant introduction and/or dispersal is high, such as along roads and trails. These blocks are divided into four density classes as well as four distance classes to determine the extent of exotic plant infestation.                                                                                                                       | The exotic bromes, Johnsongrass, and Siberian elm were by far the most widespread throughout the high priority blocks.                                                                                                                                               |
| Proportion of interior blocks infested      | Interior monitoring blocks are scattered throughout the Historic Site as part of additional scientific monitoring efforts. Exotic plants are also recorded when present in these blocks. The interior blocks represent locations other than the high priority blocks listed above and may be a better indicator of plant establishment versus introduction.                                                                                      | The proportion of interior blocks infested was very similar to the high priority blocks. Cheatgrass was detected in over 97% of the blocks, indicating that it is very widespread throughout the park.                                                               |
| Distribution of high priority species       | Data from all available sources, including the interior and high priority blocks were used to map the distribution of the high priority species from the perspective of their impact, feasibility of control, and current locations.                                                                                                                                                                                                             | Known distributions of the highest ranked species were mapped. Overall, cheatgrass, Johnsongrass, and Siberian elm appear to be the most widely distributed throughout the Historic Site.                                                                            |

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## 4.11. Landbirds

### Indicators/Measures

- Species Occurrence
  - Temporal Context
  - Spatial Context
  - Conservation Context

### Condition – Trend - Confidence Level



Good - Insufficient Data - High

#### 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 .



ROBERT SHANTZ

Figure 4.11.1-1  
Dickcissel

. . . unimpaired for the enjoyment of future generations.” Bird watching, in particular, is a popular, longstanding recreational pastime 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 birds at Washita Battlefield National Historic Site (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 Washita Battlefield NHS. 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 birds in a temporal context, we compared the occurrence of species detected during recent RMBO Surveys at Washita Battlefield NHS (described below) to a previous baseline inventory (described below) of birds at the Historic Site. This is not intended as a rigorous or quantitative comparison given the limitations of such information; rather, it is intended as a crude qualitative indicator of major changes over time. However, to do this in a more 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. Consequently, we limited our comparisons to those species for which the Historic Site is within their primary breeding range. We made this determination based primarily on the Birds of North America (BNA) species accounts (Cornell Lab of Ornithology 2012). 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 the 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 (since comparisons are based on the breeding season) exists at the Historic Site. 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 the Surrounding Region

We also evaluated species occurrence in a spatial context. Again, this is intended only as a qualitative indicator rather than a rigorous quantitative estimate (which will be possible in the future). For this assessment, we compared the recent RMBO surveys within the Historic Site to regional surveys (described below). The regional surveys were conducted in similar habitats within the surrounding area, and they serve as a general spatial reference for species occurrence within the region.

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

Our intent for this context was to determine which species that occur at Washita Battlefield NHS are considered species of concern at either national or local scales, 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

**Table 4.11.2-1. Breeding habitat classes assigned to each species that has been reported to occur at Washita Battlefield 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 is 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 the Historic Site 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 Washita Battlefield 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 primary 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 primary 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 regular 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.                                                                                   |

role in the conservation of the species, 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 primary breeding range for that 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 myriad 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 and 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

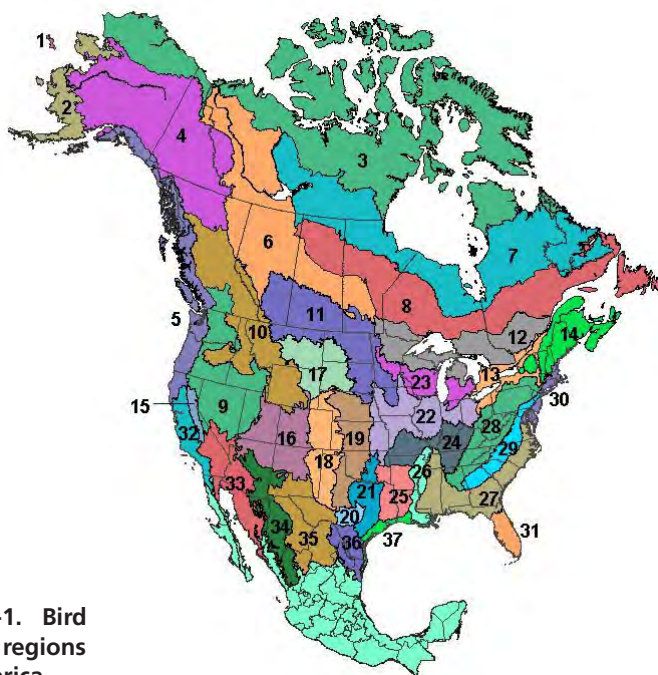


**Figure 4.11.2-1.** Bird conservation regions in North America.

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 Initiative 2012). 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). Washita Battlefield NHS lies within the Central Mixed Grass Prairie Unit (BCR-19) (Figure 4.11.2-2).

#### *Conservation Organizations Listing Species of Conservation Concern*

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

- U.S. Fish & Wildlife Service: Under the Endangered Species Act, the U.S. Fish and Wildlife Service (USFWS) lists species as threatened, endangered, or candidates for listing.
- State of Oklahoma: Under Oklahoma law (29 Okl. St. Ann. 5-402, 412, 412.1), the State of Oklahoma, through the Oklahoma Department of Wildlife Conservation (ODWC), maintains listings of species considered as threatened or endangered within the state, whether or not they are classified

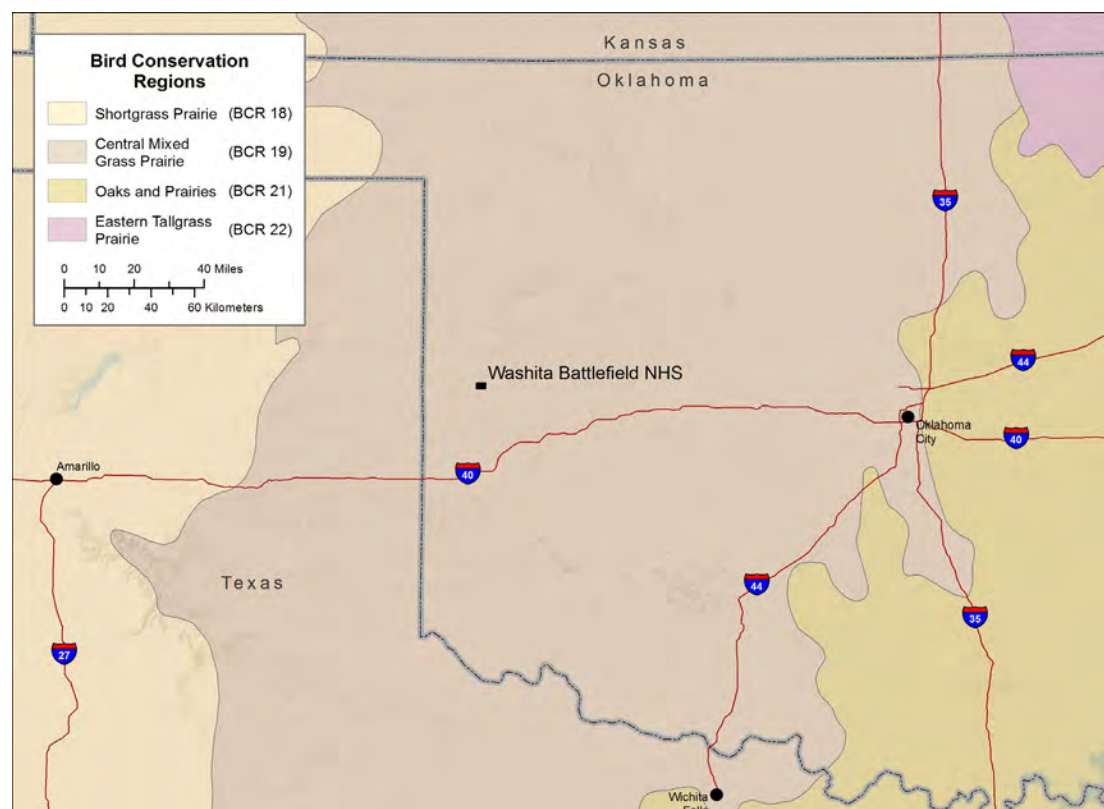


**Figure 4.11.2-2.** Bird conservation regions in the vicinity of Washita Battlefield NHS.

as federally threatened or endangered through the Endangered Species Act (ODWC 2012).

- 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]).
- State of Oklahoma: The Oklahoma Wildlife Diversity Program and biologists from state wildlife agencies, avian conservation joint ventures, and the USFWS and U.S. Forest Service developed bird conservation plans for Oklahoma’s BCRs (ODWC 2011). The work includes lists of birds considered species of greatest conservation need in Oklahoma.

#### Primary Data Sources

Data used as part of this assessment include a baseline bird inventory at Washita Battlefield NHS conducted by the Oklahoma Natural Heritage Inventory in 2001-2002 (i.e., Lomolino and Smith 2007), surveys conducted by RMBO at the Historic Site in 2009-2012, and Breeding Bird Surveys (BBS). Each of these is described below.

#### *ONHI Baseline Bird Inventory*

The Oklahoma Natural Heritage Inventory (ONHI) conducted standard point counts, and recorded incidental detections, for birds at the Historic Site five times during spring/summer and fall/winter of 2001-2002 (16-21 February 2001, 21-26 May 2001, 15-20 January 2002, 29 May-3 June 2002, and 26 November-1 December 2002; Lomolino and Smith 2007). The surveys were conducted at 30 stations spread throughout the park. Birds were counted within bands of 0-50 m and 50-100 m from the center of each station during a 10-minute survey period. Each point was counted two times during each survey session (i.e., once in the morning and once in the evening). Additional sightings were made while walking between survey points and were recorded as incidental sightings. We used these surveys to augment our overall species list of occurrence at the Historic Site (see Appendix H) and in the temporal comparison of species occurrence.

#### *RMBO Surveys at Washita Battlefield NHS*

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 16-18 points in bottomland grassland (designated as “Restoration” on the figure) and 19 points in upland grassland (“Upland”) were sampled two or three 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/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.

#### *BBS Routes*

Breeding bird surveys are conducted on over 4,100 survey routes located across the

**Figure 4.11.2-3.**  
Survey points  
sampled by the  
Rocky Mountain  
Bird Observatory at  
Washita Battlefield  
NHS in 2009-2012.



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 (39.4 km) 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. We used data from three BBS routes (Figure 4.11.2-4) near Washita Battlefield NHS for our regional comparison of species occurrence. The three routes were 18, 32, and 60 km away from the Historic Site (measured from the Historic Site to the closest point on each route). BBS data (lists of bird species [and numbers] recorded) for 2000-2010 or 2011 were used; data for 2011 were available for only one of the three BBS routes.

#### 4.11.3. Reference Conditions

##### Temporal Reference Condition for Species Occurrence

The first bird monitoring or inventory effort at Washita Battlefield NHS was the 2001-2002 baseline avian inventory by ONHI (Lomolino and Smith 2007). During their spring/summer

and fall/winter point counts, they detected 53 species of birds (reports of species detected as fly-overs are not included here).

We compared this initial list of species (accounting for those species that may have been detected outside of the breeding season, see below) to the list of species that were detected during the 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 recent RMBO surveys but were documented during the 2001-2002 baseline bird surveys. We “refined” the list of species where there were differences by excluding those species that were outside of their primary breeding range. Although this is a crude measure, it does potentially provide some insights as to major shifts that might have occurred at the park. 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 at Washita Battlefield NHS to those observed during BBSs in the region surrounding the

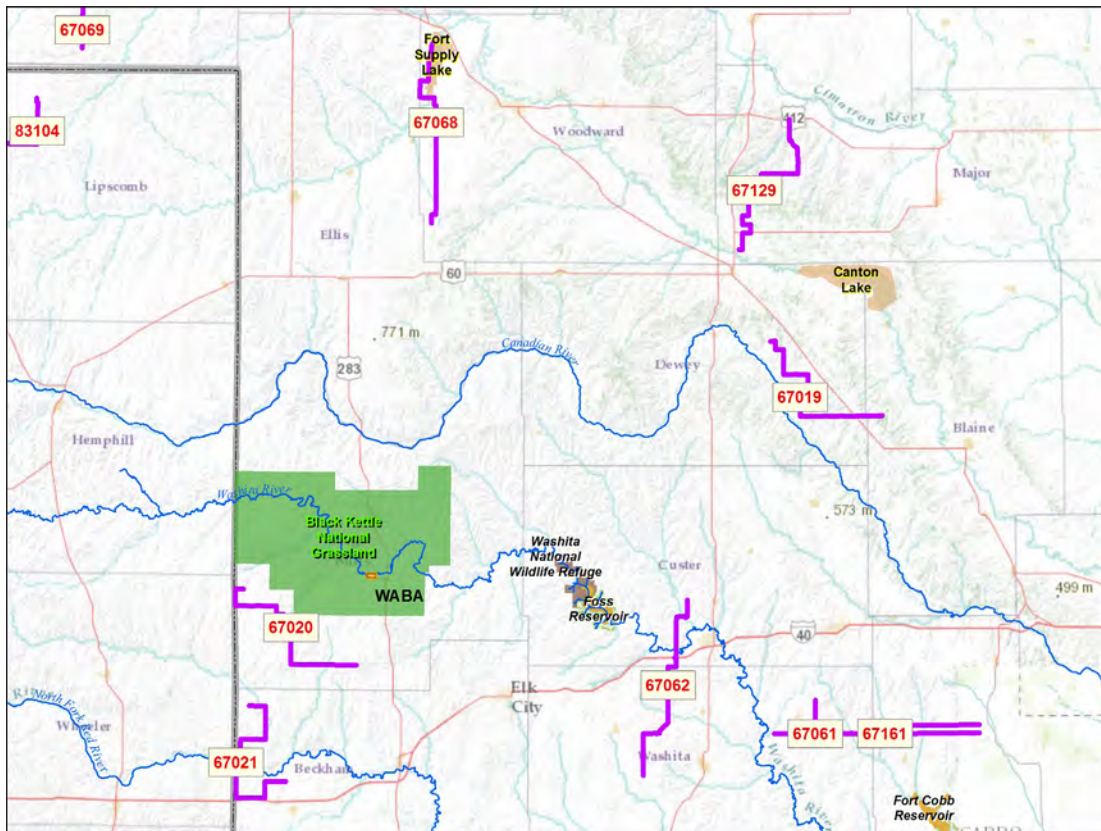


**Figure 4.11.2-4.** BBS routes nearest the Historic Site (67020, 67021, and 67062) were used for regional comparisons of bird species occurrence.

**Table 4.11.3-1. Reference conditions used to assess the current condition of 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 breeding habitat at the park were detected in the 2001-2002 surveys 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 2001-2002 surveys that are within their normal breeding range and have breeding habitat at the park were not detected during recent RMBO surveys.   | We considered condition to be good if all, or nearly all, birds that were detected during 2001-2002 surveys that are within their normal breeding range and have breeding habitat at the park 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 NHS.        | We considered condition to be of moderate concern if a few bird species that were detected during regional surveys and that are within their normal breeding range and have breeding habitat at the NHS 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 that are within their normal breeding range and have breeding habitat at the NHS were detected during recent RMBO surveys. |

**Table 4.11.4-1 Species reported from the 2001-2002 ONHI bird inventory at Washita Battlefield NHS that were not observed during the 2009-2012 RMBO surveys at the Historic Site. Also shown is range status based on Birds of North America species accounts, and breeding habitat class for birds within their normal breeding range.**

| Common Name            | Range Status                  | Breeding Habitat Class |
|------------------------|-------------------------------|------------------------|
| American Kestrel       | Breeding and Wintering        | Possibly Exists        |
| American Tree Sparrow  | Outside Normal Breeding Range | --                     |
| Bell's Vireo           | Breeding Range                | Possibly Exists        |
| Greater Roadrunner     | Year-round                    | Limited to None        |
| Harris's Sparrow       | Outside Normal Breeding Range | --                     |
| House Sparrow          | Breeding Range                | Possibly Exists        |
| Loggerhead Shrike      | Year-round                    | Possibly Exists        |
| Mallard                | Breeding and Wintering        | Possibly Exists        |
| Song Sparrow           | Wintering                     | --                     |
| Spotted Towhee         | Wintering                     | --                     |
| Summer Tanager         | Outside Normal Breeding Range | --                     |
| Upland Sandpiper       | Outside Normal Breeding Range | --                     |
| White-throated Sparrow | Wintering                     | --                     |

Historic Site. Specifically, we compared survey results at the park to the survey results for the three closest BBS routes.

#### 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 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 park.

#### **4.11.4. Condition and Trend**

There have been a total of 91 bird species reported at Washita Battlefield NHS (Appendix H). These species were detected during the 2001-2002 ONHI baseline bird inventory (Lomolino and Smith 2007) and/or the 2009-2012 RMBO point-count surveys.

Of these, the Historic Site was determined to be within the normal breeding range of 62 species (68%), based on maps from the Birds of North America species accounts

(Appendix I). One additional species (Lesser Goldfinch) was outside of its primary breeding range but within an area where it is known to occasionally breed. Ten additional species were determined to be outside, but within 100 miles, of their normal breeding ranges. Given the potential for errors in the BNA range maps and/or the potential for us to have made errors in determining whether the Historic Site was within the normal breeding range from hard copy maps (GIS data were not available), we considered these additional 10 species when assessing whether breeding habitat exists for them at the park.

#### Species Comparisons using the 2001-2002 ONHI Bird Inventory (Temporal Context)

Of the 53 species of birds recorded at the Washita Battlefield NHS in 2001-2002 (excluding fly-overs), 13 were not observed on recent (2009-2012) RMBO surveys (Table 4.11.4-1). However, seven of these 13 species are outside of their normal breeding range according to Birds of North America species accounts. Of the six remaining species, American Kestrel, Bell's Vireo, Greater Roadrunner, and House Sparrow were detected during the 2001-2002 surveys as incidental species (i.e., not during point counts); therefore, there is no information on the season in which they were observed,

or the number observed. Breeding habitat for three of the species “possibly exists” at the Historic Site, while breeding habitat for Greater Roadrunner is “limited to none.” Data from the BBS for all three of the nearest survey routes indicates that all four of the species have been observed in the vicinity of the Historic Site in at least some years from 2000-2010/2011 during the breeding season. For the last two species, Loggerhead Shrike and Mallard, Lomolino and Smith (2007) reported that the two species were detected during the fall/winter; therefore, it does not raise any concerns that the two species were not detected in breeding season surveys by RMBO. Further, we determined that breeding habitat for the two species falls into the “possibly exists” category.

A different set of species (38) was detected in the 2009-2012 surveys but not in the 2001-2002 inventory (e.g., Bullock’s Oriole, Carolina Wren, Common Nighthawk, Lincoln’s Sparrow; see Appendix H). Of these 38 species, 10 were noted as fly-overs during the 2001-2002 inventory.

Based on this temporal comparison, we have no immediate concern related to bird species occurrence at Washita Battlefield NHS at this time.

#### Species Comparisons to Surrounding Region (Spatial Context)

During Breeding Bird Surveys in the surrounding region from 2000-2010/2011, 33 species were observed that were not observed at Washita Battlefield NHS during the 2009-2012 RMBO surveys. Of these 33 species, 14 are considered outside of their normal breeding range based on the BNA species accounts (this includes species that are within their wintering range) (Table 4.11.4-2). However, six of the 14 species are within 100 miles of their breeding range edge. The Historic Site is within the breeding ranges of the remaining 19 of the 33 species. For eight of the 19 species, however, we consider the park to have limited to no breeding habitat for the species. We considered there to be breeding habitat in the “possibly exists” category for 11 of the species. None of the species have what we considered “existing” breeding

habitat. Given the status of their ranges and habitat preferences, we do not find this list particularly alarming.

In summary, after comparison of species found in the surrounding region to those reported from RMBO surveys at Washita Battlefield NHS, a concern for bird species occurrence is not justified at this time.

#### Species of Conservation Concern

There are 21 species that have been detected at the Historic Site 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 G.

- USFWS / Listed Species: There are no bird species listed by the USFWS as endangered or threatened that are known to occur at Washita Battlefield NHS (USFWS 2012). The Yellow-billed Cuckoo is listed as a candidate species, but this designation applies only to a sub-population that does not occur in Oklahoma (Table 4.11.4-3).
- State of Oklahoma / Listed Species: There are no bird species that occur at Washita Battlefield NHS that are listed as endangered or threatened by the State of Oklahoma; of four wildlife species listed by the State, none are birds (ODWC 2012).
- USFWS / Birds of Conservation Concern: There are nine 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).
- NAS / ABC: There are four species that occur or have occurred at Washita Battlefield NHS that have been listed on the NAS/ABC 2007 WatchList. All four species (Lark Bunting, Painted Bunting, Red-headed Woodpecker, and Swainson’s Hawk) are listed on the Yellow List- the first three due to population declines and the fourth because it is rare.

**Table 4.11.4-2 Thirty-three species reported from Breeding Bird Surveys in the surrounding area, 2000-2011, that were not detected during RMBO surveys (2009-2012) at the Historic Site. Also shown are range status based on Birds of North America species accounts and breeding habitat class for birds within their normal breeding range.**

| Common Name               | Range Status                               | Breeding Habitat Class:<br>(Exists, Probably Exists, Limited to None) |
|---------------------------|--------------------------------------------|-----------------------------------------------------------------------|
| American Coot             | Wintering <sup>1</sup>                     | -----                                                                 |
| American Kestrel *        | Breeding and Wintering                     | Possibly Exists                                                       |
| American Robin            | Breeding and Wintering                     | Possibly Exists                                                       |
| Ash-throated Flycatcher   | Breeding                                   | Limited to None                                                       |
| Baltimore Oriole          | Outside Normal Breeding Range <sup>1</sup> | -----                                                                 |
| Barn Owl                  | Year-round                                 | Limited to None                                                       |
| Bell's Vireo *            | Breeding                                   | Possibly Exists                                                       |
| Black-chinned Hummingbird | Outside Normal Breeding Range              | -----                                                                 |
| Blue-winged Teal          | Outside Normal Breeding Range <sup>1</sup> | -----                                                                 |
| Cattle Egret              | Outside Normal Breeding Range <sup>1</sup> | -----                                                                 |
| Chuck-will's-widow        | Breeding                                   | Limited to None                                                       |
| Double-crested Cormorant  | Outside Normal Breeding Range              | -----                                                                 |
| Eastern Screech-Owl       | Year-round                                 | Possibly Exists                                                       |
| Eurasian Collared-Dove    | Year-round                                 | Limited to None                                                       |
| European Starling         | Year-round                                 | Possibly Exists                                                       |
| Greater Roadrunner *      | Year-round                                 | Limited to None                                                       |
| Horned Lark               | Year-round                                 | Limited to None                                                       |
| House Finch               | Year-round                                 | Possibly Exists                                                       |
| House Sparrow *           | Year-round                                 | Possibly Exists                                                       |
| Ladder-backed Woodpecker  | Outside Normal Breeding Range <sup>1</sup> | -----                                                                 |
| Least Tern                | Breeding                                   | Limited to None                                                       |
| Little Blue Heron         | Outside Normal Breeding Range <sup>1</sup> | -----                                                                 |
| Loggerhead Shrike *       | Year-round                                 | Possibly Exists                                                       |
| Mallard *                 | Breeding and Wintering                     | Possibly Exists                                                       |
| Orchard Oriole            | Breeding                                   | Limited to None                                                       |
| Rock Pigeon               | Year-round                                 | Limited to None                                                       |
| Snowy Egret               | Outside Normal Breeding Range              | -----                                                                 |
| Upland Sandpiper *        | Outside Normal Breeding Range              | -----                                                                 |
| Virginia Rail             | Outside Normal Breeding Range              | -----                                                                 |
| Warbling Vireo            | Breeding                                   | Possibly Exists                                                       |
| White-winged Dove         | Outside Normal Breeding Range              | -----                                                                 |
| Wood Duck                 | Wintering                                  | -----                                                                 |
| Wood Thrush               | Outside Normal Breeding Range              | -----                                                                 |

<sup>1</sup> Within 100 miles of breeding range edge.

\* Species observed during the 2001-2002 surveys (but only Loggerhead Shrike and Mallard were detected during point counts).

**Table 4.11.4-3. Summary of species detected during 2009-2012 RMBO surveys at Washita Battlefield NHS that are of conservation concern, as listed by government agencies and nongovernmental organizations.**

| Common Name               | Listed Species |       | Species of Conservation Concern Lists |          |                 |                    |                                | State of Oklahoma |    |    |                                       |
|---------------------------|----------------|-------|---------------------------------------|----------|-----------------|--------------------|--------------------------------|-------------------|----|----|---------------------------------------|
|                           | Federal        | State | US Fish & Wildlife Service            |          | NAS/ABC         | Partners in Flight |                                |                   |    |    |                                       |
|                           |                |       | National                              | Region 2 |                 | BCR 19             | National Conservation Strategy |                   |    |    |                                       |
|                           |                |       |                                       |          |                 |                    | CC                             |                   | RC | CS | RS                                    |
| USFWS                     | ODWC           |       |                                       |          | 2007 Watch List |                    |                                |                   |    |    | Species of Greatest Conservation Need |
| Brown Thrasher            |                |       |                                       |          |                 |                    |                                |                   | ●  | ●  |                                       |
| Bullock's Oriole          |                |       |                                       |          |                 |                    |                                | ●                 |    |    | ●                                     |
| Carolina Wren             |                |       |                                       |          |                 |                    |                                |                   | ●  |    |                                       |
| Cassin's Sparrow          |                |       |                                       |          | ●               |                    |                                | ●                 | ●  |    | ●                                     |
| Dickcissel                |                |       | ●                                     |          |                 |                    |                                | ●                 | ●  | ●  |                                       |
| Eastern Meadowlark        |                |       |                                       |          |                 |                    |                                | ●                 |    | ●  |                                       |
| Field Sparrow             |                |       |                                       |          |                 |                    |                                | ●                 |    |    |                                       |
| Grasshopper Sparrow       |                |       |                                       |          |                 |                    |                                | ●                 | ●  | ●  |                                       |
| Lark Bunting              |                |       |                                       | ●        | ●               | ●                  |                                | ●                 | ●  |    |                                       |
| Lark Sparrow              |                |       |                                       |          |                 |                    |                                | ●                 |    | ●  |                                       |
| Mississippi Kite          |                |       |                                       |          | ●               |                    |                                |                   | ●  |    |                                       |
| Northern Bobwhite         |                |       |                                       |          |                 |                    |                                |                   |    |    | ●                                     |
| Painted Bunting           |                |       | ●                                     | ●        |                 | ●                  |                                |                   |    |    | ●                                     |
| Red-bellied Woodpecker    |                |       |                                       |          |                 |                    |                                |                   | ●  |    |                                       |
| Red-headed Woodpecker     |                |       | ●                                     | ●        | ●               | ●                  |                                | ●                 |    | ●  | ●                                     |
| Scissor-tailed Flycatcher |                |       |                                       |          | ●               |                    |                                | ●                 |    |    |                                       |
| Swainson's Hawk           |                |       | ●                                     |          | ●               | ●                  |                                | ●                 |    |    | ●                                     |
| Western Meadowlark        |                |       |                                       |          |                 |                    |                                | ●                 |    | ●  |                                       |
| Yellow-billed Cuckoo      | C <sup>1</sup> |       |                                       |          |                 |                    |                                | ●                 |    |    |                                       |
| Yellow-headed Blackbird   |                |       |                                       |          |                 |                    |                                |                   | ●  |    |                                       |
| Yellow Warbler            |                |       |                                       | ●        |                 |                    |                                |                   |    |    |                                       |

Federal and State Listed Species Codes

T = Threatened, E = Endangered, C = Candidate

C1 = This Candidate listing is for the western sub-population and does not include Oklahoma.

ODWC = Oklahoma Department of Wildlife Conservation

NAS/ABC - 2007 Watchlist

• = Red List • = Declining or Rare

- PIF: Eighteen of the 21 birds in Table 4.11.4-3 are listed by PIF in one or more of its categories (i.e., CC, RC, CS, RS).
- Oklahoma Species of Greatest Conservation Need: Six species that have been recorded at the Historic Site during the 2009-2012 RMBO surveys are considered Species of Greatest Conservation need by ODWC (ODWC 2011): Bullock's Oriole, Cassin's Sparrow, Northern Bobwhite, Painted Bunting, Red-headed Woodpecker, and Swainson's Hawk (Table 4.11.4-3).

