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Chickasaw National Recreation Area

Natural Resource Condition Assessment

Natural Resource Report NPS/SOPN/NRR—2016/1137



ON THE COVER

Waterfall at Travertine Creek in Chickasaw NRA. Heidi Sosinski

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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 Chickasaw National Recreation Area began in 2014, and 13 focal study natural resources were chosen for the park'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.

The landscape scale resources chosen for this assessment included viewshed, night sky, and soundscape. All of these resources were in moderate condition, given the fact that the park is adjacent to the City of Sulphur, Oklahoma and several roads, including state highways.

The park's supporting physical environment resource topics included air quality, geology, groundwater, springs, and surface water quality. The condition for each of these resources varied between moderate for geology, and significant concern for air quality, groundwater and springs, and surface water quality since Lake of the Arbuckles is included on the State of Oklahoma's (2014) 303(d) list of impaired water waterbodies.

The biological integrity resources assessed included grasslands, riparian habitat, and exotic plants for vegetation and landbirds, game species and feral mammals for wildlife. The vegetation resources were in good condition, although exotic plants were considered to be of significant concern. The wildlife conditions ranged from good for landbirds, moderate to significant concern for feral mammals and unknown for game species.

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

NRCAs Strive to Provide…

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

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

Important NRCA Success Factors

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

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

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

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



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

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

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

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

NRCA Reporting Products…

- Provide a credible, snapshot-in-time evaluation for a subset of important park natural resources and indicators, to help park managers:
- Direct limited staff and funding resources to park areas and natural resources that represent high need and/or high opportunity situations (near-term operational planning and management)
- Improve understanding and quantification for desired conditions for the park's "fundamental" and "other important" natural resources and values (longer-term strategic planning)
- Communicate succinct messages regarding current resource conditions to government program managers, to Congress, and to the general public ("resource condition status" reporting)

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

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

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

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



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

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

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



MARK BRUNSON

Boating is a popular recreation at Lake of the Arbuckles.

Chapter 2: Introduction and Resource Setting

2.1. Introduction

2.1.1. Enabling Legislation/Executive Orders

Chickasaw National Recreation Area (NRA) was authorized by an act of Congress on March 17, 1976 (Public Law 94-235, NPS 2008). The unique freshwater and mineral springs for which Chickasaw is well known for were first protected as Sulphur Springs Reservation in 1902 through the efforts of the Chickasaw and Choctaw Native American tribal units who recognized threats to these unique resources. The area was redesignated as Platt National Park in 1906, encompassing less than 364 hectares (900 acres), which was the smallest National Park in the United States at the time (NPS 2011a). In 1976, the Arbuckle District was added to Platt National Park, creating today's Chickasaw National Recreation Area.

Park Purpose

The national recreation area was established to protect the unique natural resources, preserve areas of cultural interest, provide outdoor recreation opportunities, protect scenic, scientific, natural, and historic values, and to memorialize the Chickasaw Indian Nation (NPS 2008).

Wray and Roberts (2004) state, "In order to understand the importance of Chickasaw, one must understand the attributes of the water. It is within the waters that the park's sacred and revitalizing qualities emanate, and from numerous springs that the park's major significance flows (p. 24)."

Park Significance

The significance statements for Chickasaw National Recreation Area include:

- *"Chickasaw National Recreation Area contains mineral and fresh water, which comes from one of the most complex geological and hydrological features in the United States.*
- *The cultural landscape of the Platt National Park Historic District in*

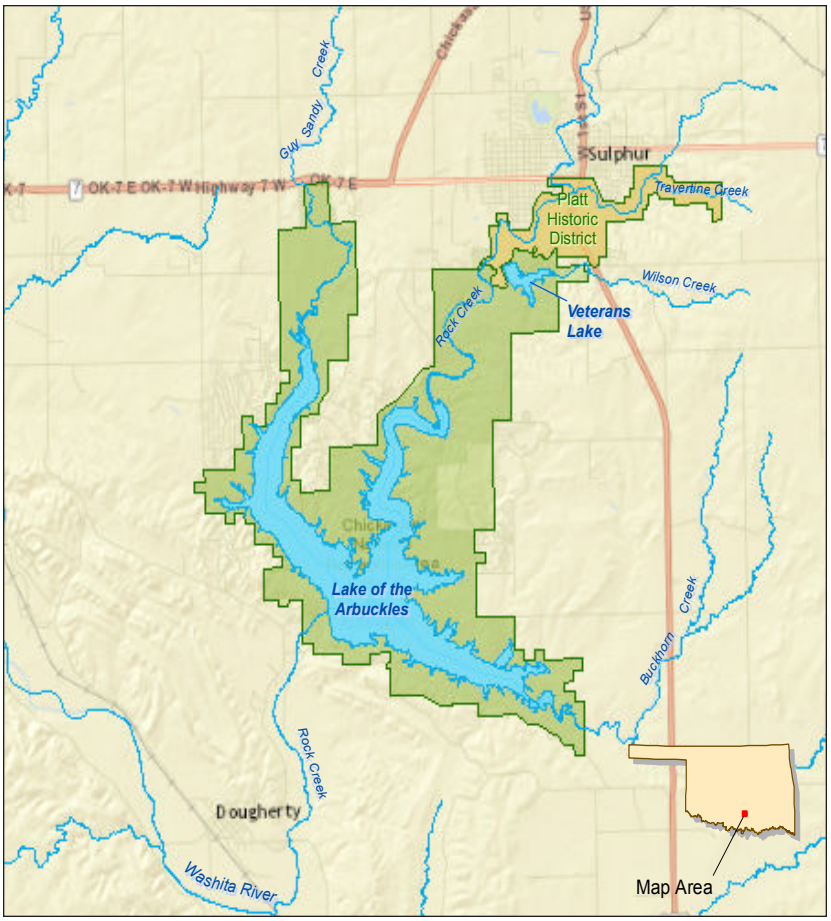


Figure 2.1.2-1. Setting of Chickasaw NRA in Sulphur, Oklahoma.

Chickasaw National Recreation Area reflects the primary era of 1933–1940, when the Civilian Conservation Corps implemented National Park Service "rustic" designs. This is one of the most intact landscapes of that period.

- *Recreational opportunities are available to experience a wide range of outdoor activities — swimming, boating, fishing, hiking, observing nature, hunting, camping, bicycling, horseback riding, family reunions, and picnicking — all of which remind us of the rural character in the history of the American people.*
- *Chickasaw National Recreation Area is home to a transition zone where the eastern deciduous forest meets the western prairies, which is unique to the central part of the United States (NPS 2008, p. 6)."*

2.1.2. Geographic Setting

The NRA is situated in south-central Oklahoma between Dallas, Texas and Oklahoma City, Oklahoma (Figure 2.1.2-1). The national recreation area includes 4,006 hectares (9,899 acres), and Lake of the Arbuckles encompasses almost 32% of the total park area (NPS 2008).

The park is situated within an area of Oklahoma characterized by complex geology. The geologic processes that resulted in major faulting, folding, uplifting and erosion have shaped the surrounding landscape into gently rolling hills, with streams and springs that were used and home to several Native American tribes and nations for the past 7,000 years (NPS 1999) and have attracted millions of visitors to the area throughout history for drinking and medicinal purposes (NPS 2008).

Climate

Chickasaw lies in a transition zone where the Eastern deciduous forest, eastern plains and the western prairies meet. From prehistoric times to the present, access to the combination of cool water, mineral springs, cool breezes, shade, and wildlife has created an experience that sets it apart from the surrounding environment (NPS 2008).

The park is located in the Great Plains ecoregion, characterized by highly variable and stormy weather patterns. Moist air masses from the Pacific Ocean lose their moisture over the Rocky Mountains, causing precipitation over the mountains and drier conditions on the leeward side. These drier conditions result in the short-grass ecosystem of the western plains. As these air masses continue across the broad, flat plain, they experience increasing interaction with arctic air masses from the north and more humid air masses to the east. The increased precipitation in these areas supports the mixed-grass prairie of the central plains and the tall-grass prairie of the eastern plains (Davey et al. 2007).

Temperature

The general temperature gradient in the area is from cooler temperatures in the northwest to warmer temperatures in the southeast. Winter temperatures generally follow a northwest-southeast gradient across the Great Plains. The El Niño-Southern Oscillation (ENSO) causes inter-annual climate variations. El Niño conditions (warm ENSO phases) are

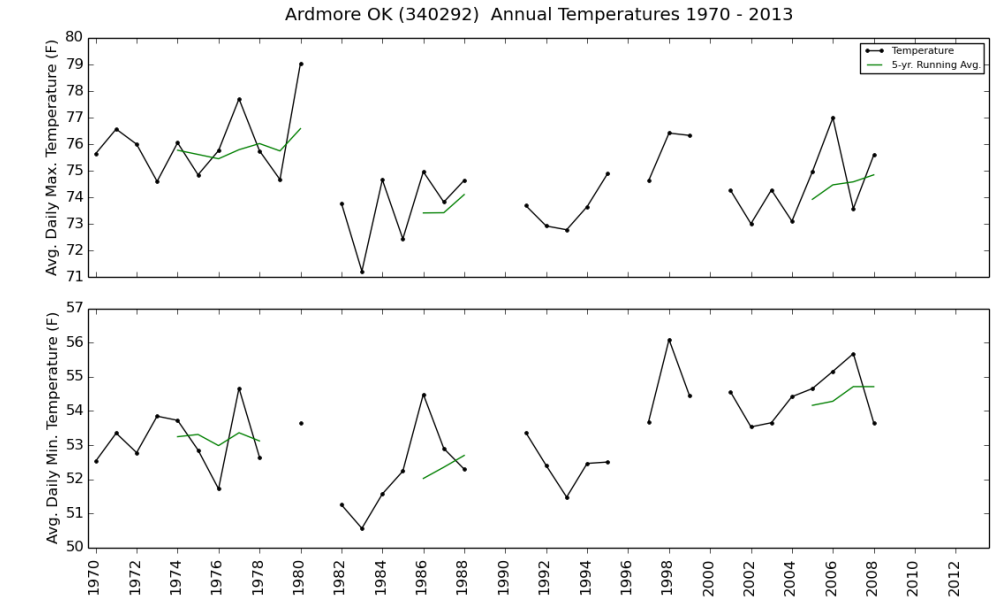


Figure 2.1.2-2. Trends in the average daily temperatures annually from 1970-2013, recorded at Ardmore, OK (www.climateanalyzer.org).

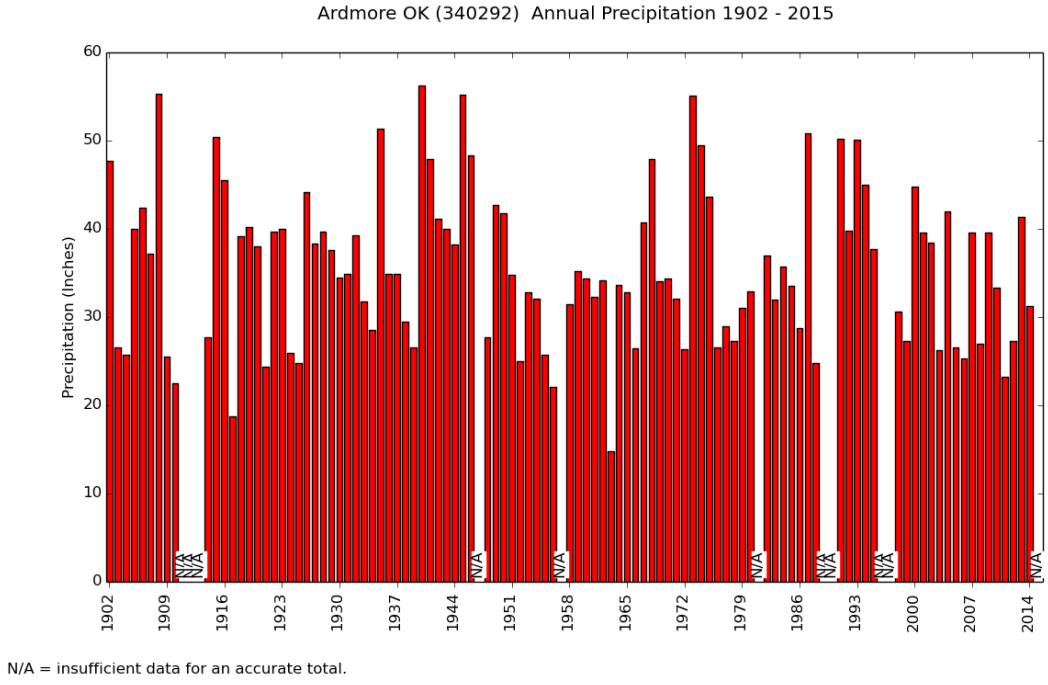


Figure 2.1.2-3. Annual precipitation, 1902-2015 (www.climateanalyzer.org).

associated with cooler, wetter conditions while La Niña conditions (cool ENSO phases) are associated with warmer, drier conditions (Davey et al. 2007).

On average, the warmest month at Chickasaw is August; the highest recorded temperature was 112°F in 2011. On average, the coolest month is January; the lowest recorded temperature was -11°F in 1989 (Figure 2.1.2-2).

Precipitation

Precipitation generally increases to the east, and the maximum average precipitation occurs in May. Precipitation varies from about 25 to 55 inches of rain a year (Figure 2.1.2-3).

2.1.3. Visitation Statistics

Monthly visitation data for the NRA were available for 1979-2014. Although there has been substantial monthly variation by year, the months receiving the greatest average

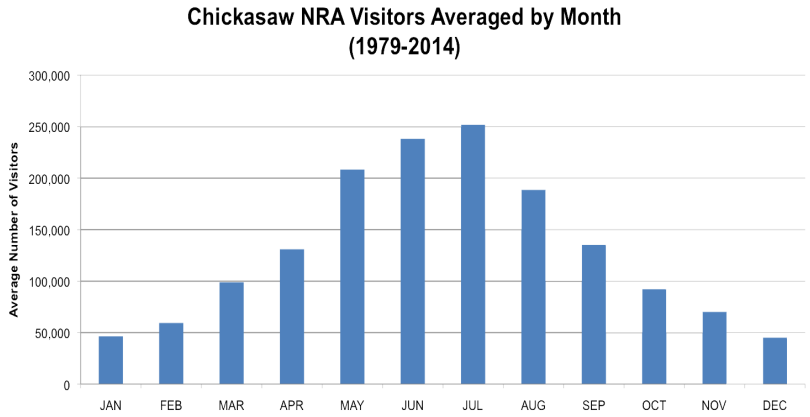


Figure 2.1.3-1. Average number of visitors to Chickasaw NRA by month, 1979-2014.

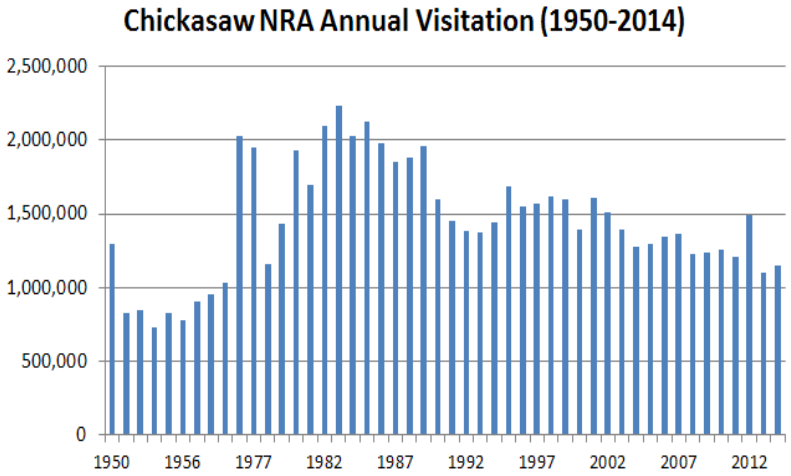


Figure 2.1.3-2. Average number of visitors to Chickasaw NRA by month, 1950-2014.

number of visitors over the recording period were May, June, and July (Figure 2.1.3-1). The total number of visitors each year ranged from 729,895 (in 1953) to 2,238,456 (in 1983). The number of visitors in 2014 was 1,152,083 (Figure 2.1.3-2) (NPS Public Use Statistics Office 2015).

2.2. Natural Resources

The natural resource topic summaries in this section are intended to be brief, providing a general overview. Detailed information can be found in the Chapter 4 condition assessments.

2.2.1. Ecological Units and Watersheds

The NRA lies within the Arbuckle Mountains geographic region and the Red River drainage basin. The park is located in the Middle Washita subbasin (HUC, 11130303) draining an area of 6,496 km^2 (2,508 miles^2) and within the Lake of the Arbuckles watershed, encompassing an area of 358.5 km^2 (138 miles^2) (Figure 2.2.1-1) (USGS 2014).

2.2.2. Resource Descriptions

The transition zone between the eastern deciduous forest and the western prairie creates a unique assemblage of flora and fauna that is supported by the water and geological resources that characterize the park and area surrounding it.

Hydrology

The presence of the mineral and freshwater springs is one of the primary reasons for the establishment of the park. The number of springs have varied throughout the years and some have completely ceased flowing. Numerous wells throughout the area were drilled in the 1920s -1930s, with many providing continuous artesian flows (NPS 1999). Vendome Well is one of the better known artesian wells and is still in existence today.

The springs are fed by the Arbuckle- Simpson aquifer, which has been extensively studied by the United States Geological Survey, Oklahoma Water Resources Board and the National Park Service (NPS 2011a). The geology of the Arbuckle-Simpson aquifer is characterized by great thicknesses of mostly carbonate rocks, uplifts, folded structures, and large fault displacements." (Christenson et al, 2011).

The two largest bodies of water in the NRA are Lake of the Arbuckles and Veterans Lake, the former of which is a reservoir and provides drinking water supplies for the park as well as several towns throughout the region (Hanson and Cates 1994). Guy Sandy, Rock, and Buckhorn Creeks provide inflow to Arbuckle Lake. Travertine Creek is a tributary to Rock Creek, and Wilson Creek feeds Veterans Lake. (Porter et al. 2010).

Geology and Soils

The Arbuckle Mountains were created by a geologic folding process, which were later covered by thousands of feet of sedimentary

deposits consisting of sandstones, shales, and conglomerates. These layers comprise the Vanoss Group and Ada Formation. Soils throughout the park can be classified into two general categories: upland and lowland. The upland soils are generally deep, gently to strongly sloping and moderately well drained. The soils along Guy Sandy and Rock Creeks, comprise the lowland soils and are typically deep, gently sloping and moderately well drained.

Air Quality

Different categories of air quality areas have been established through the authority of the Clean Air Act (CAA) of 1970: Class I and II. Like most National Park Service areas, the NRA is designated as a Class II airshed. 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 2012).

Vegetation

Mixed grasslands and oak forests cover a large portion of the upland areas, while riparian vegetation dominates the lowlands (USDI NPS 2008). In 2006, 29 distinct vegetation types based on species composition, structure, and environmental characteristics were classified and mapped for the park (Salas et al. 2010). Five classifications are considered to be local to the park only (Salas et al. 2010).

Wildlife

Birds

There have been a total of 122 bird species reported at Chickasaw NRA from the 2003-2004 Oklahoma Natural Heritage Inventory inventory and/or the 2009-2013 Rocky Mountain Bird Observatory point-count surveys. Of these, 21 are listed as species of conservation concern on one or more of the conservation lists described in Section 4.12.2.

Mammals

An inventory of mammals was conducted by the Oklahoma Natural Heritage Inventory for the park in 2003-2004. During the inventory, Kelly et al. (2004) recorded a total of 23 mammal species, primarily native wildlife.

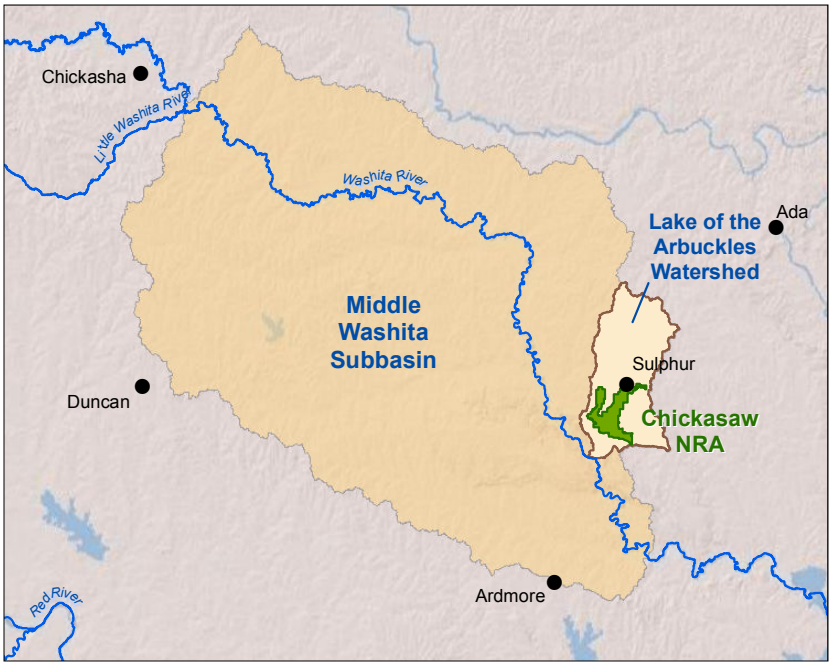


Figure 2.2.1-1. Chickasaw NRA is located within the Lake of the Arbuckles watershed, which encompasses an area of 358.5 km² (138 miles²).

Game Species

Hunting is allowed throughout certain areas of the park and is managed as a distinct wildlife management area of the Oklahoma Department of Wildlife Conservation. A variety of game species are open to hunting, including upland game (deer (*Odocoileus virginianus*)), upland game birds (dove (*Zenaida macroura*), turkey (*Meleagris gallopavo*) and bobwhite quail (*Colinus virginianus*)), waterfowl (Canada goose (*Branta canadensis*), wood duck (*Aix sponsa*), and mallard (*Anas platyrhynchos*)), and small game and furbearers (fox squirrel (*Sciurus niger*), cottontail rabbit (*Sylvilagus floridanus*), coyote (*Canis latrans*), bobcat (*Lynx rufus*), and raccoon (*Procyon lotor*)).

2.2.3. Resource Issues Overview

Drought

Drought is common in this region, and the area near Chickasaw has experienced drier than normal years regularly since 1996. Although, 2001 and 2007 were relatively wet

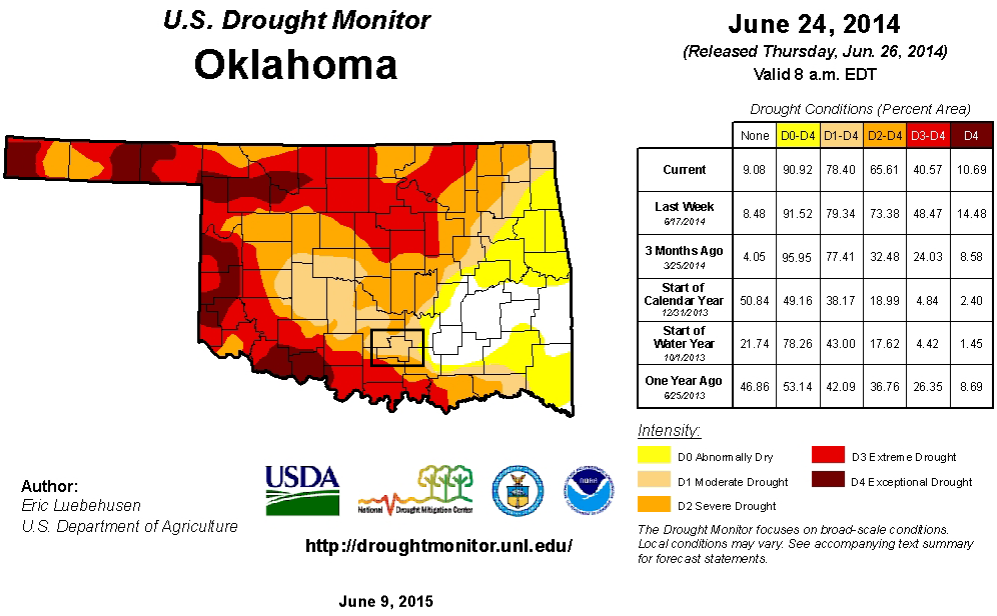


Figure 2.2.3-1. The U.S. Drought Monitor for Oklahoma indicates that most of the state was experiencing abnormally dry to moderate extreme drought conditions less than a year ago (June 26, 2014) (top figure). Now, in June 2015, with recent spring rains, only a few areas in Oklahoma's panhandle are abnormally dry (bottom figure). Boxes show the county where the park is located.

(http://droughtmonitor.unl.edu/Home/StateDroughtMonitor.aspx?OK, accessed June 9, 2015)

years. Only one year ago, Oklahoma was experiencing an abnormally dry to extreme drought phase. Now, with recent rains during the spring of 2015, only a few areas in Oklahoma's panhandle are abnormally dry (Figure 2.2.3-1).

Climate Change

The impact of global climate change may be exacerbated in the southern plains due to the region's periodic droughts and the large number of habitat specialists (Davey et al. 2007). Chickasaw NRA may be more resilient to these changes, being on the edge of two ecosystems, allowing for greater movement and adaptation to changing conditions. The primary resources at the NRA are the waters—lakes, streams, and springs. As the climate shifts and temperatures rise and drought becomes more persistent and extreme, these water sources could be endangered.

Monahan and Fisichelli (2014) assessed the magnitude and direction of changes in climate for Chickasaw for 25 variables including temperature and precipitation between 1901-2012 (historical range of variability (HRV)). Results for extreme climate were defined as experiencing either <5th percentile or >95th percentile climates relative to the HRV. The results for the extreme climate variables at the park were as follows:

- Two temperature variables were "extreme warm" (annual mean temperature, mean temperature of the warmest quarter).
- No temperature variables were "extreme cold."
- No precipitation variables were "extreme dry."
- No precipitation variables were "extreme wet."

The results for the temperature of each year between 1901-2012, the averaged temperatures over progressive 10-year intervals, and the average temperature of 2003-2012 (the most recent interval) are shown in Figure 2.2.3-2.

The results indicate that recent climate conditions have already begun shifting beyond the HRV, with the 2003-2012 decade representing the warmest decade on record. Overall, it's likely that future climate change will increasingly affect all aspects of park

resources and operations (Monahan and Fisichelli 2014).

Exotic Plants

A total of 94 species of exotic plants have been recorded in the recreation area (Folts-Zettner 2014). Some of these plants have the ability to change the ecosystem structure, alter nutrient cycles, and soil chemistry, especially when the prevalence of these species is high.

Feral Mammals

The NPSpecies mammals list for the park (NPS 2014) indicates that the feral/domestic cat is abundant in the park, and while feral hogs were not included in the NPSpecies list, they are present in the southern area of the NRA.

Cats can negatively impact native wildlife populations such as birds and rodents and feral hogs can cause extensive damage to soils, vegetation and other wildlife species as well.

Additional Threats

Additional threats facing the park that were identified during the Inventory and Monitoring vital signs development included erosion along lakes and streams, visitor effects on natural resources, groundwater withdrawals, and adjacent land-use practices (USDI NPS 2008)." The city of Sulphur, Oklahoma operates a city sewage treatment plant within the park's boundary along the west bank of Rock Creek, posing a pollution risk to park and surrounding surface waters. Residential developments and ranch lands that surround the park also pose the risk of contamination from chemical run-off and land use changes.

2.3. Resource Stewardship

2.3.1. Management Directives and Planning Guidance

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

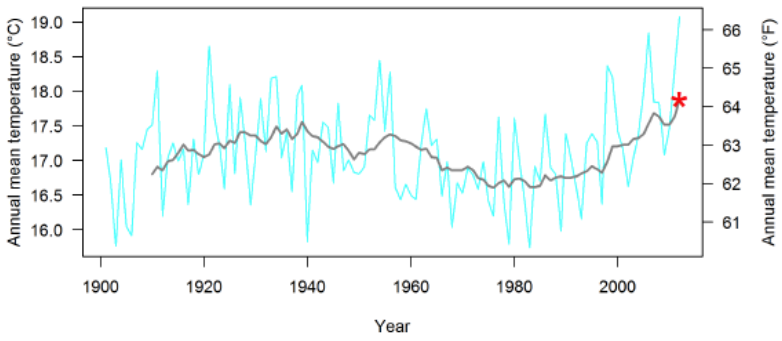


Figure 2.2.3-2. Time series used to characterize the historical range of variability and most recent percentile for annual mean temperature at Chickasaw National Recreation Area (including areas within 30-km [18.6-mi] of the park's boundary). The blue line shows temperature for each year, the gray line shows temperature averaged over progressive 10-year intervals (10-year moving windows), and the red asterisk shows the average temperature of the most recent 10-year moving window (2003–2012). The most recent percentile is calculated as the percentage of values on the gray line that fall below the red asterisk (excerpted from Monahan and Fisichelli 2014).

SOPN Program

In an effort to improve overall national 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 2011b). 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

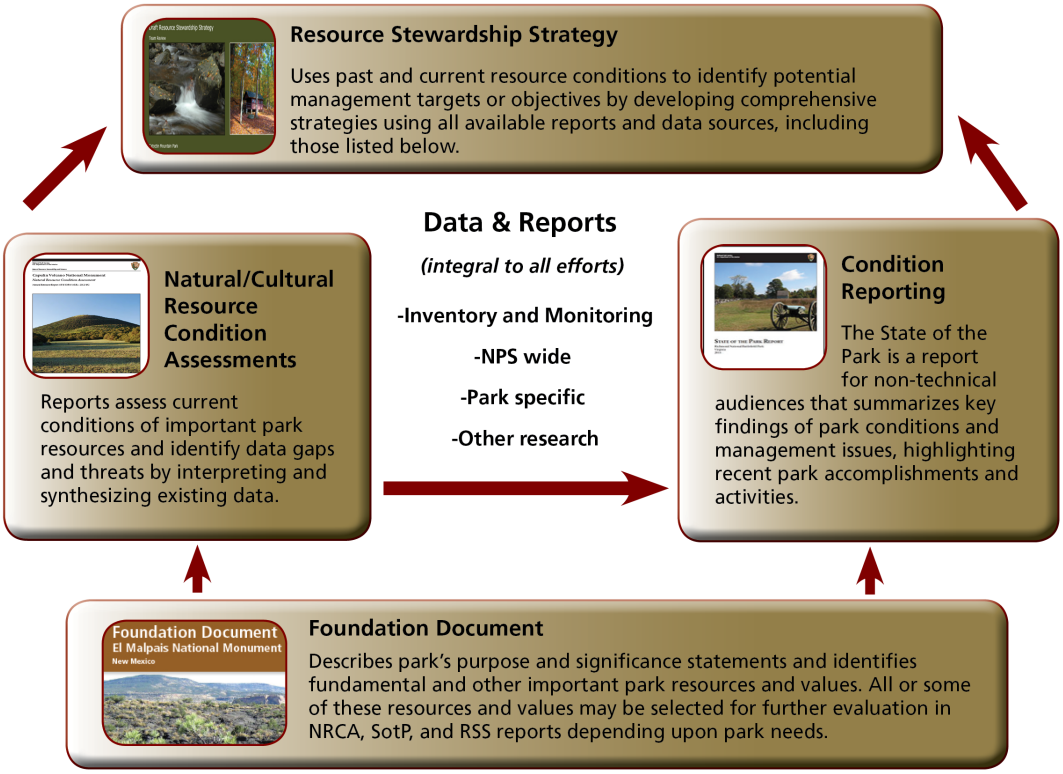


Figure 2.3.1-1. The diagram shows the relationship of NRCAs to other park planning reports.

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 2011b).

To facilitate this effort, 270 parks with significant natural resources were organized into 32 regional networks. Chickasaw NRA is part of the SOPN, which also includes 10 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. Inventories on a wide variety of natural resource topics have been completed, and long-term monitoring programs are currently underway. SOPN annually monitors and/or coordinates the monitoring of exotic plants, grasslands, and landbirds at Chickasaw.

Park Planning Reports

Natural Resource Condition Assessments

The structural framework for NRCAs is based upon, but not restricted to, the fundamental and other important values identified in a park's Foundation Document or General Management Plan. NRCAs are designed to deliver current science-based information translated into resource condition findings for a subset of a park's natural resources. The NPS State of the Park (SotP) and Resource Stewardship Strategy (RSS) reports rely on credible information found in NRCAs as well as a variety of other sources. Figure 2.3.1-1 shows the relationships between the larger reporting efforts that are developed for parks.

Foundation Document

Foundation Documents describe a park's purpose and significance and identify fundamental and other important park resources and values. A foundation document

hasn't been completed for Chickasaw at this time.

State of the Park
A State of the Park (SotP) report is intended for non-technical audiences and summarizes key findings of park conditions and management issues, highlighting recent park accomplishments and activities. NRCA condition findings are used in SotP reports, and the NRCA's Chapter 5 includes a SotP condition summary for the natural resources assessed.

Resource Stewardship Strategy
A Resource Stewardship Strategy (RSS) uses past and current resource conditions to identify potential management targets or objectives by developing comprehensive strategies using all available reports and data sources including NRCAs. National Parks are encouraged to develop an 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.

2.3.2. Status of Supporting Science
Available data and reports for this NRCA varied significantly depending upon the resource topic. The existing data used for each indicator to assess condition or to develop reference conditions are described in each indicator summary in Chapter 4. In addition to data from the SOPN and research by other scientists and programs, subject matter experts, including Chief of Resource Management Noel Osborn, who provided a significant amount of information pertaining to all resource topics, especially groundwater and geology. Washington level programs, including night sky, soundscape, water-related topics, and air quality also provided a wealth of information that was used in this NRCA.

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MARK BRUNSON

Soundscape monitoring site at Catfish Bottoms, Chickasaw NRA.

Chapter 3: Study Scoping and Design

This NRCA is a collaborative project between the Chickasaw NRA staff and the SOPN Network, all of the NPS. Stakeholders in this project include the National Recreation Area's natural resource managers, 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 National Recreation Area natural resources that were identified and agreed upon by the project team during the scoping session. Project findings will aid National Recreation Area staff in the following objectives:

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

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

3.1. Preliminary Scoping

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

These meetings and discussions focused on:

1. Confirming the purpose of the National Recreation Area and its related significance statements and related values as they relate to the chosen NRCA topics
2. Identifying important natural and cultural resources and concerns for each topic
3. Identifying data sources and gaps for each resource topic.

Certain constraints are placed NRCAs, 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 lists the chosen resources and the degree of assessment (e.g., full or limited) based upon existing data and information (refer to Table 3.2.1-1).

Specific project expectations and outcomes included the following:

- For key natural resource components, consolidate available National Recreation Area data, reports, and spatial information from appropriate sources including: National Recreation Area 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 topics 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 National Recreation Area or controlled directly by National Recreation Area management activities (e.g., viewshed condition). There are important stressors that impact key natural resource components in the National Recreation Area but are not under NPS jurisdiction.

National Recreation Area natural resource staff participated in an on-site meeting and reviewed interim and final products. National Recreation Area staff, I&M staffs, and writer/editors data mined information for each of their assigned resource topic(s).

3.2. Study Design

3.2.1. Indicator Framework, Focal Study Resources and Indicators

The National Recreation Area'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 topics 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 purposes of this NRCA, 14 key National Recreation Area 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 National Recreation Area, 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. 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 National Recreation Area resources was unknown, an attempt was made to include a qualitative framework to provide some context for interpreting condition.

3.2.2. Reporting Areas

The reporting area was treated as one unit and encompassed the entire acreage within the

Table 3.2.1-1. Chickasaw NRA Natural Resource Condition Assessment Framework

Resource	Assessment Level	Indicators and Measures
I. Landscape Condition Context		
Viewshed	Full Assessment	• Scenic and Historic Integrity (2 Measures)
Night Sky	Full Assessment	• Sky Brightness (Anthropogenic Light Ratio)
Soundscape	Full Assessment	• Audibility (% Time Audible) • Sound Level (2 Measures)
II. Supporting Environment		
Air Quality	Full Assessment	• Visibility • Level of Ozone • Atmospheric Wet Deposition in Total N and Total S
Geology	Limited Assessment	• Travertine Deposits (1 measure) • Vanoss Formation (1 measure) • Paleontological Resources (1 measure) • Seismic Activity (1 measure) • Disturbed lands (1 measure)
Surface Water Quality	Full Assessment	• Field Properties (5 measures) • *E. coli* (1 measure)
Groundwater and Springs	Full Assessment	• Springflow (2 measures) • Streamflow (2 measures) • Groundwater Head (2 measures)
III. Biological Integrity		
Vegetation		
Riparian Habitat	Full Assessment	• Hydrology (5 indicators) • Vegetation (7 indicators) • Erosion/Deposition (5 indicators)
Grasslands	Full Assessment	• Hydrology Soil/Site Stability and Hydrologic Function (10 Indicators) • Biotic integrity (5 indicators)
Exotic Plants	Full Assessment	• Potential to Alter Native Plant Communities (1 measure) • Prevalence of Exotic Plants (3 measures)
Wildlife		
Breeding Landbirds	Full Assessment	• Species Occurrence (Temporal. Spatial, and Conservation Context)
Feral Mammals	Limited Assessment	• Species Occurrence (Presence/Absence)
Game Species	Limited Assessment	• None

National Recreation Area's boundary unless otherwise noted in a specific resource topic section. Due to the nature of some of the focal study resources, areas outside of the National Recreation Area's boundary were assessed to determine overall condition within the National Recreation Area (e.g., viewshed, air quality, night sky, etc.).

3.2.3. General Approach and Methods

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

Data Mining

Data and literature were found in multiple forms: NPS reports and monitoring plans (National Recreation Area, regional, and national levels), 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 National Recreation Area, the and SOPN staff, and by the Natural Resource Program Center. Data and literature acquired throughout the data mining process were inventoried and analyzed for thoroughness, relevancy, and quality pertaining to the indicators identified in the project framework. All reasonably accessible and relevant data were used to conduct this assessment.

Subject Matter Experts

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

Data Analyses and Development

Data analyses 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 or in an appendix.

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 National Recreation Area staff during the review of draft chapters. Additionally, continued contact with National Recreation Area 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 National Recreation Area staff, researchers, subject matter experts, and assessment writers.

Indicator/Measures Assessment Format

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

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

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

We include an indicator condition and overall rationale summary table at the end of each resource topic's section to convey the relevancy of each measure to the overall condition interpretation.

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

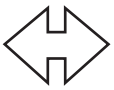
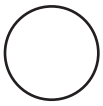
Condition Status		Trend in Condition		Confidence in Assessment	
	Warrants Significant Concern		Condition is Improving		High
	Warrants Moderate Concern		Condition is Unchanging		Medium
	Resource is in Good Condition		Condition is Deteriorating		Low
	An open (uncolored) circle indicates that current condition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

Figure 3.2.3-1. Condition, trend, and level of confidence key used in the Chickasaw NRA NRCA.

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.



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

An Overview of NRCA Chapter 4 Sections

Background and Importance

This section of the NRCA report provides information regarding the relevance of the resource to the National Recreation Area. This section also explains the characteristics of the resource that help the reader understand subsequent sections of the document.

Data and Methods

This section describes the existing datasets used for evaluating the indicators/measures. Methods used for processing or evaluating 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 National Recreation Area based on available literature, data, and expert opinions. This section highlights the key elements used in defining the condition and trend designation, represented by the condition/trend graphic, located at the beginning of each resource topic.

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

Sources of Expertise

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

Literature Cited

This section lists all of the referenced sources. A DVD is included in the final report with copies of all literature cited unless the citation

was from a book. When possible, links to websites are also included.

3.3. Literature Cited

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

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

Chapter 4: Natural Resource Conditions

In this chapter, we present the background and importance, methods, and condition assessment for each focal study resource that we considered for Chickasaw NRA. 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(s) are presented within this chapter.

Resource	Indicator	Description/ Methods	Condition
I. Landscape Condition Context			
Viewshed	Scenic and Historic Integrity	24	30
Night Sky	Sky Brightness	38	38
Soundscape	Audibility	44	48
	Sound Level	45	49
Air Quality	Visibility	55	57
	Level of Ozone	56	57
	Atmospheric Wet Deposition in Total N and Total S	56	58
Geology	Travertine Deposits	65	75
	Vanoss Formation	66	75
	Paleontological Resources	67	75
	Seismic Activity	69	76
	Disturbed lands	72	76
Surface Water Quality	Field Properties	82	90
	E. coli	83	93
Groundwater and Springs	Springflow	110	117
	Streamflow	113	117
	Groundwater Head	115	117
II. Biological Integrity			
Vegetation			
Riparian Habitat	Hydrology	125	129
	Vegetation	125	131
	Erosion/Deposition	126	133
Grasslands	Hydrology Soil/Site Stability and Hydrologic Function	140	145
	Biotic Integrity	140	145

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

Resource	Indicator	Description/ Methods	Condition
Exotic Plants	Potential to Alter Native Plant Communities	166	178
	Prevalence of Exotic Plant	168	178
Wildlife			
Breeding Landbirds	Species Occurrence	192	197
Feral Mammals: Cats and Hogs	Species Occurence	208	208
Game Species	None	n/a	215

4.1. Viewshed

Indicators/Measures

- Scenic and Historic Integrity (2 Measures)

Condition – Trend - Confidence



Moderate – Insufficient Data - Medium

4.1.1. Background and Importance

The conservation of scenery is established in the National Park Service (NPS) Organic Act ("… to conserve the scenery and the wildlife therein…"), reaffirmed by the General Authorities Act, as amended, and addressed generally in the NPS Management Policies (Section 1.4.6 and 4.0; Johnson et al. 2008). Although no management policy currently exists exclusively for scenic or viewshed management and preservation, parks are still required to protect scenic and viewshed quality as one of their most fundamental resources. According to Wondrak-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.

Chickasaw NRA is underlain by complex geological and hydrological features that support mineral and fresh water springs, lakes, and rivers, which are prominent aspects of the viewshed. The cultural landscape focuses on the Civilian Conservation Corps (CCC) era (1933-1940) when rustic buildings, trails, and other infrastructure were erected; the Platt Historic District of the NRA, which was designated a national historic landmark in 2011, is one of the most intact examples from that period. (NPS 2008).

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 NRA by visitors (Figure 4.1.1-1). The indicators we use for condition of the viewshed are based on studies related to perceptions people hold toward various features and attributes of the viewsheds. We also focus on how the historic



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Figure 4.1.1-1. View to the west, from Bromide Hill in Chickasaw NRA.

integrity of the viewshed enhances the opportunity for visitors to better understand the historical significance that the NRA had in shaping our country.

From a cultural and historical perspective, the views are not just about the scenery, but an important way to better understand the connection between natural and cultural resources at Chickasaw NRA. Visualizing this connection as part of the landscape is a critical part of the visitor experience.

4.1.2. Data and Methods

Viewsheds are considered in this assessment within two interrelated contexts: natural scenic integrity and historic integrity. Impacts that degrade one aspect likely degrade the other as well. For example, modern structures or roadways visible on the landscape may detract from the natural scenic integrity of the viewshed as well as 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. We qualitatively assess how features on the landscape contribute (or not) to the scenic and historic integrity of the site.

Indicator

Scenic and Historic Integrity

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

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 the Platt Historic District within Chickasaw NRA, and the contributions of the CCC. We evaluate features as contributing (i.e., enhancing the scenic and historic features of the landscape) or noncontributing (i.e., detracting from the scenic and historic integrity).

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

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

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

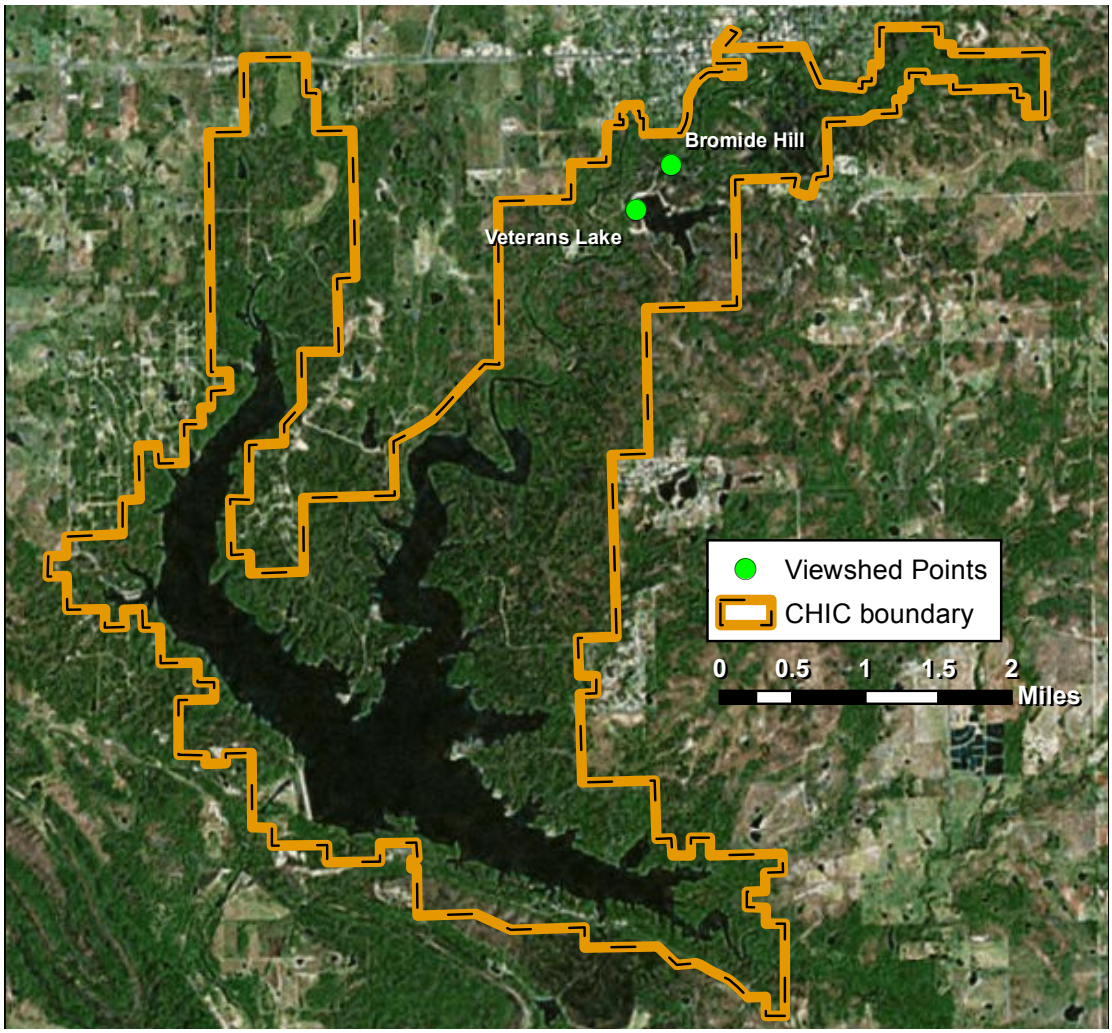


Figure 4.1.2-1. The location of the vantage points used in this assessment.

Viewshed Vantage Points

For this assessment we focused primarily on the views visitors are most likely to experience. The vantage points we used included Bromide Hill and the northwest corner of Veteran's Lake (Figure 4.1.2-1). These views represent the points from which many visitors view the surrounding landscape. As such, these views play a major role in how visitors perceive the NRA within the context of its surrounding landscape.

Measure
Intactness

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

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

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



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

(Zube et al. 1982, Kaplan and Kaplan 1989, Sheppard 2001, Kearny et al. 2008, Han 2010). Human-altered components of the landscape (e.g., roads, buildings, powerlines, and other features) that do not contribute to the scenic or historic context are often perceived as detracting from the scenic and historic character of the viewshed.

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

Measure

Conspicuousness of Noncontributing Features

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

Distance. The impact that individual human-made features have on perception is substantially influenced by the distance from the observer to the feature(s). Viewshed assessments using distance zones or classes often define three classes: foreground, middle ground, and background (Figure 4.1.2-3). For this assessment, we have used the distance classes that have been recently used by the National Park Service:

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

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



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Figure 4.1.2-3. An example of approximate distance classes used in this assessment.

- *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. 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 riparian areas), 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).

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

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

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

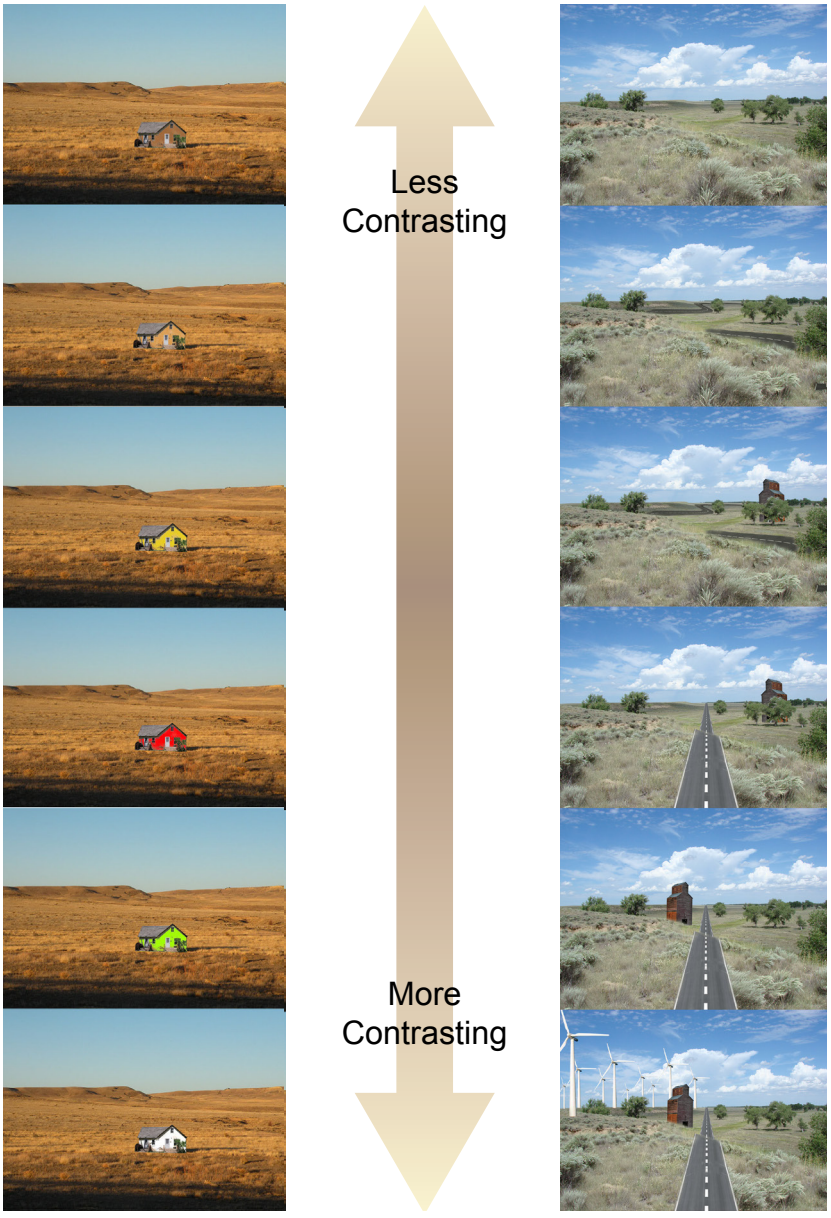


Figure 4.1.2-4. Graphic illustration of how color (left) and shape (right) can influence whether features are in harmony with the environment, or are in contrast.

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 4.1.2-4). 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'Connor 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'Connor 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). The Visual Resource Management Program of the BLM (BLM 1980), for example, places considerable focus on design techniques that minimize visual conflicts with features such as roads and power lines by aligning them with the natural contours of the landscape. Based on these characteristics of contrast, we considered the color of a feature in relative

harmony with the landscape if it closely matched the surrounding environment, or if the color tended to be darker relative to the environment. We considered the shape of a feature in relative harmony with the landscape if it was not in marked contrast to the environment.

Movement and Noise

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

Hierarchical Relationship among Conspicuousness Measures

The above-described characteristics do not act independently with respect to their influence on the conspicuousness of features; rather, they tend to have a hierarchical effect. For example, the color and shape of a house would not be important to the integrity of the NRA'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 4.1.2-5).

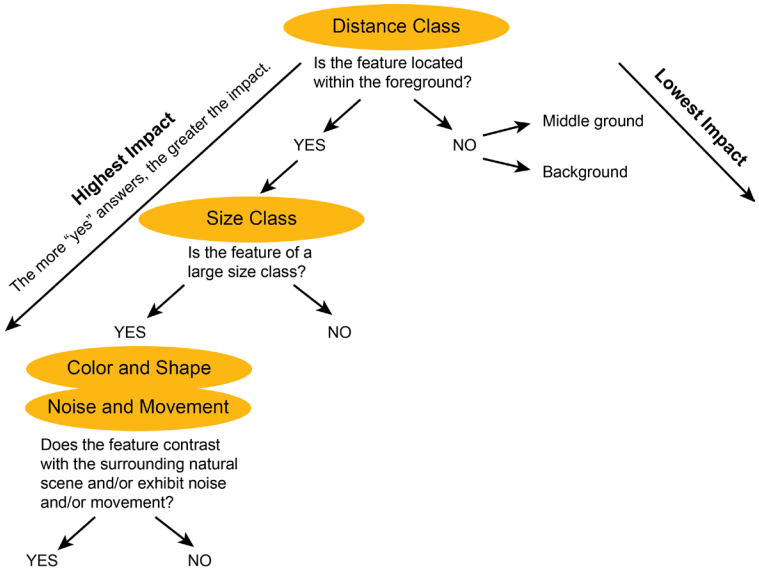


Figure 4.1.2-5. Conceptual framework for hierarchical relationship of characteristics that influence the conspicuousness of features within a viewshed.

GIS Viewshed Analyses

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

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

In addition, using 2010 data provided by NPScape (NPS 2011), road density and housing density were overlaid on the maps to provide an additional measure of viewshed integrity (intactness). NPScape was developed by the NPS Natural Resource Stewardship and Science 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

Table 4.1.3-1. Qualitative reference condition classes used for scenic and historic integrity within the viewshed at Chickasaw NRA.

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

in the NPScape database (Budde et al. 2009, Monahan et al. 2012).

4.1.3. Reference Conditions

The indicators and measures of viewshed condition at Chickasaw NRA are inter-related and intended to provide information about how well the views maintain their scenic quality and their ability to evoke a sense of place in an historic context within the Platt Historic District.

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

4.1.4. Condition and Trend

Overall, the scenic and historic integrity of the viewsheds at Chickasaw NRA are in moderate condition. The landscape surrounding the site remains somewhat intact, though noncontributing features do exist (Table 4.1.4-1; Figures 4.1.4-1 and 4.1.4-2).

From the Veteran's Lake vantage point (Figure 4.1.4-1) the development along the northeastern views are conspicuous because their light coloring makes them stand out against the dark vegetation. Similarly, the tower in the western view stands out because its shape is in such contrast to the surroundings. The park trail is prominent, of course, but is an expected part of the experience, and its smooth, contoured lines make it blend in better.

Non-contributing features consist primarily of homes, buildings, and towers. From Bromide Hill, homes and other developments

Table 4.1.4-1. Indicator and measures of viewshed condition, their corresponding assigned condition class, and the rationale for assigning condition class.

Indicator of Condition	Measures	Condition	Rationale for Condition
Scenic and Historic Integrity	Intactness of View	Moderate	Views are somewhat intact, though non-contributing features do exist, consistent with moderate condition.
	Conspicuousness of non-contributing features	Moderate	Non-contributing features are somewhat inconspicuous; consistent with moderate condition conditions.



Figure 4.1.4-1. Panoramic views in each direction from the Veteran's Lake vantage point (from top: north, east, south, and west).



Figure 4.1.4-2. Panoramic views in each direction from the Bromide Hill vantage point (eastern view, upper image; western view, lower image).

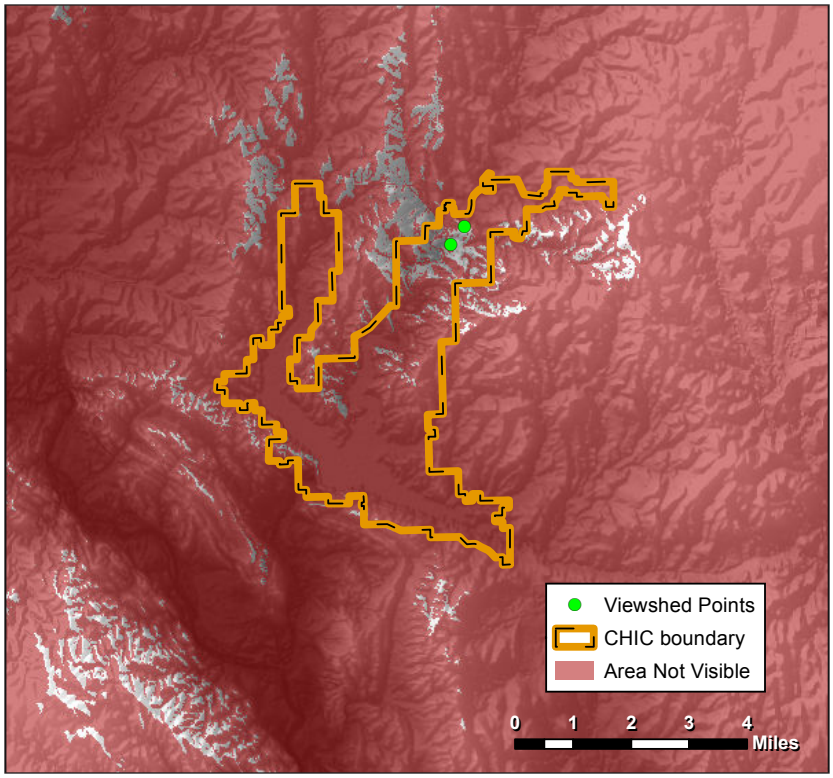


Figure 4.1.4-3. Area visible and not visible from the vantage points at Chickasaw NRA.

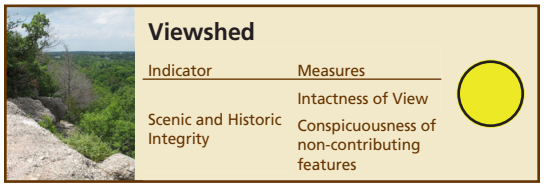
are relatively conspicuous due to their light coloring (light colored, reflective rooftops) and the contrast they represent in the context of the deciduous forest vegetation (Figure 4.1.4-2).

GIS-based Assessment

For our GIS-based analysis, we estimated the areas visible or not visible from the vantage points (Figure 4.1.4-3). It is important to keep in mind that these estimates of visible area are approximations based on digital evaluation models. These are estimates; it should not be assumed that they are exactly correct for the purposes of planning specific projects. Such cases may require verification, and adjustment if necessary, for the specific context intended.

Housing density and road density are other measures to consider regarding their visual intrusion into the landscape. The closest town to the NRA is Sulphur (less than 10 miles away), which has a population of about 5,000 people. The majority of housing density is related to town and the low-density suburban

and exurban houses around the site. Road density is primarily associated with the town (Tables 4.1.4-2 and 4.1.4-3 and Figures 4.1.4-4 and 4.1.4-5). This indicates moderate condition.



Overall Condition

Based on this assessment, we considered the viewshed at Chickasaw NRA to be in moderate condition. Non-contributing features were somewhat conspicuous interfering somewhat with the scenic and historic integrity of the landscape.

4.1.5. Sources of Expertise

For assessing the condition of this resource, we relied primary on literature for this topic. Heidi Sosinski provided GIS expertise.

Key Uncertainties

How a view is perceived is quite subjective and will always have an element of uncertainty. We have tried to base our assessment on the findings of an extensive body of literature, and have tried to be transparent with our assessment.

Table 4.1.4.2. Housing density surrounding Chickasaw NRA.

All Areas		
Density Class	Area (km²)	Percent
Private undeveloped	744.05	19.21%
< 1.5 units / square km	1813.27	46.81%
1.5 - 6 units / square km	1024.83	26.46%
> 6 units / square km	282.03	7.28%
Commercial / Industrial	9.09	0.23%
Total Area	**3873.27**	
Visible Areas Only		
Density Class	Area (km²)	Percent
Private undeveloped	7.8	13.60%
< 1.5 units / square km	24.5	42.73%
1.5 - 6 units / square km	20.67	36.05%
> 6 units / square km	4.21	7.34%
Commercial / Industrial	0.16	0.28%
Total Area	**57.34**	

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, and other variables, and has not been verified in the field.

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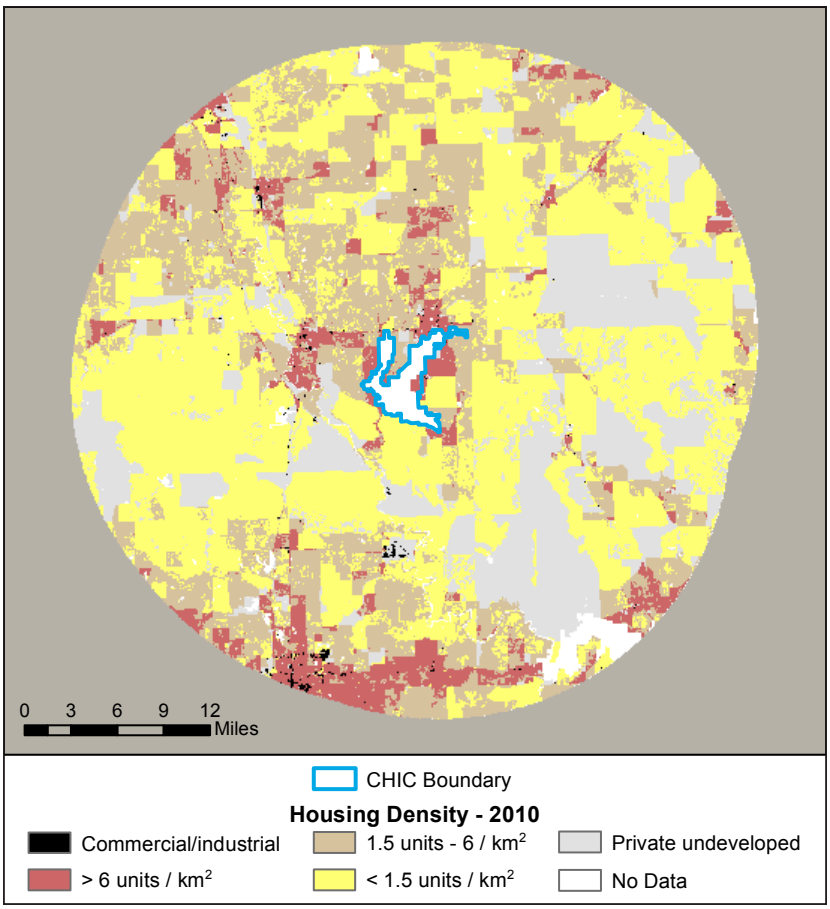


Figure 4.1.4-4. Housing density surrounding Chickasaw NRA.

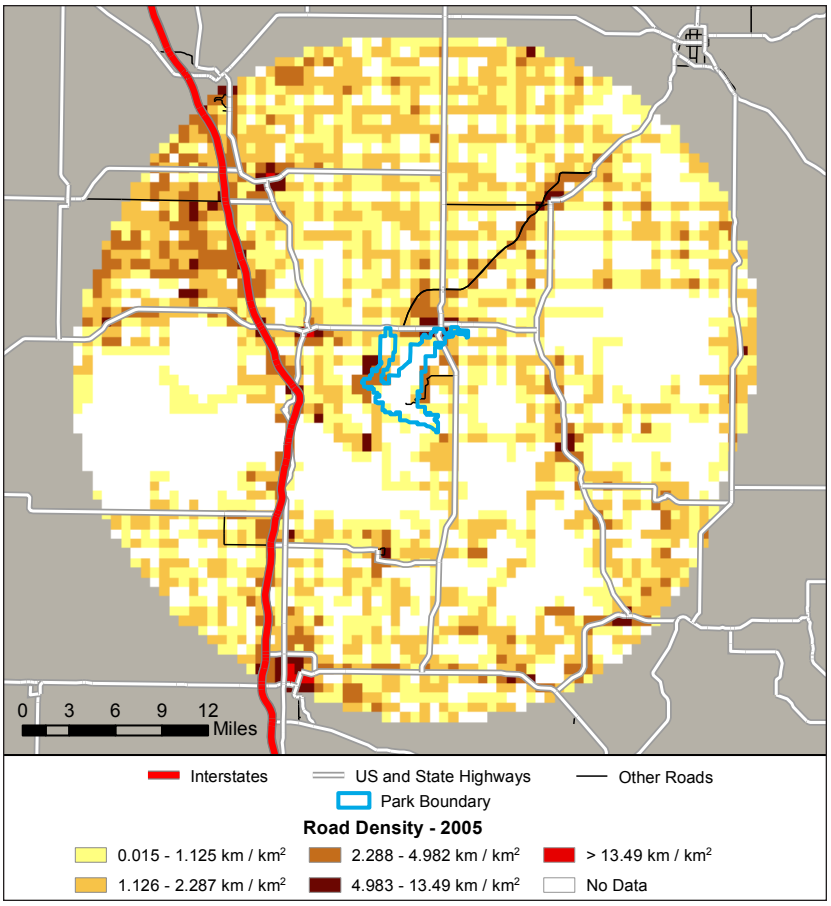


Figure 4.1.4-5. Road density surrounding Chickasaw NRA.

Table 4.1.4.3. Road density surrounding Chickasaw NRA.

All Areas		
Density Class	Area (km²)	Percent
0.015 - 1.125	1,097	43.10%
1.126 - 2.287	1,045	41.06%
2.288 - 4.982	334	13.12%
4.983 - 13.49	63	2.48%
> 13.49	6	0.24%
Total Area	**2,545**	
Visible Areas Only		
Density Class	Area (km²)	Percent
0.015 - 1.125	12	35.29%
1.126 - 2.287	7	20.59%
2.288 - 4.982	14	41.18%
4.983 - 13.49	1	2.94%
Total Area	**34**	

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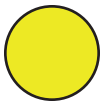
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4.2. Night Sky

Indicators/Measures

- Sky Brightness (Anthropogenic Light Ratio)

Condition – Trend – Confidence



Moderate - Insufficient Data - Medium

4.2.1. Background and Importance

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

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

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

Chickasaw National Recreation Area (NRA) is a park where people come to enjoy the lakes and springs. Campgrounds offer an opportunity for people to enjoy the night sky, especially around the lakes where there is more sky visible and less interference from vegetation. Protecting the night sky resources benefits the natural resources and is important for visitor experience.

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. When available, additional indicators and measures should also be considered in an assessment of night sky condition, but the ALR measure is the primary data source for condition assessment (see Table 4.2.2-1).

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

Indicator	Measure	Description
Sky Brightness	Anthropogenic Light Ratio	The all-sky anthropogenic light ratio describes light due to man-made sources compared to light from a natural dark sky. Understanding the lightscape and sources of light is helpful to managers to maintain dark skies for the benefit of wildlife and people alike.

Measure
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 Chickasaw NRA; modeling data are reported here.

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 78 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, see Table 4.2.3-1.

Anthropogenic Light Ratio

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

4.2.4. Condition and Trend

Modeling data provided by the NPS Night Skies Program show an ALR of 1.39 indicating moderate condition (the models have an error of ±0.1 ALR).

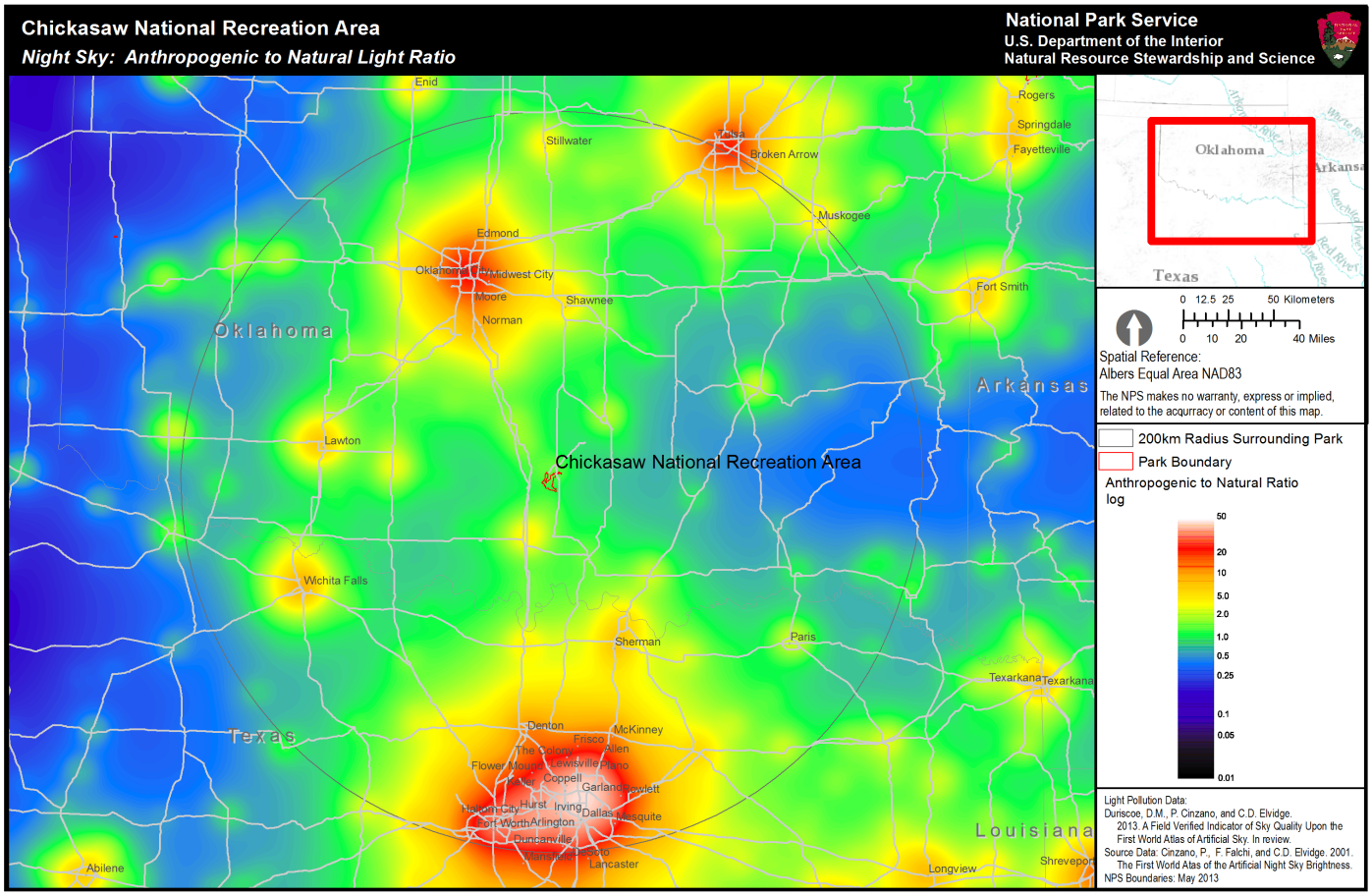
Local and Regional Context

Chickasaw NRA is located less than 10 miles from Sulphur (population 4,929); and less than 40 miles from both Ardmore (population 24,283) and Ada (population 16,810; U.S. Census Bureau 2010). The light domes from these population centers, as well as Oklahoma City (89 miles away with a population of 579,999), do impact the night sky (Figure 4.2.4-1). Site-specific variables, such as outdoor lighting of park facilities and campgrounds should also be considered.

Table 4.2.3-1. Night sky condition class summary.

Condition Class	ALR*
Good	ALR <0.33 (<26 nL average anthropogenic light in sky)
Moderate	0.33-2.0 (26-156 nL average anthropogenic light in sky)
Significant concern	ALR >2.0 (>156 nL average anthropogenic light in sky)

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



NPS Natural Sounds & Night Skies Division and NPS Inventory and Monitoring Program MAS Group 20141114

Figure 4.2.4-1. Map of average anthropogenic sky luminance and location of Chickasaw NRA.



Overall Condition

Quantitative modeling of sky brightness (all-sky anthropogenic light ratio) was used to assess the condition of the night sky. The results for this indicator are summarized and interpreted in Table 4.2.4-1. The overall condition of the NRA's night sky is moderate, based on the ALR reading and the significant influence from nearby light domes.

Uncertainties

Modeled data are based on 1996 satellite imagery, and ground truthed with NPS ground-based measures. Changes in population levels, private and commercial building growth, and energy development could impact current ALR values. This assessment should be interpreted as interim until ground-based measures of all-sky ALR are taken (C. Moore, NPS, pers. comm.).

Table 4.2.4-1. Summary of night sky indicators and measures and assessment of night sky condition at Chickasaw National Recreation Area.

Indicator	Measure	Condition	Condition Rationale
Sky Brightness	Anthropogenic Light Ratio (1.39)	Moderate	This measure results from modeling data provided by the NPS Night Sky Program. Specific thresholds for condition classes have been set by the NPS. In this case, the moderate condition likely resulted from the light domes of nearby cities. No ground-based measurement has been collected, therefore, the confidence level in this assessment is medium.

4.2.5. Sources of Expertise

Chad Moore and Jeremy White, Natural Sounds and Night Skies Division, part of the NPS Natural Resource Stewardship and Science Directorate, provided information pertaining to night sky data collection methodology and interpretation of results. Moore earned a master's degree in earth science in 1996 and began working for the NPS shortly thereafter. Moore is the Night Skies Program manager for 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. White earned his Bachelors degree in Ecology and Systematic Biology in 2004 and began working with the NPS in 2005. White is a Physical Scientist with the Night Skies Program responsible for data collection and analysis, interpretation, and public outreach. Since 2001 the team has collected sky quality inventories at over 110 U.S. national parks.

4.2.6. Literature Cited

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4.3. Soundscape

Indicators/Measures

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

Condition – Trend – Confidence



Moderate - 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. An unimpaired acoustical environment is an important part of overall NPS visitor experience and enjoyment, as well as vitally important to overall ecosystem health.

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

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



HEIDI SOSINSKI

Figure 4.3.1-1. Natural sounds, such as flowing water, contribute to Chickasaw National Recreation Area's soundscape.

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

Sound Characteristics

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

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

Besides the pitch of a sound, we also perceive the amplitude (or loudness) of a sound, which is measured in decibels (dB). The decibel scale is logarithmic, meaning that every 10 dB increase in sound pressure level (SPL) represents a tenfold increase in sound energy. This also means that small variations in SPL can have significant effects on the acoustical environment. For instance, a 6 dB reduction in background noise level would produce a 4x increase in listening area (Figure 4.3.1-2). Changes in the background noise level cause a change in listening opportunity. These lost opportunities will approach a halving of alerting distance and a 75% reduction of listening area for each 6 dB increase in affected band level (Barber et al. 2010).

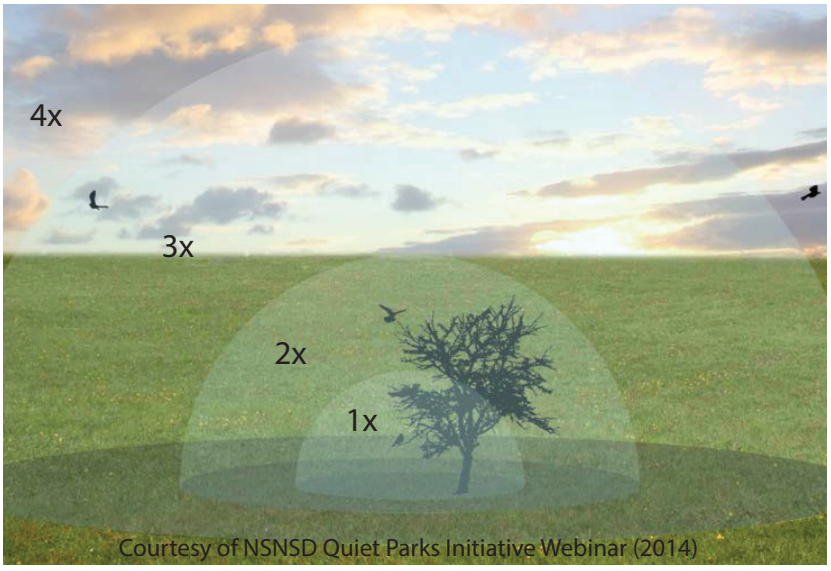


Figure 4.3.1-2. A 6 dB reduction in background noise level would produce a 4x increase in listening area (NSNSD 2014).

SPL is commonly summarized in terms of dBA (A-weighted SPL). This metric significantly discounts sounds below 1,000 Hz and above 6,000 Hz to approximate the variation in human hearing sensitivity.

4.3.2. Data and Methods

For the purposes of this rapid assessment, we conducted on-site listening sessions at four locations (described below) from May 31-June 1, 2014 (Figure 4.3.2-1). Table 4.3.2-1 summarizes the time and conditions of the recording sessions. The monitoring sites were within three different park management zones that are described in Table 4.3.2-2.

Buffalo Spring

This location was located within Historic Platt District cultural landscape along the trail

Table 4.3.2-1. Summary of on-site listening sessions at Chickasaw NRA.

Location	Date	Time(s)	Session Duration	Wind Speed	Weather
Buffalo Spring	May 31, 2014	7:50-8:50 am	60 minutes	Calm	55-79°F, Cloudy
		11:50 -12:50 pm	60 minutes	Light Breeze (4-7mph)	80-99°F, Cloudy
		4:04-5:04 pm	60 minutes	Light Air (1-3mph)	80-99°F, Partly Cloudy
Rock Creek Multi-Use Trail*	May 31, 2014	7:30-8:30 am	60 minutes	Calm	55-79°F, Cloudy
		12:06-1:06 pm	60 minutes	Calm	55-79°F, Mostly Cloudy
		4:07-5:07 pm	60 minutes	Light Breeze (4-7mph)	80-99°F, Partly Cloudy
Catfish Bottoms	June 1, 2014	7:42-8:422 am	60 minutes	Calm	55-79°F, Cloudy
		11:50 -12:50 pm	60 minutes	Light Breeze (4-7mph)	55-79°F, Mostly Cloudy
		4:06-5:06 pm	60 minutes	Light Breeze (4-7mph)	80-99°F, Partly Cloudy
Buckhorn Campground Amphitheater	June 1, 2014	7:25-8:25 am	60 minutes	Calm	55-79°F, Cloudy
		11:38 -12:38 pm	60 minutes	Calm	55-79°F, Mostly Cloudy
		4:00-5:00 pm	60 minutes	Light Breeze (4-7mph)	80-99°F, Partly Cloudy

* Two different locations were monitored along Rock Creek Trail. Refer to condition discussion for more information.

system that begins at the Travertine Nature Center. It is the easternmost location within the park. In addition to being located within the Historic Platt District cultural landscape, the area east of Travertine Nature Center, where Buffalo Springs in located has some restrictions on its use. For example, dogs are not allowed on the trails; swimming and wading are prohibited in Travertine Creek; and fishing is prohibited.

Rock Creek Multi-Use Trail:
This monitoring location was along the Rock Creek Multi-Use Trail, which is an unpaved trail system designed for hikers. This is in the preservation/conservation area of Lake of the Arbuckles and is managed for undirected discovery and natural solitude. The morning session was along Rock Creek, ~1/3 mile from the parking lot, whereas, the noon and afternoon sessions were located within the wooded section of trail. This was a data collector error due to confusion of the intended monitoring location. We report information from both sites.

Lake of the Arbuckles - Buckhorn Campground
The monitoring occurred at the Buckhorn Campground Amphitheater, which is adjacent to the Lake of the Arbuckles and campground Loop C. This site was located in the recreation area management zone where more recreational services are provided for a wide variety of activities.

Catfish Bottoms
This location was at the southern ends of the park and Lake of the Arbuckles. It is located in the preservation/conservation zone where activities are self-directed and more nature-based encouraging solitude and quiet.

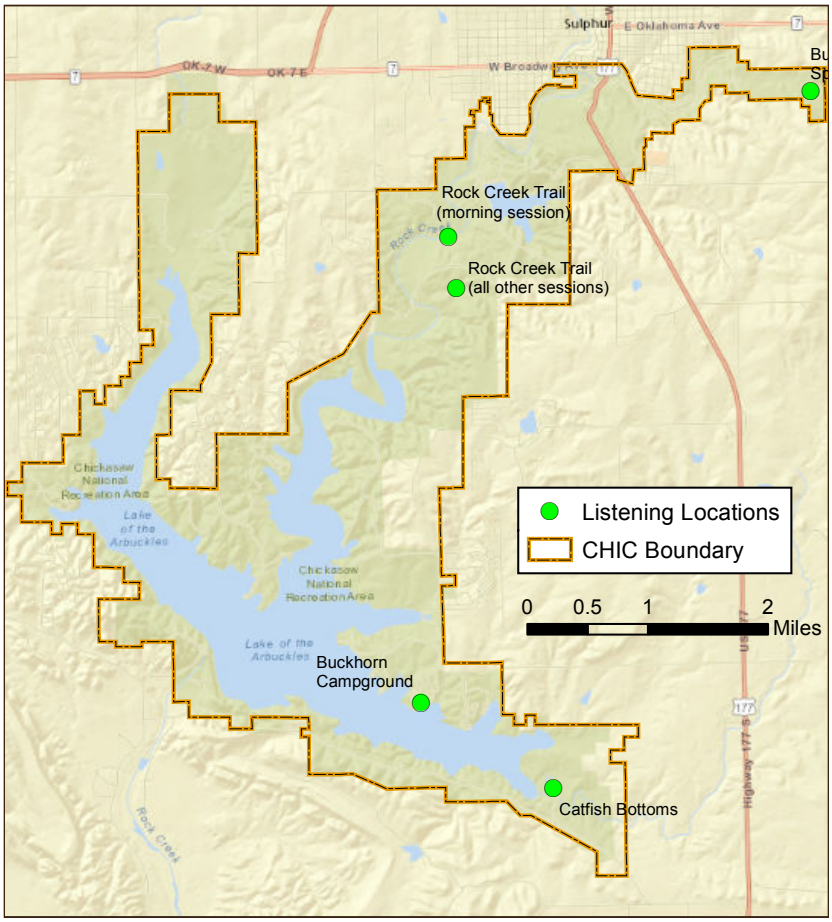


Figure 4.3.2-1. On-site acoustical listening locations.

Table 4.3.2-2. Activities and associated sounds expected within each management zone (NPS 2008) that influence the reference condition within that zone.

Management Zone (Degree of Human Activity)	Typical Activities and Associated Sounds
Historic/Cultural Area in the Historic Platt District.	In this zone activities may include automobile touring, bicycling, walking, hiking, hunting, fishing, and other activities in designated areas to the extent they are compatible with the cultural resources in the area. Visitation is maintained at moderate levels to allow some opportunities for discovery, occasional solitude, and enjoyment of the cultural setting with only moderate noise.
Preservation/Conservation Areas in the Arbuckle District	In the preservation/conservation zones, activities may include hiking, hunting, fishing, nature observation, and visitor participation in restoration activities in designated locations. There would be opportunities for solitude, natural quiet, and undirected discovery; these areas would provide for a contemplative experience.
Recreation Areas in and Adjacent to Lake of the Arbuckles and Veterans Lake.	In the Recreation areas, activities may include hiking, bicycling, horseback riding, hunting, fishing, tournaments, boating, picnicking, camping, swimming, auto touring, nature study, and special events such as family reunions, school functions, and weddings, in designated areas as appropriate. Experiences may range from quiet, personal activities to large group events.

Table 4.3.2-3. Indicators and measures used to assess the soundscape at Chickasaw NRA.

Indicator	Measure	Definition
Audibility	% Time Audible	The percent of time that a particular sound may be detected by the human ear is the measure for audibility. This measure was obtained from the on-site listening results. We categorized sounds based on noises, natural, or recreational sounds.
Sound Level	Amplitude (on-site monitoring)	Loudness or amplitude of a sound is typically measured in decibels (dB). The decibel scale is logarithmic, meaning that every 10 dB increase in sound pressure level (SPL) represents a tenfold increase in sound energy. Amplitude was assessed by comparing sounds heard to the relative sound levels shown in Figure 4.3.2-2 to qualitatively determine the relative loudness of noise(s) that were heard.
	Amplitude (Mennitt et al. (2013) modeled sound levels)	"Using long-term sound pressure level measurements from hundreds of sites across the contiguous United States, geospatial models were developed to predict sound levels. These sound models incorporated spatial representations of biological, geophysical, climatic, and anthropogenic factors to assess expected contributions to the existing sound pressure level from both anthropogenic and natural sources, which enable mapping of sound pressure levels at regional and national scales" (cited from Mennitt et al. 2013). This sound level information supplements the May 31 - June 1, 2014 on-site listening results.

Indicators and Measures

The indicators we used to assess soundscape condition were audibility and sound level, with one and two measures, respectively (Table 4.3.2-3).

Indicators/Measures

Audibility (% Time Audible)

During the on-site listening sessions, each observer listened for the designated period of time and identified all sound sources and their durations. This type of monitoring took full advantage of human binaural hearing capabilities while providing the closest match to a park visitor's experience. We gathered information about the types of sounds and how long they were heard (i.e., percent time audible), using an Apple device and Natural Sounds and Night Skies Division (NSNSD) on-site listening application.

NSNSD compiled the acoustical monitoring data, which were grouped into three categories (i.e., noise, natural, and recreational sounds), which are presented in Figure 4.3.2-2. Only sounds heard more than 3% of the time were included in the sound graphs.

Several limitations to this method included a short sample period, a small sample size, and a qualitative assessment of amplitude. The rapid assessment primarily provided a "snapshot" of soundscape condition to help

characterize the soundscape environment for this assessment.

Indicators/Measures
Sound Level (2 measures)

Sound levels were assessed in two ways (1) using sound models created by Mennitt et al. (2013) to provide quantitative parkwide/regional sound levels, and (2) qualitatively assessing noise levels during on-site monitoring using sound reference levels presented in Figure 4.3.2-3.

Qualitative Sound Level Measure
For the qualitative sound level assessment, we evaluated the relative levels of sounds heard while monitoring on-site to common sound levels reported throughout the literature (Figure 4.3.2-3). While we are aware of the fact that this qualitative approach did not capture the sound levels in a repeatable way, we believe this method still provided important on-site information to help assess condition.

Mennitt et al. (2013) Model - Quantitative Sound Level Measure
Mennitt et al. (2013) created a sound level model at regional and national scales. The model used spatial, meteorological, and actual sound level measurements from 100s of sites (primarily located in the west) to model sound levels for natural and existing conditions, as well as to model the impact of the sound levels based on the difference between the modeled natural and existing sound levels. We used the results from this model to provide a quantitative assessment of sound level at Chickasaw NRA. The sound model maps for existing, natural, and impact sound levels are included in Appendix C.

Context for Evaluating Sounds
Whether or not a given sound contributed to or detracted from the soundscape condition depended largely on whether or not that sound was appropriate for the context in which it was heard. Two of Chickasaw's park purposes are to protect the springs and waters and to provide outdoor recreation, including a wide variety of activities (e.g., hunting, fishing, boating, camping, etc. (NPS 2008)).