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

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

We also recognize that there is 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 21 species listed by one or more organizations as being of conservation concern (Table 4.11.4-3), we believe that 11 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 primary breeding range and sufficient habitat exists to support breeding. All of these 11 species have been observed on recent (2009-2012) RMBO surveys. Furthermore, all but one of the species have been observed during all of the four years of surveys (Table 4.11.4-5); the Lark Sparrow was observed in three of the four years. Some of the species, such as Dickcissel and Eastern Meadowlark,

have been observed in relatively high numbers. Dickcissel was the most abundant bird at Washita Battlefield NHS in 2009, 2011, and 2012, accounting for about 20% of the total number of birds counted in each year. Eastern Meadowlark was among the top four most abundant species at the park in each of the four survey years.

In summary, all breeding species of conservation concern that are known to occur at the Historic Site, and that are within their breeding range, have also been observed during recent RMBO surveys. Based on this, we consider the condition for species of conservation concern to be good.

#### Overall Condition

For assessing the condition of landbirds, we used one indicator/measure that assessed the occurrence of landbirds. This indicator is summarized in Table 4.11.4-6. Although our assessment is based on limited data, we found no justification to warrant concern for bird occurrence at Washita Battlefield NHS at this time.

The temporal comparison found six species that were observed at the Historic Site in 2001-2002 during the ONHI bird inventory but not in the 2009-2012 RMBO surveys. However, breeding habitat for three of the six species only "possibly exists" at the Historic Site, and habitat for one of the species is "limited to none." For the other two species, although breeding habitat possibly exists at the park, they were detected in 2001-2002 outside of the breeding season.

Similarly, there was nothing particularly surprising or alarming when comparing species observed during recent RMBO surveys to the species observed during 2000-2010/2011 Breeding Bird Surveys on the three nearest BBS routes. Thirty-three species were observed during the BBS that were not observed during the 2009-2012 RMBO surveys. Of these 33 species, nearly half are considered outside of their normal breeding range based on the BNA species accounts. For the remaining species, the Historic Site is within their breeding ranges; however, we consider the park to have limited to no

**Table 4.11.4-4. Species detected at Washita Battlefield NHS during 2009-2012 surveys 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. Also shown is whether or not they were detected in the 2001-2002 ONHI inventory.**

| Common Name               | Detected            |                        | Range Status                         | Breeding Habitat Class |
|---------------------------|---------------------|------------------------|--------------------------------------|------------------------|
|                           | 2001-2002 Inventory | 2009-2012 RMBO Surveys |                                      |                        |
| High Potential            |                     |                        |                                      |                        |
| Cassin's Sparrow          | •                   | •                      | Breeding                             | Exists                 |
| Dickcissel                | •                   | •                      | Breeding                             | Exists                 |
| Eastern Meadowlark        | •                   | •                      | Year-round                           | Exists                 |
| Field Sparrow             | •                   | •                      | Year-round                           | Exists                 |
| Grasshopper Sparrow       | •                   | •                      | Breeding                             | Exists                 |
| Lark Sparrow              | •                   | •                      | Breeding                             | Exists                 |
| Mississippi Kite          |                     | •                      | Breeding                             | Exists                 |
| Northern Bobwhite         | •                   | •                      | Breeding and Wintering               | Exists                 |
| Painted Bunting           |                     | •                      | Breeding                             | Exists                 |
| Red-bellied Woodpecker    | •                   | •                      | Year-round                           | Exists                 |
| Scissor-tailed Flycatcher | •                   | •                      | Breeding                             | Exists                 |
| Moderate Potential        |                     |                        |                                      |                        |
| Brown Thrasher            | •                   | •                      | Breeding                             | Possibly Exists        |
| Red-headed Woodpecker     | •                   | •                      | Breeding and Wintering               | Possibly Exists        |
| Swainson's Hawk           | •                   | •                      | Breeding                             | Possibly Exists        |
| Western Meadowlark        | •                   | •                      | Year-round                           | Possibly Exists        |
| Yellow-billed Cuckoo      | •                   | •                      | Breeding                             | Possibly Exists        |
| Low to No Potential       |                     |                        |                                      |                        |
| Bullock's Oriole          |                     | •                      | Breeding                             | Limited to None        |
| Yellow Warbler            |                     | •                      | Breeding                             | Limited to None        |
| Carolina Wren             |                     | •                      | Outside Normal Breeding <sup>1</sup> | ----                   |
| Lark Bunting              |                     | •                      | Outside Normal Breeding <sup>1</sup> | ----                   |
| Yellow-headed Blackbird   |                     | •                      | Outside Normal Breeding <sup>1</sup> | ----                   |

<sup>1</sup> Within 100 miles of breeding range edge.

**Table 4.11.4-5. The number of individuals of species with highest conservation potential detected at Washita Battlefield NHS during recent RMBO surveys.**

| Species                   | 2009 Survey | 2010 Survey | 2011 Survey | 2012 Survey | Total |
|---------------------------|-------------|-------------|-------------|-------------|-------|
| Cassin's Sparrow          | 9           | 3           | 66          | 4           | 82    |
| Dickcissel                | 150         | 86          | 244         | 211         | 691   |
| Eastern Meadowlark        | 36          | 157         | 159         | 97          | 449   |
| Field Sparrow             | 28          | 54          | 49          | 63          | 194   |
| Grasshopper Sparrow       | 7           | 39          | 9           | 2           | 57    |
| Lark Sparrow              | 13          | 48          | 9           | 0           | 70    |
| Mississippi Kite          | 2           | 1           | 28          | 6           | 37    |
| Northern Bobwhite         | 52          | 81          | 80          | 158         | 371   |
| Painted Bunting           | 30          | 35          | 27          | 70          | 162   |
| Red-bellied Woodpecker    | 19          | 16          | 36          | 45          | 116   |
| Scissor-tailed Flycatcher | 2           | 22          | 13          | 3           | 40    |

**Table 4.11.4-6. Summary of the landbirds indicators/measures and their contributions to the overall landbirds natural resource condition assessment.**

| Indicator/Measure                                                                                                                                  | Description of How the Indicator(s) Contributes to the Overall Resource Condition                                                                                                                                                                                                                | General Contribution of this Indicator or Measure to the Overall Resource Condition.                                                                                                                                                                                                                                                                                                                                                                                                           |
|----------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Species Occurrence <ul style="list-style-type: none"> <li>• Temporal context</li> <li>• Spatial context</li> <li>• Conservation context</li> </ul> | Although other measures that are currently not available (i.e., data for density, occupancy, etc.) may be more appropriate for this measure, we simply used occurrence for this assessment. We considered three different facets of occurrence to provide a greater perspective to this measure. | A total of 91 bird species have been reported to occur at the Historic Site, with 62 of those species occurring within or in proximity to their primary breeding range. Regionally, 33 species of birds were identified that occur in the region but have not been observed at the Historic Site during RMBO breeding bird surveys. The Historic Site has a high potential to influence 11 species that have been identified as species of concern by various bird conservation organizations. |

breeding habitat for about half of the species. For the other half, we consider there to be breeding habitat in the “possibly exists” category. None of the species have what we considered “existing” breeding habitat.

We found 11 species that we believe have relatively high conservation potential at Washita Battlefield NHS, and all of these have been observed numerous times at the Historic Site during recent years. Based on the evidence 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. 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 landbirds.

We determined the breeding ranges primarily from the BNA species accounts and had to judge from hard copies whether or not the Historic Site was within those ranges. We tried to account for this uncertainty by also considering species that were on the edge of their ranges. Similarly, there is considerable

subjectivity in our assignment of habitat classes. We based this assessment on a combination of the BNA accounts, as well as our own and local knowledge of the species in question.

#### **4.11.5. Sources of Expertise**

Ross Lock, a wildlife biologist with the Rocky Mountain Bird Observatory, provided consultation and reviewed the landbirds section.

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Washita Battlefield  
National Historic  
Site.

## Chapter 5: NRCA Discussion and Connection to *State of the Park* Reporting

### 5.1. Introduction

The purpose of this chapter is to provide a summary of the natural resource topics assessed for Washita Battlefield National Historic Site's NRCA. The format will be closely aligned to the *State of the Park* report to aid the integration of natural resource condition information derived from this NRCA into the park's *State of the Park* report.

#### *State of the Park*

As part of the stewardship of national parks for the American people, the NPS has begun to develop *State of the Park* reports to assess the overall status of each park's resources. The NPS will use the *State of the Park* report information to improve park priority setting and to synthesize and communicate complex park condition information to the public in a clear and simple way (NPS 2011a,b).

The key purposes of each *State of the Park* report is to:

- Provide to visitors and the American public a snapshot of the status and trend in the condition of a park's priority resources and values.

- Summarize and communicate complex scientific, scholarly, and park operations factual information and expert opinion using non-technical language and a visual format.
- Highlight park stewardship activities and accomplishments to maintain or improve the *State of the Park*.
- Identify key issues and challenges facing the park to help inform park management planning.

In this chapter, we will address three of the four *State of the Park* purposes by providing an overall natural resource summary table showing the resource topic condition findings, which is based on the hierarchical framework discussed in Chapter 3. The Status and Trend symbols used in the resource summary table, and throughout this report, can also be found in Chapter 3, Table 3.2.3-1.

The background color, in green, yellow, or red, represents the current condition, the direction of the arrow summarizes the condition's trend, if any, and the thickness of the outside line represents the degree of confidence in the assessment of the resource.

The Historic Site's *State of the Park* natural resource summary is shown in Table 5.1-1. The rationale provides an explanation for the overall condition of each resource topic assessed for the Historic Site's NRCA. The internet version of this NRCA report is available at <http://www.nature.nps.gov/water/nrca/reports.cfm>.

In section 5.2, we summarize each natural resource topic by individual indicators and assign condition status, along with a brief review explaining the rationale for the resource condition. We also include a resource brief, summarizing key information pertaining to each natural resource topic. Sections 5.3 and 5.4 discuss noteworthy natural resource condition highlights and key issues and challenges for consideration in management planning, respectively. All of the sections in Chapter 5 are intended to be used as a stand-alone document to aid the Historic

Site staff in developing the natural resource component of their *State of the Park* report.

## 5.2. *State of the Park* – Natural Resources

Our NRCA assessment of each natural resource topic assessed for Washita Battlefield NHS is based on a synthesis of the park's monitoring, evaluation, and management programs, as well as expert opinions and other credible scientific literature and/or programs. Copies of references and website links to sources used to assess each resource topic are provided on a DVD with the final NRCA report.

The overall assessment of the condition for a Priority Resource or Value may be based on a combination of the status and trend of multiple indicators and specific measures of condition shown in the tables below.

**Table 5.1-1 *State of the Park* Natural Resource Summary Table**

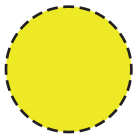
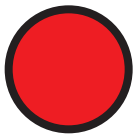
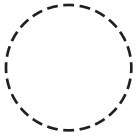
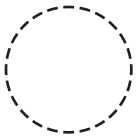
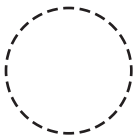
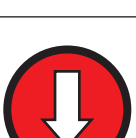
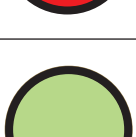
| Priority Resource or Value | Condition Status/Trend                                                              | Rationale                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
|----------------------------|-------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Natural Resources</b>   |                                                                                     |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |
| Viewshed                   |  | To assess viewshed condition, four measures of scenic and historic integrity were used, two ground-based using panoramic images from a key vantage point (intactness and conspicuousness of noncontributing features) and two aerial-perspective measures using GIS representation and analysis (road and housing density). Overall, the scenic and historic integrity of the viewsheds at Washita Battlefield National Historic Site is in moderate condition. The landscape surrounding Washita Battlefield NHS remains largely rural and sparsely developed, however, noncontributing features such as wind turbines, oil rigs, and roads are conspicuous. |
| Night Sky                  |  | The indicators used to assess the level of light pollution (or the visibility of the night skies) do so in slightly different ways. As such, they contribute equally to our overall assessment. The Bortle Scale is a direct, but qualitative assessment of the visibility of a suite of celestial objects or phenomena. Sky brightness is a direct measure of the brightness of the sky and is measured with a sky quality meter. Anthropogenic Light Ratio is a quantitative measure that was modeled to compare the average anthropogenic sky luminance to the average natural sky luminance.                                                              |
| Soundscape                 |  | The majority of sounds heard originate from outside the Historic Site's boundary. The types of noises heard and their associated characteristics are not expected for the designated uses that occur throughout the park and the visitor experience goal of preserving a reflective mood. The proximity of highways, oil/gas developments, and an airport detract from the soundscape's condition, warranting significant concern.                                                                                                                                                                                                                            |
| Air Quality                |  | Air quality monitoring is multifaceted and includes visibility, ozone, and wet deposition for total nitrogen and total sulfur. Visibility and Total Nitrogen warranted significant concern and ozone and Total Sulfur warranted moderate concern. The only trend was for visibility, which resulted in no trend, although a slight possibility of improvement.                                                                                                                                                                                                                                                                                                |

**Table 5.1-1 State of the Park Natural Resource Summary Table (continued)**

| Priority Resource or Value | Condition Status/Trend                                                              | Rationale                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
|----------------------------|-------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Geology                    |    | A geologic resource inventory scoping summary was conducted in 2011.                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |
| Surface Water              |    | No surface water data have been gathered through the Historic Site's relatively new monitoring program.                                                                                                                                                                                                                                                                                                                                                                                                                                       |
| Groundwater                |    | Two groundwater monitoring wells are located in the Washita River major alluvium aquifer, approximately 3 miles northeast (downstream) and 1.7 miles upstream of the Historic Site. The water level elevations and depths to water levels have been monitored at the wells from 1976-present and 2002-2010. The well water level recordings within the Washita River Alluvium and Terrace aquifer do not provide enough information to determine groundwater condition.                                                                       |
| Riparian Habitat           |    | A proper functioning condition for riparian areas requires integration between water flow and floodplain characteristics, vegetation types and amounts, and erosion and sediment deposition processes. All of these measures are either properly functioning or are functional-at risk, but improving, throughout the Historic Site's riparian habitat.                                                                                                                                                                                       |
| Grasslands                 |   | Based on our assessment, the condition of soil stability and hydrologic function is in relatively good condition, but the biotic integrity has several concerns. Most notably is the widespread invasion of exotic species, but there is also some concern about the diversity of forbs in the restoration areas and consider the overall condition of the grasslands at Washita Battlefield NHS to be of moderate concern with a decreasing trend.                                                                                           |
| Exotic Plants              |  | Several factors contribute to the exotic plants condition, including types of exotic, control difficulty, and the location where the plants are growing. The Historic Site has several widespread ecologically threatening plants, such as the non-native bromes, and seven of the most difficult to control species are also in the top ten list of highest significance of impact. The proportion of park-wide plots containing at least one exotic species was high, with <i>Bromus tectorum</i> found in 97% of park-wide plots surveyed. |
| Landbirds                  |  | We used one indicator/measure, species occurrence, in three separate contexts (temporal, spatial, and conservation), to assess the condition of landbirds. A total of 91 bird species have been reported at the Historic Site, with 78 of them being detected in recent (2009-2012) surveys. The Historic Site is within the normal breeding range of 62 of the species. We consider the condition of landbirds at the Historic Site to be good, but we do not have sufficient data to justify a trend in the condition at this time.         |

| Viewshed  |                                                                             |                                                                                   |                                                                                                                                                                                                                                                           |
|----------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------|-----------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Indicators of Condition                                                                      | Specific Measures                                                           | Condition Status/Trend                                                            | Rationale                                                                                                                                                                                                                                                 |
| Scenic and Historic Integrity                                                                | Housing density                                                             |  | Housing density is relatively low surrounding the Historic Site, indicating good condition.                                                                                                                                                               |
|                                                                                              | Road density                                                                |  | Road density is low to moderate surrounding the Historic Site, and includes a mix of road types (including highways and state routes) indicating moderate condition.                                                                                      |
|                                                                                              | Conspicuousness of noncontributing features                                 |  | Although located in a rural setting, the noncontributing features (oil and gas development, wind turbines, especially) are relatively conspicuous (the size and close location of the structures). We assessed the condition as moderate for this reason. |
| Intactness TBD                                                                               | The degree to which the viewshed is unaltered from its 1864 reference state |  | The Historic Site is located in a rural setting, although some features (oil and gas development, wind turbines, roads) encroach on the intactness. Overall, as measured by intactness, the Historic Site is in moderate condition.                       |

### Resource Brief

The scenic and historic integrity of Washita Battlefield National Historic Site is imparted to visitors through the viewshed--what people see when they visit the site. Not only does the condition of the viewshed impact visitor experience and enjoyment, it is often times critical to their understanding the events that occurred on the site; key aspects of the battle can be envisioned playing out on the landscape, its topography and natural setting. Viewshed condition is impacted negatively by fragmentation (a lack of intactness on the landscape), the conspicuousness of noncontributing features--or those things

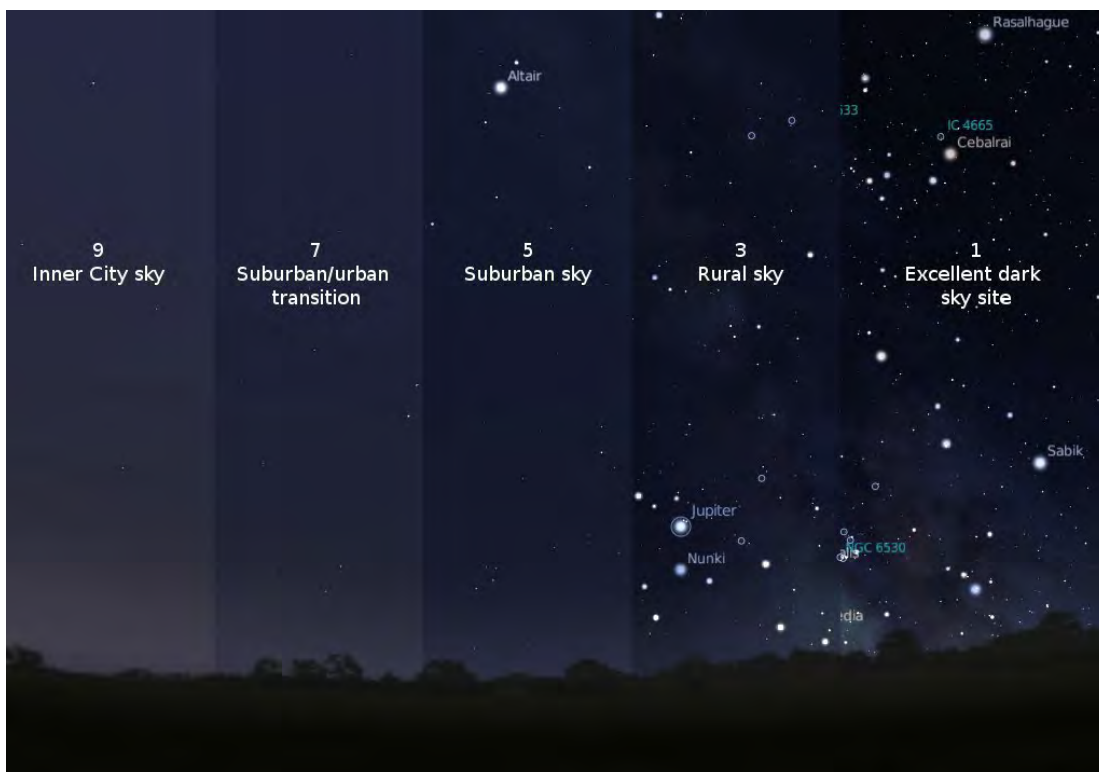
on the landscape that look out of place, and the amount of development--roads and homes that may break up the landscape and be more conspicuous. Some features contribute to scenic and historic integrity and impact viewsheds in a positive way--historic structures, features, or monuments, the natural topography and landscape features, and even a rural agricultural setting. At Washita Battlefield NHS, the surroundings are rural, but there are some significant noncontributing features that negatively impact the viewshed condition--oil and gas development, wind turbines, and roads.

| Night Sky               |                           |                                                                                   |                                                                                                                                                                                                                                                                                                                                                                                                |
|-------------------------|---------------------------|-----------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Indicators of Condition | Specific Measures         | Condition Status/<br>Trend                                                        | Rationale                                                                                                                                                                                                                                                                                                                                                                                      |
| Sky Darkness            | Bortle Scale Class        |  | This measure results from modeling conducted by the NPS Night Sky Program. No ground-based measurement has been collected.                                                                                                                                                                                                                                                                     |
| Sky Brightness          | Zenith Sky Brightness     |  | An almost continuous array of faint light domes were visible to the south (probably from Amarillo to the SW extending east to Elk City). One light dome (Cheyenne, OK) was approximately twice the brightness of the Milky Way and extended approximately 15 degrees from the horizon. Additional light pollution was contributed by surrounding oil and gas operations and other development. |
|                         | Anthropogenic Light Ratio |  | Although the Milky Way was visible almost from horizon to horizon (except about 10-15 degrees from the southern horizon), it appeared uniform and lacking detail. The ground was mostly dark with no visible shadow from the Milky Way.                                                                                                                                                        |

### Resource Brief

Natural dark skies are a valued resource for many reasons; they are an important factor for maintaining healthy biological systems and have an aesthetic appeal for recreational value. Night skies, and the objects that can be seen, also have strong cultural connections. For thousands of years, people have watched

the night sky and told stories connected to the stars, planets, and constellations that they observe. The night sky at Washita Battlefield NHS is consistent with what one would expect to see in a rural area; however, significant ambient light pollution resulted from nearby oil/gas wells.



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

| Soundscape                             |                                           |                        |                                                                                                                                                                                                                                                                                                                                                                                                                                                        |
|----------------------------------------|-------------------------------------------|------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Indicators of Condition                | Specific Measures                         | Condition Status/Trend | Rationale                                                                                                                                                                                                                                                                                                                                                                                                                                              |
| Types of Sounds                        | Types of Noises or Natural Sounds         |                        | Several noise producing sources surround the Historic Site, including highways, oil/gas developments and associated operations, such as disposal of drilling tailings and liquid disposal ponds, and a local airport where chartered services are offered. Unfortunately, the proximity of these developments are very close to the park's boundary, and with the park's relatively small size, results in a significant concern soundscape condition. |
| Characteristics of Anthropogenic Noise | Loudness, pitch, occurrence, and duration |                        | The sound characteristics associated with the noises listed above are such that they also detract from the condition of the soundscape. Unfortunately, the typical masking of noise characteristics that would occur as a result of increased biologic activity throughout the summer most likely do not improve the condition of the Historic Site's soundscape.                                                                                      |

### Resource Brief

Visitors to national parks often indicate that an important reason for visiting the parks is to enjoy the relative quiet. In a 1998 survey of the American public, 72% of respondents identified opportunities to experience natural quiet and the sounds of nature as an important reason for having national parks (Haas and Wakefield 1998). Additionally, 91% of NPS visitors “consider enjoyment of natural quiet and the sounds of nature as compelling reasons for visiting national parks” (McDonald et al. 1995). Cultural activities are also considered to contribute to a good soundscape condition and are desirable at cultural parks.

The soundscape at the Historic Site is surrounded by anthropogenic noises. Most of the noises heard are associated with surrounding developments that are very close to the Historic Site's boundary. These noises are not consistent with the park's visitor goal of creating a “reflective mood” to honor the fallen during the 1868 attack. The characteristics of the noises heard also detract from the soundscape condition. Unfortunately, the majority of noises contributing to the Historic Site's soundscape degradation originate outside the park's boundary, making it difficult to influence change.



Interpretive program held at Washita Battlefield NHS.

| Air Quality  |                                       |                                                                                   |                                                                                                                                                                                                                                                                                                                                              |
|-------------------------------------------------------------------------------------------------|---------------------------------------|-----------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Indicators of Condition                                                                         | Specific Measures                     | Condition Status/Trend                                                            | Rationale                                                                                                                                                                                                                                                                                                                                    |
| Air Quality                                                                                     | Visibility Haze Index                 |  | Five-year average of interpolated visibility values were derived to determine that the condition of visibility is of significant concern at the Historic Site. Based upon a nearby visibility monitoring site, a “no trend” for visibility was determined, with a slight possibility of improvement, although not statistically significant. |
| Air Chemistry                                                                                   | Level of Ozone                        |  | Five-year average of interpolated ozone values were derived to determine that the condition of ozone is of moderate concern at the Historic Site. In addition, a total of four plants have been identified as ozone sensitive, three of which serve as bioindicators.                                                                        |
|                                                                                                 | Atmospheric Wet Deposition in Total N |  | Five-year average of interpolated atmospheric wet deposition values were derived to determine that the condition of total nitrogen is of significant concern at the Historic Site.                                                                                                                                                           |
|                                                                                                 | Atmospheric Wet Deposition in Total S |  | Five-year average of interpolated atmospheric wet deposition values were derived to determine that the condition of total sulphur is of moderate concern at the Historic Site.                                                                                                                                                               |

### Resource Brief

Air quality doesn't just affect the air we breathe, it also affects many air quality related values such as visibility and cultural and natural resources. There are different facets to air quality monitoring including ozone levels, visibility conditions, and wet deposition levels. Based upon five-year interpolated values, visibility and atmospheric wet deposition for total nitrogen, warrant a significant concern and ozone and atmospheric wet deposition for total sulfur warrant a moderate condition at the Historic Site. Visibility is the only air quality indicator for which a monitoring station is within the required distance to

be representative of the park's air quality condition. Currently “no trend” is determined for visibility. The Historic Site contains four ozone-sensitive plant species, three of which serve as ozone bioindicators. Bioindicator species are more likely to exhibit ozone damage before other species are impacted by higher ozone levels. The Historic Site's air quality is largely influenced by activities and operations that occur outside its boundary, and the future condition of its air quality condition is ultimately dependent on local, regional, and national planning.

| Geology                 |                   |                                                                                   |                                                                                     |
|-------------------------|-------------------|-----------------------------------------------------------------------------------|-------------------------------------------------------------------------------------|
|                         |                   |                                                                                   |  |
| Indicators of Condition | Specific Measures | Condition Status/Trend                                                            | Rationale                                                                           |
| None                    | None              |  | None                                                                                |

Resource Brief

Geology, and associated soils, are the basis for vegetation communities, the hydrology, and the basic landforms and topography for an area, that then support the biotic communities. Soils, hydrology, and landform also influence human settlement patterns, and how people use the land--for farming, ranching, hunting, fishing, and other basic land uses. Landforms such as the river plain, bluffs, and knolls and also played significant roles in the battle.

The region of western Oklahoma where Washita Battlefield National Historic Site (NHS) is

located is known as “red carpet country,” and is part of the Western Red-Bed Plains physiographic province. It is characterized by gently rolling hills made of Permian (299 million to 251 million years ago) red sandstones and shale. The rock units in the area are the Cloud Chief Formation, Doxey Shale, and Elk City Sandstone. These marine, coastal, and fluvial units, respectively, record the withdrawal of a Permian sea from the area (KellerLynn 2011). The Washita River meanders through the Historic Site and Black Kettle’s winter camp was located along the banks of the river.

| Surface Water           |                                          |                        |                                                                                          |
|-------------------------|------------------------------------------|------------------------|------------------------------------------------------------------------------------------|
| Indicators of Condition | Specific Measures                        | Condition Status/Trend | Rationale                                                                                |
| Water Quality           | Physiochemistry<br>Core Water Parameters |                        | No data pertaining to core water parameters have been collected at the Historic Site.    |
|                         | Physiochemistry<br>Sediment              |                        | No data pertaining to physiochemistry sediment have been collected at the Historic Site. |
|                         | Biological Communities                   |                        | No data pertaining to biologic communities have been collected at the Historic Site.     |

### Resource Brief

The Washita River provides water in an otherwise arid landscape, making water a unique resource at the Historic Site. Perennial streams are among the most critical and impacted natural resources of the Southern Plains parks. The presence and extent of surface water has traditionally provided a focus for human habitation in the region, resulting in cultural significance coincident with reliable and abundant rivers, streams, wetlands, and springs. Core water quality parameters reflect the function of the physical and biological

environment with which water interacts. Sediment physiochemistry measures the presence of nutrients, major ions, and metals. Bioassessments determine the presence and composition of biological communities, usually stream macroinvertebrates. All of these indicators are easily measured and constitute a means of characterizing potential stressors to the health of aquatic systems. At this time, a surface water monitoring has been implemented at the Historic Site but no data have been collected.