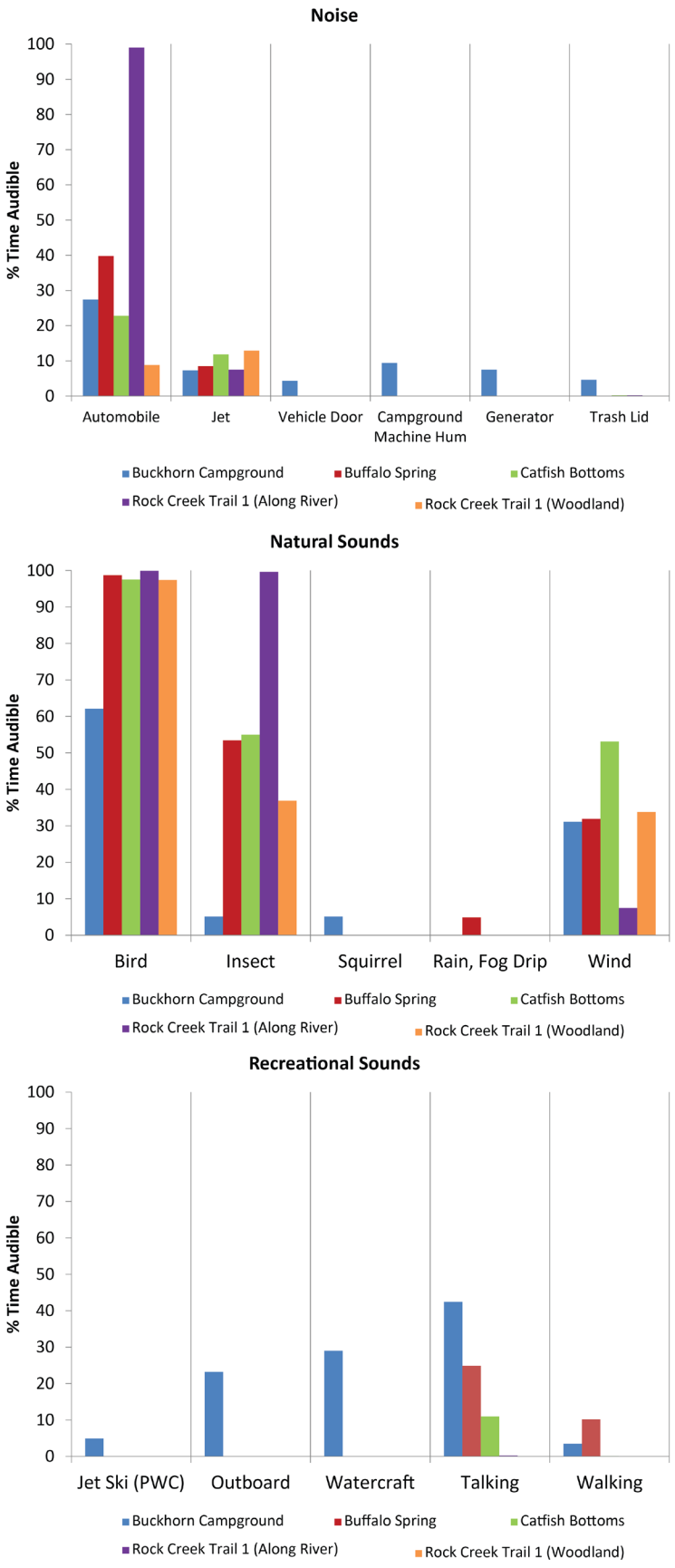


Figure 4.3.2-2. Sound sources heard and percent time audible at on-site monitoring locations organized by noise, natural, and recreational sound sources.

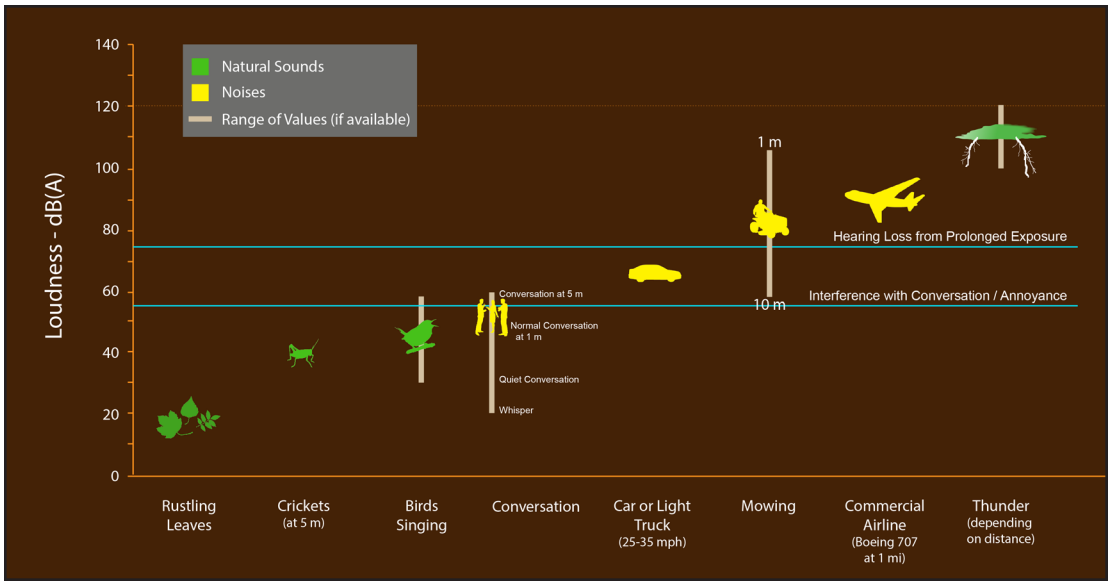


Figure 4.3.2-3. Reference dB(A) levels for qualitative sound level assessment at Chickasaw NRA.

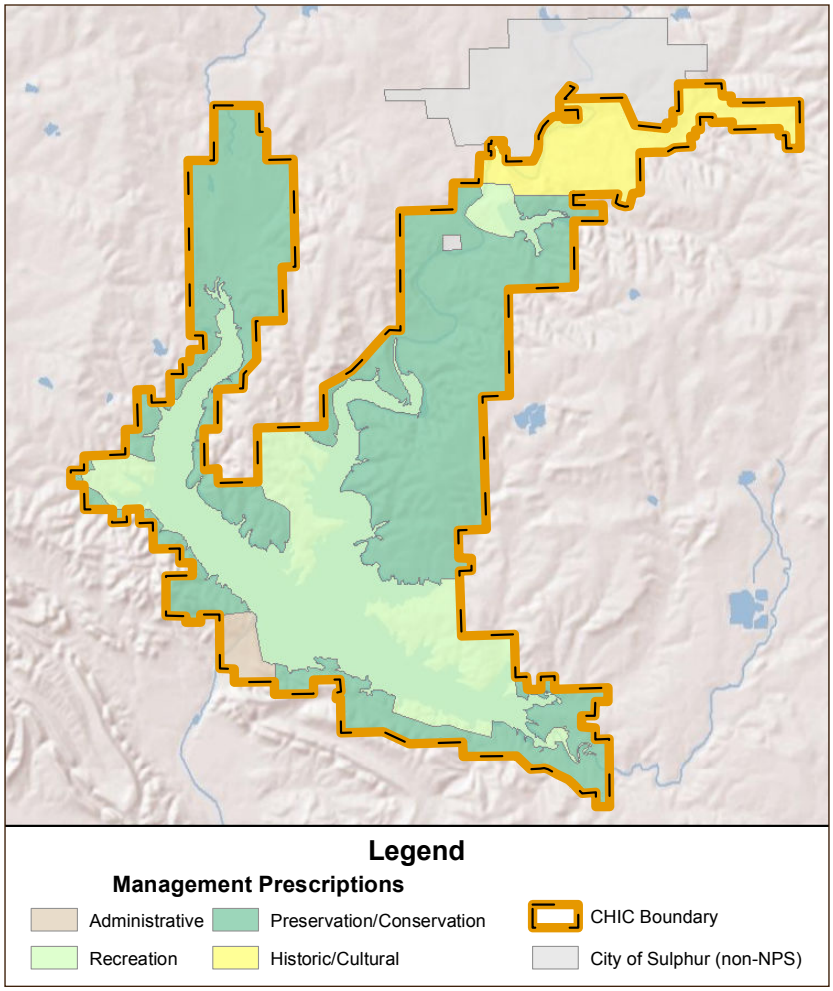


Figure 4.3.2-4. Designated management zones at Chickasaw NRA (adapted from NPS 2008).

If this were a wilderness setting, natural versus anthropogenic sounds might be a pertinent distinction for how a sound is perceived. However, the context and setting at Chickasaw NRA is quite different in that there are sounds within the recreational context that are acceptable, even though they may not be natural, depending upon where they are heard. The locations where the sounds were heard, based upon the National Recreation Area's designated management zones, affected the NRA's soundscape condition. For example, a visitor would likely be less disturbed by noises from vehicles if they were in a parking lot or camping in a developed campground than if they were hiking along a more remote trail or fishing at Catfish Bottoms. Consequently, we took into consideration where sounds were heard within the National Recreation Area and the likelihood of hearing different sounds based on the park's management zones designated uses as defined in the General Management Plan (NPS 2008) (Figure 4.3.2-4).

Thus, for the purposes of this assessment, we considered sounds that were consistent with the recreational context and designated activities to not detract from the park's soundscape condition. In contrast, some sounds, such as low flying aircraft or excessive human voices/boat motors would be evaluated as significant concern degrading the soundscape condition.

For these reasons, we considered sound types within the context of belonging to two classes: (1) natural and recreational-appropriate sounds, and (2) noise (any unwanted/

out of context sound). The first class was considered as having a neutral or positive influence on soundscape condition; whereas excessive noise, especially in locations where noise was unexpected due to designated use, was considered to have a negative effect, contributing to a more impacted soundscape condition.

4.3.3. Reference Conditions

The reference conditions for the soundscpe assessment are presented in Table 4.3.3-1. We considered the soundscape to be in good condition if sounds heard were consistent with National Recreation Area designated activities and if no excessive sound/noise levels were present regardless of designated use.

We considered a moderate condition soundscape to be one where the designated uses for a higher activity area (e.g. parking lot) began to infiltrate into lower use zones (e.g., preservation/conservation) and noise levels began to interrupt normal conversations.

A significant concern soundscape condition occurred when noises became incongruent with designated activities and/or were loud regardless of the management zone designation. Significant concern would also be warranted if noises generated by military overflights, fast moving traffic, etc., dominated the types of sounds heard.

These reference conditions were established by researching the effects of noise on human health and wildlife and on the quality of visitor experience.

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

There have been numerous studies on the effects of noise on human health, and probably the most commonly studied effects are cardiovascular. The World Health Organization (Berglund et al. 1999) suggests that even prolonged exposure to noise levels below 75dB will not result in noise-induced hearing loss. They also conclude that prolonged exposure to air and road

Table 4.3.3-1. Reference conditions used to assess the soundscape at Chickasaw NRA.

Indicator	Measure	Good	Moderate	Significant Concern
Audibility	% Time Audible	Dominant sounds are consistent with National Recreation Area's designated purpose. Natural ambient sounds such as wind, leaves rustling, birds singing, thunder claps, etc. and sounds related to recreational activities are expected. Some sources of noise (e.g., automobiles) are acceptable in the higher use areas provided they are consistent with the expectations for that location and are audible for a small percentage of the time.	The dominant sounds are generally consistent with the park's designated purpose, but noise occurs more frequently and noise from the adjacent highways, etc., begins to infiltrate into the quieter use zones.	A high percentage of the audible sounds heard are from noises such that the natural and/or recreational sense of place is compromised; therefore, the enjoyment of visitors is compromised.
Sound Level	Amplitude (loudness)	Visitors typically maintain quiet to normal conversational levels (e.g., 40-50 dB), and interpreters talking to larger groups rarely exceed 55-60 dB. There is a higher tolerance for noise levels in the more developed zones (especially along the lake area due to motorcrafts).	Noises > 55 dB cause occasional interference with normal conversations although noises greater than approximately 65 dB is still quite rare throughout the majority of the NRA.	Communication among interpreters and visitors is frequently interrupted by loud noise impacting visitor enjoyment and recreation. These are the same sound levels that may interfere with wildlife behavior and auditory signals.
	Mean L_{50} impact (dBA)	Non-urban park threshold ≤ 1.5 Listening area reduced by ≤ 30%.	Non-urban park threshold 1.5 ≤ 3.0. Listening area reduced by 30 - 50%.	Non-urban park threshold >3.0. Listening area reduced by > 50%.

traffic noises above 65-70 dB are associated with cardiovascular effects, but this is from exposure times that far exceed what is likely to be encountered during a National Recreation Area visit. The threshold levels for responses such as raising of blood pressure are much lower (i.e., 35 dBA in sleeping humans; Haralabidis et al. 2008). However, these human health responses, at the levels of noise exposure at Chickasaw NRA are not likely to cause any physical damage. Thus, for the most part, noise levels exceeding thresholds for damage to human health are not of high concern at the National Recreation Area. The most likely exception to this is for park staff operating machinery (e.g., mowers, tractors, etc.). Although damage to human health is not of high concern, this does not imply that there are no physiological responses to noise.

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

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

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

Effects of Noise on the Quality of Visitor Experience

An essential component of the designated purpose of Chickasaw NRA relative to the soundscape is to provide for visitor enjoyment and recreational opportunities. We consider condition of the soundscape relative to a visitor being able to have conversations at speaking levels. The U.S. Environmental Protection Agency (USEPA) uses a speech interference threshold (52 dBA) for speaking in a raised voice to an audience at 10 meters (USEPA 1974). This threshold addresses the effects of noise on interpretive programs in parks. Also, a threshold of 60 dBA provides a basis for estimating impacts on normal voice communications at 1 meter (USEPA 1974).

Condition is deteriorated when noise is frequent or loud enough to interrupt visitor conversations or interpretive programs.

4.3.4. Condition and Trend

Overall, the most common sounds heard at all monitoring locations during the on-site listening sessions were birds, insects, and wind. The loudest sounds heard originated from watercraft at the Buckhorn Campground Amphitheater location.

Audibility at Monitoring Locations

The majority of sounds heard were either natural or sounds related to visitor recreational activities. Bird vocalizations and insects were the primary natural sounds heard during the monitoring sessions, except for insects at Buckhorn Campground, which were difficult to hear due to the masking effects of visitor activities.

The recreational-related sounds were primarily heard at the Buckhorn Campground location, which was expected given its designation as a Recreation Area Management Zone and proximity to water-based activities. Additional sounds associated with campground activities included trash lids, a hum from a machine adjacent to the

amphitheater and generators, and sounds associated with vehicles (e.g., idling engine, horn, etc.).

Additional recreational-based sounds heard included visitors talking and walking at the Buckhorn Campground and Buffalo Spring locations and fishermen talking at Catfish Bottoms. No recreational-based sounds were heard along Rock Creek Trail that were audible more than 3% of the monitoring time.

The most common noise heard originated from automobiles along Highway 7, with the highest percent time audible at Rock Creek Trail (morning session only) and at Buffalo Spring, likely due to both locations' proximity to a major highway compared to the other monitoring locations. Interestingly, automobile noise was heard only 8.8% of the time during the noon and late afternoon Rock Creek Trail monitoring sessions when vehicle traffic is usually highest. Jet noise was heard for a similar percentage of time at all monitoring locations, which would be expected given its pervasiveness and ranged from 7.3-12.9%.

The overall percent time audibility of noise heard at the monitoring locations was relatively low, especially compared to the natural and recreational-based sounds, except at the Rock Creek Trail monitoring location where traffic was heard nearly the entire hour (morning session only). We consider this measure to be in good to moderate condition.

Sound Levels at Monitoring Locations (on-site listening results)

The relative sound levels at the NRA were based on information presented in Figure 4.3.2-3. The loudest sounds heard originated from activities within the Buckhorn Campground, primarily from watercraft and automobiles, which were both appropriate for the management zone, although loud enough to mask natural sounds such as insects.

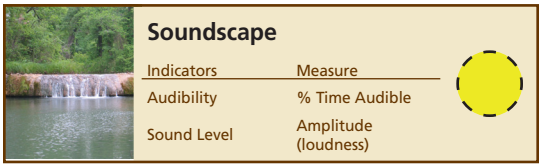
The automobile noise heard at the Buffalo Spring location was the next loudest sound heard and while frequent (almost 40% of the time), did not interrupt normal conversation levels. While automobile noise was heard 99% of the time at the Rock Creek Trail morning session location, the sound was distant and likely could be heard much of the time due to the quiet of the morning hours.

Overall, the sound levels, aside from ones expected at Buckhorn Campground, were within a level that would not interrupt normal conversations at a 1 m distance and was considered to be in good condition.

Sound Level for Monitoring Sites Based on Mennitt et al. (2013) Model

The model results for the natural ambient and existing sound levels across the entire National Recreation Area ranged from 36.0-38.8 dBA and 37.6-44.7 dBA, respectively (Mennitt et al. 2013 and E. Lynch, NSNSD, pers. comm.). Mennitt et al. (2013) suggested that in a natural environment, the average summertime L_{50}, which is the sound level exceeded half of the time and is a fair representation of expected conditions, is not expected to exceed 41 dBA. The modeled results for Chickasaw exceeds the higher level for the maximum existing sound level quartile.

The difference between the existing and natural levels is 1.6-5.9 dBA and is referred to as the impact level. According to Mennitt et al. (2013), "an impact of 3 dBA suggests that anthropogenic noise is noticeable at least 50% of the hour or more." NSNSD also provides soundscape reference conditions for the purposes of The State of the Park reports, which are used for NRCA sound assessments. The reference conditions group parks into urban versus non-urban based on U.S. Census Bureau's designation. The National Recreation Area is considered a non-urban park, which means that the modeled sound impact level is between moderate and significant concern.



Overall Condition and Trend

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

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

Indicators of Condition	Measures	Condition	Rationale for Condition
Audibility	% Time Audible	Good to Moderate	The percent time audibility of sounds was good except for the constant automobile noise heard at the Rock Creek Trail morning session location. While other noises were heard, many were within the expected range of sounds given the locations, such as boating and camping-related noises at Buckhorn Campground. The most common sounds heard at all monitoring locations were natural. Overall we consider the percent time audibility measure to be in good to moderate condition.
Sound Level	Amplitude (on-site monitoring)	Good	The loudest sounds heard were within the recreational-based zones, especially at Buckhorn Campground where boats and jet skis produced the loudest sounds. While auto noise was heard 99% of the time at the morning session monitoring location along Rock Creek, it was very low and likely a result of the morning quiet not masking the constant sound. Overall, most sounds heard would not have interrupted a normal conversation at 1 m. We consider this measure to be in good condition.
	Amplitude (Mennitt et al. (2013) modeled sound level impact)	Moderate to Significant Concern	The modeled impact sound level for the National Recreation Area ranged between 1.6-5.9 dBA. This range is between the moderate to significant concern thresholds for non-urban parks (Turina et al. 2013).

The locations where sounds were heard were consistent with designated uses, the percent time audibility of noises rarely exceeded 50% of the time, except for distant automobile noise at the Rock Creek Trail morning monitoring session. The sound impact level modeled for Chickasaw was between the moderate to significant concern thresholds. Overall, we considered the soundscape to be in moderate condition, with an unknown trend.

Level of Confidence and Key Uncertainties

This was a very brief, rapid assessment of the National Recreation Area's soundscape, establishing a relative baseline for the purposes of the NRCA. With such a small data set and short sample period, our confidence is low. Also, given the fact that the sound level model produced by Mennitt et al. (2013) did not include a boat noise layer, our confidence level in our evaluation of the soundscape condition throughout the National Recreation Area is low.

4.3.5. Sources of Expertise

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

The NSNSD provided a NRCA soundscape template, which was used to develop Chickasaw NRA's soundscape assessment. They also generated reports from the on-site listening results, which we based our discussion and provided the sound level model maps for the NRA, included in Appendix C. For more information, see http://www.nature.nps.gov/sound/.

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4.4. Air Quality

Indicators/Measures

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

Condition – Trend – Confidence



Significant Concern - Insufficient Data - Medium

4.4.1. Background and Importance

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

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

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

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

It's important to note that even though the CAA gives Class I areas the greatest protection against air quality deterioration,



NPS PHOTO

Figure 4.4.1-1. Chickasaw National Recreation Area is a Class II airshed.

NPS PHOTO



Figure 4.4.1-2. A cloudy day at Chickasaw National Recreation Area.

the legislation also aims to limit the level of additional pollution allowed in Class II areas, and potential impacts to these areas are to be considered. (NPS 2006).

Air Quality Standards

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

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

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

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

Ozone is a gaseous constituent of the atmosphere produced by reactions of nitrogen oxides (NO_x) from vehicles, powerplants, industry, and fire and volatile organic compounds from industry, solvents, and vegetation in the presence of sunlight

(Porter and Biel 2011). It is one of the most widespread air pollutants (NPS-ARD 2003), and the major constituent in smog. Ozone can be harmful to human health, and it is also phytotoxic, causing foliar damage to plants (NPS-ARD 2003). The foliar damage requires the interplay of several factors, including the interaction of the plant to the ozone, the level of ozone exposure, and the exposure environment. The highest ozone risk exists when the species of plants are highly sensitive to ozone, the exposure levels of ozone significantly exceed the thresholds for foliar injury, and the environmental conditions, particularly adequate soil moisture, foster gas exchange and the uptake of ozone by plants (Kohut 2007).

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

Air pollutants can be deposited to ecosystems through rain and snow (wet deposition) or dust and gases (dry deposition). Nitrogen and sulfur air pollutants are commonly deposited as nitrate, ammonium, and sulfate ions and can have a variety of effects on ecosystem health, including acidification, fertilization or eutrophication, and accumulation of toxins (NPS-ARD 2010a). Atmospheric deposition can also change soil pH, which in turn, affects microorganisms, understory plants, and trees (NPS-ARD 2010a). Certain ecosystems are more vulnerable to nitrogen or sulfur deposition than others, including high-elevation ecosystems in the western United States, upland areas in the eastern part of the country, areas on granitic bedrock, coastal and estuarine waters, arid ecosystems, and some grasslands (NPS-ARD 2013a). Increases in nitrogen have been found to promote invasions of fast-growing annual grasses (e.g., cheatgrass) and exotic species (e.g., Russian thistle) at the expense of native species (Brooks 2003, Allen et al. 2009, Schwinning et al. 2005). Increased grasses can increase fire risk (Rao et al. 2010), with profound implications for biodiversity in non-fire adapted ecosystems. Nitrogen may also increase water use in plants like big sagebrush (Inouye 2006).

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

4.4.2. Data and Methods

The approach we used for assessing the condition of air quality within the National Recreation Area airshed was developed by the NPS-ARD for use in Natural Resource Condition Assessments (NPS-ARD 2013a, 2010c). Given no on-site or nearby representative monitors, interpolated values generated by NPS-ARD, are averaged over five years and 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

Visibility is monitored by the Interagency Monitoring of Protected Visual Environments (IMPROVE) Program (NPS-ARD 2010a). The NPS-ARD assesses visibility based on the deviation of the current Group 50 visibility conditions from estimated Group

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

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

The deciview scale scores pristine conditions as a zero and increases as visibility decreases (NPS-ARD 2013a).

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 National Recreation Area 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 National Recreation Area. 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 (2013a) for NRCAs and listed in Table 4.4.3-1.

Visibility

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

Ozone

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

The NPS-ARD rates ozone condition as "good" if the ozone concentration is less than

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 2013a

or equal to 60 ppb, "moderate" if the ozone concentration is between 61 and 75 ppb, and of "significant concern" if the concentration is greater than or equal to 76 ppb.

Wet Deposition

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

4.4.4. Condition and Trend

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

Visibility

All visibility data used for the condition assessment were derived from NPS ARD Air Atlas interpolated five-year average values (2008-2012) (NPS-ARD 2014a). The 5-year interpolated values average for the National Recreation Area'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 Chickasaw National Recreation Area , but in considering the overall trend of visibility throughout national parks, NPS-ARD (2013b) analyzed visibility data for 157 parks during the period of 2000-2009. During that time, visibility on the clearest days improved at most sites; and visibility on the haziest days was relatively unchanged at many sites

Ozone

Ozone data used for the condition assessment were derived from the five-year interpolated values average (2008-2012) (NPS-ARD 2014b), which resulted in a significant concern ozone condition rating.

Thirteen ozone-sensitive plant species were found within the National Recreation Area (NPS-ARD 2006), and eight are ozone bioindicators (Table 4.4.4-2) (Porter 2003).

Table 4.4.4-1. Condition results for air quality indicators at Chickasaw National Recreation Area.

Data Span	Ozone	Visibility	Total N (kg/ha)	Total S (kg/ha)
2008-2012	Significant Concern (76.6)	Significant Concern (10.1)	Significant Concern (4.8)	Significant Concern (3.1)

Source: NPS-ARD (2014 a,b,c) Air Quality Estimate Tables

Table 4.4.4-2. Ozone sensitive plants found at Chickasaw National Recreation Area (NPS-ARD 2006, Porter 2003).

Scientific Name	Common Name	Bioindicator
Apios americana	Groundnut	Yes
Apocynum cannabinum	Indian hemp	No
Artemisia ludoviciana	Silver wormwood	Yes
Cercis canadensis	Redbud	Yes
Eupatorium rugosum	White snakeroot	Yes
*Fraxinus americana**	White ash	Yes
*Fraxinus pennsylvanica**	Green Ash	No
*Parthenocissus quinquefolia**	Virginia creeper	No
*Platanus occidentalis**	American sycamore	Yes
Prunus serotina	Black cherry	Yes
*Rhus copallina**	Dwarf sumac	No
*Rhus trilobata**	Skunkbush	Yes
Robinia pseudoacacia	Black locust	No
*These species only were identified by Kohut (2007) as ozone sensitive.		

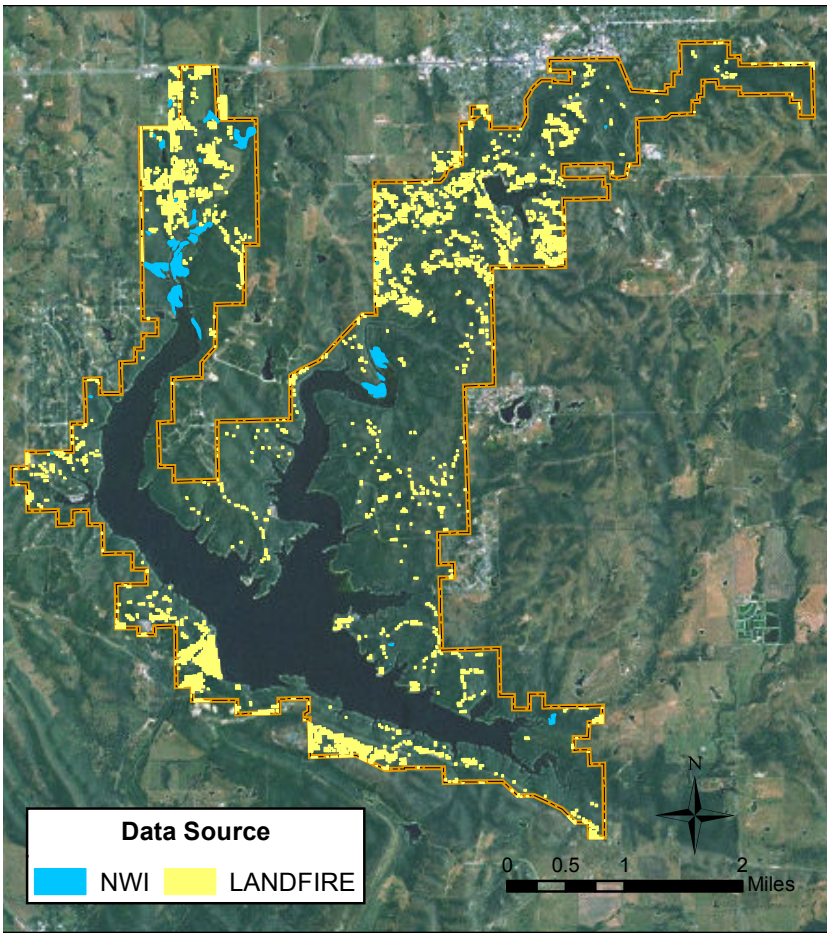


Figure 4.4.4-1. Locations of nitrogen sensitive vegetation at Chickasaw National Recreation Area.

An ozone risk assessment was conducted by Kohut (2007) for Southern Plains parks, including the NRA. The overall ozone ranking at the NRA was considered high, which is consistent with the current condition reported by NPS-ARD (2014b). We based the current ozone condition at the NRA on the most recent interpolated data (2008-2012) from NPS-ARD.

Wet Deposition

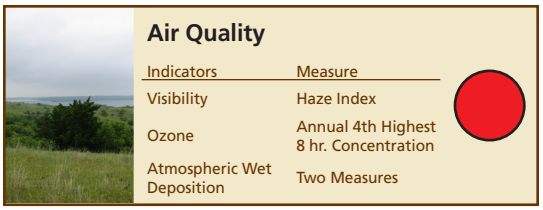
The data for atmospheric wet deposition condition were derived from NPS-ARD's 2008-2012 interpolated values (NPS-ARD 2014c). The average value for total nitrogen resulted in a significant concern rating and the condition rating was significant for total sulfur.

Sullivan et al. (2011a), studied the risk from acidification for acid pollutant exposure and ecosystem sensitivity for Southern Plains parks, including the NRA. Pollutant exposure included the type of deposition (i.e., wet, dry, cloud, fog), the oxidized and reduced forms of the chemical, if applicable, and the total quantity deposited. The ecosystem sensitivity considered the type of terrestrial and aquatic ecosystems present at the NRA and their inherent sensitivity to the atmospherically deposited chemicals. These risk rankings for Chickasaw NRA were considered moderate for acid pollutant exposure and 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 high and low, respectively at the NRA. As part of this nitrogen screening project, sensitive vegetation types were identified throughout the NRA using three datasets: LANDFIRE, National Wetlands Inventory (NWI), and National Land Cover Data (NLCD). Figure 4.4.4-1 shows the locations of these vegetation types if present.

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 2012e). A study conducted by Lehmann and Gay (2011), indicated a decrease in sulfate concentrations from 1985-2009 in the area surrounding the NRA, and an increase in nitrate concentrations. The observed sulfate decrease was statistically significant but not statistically significant for nitrate concentrations.

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



Overall Condition and Trend

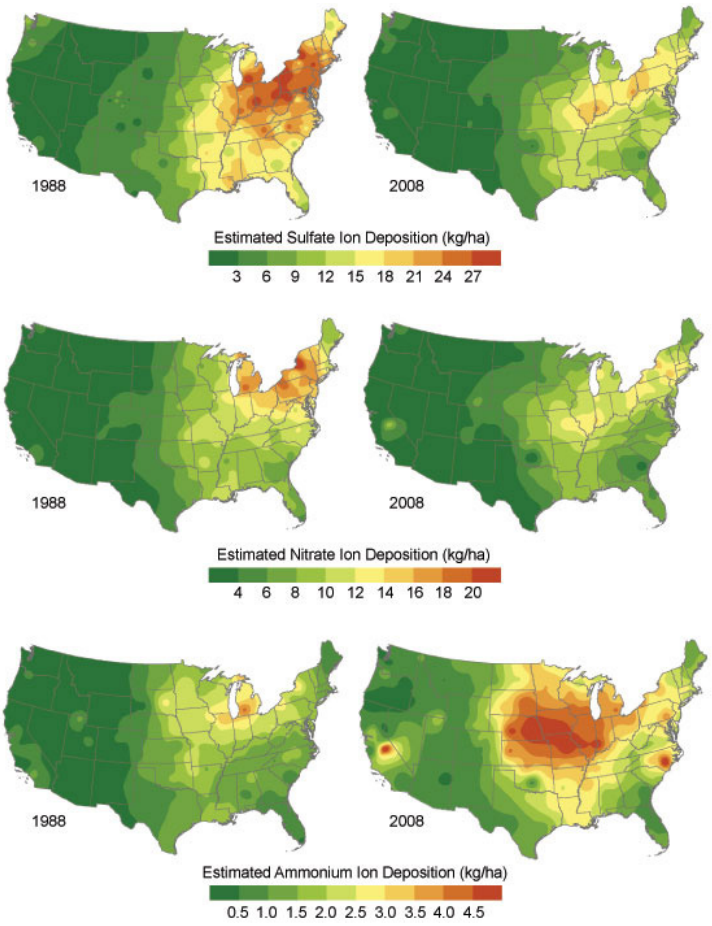
For assessing the condition of air quality, we used three air quality indicators. Our indicators/measures for this resource were intended to capture different aspects of air quality, and a summary of how they contributed to the overall condition is summarized in Table 4.4.4-3.

We consider the overall condition of air quality at Chickasaw NRA to be of significant concern with a medium confidence level due to the interpolated values.

Trends cannot be derived for any of the air quality indicators since no monitoring sites are located near enough to be representative of the conditions at the NRA and onsite monitoring does not occur.

Level of Confidence/Key Uncertainties

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



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

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

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

Indicator	Measure(s)	Condition	Condition Rationale
Visibility	Haze Index	Significant Concern	For 2008–2012, estimated average visibility in the Recreation Area was 10.1 deciviews above natural conditions, therefore, the condition status warrants significant concern based on NPS Air Resource Division benchmarks. No trend information is available because there are not sufficient on-site or nearby visibility monitor stations.
Level of Ozone	Annual 4th-Highest 8-hour Concentration	Significant Concern	The estimated ozone level for 2008–2012 at the Recreation Area was 76.6 parts per billion, therefore, the condition status warrants significant concern based on NPS Air Resource Division benchmarks. There are 13 ozone-sensitive plants in the NRA, with eight representing bioindicators. No trend information is available because there are not sufficient on-site or nearby ozone monitor stations.
Atmospheric Wet Deposition in Total N and total S	Total N in kg/ha/yr	Significant Concern	For 2008–2012, estimated wet nitrogen deposition was 4.8 kilograms per hectare per year, therefore, the condition status warrants significant concern based on NPS Air Resource Division benchmarks. No NPS-ARD trend information is available for nitrogen.
	Total S in kg/ha/yr	Significant Concern	For 2008–2012, estimated wet sulfur deposition was 3.1 kilograms per hectare per year, therefore, the resource is of significant concern based on NPS Air Resource Division benchmarks. No NPS-ARD trend information is available for sulfur.

especially nitrogen deposition, on ecosystems at Chickasaw NRA.

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.

4.4.6. Literature Cited

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4.5. Geology

Indicators/Measures

- Travertine Deposits (1 measure)
- Vanoss Formation (1 measure)
- Paleontological Resources (1 measure)
- Seismic Activity (1 measure)
- Disturbed lands (1 measure)

Condition – Trend – Confidence



Moderate- Insufficient Data - High

4.5.1. Background and Importance

Geologic resources are literally the bedrock of units in the National Park System. They make up the scenery and the landscape that is integral to the significance of most natural areas within the system. Paleontological resource are irreplaceable records of past life and are protected by the Paleontological Resources Preservation Act of 2009. Geologic processes continue to shape park landscapes, impact park ecosystems, and may present hazards to park infrastructure and human safety. Understanding of geologic resources is needed for science-based decision making in National Park System units.

Geologic resources also serve as the foundation of ecosystems. Geology is a major determinant of topography, water and soil chemistry, fertility of soils, stability of hill slopes, and flow regimes of surface water and groundwater. These factors, in turn, influence biology, including the distribution of habitats and the locations of threatened and endangered species. Geology also influences human settlement patterns and how people use natural resources—for farming, ranching, industry, construction, hunting, fishing, and recreation.

The unique freshwater and mineral springs along Travertine and Rock creeks in Chickasaw National Recreation Area (NRA) have been federally protected since 1902 and are tied to the geology of the park. The recreation area includes a 4 km (2.5 mi) reach of Rock Creek and all but the headwaters of Travertine Creek (Figure 4.5.1-1).

Chickasaw NRA is a landscape of gently rolling hills dissected by streams and ravines, and includes the Lake of the Arbuckles. Elevation in the area ranges from about 244 m (800 ft) above sea level in Rock Creek below



NPS

Figure 4.5.1-1. Travertine Creek in Chickasaw National Recreation Area.

the Arbuckle Dam to nearly 335 m (1,100 ft) southeast of Veterans Lake.

The geologic history of Chickasaw NRA is complex (Blome et al. 2013; Graham 2015). The sedimentary rocks exposed in Chickasaw (Figure 4.5.1-2) were deposited between the Middle Ordovician and the late Pennsylvanian periods, approximately between 460 and 300 million years ago. These sediments were deposited in a thick sedimentary trough, known as the Southern Oklahoma Aulacogen that formed in a failed continental rift (Christenson et al. 2011).

The region then underwent a period of intense folding and faulting during the assembly of the supercontinent Pangaea (Graham 2015). This mountain-building event formed the Arbuckle, Ouachita, and Wichita mountains of southern Oklahoma (Graham 2015). Faults associated with the formation of the aulacogen were reactivated repeatedly during tectonic events throughout the Paleozoic (Christenson et al. 2011).

Major structural features of the Chickasaw area include northwest-southeast oriented folds and faults, including the deep-seated Reagan Fault and Mill Creek Fault Zone (Blome et al. 2013).The Reagan Fault is the most significant major fault that runs through Chickasaw NRA (Noel Osborn, Chief of Resource Management, Chickasaw NRA, personal communication, 2015).

Sediments deposited in alluvial fans and other terrestrial environments as the Arbuckle Mountains eroded following their uplift are known as the Vanoss Formation. The Vanoss Formation consists of approximately 300 million year old limestone conglomerate, sandstone and shale. This unit is only mildly folded as it was deposited after the main period of mountain building (Blome et al. 2013).

This area of Oklahoma has undergone extensive erosion. The Arbuckle Mountains have been eroded to a peneplain of gentle topography. Today, the Vanoss Formation is exposed at the surface in most areas of the NRA. Rocks of the Simpson Group and the Arbuckle Group, which is not exposed at the surface in Chickasaw NRA, form the Arbuckle-Simpson Aquifer, which is the sole source aquifer for potable water in the region (Graham 2015). The Arbuckle Group is present in the subsurface of the recreation area, and Vendome Well is drilled into it.

The Vanoss Formation acts as a confining layer over the Arbuckle-Simpson Aquifer. The freshwater and mineral springs in Chickasaw NRA flow from this aquifer (Christenson et al. 2011).

Age	Stratigraphic Unit (map symbol)			Rock Description
Quaternary	Artificial fill (af)			Fill for dams and other projects.
	Alluvium (Qal)			Unconsolidated sand, silt, clay and gravel
Permian (Lower)	Potomic Group	Stratford Formation (Ps)		Shale and sandstone
Pennsylvanian (Upper)		Vanoss Formation	Shale facies (PNvs)	Primarily green, gray, and red shale and silty shale
			Conglomerate facies (PNvc)	Limestone boulders, cobbles, and pebbles in a calcareous matrix.
Pennsylvanian (Middle)	Deese Group (PNd)			Sandstone , shale, limestone conglomerate, limestone.
	Atoka and Wapanucka Formations (Pnaw)			Unfossiliferous sandstone and brown to gray shale.
Pennsylvanian (Lower)	Springer Formation (PNMs)			Black, fissile shale separated by thin beds of sandstone and limestone.
Mississippian (Upper)				
Mississippian (Middle)	Caney Shale (Mc)			Black, fissile shale with phosphatic concretions.
Mississippian (Lower)	Sycamore Limestone, Welden Limestone, Woodford Shale (MDsw)			Shale, cherty to silty limestone, black bituminous shale
Devonian (Upper)				
Devonian (Lower)	Hunton Group (DSOh)	Upper part (Dhu)		Blue to white shale and argillaceous limestone.
Silurian		Lower part (SOhl)		Fossiliferous to massive to argillaceous limestone.
Ordovician (Upper)	Sylvan Shale and Viola Group (Osv)	Sylvan Shale (Os)		Soft, green to gray, fissile shale.
		Viola Group (Ov)		Fossiliferous and cherty limestone
Ordovician (Middle)	Simpson Group	Bromide, Tulip Creek, McLish Formations (Obm)		Sandstone, shale, and limestone
		Oil Creek and Joins Formations (Ooj)		Basal conglomerate layer overlain by sandstone, limestone, and shale.
Ordovician (Lower)	Arbuckle Group (upper part)	West Spring Creek and Kindblade Formations (Owk)		Mostly limestone that grades eastward into dolomite with sandstone and shale.
		West Spring Creek Formation (Ow)		Limestone th at grades eastward into dolomite with sandstone and shale.

Figure 4.5.1-2. Generalized chart of the geologic (stratigraphic) units exposed in and around Chickasaw NRA. Modified from Graham (2015) and Blome et al. (2013). Units shaded in gray are not exposed within boundaries of the recreation area.

4.5.2. Data and Methods

We used five indicators, each with one measure, to assess the current condition and trend for

geologic resources at Chickasaw NRA (Table 4.5.2-1). The indicators evaluate the condition of the recreation area's travertine deposits, Vanoss Formation, paleontological resources, seismic activity and disturbed lands. These indicators were developed in consultation with park staff from Chickasaw NRA (Noel Osborn, personal communication, 2015).

This assessment is mostly based on the findings of the draft geologic resources inventory report prepared by the National Park Service Geologic Resources Division (Graham 2015), supplemented by other relevant reports, publications and data sets. These sources of information include the geologic map of Chickasaw NRA published in 2013 (Bloom et al. 2013). Additionally, hydrogeology studies (Christenson et al. 2009; 2011) provide insight into the Arbuckle-Simpson Aquifer, which is addressed in Section 4.8. Other sources of information include the Paleontological Resource Inventory and Monitoring report for the Southern Plains Network (Tweet et al. 2015), and the NPS Abandoned Mineral Lands (AML) Inventory and Assessment Report (Burghardt et al. 2014) and database (National Park Service 2015).

Information about seismic activity and hazards in Oklahoma, including potentially induced earthquakes, is from the United States Geological Survey (USGS) (2014), Petersen et al. (2015), and Oklahoma Geological Survey (2015).

Indicator/Measure
Travertine Deposits (1 Measure)

The travertine intactness measure evaluates whether travertine deposits remain in natural condition. Travertine is calcium carbonate (calcite) precipitated at the Earth's surface by carbonate-rich waters. Travertine deposits are found in areas where groundwater discharges, such as springs and seeps. Travertine also forms in streams where there is turbulence, usually in areas with steeper gradients.

Groundwater from the Arbuckle-Simpson aquifer is saturated with calcium carbonate ($CaCO_3$) and supersaturated in carbon dioxide (CO_2) with respect to the atmosphere. As water discharges from springs, CO_2 is released, precipitating $CaCO_3$. Turbulence aerates the water, which provides a favorable environment for growth of algae and mosses, providing absorbent, porous substrates upon which travertine can accrue. Loss of CO_2 from water by photosynthesis and evaporation also causes travertine to precipitate. Precipitation of travertine builds waterfalls, resulting in greater turbulence, thereby perpetuating the entire cycle (Figure 4.5.1-1) (Osborn et al. 2006).

In Chickasaw NRA, extensive travertine deposits are found at or near the freshwater springs that feed Travertine Creek, and along Travertine Creek itself. In the 1930s, the Civilian Conservation Corps (CCC) constructed a number of landscape features along Travertine Creek including building dams to make pools for swimming (Graham 2015). Travertine deposits occur in many of these swimming areas. Large natural deposits of travertine can be observed on Travertine Island. The CCC built picnic tables and other features using pieces of travertine on and near Travertine Island (Figure 4.5.2-1).

Travertine deposits are important because they indicate the areas of current and past springs and seeps, which are the surface

Table 4.5.2-1. The indicators and measures used to assess geology condition at Chickasaw NRA.

Indicator	Measures
Travertine Deposits	Travertine Intactness
Vanoss Formation	Vanoss Formation Intactness
Paleontological Resources	Fossil Intactness
Seismic Activity	Presence/Absence
Disturbed Lands	Abandoned Mineral Lands Prioritization Ranking



NPS/NOEL OSBORN

Figure 4.5.2-1. A picnic table in the Lost Cave Picnic Area that was built by the CCC circa 1935. The legs are made of travertine and a natural travertine deposit is in the background.



JOHN GRAHAM

Figure 4.5.2-2. The Vandoss Formation in Chickasaw NRA. The photo shows the conglomerate facies with sandstones and conglomerates forming ledges and shales making slopes (Graham 2015).

discharges of an aquifer. They can provide information about the geohydrology of an area through time. For example, travertine deposits located away from the current drainage system may indicate the location of springs that are no longer active.

Indicator/Measure

Vanoss Formation (1 Measure)

The Vanoss Formation intactness measure evaluates whether the stratigraphic unit remains in natural condition. The geologic map of the Chickasaw area (1:24,000) (Bloom et al. 2013) provides detailed information about the surface geology and structural features of the NRA. The Vanoss Formation (Figure 4.5.2-2) is the principle rock unit exposed in the recreation area. The formation consists of two units: a lower unit, which is a limestone conglomerate, and an upper shale-rich unit. The lower conglomerate averages 30 m (100 ft) thick and consists of limestone conglomerate with limestone boulders, cobbles and pebbles. The upper shale unit mostly contains shale and red sandstones, and is exposed mostly in the Guy Sandy area, and to the west of Rock Creek north of the upper end of the Lake of the Arbuckles (Blome et al. 2013).

The Vanoss Formation is late Pennsylvanian in age (approximately 300 million years old). It was deposited in a terrestrial environment consisting of alluvial fan and alluvial plain deposits eroded from the Arbuckle Mountains (Tweet et al. 2015). The Vanoss Formation has a maximum thickness of 198 m (650 ft) and thins to near zero thickness to the east (Blome et al. 2013). It is approximately 100 m (330 ft) thick at Vendome Well.

The Vanoss Formation was deposited after a period of intense faulting and folding that accompanied the rise of the Arbuckle Mountains during the Wichita and Arbuckle orogenies (periods of mountain building) (Blome et al. 2013). In the Sulphur area, the cobbles and pebbles in the Vanoss Formation conglomerate are primarily limestone and dolostone from the Arbuckle Group, and granite and quartz from the underlying Proterozoic basement rocks that were exposed to erosion in the uplifted Arbuckle Mountains (Christenson et al. 2011).