**Washita River within the Historic Site.**

| <b>Groundwater</b>      |                             |                                                                                   |  |
|-------------------------|-----------------------------|-----------------------------------------------------------------------------------|-------------------------------------------------------------------------------------|
| Indicators of Condition | Specific Measures           | Condition Status/Trend                                                            | Rationale for Resource Condition                                                    |
| Groundwater             | Change in groundwater level |  | None                                                                                |

### Resource Brief

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.

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. Oklahoma residents depend on groundwater for their water supply, with 570 million gallons per day being drawn (Tortorelli 2009). The influence from public water supply withdrawal is concentrated in two-thirds of the state (mostly eastern OK), and the demand for irrigation purposes is concentrated in the western third of the state, including the area surrounding the Historic Site (Tortorelli 2009).

Washita Battlefield's groundwater does not belong to a principal aquifer, such as the High Plains Aquifer, which is located just to the west, but instead is part of an alluvial aquifer located along the Washita River. An alluvial aquifer consists of deposits of alluvium in and along stream channels, alluvial terraces that are remnants of older alluvium, and overlying windblown deposits. The deposits consist of clay, silt, sand, and gravel, but only the sand and gravel yield water. The deposits

range in age from Tertiary to Quaternary and are a few feet to more than 100 feet thick. The alluvial aquifers generally contain water under unconfined conditions (USGS 2005). These types of aquifers are good sources for irrigation, although they are shallower and have a lower yield compared to Ogallala Formation groundwater (Reber et al. 1999).

The Oklahoma Water Resources Board (OWRB) annually monitors more than 600 groundwater wells throughout Oklahoma to collect data on water levels. Each year, primarily during the winter months, data are collected to help determine if there has been any change in groundwater levels and if any areas are experiencing groundwater depletion (OWRB 2012). One monitoring well, ID 2687, is located in the Washita River major alluvium aquifer, approximately 3 miles northeast (downstream) of the Historic Site. The water level elevations and depths to water levels have been monitored at the well from 1976-present. The USGS also monitored a groundwater well within the same aquifer from 2002-2010 approximately 1.7 miles upstream.

The condition of the groundwater resource at the Historic Site is an interplay of water levels and local geology and cannot be determined at this time.

| Riparian Habitat        |                                                                        |                                                                                     |                                                                                                                             |
|-------------------------|------------------------------------------------------------------------|-------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Indicators of Condition | Specific Measures                                                      | Condition Status/Trend                                                              | Rationale                                                                                                                                                                                                      |
| Hydrology               | Floodplain                                                             |    | The degree of channel incision and access to floodplain varied slightly throughout the reaches. Reach 1 had the highest degree of channel incision.                                                            |
|                         | Beaver dams                                                            |    | Where beaver dams were present, trails to their dens were fresh.                                                                                                                                               |
|                         | Sinuosity, width/depth ratio, and gradient                             |    | The sinuosity, width/depth ratio, and gradient measures varied between all four reaches, with the western most reach exhibiting the straightest stretch and increasing sinuosity as the river progresses east. |
|                         | Riparian wetland area                                                  |    | Riparian vegetation varied from just establishing along reach 1 to well established and improving in reach 4.                                                                                                  |
|                         | Upland watershed                                                       |    | No comments were made pertaining to the condition of the upland watershed.                                                                                                                                     |
| Vegetation              | Age class distribution of riparian habitat vegetation                  |   | The stretches where cottonwood were present, four age classes were recorded.                                                                                                                                   |
|                         | Diverse vegetation composition                                         |  | A diverse assemblage of grasses and shrubs were present, mainly throughout all reaches, however, larger woody vegetation was absent in half of the river stretches.                                            |
|                         | Soil moisture characteristics                                          |  | Species present were indicative of moist conditions and a rising water table possibly due to Tamarisk removal.                                                                                                 |
|                         | Plants have root masses capable of withstanding high streamflow events |  | Plants species present were stabilizing streambanks.                                                                                                                                                           |
|                         | Vigorous plants                                                        |  | Native plants have established and non-natives have decreased due to control efforts. Cottonwoods are recruiting.                                                                                              |
|                         | Vegetation cover                                                       |  | A variety of vegetation was growing, however, larger woody vegetation is absent within one reach.                                                                                                              |
|                         | Plant communities are coarse and/or large                              |  | No presence of coarse and/or large woody debris was observed throughout the river reaches. Although recruitment of cottonwoods is beginning along reach 2 and seed sources are located close to reach 4.       |
| Erosion/Deposition      | Floodplain and channel characteristics                                 |  | Some areas of the channel were incised, some contained water and others reaches did not. Floodplain potential has yet to be reached.                                                                           |

| Riparian Habitat             |                               |                                                                                   |                                                           |
|------------------------------|-------------------------------|-----------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------|
| Indicators of Condition      | Specific Measures             | Condition Status/Trend                                                            | Rationale                                                                                                                                    |
| Erosion/Deposition continued | Point bars                    |  | This measure ranged from just beginning to form to several present.                                                                          |
|                              | Lateral stream movement       |  | There were areas where the river had access to the floodplain and showed terracing, but reach 1 was too incised for lateral stream movement. |
|                              | Vertical stability            |  | No excessive erosion or channel lowering was observed except for along reach 1.                                                              |
|                              | Balance of water and sediment |  | This measure was in good condition even along reach 1 where the formation of a point bar was developing, signifying improvement.             |

### Resource Brief

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

An interdisciplinary team of experts from NPS' Water Resources Division and Southern Plains Inventory and Monitoring Network conducted a qualitative riparian habitat assessment at the Historic Site along

Washita River (Cummings and Folts-Zettner 2012), using "A User Guide to Assessing the Proper Functioning Condition and the Supporting Science for Lotic Areas" developed by Prichard et al. (1998). This assessment included three main categories including hydrology, vegetation, and erosion/deposition. A total of 17 common attributes and processes within each of these three categories was assessed.

Washita River was divided into 4 separate reaches, and most of the indicators, throughout all reaches, were considered to be in good condition with the exception of lack of woody debris to dissipate energy and some erosion, especially throughout the first reach. Overall, the trend was improving.

| Grasslands                                            |                                                 |                                                                                     |                                                                                                      |
|-------------------------------------------------------|-------------------------------------------------|-------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Indicators of Condition                               | Specific Measures                               | Condition Status/Trend                                                              | Rationale                                                                                                                                                                               |
| Hydrology Soil/Site Stability and Hydrologic Function | Rills                                           |    | Condition did not deviate substantially from that which would be expected for the site.                                                                                                 |
|                                                       | Water Flow Patterns                             |    | Previous minor erosion and deposition occurred but none were currently evident except at the top of the railbed.                                                                        |
|                                                       | Pedestals and/or terracettes                    |    | None observed.                                                                                                                                                                          |
|                                                       | Bare ground                                     |    | The effects of drought is increasing this measure more so in the Upland Grassland community. Non-native brome biomass increased, which decreased the amount of bare ground in 2012.     |
|                                                       | Gullies                                         |    | Past gullies are now stabilized.                                                                                                                                                        |
|                                                       | Wind-scoured, blowout and/or depositional areas |   | This measure was observed only in the <i>Artemisia</i> community.                                                                                                                       |
|                                                       | Litter Movement                                 |  | None observed.                                                                                                                                                                          |
|                                                       | Soil surface resistance to erosion              |  | None observed.                                                                                                                                                                          |
|                                                       | Soil surface loss or degradation                |  | None observed.                                                                                                                                                                          |
|                                                       | Compaction layer                                |  | Only observed on the railbed and two-tracks.                                                                                                                                            |
| Biotic Integrity                                      | Species Composition, Landscape-scale Diversity  |  | There is concern due to the widespread distribution of non-native brome grasses.                                                                                                        |
|                                                       | Species Composition, Local scale                |  | There is concern due to the widespread invasion of exotic plant species. The restored areas are lacking diversity of forb species that are expected for the Historic Site's grasslands. |

Continued Next Page

| Grasslands  |                                                                                 |                                                                                   |                                                                                                                                                                                                                                     |
|------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------|-----------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Indicators of Condition                                                                        | Specific Measures                                                               | Condition Status/Trend                                                            | Rationale                                                                                                                                                                                                                           |
|                                                                                                | Response of Annual Species to Disturbance                                       |  | Even though data from Southern Plains Inventory and Monitoring Network grassland monitoring indicated that most of the cover was comprised of perennial grasses, the proportion tended to decrease over the 3-year sampling period. |
| Biotic Integrity (continued)                                                                   | Relative proportion of functional groups (e.g., graminoid, forbs, shrubs, etc.) |  | The grassland experts did not express concern regarding the proportion of the functional vegetative groups except for the areas where restoration work has been conducted.                                                          |

### Resource Brief

Washita Battlefield NHS is located at the juncture of several ecoregions. Moisture-loving eastern species overlap the more arid southwestern species, while tall-grass prairie gives way to short-grasses. The site itself can be divided into several clear habitats: upland forest, grasslands, old field, wetlands and riparian areas.

We considered two 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.

The soil/site stability and hydrologic functioning measures throughout the Historic

Site were in good condition, indicating soils are relatively stable except for heavily disturbed areas such as the railbed.

The biotic integrity measures revealed a moderate concern and deteriorating trend based upon the widespread presence of highly invasive exotic plants. These plants are decreasing the native species composition and increasing the number of non-native annual invasive plants.

When both indicators and their measures, data, and expert opinions are taken into consideration as a whole, we believe the overall condition of the grasslands at Washita Battlefield NHS to be of moderate concern and declining.

| Exotic Plants                |                                             |                                                                                   |                                                                                                                                                                                   |
|------------------------------|---------------------------------------------|-----------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Indicators of Condition      | Specific Measures                           | Condition Status/Trend                                                            | Rationale                                                                                                                                                                                                                                                            |
| Exotic Plant Presence        | Significance of Impact                      |  | Ranking the highest in significance of impact were several grass species and woody species, including Saltcedar and Siberian elm. The exotic bromes, which ranked high, are well known for their ability to dramatically change an ecosystem sometimes irreversibly. |
| Exotic Plant Ease of Control | Feasibility of Control                      |  | A variety of species ranked highly infeasible to control including Siberian elm, field bindweed, exotic bromes, Bermudagrass, and Burr medic.                                                                                                                        |
| Exotic Plant Location        | Proportion of High Priority Blocks Infested |  | The exotic bromes, Johnsongrass, and Siberian elm were by far the most widespread throughout the high priority blocks. In 89% of the plots, bromes alone were detected.                                                                                              |
|                              | Proportion of Interior Blocks Infested      |  | The proportion of interior blocks infested was very similar to the high priority blocks. Cheatgrass was detected in over 97% of the blocks, indicating that it is very widespread throughout the park.                                                               |
| Exotic Plant Distribution    | Distribution of High Priority Species       |  | Known distributions of the highest ranked species were mapped. Overall, cheatgrass, Johnsongrass, and Siberian elm appear to be the most widely distributed throughout the Historic Site.                                                                            |

## Resource Brief

The negative impact exotic plants have on native ecosystems is well documented and most parks are faced with dire circumstances when it pertains to their ability to control and manage these pests.

Exotic Plants monitoring was conducted by Southern Plains Inventory & Monitoring Biologists for three years. Exotics are not confined to the high vector corridors, which include roads and trails, but are very widespread throughout the Historic Site. In addition, the majority of exotic species identified are not easily controlled due to their biologic characteristics, as well as the fact that most have become established throughout the interior of the park. However, exotic control efforts for Saltcedar has seemingly reduced

its presence along Washita River, which is encouraging. Overall though, the condition of exotic plants at Washita Battlefield NHS is of significant concern and appears to be declining.



**Monitoring for exotic plants helps identify resource condition.**

| Landbirds               |                      |                                                                                     |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |
|-------------------------|----------------------|-------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Indicators of Condition | Specific Measures    | Condition Status/Trend                                                              | Rationale                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
| Species Occurrence      | Temporal Context     |    | Of 53 bird species detected at the Historic Site in 2001-2002, 40 were detected in recent surveys (in 2009-2012). Of the thirteen species not detected in recent surveys, seven are outside of their normal breeding range. Of the six remaining species, breeding habitat only "possibly exists" at the park for three of the species, and breeding habitat for one other is "limited to none." Two of the six species were detected in 2001-2002 in the fall/winter (outside of the breeding season). A different set of species (38) were detected in the 2009-2012 surveys but not in the 2001-2002 inventory. Based on this temporal comparison, we have no concerns for landbirds at the Historic Site at this time. |
|                         | Spatial Context      |    | Thirty-three species were observed during 2000-2010/2011 regional surveys that were not observed during recent surveys (in 2009-2012) at the Historic Site. However, only 19 of the 33 species are within their normal breeding range, and an additional 6 are outside of but within 100 miles of their breeding range edge. Of the 19 species, none have "existing" breeding habitat at the Historic Site, although breeding habitat "possibly exists" for 11 of the species. Given the status of their ranges and habitat preferences, we have no concerns for landbirds at this time.                                                                                                                                   |
|                         | Conservation Context |  | Twenty-one 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, we consider eleven species to have high conservation potential at the park; these are species that are within (or on the edge of) their normal breeding range and have sufficient habitat at the Historic Site to support their breeding. All of these species have been observed on recent (2009-2012) RMBO surveys, some in relatively high numbers. We consider the condition of species of conservation concern to be good.                                                                                                                                |

### Resource Brief

Landbirds are a conspicuous component of many ecosystems, and changes in landbird populations may be indicators of change in the biotic or abiotic components of the environment upon which they depend (Canterbury et al. 2000; Bryce et al. 2002). Landbirds are also highly detectable and can be efficiently surveyed with the use of numerous standardized methods (Bibby et al. 2000; Buckland et al. 2001). In addition to being good indicators of ecosystem change, landbird communities are inherently valuable. The condition of landbirds at the Historic Site was assessed using one indicator/measure—species occurrence (presence/absence). We evaluated species occurrence in three contexts: a temporal context, a

spatial context, and a conservation context. The primary sources of information for the assessment were a baseline bird inventory conducted by the Oklahoma Natural Heritage Inventory in 2001-2002, breeding season surveys conducted by Rocky Mountain Bird Observatory (RMBO) in 2009-2012, and annual Breeding Bird Surveys (BBS) in the general area. A total of 91 bird species have been reported to occur at the Historic Site, with 63 of the species occurring within their normal breeding ranges. The temporal species occurrence comparison found that, of 53 bird species detected at the Historic Site in 2001-2002, 40 were detected in recent surveys. Thirteen were not detected in recent surveys. However, of the 13 species, seven

were outside of their normal breeding range; of the remaining six species: breeding habitat only “possibly exists” at the Historic Site for three, breeding habitat for one is “limited to none,” and two of the species were detected outside of the breeding season. Thirty-eight different species were detected in recent surveys at the Historic Site but not in the 2001-2002 inventory. The spatial comparison found that 33 species were observed during 2000-2010/2011 BBS in the surrounding area but not at the Historic Site in 2009-2012. However, only 19 of the species are within their normal breeding range. Of these, none have “existing” breeding habitat at the park; breeding habitat “possibly exists” for 11 of the species. Therefore, we have no particular concerns with species occurrence from the spatial comparison. Twenty-one 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, eleven species are considered as having high conservation potential; these are species that are within (or on the edge of) their normal breeding range, and sufficient habitat exists at the Historic Site to support their breeding. Almost all of the species have been observed during all four years of recent surveys, and



ROBERT SHANTZ

**The Cassin's Sparrow is one of the eleven species identified as species of conservation concern with the highest conservation potential at Washita Battlefield NHS..**

some of the species have been observed in relatively high numbers. We consider the condition of species of conservation concern to be good. Overall, the condition of landbirds at the Historic Site is good. Adequate information does not exist at this time to evaluate trends in the condition.

### 5.3. Noteworthy Resource Condition Highlights

The list below provides examples of noteworthy highlights that will help to maintain or improve the condition of the Historic Site's natural resources.

#### Landscape Level Resources

##### *Viewshed*

- From the overlook, visitors viewing the river corridor, knolls, and other landforms will understand the historic events that took place here. The trail through the park generally encourages a connection with the landscape and the historical events, through the viewsheds.

#### Vegetation Resources

##### *Grasslands*

- The overall current condition of the soil/site stability/hydrologic at Washita Battlefield NHS was good, with departures from expected generally being not more than slight to moderate

##### *Riparian Habitat*

- All measures of hydrology, vegetation, and erosion/deposition indicate that the condition of the riparian habitat is improving along the Washita River.

##### *Exotic Plants*

- Active removal of Tamarisk is improving the condition of the riparian habitat along the Washita River.

#### Wildlife Resources

##### *Landbirds*

- A total of 91 bird species have been reported to occur at the Historic Site, with 78 of the species detected during 2009-2012 surveys. Twenty-seven percent of the 78 species (or 21 species) are considered species of conservation concern. Eleven of these 21 species have high conservation potential at the Historic Site, because they are within their normal breeding ranges and breeding habitat exists for them at the park

### 5.4. Key Issues and Challenges for Consideration in Management Planning

Washita Battlefield NHS continues to contribute to the successful preservation of natural resources that are representative of the Southern Plains shortgrass prairie ecosystem of North America. In collaboration with its many partnerships, the Historic Site continues working towards understanding, monitoring, and preserving these important resources. This section provides some interpretations of some key issues and challenges identified throughout the development of this NRCA are discussed below.

#### Landscape Level Resources

Because most of the landscape level resources are greatly influenced by developments outside the Historic Site's boundary, preservation of these resources will require cooperation with surrounding landowners as well as local and regional governments.

Unfortunately, the prominence or conspicuousness of the oil and gas development, wind turbines, and main road so close to the Historic Site's boundary detracts from the condition of viewshed, night sky, and soundscape resources, as well as from the visitor experience. This is a challenge, since there is little park management and planning can do to address this issue. The potential for more future developments of wind farms and/or oil and gas extraction poses additional risks to the quality of the landscape-level resources.

A visible light dome from Cheyenne and light point sources from nearby oil/gas rigs create significant disturbance to night sky quality. As oil and gas activity continues to grow in this region, this is likely to cause significant encroachment on the site, and impact other resources (viewshed, soundscape, air quality, for example) in addition to night sky.

#### Supporting Environment Resources

In large part, there are several data gaps for the supporting environment resources, which include geology, surface water, air

quality, and groundwater. Air quality is the exception since values can be extrapolated from other air quality monitoring locations. Unfortunately, the air quality values warrant a significant concern air quality condition at the Historic Site, but on-site monitoring of ozone-sensitive plants may augment park-based knowledge of the extent of impact, if any. Conducting baseline inventories for the remainder of these supporting environment resources will greatly expand the knowledge base.

### Vegetation Resources

The interplay of drought, invasive plant species presence, and lack of species diversity, mainly forbs, within the restored areas, is negatively affecting the grassland condition at the Historic Site. At the present time, native species are still present, but should non-native bromes persist or become dominant, this would constitute a loss of landscape diversity toward an increasing monoculture of bromes. Unknown at this time is how these factors will progress and whether the grassland condition will continue to deteriorate.

Aggressive exotic plants, including the annual bromes and Johnsongrass, are widely distributed throughout the park and not contained along the high vector areas. The widespread distribution and aggressiveness of the types of invasive plants present make them difficult to manage.

The Historic Site has been considering various management options that might be used to control exotic species and fire will certainly be one of several potential tools in this effort. The subject matter experts agreed that pulsed grazing, if done correctly, could be a good option given the current state of widespread exotic bromes, but also agreed that fire would likely need to play a future role in management of these grasslands.

### Wildlife Resources

There do not appear to be any issues for management of landbirds at this time. Annual breeding season surveys conducted by RMBO will continue to build on the current

foundation of information on bird occurrence at the Historic Site.

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# Appendix A: Team Members and Subject Matter Experts

**Table A.1. Washita Battlefield National Historic Site NRCA Project Team Members**

| Washita Battlefield 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  |
| Tucker Blythe, NPS Washita Battlefield NHS Superintendent                           |
| Nina Chambers, Northern Rockies Conservation Cooperative, Writer/Editor             |
| Lisa Conard-Frost, NPS Washita Battlefield NHS Former Superintendent                |
| Tomye Folts-Zettner, NPS Southern Plains Inventory and Monitoring Network Biologist |
| Heidi Sosinski, NPS Southern Plains Inventory and Monitoring Network Data Manager   |
| Kim Struthers, Utah State University, Writer/Editor                                 |
| Frank Torres, NPS Washita Battlefield NHS, Chief of Interpretation and Operations   |
| Patty Valentine-Darby, University of West Florida, Biologist and Writer/Editor      |
| Dick Zahm, NPS Washita Battlefield NHS, Natural Resources Manager                   |

**Table A.2. Washita Battlefield 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                                             | Provided program level review                                                                                                                                                              |
| Melanie Myers, Colorado State University GIS Analyst                                                                    | Viewshed                                        | Provided viewshed analyses                                                                                                                                                                 |
| Chad Moore, National Park Service Night Sky Program Manager                                                             | Night Sky                                       | Provided NPS guidance on night sky monitoring and review of night sky section                                                                                                              |
| Emma Lynch, National Park Service Natural Sounds Program Acoustical Resource Specialist                                 | Soundscape                                      | Reviewed soundscape section                                                                                                                                                                |
| Lochen Wood, National Park Service Natural Sounds Environmental Protection 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                                                                                                                                                                   |
| Pete Biggam, National Park Service Geologic Resources Division Soil Scientist                                           | Soils                                           | Provided guidance and expert opinion on soils                                                                                                                                              |
| Jalyn Cummings, National Park Service Water Resources Division, Hydrologist                                             | Riparian Wetlands                               | Provided expert opinion on riparian wetlands during June 2012 field visit and submitted report                                                                                             |
| Alan Knapp, Colorado State University Department of Biology Professor                                                   | Grasslands                                      | Provided expert opinion about grasslands during May 2012 field visit                                                                                                                       |
| Tim Seastedt, University of Colorado, Department of Ecology and Evolutionary Biology Professor                          | Grasslands                                      | Provided expert opinion about grasslands during May 2012 field visit                                                                                                                       |
| Tomye Folts-Zettner National Park Service Southern Plains Inventory and Monitoring Network Biologist/Botanist           | Grasslands, Exotic Plants and Riparian Wetlands | Provided expert opinion on grasslands, exotic plants and riparian habitat sections. Provided full document review.                                                                         |
| Ross Lock Rocky Mountain Bird Observatory Wildlife Biologist                                                            | Landbirds                                       | Provided expertise and information in development of the chapters, reviewed the approach taken in Capulin Volcano NM's NRCA landbird analyses that was applied to WABA's landbirds section |



## Appendix B: Viewshed Analysis Steps

The process Melanie Myers and Heidi Sosinski used to complete the Washita Battlefield NHP's viewshed analyses is listed below.

Downloaded spatial data from Internet.

Downloaded 1/3 arc second national elevation dataset (NED) grid (roughly equivalent to a 30 m digital elevation model [DEM]) from The National Map Seamless Server (<http://seamless.usgs.gov/>). The x and y values for the NED are in arc seconds while the z data are in meters. Projected NED into NAD83 UTM 13 to get all data in meters.

Downloaded Washita Battlefield 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 entrance and upper parking lot.

Used Edit > Create New Feature tool to create an observation points (the Overlook). Saved file as obs\_point.shp

Added field named "OFFSETA" (type = double) to shapefile and set value to 1.68 for each record in the attribute table. The value of 1.68 in the field "OFFSETA" represents an observer height of 1.68m (~5'6").

Initial analysis showed that using the default observer value in OFFSETA underestimated the visible area when compared to actual visibility on site. To account for this, an additional offset of 10m was added to all analysis.

Added field named "OFFSETB" (type = double) and set the value to 10. The value of 10 in the field "OFFSETB" represents the additional 10 meters needed to reflect actual visibility.

Ran Viewshed Analysis using ESRI Spatial Analyst Viewshed Tool.

Using the Viewshed Tool in ESRI's ArcGIS 10, Spatial Analyst Toolbox, ran viewsheds using the following inputs.

Input raster = 1/3 arc second NED.

Input point observer feature = obs\_point.shp.

Additional viewshed analysis were conducted to account for oil/gas and windfarm activity in the vicinity. Each new value incorporates the same 10m correction used in the initial analysis. The value of "OFFSETB" was adjusted to 53 (43m for the height of an average oil rig ) 90 (80m for the height of a wind turbine) or 128.5 (118m for the height of a wind turbine including blades).

After the viewshed analyses were complete, housing and road density data were obtained and modified to depict past, present, and future densities around the Historic Site. These datasets were created by the NPS's Natural Resource Program Center by

**Table B.1. The original classes from NPScape and new classes assigned to housing densities for this assessment of the viewshed at Washita Battlefield NHP**

| Original Class           | New Class               |
|--------------------------|-------------------------|
| Private undeveloped      | Private undeveloped     |
| <1.5 units/square km     | <1.5 units/square km    |
| 1.5–3 units/square km    | 1.5–6 units/square km   |
| 4–6 units/square km      |                         |
| 7–12 units/square km     | > 6 units / square km   |
| 13–24 units/square km    |                         |
| 25–49 units/square km    |                         |
| 50–145 units/square km   |                         |
| 146–494 units/square km  |                         |
| 495–1234 units/square km | > 6 units / square km   |
| Commercial / Industrial  |                         |
| Commercial / Industrial  | Commercial / Industrial |

compiling and analyzing landscape-scale US Census Bureau data that linked measurable attributes of landscape (i.e., road density, population and housing density, etc.) to resources within natural resource based parks. This resulted in the creation of a dataset titled NPScape (Budde et al. 2009; Gross et al. 2009). The following modifications were made to NPScape data for purposes of this assessment:

Downloaded spatial data from Internet.

Downloaded Historic Site-specific NPScape data from the NPScape website (<http://science.nature.nps.gov/im/monitor/npscape/index.cfm>).

Simplified NPScape Housing Density Projections.

Converted Washita Battlefield NHP 30 km housing density projection rasters to polygon shape files.

Combined classes to reduce number of original classes to five (Table B.1).