A major unconformity (Figure 4.5.2-3) is at the lower contact of the Vanoss Formation. The Deese Formation and other units below

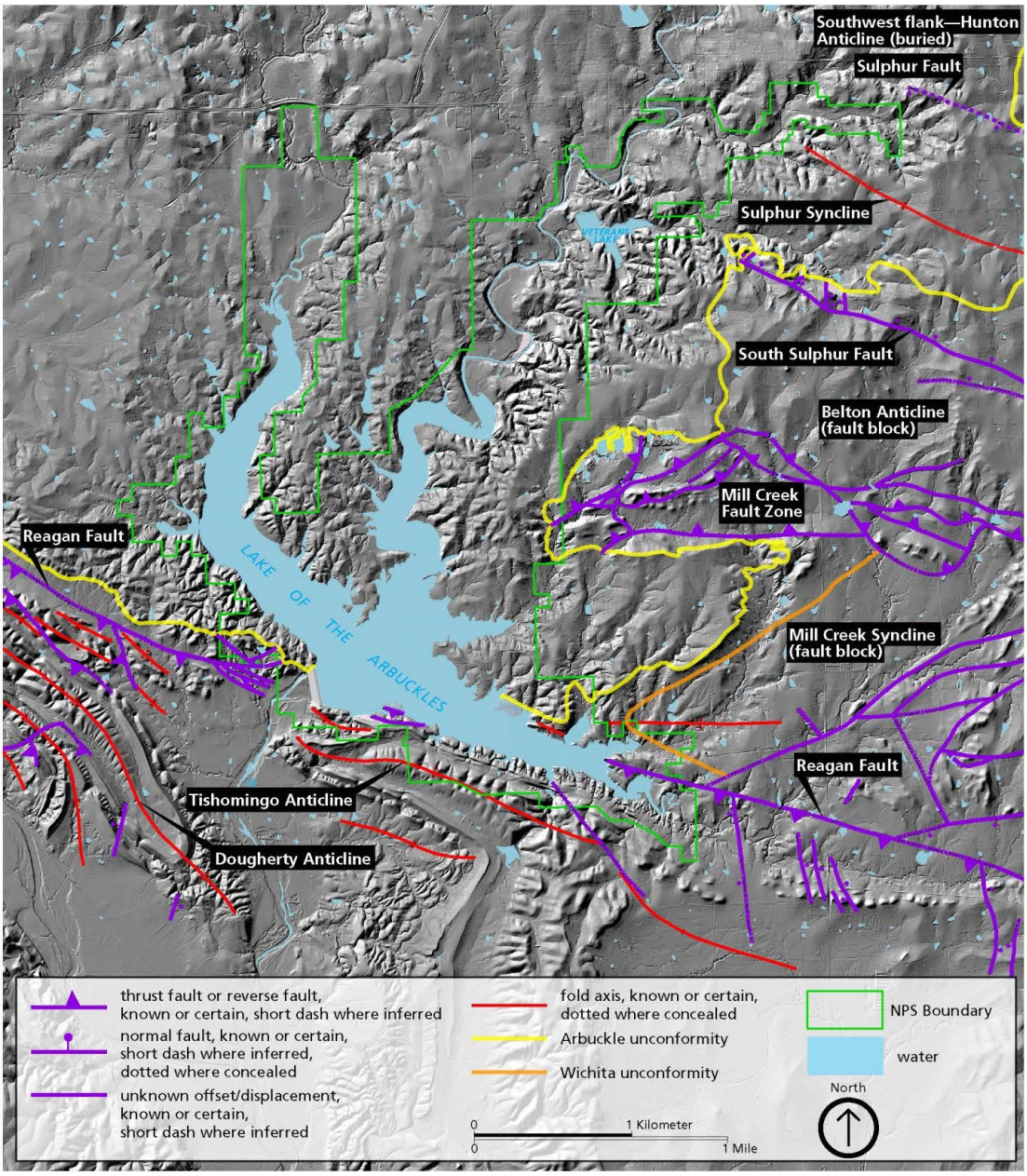


Figure 4.5.2-3. Map showing the Arbuckle unconformity at the base of the Vanoss Formation and structural features in and near Chickasaw National Recreation Area.

Graphic by Trista Thornberry-Ehrlich (Colorado State University) after Blome et al. (2013), using GRI GIS data (Graham 2015).

the Vanoss Formation were intensely faulted and folded by the Wichita orogeny prior to deposition of the Vanoss Formation, which is only broadly warped (Blome et al. 2015).

Another important aspect of the Vanoss Formation is that it functions as a confining unit above the Arbuckle-Simpson aquifer. The tightly-cemented Vanoss Formation has low permeability which restricts water movement (Christenson et al. 2011).

Bromide Hill is the chief topographic feature in the park, rising approximately 43 m (140 ft) above Rock Creek. The conglomerate unit of the Vanoss Formation caps Bromide Hill. Although the Vanoss conglomerate is generally resistant to erosion, there is a risk of rock fall from the vertical cliff that is being undercut by the creek (Graham 2015). Three mineral springs (Sulphur, Medicine and Bromide) flow from the base of the hill.

Indicator/Measure

Paleontological Resources (1 Measure)

The fossil intactness measure evaluates whether paleontological resources remain in natural condition. Paleontological resources (commonly known as fossils) are remains of

life preserved in a geologic context (Santucci et al. 2009). Paleontological resources may be body fossils, which are the actual remains of organisms, or trace fossils, which are evidence of biological activity, such as tracks or burrows. In addition to providing a record of the history of life, paleontological resources also provide information about past climates and past ecosystems throughout geologic time.

Fossils are finite resources with great scientific, educational and interpretive value regardless if they are common or rare. In situ paleontological resources at or near the surface will ultimately deteriorate over time, and their deterioration or loss is impacted by both natural erosion and human activities, including inadvertent ones and fossil theft (Santucci and Koch 2003).

NPS Management Policies stipulate that paleontological resources are subject to the "no impairment" standard per the 1916 NPS Organic Act (NPS 2006). Paleontological resources in national park sites are further protected by the Paleontological Resources Preservation Act of 2009 which directs the NPS to develop plans for fossil inventories, monitoring, and scientific and educational use, calls for the management and protection of paleontological resources using scientific principles and expertise, and provides other mandates to enhance the stewardship of fossil resources (Tweet et al. 2015).

The Paleontological Inventory and Monitoring Report for the Southern Plains Network (Tweet et al. 2015) provides information on the occurrence of paleontological resources in Chickasaw NRA. This report is a compilation of baseline paleontological resource information largely based on an extensive literature search. The report also provides preliminary recommendations for paleontological resource management.

Additional information about paleontological resources at Chickasaw NRA includes the Geologic Resource Inventory (Graham 2015) and the geologic map of the Chickasaw area (Blome et al. 2013).

The condition of paleontological resources is assessed for accelerated erosion and the impacts of human activity.

Anthropogenic factors such as climate change can cause accelerated erosion when it submits paleontological resources to additional or increased weathering or erosional agents. Diurnal and annual changes in temperatures that fluctuate above and below the freezing temperatures cause increased weathering and erosion. The freeze-thaw index is the number of 24-hour periods per year when temperatures pass across the freezing temperature. (Santucci et al. 2009). If climate change would cause an increase in the freeze -thaw index, it would have a negative impact on fossil resources. If it decreases the freeze-thaw index, then the rate of weathering and erosion due to physical factors theoretically should be decreased.

All the rock units exposed in Chickasaw NRA are sedimentary (Blome et al. 2013), which is the type of rock in which most fossils are found. These rocks were deposited during the Paleozoic Era (Ordovician to Pennsylvanian periods) approximately between 300 and 460 million years ago. Most sedimentary rocks exposed in the recreation area were deposited in marine conditions. Body fossils of marine invertebrate organisms such as brachiopods, corals, bryozoans and criniods are locally abundant (Tweet et al. 2015).

Fossils are present in approximately half of the rock units mapped in Chickasaw NRA (Table 4.5.2-1) (Tweet at al. 2015). The Caney Shale, Woodford Shale, Upper part of the Hunton Group (Bois d'Arc Formation and Haragan Formation), Lower Part part of Hunton Group (Henryhouse Formation, Clarita Formation, Cochrane Formation), and the Viola Group are known to be fossiliferous in Chickasaw NRA. The Bromide Formation was determined to be provisionally fossiliferous in the recreation area based on the abundance of fossils in the unit elsewhere. The Deese Formation and the Sylvan Shale both may be fossiliferous within recreation area boundaries, but the location of reported fossils in the scientific literature is unclear (Tweet et al. 2015).

Table 4.5.2-1. Known paleontological resources in Chickasaw NRA (Tweet et al. 2015).

Rock Unit		Age	Fossils
Deese Group[1]		Middle Pennsylvanian	Foraminifera and brachiopods
Caney Shale		Middle-Late Mississippian	Brachiopods, ostracodes, acanthodians, and unspecified fossils; possibly also foraminifera
Woodford Shale		Late Devonian–Early Mississippian	Acritarchs, chlorophyte algae, other palynomorphs
Upper Hunton Group	Bois d'Arc Formation	Early Devonian	Brachiopods, trilobites, crinoids, and unspecified fossils
	Haragan Formation	Early Devonian	Rugose corals, bryozoans, brachiopods, bivalves, gastropods, trilobites, ostracodes, crinoids, conodonts, and burrows
Lower Hunton Group	Henryhouse Formation	Late Silurian	Corals, bryozoans, brachiopods, trilobites, and crinoids in situ; ostracodes reworked into the overlying lower Haragan Formation
	Clarita Formation	Early–Middle Silurian	Foraminifera, brachiopods, pelmatozoan plates, and conodonts
	Cochrane Formation	Early Silurian	Conodonts
Sylvan Shale[1]		Late Ordovician	Graptolites
Viola Group		Late Ordovician	Bryozoans, brachiopods, trilobites, ostracodes, and echinoderms
Bromide Formation[2]		Middle–Late Ordovician	Bryozoans, brachiopods, bivalves, ostracodes, trilobites, echinoderms, and graptolites

[1]These units may be fossiliferous within Chickasaw NRA (Tweet et al. 2015) Ambiguities in the scientific literature make definitive inference of exact fossil localities difficult. The units are known to be fossiliferous in the overall Chickasaw area.

[2]No published reports indicate fossil localities within Chickasaw NRA. However, because the unit is very fossiliferous, it was determined to be provisionally fossiliferous in the recreation area (Tweet et al. 2015).

Fossils have not been found in the Joins Formation, Oil Creek Formation, Tulip Creek Formation, McLish Formation, Sycamore Limestone, Vanoss Formation, and Quaternary sediments within the recreation area, although the possibility exists that fossils may be found in these units in the future (Tweet et al. 2015).

Of the rock units that are known to contain fossils in Chickasaw NRA, the Haragan Formation in the upper part of the Hunton Group is the most fossil-rich (Tweet et al. 2015). In the recreation area, the Hunton Group is mapped south of the Lake of the Arbuckles and in a small area along the east boundary (Figure 4.5.2-4) (Blome et al. 2013).

The Vanoss Formation, which contains few fossils throughout its exposure and no known fossils within Chickasaw, is exposed at the surface in most of the recreation area. Therefore, potential exposures of fossils are mostly limited to areas where other formations are exposed, which are south of the Lake of the Arbuckles, north of the Buckhorn Creek arm of the lake, and a small area on the along the east boundary of the recreation area (Figure 4.5.2-4).

Further, the distribution of paleontological resources is not uniform within an area, with concentrations that are frequently localized (Santucci et al. 2009). Some areas of even a highly fossiliferous unit such as the Haragan Formation will have more fossils than other areas depending on minor variations in the environment at the time of deposition of the sediments.

Indicator/Measure

Seismic Activity (1 Measure)

The USGS is responsible for assessing seismic activity and risk across the United States. USGS seismic hazard maps show the distribution of ground motion levels from earthquakes that have a certain probability of occurring over a set period of time (USGS 2015a).

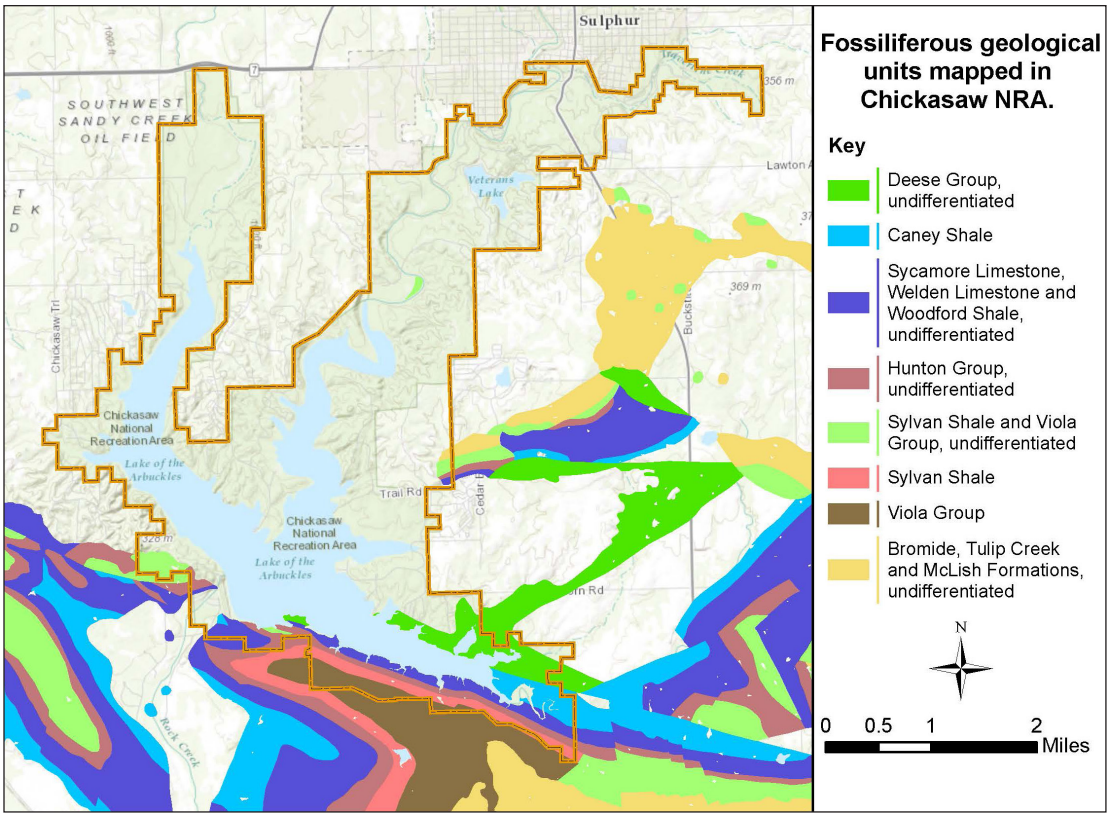


Figure 4.5.2-4 Map showing fossiliferous geologic units in Chickasaw NRA. Modified from Blome et al. (2013).

The Hunton Group consists of the Cochrane, Clarita, Henryhouse, Haragan, and Bois d'Arc formations in Chickasaw NRA. The Keel Formation does not appear to be present in the Chickasaw area (Tweet et al. 2015). The Hunton Group was mapped either as undifferentiated, the upper part of Hunton Group (Bois d.Arc and Haragan Formations) or lower Hunton Group (Henryhouse, Clarita and Cochrane formations) (Blome et al 2013).

Historically, with its location in the center of a tectonic plate, Oklahoma has had few earthquakes and a relatively low seismic hazard. Southern Oklahoma does have a slightly higher seismic hazard than most areas of the central and eastern United States because of the Southern Oklahoma Aulacogen (a sediment-filled failed rift), which formed when North America experienced incipient rifting during the break up of the supercontinent Rodinia in the late Proterozoic. The Meers Fault is located in this failed rift zone and has been active in the late Quaternary (Crone and Wheeler 2000).

Like at the New Madrid Seismic Zone in Missouri and in other failed rift zones, the faulting at the failed rift produced a zone of weakness in the North American continent (Crone and Wheeler 2000) that has an increased seismic hazard relative to other areas of the continental interior as shown in the 2014 Seismic Hazard Assessment (Figure 4.5.2-5) (USGS 2014). The 2014 Seismic Hazard Map indicates that the Chickasaw area has a 2% chance that an earthquake peak ground acceleration of between 14 and 20 g (percent of gravity) being exceeded in 50 years due to natural earthquakes (USGS 2014).

In the last five to seven years, Oklahoma has experienced a dramatic increase in earthquakes (Petersen et al. 2015; Oklahoma Geological Survey 2015) (Figure 4.5.2-6). These earthquakes are thought to have been induced by injection of wastewater from oil and gas production in deep wells (Oklahoma Geological Survey 2015; Keranen et al. 2013).

Most of these induced earthquakes have occurred in the crystalline basement , which is deeper than most injection wells (Oklahoma Geological Survey 2015). However, approximately 62% of wastewater injected in Oklahoma is into the Arbuckle Formation, which directly overlies the basement rocks (Murray 2014). The Arbuckle Group is highly faulted in the Chickasaw area (Christenson et al. 2011), and many of these faults penetrate the crystalline basement. Further, induced seismicity often results from reactivation of deeper faults from wastewater injection at shallower depths (Oklahoma Geological Survey 2015).

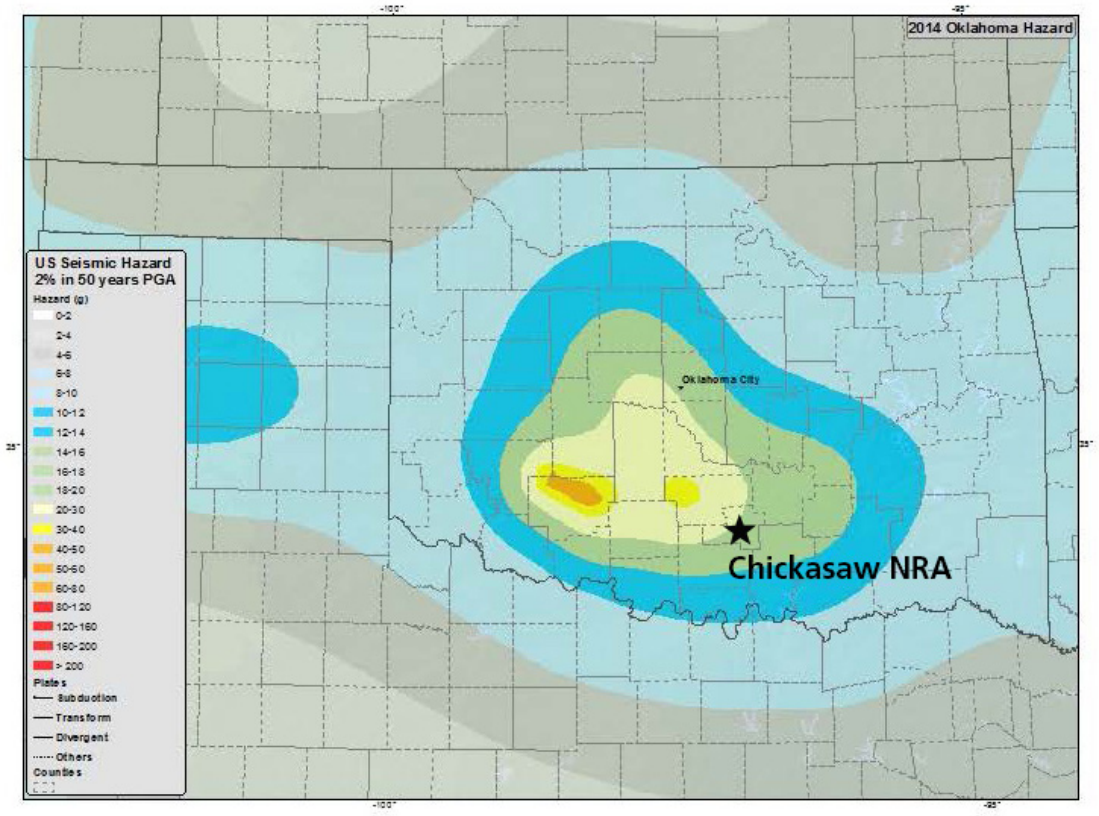


Figure 4.5.2-5. The Seismic Hazard Map for Oklahoma, showing the location of Chickasaw (modified from USGS 2014).

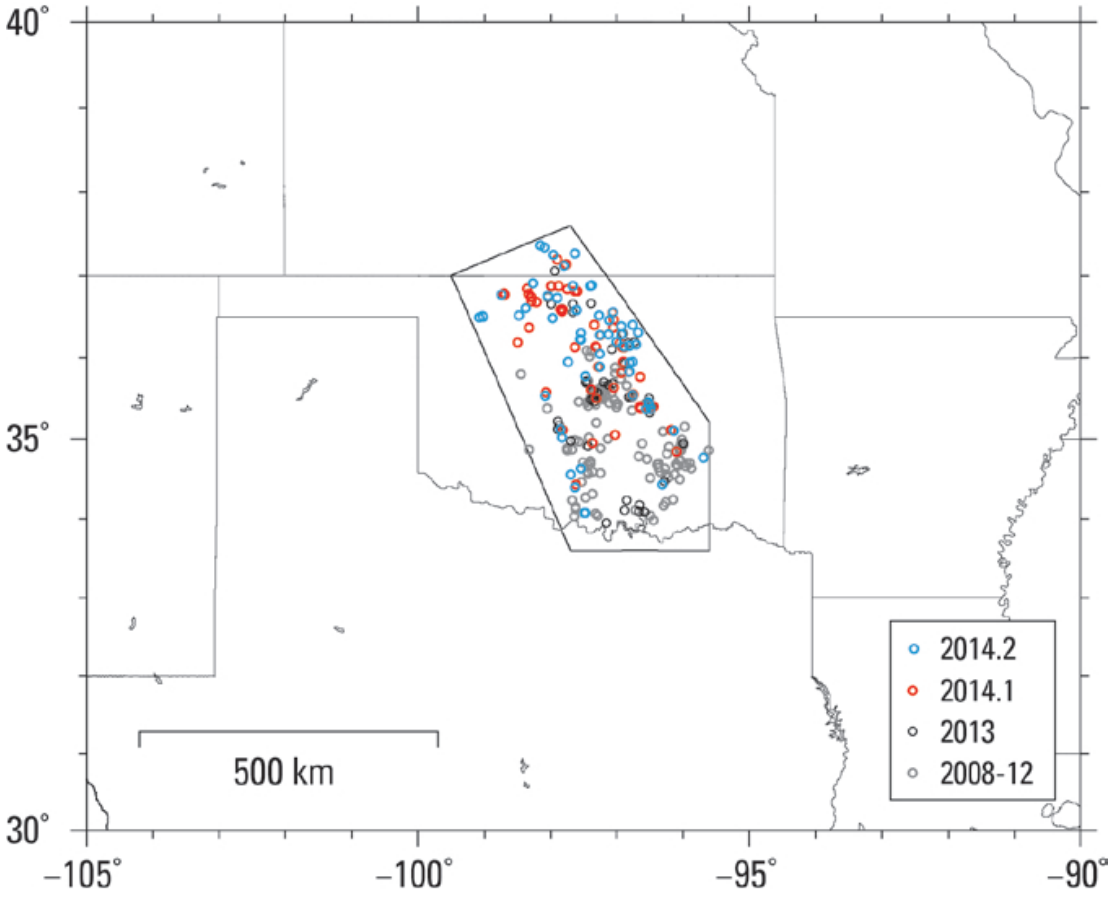


Figure 4.5.2-6. The induced seismicity zone in Oklahoma, showing the location of earthquakes 2008 though 2014 (Petersen et al. 2015).

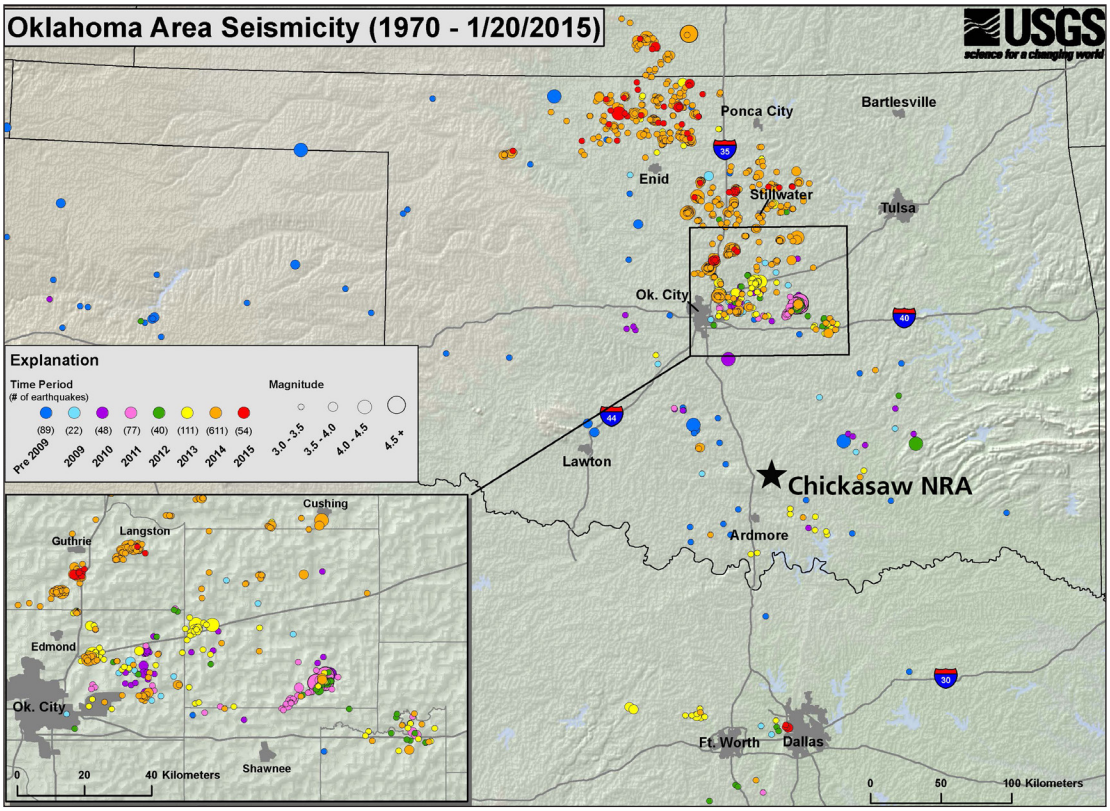


Figure 4.5.2-7. Earthquakes in Oklahoma between 1970 and January 2015. Modified from USGS (2015b).

While no earthquake with an epicenter within the boundaries of Chickasaw NRA has occurred (Figure 4.5.2-7) (USGS 2015b), earthquakes have occurred in the region, and oil and gas development, including injection wells, is located west of the recreation area. Several deep-seated faults that penetrate the basement, including the Reagan Fault and the Mill Creek Fault Zone, are located in Chickasaw NRA.

Indicator/Measure
Disturbed Lands (1 Measure)

Disturbed lands in Chickasaw NRA consist of abandoned mineral lands (AML). This indicator uses the abandoned mineral lands (AML) prioritization ranking assigned by the NPS AML program to measure the condition. AML sites are locales that contain facilities, structures, and disturbances associated with past mineral exploration, extraction, processing, and transportation for which the NPS takes action to mitigate, reclaim, or restore in order to reduce hazards and impacts to park resources (Burghardt et al. 2014). The National Park Service Abandoned Mineral Lands Program issued a comprehensive inventory and assessment report on AML sites in the National Park System (Burghardt et al. 2014). The report identified two sites in Chickasaw NRA that require mitigation.

Burghardt et al. (2014) lists criteria used to prioritize AML features for remedial action. Each site is assigned rankings for hazards, access, resource significance, and resource impacts. Table 4.5.2-2 provides these rankings for Chickasaw's two sites using additional information from the NPS service-wide AML database (NPS 2015).

The hazard and access elements are assigned numeric rankings between 0 and 5 (low to high) by the NPS AML program based on the presence of identifiable characteristics, such as the presence of a deep pool of water from which it would be difficult to climb out (a hazard element), or the AML site being accessible by a good road leading to it (an access element). The resource significance and resource impact rankings have possible values of 0, 2 or 4 for low, medium and high.

The NPS prioritization system for sites that need mitigation is based on the severity of

Table 4.5.2-2. Prioritization rankings for Abandoned Mineral Lands at Chickasaw NRA.

Indicator	Hazard Rating	Hazards	Access Rating	Access	Resource Signiif. Rating	Resource Significance	Resource Impact Ranking	Resource Impact
CHIC Pit Dry	3 (High)	Highwall	5 (High)	Road to site (through private land)	0	Unknown impact to biological resources	0	Unknown resource impact
CHIC Pit West	4 (High)	Highwall, drowning, litter	5 (High)	Road to site (through private land)	0	Unknown impact to biological resources	0	Water was tested and was uncontaminated

Data are from Burghardt et al. 2014 and NPS 2015b.

public safety hazard and the level of impact on park resources (Burghardt et al. 2014). Sites with a hazard level of at least 3, or a resource impact level of 4, are assigned as high priority. Medium priority AML have either a hazard level or resource impact level of 2. All other AML features that require mitigation are considered low priority.

Both AML sites in Chickasaw NRA are surface mines (quarries) with a single feature, both mined for gilsonite, an asphalt-like rock (NPS 2015). CHIC Pit Dry covers 7 acres, and CHIC Pit West covers 4 acres. Both sites show evidence of moderate visitation, are accessible by road through private land or via hiking, and are in areas used for hunting or other activities. Both also have highwalls (vertical or near-vertical walls resulting from an excavation into a hillside) (Burghardt et al. 2014). CHIC Pit West also has a pool of water as deep as 21 m (70 ft).

CHIC Pit Dry is assigned a hazard ranking of 3 (high) because of the highwall, and CHIC Pit West is ranked 4 (high) for hazard elements because of the highwall and risk of drowning. Both sites had an access rating of 5 (high) as easily accessible. Resource significance and resource impact rankings were both low.

4.5.3. Reference Conditions

The reference conditions by which geology condition was assessed are listed in Table 4.5.3-1. The reference conditions for travertine deposits, the Vanoss Formation and paleontological resources at El Malpais NM are based on the "no impairment" standard for geologic resources in NPS Management Policies (NPS 2006).

Travertine Deposits

Travertine deposits that have no concerns or issues and are in a natural state are considered to be in good condition. If there are some areas of moderate concerns related to impacts to travertine deposits, the condition is considered to be moderate. A condition of significant concern exists when impacts or potential impacts to travertine deposits have been identified.

Vanoss Formation

Outcrops of the Vanoss Formation that have no concerns or issues and are in a natural state are considered to be in good condition. If there are some areas of moderate concerns related to the Vanoss Formation, the condition is considered to be moderate. A condition of significant concern exists when impacts or potential impacts to the Vanoss Formation have been identified.

Paleontological Resources

Paleontological resources that have no concerns or issues and are in a natural state related to them are considered to be in good condition. If there are some areas of moderate concerns related to impacts to paleontological resources, the condition is considered to be moderate. A condition of significant concern exists when impacts or potential impacts to fossil resources have been identified.

Natural processes and human activities pose threats to in situ fossils at or near the surface (Santucci et al. 2009). Natural weathering and

Table 4.5.3-1. Reference conditions used to assess the current condition of geology for each indicator.

Indicator	Measure	Good	Moderate Concern	Significant Concern
Travertine Deposits	Travertine Intactness	No concerns or issues about travertine deposits have been identified. Geologic resources and processes are in a generally natural state and function.	Some areas of moderate concern related to impacts to travertine deposits.	Areas of concern have been identified that have the potential to impact travertine deposits.
Vanoss Formation	Vanoss Formation Intactness	No concerns or issues about the Vanoss Formation have been identified. Geologic resources and processes are in a generally natural state and function.	Some areas of moderate concern related to impacts to the Vanoss Formation.	Areas of concern have been identified that have the potential to impact the Vanoss Formation.
Paleontological resources	Fossil Intactness	No concerns or issues about paleontological resources have been identified. Paleontological resources are in a generally natural state and function.	Some areas of moderate concern related to impacts to paleontological resources.	Areas of concern have been identified that have the potential to impact paleontological resources.
Seismic Activity	Presence/Absence	No earthquakes have occurred in the park.	Earthquakes have occurred in the park.	
Disturbed lands	Abandoned Mineral Land Prioritization Ranking	AML sites that require mitigation are ranked as low priority by the NPS AML Program.	AML sites that require mitigation are ranked as medium priority by the NPS AML Program.	AML sites that require mitigation are ranked as high priority by the NPS AML Program.

erosion, accelerated erosion due to climate change and geohazards can adversely impact paleontological resources. Human impacts may be intentional (collection or theft of fossils) or inadvertent, such as trampling of fossil site. A fossil site located a few miles outside of Chickasaw NRA in the Haragan Formation illustrates the impact that collecting can have on paleontological resources (Tweet et al. 2015). Since 1901, the White Mound site has decreased in height from more than 11 m (35 ft) to 6 m (20 ft).

Seismic Activity

The reference conditions for seismic activity is based on the presence or absence of earthquakes in the park.

Disturbed Lands

Our reference conditions for the Abandoned Mineral Land measure for the disturbed lands indicator are based on the priority rankings used in the NPS AML Inventory and Assessment Report (Burghardt et al., 2014). AML sites that are assigned a low priority for mitigation are considered to be in good condition. Sites with a medium priority are considered to be in moderate condition, and high priority AML sites are considered to be of significant concern. AML sites that do not require mitigation are also considered to be in good condition.

4.5.4. Condition and Trend

We used five indicators to assess the condition of geologic resources at Chickasaw NRA: travertine deposits, the Vanoss Formation, paleontological resources, seismic activity, and disturbed lands (Table 4.5.4-1).

Travertine Deposits

The extent of the travertine deposits in the recreation area has not been mapped (Noel Osborn, personal communication, 2015). Mapping these deposits may provide further insight into the geohydrology of the area, and may also provide insight into past flooding and other impacts to the surface hydrology of the Travertine and Rock Creek areas.

The Platt Historic District, which encompasses Travertine and Rock Creek, has been designated as a National Historic Landmark because of the landscape modifications of the Civilian Conservation Corps which included building spring pavilions, swimming holes

Table 4.5.4-1. Indicator, measure, and rationale of geology condition.

Indicator of Condition	Measure	Condition	Rationale for Condition
Travertine Deposits	Travertine Intactness	Unknown	With the exception of modifications to springs and Travertine Creek by the CCC, the travertine deposits in Chickasaw NRA remain in natural condition. Future deposition of travertine is dependent on future flow from freshwater springs. The travertine deposits in the NRA have not been mapped.
Vanoss Formation	Vanoss Formation Intactness	Good	The Vanoss Formation is in natural condition in Chickasaw NRA. While some risk of rock fall at Bromide Hill exists, the conglomerate unit is generally resistant to erosion.
Paleontological Resources	Fossil Intactness	Unknown	Fossils within Chickasaw are not experiencing accelerated erosion due to climatic factors. The recreation area's freeze-thaw index has decreased with warmer temperatures. However, fossil localities within Chickasaw are not being monitored for impacts of human activities, which may include fossil collecting.
Seismic Activity	Presence/ Absence	Good	Oklahoma has experienced a sharp increase in earthquakes in the last 5 to 7 years, which are suspected to result from wastewater injection in deep wells. Chickasaw is in the area of potentially induced earthquakes, which are likely to occur on preexisting faults. Several major faults cut across the region, but no earthquakes have occurred in the park to date.
Disturbed Lands	Abandoned Mineral Land Prioritization Ranking	Significant Concern	The two AML sites in Chickasaw NRA were ranked as high priority for mitigation by the NPS AML program because of their hazards and easy access for visitation.

and dams on the creeks, the stone picnic table and benches, and other features. However, the travertine deposits in the recreation area remain in their natural condition with the exception of these historic modifications.

The continuation of travertine deposition in the recreation area is dependent on the continued flow of the freshwater springs, which can be impacted by drought and groundwater use in the Arbuckle-Simpson aquifer.

Overall, the condition of travertine deposits at Chickasaw NRA is unknown because these deposits have not been geologically mapped nor systematically studied.

Vanoss Formation

Because the Vanoss Formation is in natural condition within Chickasaw NRA, it is considered to be in good condition. No significant areas of concern have been identified related to the Vanoss Formation with the exception of the potential of rock fall from Bromide Hill.

Paleontological Resources

In situ paleontological resources can be impacted by natural processes, accelerated erosion due to climate change, and human activities, such as illegal collection.

NPS Management Policies (NPS 2006) do not allow for intervention in natural processes such as weathering and erosion except in special situations. Therefore, the impact of natural weathering and erosion on Chickasaw's fossils is not considered in this assessment.

The impact of climate change for accelerated erosion of paleontological resources is assessed using the freeze-thaw index. The average daily high temperature over the period of record at the NOAA Chickasaw NRA weather station is above freezing, while winter lows are typically below freezing (Western Regional Climate Center 2015). The

climate change exposure brief for Chickasaw NRA (Monahan and Fisichelli 2014) indicates that the temperature of the mean coldest month has gotten warmer compared to historical conditions, meaning that freeze-thaw index for the recreation area has likely decreased. Therefore, the accelerated erosion of paleontological resources due to climatic factors does not appear to be occurring.

With the exception of stratigraphic section descriptions within the boundaries of Chickasaw NRA (for example, Amsden 1960), fossil locations in Chickasaw have not been extensively described or inventoried, and are not being monitored (Noel Osborn, personal communication, 2015). It is, therefore, not known if loss of or theft of fossils is occurring in the recreation area. Historically, fossil collecting occurred at the Goddard Youth Camp within the boundaries of the recreation area (Noel Osborn, personal communication, 2015). The impact of human activities on paleontological resources within Chickasaw is unknown, although it may be of concern given that fossil collecting has been an activity of the youth camp in the past, and it may still be occurring.

Overall, the condition of paleontological resources in Chickasaw NRA is unknown. A high degree of uncertainty exists for this condition assessment given that fossil localities have not been inventoried, are not being monitored, and because collection of fossils may occur within the recreation area. If fossil collecting is occurring, it would be of significant concern.

Seismic Activity

No earthquakes have occurred within the park, but the potential for increased seismic activity at Chickasaw NRA is of concern. Oklahoma, primarily to the east and north of Oklahoma City, is experiencing a markedly increased number of earthquakes that are unlikely to be a result of natural processes (Oklahoma Geological Survey 2015). The most likely cause of this increased seismic activity is wastewater injection associated with oil and gas development in deep wells (Keranen et al. 2013; Oklahoma Geological Survey 2015). The USGS (Petersen et al. 2015) indicated that central Oklahoma is an area of increased seismic hazard where suspected nontectonic earthquakes have occurred, although they have not yet released a specific seismic hazard model for these induced earthquakes.

Like natural earthquakes, induced earthquakes usually occur on pre-existing faults. A number of significant faults, including the Reagan Fault near the Arbuckle Dam and the Mill Creek Fault Zone (Figure 4.5.2-2), are present in Chickasaw NRA (Blome et al. 2013). Additional unmapped faults are present in the area (Noel Osborn, personal communication, 2015). Wastewater injection can weaken a fault by increasing pore pressure (Ellsworth 2013). Impacts of injected wastewater can travel several kilometers (miles) in highly permeable rock units such as the Arbuckle Group (Oklahoma Geological Survey 2015).

Deep-seated faults such as the Reagan Fault and the Mill Creek Fault Zone are of the most concern for induced seismicity since many of the earthquakes have occurred in the crystalline basement (Murray 2014).

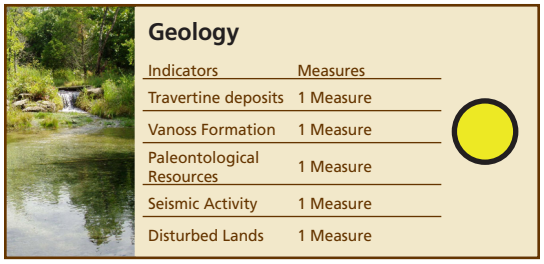
Because the mechanisms of earthquake induction are not fully understood, and because future earthquake rates may depend on regulatory and economic factors, the increased potential for seismic activity may vary in the future (Petersen et al. 2015).

Disturbed Lands

Chickasaw NRA contains only two inventoried AML sites, which are abandoned gilsonite quarries that both require mitigation. Both sites present highwall hazards with the potential of fatal falls. One site also presents a drowning hazard. The sites are easily accessible with a good road (NPS 2015). Because of the high ranking for hazards and the easy access to the sites, they are assigned a high priority for mitigation by the NPS AML program (Burghardt et al. 2014). We consider AML sites that require mitigation that are assigned a high priority ranking to be of significant concern.

The inventory and assessment report included estimates of $20,000 for mitigation of the

CHIC Pit Dry site, and $120,000 for the CHIC Pit West site in 2013 dollars (Burghardt et al. 2014). Mitigation at both sites should include fencing to restrict access. A mechanism to drain water from CHIC Pit West is also noted as a mitigation need (NPS 2015).



Overall Condition and Trend

Of the five indicators for the assessment of geologic resources at Chickasaw NRA, two were in good condition (Vanoss Formation and Seismic Activity), one was in a condition of significant concern (disturbed lands), and two were in unknown condition (travertine deposits and paleontological resources). The overall condition of the geologic resources at Chickasaw NRA is determined to be moderate.

With the exception of the increased potential for seismic activity due to the injection of wastewater in deep wells, the trend of the condition of geologic resources in Chickasaw is stable.

The potential for seismic activity has increased over the last five to seven years (Petersen et al. 2015), leading to a negative trend in the condition of the seismic activity indicator. However, future earthquakes may change in the future as the rates of induced earthquakes may depend on potential changes to the practice of wastewater injection in deep well (Petersen et al. 2015).

Level of Confidence/Key Uncertainties

We have a high level of confidence in this condition assessment because, with the exception of the case of the travertine deposits, a large number of recent reports and datasets were available (e.g., Blome et al. 2013; Graham 2015; Burghardt et al. 2014; Tweet et al. 2015; and Petersen et al. 2015).

Key uncertainties include the extent and condition of travertine deposit that have not been mapped, and future practices in wastewater injection during oil and gas operations. The condition of paleontological resources is also unknown because fossil sites are not being monitored. Without monitoring, the impact of possible collection is not known. If there has been collecting, and especially if it is continuing, then it is of serious concern.

4.5.5. Sources of Expertise

The National Park Service's Geologic Resources Division conducts geologic inventories and resource evaluations, and produces digital geologic maps in close partnership with the Inventory and Monitoring Program, park staff, and partners. This section is based largely on a draft report (Graham 2015) produced by the Geologic Resources Division, and the Southern Plains Network Paleontological Resource Inventory and Monitoring report (Tweet et al. 2015). Seismological reports (USGS 2014; Petersen et al. 2015) were used as the basis for the assessment of the potential for increased seismicity.

Allyson Mathis is a researcher/science writer with Utah State University and a geologist by training. Noel Osborn, Chief of Resource Management at Chickasaw NRA, is a hydrogeologist.

The section was reviewed by Tim Connors, Geologist, NPS Geologic Resources Division. Paleontologists Justin Tweet and Vincent Santucci reviewed the paleontology subsections, and John Burghardt, NPS AML Program Coordinator, reviewed the disturbed lands subsection.

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4.6. Surface Water Quality

Indicators/Measures

- Field Properties (5 measures)
- *Escherichia coli* (1 measure)

Condition – Trend - Confidence



Moderate– Insufficient Data - Low

4.6.1. Background and Importance

The surface hydrology within Chickasaw National Recreation Area (NRA) consists of two reservoir lakes, Lake of the Arbuckles and Veteran's Lake, and several streams and creeks, which provide inflow to both reservoirs (Figure 4.6.1-1). Lake of the Arbuckles was constructed for recreational purposes in 1966 and is located in the southern portion of the NRA. It is fed by Rock, Travertine (which is fed by Buffalo and Antelope Springs), Buckhorn (a tributary of Rock Creek), and Guy Sandy Creeks. The reservoir can occupy a surface area as large as 1,267 ha (3,130 acres) when full. Veteran's Lake was constructed between 1933 and 1936 as a memorial to World War I veterans and has a surface area of approximately 26 ha (64 acres) and was created by damming Wilson Creek, which is the lake's primary source of inflow (Wikle et al. 1998; Hanson and Cates 1994). While both reservoirs provide recreational opportunities to park visitors, only Lake of the Arbuckles serves as a public water supply for surrounding communities and is important for flood control (Wikle et al. 1998). The drainage area for each creek and percentage of area located within the NRA's boundary are shown in Table 4.6.1-1 (table modified from Hanson and Cates 1992). Almost 62% of Travertine Creek's drainage area is located within the park, whereas less than 1% of Buckhorn Creek's drainage area is within the park.

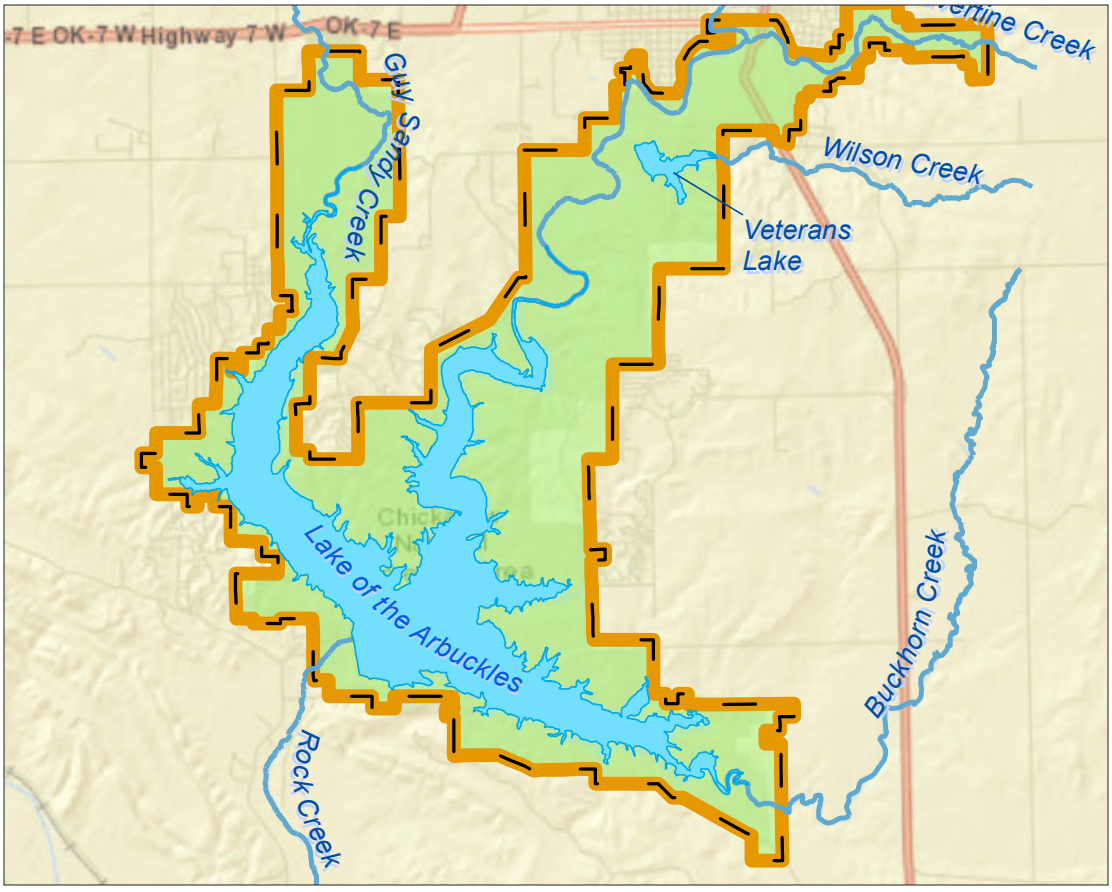


Figure 4.6.1-1 Chickasaw NRA contains two reservoirs that are fed by several creeks, offering many water-based recreational opportunities to visitors.

4.6.2. Data and Methods

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 2014). Surface water quality is important for maintaining a healthy habitat for many aquatic organisms, wildlife, and humans and can provide insights into overall system productivity, shift species abundance and distributions, and alter nutrient cycles (USDI NPS 2008). Field properties reflect the function of the physical and biological environment with which water interacts and constitute a means of characterizing potential stressors to the health of aquatic systems.

Table 4.6.1-1. Total drainage area of creeks located within Chickasaw National Recreation Area (adapted from Hanson and Cates 1994).

Creek Name	Drainage Area (mi^2)	% in Park
Rock Creek at confluence with Travertine Creek	38.4	1
Wilson Creek at confluence with Rock Creek below Veterans Lake	4.20	16
Travertine Creek at confluence with Rock Creek	3.87	61.7
Buckhorn Creek at confluence with Rock Creek	27.0	<1
Guy Sandy Creek at confluence with Rock Creek	44.0	23

Table 4.6.2-1. Monitoring locations and associated parameters summary at Chickasaw National Recreation Area from 2000-2014.

Monitoring Location*	Water Quality	
	Field Properties (since 2000)	*E. coli* (since 2005)
Streams		
Rock Creek (40 ft Hole)	•	•
Rock Creek (Black Sulphur Swimming Area)		•
Upper Guy Sandy Creek (State Ramp)	•	
Travertine Creek (Cold Springs)	•	
Travertine Creek (Little Niagara Falls)		•
Travertine Creek (Bear Falls)		•
Travertine Creek (Panther Falls)		•
Buckhorn Creek (Hatchery)	•	
Buckhorn Creek (Powerlines)	•	
Springs		
Antelope Spring	•	
Buffalo Spring	•	
Lakes		
Lake of the Arbuckles (Guy Sandy Arm)	•	
Lake of the Arbuckles (Arbuckle Dam)	•	
Lake of the Arbuckles (Buckhorn Arm)	•	
Lake of the Arbuckles (Rock Creek Arm)	•	
Lake of the Arbuckles (Buckhorn D Loop)		•
Lake of the Arbuckles (Buckhorn Pavilion)		•
Lake of the Arbuckles (Point Turnaround)		•
Veterans Lake	•	•
TOTAL SITES	12*	9

*Field properties monitoring was discontinued at Rock Creek (Ballfield) location in 2007 due to safety concerns.

The NRA has collected water quality data over several years, with its most recent program beginning in 2000, of which this assessment for current condition is based upon. Monitoring has occurred intermittently, measuring either water quality field properties and/or *Escherichia coli (E. coli)* at 19 locations, two of which include both field parameters and *E. coli* (Figure 4.6.2-1) (Table 4.6.2-1).

Indicators/Measures

Field Properties: temperature, specific conductance, pH, dissolved oxygen, and total dissolved solids

Water quality monitoring data for the NRA's current program were collected by Emily Clark, Hydro-technician for the park, from 12 sites that included locations within 5 lakes, 5 streams and 2 springs. The field properties measured were temperature, specific conductance (the ability of a solution to conduct an electrical current, i.e., the lower the conductivity, the "purer" the water), dissolved oxygen, total dissolved solids and pH.

In general, data collection was continuous and began in March or April 2000 for the stream locations, in May or July 2000 at Arbuckle Lake locations, and in July 2001 at Veteran's Lake. Data collection continued through early 2014 (either January or March depending upon location). The exception was in 2007 when no data were collected at most of the monitoring sites beginning in August through either April or August 2008. Data collection for field properties at the springs began later, starting in July 2005 and

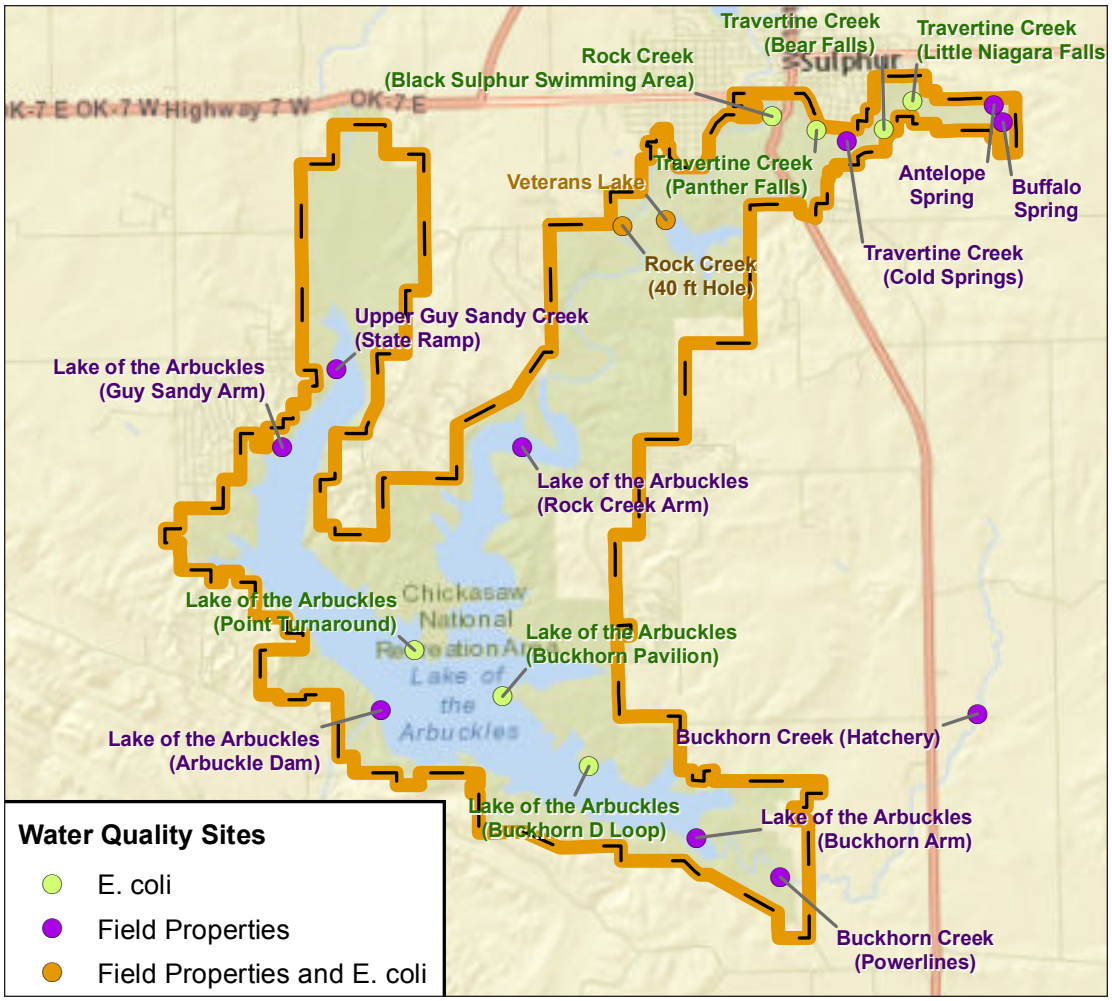


Figure 4.6.2-1. Chickasaw NRA staff monitor water quality at 19 locations. The sites shown include ones where field property data are collected.

ended in January and March 2014. Several time spans were lacking data for the springs due to no flow conditions. Measurements for additional parameters were collected (NO_3 and turbidity) but were limited and discontinued more than five years prior to this assessment and thus were omitted.

Statistical summaries for the five field properties are provided for the streams and springs in Table 4.6.2-2 and for the lake monitoring locations in Table 4.6.2-3. Annual box-and-whisker plots of the field properties, which provide graphical overviews of the data, their distributions, and outliers, are presented for the streams and springs in Figures 4.6.2-2 to 4.6.2-6 and for the lake sites in Figures 4.6.2-7 to 4.6.2-11.

Indicators/Measures

E. coli (Abundance)

E. coli was monitored weekly during the summer months at popular swimming areas and monthly during the winter months using the Colilert© method for estimating abundance of *E. coli* at nine locations. The sites included five sites on Travertine and Rock Creeks, three on Lake of the Arbuckles, and one on Veterans Lake. Two of the locations were the same as the field properties collecting locations. *E. coli* summary statistics are presented in Table 4.6.2-4 and annual box-and-whisker plots of the nine monitoring locations are presented in Figure 4.6.2-12.

Table 4.6.2-2. Summary statistics for field properties at the streams and springs water quality monitoring sites.

Site Location	NPS Inventory and Monitoring Core Water Quality Parameters				
	Temperature (°F)	Specific Conductance (µS/cm)	pH (SU)	Disolved Oxygen (mg/L)	Total Disolved Solids (g/L)
Rock Creek (40 ft Hole)					
Number of observations	87	86	78	83	85
Minimum	40.2	483.8	6.45	0.88	0.309
Maximum	83.7	1673.0	8.64	15.53	1.088
Mean	65.3	938.6	7.99	8.66	0.593
Standard deviation	12.9	293.9	0.40	2.79	0.175
10%ile	45.1	599.7	7.35	5.98	0.384
25%ile	54.2	718.8	7.89	6.82	0.475
50%ile (Median)	68.8	889.9	8.14	8.88	0.572
75%ile	77.2	1155.5	8.22	10.37	0.689
90%ile	80.8	1360.0	8.30	12.20	0.852
Upper Guy Sandy Creek (State Ramp)					
Number of observations	69	68	60	67	67
Minimum	39.28	290.0	6.47	1.84	0.189
Maximum	92.55	1042.0	8.77	13.59	0.678
Mean	67.71	454.8	8.05	7.6	0.296
Standard deviation	14.15	137.9	0.54	2.4	0.088
10%ile	45.90	325.0	7.17	4.5	0.211
25%ile	56.77	353.8	7.90	6.0	0.231
50%ile (Median)	71.40	413.7	8.15	7.2	0.269
75%ile	78.44	545.6	8.44	8.9	0.349
90%ile	83.56	610.0	8.61	11.2	0.396
Travertine Creek (Cold Springs)					
Number of observations	85*	85	77	82	84
Minimum	39.7	453.6	6.86	1.50	0.284
Maximum	78.1	954.0	8.82	14.68	0.620
Mean	63.1	555.9	8.07	8.9	0.357
Standard deviation	9.0	61.3	0.40	2.4	0.041
10%ile	50.2	488.2	7.38	6.1	0.311
25%ile	55.9	522.0	8.03	7.7	0.331
50%ile (Median)	65.8	558.8	8.18	8.9	0.361
75%ile	69.4	584.2	8.29	10.2	0.376
90%ile	74.1	599.0	8.42	11.7	0.387
Buckhorn Creek (Hatchery)					
Number of observations	83**	83	75	80	82
Minimum	44.3	212.0	6.19	1.39	0.138
Maximum	81.0	1011.0	8.79	14.02	0.657
Mean	64.2	555.2	8.0	8.77	0.37
Standard deviation	9.8	122.3	7.5	8.14	8.75
10%ile	50.8	471.9	7.3	6.53	0.33
25%ile	55.6	528.3	7.9	7.24	0.34
50%ile (Median)	68.0	571.4	8.2	8.58	0.37

Table 4.6.2-2. Summary statistics for field properties at the streams and springs water quality monitoring sites (continued).

Site Location	NPS Inventory and Monitoring Core Water Quality Parameters				
	Temperature (°F)	Specific Conductance (µS/cm)	pH (SU)	Disolved Oxygen (mg/L)	Total Disolved Solids (g/L)
Buckhorn Creek (Hatchery) continued					
75%ile	71.4	601.5	8.3	10.07	0.39
90%ile	74.8	621.3	8.4	11.80	0.40
Buckhorn Creek (Powerlines)					
Number of observations	84	83	75	80	82
Minimum	27.32	294	5.59	1.39	0.217
Maximum	84.13	881	8.75	15.79	0.572
Mean	64.0	509.4	8.0	8.8	0.34
Standard deviation	13.6	85.1	0.6	2.8	0.05
10%ile	44.7	393.0	7.2	6.0	0.29
25%ile	53.1	475.2	8.0	7.1	0.32
50%ile (Median)	67.7	519.0	8.2	8.2	0.34
75%ile	76.1	564.5	8.3	10.2	0.37
90%ile	80.0	584.0	8.4	12.7	0.39
Antelope Spring					
Number of observations	41	40	35	38	39
Minimum	62.28	497.00	7.10	0.67	0.32
Maximum	64.40	1019.00	7.83	7.53	0.66
Mean	64.0	610.9	7.38	1.78	.395
Standard deviation	0.42	74.7	0.22	1.56	0.048
10%ile	63.9	557.0	7.14	0.75	0.361
25%ile	64.0	585.0	7.22	0.80	0.380
50%ile (Median)	64.0	603.2	7.4	1.02	0.391
75%ile	64.2	617.0	7.49	2.32	0.401
90%ile	64.3	627.0	7.76	4.64	0.416
Buffalo Spring					
Number of observations	46	46	40	43	45
Minimum	53.20	488.40	7.11	1.65	0.28
Maximum	67.60	1003.00	7.98	9.37	0.65
Mean	63.5	608.4	7.35	3.68	0.39
Standard deviation	2.3	71.2	0.19	1.75	0.047
10%ile	61.4	561.0	7.14	1.93	0.360
25%ile	63.0	588.8	7.21	2.21	0.382
50%ile (Median)	63.9	599.5	7.30	3.18	0.390
75%ile	64.4	610.5	7.47	4.85	0.397
90%ile	65.8	643.0	7.60	5.78	0.416

*One outlier for Travertine Creek (Cold Springs) temperature (16.75 °F) was not included in the summary statistics.

**One outlier for Buckhorn Creek (Hatchery) temperature (15.34 °F) was not included in the summary statistics.

Both temperature outliers were likely recorded as degree Celsius but were reported as Fahrenheit.

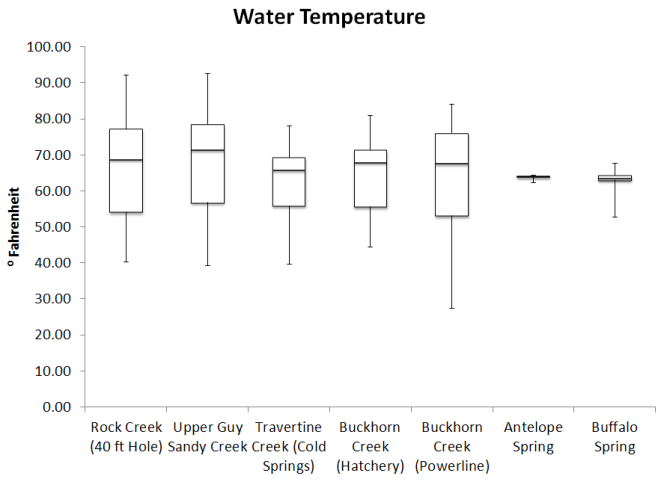


Figure 4.6.2-2. Water temperature annual plots for the streams and springs monitoring sites

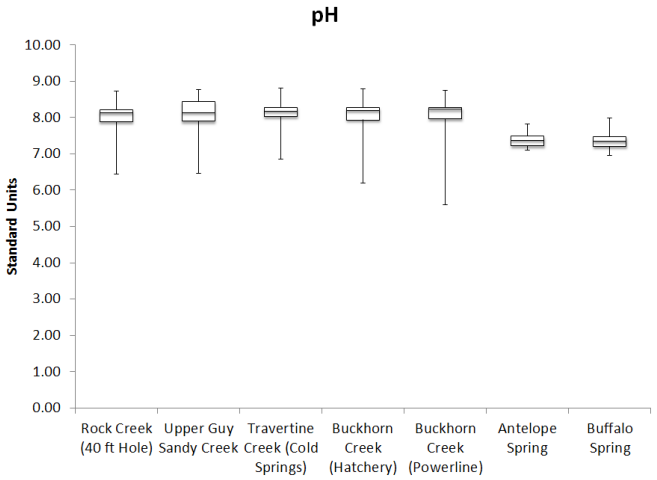


Figure 4.6.2-3. pH annual plots for the streams and springs monitoring sites

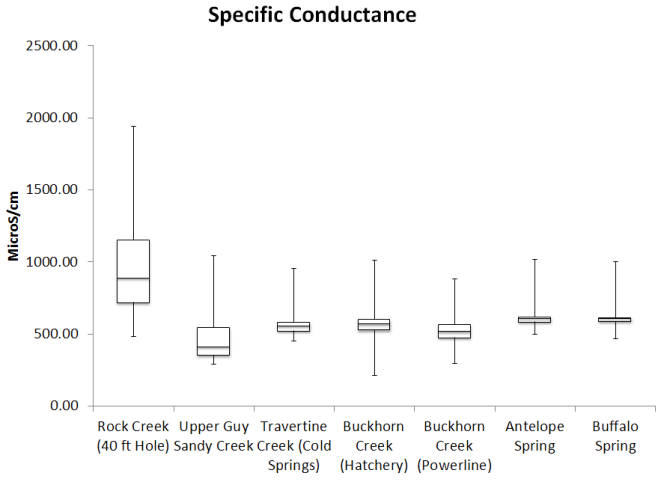


Figure 4.6.2-4. Specific conductance annual plots for the streams and springs monitoring sites

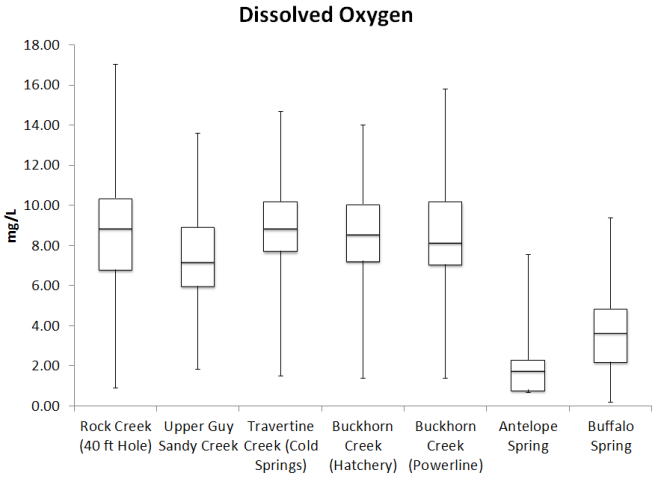


Figure 4.6.2-5. Dissolved oxygen annual plots for the streams and springs monitoring sites

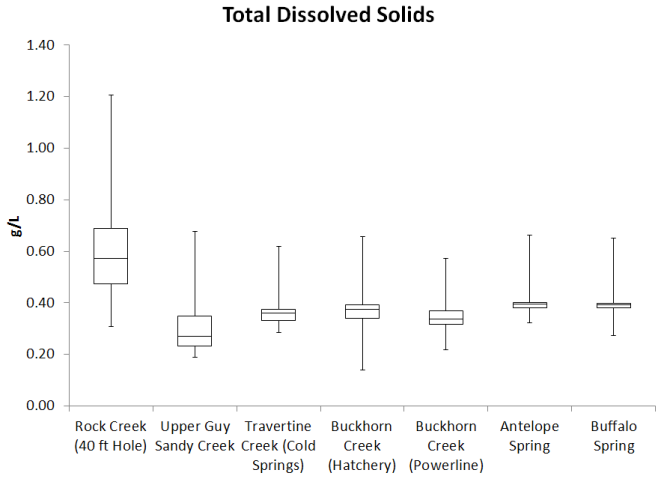


Figure 4.6.2-6. Total dissolved solids annual plots for the streams and springs monitoring sites

Table 4.6.2-3. Summary statistics for field properties at the lake water quality monitoring sites.

Site Location	NPS Inventory and Monitoring Core Water Quality Parameters				Additional Parameters
	Temperature (°F)	Specific Conductance (µS/cm)	pH (SU)	Disolved Oxygen (mg/L)	Total Disolved Solids (g/L)
Arbuckle Lake - Rock Creek Arm					
Number of observations	54	53	51	52	50
Minimum	43.2	271.6	6.33	1.63	0.174
Maximum	91.81	489.0	8.79	12.59	0.347
Mean	69.1	381.2	8.10	8.06	0.252
Standard deviation	15.3	41.0	0.56	2.36	0.034
10%ile	47.2	340.7	7.19	4.92	0.218
25%ile	54.0	356.0	8.05	6.92	0.229
50%ile (Median)	71.5	371.0	8.32	8.39	0.244
75%ile	83.1	393.8	8.42	9.23	0.269
90%ile	86.5	433.0	8.51	10.89	0.292
Arbuckle Lake - Guy Sandy Arm					
Number of observations	55	55	53	53	54
Minimum	42.82	298.2	6.48	2.17	0.191
Maximum	90.72	423.0	8.92	12.93	0.341
Mean	69.5	361.1	8.13	8.2	0.241
Standard deviation	15.0	30.8	0.56	2.3	0.035
10%ile	48.1	325.0	7.02	5.3	0.211
25%ile	54.6	334.8	8.14	7.4	0.216
50%ile (Median)	73.4	352.8	8.31	8.2	0.232
75%ile	83.0	385.6	8.44	9.5	0.254
90%ile	86.2	400.5	8.57	10.8	0.294
Arbuckle Lake - Buckhorn Arm					
Number of observations	52	52	50	49*	51
Minimum	41.5	172.3	6.61	1.54	0.110
Maximum	88.3	487.0	8.94	13.81	0.341
Mean	68.5	364.9	8.08	7.70	0.24
Standard deviation	14.3	41.3	0.51	2.32	0.035
10%ile	48.7	334.0	7.23	4.01	0.216
25%ile	56.4	346.8	7.92	6.88	0.222
50%ile (Median)	73.2	362.9	8.25	7.89	0.235
75%ile	80.9	384.3	8.38	8.79	0.254
90%ile	85.0	404.4	8.49	9.88	0.285
Arbuckle Lake - by Arbuckle Dam					
Number of observations	55	55	53	53	54
Minimum	42.0	312.7	6.59	1.65	0.200
Maximum	88.3	427.0	8.89	15.61	0.334
Mean	68.8	362.7	8.14	8.1	0.242
Standard deviation	14.9	29.3	0.52	2.4	0.032
10%ile	46.3	330.0	7.21	5.2	0.212
25%ile	53.8	337.5	8.12	6.8	0.217
50%ile (Median)	73.3	356.3	8.32	8.3	0.233

Table 4.6.2-3. Summary statistics for field properties at the lake water quality monitoring sites. (continued).

Site Location	NPS Inventory and Monitoring Core Water Quality Parameters				Additional Parameters
	Temperature (°F)	Specific Conductance (µS/cm)	pH (SU)	Disolved Oxygen (mg/L)	Total Disolved Solids (g/L)
Arbuckle Lake - by Arbuckle Dam continued					
75%ile	82.5	383.9	8.4	9.5	0.256
90%ile	85.7	406.0	8.6	10.3	0.291
Veterans Lake					
Number of observations	73**	73	65	52	72
Minimum	31.2	230.6	6.79	1.34	0.156
Maximum	91.8	579.0	8.70	13.74	0.380
Mean	67.5	340.8	8.18	8.0	0.22
Standard deviation	15.3	59.0	0.34	2.8	0.04
10%ile	44.8	267.0	7.82	4.3	0.18
25%ile	55.4	303.0	8.13	6.1	0.19
50%ile (Median)	71.6	347.8	8.24	7.7	0.22
75%ile	81.3	371.0	8.38	10.0	0.24
90%ile	85.6	394.0	8.49	8.8	0.27

*One outlier for Buckhorn Arm's dissolved oxygen (96.90) was not included in the summary statistics.

**One outlier for Veteran's Lake temperature (31.2 °F) was not included in the summary statistics.

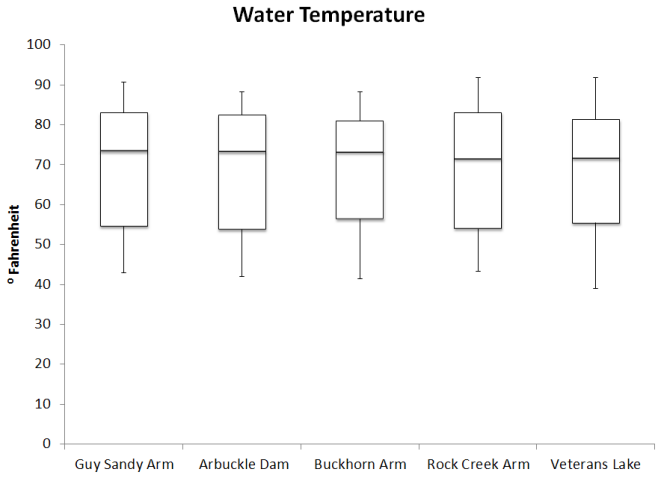


Figure 4.6.2-7 Water temperature annual plots for the lakes monitoring sites

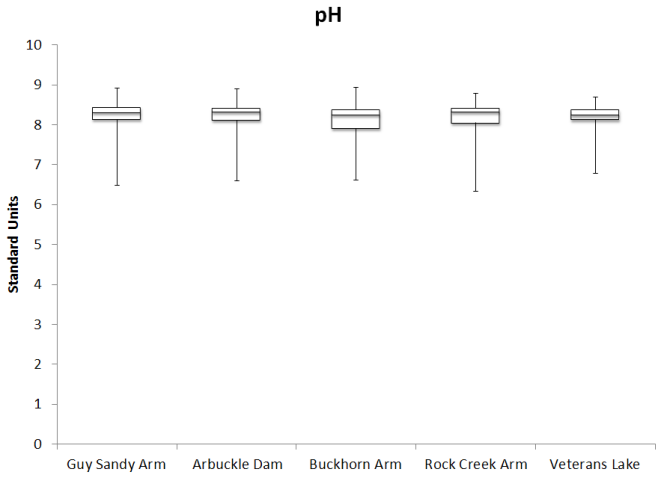


Figure 4.6.2-8 pH annual plots for the lakes monitoring sites

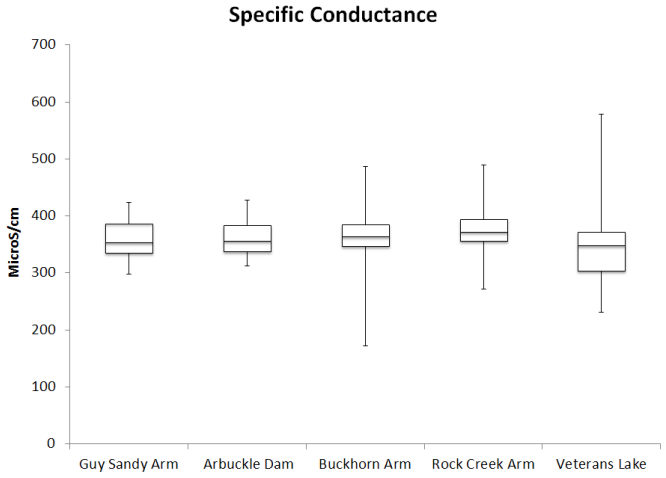


Figure 4.6.2-9 Specific conductance annual plots for the lakes monitoring sites

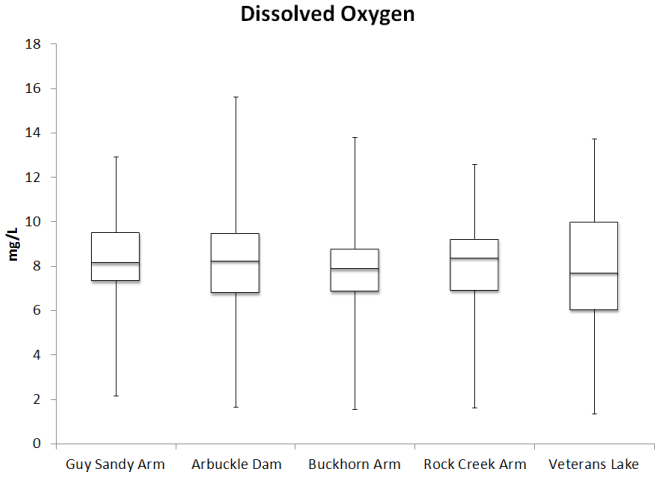


Figure 4.6.2-10 Dissolved oxygen annual plots for the lakes monitoring sites

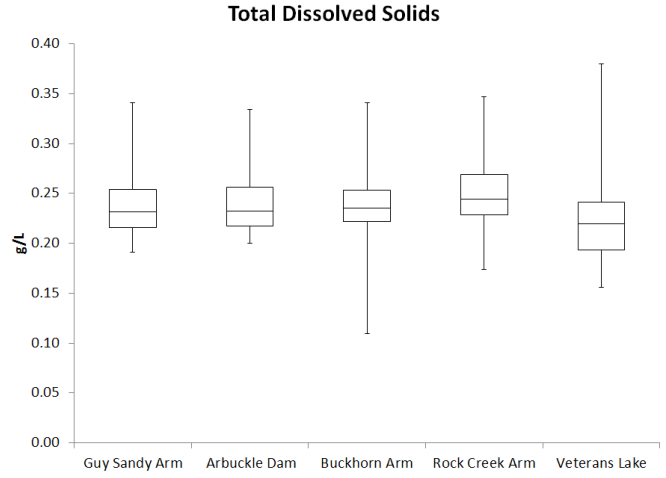


Figure 4.6.2-11 Total dissolved solids annual plots for the lakes monitoring sites

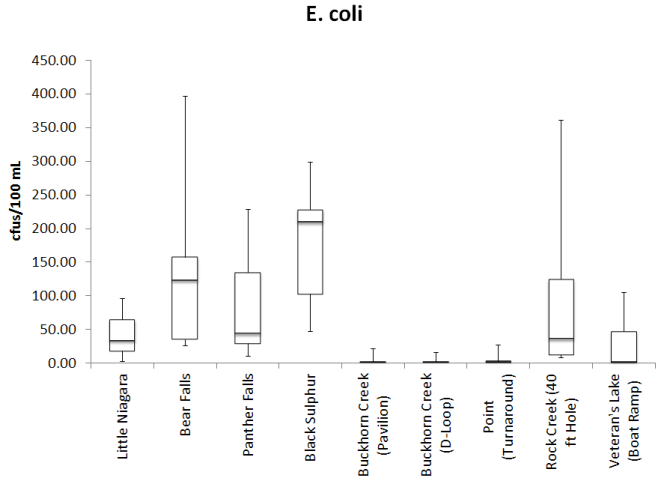


Figure 4.6.2-12. Annual plots for the *E. coli* monitoring sites.

Table 4.6.2-4. Summary statistics for *E. coli* bacteria at water quality monitoring sites.

E. coli Summary Statistics	Little Niagara	Bear Falls	Panther Falls	Black Sulphur	Buckhorn Creek (Pavilion)	Buckhorn (D-Loop)	Point (Turn-around)	Rock Creek (40 ft hole)	Veteran's Lake (Boat Ramp)
Number of observations	3	8	8	9	8	8	8	8	8
Minimum	2.00	25.90	10.80	47.10	1.00	1.00	1.00	8.50	1.00
Maximum	95.90	396.80	228.20	298.70	20.90	16.00	26.90	360.90	104.60
Mean	43.83	135.68	81.99	178.64	3.61	3.00	5.01	94.34	28.65
Standard deviation	47.78	122.95	77.42	85.81	6.99	5.26	8.96	124.21	42.42
10%ile	2.00	25.90	10.80	47.10	1.00	1.00	1.00	8.50	1.00
25%ile	17.80	35.20	29.20	102.20	1.00	1.00	1.00	12.28	1.00
50%ile (Median)	33.60	123.50	44.40	209.80	1.00	1.00	1.50	36.15	1.50
75%ile	64.75	157.73	134.43	228.50	1.25	1.25	2.80	124.58	47.15
90%ile	95.90	396.80	228.20	298.70	20.90	16.00	26.90	360.90	104.60

4.6.3. Reference Conditions

The Oklahoma Water Resources Board (OWRB) establishes goals and standards for the quality of waterbodies throughout Oklahoma in accordance with the federal Clean Water Act (OWRB 2013). These standards were developed to maintain the quality of surface waters and to promote and protect as many beneficial uses as are attainable, ensuring degradation of existing water quality does not occur. Standards criteria are either qualitative or quantitative and are based on designated uses of a waterbody. The water quality standards for the parameters monitored are listed in Table 4.6.3-1

Table 4.6.3-1. Surface water quality standards for the parameters monitored at Chickasaw NRA (OWRB 2013).

Parameter	Standard Value
Water Temperature	85°F (28.9 °C) maximum
pH	6.5 - 9.0 SU
Dissolved Oxygen	5.0 mg/L (minimum) during summer and winter
Total Dissolved Solids	700 mg/L
E. coli	235 colonies per 100 milliliters in individual samples or a five-sample geometric mean of 126 colonies per 100 milliliters over 30 days per site.
Specific Conductivity	no standard

The designated beneficial use categories for Chickasaw's lakes and streams include the warm water aquatic community subcategory of the beneficial use classification fish and wildlife propagation, aesthetics, irrigation agriculture subcategory of the agriculture beneficial use, and primary body contact recreation (OWRB 2013). Limitations identified for Guy Sandy Creek and Rock Creek, including Lake of the Arbuckles, are high quality waters and sensitive public and private water supply designations, respectively. The OWRB standards attempt to ensure that these high quality waters are maintained and protected due to conditions that make them more susceptible to pollution events (OWRB 2013).

4.6.4. Condition and Trend

The water quality monitoring results were compared to the standards/guidelines established by OWRB (2013) to assess current condition and are summarized below. However, water quality standards for warm water aquatic community/fish and wildlife propagation do not apply to the springs.

Field Properties Streams and Springs

Temperature

Median water temperatures in the stream sites ranged from 65.8°F in Travertine Creek (Cold Springs) to 71.4°F in Upper Guy Sandy Creek. Median water temperatures were colder in both Antelope Spring (64.0 °F) and Buffalo Spring (63.0°F). Overall, two stream sites, Upper Guy Sandy Creek and Buckhorn Creek (Hatchery) appeared to be increasing in temperature, and Travertine Creek (Cold Springs), Rock Creek (40 Ft Hole), and Buckhorn Creek (Powerline), appeared to be slightly decreasing. However, many of the stream sites have limited (0-1) cold weather observations between the end of 2005 and the beginning of 2009 and Upper Guy Sandy Creek was missing 10 of 13 observations since January 2013 because the site was dry. Of the two spring sites, Antelope Spring had more consistent temperature recordings over the period of record, ranging from 62.4 - 64.4°F. Spring temperatures are normally close to those measured in the shallow aquifer, and are related to the mean annual temperature of the region (about 61 °F) (N. Osborn, 2015, pers. comm.). Buffalo Spring temperatures ranged from 53.2 - 67.6°F. It should be noted that the 53.2°F, recorded on 3/25/14, is more than 10 degrees below the average. Buffalo Spring is a shallow pool enclosed by a stone wall, and temperature could be affected by surface temperature (N. Osborn, 2015, pers. comm.). Also both springs had numerous dry periods, especially since 10/12/12. Of the 15 observations taken after that date, Antelope Spring was dry 12 times and Buffalo Spring was dry 9 times. Of all locations, only Upper Guy Sandy Creek included readings that exceeded the state's water quality critical temperature standard. All five readings (7.2%) occurred since 2008, and most recently in August 2013.

pH

Median pH values were lower at the two springs (7.38 SU and 7.35 SU) compared to the stream sites where median values ranged from 8.14- 8.23 SU. As noted by Porter et al. (2010), many of the lower pH values (5.59-6.86 SU) were recorded at stream sites between the end of 2000 and 2003. The reasons for this are poorly understood but could help explain the slightly increasing values over the period of record (Porter et al. 2010). Since 2003, there has been less fluctuation in observed pH values. The two springs sites had less fluctuation in pH, ranging from 7.10 -7.83 SU at Antelope Spring and 7.11- 7.98 SU at Buffalo Spring. Three sites, Upper Guy Sandy Creek, Antelope Spring, and Buffalo Spring, were lacking several measurements each due to drought or dry conditions (Clark 2014). Only Buckhorn Creek (Powerline) had two readings below the state's water quality standard criterion of 6.5 SU.

Specific Conductance

Median specific conductance values ranged from 413.7 µS/cm at Upper Guy Sandy Creek to 889.9 µS/cm at Rock Creek (40 Ft Hole). All of the sites had their highest values recorded on 9/2007, however, Upper Guy Sandy Creek had the largest decrease following the 9/2007 event, which was a hot, dry period. Of the 27 observations recorded at Upper Guy Sandy Creek prior to 9/2007, the average was 563.9 µS/cm. In the 48 readings after 9/2007, the average was 366.5 µS/cm. As with the other measures, Upper Guy Sandy Creek was missing 10 of 13 observations since 1/2013 due to drought or dry conditions. Specific conductance at Rock Creek (40 Ft Hole) appeared to be increasing over this period of record, with significantly more fluctuations in value. Except as noted, all sites remained relatively consistent in values. Although no specific conductance standard is identified by Oklahoma, it's an indicator of total dissolved solids, and the state's standard for total dissolved solids is 700 mg/L, which was attained in most measurements (refer to following discussion).

Total Dissolved Solids

Median total dissolved solids ranged from 270 mg/L at Upper Guy Sandy Creek to 507 mg/L at Rock Creek (40 Ft Hole). Over the period of record, Rock Creek (40 Ft Hole) generally had more fluctuation in total dissolved solids than at the other sites and appeared to be increasing. Conversely, total dissolved solids appeared to be decreasing over the period of record at Upper Guy Sandy Creek. All sites, except Rock Creek (40 Ft Hole), recorded high concentrations on 9/27/2007. As noted previously, Upper Guy Sandy Creek, Antelope Spring and Buffalo Spring were all missing data due to drought or dry conditions. Of all stream and spring monitoring sites, only Rock Creek (40 Ft Hole) exceeded the state's water quality criterion of 700 mg/L 23.5% of the time, with the last exceedance occurring in February 2014.

Dissolved Oxygen

Median concentration of dissolved oxygen at Antelope Spring was 1.78 mg/L and at Buffalo Spring was 3.68 mg/L. These values were lower than the stream sites, which was normal since groundwater typically has low dissolved oxygen. The standard for warm water aquatic community fish and wildlife propagation does not apply to springs since fish and wildlife don't live in the aquifer. The streams' dissolved oxygen values ranged from 7.20 mg/L at Upper Guy Sandy Creek to 8.88 mg/L at Rock Creek (40 Ft Hole). However, all sites had recordings that were below the dissolved oxygen standard, ranging from 5% of the values at Buckhorn Creek (Hatchery) to 10.4% at Upper Guy Sandy Creek.

Field Properties Lakes

Temperature

Median water temperature was similar among all lake sites, ranging from 71.6 ºF at Veterans Lake to 73.4 ºF at the Guy Sandy Arm site on Arbuckle Lake. Low temperatures ranged from 41.5 - 43.2 ºF and high temperatures ranged from 88.3 - 91.8 ºF. All of the lake sites had readings that exceeded the state's water quality critical temperature criterion of 85 ºF, ranging from 7.7% at Buckhorn Arm to 16.7% at Rock Creek Arm. Most sites, except for Veterans Lake, have had fewer exceedances since 2007. Only Veterans Lake increased in temperature since 2007, with the last occurrence in 7/2011. Temperatures

were primarily recorded during the warmer months.

pH

Median pH values were similar among all lake sites, ranging from 8.24-8.32 SU. All sites shared considerable fluctuation in pH, with lower readings generally occurring during spring 2001 and higher readings occurring during spring 2003. Only two sites, Guy Sandy Arm (in 2001) and Rock Creek Arm (2001), had values below the state pH criterion. All sites generally showed a slightly increasing trend over the period of record although there appeared to be a slight decrease in the last two recorded years.

Specific Conductance

Median specific conductance values were similar at all lake sites, with a low in Veterans Lake of 347µS/cm and a high in Rock Creek Arm of Arbuckle Lake of 371µS/cm. Arbuckle Lake at Buckhorn Arm had the lowest reading during the period of record of 172 µS/cm (2001) and Veterans Lake had the highest reading of 579µS/cm (2007). Veterans Lake also had the widest range in values from a low of 230 µS/cm (2001) to a high of 579 µS/cm (2007). All of the lowest readings occurred in 2001.

Total Dissolved Solids

Median total dissolved solids concentrations were similar across all lake sites, ranging from 220 mg/L at Veterans Lake to 240 mg/L at Arbuckle Lake at both Buckhorn Arm and Rock Creek Arm. All low concentrations occurred in 2001, ranging from 110 mg/L at Buckhorn Arm site to 191 mg/L at Guy Sandy Arm site. All high concentrations occurred between 2011 and 2013, ranging from 334 mg/L at the Arbuckle Dam site to 380 mg/L at Veterans Lake. All lake sites appeared to be showing a slight increase in total dissolved solid concentrations over the period of record, however, no values exceeded the state standard.

Dissolved Oxygen

Median dissolved oxygen concentrations were similar across all lake sites, ranging from 7.7 mg/L in Veterans Lake to 8.4 mg/L in Arbuckle Lake at Rock Creek Arm. There were 30 (11.5%) of 260 observations recorded below the state water-quality criterion of 5 mg/L. One third of those occurrences were recorded in Veterans Lake. In general, all lake sites appeared to be showing a slight increase in dissolved oxygen concentrations over the period of record.