# Appendix C: Bortle Dark-Sky Scale

## Key for the Summer Sky— Latitudes 30° to 50° N

The Milky Way is not visible and sky glow extends above 35 degrees. Little to no dark adaptation is possible. Ground texture is easily seen, and artificial light dominates the landscape. Visible constellations are limited to the very brightest if any. The sky has a uniform washed out appearance.<sup>1</sup>

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.<sup>2</sup>

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 Zodiacal 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.<sup>3</sup>

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. Zodiacal 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 Magazine 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](http://www.nature.nps.gov/night)

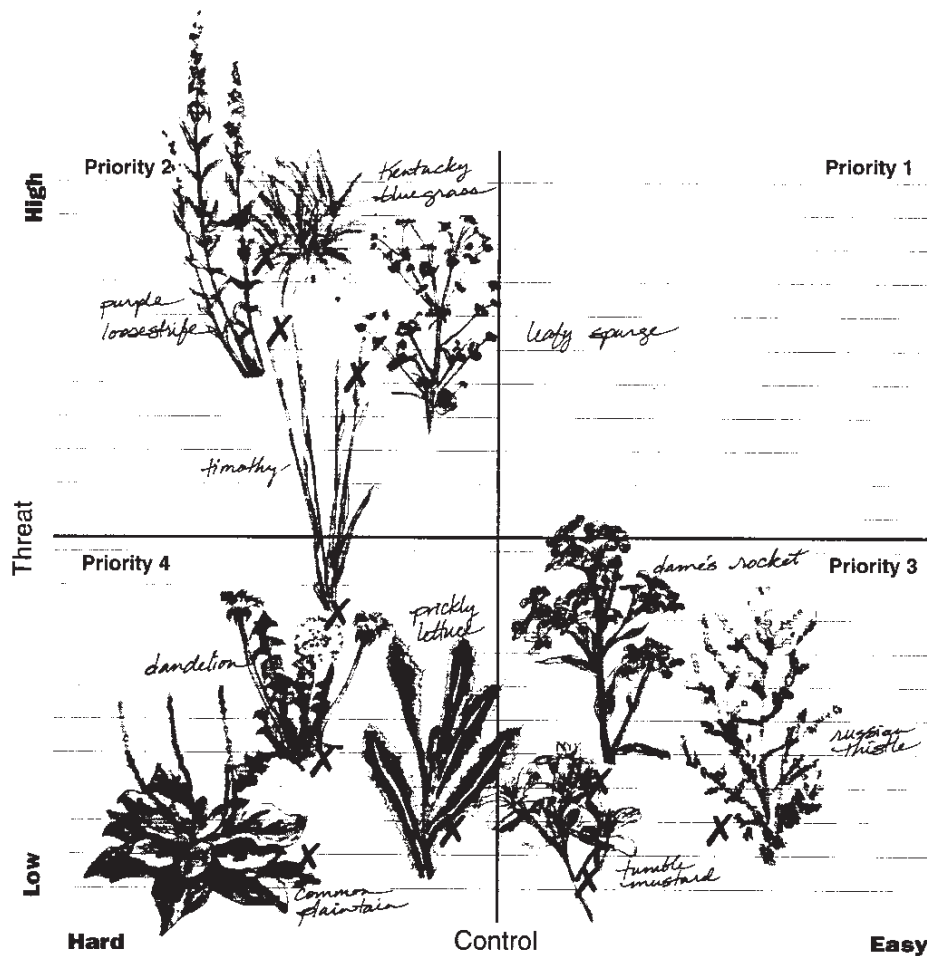
August 2, 2012

# Appendix D: Handbook for Ranking Exotic Plants for Management and Control

## Handbook for Ranking Exotic Plants for Management and Control

Ronald D. Hiebert  
and  
James Stubbendieck

Natural Resources Report NPS/NRMWRO/NRR-93/08



United States Department of the Interior • National Park Service • Midwest Regional Office

The National Park Service disseminates reports on high priority, current resources management information, with managerial application for managers, through the Natural Resources Report Series. Technologies and resource management methods, “how to” resource management papers, proceedings on resource management workshops or conferences, natural resources program recommendations, and descriptions and resource action plans are also disseminated through this series. Documents in this series usually contain information of a preliminary nature and are prepared primarily for internal use within the National Park Service. This information is not intended for use in the open literature.

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# **Handbook for Ranking Exotic Plants for Management and Control**

**Ronald D. Hiebert**

**National Park Service  
Midwest Regional Office  
1709 Jackson Street  
Omaha, NE 68102**

**and**

**James Stubbendieck**

**Department of Agronomy  
University of Nebraska  
Lincoln, NE 68583**

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## Introduction

Exotic, alien, introduced, nonindigenous, and nonnative are all synonyms for species that humans intentionally or unintentionally introduced into an area outside of a species' natural range. The National Park Service (NPS) defines exotic species as those occurring in a given place as a result of direct or indirect, deliberate, or accidental actions of humans. Thus, species native to the North American continent if outside their normal range due to the actions of humans are considered exotics by the National Park Service. The reader is directed to the *Natural Resources Management Guideline* (U.S. Department of the Interior, National Park Service 1991, NPS-77) to further clarify the definition.

Most exotic plant species cause minor effects on natural ecosystems. For example, Great Smoky Mountains National Park has approximately 1,500 vascular plant species, 400 of which are exotics--10 species are considered to be threatening to park resources. Of the 1,400 vascular plants at Indiana Dunes National Lakeshore, 300 are exotics, 14 of which are considered to be major threats. However, some exotic species can be extremely disruptive, such as disrupting the accurate presentation of a historic scene, damaging historic or archeological resources, interfering with natural processes, and threatening the survival of naturally evolved plant assemblages and individual native species.

Exotic species are often major roadblocks to managing natural resources in parks and other natural areas. Managing exotic plants is an extremely expensive, labor-intensive, and almost always a long-term proposition. Managers must not only be concerned with the level of impact that an exotic can cause but must also consider the impact of removing the species. Removal can often disturb areas that are easily colonized by the same or other exotic species (Westman 1990). The intensity and longevity of a control program are also important factors to consider in managing exotic plants. Therefore, managers must make sound decisions on where to place one's effort.

NPS policies, as they relate to managing natural resources, require that managers implement programs to maintain, restore, and perpetuate fundamental ecological processes as well as individual species and features. Managers are directed to manage not only for individual species but to maintain all the components and processes of naturally evolving park ecosystems (U.S. Department of the Interior, National Park Service 1988). Specific NPS

policy on exotic species directs park managers to give high priority to controlling and managing exotic species that have substantial impacts on park resources and that are believed to be easily managed. High priority should also be given to managing and monitoring exotic plant species that presently may not cause major impacts to park resources but have life history characteristics associated with colonizing or weedy species (Baker 1965) or are known to cause major impacts in other natural areas. Low priority should be given to species that cause little impact, are virtually impossible to control, or both.

A ranking system has been developed for resource managers to sort exotic plants within a park according to the species level of impact and its innate ability to become a pest. This information can then be weighed against the perceived feasibility or ease of control. The Exotic Species Ranking System is designed to first separate the innocuous species from the disruptive species. The separation allows researchers to then concentrate further efforts on species in the disruptive category. The system is also designed to identify those species that are not presently a serious threat but have the potential to become a threat and, thus, should be monitored closely. Finally, the system asks the park manager and the ecologist to consider the cost of delaying any action.

This handbook describes the rationale of the ranking system and its components and how to adapt the system to different situations and different areas of the country. The handbook also describes the information that is needed to apply the system, what the user should know, and how to use the system. Examples of products are given, along with suggestions of their application to management.

## An Exotic Plant Ranking System

### Why Use an Analytical Approach?

Several sound reasons exist for using an analytical approach as the basis of prioritizing exotic species. One of the basic reasons for using a decision analysis process is to get scientists involved in the decision-making process. Using a consistent and logical decision-making process prevents a biologist from compromising scientific excellence by becoming involved in environmental decisions based on incomplete information. Selecting an action alternative is similar to selecting a hypothesis. The action becomes an experimental manipulation to test the validity of the “hypothesis.” A decision analysis process not only adds validity to a decision, but this process often demonstrates that inaction due to lack of complete information can have serious consequences (Maguire 1991).

If an analytical approach was not employed, decisions would most likely be based on the opinion of an individual or a group of individuals or decisions would be based on precedent. Granted, many field ecologists have a good idea of which exotic species are impacting natural ecosystem processes or impacting species composition. However, decisions based on judgment alone are rarely based on defined criteria, do not usually document the reasoning process, and give no assurance that the full array of significant factors were considered. Such decisions may suffer from personal biases and political whims. Decisions are hard to defend if challenged, and proposals for funding are hard to justify. Decisions based on precedent may be easier to defend but are not responsive to the variation in exotic species or natural system interactions over space and time. Thus, priorities set for managing exotic species based on precedent may not reflect current ecological and economic realities.

On the other hand, consistently using an analytical tool such as the Exotic Species Ranking System, can ensure that ecological knowledge is applied to the decision process and can remedy some of the problems associated with decisions based on judgment and precedent alone. An analytical framework encourages researchers to consider the full range of factors and consequences of their decisions. An analytical framework documents the procedures and the reasons for the decisions made, thus reducing the risk aversion characteristic of park managers. Decisions are defensible. Solid justification for program authorization and funding is at hand.

## Origin

An earlier version of the system presented here was developed by Ron Hiebert. The system was modeled after a ranking system that was developed at Point Reyes National Seashore (Self 1986). The purpose of this system was to rank the effects of exotic species on the natural recovery of former residential sites at Indiana Dunes National Lakeshore. Hiebert (1990) observed that some exotic species were found only in severely and recently disturbed areas and seemed to have little effect on the succession process. Other exotic species were persistent but did not reproduce or spread, while others were persistent and had high rates of reproduction. Populations of some exotics were expanding within disturbed areas, while others were observed to invade surrounding undisturbed sites. Some of the most invasive and disruptive species were those with life history characteristics (high seed output, long-distance dispersal adaptations, ability to reproduce vegetatively) consistent with those related to weediness (Baker 1965). The present system was developed to support general NPS and park-specific policy, giving high priority to species causing major impacts (and are easily controlled) and giving low priority to species causing little impact (and extremely difficult to control).

Also, the system is designed to identify species that are currently rare and causing little impact but have a high potential to become a problem in the future.

The ranking system presented in this handbook has since been applied to ranking the exotic plants of Indiana Dunes (Klick et al. 1989) and six small national park system areas dominated by prairies and savannahs (Stubbendieck et al. 1992). As part of the latter, 14 plant ecologists reviewed the system. The system was modified to rank exotic plants in Olympic National Park (Olson et al. 1991) and was modified and used to rank both exotic plants and animals in the state of Minnesota (Minnesota Department of Natural Resources 1991). The system has been revised based on the above experiences and recommendations of users and expert reviewers.

## Rationale For Use

The ranking system provides an ecologist or resource management specialist with a tool to sort exotic plant species based on their present level of impact and their innate ability to become a pest. Based on conscientious consideration of all the factors in the system, a person with good taxonomic and ecological skills should be able to separate those species that are innocuous from those that are disruptive or have a high potential to become disruptive. The resulting species rank can then be weighed against the ease or feasibility of control, and the urgency of action or the cost of delay in action can be determined.

For example, purple loosestrife (*Lythrum salicaria*) is ranked as the most disruptive exotic plant at Indiana Dunes National Lakeshore. Extensive efforts to eradicate or control its spread have not been successful. However, due to the significance of the impact, the National Park Service is funding research on its basic biology and on experimental control methods. In contrast, Scotch pine (*Pinus sylvestris*) is found to rarely reproduce and to cause only minor impacts throughout most of the park. Significant impacts are limited to one small prairie opening. Control is relatively simple--saw the pine down. Therefore, the park decided to eradicate Scotch pine from the prairie opening and to monitor its status in other park locations.

An example of the urgency ranking as applied is European alder (*Alnus glutinosa*). This species was found at or in close proximity to one razed residential site at Indiana Dunes National Lakeshore. However, the species had spread into a large, dense clone of thousands of ramets in just six years and was also reproducing sexually. The species was reported to be highly invasive and to cause major impacts in other natural areas. Therefore, the National Park Service considered quick action to be prudent.

In summary, the ranking system encourages resource managers to logically apply criteria that address the present impact of a species on ecological

processes and structure and on other park resources. The ranking system also predicts the potential of a species to become a pest in the future. Normally, applying the system will greatly reduce the list of exotic species with which a park manager needs to be concerned. The decision to take management action against a species determined to be disruptive then can be weighed on the basis of the level of impact, the feasibility of successful control, and the prediction of the cost

of delay in action. The information accumulated in the system's application serves as solid documentation to support management's decisions and to justify program funding

## Description

The Exotic Species Ranking System in Table 1 uses numerical ratings, is written in outline format, and is divided into two main sections: I. Significance of Impact and II. Feasibility of Control or Management. Each section is based on a scale of 100 points.

**Table 1. Exotic Species Ranking System (Ronald D. Hiebert)**

### I. Significance of Impact

#### A. Current Level of Impact

1. Distribution relative to disturbance regime
  - a. found only within sites disturbed within the last 3 years of sites regularly disturbed -10
  - b. found in sites disturbed within the last 10 years 1
  - c. found in midsuccessional sites disturbed 11-50 years before present (BP) 2
  - d. found in late-successional sites disturbed 51-100 years BP 5
  - e. found in high-quality natural areas with no known major disturbance for 100 years 10
2. Abundance
  - a. number of populations (stands)
    - (1) few; scattered (<5) 1
    - (2) intermediate number; patchy (6-10) 3
    - (3) several; widespread and dense (>10) 5
  - b. areal extent of populations
    - (1) <5 ha
    - (2) 5-10 ha 2
    - (3) 11-50 ha 3
    - (4) >50 ha 5
3. Effect on natural processes and character
  - a. plant species having little or no effect 0
  - b. delays establishment of native species in disturbed sites up to 10 years 3
  - c. long-term (more than 10 years) modification or retardation of succession 7
  - d. invades and modifies existing native communities 10
  - e. invades and replaces native communities 15
4. Significance of threat to park resources
  - a. threat to secondary resources negligible 0
  - b. threat to areas' secondary (successional) resources 2
  - c. endangerment to areas' secondary (successional) resources 4
  - d. threat to areas' primary resources 8
  - e. endangerment to areas' primary resources 10

Table 1 (cont).

|                                                                                               |                     |
|-----------------------------------------------------------------------------------------------|---------------------|
| 5. Level of visual impact to an ecologist                                                     |                     |
| a. little or no visual impact on landscape                                                    | 0                   |
| b. minor visual impact on natural landscape                                                   | 2                   |
| c. significant visual impact on natural landscape                                             | 4                   |
| d. major visual impact on natural landscape                                                   | 5                   |
|                                                                                               | Total Possible = 50 |
| B. Innate Ability of Species to Become a Pest                                                 |                     |
| 1. Ability to complete reproductive cycle in area of concern                                  |                     |
| a. not observed to complete reproductive cycle                                                | 0                   |
| b. observed to complete reproductive cycle                                                    | 5                   |
| 2. Mode of reproduction                                                                       |                     |
| a. reproduces almost entirely by vegetative means                                             | 1                   |
| b. reproduces only by seeds                                                                   | 3                   |
| c. reproduces vegetatively and by seed                                                        | 5                   |
| 3. Vegetative reproduction                                                                    |                     |
| a. no vegetative reproduction                                                                 | 0                   |
| b. vegetative reproduction rate maintains population                                          | 1                   |
| c. vegetative reproduction rate results in moderate increase in population size               | 3                   |
| d. vegetative reproduction rate results in rapid increase in population size                  | 5                   |
| 4. Frequency of sexual reproduction for mature plant                                          |                     |
| a. almost never reproduces sexually in area                                                   | 0                   |
| b. once every five or more years                                                              | 1                   |
| c. every other year                                                                           | 3                   |
| d. one or more times a year                                                                   | 5                   |
| 5. Number of seeds per plant                                                                  |                     |
| a. few (0-10)                                                                                 | 1                   |
| b. moderate (11-1,000)                                                                        | 3                   |
| c. many-seeded (>1,000)                                                                       | 5                   |
| 6. Dispersal ability                                                                          |                     |
| a. little potential for long-distance dispersal                                               | 0                   |
| b. great potential for long-distance dispersal                                                | 5                   |
| 7. Germination requirements                                                                   |                     |
| a. requires open soil and disturbance to germinate                                            | 0                   |
| b. can germinate in vegetated areas but in a narrow range or in special conditions            | 3                   |
| c. can germinate in existing vegetation in a wide range of conditions                         | 5                   |
| 8. Competitive ability                                                                        |                     |
| a. poor competitor for limiting factors                                                       | 0                   |
| b. moderately competitive for limiting factors                                                | 3                   |
| c. highly competitive for limiting factors                                                    | 5                   |
| 9. Known level of impact in natural areas                                                     |                     |
| a. not known to cause impacts in any other natural area                                       | 0                   |
| b. known to cause impacts in natural areas, but in other habitats and different climate zones | 1                   |
| c. known to cause low impact in natural areas in similar habitats and climate zones           | 3                   |
| d. known to cause moderate impact in natural areas in similar habitats and climate zones      | 5                   |
| e. known to cause high impact in natural areas in similar habitats and climate zones          | 10                  |
|                                                                                               | Total Possible = 50 |

Table 1 (cont).

|                                                                                                                                                                              |        |  |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------|--|
| II. Feasibility of Control or Management                                                                                                                                     |        |  |
| A. Abundance Within Park                                                                                                                                                     |        |  |
| 1. Number of populations (stands)                                                                                                                                            |        |  |
| a. several; widespread and dense                                                                                                                                             | 1      |  |
| b. intermediate number; patchy                                                                                                                                               | 3      |  |
| c. few; scattered                                                                                                                                                            | 5      |  |
| 2. Areal extent of populations                                                                                                                                               |        |  |
| a. > 50                                                                                                                                                                      | 1      |  |
| b. 11-50 ha                                                                                                                                                                  | 2      |  |
| c. 5-10                                                                                                                                                                      | 3      |  |
| d. < 5ha                                                                                                                                                                     | 5      |  |
| B. Ease of Control                                                                                                                                                           |        |  |
| 1. Seed banks                                                                                                                                                                |        |  |
| a. seeds remain viable in the soil for at least 3 years                                                                                                                      | 0      |  |
| b. seeds remain viable in the soil for 2-3 years                                                                                                                             | 5      |  |
| c. seeds viable in the soil for 1 year or less                                                                                                                               | 15     |  |
| 2. Vegetative regeneration                                                                                                                                                   |        |  |
| a. any plant part is a viable propagule                                                                                                                                      | 0      |  |
| b. sprouts from roots or stumps                                                                                                                                              | 5      |  |
| c. no resprouting following removal of aboveground growth                                                                                                                    | 10     |  |
| 3. Level of effort required                                                                                                                                                  |        |  |
| a. repeated chemical or mechanical control measures required                                                                                                                 | 1      |  |
| b. one or two chemical or mechanical treatments required                                                                                                                     | 5      |  |
| c. can be controlled with one chemical treatment                                                                                                                             | 10     |  |
| d. effective control can be achieved with mechanical treatment                                                                                                               | 15     |  |
| 4. Abundance and proximity of propagules near park                                                                                                                           |        |  |
| a. many sources of propagules near park                                                                                                                                      | 0      |  |
| b. few sources of propagules near park, but these are readily dispersed                                                                                                      | 5      |  |
| c. few sources of propagules near park, but these are not readily dispersed                                                                                                  | 10     |  |
| d. no sources of propagules are in close proximity                                                                                                                           | 15     |  |
| C. Side Effects of Chemical/Mechanical Control Measures                                                                                                                      |        |  |
| 1. control measures will cause major impacts to community                                                                                                                    | 0      |  |
| 2. control measures will cause moderate impacts to community                                                                                                                 | 5      |  |
| 3. control measures will have little or no impact on community                                                                                                               | 15     |  |
| D. Effectiveness of Community Management                                                                                                                                     |        |  |
| 1. the following options are not effective                                                                                                                                   | 0      |  |
| 2. cultural techniques (burning, flooding) can be used to control target species                                                                                             | 5      |  |
| 3. routine management of community or restoration or preservation practices (e.g., prescribed burning, flooding, controlled disturbance) effectively controls target species | 10     |  |
| E. Biological Control                                                                                                                                                        |        |  |
| 1. biological control not feasible (not practical possible, or probable)                                                                                                     | 0      |  |
| 2. potential may exist for biological control                                                                                                                                | 5      |  |
| 3. biological control feasible                                                                                                                                               | 10     |  |
| Total Possible = 100                                                                                                                                                         |        |  |
| Urgency                                                                                                                                                                      |        |  |
| 1. Delay in action will result in large increase in effort required for successful control.                                                                                  | High   |  |
| 2. Delay in action will result in moderate increase in effort required for successful control.                                                                               | Medium |  |
| 3. Delay in action will result in little increase in effort required for successful control.                                                                                 | Low    |  |

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I. Significance of Impact is further divided into A. Current Level of Impact and B. Innate Ability of Species to Become a Pest. Stubbendieck et al. (1992) considered a species with a combined score of over 50 points for significance of impact to be

seriously disruptive and needing appropriate attention. Species receiving high scores for feasibility of control will be easier to control than those receiving lower scores. A step-by-step description of the system follows.

I. Significance of Impact

- A. Current Level of Impact: This section concentrates on ranking the species based on the present degree and extent of impact caused by the exotic species. Element 1 addresses where the species is found along a disturbance regime. If the species is found in only sites that are recently or frequently disturbed, the species is not considered a serious threat. If the species is found in mature undisturbed natural communities, the species is considered a serious threat. Element 2 addresses how many populations (stands) are found in the park and the size of the populations. Element 3 rates a species based on its effects on the ecological processes and structure of native communities. Element 4 addresses which park resources are threatened. Finally, element 5 addresses the visual impact as seen by an ecologist.
- B. Innate Ability of Species to Become a Pest: This section ranks a species based on the life history traits that preadapt it to become a problem and its known impacts in other areas. Important life history characteristics include potential rate of increase, adaptations for long-distance dispersal, and the breadth of habitats in which the species can colonize and thrive. Element 1 is essentially a screening device. If the species cannot reproduce in the area, the species most likely will not pose much of a threat. Likely species that will not reproduce in an area are horticultural species transferred from areas with different environmental conditions. Element 2 addresses how a species reproduces. The assumption is that vegetative reproduction allows an adapted ecotype to be maintained, resulting in local spread. Sexual reproduction allows for the maintenance of genetic variation and propagules for long-distance dispersal and the possibility of forming highly adapted gene combinations. If the species can reproduce both vegetatively and sexually, that species has the best of both worlds.

Elements 3, 4, and 5 address the factors that determine the intrinsic rate of increase of a species--how many seeds are produced how often. Element 6 deals with the species ability to disperse. This factor can usually be rated based on the presence or absence of special adaptations for seed or fruit dispersal, such as wings and pappi for wind dispersal, bladders for water dispersal, or bristles for animal dispersal. Element 7 asks if the species needs bare soil (disturbed) to germinate or if the species can germinate in a relatively closed (undisturbed) community. Element 8 looks at what the species can do once the species has colonized an area. Is the species able to outcompete native species for light, water, etc.? Finally, scientists should not ignore what the effects of the species have been in other natural areas.

## II. Feasibility of Control or Management

Less is known about the feasibility of managing exotic plants in natural areas than what impacts they have on the natural systems. Most research efforts in controlling plants have been in agriculture where the goal is to control all but one species while not harming the single-crop species. In natural areas, the goal is to control one or a few species while not harming diverse assemblages of native species. However, many factors will affect the funds and effort required for control and the probability of success.

- A. **Abundance Within Park:** No explanation is needed here. The larger the populations and the larger the number of populations, the larger the funds and effort required to manage the species.
- B. **Ease of Control:** This section not only deals with life history characteristics that impact the level of effort that will be needed to control the species, but also the probability of success if unlimited funds and personnel are used. Element 1 addresses the seed bank which directly influences the needed duration of a control program. Information on the longevity of viable seeds in soil is not available for many species, therefore making this element hard to score. However, a best estimate should be made based on the information that is available. Element 2 addresses the vegetative reproduction of the species, which influences the number and kinds of treatments required to control the species, whether the underground parts of the plant must be removed, and also dictates the protocol for disposal of plant material. Element 3 not only addresses the level of effort required, but also the kind(s) of control measures required. Element 3 follows the preferred steps of the NPS Integrated Pest Management Program in that mechanical treatment is preferred over chemical treatment. Element 4 deals with the presence or absence of propagules adjacent to the park and the probability of propagules being dispersed into the park. Consideration should be given to the park's ability to control the species outside its boundaries through cooperative control programs.
- C. **Side Effects of Chemical/Mechanical Control Measures:** As stated earlier, researchers must consider what effects eradication or control measures will have on the system being restored or preserved. Will the treatment open up areas for the same species to recolonize or be invaded by other equally or more impacting exotics? In some cases, the lesser of two unsatisfactory options may be not taking any action.
- D. **Effectiveness of Community Management:** Controlling exotic species through sound management of the system based on ecological study is by far the preferred control method. In some cases, controlling trampling by visitors, restoring historical fire regimes, or restoring shoreline processes or natural hydrological regimes will shift the competitive edge to the desired native species.
- E. **Biological Control:** Biological control is ecologically feasible for many exotic species. However, due to the high costs to develop well-tested biological control agents, it is only economically feasible for exotic species causing major impacts over a broad geographical area and normally only if the species are causing an economic impact as well as an ecological impact. Similarly, biological control is not feasible if the species to be controlled has some economic value. Abundance of closely related native species in the area where the exotic is to be controlled also lowers the feasibility because of possible negative side effects. The responsibility of conducting long-term studies involved with selecting and screening possible control agents lies with the U.S. Department of Agriculture.

**Urgency:** After the species are ranked according to their level of impact and feasibility of control or management, the exotic species that demands the most attention should be addressed first. The cost of delaying an action either financially or in impact to the natural resources of the park is a good criterion to use in making this often difficult decision.

## How to Use the System

Work will be conducted both in the field and in the library. Individuals using the Exotic Species Ranking System must have training in biology because the system requires interpreting specific biological information on each species in the field as well as in the literature. A working knowledge of plant taxonomy is required to properly identify species in the field. Identification may be difficult for the less trained because some of the exotic species are members of genera containing native species as well, and proper separation may be made on relatively fine differences between plants.

The first step in using the Exotic Species Ranking System is to inventory the exotic plant species. Names of plant species should be assembled from (1) species lists and research reports for the park, (2) the catalog of specimens from the park herbarium, and (3) a preliminary field survey of the vegetation. Each species on the completed list should be checked in references, especially the flora for the area, to determine if a species is native or exotic.

The second step is to conduct an intensive survey of the park. The survey should include the location and extent of populations of each exotic species. The information obtained in this survey will be used to complete Current Level of Impact (I.A.), a portion of Innate Ability of Species to Become a Pest (I.B.), and Abundance within Park (II.A.) Usually, two surveys are required. One survey should be conducted in late spring when most cool-season species are flowering, and the second should be conducted in late summer to correspond with flowering of warm-season species. The extent and number of populations should be drawn on a map during the survey. The map will be important for managers to locate exotic species for continued monitoring and future control.

The third step is a comprehensive search of the literature for information on the ecology, biology, and control methods for each exotic species. Information from this part of the process will be used for a portion of Innate Ability of Species to Become a Pest (I.B.) and the majority of II. Feasibility of Control or Management. Computer data bases in most libraries simplify the search procedure. Key words for the search should include the scientific and common names for each species. Not all of the articles will be applicable, but the computer-generated titles and abstracts generally will indicate whether the complete article should be located. The most commonly used journals are listed in Appendix A. Making photocopies of the article for both the ranking process and to place in the files for future reference may be helpful. Unfortunately, the amount of information in the literature varies considerably with the species. For example, articles on common exotic species such as Kentucky bluegrass (*Poa pratensis*) are abundant. Many of the articles are related to turf and turf grass management and have essentially no value for the ranking process. Considerable time is required to separate articles with useful information from the available literature. On the other hand, the literature

contains few articles on less abundant exotic species. Occasionally, ranking an individual species may be difficult because not enough information can be located. For example, no reference may be available that contains few articles on less abundant exotic species. Occasionally, ranking an individual species may address the length of time seeds remain viable in the soil. The person ranking the species may then need to investigate seed bank ecology of other species within the genus or make a decision based on seed morphology.

An additional source of information may be the element stewardship abstracts prepared by The Nature Conservancy. These comprehensive abstracts are available for some of the common species.

The next step of the process is to complete the Exotic Species Ranking System Data Summary Form (see Appendix B for a blank form) for each species by bringing together all of the information that has been gathered in the previous three steps. The person conducting the ranking should read each step of the Exotic Species Ranking System outline in Table 1 and, based on information gathered, select the appropriate numerical value. That value is placed on the Data Summary Form.

## **An Example: Pipestone National Monument**

Intensive exotic species surveys at Pipestone National Monument in Minnesota were conducted during 1989-91. Over 70 exotic species were located and ranked using the Exotic Species Ranking System (Table 2); 11 species were ranked as being highly disruptive (a total of 50 or more points for I. Significance of Impact). These results show that a relatively low proportion of the exotic species will be highly disruptive. None of the highly disruptive species was classified as being easy to control (Figure 1).

Of the 11 highly disruptive exotic species, feasibility of control of quackgrass (*Agropyron repens*) scored the least (16), while feasibility of control of white sweetclover (*Melilotus alba*) scored the greatest (48). Based on knowledge of the individual exotic species, control of only Canada thistle (*Cirsium arvense*) was considered to be urgent.

### **Canada Thistle**

A Data Summary Form for Canada thistle at Pipestone National Monument is presented in Table 3. The data summary in Table 3 may be compared to the outline of the Exotic Species Ranking System in Table 1 to see how Canada thistle was evaluated for each step.

### **Species Abstract**

An additional product that may be obtained from the Exotic Species Ranking System is an abstract for each important species. Generally, important species are those ranked as highly disruptive (a total of 50 or more points for I. Significance of Impact). An outline of the format for a species abstract may be found in Table 4. An example of a species abstract prepared for Canada thistle is in Appendix C.