According to the 2012 Oklahoma Water Resources Beneficial Use Monitoring report, Lake of the Arbuckles is fully supporting the Fish and Wildlife beneficial use based on pH and turbidity, but not supporting based on anoxic conditions present during the summer (up to 57% of water column <2.0 mg/L in summer). As a result, Arbuckle Lake has been and still is currently listed on the Oklahoma Department of Environmental Quality 303(d) list of impaired waters due to low dissolved-oxygen concentrations. The impairment is based on the warm water aquatic community fish and wildlife propagation beneficial use (OWRB 2012), which is detrimental to aquatic organisms creating an anoxic environment. However, no fish kills have been observed or recorded since at least before 2008 when Hydrotechnician, Emily Clark started working at the park. According to Chief of Resource Management, Noel Osborn, the lake supports a great fishery, with record breaking bass.

Previous investigators, beginning as early as 1970s and less than a decade after the reservoir's construction, suggested that Lake of the Arbuckles is a highly eutrophied lake and does not support the organisms, such as fish and macroinvertebrates, due to the anoxic conditions in the hypolimnion (Summerfelt and Gebhart 1975; Wilhm 1975; Streebin and Harp 1977). This would appear to be more of a property of the reservoir itself versus a degradation in water quality due to anthropogenic inputs. Clark (2014) reported that during the 2013 field season, "there is no known outside cause (e.g. neighboring fertilized agricultural fields, pollution, etc.) that would result in the lake's low oxygen levels."

Communication between park staff and OWRB concerning the dissolved oxygen levels in Lake of the Arbuckles is ongoing

Table 4.6.4-1. Summary of the surface water quality indicators and their contributions to the overall condition at Chickasaw NRA.

Indicator of Condition	Measure	Condition	Rationale for Condition
Field Properties	5 Measures	Significant Concern	With a few exceptions, most of the field properties were within state standards, however, low dissolved oxygen levels in Lake of the Arbuckles does not meet the state's current standard. The low dissolved oxygen may be an inherent characteristic of the reservoir, but until a new standard is approved, and the lake is removed from the state's 303(d) list, we consider this measure to be of significant concern but with low confidence.
E. coli	1 Measure	Good	Based on 2013 - 2014 data, we consider *E. coli* levels to be in good condition. However, high levels of *E. coli* have been detected over many of the monitoring years. Porter et al. (2010) reported that samples collected at Little Niagara and Bear Falls swimming areas exceeded the criterion more than 25% of the time but that levels appeared to be decreasing over time. The park actively monitors this parameter and closes swimming areas when necessary to protect human health.

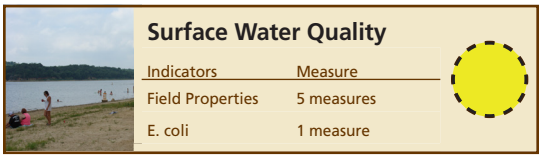
to identify a total maximum daily load that is relevant to the inherent characteristics of the lake, thereby removing it from the state's impaired waterbodies list (Clark 2014, N. Osborn, pers. comm. 2015). OWRB (2010) has proposed amendments to the dissolved oxygen standards and procedures to avoid inappropriate 303(d) listings, which would address Lake of the Arbuckles listing. However, the Environmental Protection Agency has yet to approve the changes.

E. coli

In 2014, *E. coli* levels were monitored monthly from January - April, then weekly during the high visitation summer months (July - August). A total of 68 collections were made between the nine monitoring locations. Only a total of four exceedances occurred throughout the period of record at three locations (one at Rock Creek (40 ft Hole) in January; two at Black Sulphur (January and July 10); and one at Bear Falls on July 10, which represented the highest count level of 396.80/100 mL).

In 2013, only one *E. coli* result was extremely high, which was taken from Bear Falls in the spring but was believed to be a contaminated sample (Clark 2014). During the early 2013 summer, several sites were restricted to visitor use due to low water levels and high *E. coli* counts. Activity resumed later in the season and though occasional results exceeded the state standard, Clark (2013) reported that overall, no "alarming or extreme problems" with *E. coli* occurred in 2013.

Overall, we consider *E. coli* levels to be in good condition, however, high levels of *E. coli* have been detected over many of the monitoring years. Porter et al. (2010) reported that samples collected at Little Niagara and Bear Falls swimming areas exceeded the criterion more than 25% of the time, but that levels appeared to be decreasing over time.



Overall Condition

A summary of each indicator and its contribution to the water quality condition at Chickasaw is listed in Table 4.6.4-1.

Overall, the water quality parameters measured at the park met Oklahoma's water quality standards, except for dissolved oxygen, and to a lesser extent, *E. coli*. Higher levels of these parameters have been consistently recorded throughout the park's water quality

monitoring history. In 1997, the NPS Water Resources Division developed a Baseline Water Quality Data Inventory and Analysis report for the NRA (NPS 1997), assessing water quality data (30,222 measurements) from 1951 to 1995. In summary, dissolved oxygen, fecal coliform, copper and chloride were the parameters most often exceeding the established water quality standards. Of these parameters, *E. coli* levels in the main swimming areas of the park were of primary concern (NPS 1997; Wikle et al. 1998; Becker 2006). Streebin and Harp (1977) reported a direct relationship between the number of swimmers and fecal coliform counts at the popular swimming areas within the park.

In addition, Porter et al. (2010) indicated that water quality data collected between 2000-2009 were more common during the warmer months than the cooler months, potentially skewing the data and trends. The data collected between 2010-2104 were also primarily collected throughout the warmer season for the field properties, which is common given the realities of budget constraints and months of highest visitation when *E. coli* levels are of most concern due to the human health impact related to water-based recreational activities.

Even though the dissolved oxygen levels do not meet the state's standard in Lake of the Arbuckles, OWRB and the park are actively engaged in trying to amend the standard to eliminate unnecessary 303(d) listings. However, since our reference criteria are based on current state standards, we consider the dissolved oxygen to be of significant concern but with low confidence and have rated the overall water quality as moderate.

Level of Confidence/Key Uncertainties/ Threats

Rock Creek flows through several miles of land before it reaches the NRA. A variety of different land uses throughout the drainage area, including livestock holding pens, rangelands, industrial operations, City of Sulphur's sanitary sewer system and impervious surface runoff threaten the water quality within the park and have created water quality issues in the past (Streebin and Harp 1977; Becker 2004). Aside from the higher *E. coli* levels at the popular swimming areas, many of the potential anthropogenic impacts to water quality originate from outside park boundaries.

Hydrilla verticillata was observed in 2012 and 2013 off the Buckhorn Pavilion area, which is a highly undesirable invasive aquatic plant. Also, in 2012, Clark (2014) reported an observance of blue green algae. Streebin and Harp (1977) reported algal blooms and associated water quality problems downstream in Lake of the Arbuckles as early as mid-1970s.

4.6.5. Sources of Expertise

The park conducts routine water quality monitoring at Chickasaw and provided the data for this assessment. Consultation with the NPS Water Resources Division occurred at the beginning of the assessment process.

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4.7. Groundwater and Springs

Indicators/Measures

- Springflow (2 measures)
- Streamflow (2 measures)
- Groundwater Head (2 measures)

Condition - Trend - Confidence



Significant Concern - Varied - High

4.7.1. Background and Importance

Chickasaw National Recreation Area (NRA) was originally established as Sulphur Springs Reservation in 1902 through an agreement with the Chickasaw and Choctaw nations and the federal government. The Chickasaw Nation sold the land to the government in order to protect the unique freshwater and mineral springs along Sulphur (later named Travertine) and Rock Creeks. The springs and streams in the Platt District (originally established in 1906 as Platt National Park) of Chickasaw NRA have had cultural, economic, and environmental significance throughout the history of the region. Archaeological evidence demonstrates that human use of spring water in the area dates back 7,000 years (Wikle et al. 1998).

Groundwater supplies water to the freshwater and mineral-water springs that were historically a focal point of visitor activity and a principal natural resource. Mineralized water, which was highly prized for its perceived medicinal value, was used primarily for drinking. In addition to supplying springflow, groundwater provides base flow to Travertine and Rock Creeks, which supply water to Lake of the Arbuckles. Today, visitors come to the 928 acres (376 hectares) Platt District, located in the northeast corner of the park, for recreational purposes-to swim in Travertine Creek, visit the springs, hike, picnic, and camp (Figure 4.7.1-1).

Springs are unique ecosystems that provide habitat for a large diversity of aquatic and terrestrial life. Spring habitats differ from other flowing-water systems in that they have constant flow and temperature, exist as small and isolated habitat areas, and have a general lack of large aquatic predators. National Park Service (NPS) Management Policy 4.6.1 states that the NPS will perpetuate surface waters and groundwater as integral components of park aquatic and terrestrial ecosystems (NPS 2006).

Springs

The first comprehensive evaluation of springs in the former Platt National Park was made



NPS-CHICKASAW NRA

Figure 4.7.1-1. Buffalo Spring is one of several springs located in Chickasaw National Recreation Area's historic Platt District.

by Dr. Charles Gould, professor of geology at the University of Oklahoma and head of the Oklahoma Geological Survey (Boeger 1987). In July 1906, Gould conducted a field survey of 33 springs, in which he documented the approximate location and estimated the flow of each spring (Table 4.7.1-1, listed in downstream order). Gould indicated that six of the springs were freshwater and 27 were mineralized. He estimated the total discharge from these 33 springs to be 3,741 gallons per minute (gpm). Gould organized the springs into eight groups based on their chemical character and proximity to one another (Gould 1906).

In November 1939, Gould returned with Schoff to Platt National Park to assess springflow. Gould noted that the water from the seven springs of the Pavilion Springs group had been combined to issue from a single orifice, and that the waters from three of the Beach Springs (currently known as "Black Sulphur Springs") had also been combined into a single outlet. Gould and Schoff were unable to measure springs in the Bromide group because the water from these springs was being pumped into tanks. They were unable to find 14 of the 27 mineral springs, and no mention was made of the 14 springs in the Churchill Park Group or Ravine Group. Gould and Schoff concluded that the mineral springs in Platt National Park were flowing approximately one-fifth (20 percent) as they did in 1906. At the time of their survey, Antelope and Buffalo springs had been dry for 14 months (Gould and Schoff 1939). In fact, precipitation in 1939 was 43.1 cm (16.97

Table 4.7.1-1. List of Springs Inventoried in 1906 (Gould 1906).

Spring Group	Spring No.	Spring Name	Dishcarge (gpm)	Character
Sulphur Creek Group (2)	1 2	Antelope Buffalo	2,000 1,500	fresh fresh
Chalybeate Group (2)	3 4	Cunningham Buse	weak weak	iron iron
Pavilion Springs Group (7)	5 6 7 8 9 10 11	Big Tom Arsenic Little Tom Swords Townsley's Dog Unnamed	40 8 3 5 2 2 2	sulphur sulphur sulphur sulphur sulphur sulphur sulphur
Hillside Spring Group (1) (may have been two at one time)	12	Hillside	80	sulphur
Beach Springs Group (4) (currently known as Black Sulphur Springs)	13 14 15 16	Unnamed Unnamed Unnamed Sand Spring	70 unknown	sulphur sulphur
Bromide Springs Group (3)	17 18 19	Bromide Cliff Bromide Unnamed	1 0.5 1	bromide bromide
Ravine Springs Group (7)	20 21 22 23 24 25 26	Bromide Sulphur Sulphur Taff's Iron Soda Sulphur Sulphur	2 unknown 3 unknown unknown 2 2	sulphur/bromide sulphur sulphur iron soda sulphur sulphur
Churchill Park Group (7)	27 28 29 30 31 32 33	Wilson Churchill Rucker's Iron Jericho Unnamed Unnamed	6 5 3 unknown 3 unknown unknown	sulphur sulphur fresh iron fresh fresh fresh

in) below normal precipitation of 108.5 cm (42.17 in) and was near the end of a historically dry period (Oklahoma Climatological Survey. 2015).

In 1987, a spring survey was performed by Tom Taylor, the NRA's resource specialist, in an attempt to locate all of the springs that were documented by Gould. Using information provided by Gould, Taylor was able to locate 21 of the original 33 springs, several of which had only seasonal flow (Taylor 1988). Taylor was unable to locate Cunningham and Buse springs (both in the Chalybeate group), which Gould reported to be on the bank of Sulphur Creek; and Sand Spring, which Gould reported to be in the channel of Rock Creek. It is possible that these creeks changed their course through natural processes. Also not found were Sulphur and Soda Springs in the Ravine Group, and the seven springs in the Churchill Park Group. Bromide and Medicine Springs in the Bromide Group had been dry since 1974, but Gould's spring number 19 (later known as "sodium chloride" and "pipe" spring) continued to flow a small amount (less than 1 gpm) from a cast iron pipe set in the bed of Rock Creek. Taylor identified two springs, named the "Red Flag" springs, which were not identified by Gould. These springs are located about 64 m (70 yards) downstream from the sulphur springs in the Ravine Group. Taylor did not measure spring discharge as part of the survey.

From July 18 through August 5, 1988, Hanson and Cates conducted an inventory of surface- and groundwater resources in the vicinity of the City of Sulphur and Chickasaw NRA. Their inventory included discharge measurements of springs, streams, and flowing artesian wells (Hanson and Cates 1988).

Spring Improvements

Over the years, many of the springs have been "improved" (altered) to enhance their scenic beauty and to provide visitors easier access to the water. With the exception of Antelope Spring, none of the remaining springs are in their natural condition.

Streams

Travertine Creek begins immediately to the east of the Platt District and flows about two miles westerly through the District before joining Rock Creek (Figure 4.7.1-2). Flow in Travertine Creek is intermittent until it reaches Antelope and Buffalo springs, where it derives the majority of its flow. Travertine Creek derives dry-weather flow (base flow) from springs and groundwater seepage along the creek bed. Other flows contributing to the creek include artesian-well flows from some of the Sulphur municipal wells and Vendome Well. During precipitation events, Travertine Creek receives runoff from its 10 km^2 (3.87 mi^2) drainage area (Hanson and Cates 1994).

Except for the mineralized outflow from Vendome Well, which flows into Travertine Creek shortly before its confluence with Rock Creek, flow into Travertine Creek is freshwater. Originally named Sulphur Creek, the creek was later named "Travertine" at the recommendation of Charles Gould (1906). In the 1930s, The Civilian Conservation Corps (CCC) and NPS enhanced the recreational use of Travertine Creek by constructing a series of natural rock dams and concrete retaining walls to provide picturesque falls and swimming areas. At least five dams were constructed, the largest of which is the dam that creates the Little Niagara Falls and associated swimming area. Scenic beauty at Antelope Spring, which issues from a ledge of conglomerate rock, was enhanced with two dams, lily ponds, and a waterfall (Hohmann and Grala 2004).

Rock Creek begins 16 km (10 mi) north of the Platt District and flows south into Lake of the Arbuckles before discharging into the Washita River near Dougherty, Oklahoma. Before entering the Platt District, Rock Creek receives water from several unregulated flowing artesian wells. After entering the Platt District, Rock Creek gains water from an artesian well, several small mineral springs, and Travertine Creek.

Rock Creek has a drainage area of 114 km^2 (44 mi^2) at the United States Geological Survey (USGS) streamgage (station 07329852)

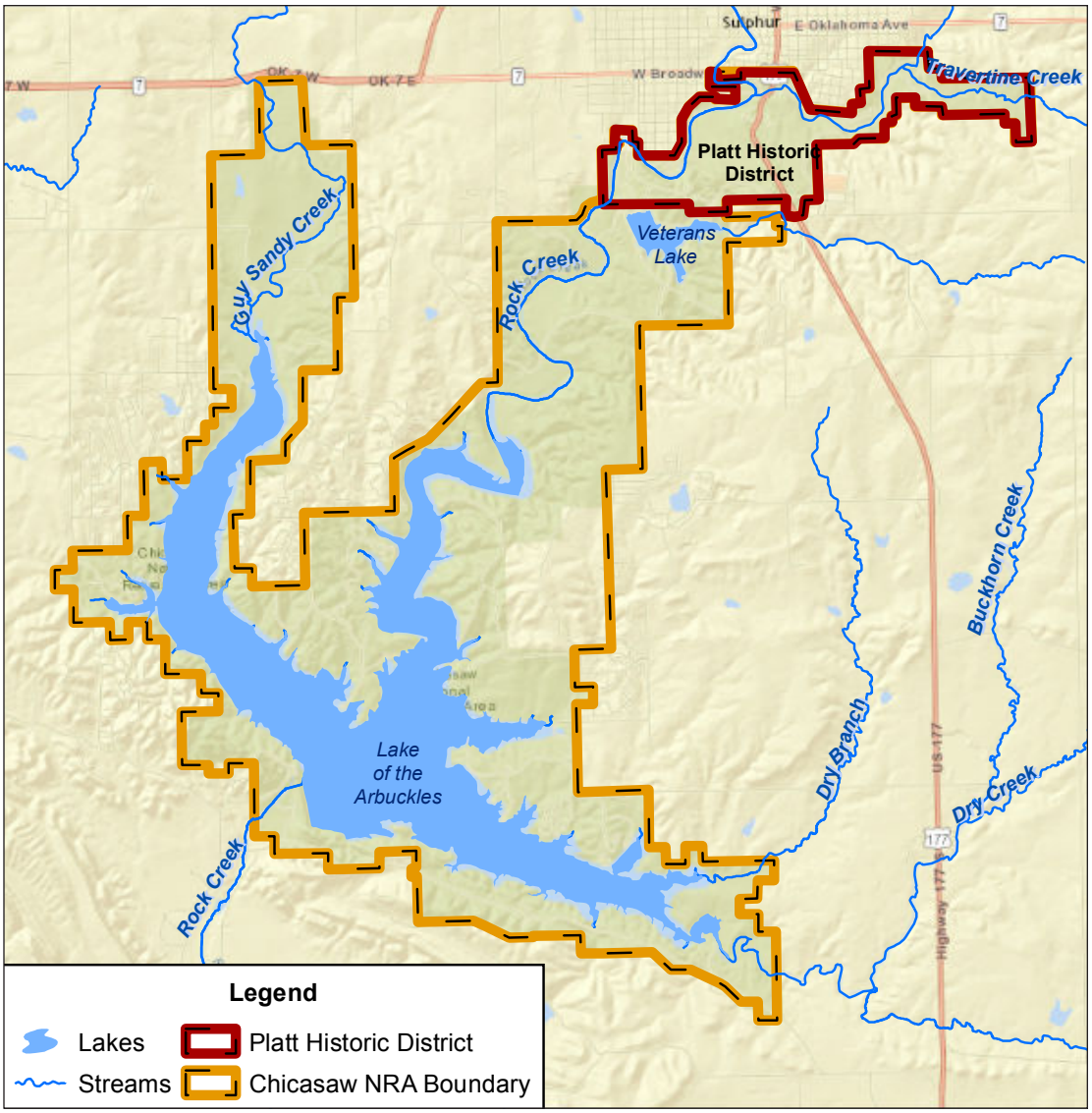


Figure 4.7.1-2. Location map showing Chickasaw NRA boundary, Platt District boundary, lakes, and streams.

(USGS 2015), which is located at the western edge of the Platt District (Figure 4.7.1-2).

Nine floodwater retarding structures built by the Soil Conservation Service in the 1960s reduce peak flow on Rock Creek by catching and retaining surface water during periods of high flow and then releasing it as controlled discharges (Becker 2005).

Hydrogeology

Springs in the Platt District are supplied by water from the Arbuckle-Simpson aquifer. The Arbuckle-Simpson aquifer is contained in three major rock units: the Timbered Hills, Arbuckle, and Simpson Groups. These rock units are exposed at land surface over an area of about 1347 km^2 (520 mi^2) in south-central Oklahoma and consist of three outcrop areas, designated as the eastern, central, and western Arbuckle-Simpson aquifers (Figure 4.7.1-3). The aquifer lies in an uplifted area commonly referred to as the Arbuckle Mountains, which is characterized by great thicknesses of mostly carbonate rocks, uplifts, folded structures, and large fault displacements (Christenson et al. 2011).

The Timbered Hills Group overlies the irregular surface of eroded igneous and metamorphic rocks and is exposed only in small areas in the Arbuckle-Simpson aquifer. The Timbered Hills Group consists of sandstone and sandy dolostone in the eastern Arbuckle-Simpson aquifer (Johnson 1991). Because no identifiable confining layer separates the Timbered Hills Group from the Arbuckle Group, the Timbered Hills Group

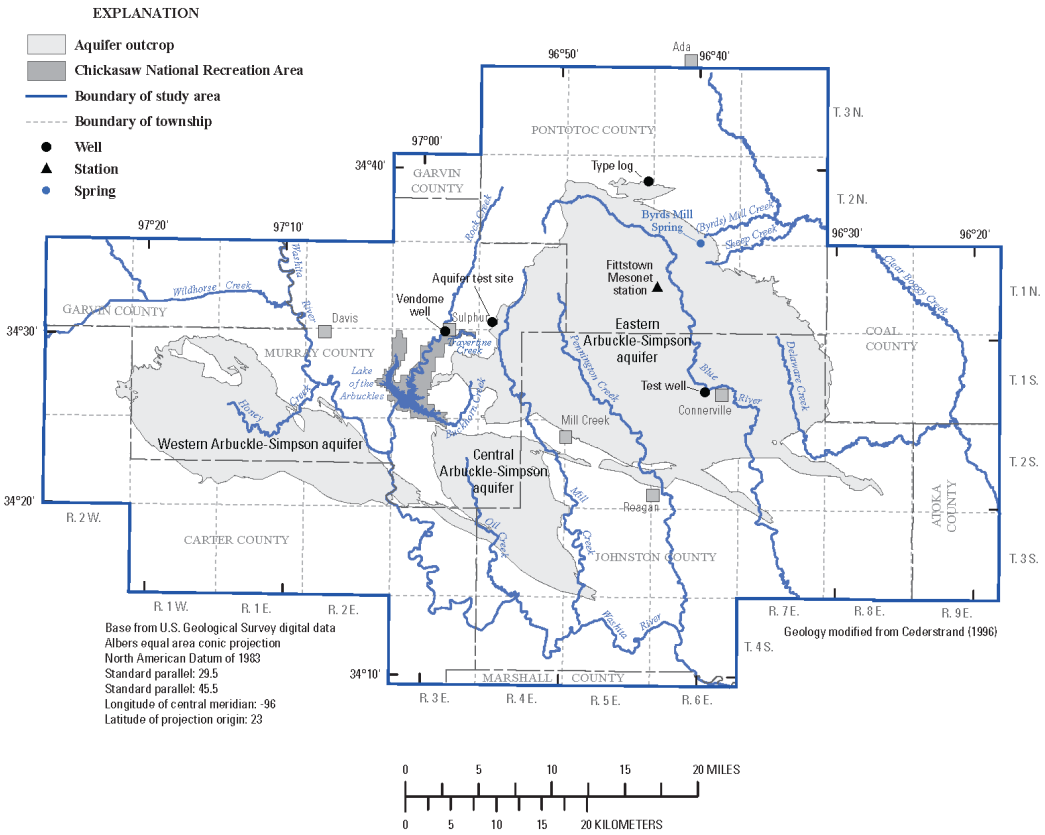


Figure 4.7.1-3. Map showing outcrop areas of the Arbuckle-Simpson aquifer (Christenson et al. 2011).

is considered to be part of the Arbuckle-Simpson aquifer (Christenson et al. 2011).

The Arbuckle Group constitutes the major part of the Arbuckle-Simpson aquifer in terms of thickness, outcrop extent, and volume of groundwater. The Arbuckle Group consists of as much as 2,042 m (6,700 ft) of limestone in the western Arbuckle-Simpson aquifer and thins to an estimated 914 m (3,000 ft) of predominantly dolostone in the eastern Arbuckle-Simpson aquifer. Combined thickness of the Arbuckle and Timbered Hills Groups in the vicinity of the Platt District is about 1,219 m (4,000 ft). Water is obtained from cavities, solution channels, fractures, and intercrystalline porosity in the limestone and dolostone (Christenson et al. 2011).

The overlying Simpson Group consists of sandstones, shales, and limestones. Although the Simpson Group is as thick as 305 m (1,000 ft) in structurally low areas east of the park, its thickness ranges from zero to about 30.5 m (100 ft) in the Platt District. Water in the Simpson Group is stored primarily in pore spaces between the sand grains in the sandstones (Christenson et al. 2011).

The Vanoss Formation lies unconformably over the Arbuckle and Simpson Groups on the western flank of the eastern Arbuckle-Simpson aquifer. In the Platt District, the Vanoss Formation consists primarily of limestone conglomerate. The Vanoss Formation thickens from east to west in the Platt District, from about 18.3 m - 100.5 m (60 ft - 330 ft). The low-permeable, tightly cemented conglomerate of the Vanoss Formation serves as a confining layer to the underlying Arbuckle-Simpson aquifer (Christenson et al. 2011).

Groundwater Recharge

The primary source of groundwater in the Arbuckle-Simpson aquifer is diffuse recharge from precipitation in the outcrop area. Recharge begins as precipitation on the land surface and infiltrates into the soil. Some of the soil moisture returns to the atmosphere from evaporation and transpiration by plants (termed "evapotranspiration"), but some fraction moves downward through the soil zone, through the unsaturated zone to recharge groundwater in the saturated zone (Christenson et al. 2011).

Table 4.7.1-2. Area-weighted average annual recharge for the eastern Arbuckle-Simpson aquifer for water years 2004-2008 (Table 19 from p. 71 of Christenson et al. 2011).

	Water Year					5-year Average
	2004	2005	2006	2007	2008	
Recharge (inches)	3.28	7.57	2.57	11.61	2.85	5.58

The amount of precipitation that recharges an aquifer depends on many factors, such as the amount of water stored in the unsaturated zone, the slope of the land surface, the type of rocks and soils that form the aquifer, the type of vegetation and land use overlying the aquifer, and the intensity, season, and duration of precipitation. For example, equal amounts of precipitation falling on an aquifer in winter and summer will tend to produce more recharge in winter than in summer because evapotranspiration of water in the soil zone is less in the winter (Christenson et al. 2011).

The rate of recharge varies with space and time. Christenson et al. (2011) determined the area-weighted annual recharge rate of the eastern Arbuckle-Simpson aquifer to be 14.17cm (5.58 in) per year for the 5-water-year time period starting October 1, 2003, through September 30, 2008 (corresponding to water years 2004 through 2008). The recharge rate ranged from 6.53 cm (2.57 in) in water year 2006 to 29.49 cm (11.61 in) in water year 2007 (Table 4.7.1-2).

Groundwater Flow and Discharge

Once in the saturated zone, groundwater moves through pores, fractures, and solution cavities in the aquifer from areas of high head (elevation) to areas of low head along streams and springs.

A potentiometric-surface map is constructed by contouring measurements of static head in wells. The elevation of the potentiometric surface at any point reflects the height to which a column of water will rise in a tightly cased well. A potentiometric-surface map can be used to infer the direction of groundwater flow. A potentiometric-surface map of the eastern Arbuckle-Simpson aquifer, representing static heads measured in August 1995, shows the potentiometric surface slopes from northeast to the southwest, indicating groundwater flow toward Travertine Creek (Figure 4.7.1-4). Groundwater flowing

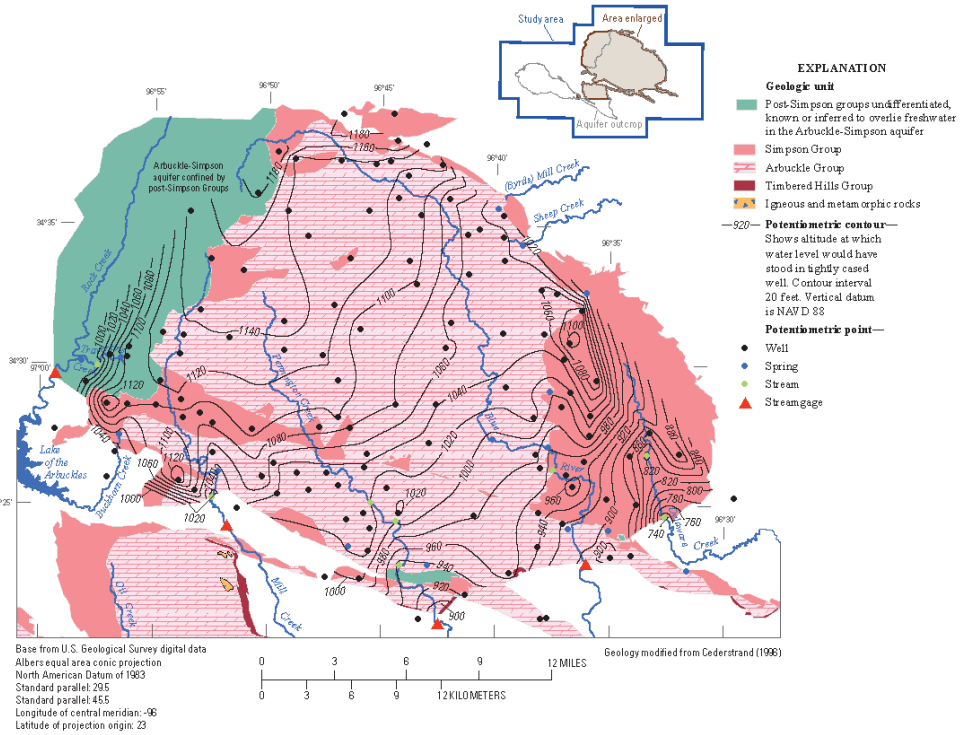


Figure 4.7.1-4. Map showing potentiometric surface (Christenson et al. 2011).

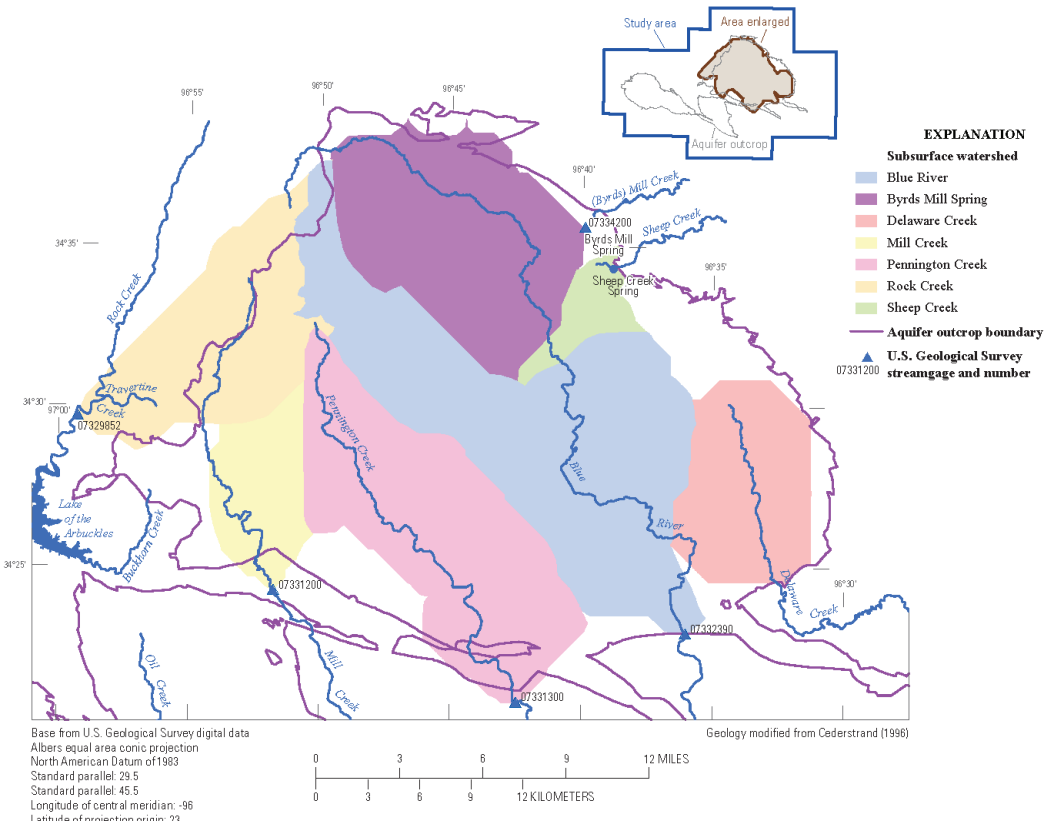


Figure 4.7.1-5. Map showing subsurface watersheds (Christenson et al. 2011).

beneath the Vanoss Formation discharges to Travertine Creek and to springs in Chickasaw NRA (Christenson et al. 2011).

A subsurface watershed is the geographic area in the subsurface that contributes flowing groundwater to a specific point. The area and boundaries of a subsurface watershed can, and commonly will, deviate to some degree from the surface watershed (refer to riparian section Figure 4.8.1-2 for a surface watershed map). Subsurface watersheds on the eastern Arbuckle-Simpson aquifer were constructed using the same depth-to-water and wellhead elevations used to construct the potentiometric-surface map shown in Figure 4.7.1-4 (Christenson et al. 2011).

The subsurface watersheds delineated on primary discharge areas on the eastern Arbuckle-Simpson aquifer are shown in Figure 4.7.1-5. The Rock Creek subsurface watershed, which includes Travertine Creek and Vendome Well, was delineated to the streamgage on Rock Creek. The subsurface watershed, which encompasses about 88 km^2 (34 mi^2) east and northeast of the streamgage, extends into the area where the Arbuckle Group is at the land surface, but the Rock Creek surface watershed is not (Christenson et al. 2011). The portion of the subsurface watershed that is in the aquifer outcrop area represents the recharge area for the groundwater flowing into the Platt District.

Groundwater Withdrawals

Most groundwater discharge from the Arbuckle-Simpson aquifer is to springs and streams, but some groundwater discharge is to water wells. Average annual reported groundwater use from the eastern Arbuckle-Simpson aquifer from 1964 through 2008 was 4,299 acre-ft. Figure 4.7.1-6 shows annual water use from 1964 to 2008 of the eastern Arbuckle-Simpson aquifer and a breakdown of each use. Most of the groundwater withdrawals served public water supply systems (63 percent), followed by mining (15 percent), and irrigation (7 percent) (Christenson et al. 2011).

Current permitted groundwater use near Chickasaw NRA is for public water supply by the City of Sulphur, whose well field is adjacent to the Platt District, and Murray County Rural Water District no. 1, whose well

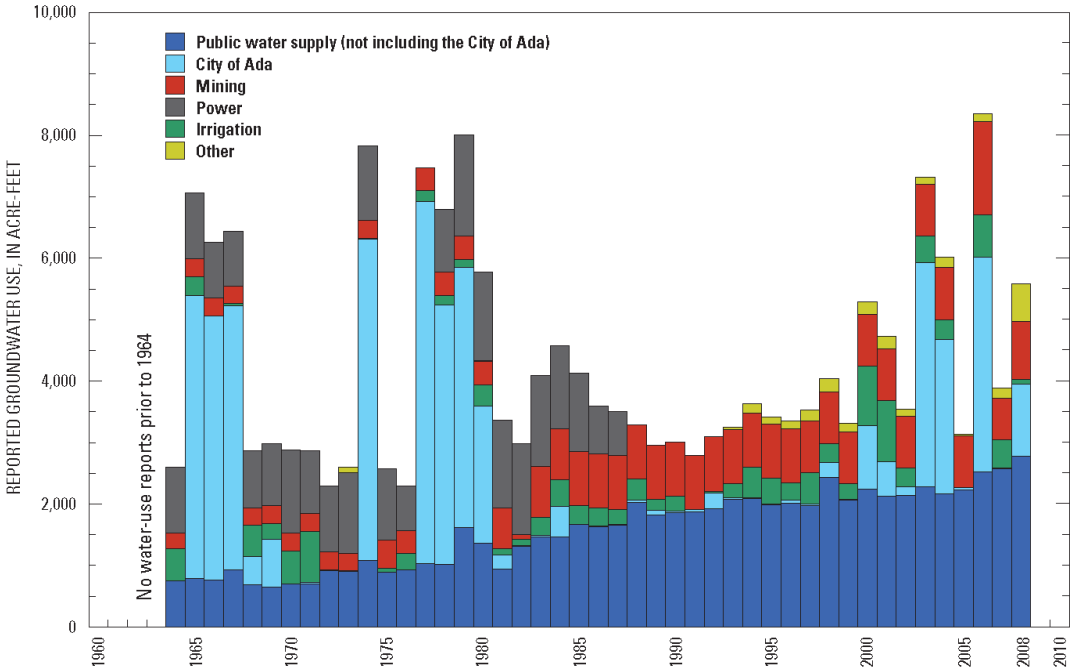


Figure 4.7.1-6. Bar graph showing reported groundwater use from the eastern Arbuckle-Simpson aquifer, 1964-2008 (Christenson et al. 2011).

field is about 2.4 km (1.5 mi) northeast of the Platt District (Figure 4.7.1-7). Average annual reported use by the City of Sulphur was 957 acre-ft from 1964 to 2008. Average annual reported use by Murray County Rural Water District was about 500 acre-ft from 1983 to 2008. Oklahoma Gas and Electric Company produced groundwater for power generation from three wells north of Sulphur (Figure 4.7.1-7) until 1988, when the power plant ceased operation. Average annual reported use by the power plant from 1964 to 1998 was 586 acre-ft (Christenson et al. 2011).

A substantial amount of groundwater has been discharged from unregulated flowing artesian wells in the vicinity of the Platt District and the City of Sulphur. Wells that are drilled through the tightly cemented Vanoss Formation into the Arbuckle-Simpson aquifer commonly flow along Rock Creek, where the water levels in the aquifer are about 61 m (200 ft) lower than water levels in the recharge area east of the park.

The first known flowing artesian well in the Sulphur area was the Bridgeman Well, drilled in 1889. Since that time, references have been made to approximately 43 flowing wells (Christenson et al. 2011), but some duplication of sites may exist because different names apparently refer to the same well (Hanson and Cates 1994). Figure 4.7.1-7 shows artesian wells with known locations.

Total discharge was estimated to be 20,500 gpm (33,070 acre-ft/yr) from 16 flowing wells in the Sulphur area during 1937 (Gould and Schoff 1939).

In a report by Gould and Schoff (1939), Gould reported that:

> For many years geologists in Oklahoma and elsewhere have watched this unrestricted waste of water from the artesian wells at Sulphur with growing concern. Remembering the history of other artesian basins throughout the world, these geologists believed that in all probability it was only a question of time until the water in the Sulphur artesian basin would begin to fail.

In the same report (Gould and Schoff 1939), Schoff reports that:

> The mineral springs on the park now flow approximately one-fifth as much water as they did in 1906. It is believed that this decline in flow is

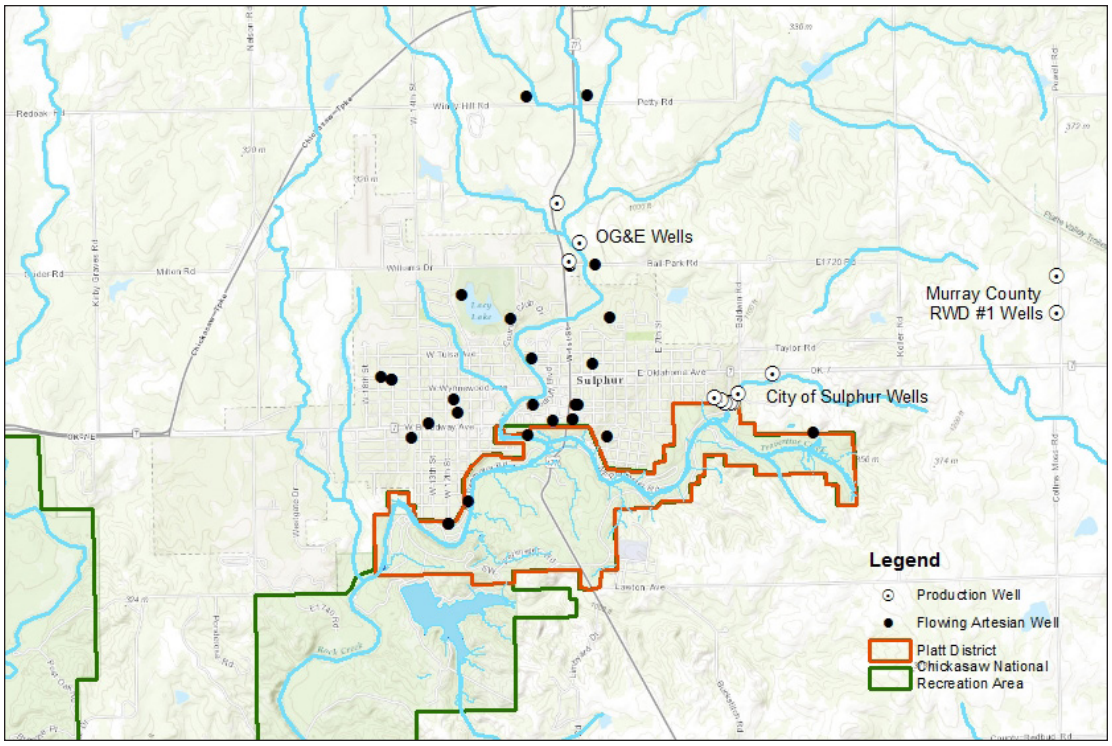


Figure 4.7.1-7. Map showing artesian and production wells in the Sulphur area.

due very largely to the uninterrupted flow of water from the artesian wells in Sulphur.

On two different occasions, Gould, then the State Geologist, introduced into the State Legislature a bill to regulate the flow of water in artesian wells throughout the State. Both bills died in committee (Gould and Schoff 1939).

As seen in Table 4.7.2-4, discharge from artesian wells declined substantially from 1939 to 2006, to about 5 percent of the total flow reported in 1939. The depletion most likely resulted from a gradual lowering in the hydraulic head of the Arbuckle-Simpson aquifer caused by many years of uncontrolled discharge of wells (Hansen and Cates 1994).

Vendome Well

Of all the artesian wells in the Sulphur area, the largest and best-known is Vendome Well. Drilled outside of the former Platt National Park boundaries in 1922, the original Vendome Well flowed more than 2,500 gpm. Until 1975, the well supplied water to a private swimming pool named the "Vendome Plunge."

Discharge from the well flowed from a ditch into Travertine Creek. In 1933, the CCC redesigned the ditch carrying the outflow from Vendome Well to an artificial creek with wading pools, meandering course, waterfalls, and foot bridges (Hohmann and Grala 2004).

The park acquired the well and property in 1979, and Vendome Well still remains a popular tourist attraction where visitors routinely collect jugs of sulphur water from a spigot at the well and is a cultural landmark for Sulphur residents (Nicholl et al. 1999).

By 1994, flow from the well had decreased to less than 500 gpm, indicating a decrease in pressure and water quantity of the reservoir (Shaver 1994). A videotape from a down-hole video camera indicated that the well casing had been laden with calcium precipitates and was corroded and perforated (Shaver 1994).

Concern over the decline in flow, the possibility of saline water flowing up behind the casing and potentially contaminating upper freshwater zones, and the possibility that the unregulated flow of the well may have been detrimental to other artesian wells and springs in the region led the NPS to plug and abandon the original well and re-drill

a new well in 1998 about 10.6 m (35 ft) west of the original one. According to Shaver (1994), "Given the political ramifications of this action (plugging of a tourist attraction), another well should be drilled adjacent to the old well. The drilling and casing of the new well would then fit today's standards and the well's flow could be monitored and checked."

At 122 m (400 ft), the new well (termed "Vendome Well #2" for this report) yielded only 60 gpm. After reaching a depth of 236.2 m (775 ft), the well yielded 900 gpm. Stainless steel casing was installed to a depth of 91.4 m (300 ft) (OWRB (1998) well drillers log 40305), and the water was piped to the center of the extant concrete enclosure (Figure 4.7.1-8).

The park's 2008 General Management Plan (NPS 2008) called for management of Vendome Well #2 to reduce the discharge of groundwater during times when it was not being used or enjoyed by the public in order to conserve the water resources of the Arbuckle-Simpson aquifer. In 2009, the park installed an automatic valve that could reduce the flow (Chickasaw National Recreation Area News Release 2010).

On 8/13/2009, the flow of Vendome Well #2 was measured to be 1.28 cubic feet per second (cfs) (575 gpm) with the valve completely open. At this unrestricted flow rate, the well would discharge about 927 acre-ft/yr. Current (2015) daytime restricted flow is about 0.82 cfs (368 gpm). Between the hours of 10:00 pm and 6:00 am, night-time flow is reduced to about 0.22 cfs (99 gpm). At the current restricted flow rates, the well discharges about 450 acre-ft/year, almost 50 percent less than the unrestricted flow.