**Table 2. Ranking of exotic plant species (arranged alphabetically) at Pipestone National Monument.**

| Species                         | Significance of Impact  |                                 |       |                        |         |
|---------------------------------|-------------------------|---------------------------------|-------|------------------------|---------|
|                                 | Current Level of Impact | Innate Ability to Become a Pest | Total | Feasibility of Control | Urgency |
| <i>Agropyron cristatum</i>      | -8                      | 27                              | 19    | 56                     | Low     |
| <i>Agropyron repens</i>         | 28                      | 36                              | 64    | 16                     | Medium  |
| <i>Agrostis stolonifera</i>     | 7                       | 25                              | 32    | 41                     | Low     |
| <i>Asparagus officinalis</i>    | 4                       | 25                              | 29    | 65                     | Low     |
| <i>Brassica kaber</i>           | -8                      | 16                              | 8     | 65                     | Low     |
| <i>Bromus inermis</i>           | 42                      | 43                              | 85    | 18                     | Medium  |
| <i>Bromus japonicus</i>         | 18                      | 20                              | 38    | 51                     | Low     |
| <i>Bromus tectorum</i>          | 17                      | 20                              | 37    | 38                     | Low     |
| <i>Campanula rapunculoides</i>  | 6                       | 26                              | 32    | 46                     | Low     |
| <i>Capsella bursa-pastoris</i>  | -2                      | 17                              | 15    | 37                     | Low     |
| <i>Carduus nutans</i>           | 19                      | 34                              | 53    | 31                     | Medium  |
| <i>Chenopodium album</i>        | -5                      | 18                              | 13    | 56                     | Low     |
| <i>Cirsium arvense</i>          | 19                      | 40                              | 59    | 17                     | High    |
| <i>Cornilla varia</i>           | 12                      | 32                              | 44    | 34                     | Medium  |
| <i>Dianthus armeria</i>         | 4                       | 16                              | 20    | 60                     | Low     |
| <i>Digitaria sanguinalis</i>    | 13                      | 24                              | 37    | 36                     | Medium  |
| <i>Eleagnus angustifolia</i>    | 17                      | 30                              | 47    | 30                     | Medium  |
| <i>Eragrostis cilianensis</i>   | -8                      | 16                              | 8     | 50                     | Low     |
| <i>Euphorbia esula</i>          | 24                      | 48                              | 72    | 31                     | High    |
| <i>Hesperis matronalis</i>      | -4                      | 19                              | 15    | 63                     | Low     |
| <i>Kochia scoparia</i>          | -8                      | 31                              | 23    | 55                     | Low     |
| <i>Lactuca serriola</i>         | -4                      | 17                              | 13    | 49                     | Low     |
| <i>Lappula echinata</i>         | 7                       | 32                              | 39    | 50                     | Low     |
| <i>Lappula redowskii</i>        | 6                       | 30                              | 36    | 50                     | Low     |
| <i>Leonurus cardiaca</i>        | 9                       | 19                              | 28    | 43                     | Low     |
| <i>Lepidium campestre</i>       | 13                      | 20                              | 33    | 33                     | Low     |
| <i>Linaria vulgaris</i>         | 18                      | 29                              | 47    | 41                     | Medium  |
| <i>Lithospermum arvense</i>     | 4                       | 23                              | 27    | 65                     | Low     |
| <i>Lolium perenne</i>           | -8                      | 19                              | 11    | 50                     | Low     |
| <i>Lonicera tatarica</i>        | 33                      | 39                              | 72    | 25                     | Medium  |
| <i>Matricaria matricariodes</i> | -8                      | 17                              | 9     | 65                     | Low     |
| <i>Medicago lupulina</i>        | -5                      | 24                              | 19    | 41                     | Low     |
| <i>Medicago sativa</i>          | 10                      | 34                              | 44    | 34                     | Low     |
| <i>Melilotus alba</i>           | 17                      | 34                              | 51    | 48                     | Medium  |
| <i>Melilotus officianilis</i>   | 14                      | 34                              | 48    | 42                     | Medium  |
| <i>Nepeta cataria</i>           | 9                       | 21                              | 30    | 46                     | Low     |
| <i>Philadelphus coronarius</i>  | 9                       | 22                              | 31    | 45                     | Low     |
| <i>Phleum pratense</i>          | 10                      | 30                              | 40    | 36                     | Low     |

**Table 2 (cont).**

| <b>Species</b>                 | <b>Significance of Impact</b>  |                                        |              |                               |                |
|--------------------------------|--------------------------------|----------------------------------------|--------------|-------------------------------|----------------|
|                                | <b>Current Level of Impact</b> | <b>Innate Ability to Become a Pest</b> | <b>Total</b> | <b>Feasibility of Control</b> | <b>Urgency</b> |
| <i>Plantago major</i>          | -8                             | 24                                     | 16           | 30                            | Low            |
| <i>Poa compressa</i>           | 33                             | 34                                     | 67           | 21                            | Medium         |
| <i>Poa palustris</i>           | 18                             | 20                                     | 38           | 51                            | Low            |
| <i>Poa pratensis</i>           | 38                             | 43                                     | 81           | 23                            | Medium         |
| <i>Polygonum achoreum</i>      | -8                             | 22                                     | 14           | 60                            | Low            |
| <i>Polygonum aviculare</i>     | -4                             | 22                                     | 18           | 46                            | Low            |
| <i>Polygonum hydropiper</i>    | 3                              | 30                                     | 33           | 30                            | Low            |
| <i>Polygonum persicaria</i>    | 13                             | 21                                     | 34           | 45                            | Low            |
| <i>Populus nigra</i>           | 6                              | 30                                     | 36           | 45                            | Low            |
| <i>Portulaca oleracea</i>      | 10                             | 24                                     | 34           | 31                            | Low            |
| <i>Potentilla fruticosa</i>    | 6                              | 25                                     | 31           | 60                            | Low            |
| <i>Potentilla recta</i>        | 18                             | 22                                     | 40           | 31                            | Low            |
| <i>Ranunculus testiculatus</i> | -8                             | 21                                     | 13           | 75                            | Low            |
| <i>Rhamnus cathartica</i>      | 45                             | 44                                     | 89           | 18                            | Medium         |
| <i>Rumex crispus</i>           | -6                             | 27                                     | 21           | 35                            | Low            |
| <i>Salsola iberica</i>         | -6                             | 31                                     | 25           | 75                            | Low            |
| <i>Setaria faberi</i>          | -8                             | 26                                     | 18           | 55                            | Low            |
| <i>Setaria glauca</i>          | -8                             | 29                                     | 21           | 55                            | Low            |
| <i>Setaria viridis</i>         | -2                             | 26                                     | 24           | 38                            | Low            |
| <i>Silene cserei</i>           | -8                             | 16                                     | 8            | 60                            | Low            |
| <i>Silene pratensis</i>        | -8                             | 19                                     | 11           | 60                            | Low            |
| <i>Sisymbrium altissimum</i>   | -8                             | 21                                     | 13           | 60                            | Low            |
| <i>Solanum dulcamara</i>       | -1                             | 22                                     | 21           | 50                            | Low            |
| <i>Sonchus arvensis</i>        | 20                             | 39                                     | 59           | 22                            | Medium         |
| <i>Taraxacum officinale</i>    | -4                             | 33                                     | 29           | 34                            | Low            |
| <i>Thalspi arvense</i>         | -8                             | 18                                     | 10           | 55                            | Low            |
| <i>Tragopogon dubius</i>       | 7                              | 26                                     | 33           | 31                            | Low            |
| <i>Trifolium hybridum</i>      | -8                             | 25                                     | 13           | 50                            | Low            |
| <i>Trifolium pratense</i>      | 18                             | 23                                     | 41           | 36                            | Low            |
| <i>Trifolium repens</i>        | 11                             | 29                                     | 40           | 36                            | Low            |
| <i>Ulmus pumila</i>            | 18                             | 29                                     | 47           | 36                            | Low            |
| <i>Verbascum thapsus</i>       | 15                             | 22                                     | 37           | 36                            | Medium         |
| <i>Veronica arvensis</i>       | 6                              | 19                                     | 25           | 55                            | Low            |

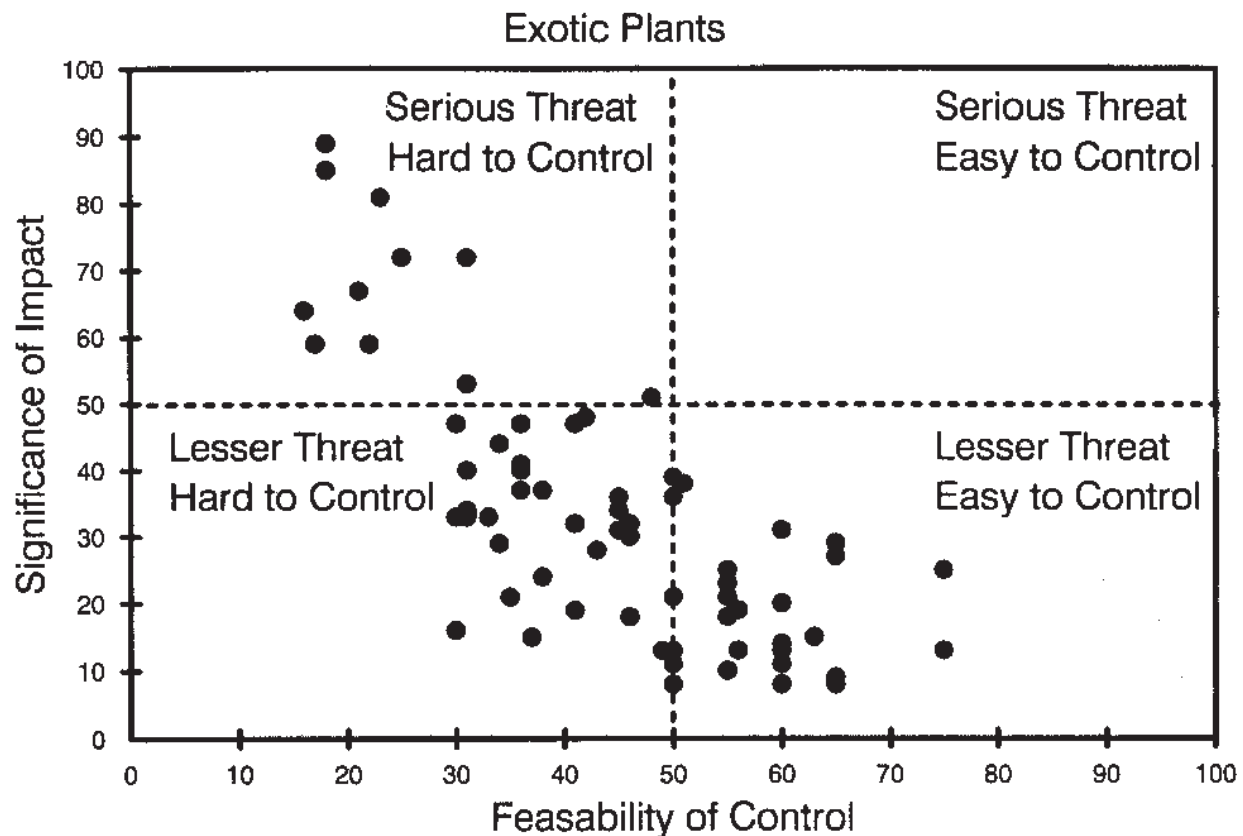


**Figure 1. Plot of level of impact vs. feasibility of control for exotic plant species at Pipestone National Monument, Minnesota.**

### Adaptability

The system presented in this handbook was designed to rank exotic plants in parks and natural areas in the Midwestern states with medium-to-high productivity and fairly rapid successional rates. However, the system is designed to be adaptable for different biogeographical areas or groups of organisms, or to be applied at various scales. To adapt the system to different biogeographical areas, the time scale for disturbance regimes can be modified as appropriate. The system was adapted to rank plants

and animals at a statewide scale by the state of Minnesota. This ranking was done by the Minnesota Department of Natural Resources. The Minnesota task force applied the system to plants and animals, including birds, mammals, fish, reptiles, amphibians, insects, mollusks, and crustaceans. Rather than use the methods presented here for a single park or natural area, the task force applied them on a statewide basis using averages per county for the abundances ratings.

**Table 3. Completed Exotic Species Ranking Summary Form for Canada thistle (*Cirsium arvense*) at Pipestone National Monument.**

| Exotic Species Ranking System<br>Data Summary Form |    |                                 |      |
|----------------------------------------------------|----|---------------------------------|------|
| Park: <u>Pipestone National Monument</u>           |    | Species: <i>Cirsium arvense</i> |      |
| Significance of Impact:                            |    |                                 |      |
| Current Level of Impact (50)                       | 19 |                                 |      |
| Innate Ability to Become a Pest (50)               | 40 | Total (100)                     | 59   |
|                                                    |    |                                 |      |
| Feasibility of Control:                            |    | Total (100)                     | 17   |
|                                                    |    |                                 |      |
| Urgency:                                           |    |                                 | High |

**I. Significance of Impact:****A. Current Level of Impact**

|                                                                   |    |
|-------------------------------------------------------------------|----|
| 1. Distribution relative to disturbance regime (-10, 1, 2, 5, 10) | 2  |
| 2. Abundance                                                      |    |
| a. number of populations (1, 3, 5)                                | 3  |
| b. areal extent of populations (1, 2, 3, 5)                       | 1  |
| 3. Effect on natural processes and character (0, 3, 7, 10, 15)    | 7  |
| 4. Significance of threat to park resources (0, 2, 4, 8, 10)      | 4  |
| 5. Level of visual impact to an ecologist (0, 2, 4, 5)            | 2  |
| Total (50 possible)                                               | 19 |

**B. Innate Ability of Species to Become a Pest**

|                                                             |    |
|-------------------------------------------------------------|----|
| 1. Ability to complete life cycle in area of concern (0, 5) | 5  |
| 2. Mode of reproduction (1, 3, 5)                           | 5  |
| 3. Vegetative reproduction (0, 1, 3, 5)                     | 5  |
| 4. Frequency of sexual reproduction (0, 1, 3, 5)            | 5  |
| 5. Number of seeds per plant (1, 3, 5)                      | 5  |
| 6. Dispersal ability (0, 5)                                 | 5  |
| 7. Germination requirements (0, 3, 5)                       | 0  |
| 8. Competitive ability (0, 3, 5)                            | 5  |
| 9. Known level of impact in natural areas (0, 1, 3, 5, 10)  | 5  |
| Total (50 possible)                                         | 40 |
| A + B (100 possible)                                        | 59 |

**Table 3 (cont).****II. Feasibility of Control or Management****A. Abundance Within Park**

- |                                             |   |
|---------------------------------------------|---|
| 1. Number of populations (1, 3, 5)          | 3 |
| 2. Areal extent of populations (1, 2, 3, 5) | 3 |

**B. Ease of Control**

- |                                                         |   |
|---------------------------------------------------------|---|
| 1. Seed banks (0, 5, 15)                                | 0 |
| 2. Vegetative regeneration (0, 5, 15)                   | 0 |
| 3. Level of effort required (1, 5, 10, 15)              | 1 |
| 4. Abundance and proximity of propagules (0, 5, 10, 15) | 0 |

**C. Side Effects of Chemical/Mechanical Control (0, 5, 15)** 5**D. Effectiveness of Community Management (0, 5, 10)** 0**E. Biological Control (0, 5,10)** 5

|                      |    |
|----------------------|----|
| Total (100 possible) | 17 |
|----------------------|----|

|          |      |
|----------|------|
| Urgency: | High |
|----------|------|

**Table 4. Outline of a species abstract.**

Park (full name and abbreviation)

Scientific Name (with authority)

Synonyms (if any)

Common Name(s)

Urgency Ranking

Overall Ranking

Significance of Impact

A. Current impact

B. Ability of species to become a pest

Feasibility of Control or Management

Taxonomic Description:

A. Life form

B. Height

C. Vegetative characteristics

Stems

Underground (roots, rhizomes, etc.)

Leaves

arrangement

type

sheaths and ligules (of grasses)

size

margins

surfaces (pubescence)

attachment

petiole

D. Floral characteristics

Inflorescence

type

size

Flowers of forbs and woody plants

type

size

bracts

calyx

corolla

color

anthers and ovary

Spikelets of grasses

florets

glumes

lemmas

paleas

awns

**Table 4 (cont).**

- E. Fruit characteristics
    - Type
    - Shape
    - Size
    - Color
    - Attachments for dispersal
  - F. Varieties (if any)
- Biology and Ecology:
- A. Origin
  - B. Habitat
  - C. Distribution (current and historical)
  - D. Climatic and ecological range
    - Soils
    - Disturbance
    - Temperature
    - Precipitation
    - Soil moisture
    - Light
    - Fertility
    - Other
  - E. Reproduction
    - Type (asexual or sexual with flowering period)
    - Ecological requirements
    - Rate
    - Seed production (including number per plant)
    - Dispersal
    - Longevity in seed bank
  - F. Germination
- Distribution:
- A. Number in the park
  - B. Size of populations
  - C. Location and successional sites
  - D. Relationship to disturbance
  - E. Invasion potential
  - F. Visual impact
- Control:
- A. Considerations
  - B. Mechanical
  - C. Cultural
  - D. Chemical
  - E. Biological
- References:
- Local Control Experts:
- A. Extension weed control specialists
  - B. Department of Natural Resources
  - C. Other

## Applying Results to Management Action

The logical species to give the highest priority are those that seriously threaten natural resources yet appear to be easy to control. The lowest priority should be given to those species that pose little threat and would be difficult to control. An easy way to categorize the ranked exotics is to plot the level of impact against the feasibility of control. Plots for Pipestone National Monument and Wilson's Creek National Battlefield are in Figures 1 and 2. As demonstrated in these two cases, the majority of the species are not considered to be a serious threat to park resources. This pattern is consistent with all surveys done to date. Also of note is that no species fall in the quadrant of serious threat and easy to control. We predict that this scenario will be the norm. Deciding which species or group of species in which areas need to be targeted for control is not easy. However, the resource manager now has only a few species to consider and should be equipped with most of the information available to guide a decision. The information will also aid in developing at least rough cost estimates and needed time commitments for various control scenarios. The resource manager also has the background information to defend a decision. The urgency ranking should also help indicate the resource and financial costs of delay in action.

The resource manager may determine that the most serious threat is uncontrollable on a parkwide basis. Control efforts may need to be restricted to rare communities or to areas where the exotic species threatens an endangered species. Control efforts may be futile within the park without cooperation from neighbors, as ample propagules for reinvasion exist near park boundaries. The only known successful control may require using an herbicide that has possible serious side effects. A decision to divert at least a portion of the effort towards investigating ways to shift the competitive advantage from the exotic to the native species or developing methods for easy and economic control of selected exotics may be appropriate. A decision often will require selecting the lesser of several evils. However, with diligence, by soundly applying

information to management decisions, and documenting and communicating successful and unsuccessful control efforts, progress can be made in managing exotic species in natural areas.

## Cautions

As with any tool, this system can be misused.

1. This ranking system provides a tool to resource managers and biologists who are knowledgeable of the area and species under investigation. They will benefit by using the system to consistently consider all of the important ecological and managerial elements for all exotic species. The ranking system provides the information in a format that can serve as a solid foundation on which to base an action plan. However, as is the case with most tools, the system can be misused or even be harmful if not used as intended or if not used by a skillful craftsman.
2. Separating the innocuous species from the disruptive species and consistently generating information on exotic species is the purpose of the system. The actual numeric values have little meaning or value.
3. The information provided by using this system to survey and rank exotic species is good for a specific place and time. Ecological systems are highly dynamic, and the distribution abundance and level and type of impact will change over time and space.

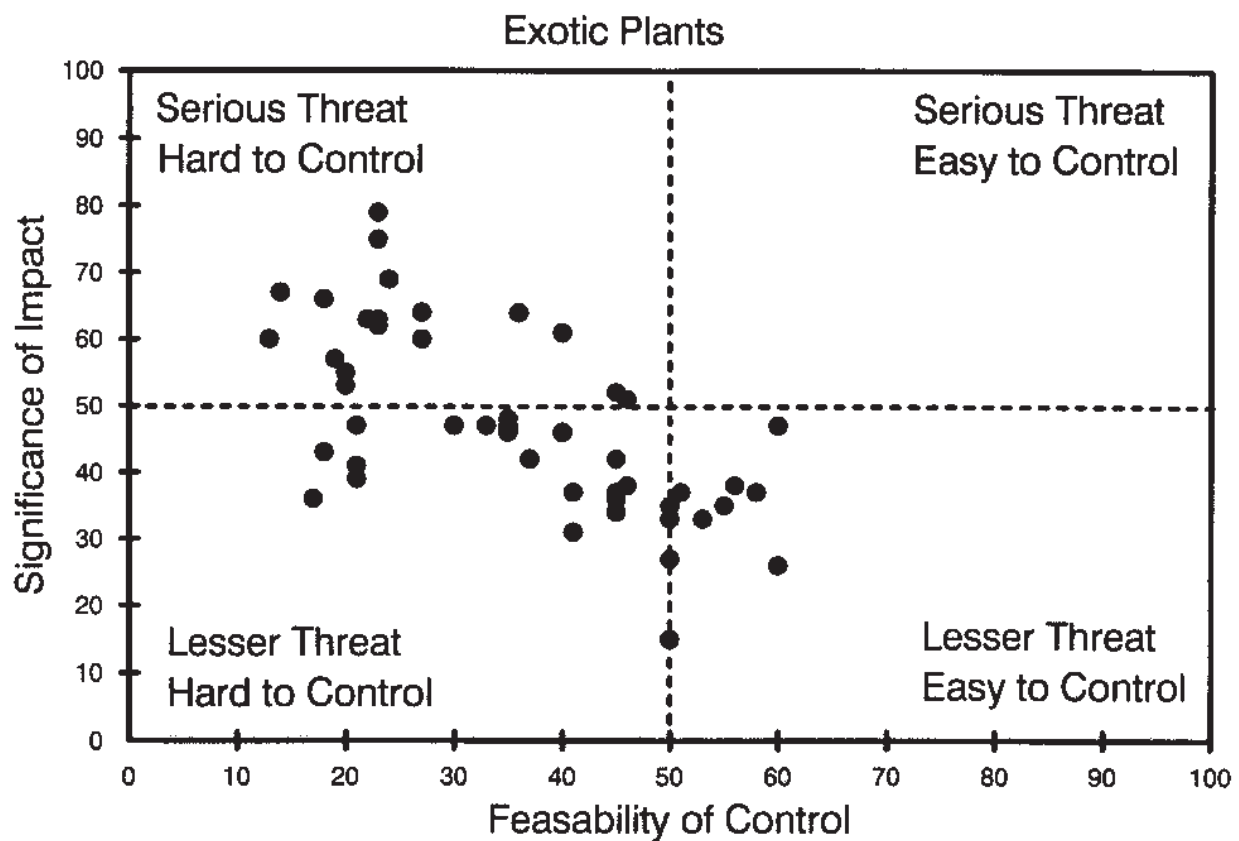


**Figure 2. Plot of level of impact vs. feasibility of control for exotic plant species at Wilson's Creek National Battlefield, Missouri.**

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## Names of Journals of Commonly Used Sources of Information for Exotic Species

### Journals

Acta Biotheroretica  
African Journal of Ecology  
Agronomy Journal  
American Journal of Botany  
American Midlands Naturalist  
American Naturalist  
Annual Review of Ecology & Systematics  
Annals of Botany  
Biological Conservation  
Botanical Gazette  
Bulletin of the Torrey Botanical Club  
Canadian Journal of Botany  
Canadian Journal of Plant Science  
Weed Technology  
Conservation Biology  
Crop Science  
Ecological Modelling  
Ecology  
Environmental Ecology  
Environmental Management  
Grass and Forage Science  
Great Basin Naturalist  
HortScience  
Journal of Agricultural Economics  
Journal of Applied Ecology  
Journal of Arid Environments  
Journal of Biogeography  
Journal of Ecology  
Journal of Economic Entomology  
Journal of Entomological Science  
Journal of Range Management  
Journal of Vegetation Science  
Natural Areas Journal  
New Phytologist  
Oecologia  
Oikos  
Paleobiology  
Physiologia Planatarum  
Phytopathology  
Plant Disease  
Plant Physiology  
Quarterly Review of Biology

### Journals

Rangelands  
Restoration and Management Notes  
SIDA  
Soil Science  
Soviet Journal of Ecology  
Vegetatio  
Weed Research  
Weed Science  
Weeds

## Exotic Species Ranking System Data Summary Form

Park: \_\_\_\_\_ Species: \_\_\_\_\_

### Significance of Impact:

Current Level of Impact (50) \_\_\_\_\_

Innate Ability to Become a Pest (50) \_\_\_\_\_

Total (100) \_\_\_\_\_

### Feasibility of Control:

Total (100) \_\_\_\_\_

Urgency: \_\_\_\_\_

### I. Significance of Impact.

#### A. Current Level of Impact

1. Distribution relative to disturbance regime (-10,1, 2, 5,10) \_\_\_\_\_
2. Abundance \_\_\_\_\_
  - a. number of populations (1, 3, 5) \_\_\_\_\_
  - b. areal extent of populations (1, 2, 3, 5) \_\_\_\_\_
3. Effect on natural processes and character (0, 3, 7, 10, 15) \_\_\_\_\_
4. Significance of threat to park resources (0, 2, 4, 8, 10) \_\_\_\_\_
5. Level of visual impact to an ecologist (0, 2, 4, 5) \_\_\_\_\_

Total (50 possible) \_\_\_\_\_

#### B. Innate Ability of Species to Become a Pest

1. Ability to complete life cycle in area of concern (0, 5) \_\_\_\_\_
2. Mode of reproduction (1, 3, 5) \_\_\_\_\_
3. Vegetative reproduction (0, 1, 3, 5) \_\_\_\_\_
4. Frequent of sexual reproduction (0, 1, 3, 5) \_\_\_\_\_
5. Number of seeds per plant (1, 3, 5) \_\_\_\_\_
6. Dispersal ability (0, 5) \_\_\_\_\_
7. Germination requirements (0, 3, 5) \_\_\_\_\_
8. Competitive ability (0, 3, 5) \_\_\_\_\_
9. Known level of impact in natural areas (0, 1, 3, 5, 10) \_\_\_\_\_

Total (50 possible) \_\_\_\_\_

A + B (100 possible) \_\_\_\_\_

23

## II. Feasibility of Control or Management

### A. Abundance Within Park

1. Number of populations (1, 3, 5) \_\_\_\_\_
2. Areal extent of populations (1, 2, 3, 5) \_\_\_\_\_

### B. Ease of Control

1. Seed banks (0, 5, 15) \_\_\_\_\_
2. Vegetative regeneration (0, 5, 15) \_\_\_\_\_
3. Level of effort required (1, 5, 10, 15) \_\_\_\_\_
4. Abundance and proximity of propagules (0, 5, 10, 15) \_\_\_\_\_

### C. Side Effects of Chemical/Mechanical Control (0, 5, 15) \_\_\_\_\_

### D. Effectiveness of Community Management (0, 5, 10) \_\_\_\_\_

### E. Biological Control (0, 5, 10) \_\_\_\_\_

Total (100 possible) \_\_\_\_\_

---

Urgency: \_\_\_\_\_

### Species Abstract of Canada Thistle at Pipestone National Monument, Minnesota

|                                       |                                                  |
|---------------------------------------|--------------------------------------------------|
| Park:                                 | Pipestone National Monument                      |
| Species:                              | <i>Cirsium arvense</i><br>(L.) Scop.             |
| Common Name:<br>California thistle    | Canada thistle, field thistle, creeping thistle, |
| Urgency Ranking:                      | High                                             |
| Overall Ranking:                      | 8                                                |
| Significance of Impact:               | 59                                               |
| A. Current impact:                    | 19                                               |
| B. Ability to become a pest:          | 40                                               |
| Feasibility of Control or Management: | 17                                               |

#### Taxonomic Description:

Canada thistle is a dioecious, perennial forb reaching heights of up to 1.5 m. This species's erect stem is highly branched above, green, and glabrescent-to-covered with dense cobweb-like hairs. Canada thistle usually occurs in small to large patches with numerous individuals arising from horizontal, lateral roots bearing adventitious shoots. Leaves are simple and placed alternately on the stem. Lower cauline leaves are 5-18 cm long and 1.5-6 cm wide, oblong to oblanceolate, and entirely or shallowly to pinnately lobed. Each lobe has few to many spines, and some spines are up to 5 mm in length. Both leaf surfaces may be glabrous, or the upper surface may be lightly pubescent while the lower surface is densely pubescent. Cauline leaves are reduced in size upwards and less lobed. Leaves may have a petiole up to 1 cm long, sessile, clasping, or short decurrent. Heads are numerous and occur in terminal corymb-like clusters. Each head is discoid and unisexual or incompletely dioecious. Pistillate flowers are 1-2 cm high and 0.5-1 cm wide, and staminate flowers are somewhat shorter. Bracts are imbricate, in five to six rows, ovate to lanceolate (2-6 mm long and up to 1.2 mm wide), spine-tipped with a spine up to 1 mm long, and glabrous to covered with a dense cobweb-like hair. The corolla is tubular and pink or purple in color (occasionally white). Staminate corolla tubes are 12-14 mm long, and anthers are 3.5-4 mm long and occasionally have vestigial pistillate parts. Pistillate corollas are longer (19-24 mm long) and may have vestigial anthers. Achenes are light brown to straw-colored (2-4 mm long and up to 1.5 mm wide). Each achene has a pappus of numerous white to grayish plumose bristles reaching up to 2.5 cm in length. Four varieties of this species have been recognized: var. *vestitum* Wimm. & Grab., var. *integrifolium* Wimm. & Grab., var. *arvense* (L.) Scop., and var. *horridum* Wimm. & Grab.