Geochemistry

Groundwater in the outcrop area of the Arbuckle–Simpson aquifer is generally a calcium bicarbonate or calcium magnesium bicarbonate water type. Calcium bicarbonate water type is found in the western Arbuckle-Simpson aquifer, where the Arbuckle Group is predominantly limestone (calcium carbonate), and calcium magnesium bicarbonate water is found in the eastern Arbuckle-Simpson aquifer, where the Arbuckle Group is predominantly dolostone (calcium magnesium carbonate) (Christenson et al. 2009a).

Water from the freshwater springs near the eastern end of the Platt District is a calcium





Figure 4.7.1-8. Photo of Vendome Well today (left) and original Vendome Well and pool (right).

Table 4.7.1-3. Chemical analyses of water sampled from springs and Vendome Well #2 in Chickasaw NRA.

Site	Chemical Analysis (mg/L)							
	Na	Ca	Mg	Cl	HCO_3	SO_4	$CaCO_3$	TDS
Buffalo Spring[1]	3.11	77.1	34.2	2.70	395	14.4	325	338
Antelope Spring[1]	3.50	78.4	35.7	2.98	395	16.9	325	334
Hillside Spring[1]	52.7	66.4	28.8	66.3	387	15.2	318	437
Pavilion Spring[1]	81.9	70.3	31.0	106	392	16.4	322	500
Black Sulphur Spring[2]	254	51	28	350	316	-----	244	810
Vendome Well[1]	330	83.0	36.4	593	346	33.2	287	1,310
Medicine Spring[2]	1,490	68	36	2,370	610	14	318	4,520

[1]Winton, Kimberly T. (2003) [2]Schornick et al. (1976)

magnesium bicarbonate type. Water from the highly mineralized springs near the western end of the Platt District is a sodium chloride type (Christenson et al. 2009a). Water from Hillside, Pavilion, and Black Sulphur Springs and the original Vendome Well is a mix of the two water types (Hanson and Cates 1994).

Groundwater in the outcrop area, where the aquifer is recharged with rain water, is considered fresh, and dissolved solids concentrations of water samples from wells and springs in the outcrop area are low, with a median of 347 mg/L. Beyond the outcrop area of the aquifer, the water chemistry changes quickly and becomes saline (dissolved solids greater than 1,000 mg/L) (Christenson et al. 2009a).

Dissolved solids concentrations in water samples from springs in the Platt District increase from east to west. Within a distance of less than 3 miles, concentrations of dissolved solids increase from 338 mg/L at Buffalo Spring to 4,520 mg/L at Medicine Spring (Table 4.7.1-3).

Just a few miles west of Rock Creek, the Arbuckle and Simpson Groups contain brine (dissolved solids concentrations greater than 35,000 mg/L, the average concentration of seawater) and are major producers of oil and gas. Groundwater sampled from an oil well, completed in the Simpson Group about 4 miles west of the Platt District, had a dissolved solids concentration of 88,600 mg/L (Christenson et al. 2009a).

The increase in dissolved solids concentrations in water samples from wells and springs in and near the Platt District is likely because of mixing of fresh groundwater (dissolved solids less than 1,000 mg/L) originating from recharge on the outcrop of the aquifer and a small amount of brine from the saline part of the aquifer (Christenson et al. 2009a). Chemical analyses reveal that water discharging from Vendome Well #2 is a mixture of about 99 percent water from the freshwater zone in the Arbuckle-Simpson aquifer and 1 percent brine from the saline-water zone.

Recharge and Residence Time

Christensen et al. (2009a) used age-dating tracers (Carbon-14, tritium, terrigenic helium gas, and chlorofluorocarbons) to determine the approximate time of recharge and residence time of groundwater in the Arbuckle-Simpson aquifer. Chlorofluorocarbon and tritium concentrations in water samples from Antelope Spring indicate water entered the aquifer around 1960 (Christenson et al. 2009a). Terrigenic helium in water samples from large springs in the Arbuckle-Simpson aquifer is probably derived by the uptake of helium from crustal rocks, such as the igneous rocks that underlie the aquifer. Water samples from Antelope Spring had high concentrations of terrigenic helium. Although Antelope Spring had a modern groundwater age, the high concentration of terrigenic helium indicates that at least some fraction of the water has flowed along a long, deep flow path before

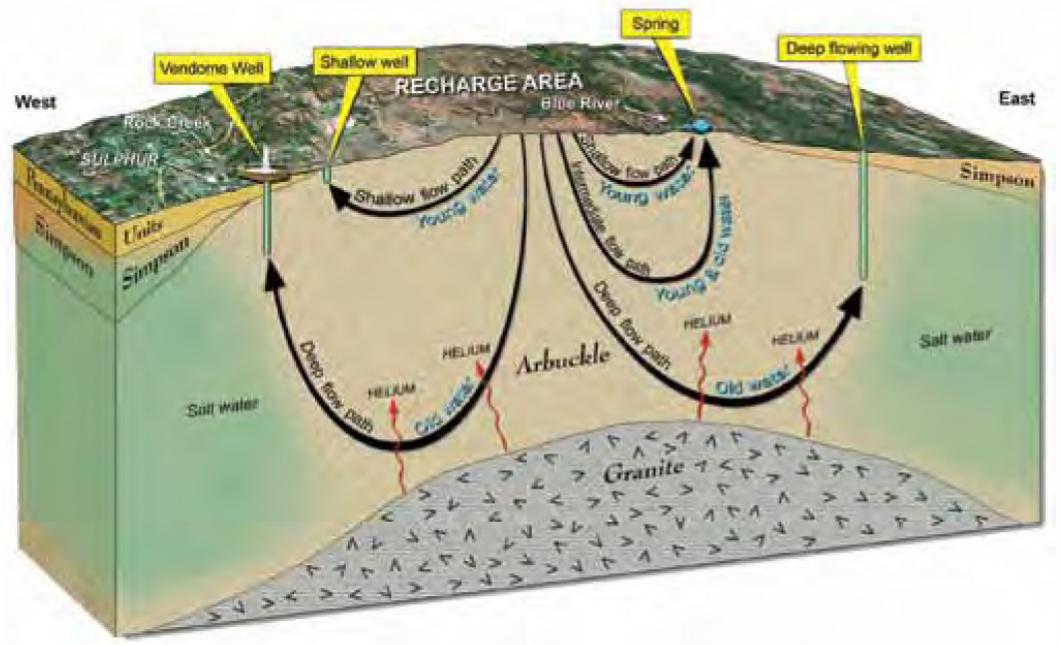


Figure 4.7.1-9. Schematic section showing flow paths of water in the Arbuckle-Simpson aquifer (Christenson et al. 2009b).

being discharged at the spring (Figure 4.7.1-9) (Christenson et al. 2009a).

Water samples from Vendome Well #2 did not contain tritium or chlorofluorocarbons, indicating that the water from the well was recharged more than 60 years ago. Using carbon-14, water from Vendome Well #2 was dated at about 10,500 years before present. Water samples from the well also contained high concentrations of terrigenic helium, indicating that water from the well travels along long flow paths deep in the aquifer (Christenson et al. 2009a).

Concentrations of dissolved argon, neon, and xenon in water samples were used to determine the temperature of the water when it recharged the aquifer. The recharge temperature of water samples from Vendome Well #2 was 6.6 degrees Celsius (44 degrees Fahrenheit), too cold to be associated with present day temperatures. The colder recharge temperature is consistent with recharge from an earlier, cooler time period (Christenson et al., 2009a).

Water Rights and Issues

Proposed development of water supplies from the Arbuckle-Simpson aquifer led to concerns that large-scale withdrawals of water would cause decreased flow in streams and springs, which in turn could result in the loss of water supplies, recreational opportunities, and aquatic habitat. In response to these concerns, the Oklahoma Senate passed Senate Bill 288 in 2003, which imposed a moratorium on the issuance of any groundwater permit until the Oklahoma Water Resources Board (OWRB) completed a hydrological study of the groundwater basin and approved a maximum annual yield that would ensure that permitted groundwater withdrawals would not reduce the natural flow of water from springs or streams emanating from the basin. The OWRB, in collaboration with the U.S. Bureau of Reclamation, the USGS, Oklahoma State University, and the University of Oklahoma, studied the Arbuckle-Simpson aquifer to provide the scientific information needed to determine the volume of water that could be withdrawn from the aquifer while protecting springs and streams. The six-year investigation, termed the "Arbuckle-Simpson Hydrology Study", was conducted between 2003 and 2009 and greatly improved our understanding of the hydrogeology and the groundwater-flow system at the NRA.

In October 2013, the OWRB approved the maximum annual yield that placed a cap of 0.2 acre-feet per acre of land on the amount of water permitted holders could withdraw from the groundwater basin each year.

4.7.2. Data and Methods

Table 4.7.2-1. The indicators and measures used to access groundwater condition at Chickasaw NRA.

Indicator of Condition	Measure	Resource
Springflow	Freshwater Discharge	Antelope and Buffalo Springs
	Mineral Water Discharge	Pavilion, Hillside, and Black Sulphur Springs
Streamflow	Freshwater Discharge	Travertine Creek
	Mineral Water Discharge	Rock Creek (low flow)
Groundwater Head	Freshwater Groundwater Level	East and West Observation Wells
	Mineral Water Artesian Well Discharge	Artesian Wells: Vendome and Vendome #2

We used three indicators, each with two measures, to assess the current condition and trend for groundwater resources at Chickasaw NRA (Table 4.7.2-1). The indicators evaluate the condition of the recreation area's springflow, streamflow, and groundwater head. These indicators were measured separately for freshwater and mineral-water resources. Freshwater springs (Antelope and Buffalo), streams (Travertine Creek), and groundwater in the observation wells represent water from the freshwater system, which is strongly affected by aquifer recharge east of the park. Groundwater in the freshwater system was recharged less than 60 years ago and flows along shorter flow paths and shallower depths than water in the mineral-water system. Mineral springs (Pavilion, Hillside, and Black Sulphur), groundwater discharging to Rock Creek as base flow, and artesian well discharge represent groundwater in the mineral-water system. Groundwater in the mineral-water system is a mix of water from the freshwater system and saline water that originates from a deeper, older system than the freshwater system (Christensen et al. 2009a).

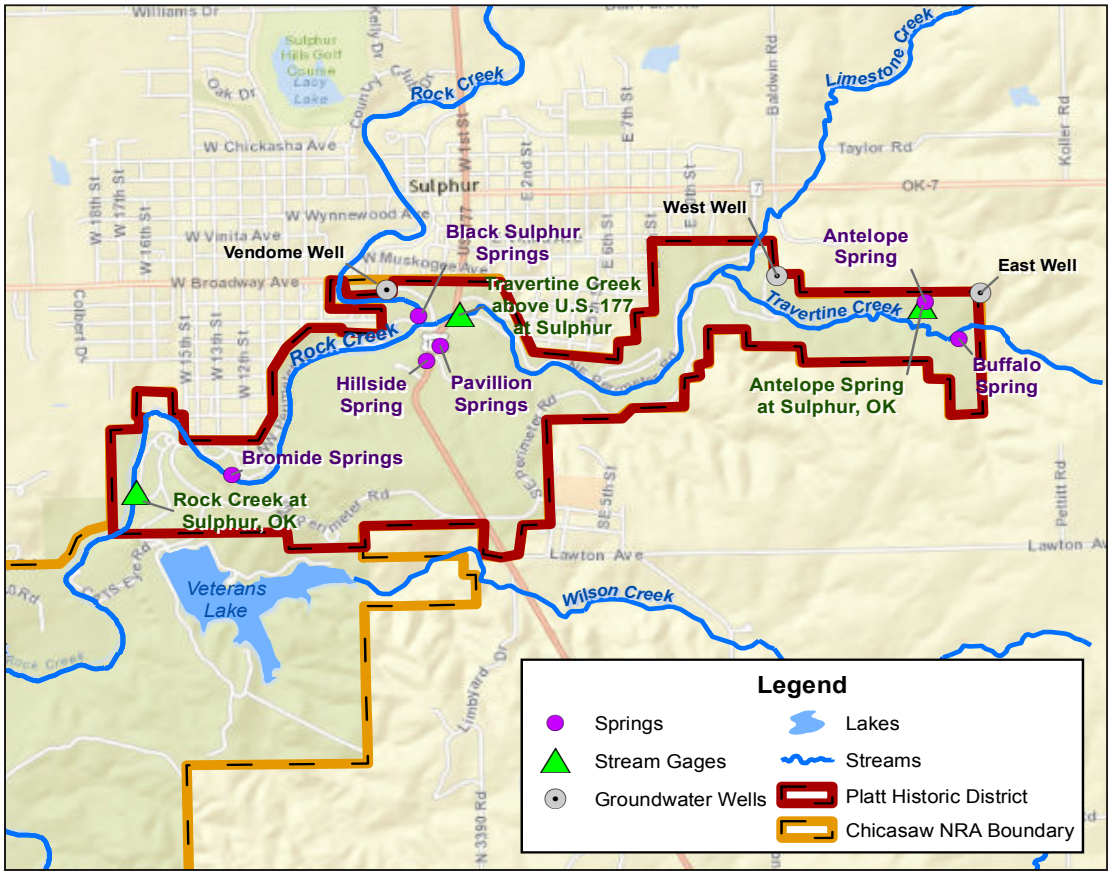


Figure 4.7.2-1. Location map showing the streams, springs, wells, and gages located throughout the Platt Historic District.

Table 4.7.2-2. Summary of hydrologic data available through USGS gage stations in Chickasaw National Recreation Area.

Site Name	Site ID	Parameters	Period of Record	Comments
Rock Creek at Sulphur	07329852	Discharge	1989-present (2015)	n/a
Travertine Creek above U.S. 177 at Sulphur	073298507	Discharge	10/2013-present (2015)	n/a
Antelope Spring at Sulphur	07329849	Discharge	1985-present (2015)	Discontinuous record
CNRA GW Well 2 (East)	343017096	Water Level	1972-present; (2015)	Discontinuous record; Naturally occurring asphalt can cause erroneous measurements
CNRA GW Well 1 (West)	343022096	Water Level	1972-present; (2015)	Discontinuous record; Naturally occurring asphalt can cause erroneous measurements

Table 4.7.2-3. Spring discharge for various time periods.

Spring Group		Discharge (gallons per minute)					
		1906[1]	1939[2]	1988[3]	2004-2015[4]		
					Min.	Mean.	Max.
Sulphur	Antelope	2,000	0	1,257	0	1,030	4,710
	Buffalo	1,500	0	2,016	0	1,110	3,870
Chalybeate		weak	NA	NA	NA	NA	NA
Pavilion		62	12	87	2.24	14.4	41.7
Hillside		80	10	45	2.24	9.87	24.2
Beach (Black Sulphur)		70	10	26	30.1	43.5	59.2
Bromide		2.5	NA	0	NA	NA	NA
Ravine		9	NA	0	NA	NA	NA
Churchill Park		17	NA	0	0	0	0

[1] Gould (1906) [2] Gould and Schoff (1939) [3] Hanson and Cates (1988) [4] NPS (2015)

Three types of data were used for this assessment: historic measurements, USGS gage data, and NPS periodic measurements. Historic measurements from springs and flowing artesian wells were collected during surveys by Gould in 1906 and by Gould and Schoff in 1939. The USGS operates 3 streamgage stations and 2 gages at groundwater observation wells in the Platt District (locations shown in Figure 4.7.2-1). A summary of the data collected at these stations is provided in Table 4.7.2-2.

Indicator/Measure

Springflow (Fresh and Mineral Water Discharge)

The springflow measure evaluates whether springs, both fresh and mineral, flow in their natural condition. Short-term declines in springflow may indicate local effects of groundwater withdrawals and/or seasonal climatic conditions; long-term declines may indicate depletion from groundwater withdrawals and/or climate change.

The limited discharge data available for the springs, presented in Table 4.7.2-3, show that many of the springs first observed by Gould in 1906 no longer flow, and flows from the remaining mineral springs (Pavilion, Hillside, and Black Sulphur Springs) are substantially less than those reported in 1906.

From 2004-15, NPS staff periodically monitored discharge at 5 spring sites and Vendome Well #2. Methods used to measure discharge included current meter, flume, and volumetric methods, depending on site-specific factors. Discharge was measured

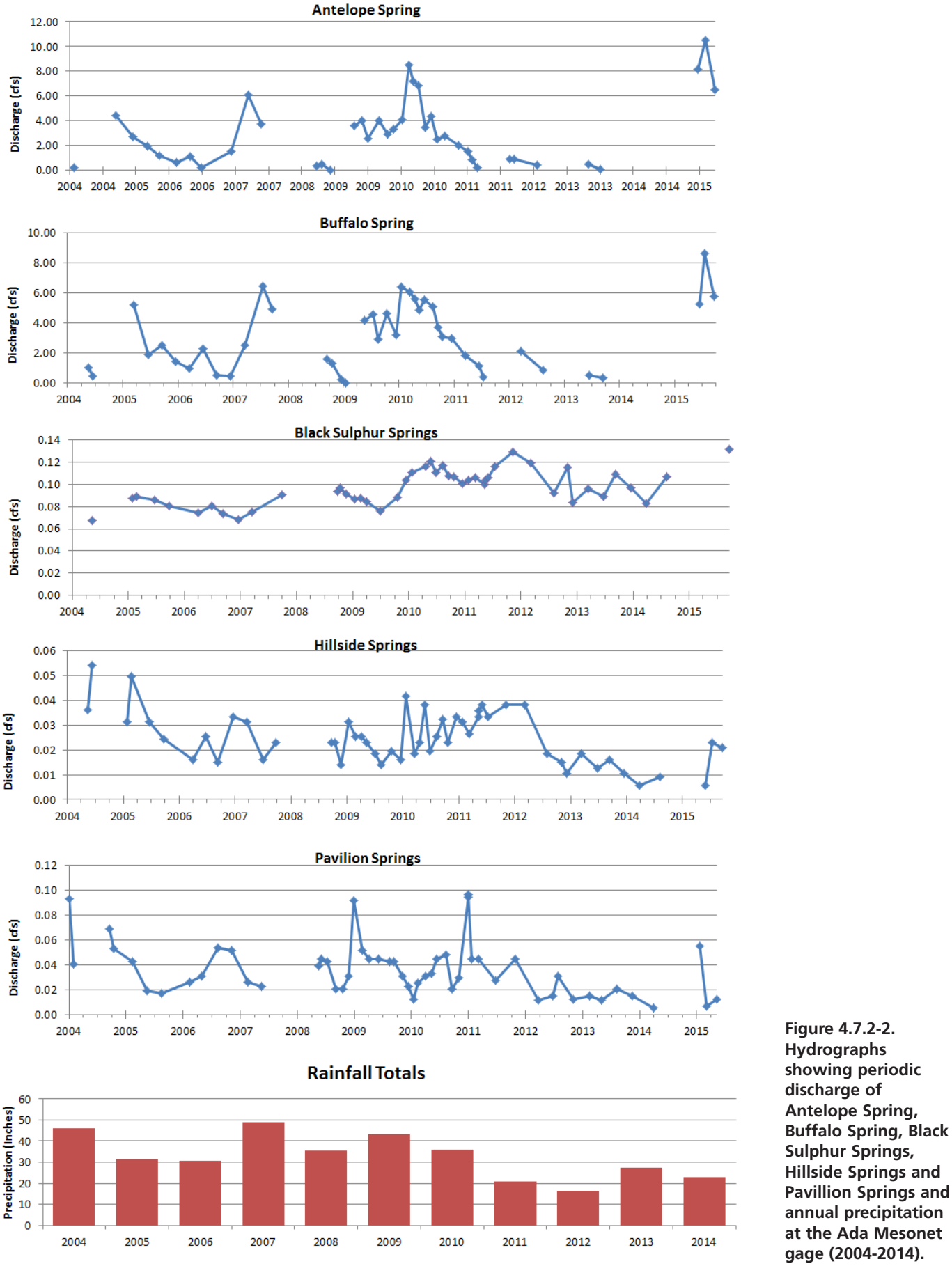


Figure 4.7.2-2. Hydrographs showing periodic discharge of Antelope Spring, Buffalo Spring, Black Sulphur Springs, Hillside Springs and Pavillion Springs and annual precipitation at the Ada Mesonet gage (2004-2014).

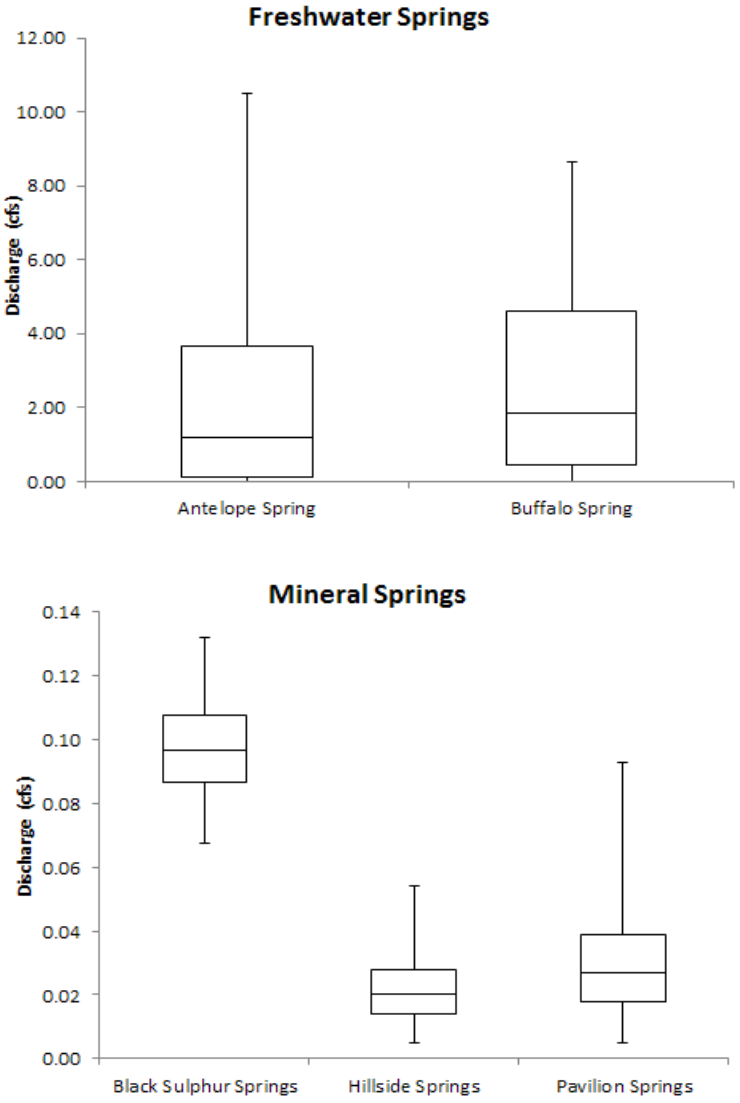


Figure 4.7.2-3. Box and whisker plots of discharge measurements at freshwater springs (Antelope and Buffalo) and mineral springs (Pavillion, Hillside, and Black Sulphur Springs).

with a current meter at Antelope Spring, the Buffalo Spring outflow, the Pavilion Springs Highway 177 underpass, and the Vendome Well channel leading from the well to the Flower Park parking lot. A portable Parshall Flume was used to measure discharge at Hillside Spring, where the depth was too shallow and velocities too low for a current meter. A volumetric method using a bucket and stopwatch was used to measure discharge at the Black Sulphur Springs outflow pipe by the Rock Creek causeway.

Periodic measurements of spring discharge for five springs sites are shown in Figure 4.7.2-2. Box-and-whisker plots of discharge measurements, which provide graphical overviews of the data, their distributions, and outliers, are presented for the freshwater springs and mineral springs in Figure 4.7.2-3.

Discharge rates of both the freshwater springs (Antelope and Buffalo) and mineral springs (Pavilion, Hillside, and Black Sulphur) correlate with seasonal precipitation; springflow is highest during wet periods and lowest during dry periods.

Examination of Figure 4.7.2-2 indicates a possible long-term decline in spring discharge of Pavilion and Hillside Springs, and a possible increase in spring discharge of Black Sulphur Spring. The decline in flow at Pavilion and Hillside springs is most likely due to decreasing groundwater head due to flowing artesian wells. The potential increase in discharge at Black Sulphur Springs is unexpected. Black Sulphur Springs are located a short distance from Vendome Well #2. Close examination of the hydrograph of Black Sulphur Springs in Figure 4.7.2-2 indicates higher discharge rates occur after 2009, when Vendome Well #2 flow was reduced. It is possible that the reduction in Vendome Well #2 discharge caused the increase in discharge at Black Sulphur Springs.

Antelope and Buffalo springs have been dry on numerous occasions. The longest continuous dry period (33 months) occurred from April 1954 to May 1957. When precipitation has been below normal for three or more years, both springs have gone dry (Hanson and Cates 1994). Figure 4.7.2-4 shows the relationship between times when Antelope Spring was dry and times when precipitation was below normal for multiple years.

Once there is sufficient precipitation to recharge the aquifer, both Antelope and Buffalo springs resume flowing within a few days of each other (Hanson and Cates 1994). An example of this rapid response to recharge is illustrated in Figure 4.7.2-5, which shows discharge from Antelope Spring and precipitation from May 1 to October 1, 2015. Antelope Spring had been dry multiple times for a total of 32 months during a 5-year

period of rainfall deficit (Figure 4.7.2-4). From May 5-10, the Sulphur Mesonet weather station recorded 7.74 inches (19.66 centemeters) of rain. On May 8, discharge at Antelope Spring increased from 0.03 to 0.16 cfs. Subsequent rain events in May, June, and July resulted in flash floods and lake flooding. A total of 105.26 cm (41.44 inches) of rain fell between May 5 and July 8. Discharge from Antelope Spring went from negligible flow in early May to 9.7 cfs in July.

The mineral springs (Pavilion, Hillside, and Black Sulphur) flow continuously, even during prolonged droughts (Hanson and Cates 1994). The altitudes of Antelope and Buffalo springs 329 m and 328 m (1,081 ft and 1,079 ft), respectively are about 38.1 to 42.6 m (125 to 140 ft) higher than the altitudes of Pavilion, Hillside, and Black Sulphur Springs. Springs located at the higher altitudes in the eastern Arbuckle-Simpson aquifer go dry sooner than lower-altitude springs, so it is not surprising that Antelope and Buffalo springs respond sooner to declining groundwater levels than the mineral springs located at lower altitudes along Rock Creek.

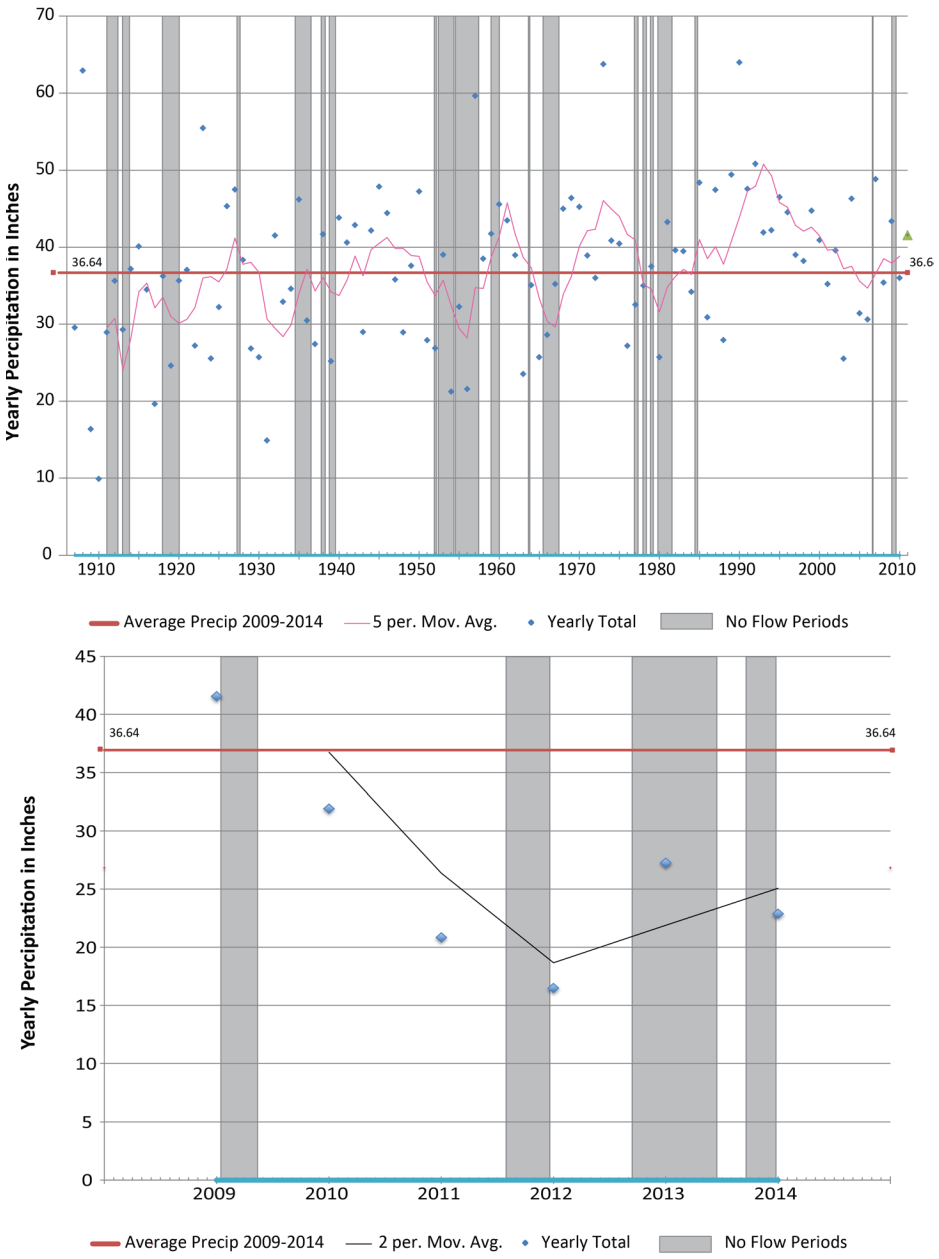


Figure 4.7.2-4. Antelope Spring is dry during periods when precipitation is below normal. Graph showing annual precipitation (1910-2014), average precipitation, 5 and 2-year moving average of precipitation, and periods when Antelope Spring was dry.

Indicator/Measure
Streamflow (Fresh and Mineral Water Discharge)

The Travertine Creek streamgage (station number 073298507), located just above the confluence of Travertine Creek with Rock Creek, was installed in October, 2013 to monitor base flow into Travertine Creek. Base flow can be computed from stream hydrographs using programs such as PART (Rutledge, 1998), which uses streamflow partitioning to estimate a daily record of base flow under the streamflow record. Base flow in Travertine Creek represents fresh groundwater discharge from springs and seeps.

Base flow in Rock Creek at the Rock Creek streamgage represents a mix of freshwater from Travertine Creek and mineral waters from artesian wells and mineral springs. Seventy-six water samples collected at the Rock Creek streamgage from 1990 to 1995 had moderate concentrations of sodium, sulfate, and chloride. Increases in concentrations of sodium, sulfate, and chloride with decreased streamflow indicate that mineral waters from springs and artesian wells have the greatest

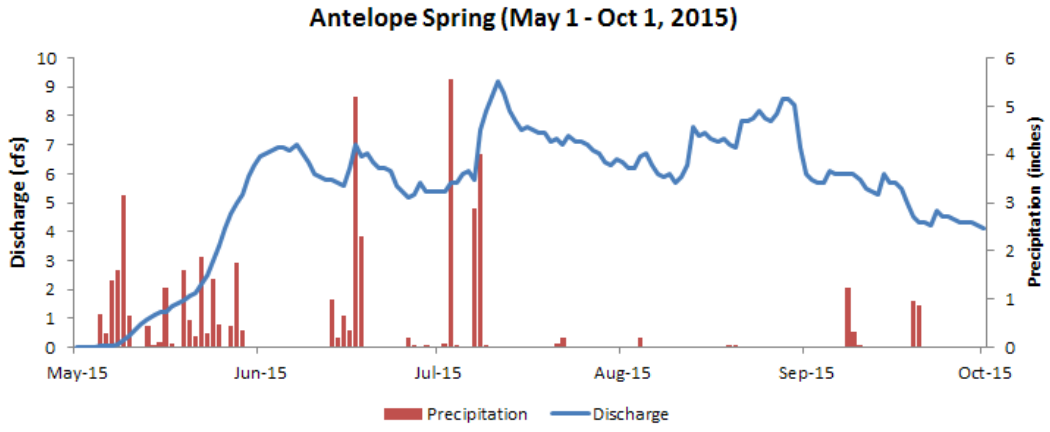


Figure 4.7.2-5. A comparison of Antelope Spring discharge to precipitation measured at the Sulphur Mesonet station from May 1 to October 1, 2015.

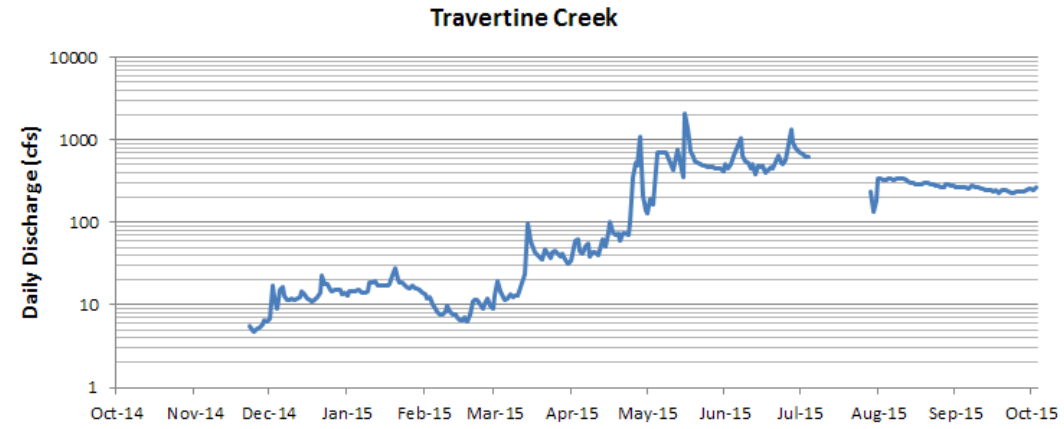


Figure 4.7.2-6. Travertine Creek hydrograph (Oct. 13, 2014 - Oct. 15, 2015).

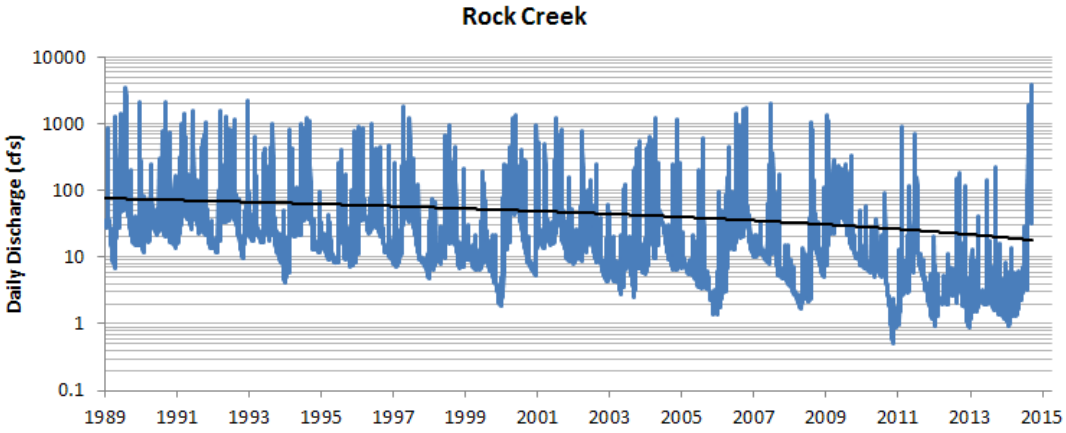


Figure 4.7.2-7. Rock Creek hydrograph (1989-2015).

effect on surface-water quality in Rock Creek during dry or low-flow periods (Andrews and Burrough, 2002).

The period of record for the Travertine Creek streamgage is too short for computing base flow and for determining long-term trends. However, as illustrated in Figure 4.7.2-6, base flow sustains Travertine Creek flow, even during extended dry periods.

The Rock Creek streamgage (station number 07329852), located in the southwest area of the Platt District, has recorded streamflow since 1989. Mean monthly discharge from calendar year 1990 to 2014, ranged from a low of 16 cfs in August to a high of 76 cfs in May. The maximum recorded peak flow was 10,400 cfs on April 26, 1990 (USGS 2015).

Inspection of Figure 4.7.2-7, showing Rock Creek's daily mean discharge from 1990 to 2015, indicates a downward trend in low

flows. Possible explanations for this trend are reduced discharge from flowing artesian wells and/or Travertine Creek.

Indicator/Measure
Groundwater Head (Groundwater Level and Artesian Well Discharge)

The groundwater head indicator evaluates whether groundwater head (elevation) is in its natural condition. Groundwater levels in the two NPS observation wells are an indicator of groundwater conditions in the freshwater system of the aquifer, which are strongly affected by aquifer recharge east of the park. Groundwater discharge in flowing artesian wells is an indicator of groundwater conditions in mineral waters that originate from a deeper, older groundwater system. Short-term declines in groundwater head may indicate local effects of groundwater withdrawals and/or seasonal climatic conditions; long-term declines may indicate depletion from groundwater withdrawals and/or climate change.

Groundwater Levels in Observation Wells

In 1972, NPS drilled two groundwater observation wells, named "East" and "West", along the north boundary of the Platt District to identify potential effects from the City of Sulphur well field and to better understand how water levels in the Arbuckle-Simpson aquifer are related to discharge of Antelope and Buffalo springs. The East Well is 72.5 m (238 ft) deep, and the West Well is 132.5 m (435 ft) deep. Both wells penetrate the Arbuckle Group. The wells contain naturally occurring asphalt, which has caused erroneous water-level records during some periods (Hanson and Cates 1994).

Continuous water-level records have been collected at both wells for various time periods since December 1973. In addition to continuous monitoring, periodic water-level measurements were taken by NPS from December 1973 to January 1986. Selected water-level measurements at 5–day intervals are stored in the USGS National Water Information System (NWIS). For periods when the record is considered unreliable because of asphalt buildup in the wells, only the periodic water-level measurements made by NPS are stored in NWIS.

As illustrated in Figure 4.7.2-8, groundwater levels in both wells correlate with seasonal and annual changes in precipitation, and groundwater levels are lowest following extended dry periods. Groundwater levels also correlate with Antelope Spring discharge. No long-term trends are apparent in groundwater levels.

Groundwater Discharge in Flowing Artesian Wells

Discharge from flowing artesian wells peaked in the 1930s (Table 4.7.2-4). In 1939, Gould (1939) reported that discharge from 16 of the larger wells was 20,500 gpm (33,100 acre-ft/year). By 2006, many of the historic wells had ceased to flow or had been capped, and the discharge rate of the remaining wells had declined to 900 gpm (1,740 acre-ft/year) (Badra 2006).

Hanson and Cates (1988) documented 43 flowing artesian wells that were drilled in the area of Chickasaw NRA from 1889 to 1987. They identified only 16 flowing wells in 1988, with an estimated discharge of 1,542 gpm (2,485 acre-ft/yr), which was about 7.5 percent of the total flow reported in 1939 by Gould and Schoff.

In 2006, OWRB staff located 21 artesian wells in the Sulphur area, of which 16 were still flowing. Total discharge from the 16 flowing wells was estimated to be about 900 gpm (1,740 acre-ft/year). Vendome Well #2 had the highest discharge, averaging 600 gpm (968 acre-ft/year), which accounted for 67 percent of the total estimated discharge. Five artesian wells were not flowing, either because they were capped or because they ceased to flow (Badra 2006).

Historic, periodic measurements of the first Vendome Well show a long-term decline in the discharge rate from 2,500 gpm in 1937 to 763 gpm in 1955, and then to 500 gpm in 1998 (Table 4.7.2-5). The first Vendome Well was plugged in 1998, and a new well, Vendome Well (#2), was drilled to 236.2 m (775 ft), 125 m (410 ft) deeper than the original well

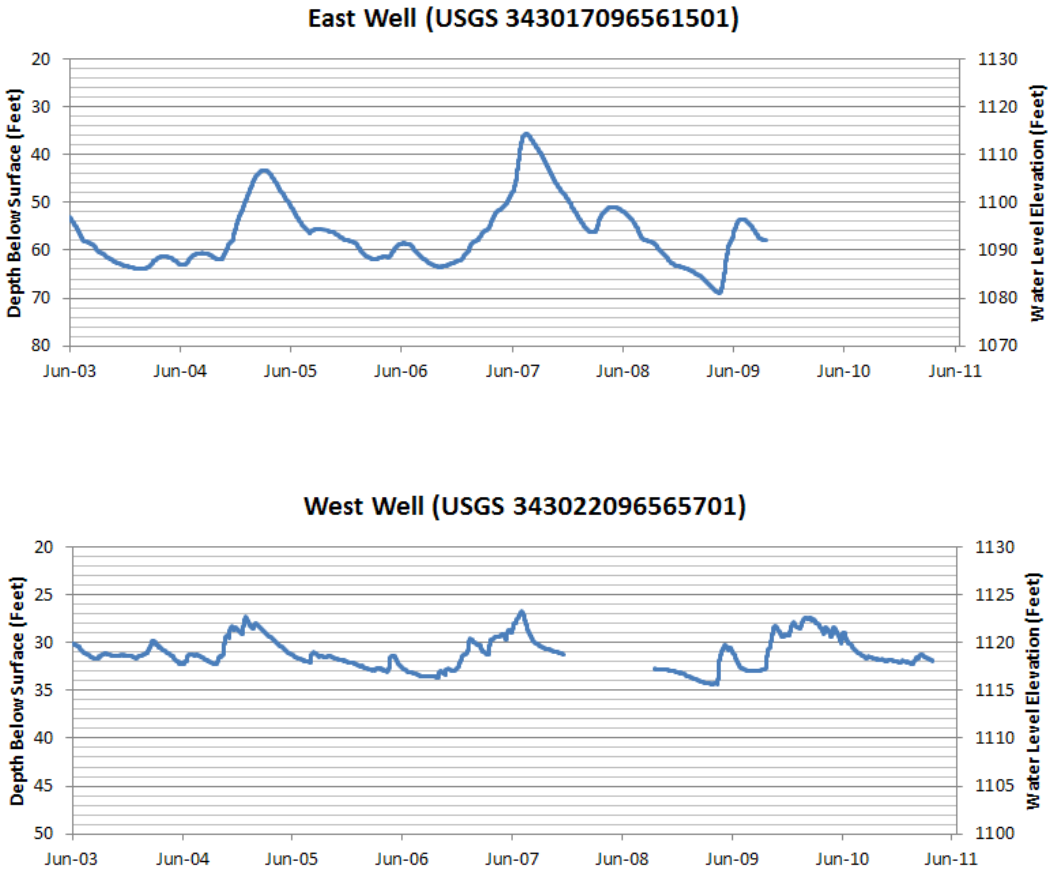


Figure 4.7.2-8. Hydrographs of groundwater observation wells (2003-2010).

Table 4.7.2-4. Measured discharge of flowing artesian wells in and near Chickasaw National Recreation Area.

Date discharge measured (years)	Number of wells measured	Discharge (gallons/ minute)	Discharge (acre-feet/ year)[1]
1889-1910[1]	7	4,050	6,530[1]
1921-1930[1]	16	15,250	24,600[2]
1939[2]	16	20,500	33,100[3]
1988[3]	16	1,542	2,485[4]
2006[4]	16	900	1,740[4]

[1]Hanson and Cates (1994), [2]Gould and Schoff (1939) [3]Hanson and Cates (1988) [4]Badra (2006)

Table 4.7.2-5. Measured discharge of the first Vendome Well.