### Biology and Ecology:

Canada thistle is a highly competitive and noxious weed. It was apparently introduced from Eurasia into North America in colonial times as a contaminate of agricultural seed. Now a naturalized weed, Canada thistle is most commonly found in agricultural lands, pastures, and rangelands. The weed has also become established in forests, riversides, roadsides, lawns, gardens, abandoned fields, and ditchbanks. Canada thistle can now be found in all of the lower 48 states and all of the Canadian provinces.

Canada thistle is most common in open, mesophytic areas. It has a temperature tolerance of -35° to 40° C. Optimal annual precipitation is 400-750 mm. The species grows in a wide variety of soils, including sand dunes, but is most abundant in clayey soils. It can tolerate saline soils and wet or dry soils, but grows best in dry soils. Disturbance is necessary for initial establishment; however, once established it may rapidly spread by both rhizomes and seed. Canada thistle is not generally shade tolerant. Its growth is reduced when light falls to 60-70% of full daylight, and death occurs when light is reduced to 20% of full sun. This tolerance level may explain why Canada thistle does not persist in prairies in good to excellent condition. The species also does not readily tolerate waterlogged, poorly aerated soils. However, it may be found growing in these conditions in a lowered condition.

Extensive rhizomes of Canada thistle make it unique among the thistles. Rhizomes develop at depths far below the zone of rhizome development for most species. Most rhizome development occurs in the first 75 cm of the soil, but has been reported to occur at nearly 7 m. Lateral root growth of up to 6 m in one growing season has been recorded. Root buds are produced on lateral roots at 6-12-cm intervals. With these closely placed buds, root fragments as small as 8 mm in length and 3-6 mm thick have produced new shoots, and root fragments 13 cm in length nearly always produce new shoots. Root fragments can produce viable shoots in as few as five days. Root/shoot elongation increases with temperature and photoperiod. Elongation is greatest at 25°/15° C day/night temperatures, soil temperatures of 30° C, and a photoperiod of 15 hours. Root reserves are lowest just before flowering and are the greatest in early fall when aboveground growth stops.

Shoots begin to emerge in the early spring when soil temperatures reach about 5° C. Development of rosette leaves occurs first followed by vertical elongation in early summer. Flowering is generally from June to September, when day length reaches 14 to 18 hours. Canada thistle is incompletely dioecious, with the staminate and pistillate flowers usually borne on separate plants. Therefore, natural patches are usually of one sex. Flowers are pollinated by insects, primarily honey bees and some wasps. Each plant produces from 30 to 100 heads in a season. Each pistillate head has about 100 fertile florets, and about 83 to 90 will form seeds. One plant has the potential to produce up to 5,200 seeds in a season, but the average seed production is about 1,530 seeds per plant. Seeds are dispersed primarily by wind. Seed size is variable, averaging 650,000 to nearly 1,500,000 per kg.

Germination rates of between 50% and 95% have been observed. An average of 90% of the yearly seed production germinates within one year. Studies have shown that some seeds can remain viable in the soil for up to 21 years and up to four months in water. Optimal germination in the laboratory occurs with temperatures at a constant 30° C or where temperatures alternate between 20° and 30° or 30° and 40° C. Germination is restricted with osmotic pressures above 5 bars. Optimal germination is between pH 5.8 and 7.0. Each crop of seed produces a succession of seedlings. Some will germinate that fall and produce a rosette. These will then flower the next summer. Other seeds will not germinate until the next spring (or later) and may or may not flower that year.

Some evidence indicates that Canada thistle may have an allelopathic effect; however, no specific compound has been isolated. Autotoxicity has been hypothesized in some circumstances.

---

**Distribution:**

An intermediate number of Canada thistle plants are present at Pipestone National Monument. They occur in patches and cover less than a total of 5 ha. Canada thistle plants are found in midsuccessional sites that were disturbed in the last 11 to 50 years. These plants have the potential to invade and modify existing native plant communities and may endanger the secondary successional resources. The plants have a minor visual impact on the park.

**Control:**

Numerous control options exist for Canada thistle. Biological, chemical, cultural, and mechanical methods have all been used with varying levels of success. An important consideration in controlling Canada thistle is that the seeds have the potential to remain viable in the seed bank for at least 20 years. Thus, removing living plants may not totally eliminate the problem. A further consideration is that many sources of new propagules surround the park.

An important consideration prior to applying any control method is to determine if enough desirable plants are present to replace the Canada thistle. If desirable vegetation is absent or not present in enough numbers, control will be of little value. Most control methods will have a detrimental effect on other plant species, and they all constitute a disturbance that will favor reinvasion by Canada thistle or by other exotic species. Researchers should note that many native thistles are present in the area, and they should not be subjected to control. Proper identification is important.

Frequent mowing over a number of years will control Canada thistle. Mowing has been the primary control method employed at Pipestone. Most studies indicate a need to mow patches of Canada thistle at least twice a year to prevent seed dispersal and reduce root reserves. Systematic monthly mowings may be necessary to prevent lateral flower bud development and to keep root reserves depleted. Tillage may be used to control Canada thistle; however, tillage may result in an increase in abundance due to spreading rootstalks and the subsequent disturbance. Tillage should be to a depth of 10 cm when the elongated shoots are 8 to 10 days old. Tillage should be repeated at a minimum of 21-day intervals. Canada thistle has a relatively high light requirement, and smother crops may provide some measure of control by shading. Smother plants that have been used include sweet clover, alfalfa, millet, sorghum, hemp, and small grains.

No prescribed burning studies have been conducted to specifically control Canada thistle. Supplementary information has shown that repeated burning in May or June reduced thistle abundance in grasslands. In most of these studies, Canada thistle showed an initial increase in abundance, followed by a notable reduction in abundance.

A number of chemical control options exist for Canada thistle. Many herbicides discussed here are not specific to Canada thistle or may not be specifically licensed for this particular type of use. Thus, users must read and follow all label directions. Before “modern” herbicides were introduced, compounds such as sodium chloride, sodium arsenite, calcium arsenite, sodium chlorate, and carbon bisulfide were all used in attempts to control Canada thistle. Numerous herbicides are now available for controlling Canada thistle. Tordon (picloram) is probably the most effective. Tordon may give a 95% control in the first year when applied at a rate of 0.56-1.23 kg ai/ha in the spring before flowering or in the fall during active rosette growth. Banvel (dicamba) applied at 0.56-6.73 kg ai/ha or 2,4-D (amine) at 0.56-2.24 kg ai/ha will suppress or control Canada thistle. However, more effective control may be achieved by combining the two herbicides in a 1:1 mixture. This mixture should be applied in the spring before flowering or in the fall when the rosettes are actively growing. Roundup (glyphosate) applied at a rate of 1-2 kg ai/ha at the bud stage or during the active growth period in the fall will also control this thistle. Amitrole-T (amitrol) applied at rates of 2.24-4.48 kg

ai/ha when the plants are in the bud stage has yielded 70% control in the first year. Most herbicides, except Tordon, should not be applied while the plants are in a moisture-stressed condition. Other herbicides that have shown potential to control Canada thistle are Buctril 2EC (bromoxynil), Curtail (clopyralid plus 2,4-D), and Stinger (clopyralid).

Biological control of Canada thistle has received some attention. Over 80 native species of insects and over 50 species of animals and fungi use Canada thistle to some extent. A few species have the potential for providing some measure of control. Only four insects may be a threat to Canada thistle. These four are composed of two beetles [*Cassia rubiginosa* Muell. (Coleoptera: Chrysomelidae) and *Cleonus piger* (Coleoptera: Curculionidae)], one fly [*Orellia ruficauda* Fab. (Diptera: Tephritidae)], and the painted lady butterfly [*Vanessa cardui* L. (Lepidoptera: Nymphalidae)]. Only *Orellia ruficauda* appears to do significant damage to Canada thistle, and this level of damage is not sufficient for control. Five European insect species [*Ceutorhynchus litura* F. (Coleoptera: Curculionidae), *Rhinocyllus conicus* Froelich (Coleoptera: Curculionidae), *Altica carduorum* Guerin-Meneville (Coleoptera: Chrysomelidae), *Lema cyanella* L. (Coleoptera: Chrysomelidae), and *Urophora cardui* L. (Diptera: Tephritidae)] have all been released in North America for Canada thistle control. To date, only *Ceutorhynchus litura* has become established, spread, and begun to suppress this plant.

Fungus species of the genus *Puccinia* hold some promise as control agents. *Puccinia punctiformis* (Strauss) Roehling (Fungus: Uredinales) has been tested in Europe and New Zealand and has been found to only reduce plant vigor. The best biological control of Canada thistle has come when this fungus has been used in conjunction with either 2,4-D, or *Ceutorhynchus litura*. Plants treated with the fungus followed by weevil introduction had over a 50% increase in damage over nontreated plants.

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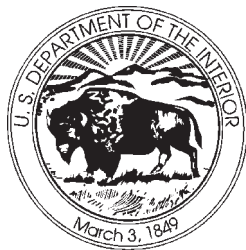
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Local Control Experts:

Extension Weed Specialist  
 Department of Agronomy and Plant Genetics  
 University of Minnesota  
 St. Paul, MN 55155  
 (612) 625-5753

Department of Natural Resources  
 Box 25 DNR Building  
 500 Lafayette Rd.  
 St. Paul, MN 5515S  
 (612) 296-0778

## Notes



As the nation's principal conservation agency, the Department of the Interior has responsibility for most of our nationally owned public lands and natural resources. This includes fostering sound use of our land and water resources; protecting our fish, wildlife, and biological diversity; preserving the environmental and cultural values of our national parks and historical places; and providing for the enjoyment of life through outdoor recreation. The department assesses our energy and mineral resources and works to ensure that their development is in the best interests of all our people by encouraging stewardship and citizen participation in their care. The department also has a major responsibility for American Indian reservation communities and for people who live in island territories under U.S. administration.

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# Appendix E: Additional Documented Exotic Plant Species

**Table B-1. Plant species not included in Washita Battlefield National Historic Site's exotic plants table but documented as occurring**

| Scientific Name               | Common Name               | Comment*                                                                                                            | Source                                       |
|-------------------------------|---------------------------|---------------------------------------------------------------------------------------------------------------------|----------------------------------------------|
| <i>Acroptilon repens</i>      | Russian knapweed          | Plant is found in Oklahoma and has been recently vouchered for in Roger Mills County (pers. comm. T. Folts-Zettner) | SOPN Exotic Watch List                       |
| <i>Agropyron cristatum</i>    | Crested wheatgrass        | Plant is found in Oklahoma but hasn't been vouchered for in Roger Mills County (pers. comm. T. Folts-Zettner)       | SOPN Exotic Watch List                       |
| <i>Albizia julibrissin</i>    | Mimosa                    | Misidentified during SOPN 2010 survey and was native mimosa                                                         | Folts-Zettner and Sosinski 2012              |
| <i>Ambrosia artemisifolia</i> | Ragweed                   | Not identified to species level, therefore, cannot determine if this was a native or non-native plant.              | Milner et al. 2003                           |
| <i>Asparagus officinalis</i>  | Asparagus                 | A landscape plant (pers. comm. T. Folts-Zettner)                                                                    | SOPN Exotic Watch List                       |
| <i>Bignonia capreolata</i>    | Crossvine                 | Considered to be a native plant (pers. comm. T. Folts-Zettner)                                                      | SOPN Exotic Watch List                       |
| <i>Bromus secalinus</i>       | Rye brome                 | Misidentified and should have been <i>Bromus tectorum</i> , which is found in the park                              | Stotts and Dubey 1998                        |
| <i>Cardaria draba</i>         | Hoary cress               | Plant is found in Oklahoma but hasn't been vouchered for in Roger Mills County (pers. comm. T. Folts-Zettner)       | SOPN Exotic Watch List                       |
| <i>Conyza canadensis</i>      | Horseweed                 | This is considered to be a native plant at WABA since it is native to the continental US.                           | Milner et al. 2003                           |
| <i>Dianthus chinensis</i>     | China pink                | A landscape plant (pers. comm. T. Folts-Zettner)                                                                    | SOPN Exotic Watch List                       |
| <i>Digitaria ciliaris</i>     | Smooth crabgrass          | Not documented in any reports as occurring.                                                                         | Folts-Zettner 2009, WABA_09.xls, Exotics Tab |
| <i>Eupatorium dentata</i>     | N/A                       | Misreferenced in report and should be <i>Euphorbia dentata</i>                                                      | Folts-Zettner and Sosinski 2012              |
| <i>Grindelia squarrosa</i>    | Curlycup gumweed          | This is considered to be a native plant at WABA since it is native to the continental US.                           | Milner et al. 2003                           |
| <i>Gymnocladus dioica</i>     | Kentucky coffee bean tree | This is considered to be a native plant at WABA since it is native to the continental US                            | Milner et al. 2003                           |
| <i>Helianthus annuus</i>      | Annual sunflower          | This is considered to be a native plant at WABA since it is native to the continental US.                           | Milner et al. 2003                           |
| <i>Iris lutescens</i>         | Crimean iris              | A landscape plant (pers. comm. T. Folts-Zettner)                                                                    | SOPN Exotic Watch List                       |
| <i>Jasminum nudiflorum</i>    | Winter jasmine            | A landscape plant (pers. comm. T. Folts-Zettner)                                                                    | SOPN Exotic Watch List                       |
| <i>Juglans nigra</i>          | Black walnut              | This is considered to be a native plant at WABA since it is native to the continental US.                           | Milner et al. 2003                           |
| <i>Juniperus chinensis</i>    | Chinese juniper           | This is non-native but no longer present in the park.                                                               | Milner et al. 2003                           |
| <i>Juniperus virginiana</i>   | Eastern red cedar         | This is considered to be a native plant at WABA since it is native to the continental US.                           | Milner et al. 2003                           |
| <i>Lonicera maackii</i>       | Amur honeysuckle          | Plant is found in Oklahoma but hasn't been vouchered for in Roger Mills County (pers. comm. T. Folts-Zettner)       | SOPN Exotic Watch List                       |
| <i>Maclura pomifera</i>       | Osage orange              | This is considered to be a native plant at WABA since it is native to the continental US.                           | Milner et al. 2003                           |
| <i>Malva neglecta</i>         | Common mallow             | Plant is found in Oklahoma but hasn't been vouchered for in Roger Mills County (pers. comm. T. Folts-Zettner)       | SOPN Exotic Watch List                       |
| <i>Marrubium vulgare</i>      | Common horehound          | Plant is found in Oklahoma but hasn't been vouchered for in Roger Mills County (pers. comm. T. Folts-Zettner)       | SOPN Exotic Watch List                       |
| <i>Medicago polymorpha</i>    | Bur clover                | Plant is found in Oklahoma but hasn't been vouchered for in Roger Mills County (pers. comm. T. Folts-Zettner)       | SOPN Exotic Watch List                       |

**Table B-1. Plant species not included in Washita Battlefield National Historic Site's exotic plants table but documented as occurring (continued)**

| Scientific Name             | Common Name                 | Comment*                                                                                                                                       | Source                                     |
|-----------------------------|-----------------------------|------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------|
| <i>Mirabilis jalapa</i>     | Marvel of Peru              | Plant is found in Oklahoma but hasn't been vouchered for in Roger Mills County (pers. comm. T. Folts-Zettner)                                  | SOPN Exotic Watch List                     |
| <i>Nandina domestica</i>    | Bamboo                      | A landscape plant (pers. comm. T. Folts-Zettner)                                                                                               | SOPN Exotic Watch List                     |
| <i>Panicum coloratum</i>    | Kleingrass                  | Plant not vouchered for state of Oklahoma (pers. comm. T. Folts-Zettner)                                                                       | SOPN Exotic Watch List                     |
| <i>Panicum miliaceum</i>    | Proso millet                | Plant is found in Oklahoma but hasn't been vouchered for in Roger Mills County (pers. comm. T. Folts-Zettner)                                  | SOPN Exotic Watch List                     |
| <i>Pinus nigra</i>          | Austrian pine               | A landscape plant (pers. comm. T. Folts-Zettner)                                                                                               | SOPN Exotic Watch List                     |
| <i>Pluchea</i> Cass.        | Camphor weed                | This is considered to be a native plant at WABA since it is native to the continental US.                                                      | Milner et al. 2003                         |
| <i>Polypogon viridis</i>    | Beardless rabbitsfoot grass | Misidentified; should be <i>P. monspeliensis</i> (pers. comm. T. Folts-Zettner)                                                                | SOPN Exotic Watch List                     |
| <i>Potentilla recta</i>     | Cinquefoil                  | Plant is found in Oklahoma but hasn't been vouchered for in Roger Mills County (pers. comm. T. Folts-Zettner)                                  | SOPN Exotic Watch List                     |
| <i>Ricinus communis</i>     | Caster bean                 | Plant is found in Oklahoma but hasn't been vouchered for in Roger Mills County (pers. comm. T. Folts-Zettner)                                  | SOPN Exotic Watch List                     |
| <i>Robinea pseudoacacia</i> | Black locust                | This is considered to be a native plant at WABA since it is native to the continental US.                                                      | Inglis and Wagner 2001; Milner et al. 2003 |
| <i>Rumex obtusifolius</i>   | Bitter dock                 | Plant is found in Oklahoma but hasn't been vouchered for in Roger Mills County (pers. comm. T. Folts-Zettner)                                  | SOPN Exotic Watch List                     |
| <i>Rumex stenophyllus</i>   | Narrowleaf dock             | Plant is found in Oklahoma but hasn't been vouchered for in Roger Mills County (pers. comm. T. Folts-Zettner)                                  | SOPN Exotic Watch List                     |
| <i>Salvia uliginosa</i>     | Bog sage                    | A landscape plant (pers. comm. T. Folts-Zettner)                                                                                               | SOPN Exotic Watch List                     |
| <i>Salsola kali</i>         | Russian thistle             | May be present but difficult to distinguish from <i>S. tragus</i> . Has not been vouchered in state of OK (pers. comm. T. Folts-Zettner)       | SOPN Exotic Watch List                     |
| <i>Scorzonera laciniata</i> | Cutleaf vipergrass          | A landscape plant (pers. comm. T. Folts-Zettner)                                                                                               | SOPN Exotic Watch List                     |
| <i>Sonchus arvensis</i>     | Sowthistle                  | Misidentified and should have been <i>Sonchus aper</i> , which is found in the park                                                            | Stotts and Dubey 1998                      |
| <i>Sorghastrum nutans</i>   | Indiangrass                 | Incorrectly highlighted as a non-native plant (p. 127). <i>Sorghum halepense</i> should have been highlighted instead.                         | Folts-Zettner et al. 2012                  |
| N/A                         | Downey brome                | This species was listed separately from cheatgrass, indicating two species, but we are treating downey brome as the same species as cheatgrass | Milner et al. 2003                         |
| N/A                         | Soapberry                   | This is a native plant and species was not identified with scientific name. Also, the non-native is not called soapberry.                      | Milner et al. 2003                         |
| N/A                         | Fruit trees                 | These are non-native but no longer present in the park.                                                                                        | Milner et al. 2003                         |

\* Information pertaining to each species nativity and/or presence in the park came from personal communication with Tomye Folts-Zettner, 2012.

## Appendix F: Maps of the Known Distribution of Exotic Plant Species



Figure F-1.  
Red-root pigweed  
(*Amaranthus  
retroflexus*)

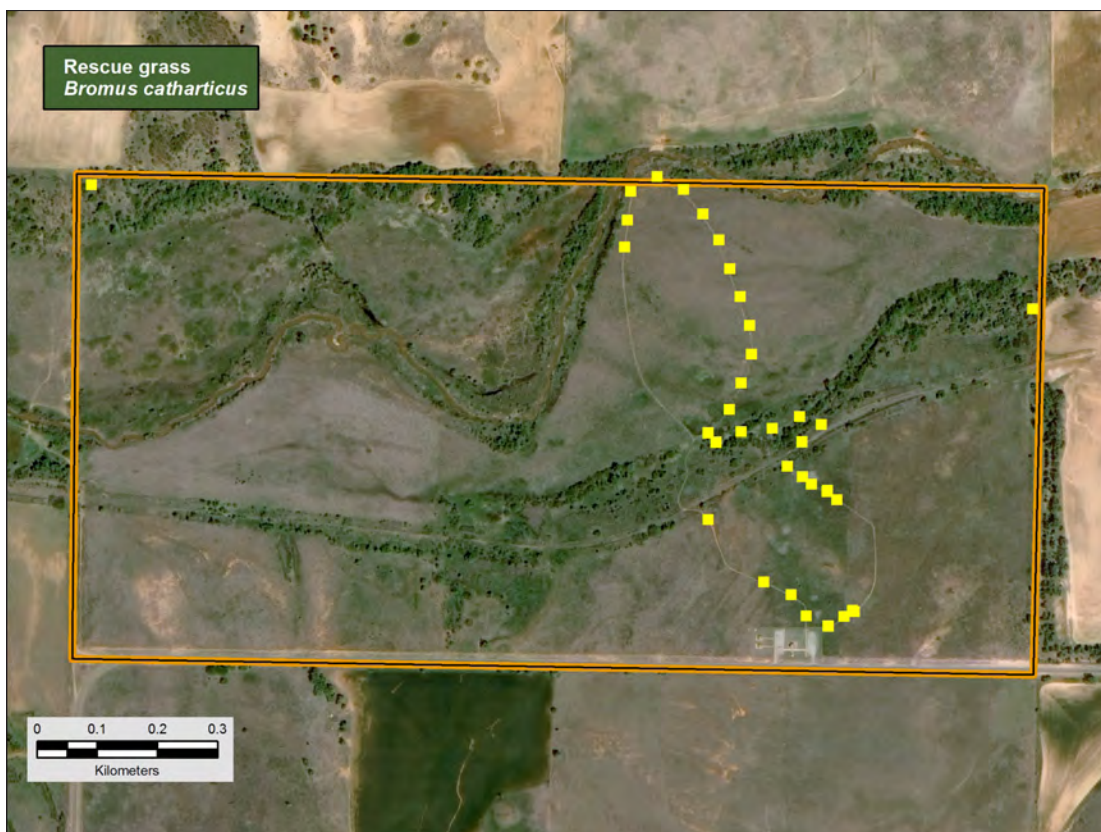


Figure F-2.  
Rescuegrass (*Bromus  
catharticus*)

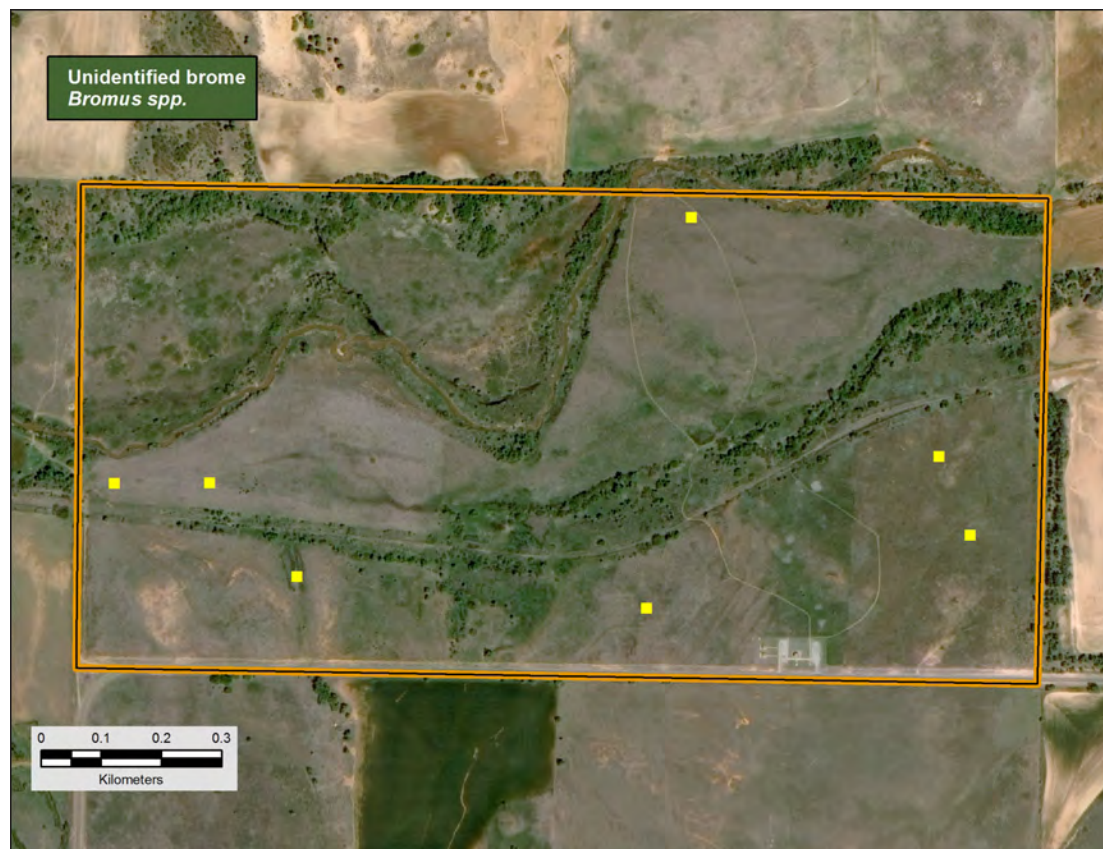


Figure F-3.  
Unidentified brome  
(*Bromus spp.*)

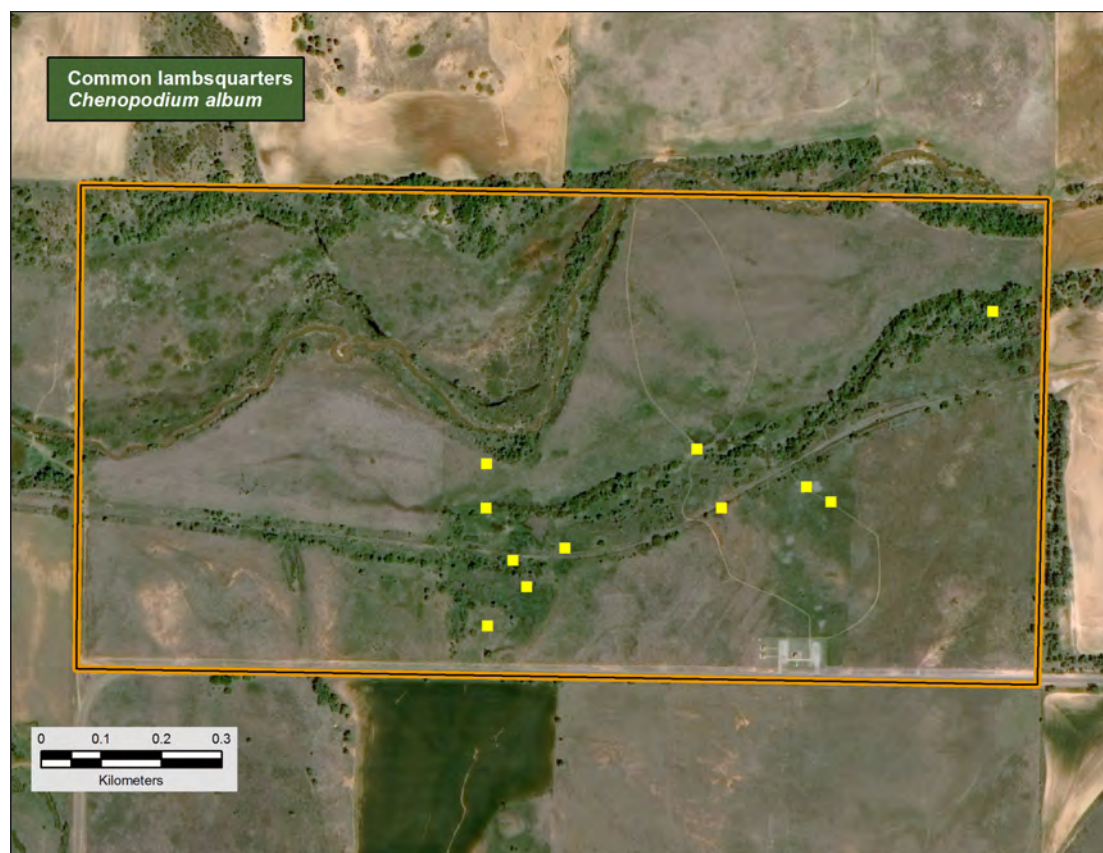


Figure F-4.  
Common  
lambsquarters  
(*Chenopodium  
album*)



Figure F-5.  
Canadian thistle  
(*Cirsium arvense*)

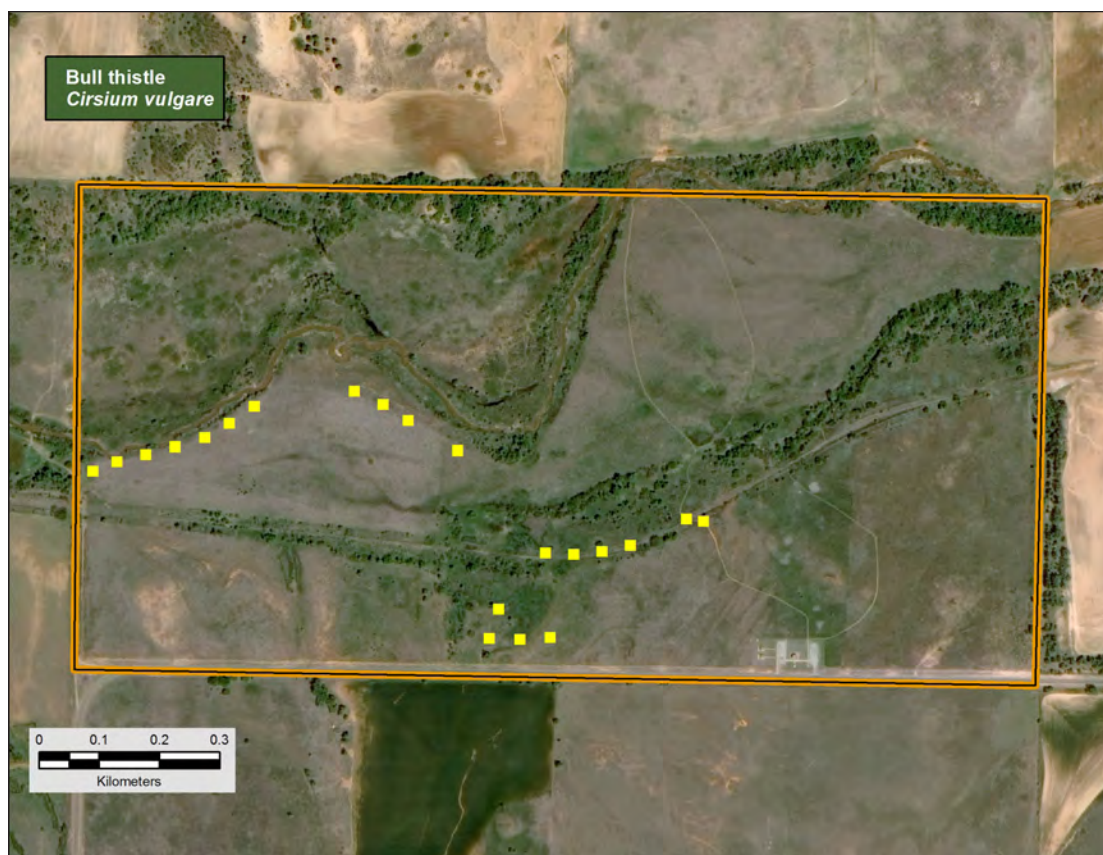


Figure F-6.  
Bull thistle (*Cirsium*  
*vulgare*)

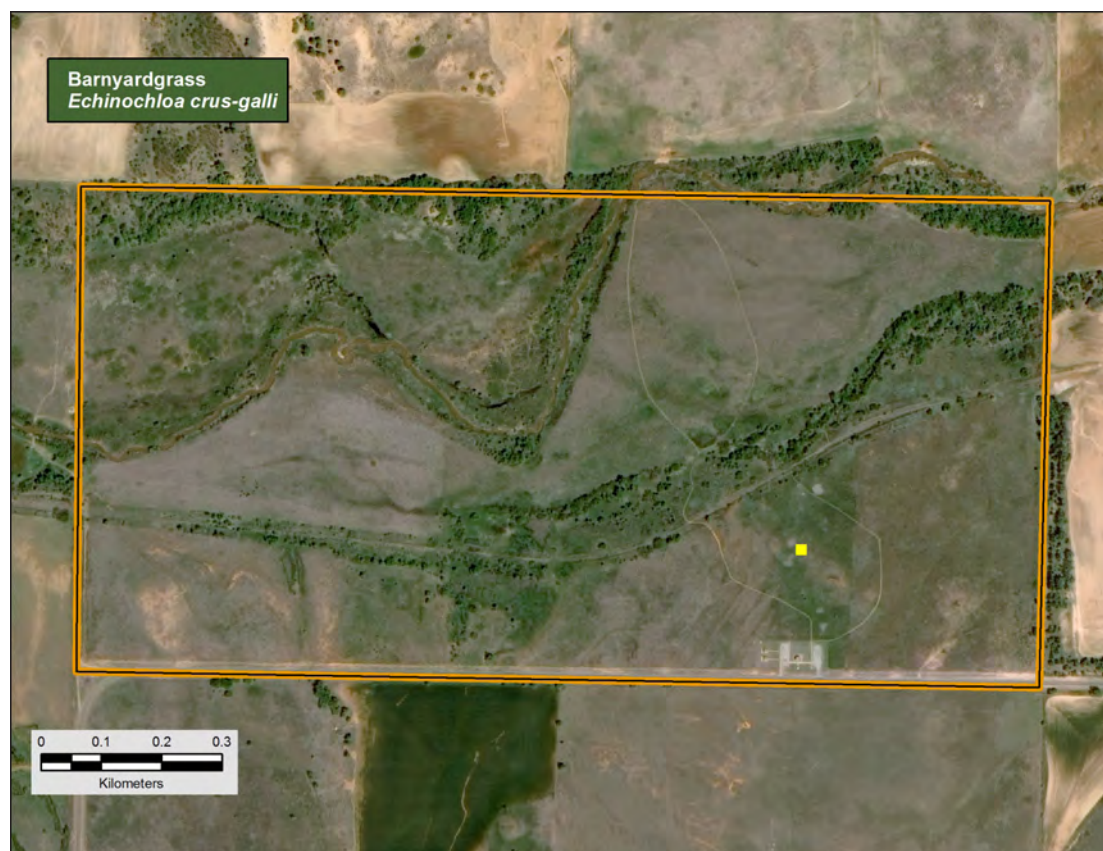


Figure F-7.  
Barnyardgrass  
(*Echinochloa crus-galli*)

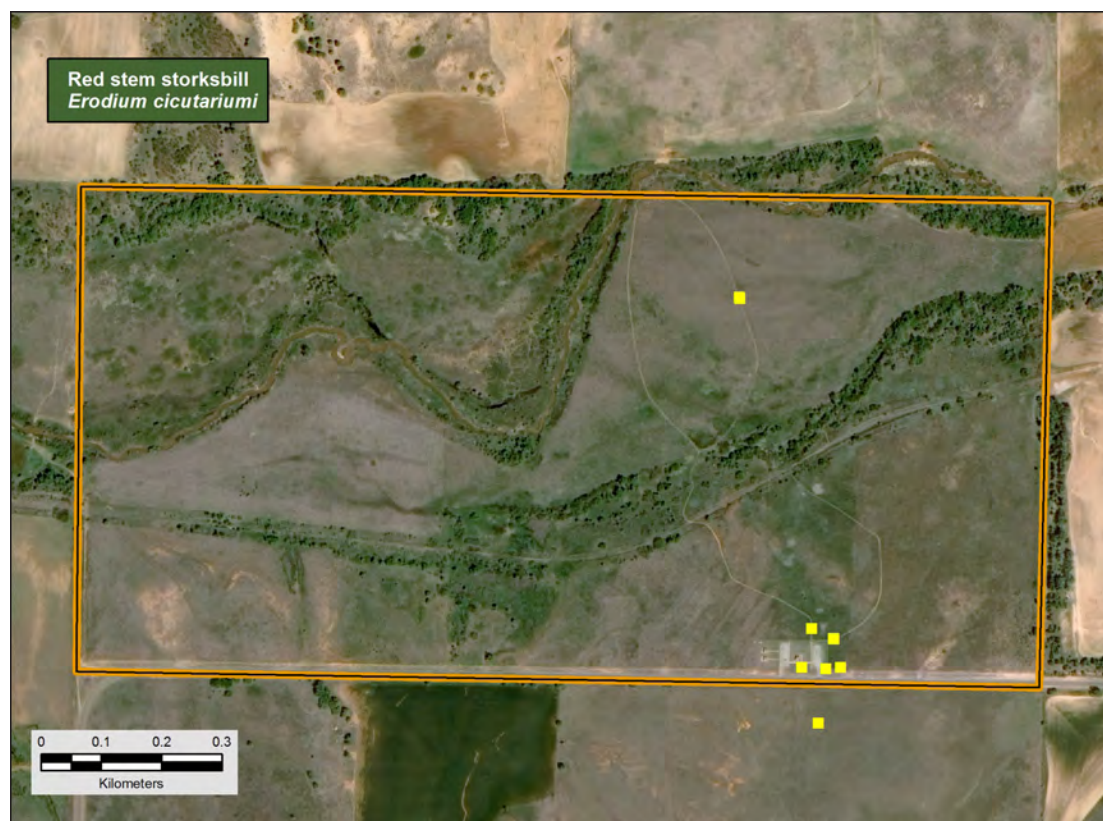


Figure F-8.  
Red stem storksbill  
(*Erodium cicutarium*)

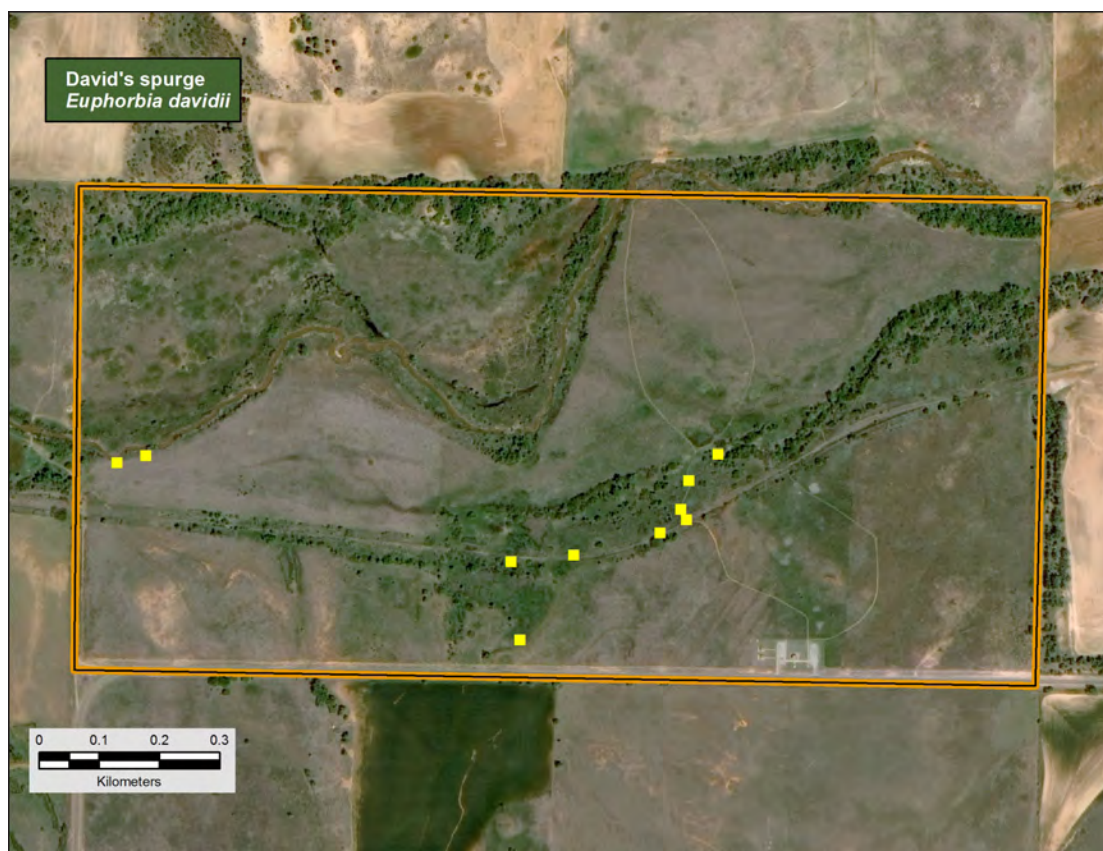


Figure F-9.  
Toothed spurge  
(*Eupatorium  
dentata*)

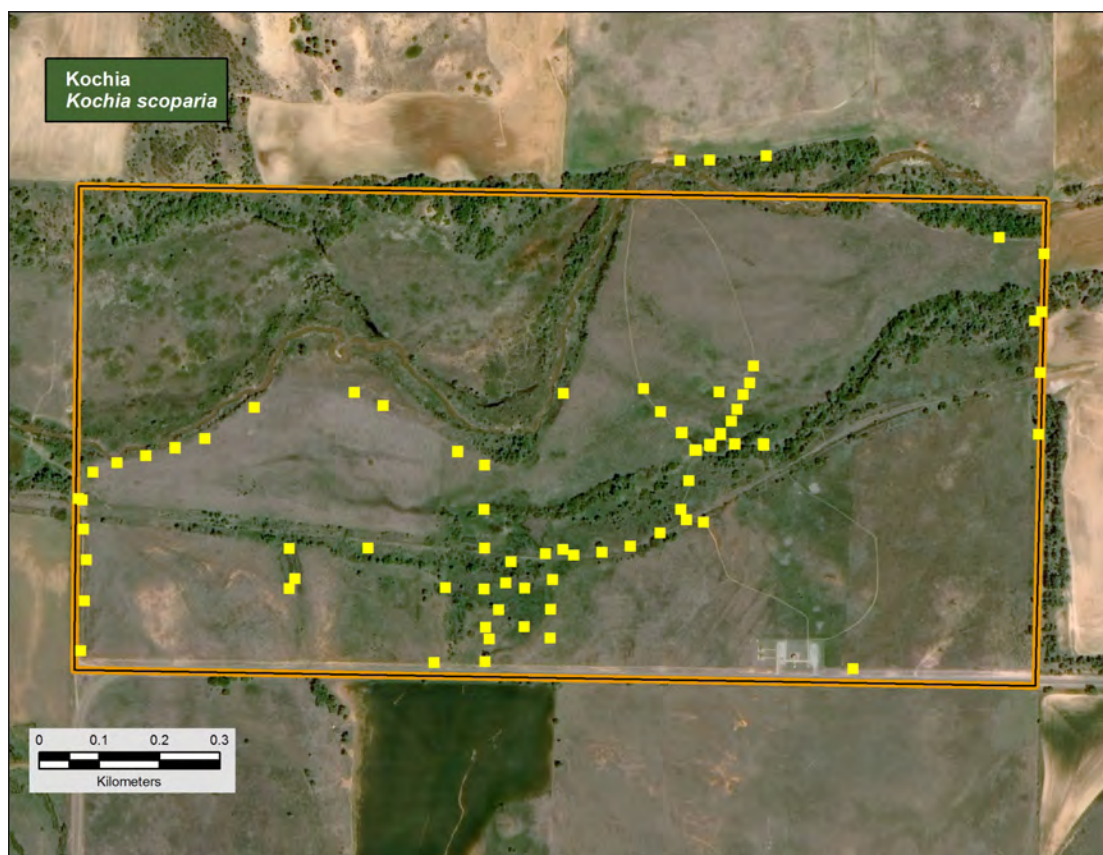


Figure F-10.  
Kochia (*Kochia  
scoparia*)

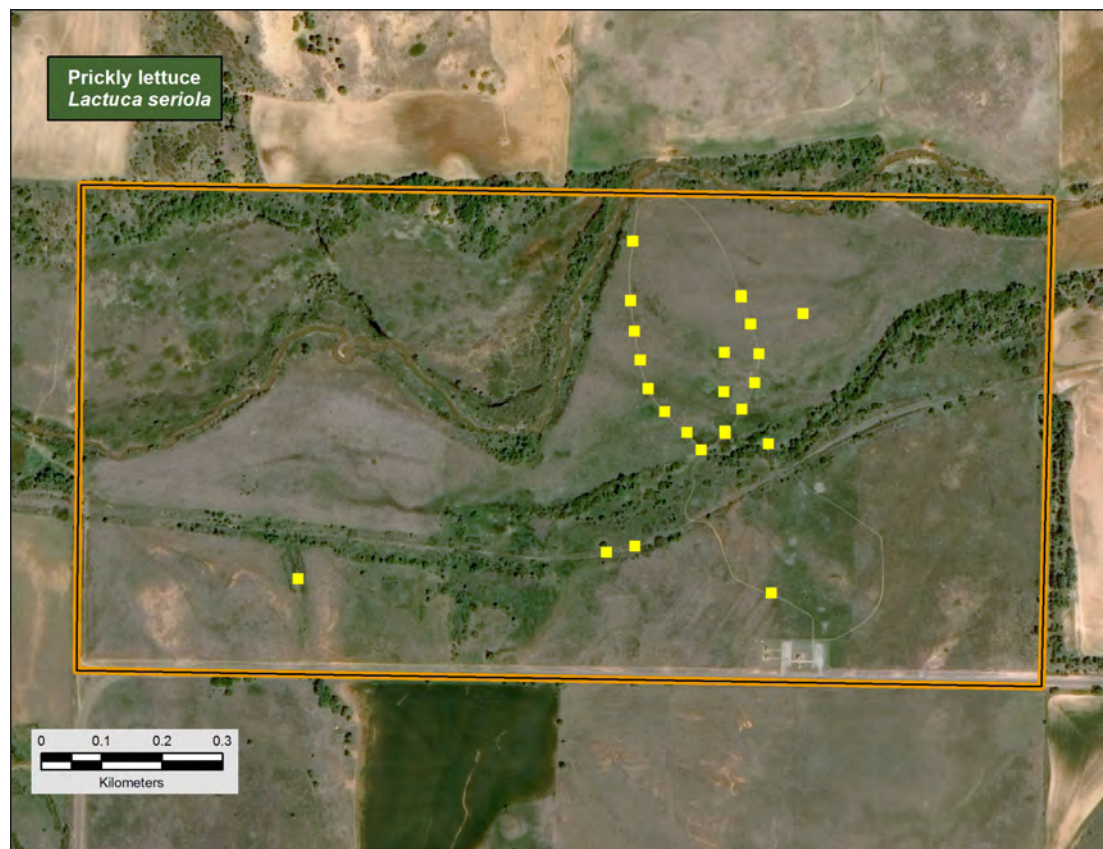


Figure F-11.  
Prickly lettuce  
(*Lactuca serriola*)

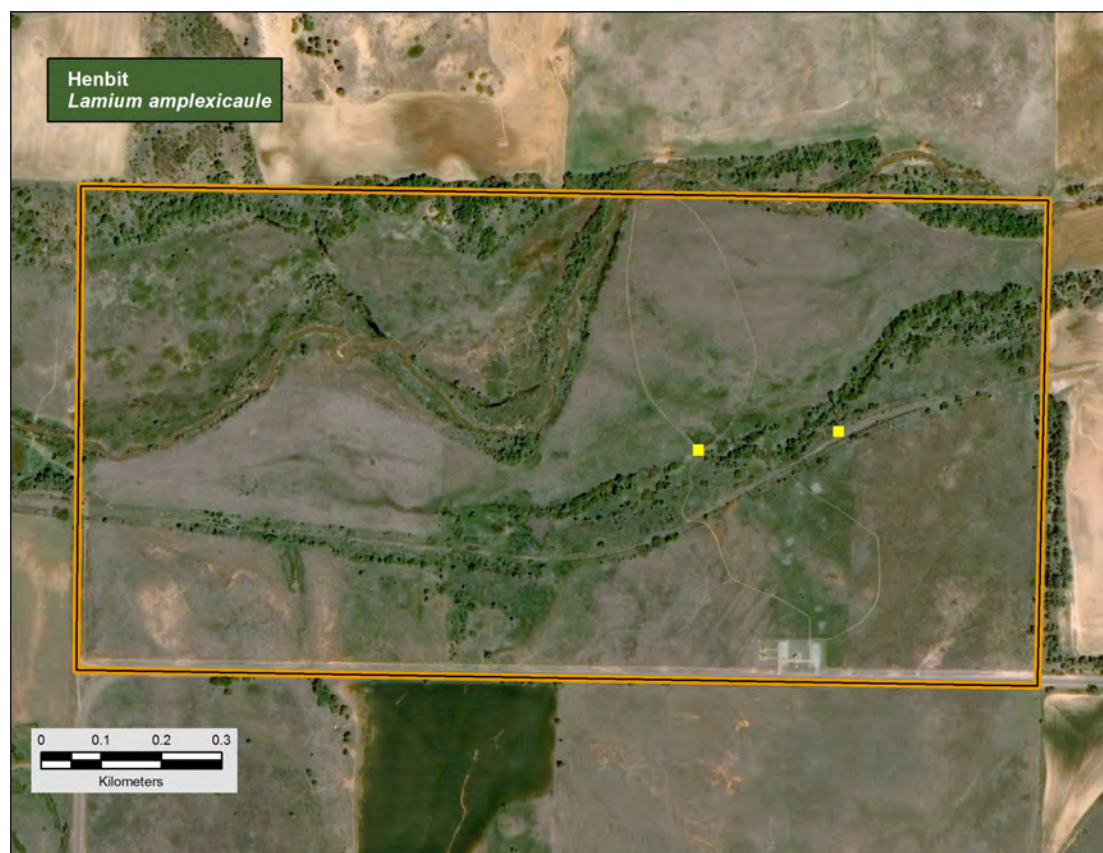


Figure F-12.  
Henbit (*Lamium amplexicaule*)



Figure F-13.  
Perennial rye (*Lolium perenne*)



Figure F-14.  
Black medic clover  
(*Medicago lupulina*)

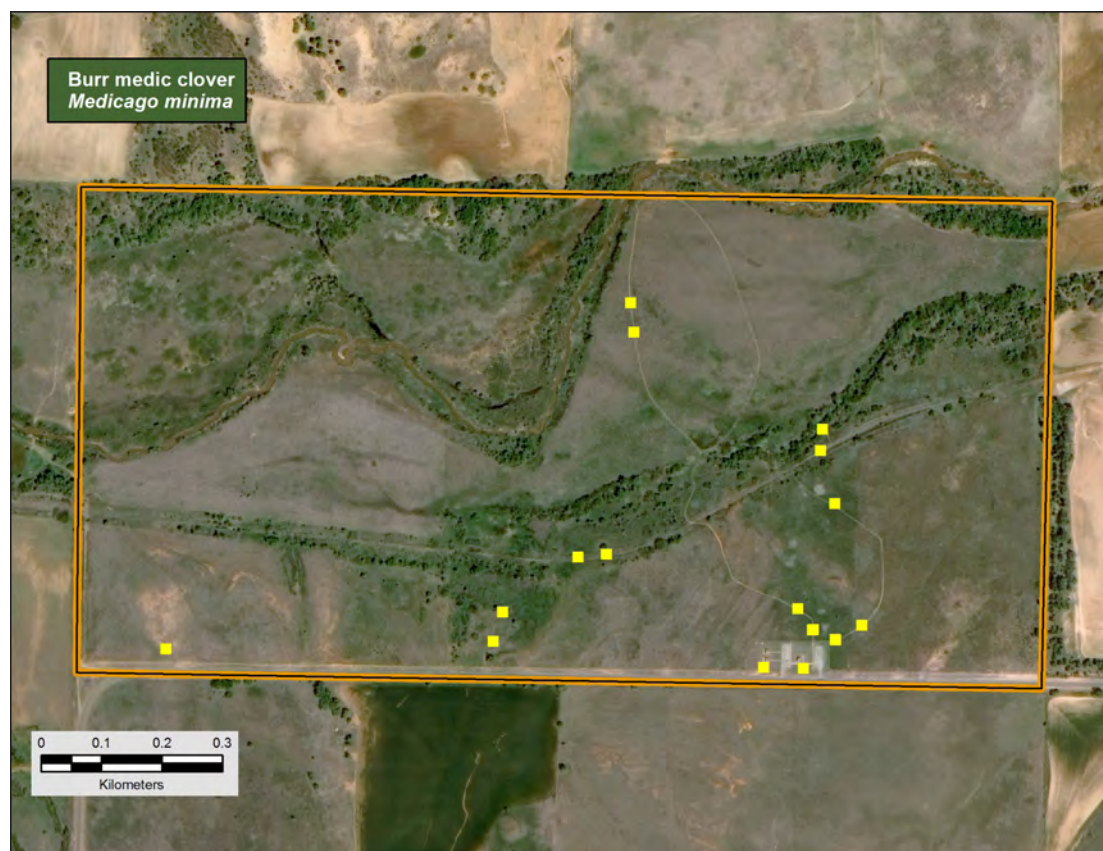


Figure F-15.  
Burr medic clover  
(*Medicago minima*)



Figure F-16.  
Scotch thistle  
(*Onopordum  
acanthium*)



Figure F-17.  
Klein grass (*Panicum coloratum*)

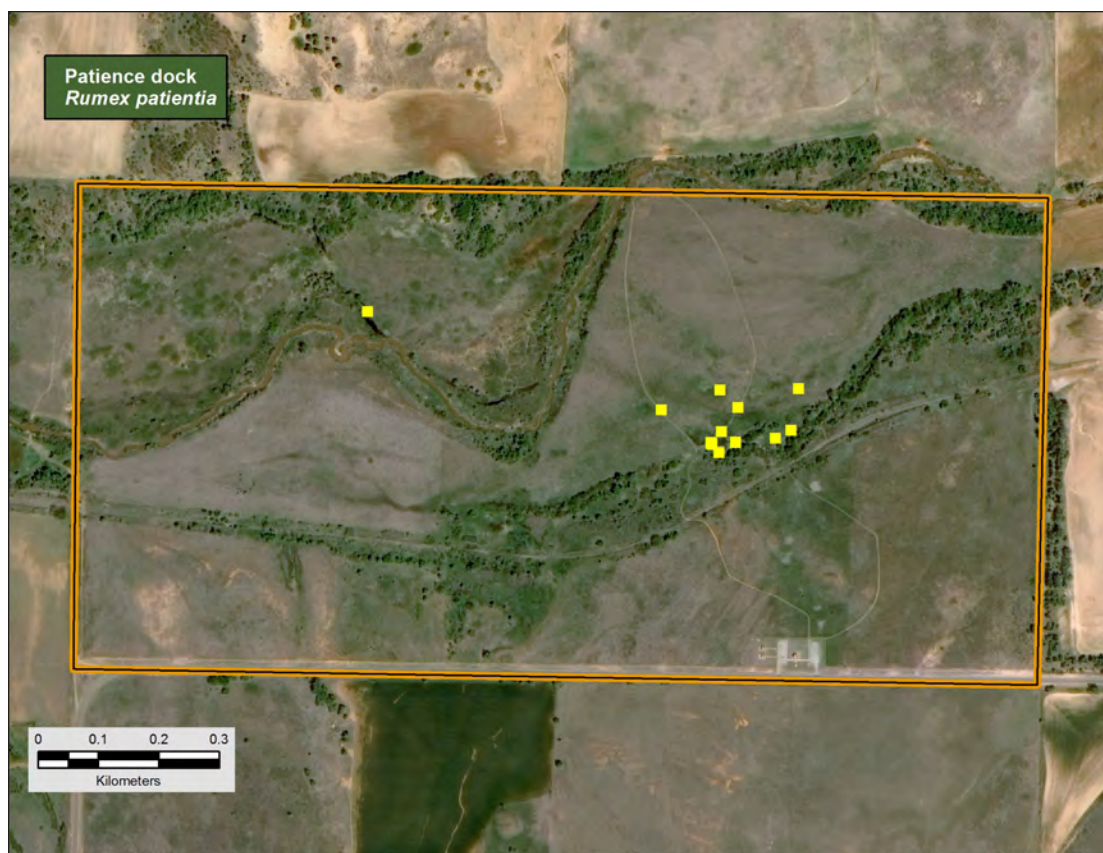


Figure F-18.  
Patience dock  
(*Rumex patientia*)

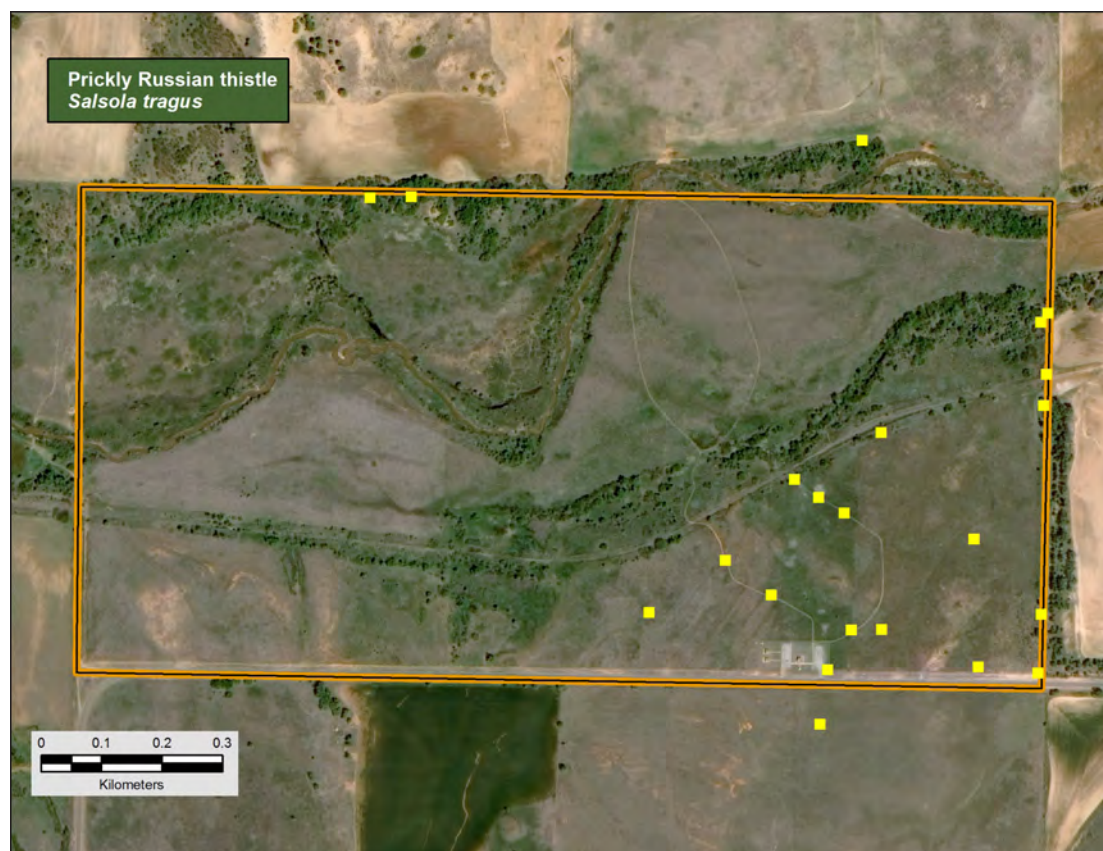


Figure F-19.  
Prickly Russian  
thistle (*Salsola*  
*tragus*)

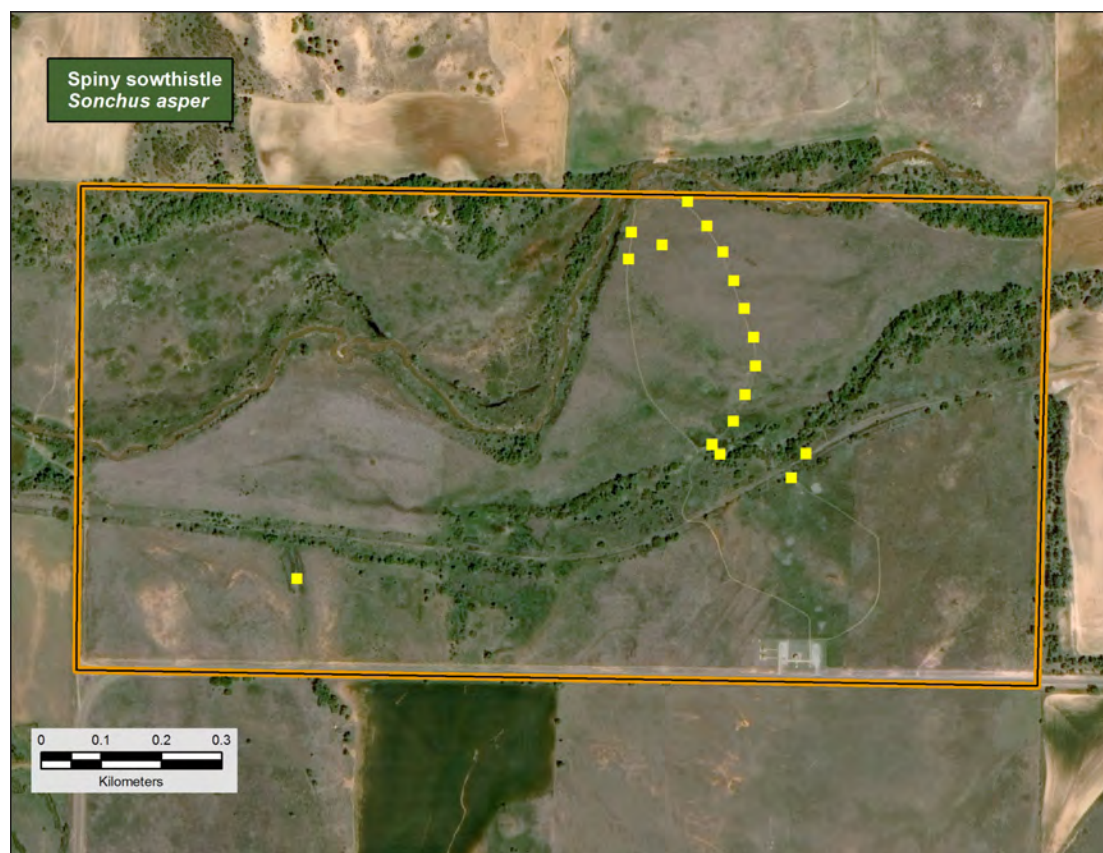


Figure F-20.  
Spiny sowthistle  
(*Sonchus asper*)



Figure F-21.  
Dandelion  
(*Taraxacum officinale*)

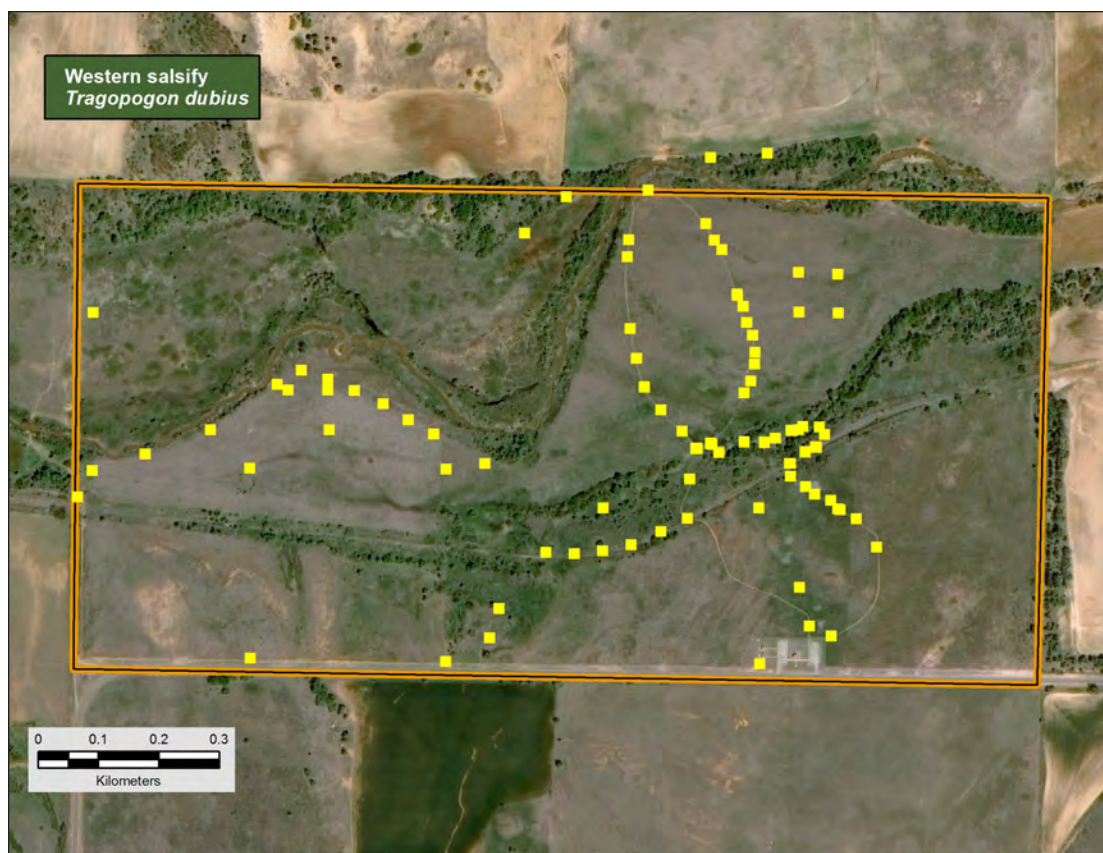


Figure F-22.  
Western salsify  
(*Tragopogon dubius*)

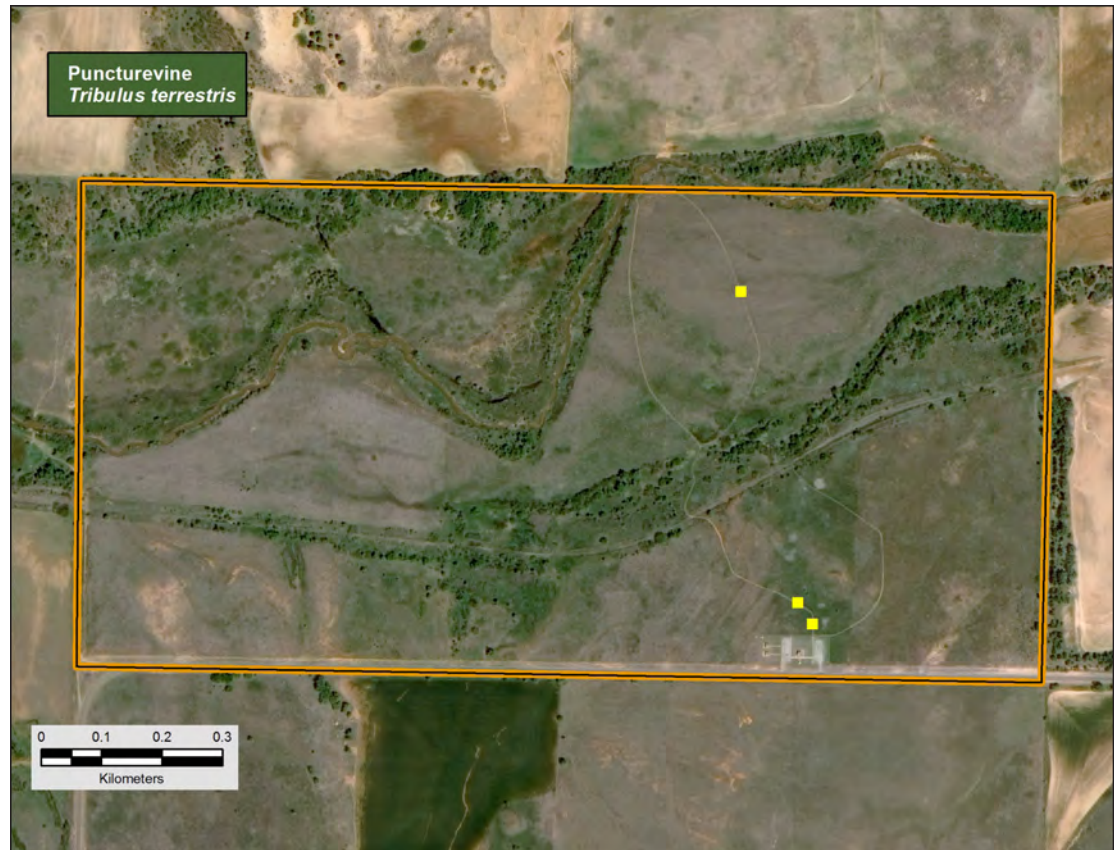


**Figure F-23.**  
Puncturevine  
(*Tribulus terrestris*)

## Appendix G: Background on Bird Species of Conservation Concern Lists

This appendix provides background information on the organizations and efforts to determine species of birds that are in need of conservation. The information presented here supports Section 4.11.2, Data and Methods, of the landbird 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 Wahsita Battlefield 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 myriad 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 and 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 Initiative 2012). 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.

### 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 Oklahoma*

Under Oklahoma law (29 Okl. St. Ann. 5-402, 412, 412.1), the State of Oklahoma,

through the Oklahoma Department of Wildlife Conservation (ODWC), maintains listings of species considered as threatened or endangered within the state, whether or not they are classified as federally threatened or endangered through the Endangered Species Act (ODWC 2012).

### ***USFWS Birds of Conservation Concern***

The USFWS has responsibilities for wildlife, including birds, in addition to endangered and threatened species. The Fish and Wildlife Conservation Act, as amended in 1988, further mandates that the USFWS “identify species, subspecies, and populations of all migratory nongame birds (i.e., Birds of Conservation Concern) that, without additional conservation actions, are likely to become candidates for listing under the Endangered Species Act” (USFWS 2008). The agency’s 2008 effort, *Birds of Conservation Concern*, is one effort to fulfill the Act’s requirements. The report includes both migratory and non-migratory bird species (beyond those federally-listed as threatened or endangered) that USFWS considers the highest conservation priorities. Three geographic scales are included— National, USFWS Regional, and the NABCI BCRs. The information used to compile the lists came primarily from the following three bird conservation plans: the Partners in Flight 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 Union for Conservation of Nature’s “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 Bird Conservation Regions (BCRs), the common planning unit under the North American Bird Conservation Initiative, 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.

#### *Oklahoma Species of Greatest Conservation Need*

The Oklahoma Wildlife Diversity Program and biologists from state wildlife agencies, avian conservation joint ventures, and the U.S. Fish and Wildlife Service and U.S. Forest Service developed bird conservation plans for Oklahoma's BCRs (ODWC 2011). The *North American Bird Conservation Initiative Planning for Oklahoma* report includes information for each of the six BCRs in the state, including regionally important bird species and their habitat needs, bird conservation opportunity areas, priority conservation actions, and regional habitat management recommendations. The report also presents lists of birds found in each of the six BCRs, including those birds considered species of greatest conservation need in Oklahoma.

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## Appendix H: Washita Battlefield NHS Bird List

Listed below is the full list of species reported to occur or have occurred at Washita Battlefield NHS. The sources did not provide information on residency and abundance classes for each species, but the ONHI Baseline Bird Inventory provided separate tables for the species detected in the spring/summer vs. the fall/winter.

| Common Name           | 2001-2002 ONHI Bird Inventory | 2009-2012 Surveys (RMBO) |
|-----------------------|-------------------------------|--------------------------|
| American Crow         | X                             | X                        |
| American Goldfinch    | X                             | X                        |
| American Kestrel      | X                             |                          |
| American Tree Sparrow | X                             |                          |
| Barn Swallow          |                               | X                        |
| Barred Owl            |                               | X                        |
| Bell's Vireo          | X                             |                          |
| Belted Kingfisher     |                               | X                        |
| Bewick's Wren         | X                             | X                        |
| Blue-gray Gnatcatcher | X                             | X                        |
| Blue Grosbeak         | X                             | X                        |
| Blue Jay              | X                             | X                        |
| Brown-headed Cowbird  | X                             | X                        |
| Brown Thrasher        | X                             | X                        |
| Bullock's Oriole      |                               | X                        |
| Canada goose          |                               | X                        |
| Carolina Chickadee    | X                             | X                        |
| Carolina Wren         |                               | X                        |
| Cassin's Sparrow      | X                             | X                        |
| Cedar Waxwing         |                               | X                        |
| Chimney Swift         |                               | X                        |
| Chipping Sparrow      |                               | X                        |
| Clay-colored Sparrow  |                               | X                        |
| Cliff Swallow         |                               | X                        |
| Common Grackle        | X                             | X                        |
| Common Nighthawk      |                               | X                        |
| Common Yellowthroat   |                               | X                        |
| Cooper's Hawk         |                               | X                        |
| Dark-eyed Junco       | X                             | X                        |

| Common Name                   | 2001-2002 ONHI Bird Inventory | 2009-2012 Surveys (RMBO) |
|-------------------------------|-------------------------------|--------------------------|
| Dickcissel                    | X                             | X                        |
| Downy Woodpecker              | X                             | X                        |
| Eastern Bluebird              | X                             | X                        |
| Eastern Meadowlark            | X                             | X                        |
| Eastern Kingbird              |                               | X                        |
| Eastern Phoebe                | X                             | X                        |
| Field Sparrow                 | X                             | X                        |
| Grasshopper Sparrow           | X                             | X                        |
| Great Blue Heron              |                               | X                        |
| Great Crested Flycatcher      | X                             | X                        |
| Great Egret                   |                               | X                        |
| Great Horned Owl              | X                             | X                        |
| Greater Roadrunner            | X                             |                          |
| Great-tailed Grackle          |                               | X                        |
| Green Heron                   | X                             | X                        |
| Hairy Woodpecker              | X                             | X                        |
| Harris's Sparrow              | X                             |                          |
| House Sparrow                 | X                             |                          |
| House Wren                    |                               | X                        |
| Indigo Bunting                | X                             | X                        |
| Killdeer                      | X                             | X                        |
| Lark Bunting                  |                               | X                        |
| Lark Sparrow                  | X                             | X                        |
| Lesser Goldfinch              |                               | X                        |
| Lincoln's Sparrow             |                               | X                        |
| Loggerhead Shrike             | X                             |                          |
| Mallard                       | X                             |                          |
| Mississippi Kite              |                               | X                        |
| Mourning Dove                 | X                             | X                        |
| Northern Bobwhite             | X                             | X                        |
| Northern Cardinal             | X                             | X                        |
| Northern Flicker              | X                             | X                        |
| Northern Mockingbird          |                               | X                        |
| Northern Rough-winged Swallow |                               | X                        |
| Painted Bunting               |                               | X                        |
| Pileated Woodpecker           |                               | X                        |

| Common Name               | 2001-2002 ONHI Bird Inventory | 2009-2012 Surveys (RMBO) |
|---------------------------|-------------------------------|--------------------------|
| Purple Martin             |                               | X                        |
| Red-bellied Woodpecker    | X                             | X                        |
| Red-headed Woodpecker     | X                             | X                        |
| Red-tailed Hawk           |                               | X                        |
| Red-winged Blackbird      | X                             | X                        |
| Ring-necked Pheasant      |                               | X                        |
| Ruby-throated Hummingbird |                               | X                        |
| Savannah Sparrow          |                               | X                        |
| Scissor-tailed Flycatcher | X                             | X                        |
| Song Sparrow              | X                             |                          |
| Spotted Towhee            | X                             |                          |
| Summer Tanager            | X                             |                          |
| Swainson's Hawk           | X                             | X                        |
| Tree Swallow              |                               | X                        |
| Tufted Titmouse           |                               | X                        |
| Turkey Vulture            |                               | X                        |
| Upland Sandpiper          | X                             |                          |
| Western Kingbird          | X                             | X                        |
| Western Meadowlark        | X                             | X                        |
| White-crowned Sparrow     | X                             | X                        |
| White-throated Sparrow    | X                             |                          |
| Wild Turkey               | X                             | X                        |
| Yellow-billed Cuckoo      | X                             | X                        |
| Yellow-headed Blackbird   |                               | X                        |
| Yellow-rumped Warbler     |                               | X                        |
| Yellow Warbler            |                               | X                        |



# Appendix I: Bird Distribution Status

The distribution status of species that have occurred at Washita Battlefield NHS (reported in 2001-2002 and 2009-2012 surveys) was determined using Birds of North America species accounts as a general reference.

Comparisons with reference conditions were made primarily for species for which the NHS was within 100 miles or closer of the primary breeding range.

| Common Name           | Range Status                                                           |
|-----------------------|------------------------------------------------------------------------|
| American Crow         | Breeding and Wintering                                                 |
| American Goldfinch    | Outside Normal Breeding Range <sup>1</sup> (but in Non-breeding Range) |
| American Kestrel      | Breeding and Wintering                                                 |
| American Tree Sparrow | Outside Normal Breeding Range (but in Non-breeding Range)              |
| Barn Swallow          | Breeding                                                               |
| Barred Owl            | Outside Normal Breeding Range <sup>1</sup>                             |
| Bell's Vireo          | Breeding                                                               |
| Belted Kingfisher     | Year-round                                                             |
| Bewick's Wren         | Year-round                                                             |
| Blue-gray Gnatcatcher | Breeding                                                               |
| Blue Grosbeak         | Breeding                                                               |
| Blue Jay              | Year-round                                                             |
| Brown-headed Cowbird  | Year-round                                                             |
| Brown Thrasher        | Breeding                                                               |
| Bullock's Oriole      | Breeding                                                               |
| Canada goose          | Outside Normal Breeding Range <sup>1</sup> (and Wintering)             |
| Carolina Chickadee    | Year-round                                                             |
| Carolina Wren         | Outside Normal Breeding Range <sup>1</sup>                             |
| Cassin's Sparrow      | Breeding                                                               |
| Cedar Waxwing         | Wintering                                                              |
| Chimney Swift         | Breeding                                                               |
| Chipping Sparrow      | Outside Normal Breeding Range (and at edge of Wintering)               |
| Clay-colored Sparrow  | Outside Normal Breeding Range                                          |
| Cliff Swallow         | Breeding                                                               |
| Common Grackle        | Year-round                                                             |
| Common Nighthawk      | Breeding                                                               |
| Common Yellowthroat   | Outside Normal Breeding Range <sup>1</sup>                             |

<sup>1</sup> Within 100 miles of breeding range edge.

<sup>2</sup> Outside primary breeding range but known to breed in area of NHS on occasion.

| Common Name              | Range Status                                              |
|--------------------------|-----------------------------------------------------------|
| Cooper's Hawk            | Year-round                                                |
| Dark-eyed Junco          | Wintering                                                 |
| Dickcissel               | Breeding                                                  |
| Downy Woodpecker         | Year-round                                                |
| Eastern Bluebird         | Year-round                                                |
| Eastern Meadowlark       | Year-round                                                |
| Eastern Kingbird         | Breeding                                                  |
| Eastern Phoebe           | Breeding                                                  |
| Field Sparrow            | Year-round                                                |
| Grasshopper Sparrow      | Breeding                                                  |
| Great Blue Heron         | Year-round                                                |
| Great Crested Flycatcher | Breeding                                                  |
| Great Egret              | Outside Normal Breeding Range <sup>1</sup>                |
| Great Horned Owl         | Year-round                                                |
| Greater Roadrunner       | Year-round                                                |
| Great-tailed Grackle     | Breeding and Wintering                                    |
| Green Heron              | Breeding (just on edge)                                   |
| Hairy Woodpecker         | Year-round                                                |
| Harris's Sparrow         | Outside Normal Breeding Range (but in Non-breeding Range) |
| House Sparrow            | Breeding                                                  |
| House Wren               | Breeding                                                  |
| Indigo Bunting           | Breeding                                                  |
| Killdeer                 | Breeding and Wintering                                    |
| Lark Bunting             | Outside Normal Breeding Range <sup>1</sup>                |
| Lark Sparrow             | Breeding                                                  |
| Lesser Goldfinch         | Outside Primary Breeding Range <sup>2</sup>               |
| Lincoln's Sparrow        | Wintering                                                 |
| Loggerhead Shrike        | Year-round                                                |
| Mallard                  | Breeding and Wintering                                    |
| Mississippi Kite         | Breeding                                                  |
| Mourning Dove            | Year-round                                                |
| Northern Bobwhite        | Breeding and Wintering                                    |
| Northern Cardinal        | Year-round                                                |
| Northern Flicker         | Year-round                                                |

<sup>1</sup> Within 100 miles of breeding range edge.

<sup>2</sup> Outside primary breeding range but known to breed in area of NHS on occasion.

| Common Name                   | Range Status                                              |
|-------------------------------|-----------------------------------------------------------|
| Northern Mockingbird          | Year-round                                                |
| Northern Rough-winged Swallow | Breeding                                                  |
| Painted Bunting               | Breeding                                                  |
| Pileated Woodpecker           | Outside Normal Breeding Range                             |
| Purple Martin                 | Breeding                                                  |
| Red-bellied Woodpecker        | Year-round                                                |
| Red-headed Woodpecker         | Breeding and Wintering                                    |
| Red-tailed Hawk               | Year-round                                                |
| Red-winged Blackbird          | Year-round                                                |
| Ruby-throated Hummingbird     | Outside Normal Breeding Range <sup>1</sup>                |
| Savannah Sparrow              | Outside Normal Breeding Range (but in Non-breeding Range) |
| Scissor-tailed Flycatcher     | Breeding                                                  |
| Song Sparrow                  | Wintering                                                 |
| Spotted Towhee                | Wintering                                                 |
| Summer Tanager                | Outside Normal Breeding Range                             |
| Swainson's Hawk               | Breeding                                                  |
| Tree Swallow                  | Wintering                                                 |
| Tufted Titmouse               | Outside Normal Breeding Range <sup>1</sup>                |
| Turkey Vulture                | Breeding                                                  |
| Upland Sandpiper              | Outside Normal Breeding Range                             |
| Western Kingbird              | Breeding                                                  |
| Western Meadowlark            | Year-round                                                |
| White-crowned Sparrow         | Wintering                                                 |
| White-throated Sparrow        | Wintering                                                 |
| Wild Turkey                   | Year-round                                                |
| Yellow-billed Cuckoo          | Breeding                                                  |
| Yellow-headed Blackbird       | Outside Normal Breeding Range <sup>1</sup>                |
| Yellow-rumped Warbler         | Edge of wintering range                                   |
| Yellow Warbler                | Breeding                                                  |

<sup>1</sup> Within 100 miles of breeding range edge.

<sup>2</sup> Outside primary breeding range but known to breed in area of NHS on occasion.



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**Natural Resource Stewardship and Science**

1201 Oak Ridge Drive, Suite 150  
Fort Collins, Colorado 80525

[www.nature.nps.gov](http://www.nature.nps.gov)

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