Date measured	Discharge		
	(cubic feet/second)	(gallons/min)	(acre-feet/year)
1937[1]	5.57	2,500	4,033
11/15/1955[1]	1.70	763	1,230
7/10/1957[1]	1.65	740	1,194
10/29/1985[1]	1.40	628	1,015
1998[2]	1.11	500	807

[1]Hanson and Cates (1994), [2]NPS Staff

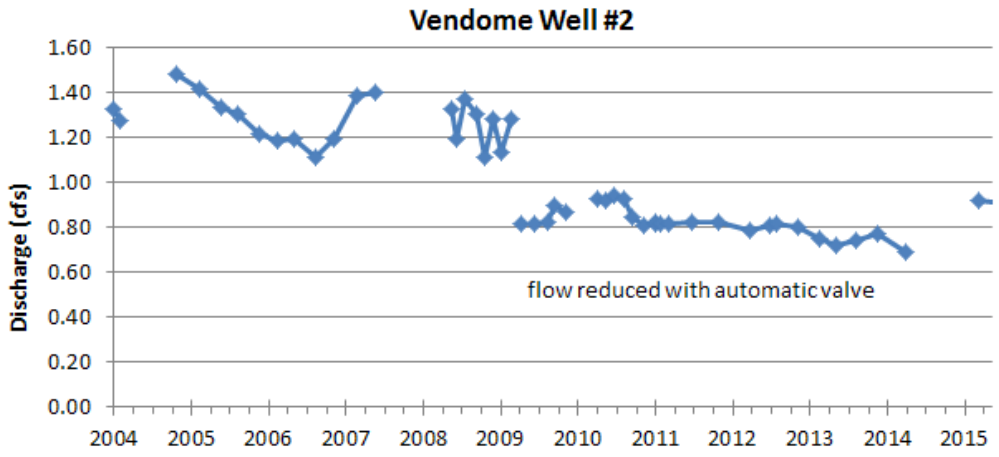


Figure 4.7.2-9. Periodic discharge measurements of Vendome Well #2 (2004-2015).

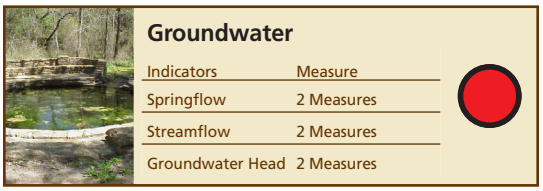
depth of 111.2 m (365 ft). The initial discharge rate of the new well was about 900 gpm, but discharge decreased to 574 gpm by August 2009. After August 2009, the flow of the well was restricted with an automatic valve to a lower rate.

Figure 4.7.2-9, showing periodic discharge measurements of Vendome Well #2 from 2004-15, shows a correlation between precipitation and discharge similar to that of the springs. Adjusting for the reduced flow of the well after 2009, there does appear to be a decline in discharge from the new Vendome Well.

4.7.3. Reference Conditions

The groundwater system has degraded since 1906, but has reached a somewhat stable state since monitoring began in 1988. The condition of groundwater resources is assessed for long-term declines in springflow, streamflow, and groundwater head and the effects of human activity since 1988. Anthropogenic factors such as climate change and groundwater withdrawals can cause lower groundwater head, springflow and streamflow. The reference conditions by which groundwater condition in the NRA was assessed are listed in Table 4.7.3-1.

4.7.4. Condition and Trend



Overall Condition

Because long-term declines were observed in artesian well discharge, springflows of two mineral springs, and low (dry-weather) flows of Rock Creek, we assigned an overall condition class of significant concern for the park's groundwater resources. A summary of the condition rationale is presented in Table 4.7.4-1

Threats

The two largest threats to groundwater resources of the Platt District are groundwater withdrawals and climate change.

As part of the Arbuckle-Simpson Hydrology Study, a MODFLOW groundwater-flow model was developed to simulate groundwater flow in the eastern Arbuckle-Simpson aquifer.

Table 4.7.3-1. Reference condition classes for assessing groundwater condition.

Condition Class	Description
Good	Since 1988, no long-term decline in springflow, streamflow, groundwater level, or artesian well discharge.
Moderate	Since 1988, long-term decline in artesian well discharge.
Significant Concern	Since 1988, long-term decline in artesian well discharge and long-term decline in springflow, streamflow, and/or groundwater level.

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

Indicator of Condition	Measure	Condition/Trend	Rationale for Condition
Springflow	Freshwater Discharge	Good/Stable	Hydrographs of Antelope and Buffalo Springs discharge from 2004-2015 show a correlation with seasonal precipitation, but no long-term trends.
	Mineral Water Discharge	Pavilion & Hillside: Significant Concern/ Decreasing Black Sulphur: Good/Increasing Overall: Moderate/Decreasing	Hydrographs of Pavilion, Hillside, and Black Sulphur Springs discharge from 2004 to 2015 indicates a possible long-term decline in spring discharge of Pavilion and Hillside Springs (Significant Concern/Decreasing) and a possible increase in spring discharge of Black Sulphur Spring. (Overall Moderate/Decreasing)
Streamflow	Freshwater Discharge	Unknown/Unknown	The period of record for the Travertine Creek streamgage is too short for computing base flow and for determining long-term trends.
	Mineral Water Discharge	Significant Concern/ Decreasing	The Rock Creek streamgage, located in the southwest area of the Platt District, has recorded streamflow since 1989. Daily mean discharge from 1989 to 2015, indicates a downward trend in low flows.
Groundwater Head	Freshwater Groundwater Level	Good/Stable	Freshwater: Groundwater levels in 2 observation wells correlate with seasonal changes in precipitation and with Antelope and Buffalo Spring discharge, but no long-term trends.
	Mineral Water Artesian Well Discharge	Significant Concern/ Decreasing	Mineral: Discharge measurements from Vendome Well #2 show a continued long-term decline.

The MODFLOW model was used to simulate the aquifer with no groundwater withdrawals, which allowed for the computation of base flow to streams at a time prior to development of wells in the aquifer. Model simulations demonstrated that in order to maintain flow in springs and streams, long-term withdrawals of groundwater must be less than the long-term recharge rate. When 2011 groundwater withdrawals were removed from the simulation, average (pre-development) base flow of Travertine Creek was 9.6 percent greater, indicating permitted withdrawals have resulted in a 9.6 percent decrease in the base flow of Travertine Creek. The model also demonstrated that increasing groundwater withdrawals from the aquifer will result in fewer locations where groundwater is discharging to streams and springs, and that the higher-altitude springs and streams will be the first to cease flowing (Christenson et al. 2011).

The equal proportionate share (EPS) of 0.2 acre-ft/yr approved by the OWRB in 2013, will help prevent over-drafting the aquifer. However, not all groundwater withdrawals from the Arbuckle-Simpson aquifer are regulated. Of concern to the NRA is the nearby well field of the City of Sulphur. Most of the City's wells were drilled in 1922 and are not subject to the EPS allocation of 0.2 acre-ft/yr. The City has a prior groundwater right of 1,120 ac-ft/yr. Similarly, OG&E has a prior groundwater right of 2,214 acre-ft/yr, which could potentially be used in the future.

Additionally, the number of limestone and sandstone quarries on the eastern Arbuckle-Simpson aquifer has increased during the last 15 years. The quarries de-water large pits in order to mine the rock. Thanks to recent legislation that applies only to the Arbuckle-Simpson aquifer, water from the pits (termed "pit water") that is used for mining purposes, such as washing quarried rock and dust suppression, is regulated by OWRB. However,

a substantial amount of unused pit water, which is not regulated, leaves the aquifer by flowing into streams or by evaporating. Another unregulated use of groundwater is the discharge from flowing artesian wells in the Sulphur area, of which a few (including Vendome Well #2) still remain.

Climate change may affect groundwater resources in the NRA. Seasonal and annual variations in streamflow, springflow, and groundwater head within the Platt District are strongly influenced by the amount of aquifer recharge, which is controlled primarily by the amount and timing of precipitation on the recharge area east of the park. Changes in timing, duration, and intensity of precipitation could affect the amount of recharge to the aquifer. Higher temperatures could result in lower recharge rates. Lower recharge rates would result in decreased flow in spring and streams.

4.7.5. Sources of Expertise

Noel Osborn is Chief of Resource Management at Chickasaw National Recreation Area. She has her Masters in Geology, and she specializes in groundwater. While working at the Oklahoma Water Resources Board (22 years) and the U.S. Geological Survey (3 years), Noel managed and conducted many groundwater studies. Noel was the project manager and a lead scientist of the 6-year Arbuckle-Simpson Hydrology Study.

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4.8. Riparian Habitat

Indicators/Measures

- Hydrology (4 measures)
- Vegetation (6 measures)
- Erosion/Deposition (5 measures)

Condition – Trend– Confidence



Good - Insufficient Data - High

***Sections were excerpted from the Condition Assessment of the Rock Creek and Guy Sandy Creek riparian areas within Chickasaw National Recreation Area developed for the purposes of this condition assessment (Martin et al. 2015). For the full report, go to http://www.nature.nps.gov/publications/nrpm/nrr.cfm.*

4.8.1. Background and Importance

Riparian wetlands are a type of non-tidal wetland formed along river and stream floodplains. These wetlands serve many functions including water purification, flood control, buffering riverbank erosion, habitat for numerous wildlife, fish, shellfish, and plant species, and also provide many recreational opportunities. Riparian habitat 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 (NPS 2002), Procedural Manual #77-1 (NPS 2012), and NPS Management Policies (2006) to ensure a "no net loss" of wetlands throughout the NPS.

Park Setting

Chickasaw National Recreation Area (NRA) is located at a transition zone between the Eastern Temperate Forest and Great Plains ecoregions (Figure 4.8.1-1), and has a moist, sub-humid climate (Fairchild et al. 1990) where most precipitation falls as rain. Maximum precipitation generally occurs during April through June, with another wet season of lesser magnitude usually taking place during September and October. The dry season is normally from November to February (Harp et al. 1984). In addition to

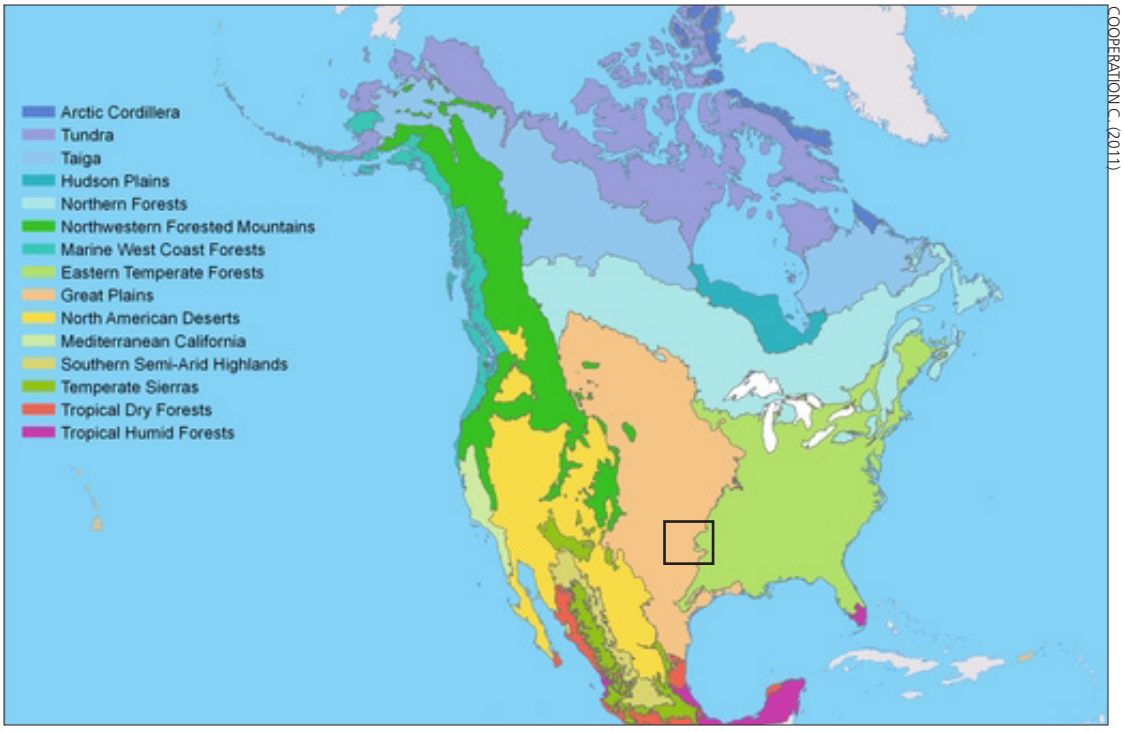


Figure 4.8.1-1. Chickasaw National Recreation Area is located at a transition zone between the Eastern Temperate Forest and Great Plains ecoregions,

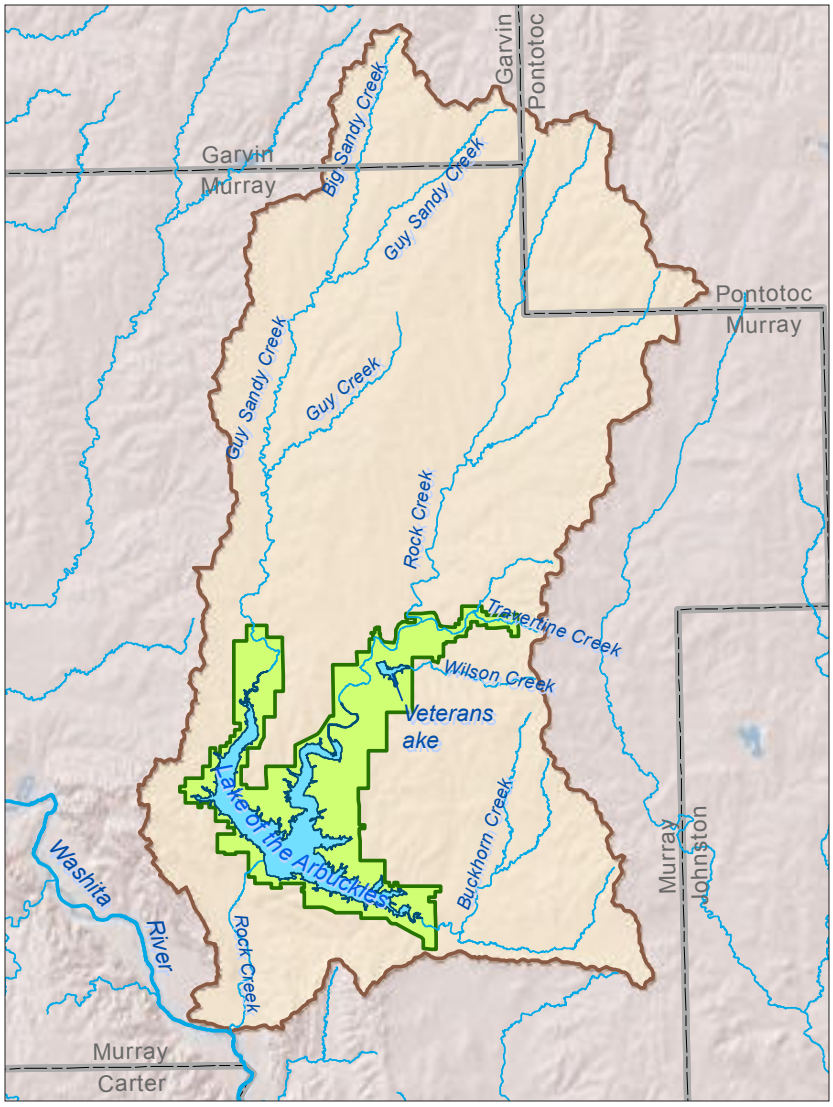


Figure 4.8.1-2. Watershed map for the vicinity of Chickasaw National Recreation Area.

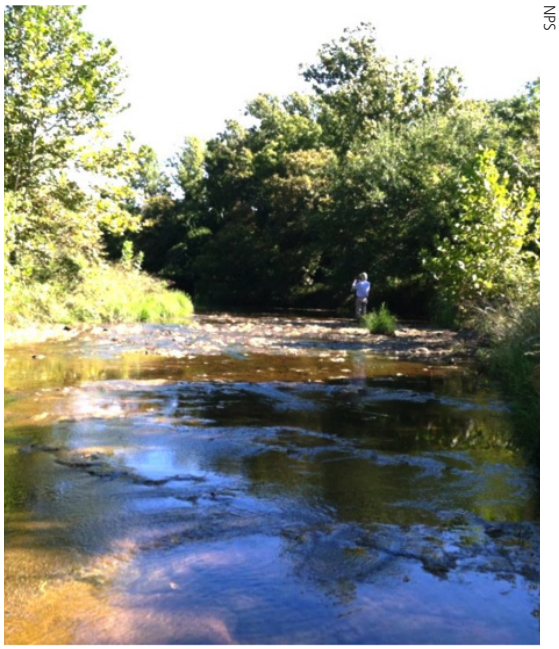
seasonal variability, rainfall may vary markedly from year to year. A recent estimate of mean annual precipitation using a 30-year average from 1971-2000 is 41.54 inches (Christenson et al. 2011). Estimates using other periods of record may be expected to vary somewhat, but should be within this range.

Figure 4.8.1-2 shows the contributing watersheds for the two drainages that were assessed at the NRA (Rock Creek and Guy Sandy Creek). Other surface water resources in the park include Lake of the Arbuckles (130 acres), Veterans Lake (64 acres), Travertine Creek, Wilson Creek, and Buckhorn Creek (Porter et al. 2010). Travertine Creek is a tributary to Rock Creek and usually flows perennially, although at the time of our site visit, discharge was at a minimum. Rock Creek, Guy Sandy Creek, and Buckhorn Creek flow directly into Lake of the Arbuckles, which was constructed for flood control and water supply by the Bureau of Reclamation in 1966. Veterans Lake is a manmade impoundment built on-line with Wilson Creek.

Rock Creek

Rock Creek begins 10 miles north of the park and flows south through the park and into Lake of the Arbuckles before discharging into the Washita River, where it drains about 140 square miles (Hanson and Cates, 1994). The watershed above the USGS streamgage on Rock Creek (Rock Creek at Sulphur, OK, gage #07329852) is 44.1 square miles. The creek is situated in an extensive v-shaped valley that trends south-southwest and is as much as 150 feet below the surrounding plains. The valley is cut through the resistant conglomerate facies of the Vanoss Formation. Lateral erosion has widened the valley in a downstream direction (Wikle et al. 1998), and the valley may be as much as 1000 feet wide in places. However, the portion of the valley that contains the active channel of Rock Creek is probably limited to about 100 feet wide.

Flow in Rock Creek is perennial and is supported by a number of sources. Travertine Creek is the primary tributary to Rock Creek and its flow is derived almost entirely from groundwater discharge from the Arbuckle-Simpson aquifer. Rock Creek also receives groundwater discharge from springs and from uncontrolled flowing artesian wells in the immediate vicinity of the park, also emanating from the Arbuckle-Simpson aquifer. Consequently, a substantial portion of the flow in Rock Creek is base flow from the aquifer periodically supplemented with direct surface runoff. The morphology of the Rock Creek channel is primarily bedrock controlled (Figure 4.8.1-3) and the associated alluvium appears to be thin and mostly discontinuous. Where present in sufficient quantities, the alluvium contains some groundwater of meteoric origin that supports the riparian system, but for the most part, the underlying Arbuckle-Simpson aquifer is the


NPS

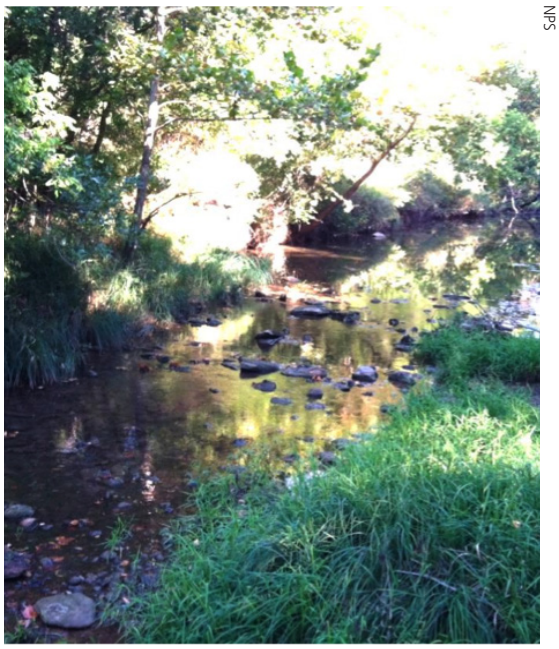

NPS

Figure 4.8.1-3. Rock Creek immediately above "40 foot hole" looking upstream. Shallow bedrock is visible in the channel bed in this entire section of the creek (left). Rock Creek at the crossing at Black Sulphur Springs, facing downstream. Bedrock outcrops are present on the left bank, but also note that alluvium supports the herbaceous vegetation on the right side of the photo (right).

primary source of riparian water within the National Recreation Area.

Guy Sandy Creek

In stark contrast to Rock Creek, Guy Sandy Creek is almost entirely an alluvial channel. In the upper reaches within the park (just downstream of State Highway 7) there is evidence of some shallow bedrock, but throughout most of its length in the park, the channel is coarse sand and fine gravel composed of quartz, feldspars, and limestone clasts. This lithologic composition contrasts with the material in the banks and overbank areas, which appear to be fine-grained soil with some thin lenses of limestone pebbles (Figure 4.8.1-4).

The Guy Sandy Creek watershed is immediately west of the Rock Creek watershed and has a similar length and orientation. Additionally, almost the entire Guy Sandy Creek watershed is underlain by the upper shale facies of the Vanoss Formation (Blome et al. 2013), a more erodible layer than the underlying lower limestone conglomerate facies. This difference in the surficial geology is likely a major factor in the morphological differences between the two drainages.

In addition to these geological differences, Guy Sandy Creek obviously supports a very different type of flow regime compared to that of Rock Creek. Based on observation and reports from park staff, Guy Sandy Creek is an ephemeral drainage that flows only in response to substantial rainfall events. During the time of our site visit, the channel was completely dry except for a few shallow pools in the area where we observed bedrock in the channel bottom. This ephemeral flow regime suggests that the creek probably has limited, if any, connection to the Arbuckle-Simpson aquifer. The alluvial reaches of the channel were not only completely dry, but there was no evidence of a persistent, shallow water table anywhere near the surface of the channel. It appears that the coarseness of the channel


NPS

Figure 4.8.1-4. A typical view of Guy Sandy Creek along the assessed reach. Note the high cutbank that supports riparian vegetation, and the apparent difference between the material in the channel and the exposed bank.

substrate and the resulting lack of water-holding capacity prevents establishment of most perennial riparian-wetland vegetation. Interestingly, the adjacent terrace/floodplain level, which was about three to six feet above the channel bottom, supports abundant riparian vegetation (Figure 4.8.1-4). However, given the difference in elevation of the terrace level and the channel, it is not likely that there is a persistent shallow water table supporting the riparian vegetation on the terraces. Rather, we suspect that because the terrace deposits are primarily fine-grained material, they are able to retain enough soil moisture to support the riparian system.

4.8.2. Data and Methods

The purpose of the riparian habitat assessment was to determine the overall functional condition or ecological "health" of the river channel and its associated riparian corridor. To complete this assessment, we used "A User Guide to Assessing the Proper Functioning Condition (PFC) and the Supporting Science for Lotic Areas" (Prichard et. al. 1998). For this method, "Proper Functioning Condition" is the highest rating that can be given to a riparian area based on the perceived stability of the physical system, which in turn is dictated by the interaction of geologic formations, soil, water, and vegetation. This determination was made by an interdisciplinary team of technical experts from NPS' Water Resources Division and the Southern Plains Inventory & Monitoring Network (SOPN), who evaluated 15 hydrology, vegetation and erosion/deposition measures for Rock and Guy Sandy Creeks (Figure 4.8.2-1). The creeks were not divided into shorter assessment reaches since no significant differences in geomorphology, hydrology, vegetation, land use or other factors were present within each creek.

A riparian area in PFC is in dynamic equilibrium with its stream flow forces and channel processes. The system adjusts to handle larger runoff events with limited change in channel characteristics and associated riparian-wetland plant communities. This limited change, such as some cutbank erosion and point bar expansion in stream meanders, is within the context of natural stream

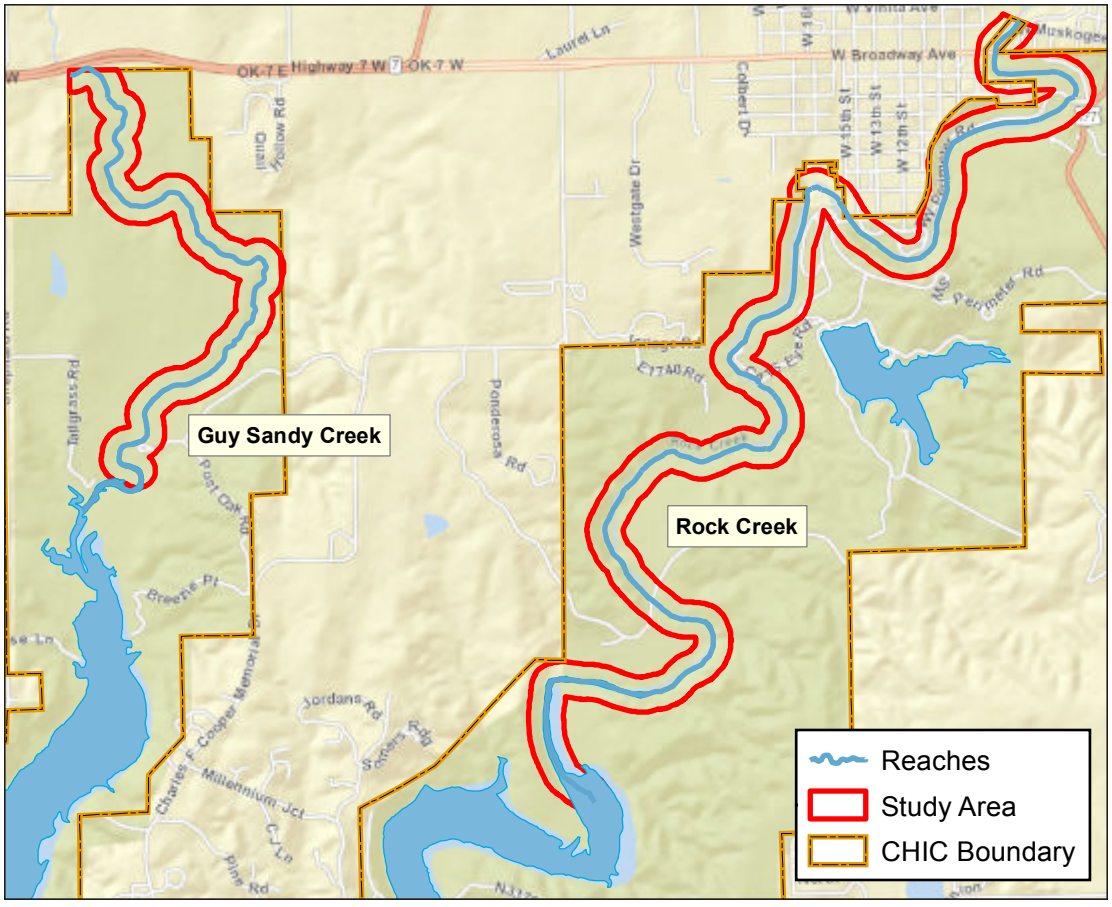


Figure 4.8.2-1. The riparian habitat rapid assessment locations along Rock and Guy Sandy Creeks.

evolution and provides new geomorphic features for riparian-wetland vegetation recruitment. Because of this resiliency, riparian areas in PFC can maintain aquatic habitat, water quality enhancement, and other important ecosystem functions even after moderately large runoff events. In contrast, nonfunctional systems subjected to the same flows might exhibit excessive erosion and sediment loading, loss of aquatic and wetland habitat, and so on.

Both terrestrial and aquatic attributes and processes are important in riparian wetland areas and are used to assess the condition of a given area.

The indicators used for this assessment included hydrology, vegetation, and erosion/deposition. The measures within each of these three categories, which included both attributes and processes, are listed below.

Indicator
Hydrology (4 measures)

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

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

Measure: Sinuosity, width/depth ratio, and gradient are in balance
Several channel parameters; specifically sinuosity, gradient, and width-to-depth ratio are closely related to a stream's ability to dissipate hydraulic energy during flood flows. When these parameters are in balance with the landscape setting, the channel is able to convey larger runoff events with limited change in channel characteristics and associated riparian-wetland plant communities.

Measure: Riparian wetland area is widening or has achieved potential extent
Sediment capture develops floodplains, which in turn, aids functionality of a riparian wetland area. In addition, as sediment is deposited, vegetation can "take root", increasing certain types of vegetation such as sedges, willows, and rushes.

Measure: Upland watershed is not contributing to riparian wetland degradation
Assessing changes in water and/or sediment supply from uplands can help determine functionality of the riparian wetland area affected. Changes in upland conditions can affect the discharge, timing, and duration of streamflow events in lower areas, possibly degrading a riparian wetland's condition.

Indicator
Vegetation (6 measures)

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

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

Measure: There is diverse composition of riparian wetland vegetation

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

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

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

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

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

Measure: Riparian wetland plants exhibit high vigor

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

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

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

Indicator

Erosion/Deposition (5 measures)

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

Measure: Floodplain and channel characteristics are adequate to dissipate energy

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

Measure: Point bars are revegetating

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

Measure: Lateral stream movement is associated with natural sinuosity

Streams naturally adjust their channel by moving side to side without degrading the overall wetland environment. The movement

Table 4.8.3-1. The reference conditions used to determine whether the condition of the riparian habitat was 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.

is affected by many factors such as the type of stream, the type of materials that form the streambanks, and the types and amounts of vegetation growing along the banks. For example, streambanks composed of sandy materials will more easily erode than materials such as clay or silt, which provide more cohesiveness. Excessive movement can negatively impact a river/riparian area by diminishing the system's ability to dissipate energy.

Measure: System is vertically stable

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

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

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

4.8.3. Reference Conditions

A riparian wetland area needs to be in dynamic equilibrium with its streamflow forces and channel processes to be considered in proper functioning condition. This requires the system to maintain itself and/or recover after large runoff events without significant changes to the stream channel characteristics or to the riparian wetland vegetative communities. 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 NRA's riparian wetland was assessed and is based on the condition definitions developed by Prichard et al. (1998) and are summarized in 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 NRA's assessment therefore was excluded.

4.8.4. Condition and Trend

Table 4.8.4.1 summarizes the results for the measures that were assessed for Rock and Guy Sandy Creeks' riparian habitat condition assessments.

Table 4.8.4-1. Results for the riparian habitat condition assessment along Rock Creek and Guy Sandy Creek at Chickasaw NRA (Martin et al. 2015).

Indicator/Measure	Rock Creek	Guy Sandy Creek
Hydrology		
Floodplain	We observed evidence of overbank flow from a recent 50 cfs flow event.	Yes, this measure was in proper functioning condition.
Sinuosity, width/depth ratio, and gradient	Large scale channel sinuosity was approximately 1.8 and field observations of width/depth ratio ranged from 15-30. Approximately 0.4% channel gradient was controlled by bedrock. These channel characteristics were as expected for a stable channel in this watershed.	Large-scale channel sinuosity was 1.5 and was approximately the same for the inner channel. The continuous single-thread channel and stable point bar/cutbank form throughout the reach indicated that the channel gradient was in balance with the landscape setting.
Riparian wetland area	Mid-channel, side-channel and point bars were all heavily-vegetated with riparian/wetland species. Riparian zone appeared to be at or near its potential width (not narrowing). Bedrock banks in many areas constrained lateral stream movement.	Channel was not incising or showing any indication of trending toward a braided channel form. Sinuous, single-thread channel with point bar/cutbank form indicated stable morphology and a riparian zone that was approaching or at its potential width (not narrowing).
Upland watershed	There was no evidence of excessive deposition.	Despite the abundance of coarse sand in the channel and on point bars throughout the reach, the watershed did not show any discrete source areas for excessive sediment. The single-thread channel form appeared stable and did not indicate an oversupply of sediment.
Vegetation		
Diverse age-class distribution of riparian-wetland vegetation	This measure was in proper functioning condition for both woody and herbaceous riparian-wetland vegetation.	This was fully functioning for woody species, but not for herbaceous species. Tree roots were providing bank stabilization in most areas. Almost the entire reach was devoid of rhizomatous herbaceous wetland-riparian vegetation, but this did not appear to be adversely affecting channel stability.
Diverse composition of riparian-wetland vegetation	Riparian-wetland vegetation is highly diverse throughout the riparian zone. A variety of woody species, including various oak species, were dominant or common in the riparian zone throughout the reach. Several herbaceous vegetation species were present along the banks and lower bar features over most of the reach and growing on other channel and low floodplain features along the reach.	A very diverse woody plant community, including various oaks, were common or dominant in the riparian zone throughout the reach. Rhizomatous herbaceous wetland-riparian vegetation was mostly absent, but was apparently not required for channel stability in this reach.
Species present indicated maintenance of riparian-wetland soil moisture characteristics	Yes, this measure was in proper functioning condition.	The overbank riparian tree community appeared to be healthy, diverse, and reproducing. However, point bars, side channel bars and lower banks were almost completely devoid of perennial riparian-wetland vegetation. We observed occasional black willows on these channel features, but there was almost no rhizomatous herbaceous wetland-riparian vegetation on the great majority of the reach. As we approached Highway 7, shallow bedrock appeared to allow pooling of water near the surface in a few channel locations.
Root masses were capable of withstanding high-streamflow events	Yes, this measure was in proper functioning condition.	The intermittent channel with deep, coarse sand substrate doesn't support rhizomatous herbaceous wetland-riparian vegetation on the majority of the reach. However, the vigorous woody riparian community on the overbank areas, and the channel form itself, appear to be sufficient to maintain bank and overall channel stability.
Vigorous plants	Yes, this measure was in proper functioning condition.	Woody riparian community exhibited high vigor.
Vegetative cover was present to protect banks and dissipate energy	Yes, this measure was in proper functioning condition.	Yes, this measure was in proper functioning condition.

Table 4.8.4-1. Results for the riparian habitat condition assessment along Rock Creek and Guy Sandy Creek at Chickasaw NRA (Martin et al. 2015) (cont.)

Indicator/Measure	Rock Creek	Guy Sandy Creek
Erosion/Deposition		
Floodplain and channel characteristics	Yes, this measure was in proper functioning condition.	There was minimal channel roughness – most energy dissipation occurred due to bed mobilization and sediment transport.
Point bars	Yes, this measure was in proper functioning condition.	It appeared that the coarseness of the point bar substrate (deep sand) and the resulting lack of water-holding capacity prevented establishment of most perennial riparian-wetland vegetation.
Lateral stream movement	Large-scale sinuosity was controlled by bedrock in much of the reach, but natural lateral channel migration did occur where point bar/cutbank morphology was possible.	Yes, this measure was in proper functioning condition.
Vertical stability	Bedrock channel provides vertical control throughout the assessment reach.	Yes, this measure was in proper functioning condition.
Balance of water and sediment	Yes, this measure was in proper functioning condition.	The reach was characterized by a continuous, stable, single-thread channel form with no signs of excessive erosion or sediment deposition.

Rock Creek and Guy Sandy Creek Hydrology

The USGS has operated a gage (#07329852) on Rock Creek inside the park since 1990, and as of 2014 it has a 24-year record of annual peak flows. Review of the available data indicated that a discharge of about 1000 cubic feet per second (cfs) has been exceeded almost every year since the gage has been in operation, and these peaks occured in any month during the year (Figure 4.8.4-1). Review of the daily flow record indicated a very cyclic, diurnal oscillation suggesting a distinct influence from evapotranspiration. Additionally, the daily record appeared to respond rather rapidly to precipitation input.

Unfortunately, there is no gage record for Guy Sandy Creek. Geomorphic evidence and reports from park staff indicated that this creek supports a substantial flow just about every year, however, the magnitude of these flows is not known. Throughout the length of the channel, we observed a continuous "inner channel" with well-formed point bars and cutbanks indicating regular periods of relatively low flow. Additionally, we identified numerous locations of flood debris well above the channel bottom indicating occurrences of more substantial flows that likely filled the channel between the two terraces.

The focus of the hydrology section of the PFC assessment was to determine if the observed channel and floodplain morphology was stable and in balance with the landscape setting, given prevailing hydrologic and sediment inputs. This was done by estimating the frequency of floodplain inundation, evaluating several channel morphology parameters (sinuosity, slope, and width-to-depth ratio) against expected values for the landscape setting, determining the width and trend (widening or narrowing) of the

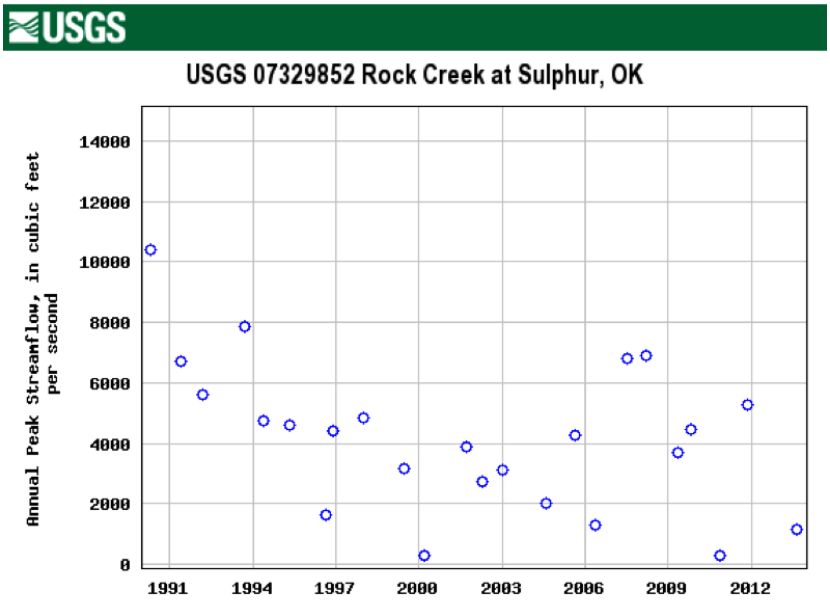


Figure 4.8.4-1. Annual peak flow record for the Rock Creek at Sulphur, OK, gage #07329852 (USGS 2015).

riparian-wetland area, and evaluating the influence of upland watershed conditions on hydrologic and sediment characteristics.

To support a healthy riparian system, high flows must exceed the channel capacity and spill onto the floodplain on a fairly frequent basis. At the time of our site visit, the stage of Rock Creek was below bankfull with a discharge of a few cubic feet per second. Throughout this reach, the adjacent floodplain and low terrace levels were very close in elevation to the channel. Review of the Rock Creek gage record indicated that a discharge of about 1000 cfs was exceeded just about every year. So, based on observations made during the site visit and our knowledge of the creek's flow regime from the gage record, we concluded that the lower terraces and other near-channel features were inundated on a relatively frequent basis and we rated this measure as properly functioning for Rock Creek.

There was no flow in Guy Sandy Creek during our site visit, nor were there any signs of very recent flow throughout the assessed reach. Looking at the greater channel morphology, there was a substantial difference in elevation (3-6 feet) between the active channel and the adjacent terrace level. However, the inner channel displayed well-developed point bar/cut bank morphology, and the tops of these channel features were very close to the elevation of the channel bottom. There was no quantitative record of discharge for Guy Sandy Creek, but based on the morphology of the inner channel and observed flood debris adjacent to the channel bottom on point bars, side channel bars and similar surfaces, it appeared that these features were inundated at least periodically. Consequently, we rated this measure as properly functioning for Guy Sandy Creek.

Several channel parameters, specifically sinuosity, gradient, and width-to-depth ratio are closely related to a stream's ability to dissipate hydraulic energy during flood flows. When these parameters are in balance with the landscape setting, the channel is able to handle larger runoff events with limited change in channel characteristics and associated riparian-wetland plant communities. Because of this limited change, beneficial riparian functions and values are maintained.

The large-scale sinuosity (channel length/ linear distance) of Rock Creek was about 1.8 and for Guy Sandy Creek it was a bit less, with a value of about 1.5. Both of these values represented moderate sinuosity and indicated the presence of a meander pattern that would result in good energy dissipation during bankfull and overbank flows. Furthermore, there was additional smaller scale sinuosity established by mid- and side-channel bars within the channels of both drainages, further adding to the potential to dissipate flood energy. The Rock Creek drainage also had numerous bedrock outcrops and bed steps that helped to dissipate flow energy, mostly through induced turbulence. The channel gradients (slopes) for both Rock Creek and Guy Sandy Creek were in the range of about 0.2 percent, well below the stable range of less than 2.0 percent for this channel type. Estimated width-to-depth ratios for Rock Creek were in the range of about 15-30. Guy Sandy Creek was a bit more difficult to estimate given no knowledge of prevailing flows, but based on observed channel morphology, width-to-depth ratios were likely in the range of about 10-20. Both of these ranges were close to or above the stability threshold of 12 for these channel types. So, based on all of the channel and valley parameters, we concluded that the channel morphology for both of these drainages was in balance with the landscape setting and properly functioning for both Rock Creek and Guy Sandy Creek.

A healthy riparian system for this landscape setting supports a broad distribution of flood waters during out of bank flows and continual channel migration that facilitates the establishment and maintenance of riparian vegetation. During the assessment of Rock Creek, we observed bedrock banks throughout much of the reach that served to constrain lateral stream movement. Many mid-channel, side-channel and point bars had formed and all were heavily-vegetated with riparian/wetland species. The riparian zone appeared to be at or near its potential width

with no indication of narrowing. For Guy Sandy Creek, the channel was not incising or showing any indication of trending toward a braided channel form. The sinuous, single-thread channel with point bar/cutbank form indicated a stable morphology and a riparian zone that was approaching or at its potential width (not narrowing). Consequently, we rated this measure for both Rock and Guy Sandy Creeks as properly functioning.

During the site visit we did not observe any evidence of excessive deposition in the channels or on the floodplains. In fact, the Rock Creek channel was very clear of fines throughout much of its length. While the Guy Sandy Creek channel was almost entirely sediment, we did not identify any areas of excessive deposition and the overall sediment input appeared to be in balance with the channel's capacity for sediment transport. As discussed above, the Guy Sandy Creek channel form was stable and in balance with the landscape setting. Furthermore, our examination of aerial photographs and a tour of the upper watershed did not show any land use activities that would be expected to generate excessive sediment inputs. Consequently, we concluded that the upland watershed was not contributing to riparian-wetland degradation for either drainage and was fully functioning for Rock and Guy Sandy Creeks.

Rock and Guy Sandy Creeks Vegetation

For Rock Creek, the tree species American sycamore (*Platanus occidentalis*), green ash (*Fraxinus pennsylvanica*), slippery elm (*Ulmus rubra*), American elm (*Ulmus americana*) and box elder (*Acer negundo*) and various oaks were common or dominant in the riparian zone throughout the assessment reach. These species were present in multiple age classes, including young (recruitment age) plants that should support long-term maintenance of a healthy riparian system. Herbaceous wetland species including rice cutgrass (*Leersia oryzoides*), scouring rush horsetail (*Equisetum hyemale*) and Emory's sedge (*Carex emoryi*) were dominant or co-dominant along the banks and lower bar features over most of the reach. They were vigorous and spreading, indicating their ability to help maintain the perennial wetland herbaceous community over time. Bushy knotweed (*Polygonum ramosissimum*), false indigo bush (*Amorpha fruticosa*), redtop (*Agrostis gigantea*), Johnsongrass (*Sorghum halepense*), Bermudagrass (*Cynodon dactylon*), Canada wildrye (*Elymus canadensis*) and *Eupatorium sp.* were scattered on banks and other channel and low floodplain features along the reach, but they were not considered to be dominant overall. Other unidentified species in the Cyperaceae (sedge) family were observed along Rock Creek, but they were also not dominant. Based on these observations we considered this measure to be fully functioning for Rock Creek.

For Guy Sandy Creek, American sycamore, green ash, slippery elm, American elm, box elder, black willow (*Salix nigra*) and various oaks were common or dominant in the riparian forest on the terrace/floodplain above the inner channel. These species were present in multiple age classes, including young (recruitment age) plants that should support long-term maintenance of a healthy riparian system. The point bars, side channel bars and banks of the inner channel were almost completely devoid of perennial riparian-wetland vegetation. We observed occasional black willows on these channel features, but there was almost no perennial herbaceous wetland-riparian vegetation. Wetland annuals including bushy knotweed and *Polygonum sp.* were present, but almost all other plants on these features were facultative or drier species. Near Highway 7, shallow bedrock appeared to allow pooling of water at the surface in a few channel locations. We observed the obligate wetland species Emory's sedge and the facultative wetland species scouring rush horsetail (*Equisetum hyemale*) at these locations, but this was not at all representative of the larger assessment reach.

Based on our observations along Guy Sandy Creek, the woody vegetation was in good condition but the herbaceous vegetation was not. Tree roots were providing adequate bank stabilization along the edges of the floodplain/terrace above the inner channel along Guy Sandy Creek, and the lack of perennial

herbaceous wetland-riparian vegetation did not appear to be adversely affecting overall channel stability.

For Rock Creek, woody and perennial herbaceous riparian-wetland vegetation was very diverse on the channel banks, side channel bars, and overbank areas and in proper functioning condition. For Guy Sandy Creek, the woody riparian-wetland vegetation on the terrace/floodplain above the inner channel was also very diverse, but the point bars, side channel bars and banks of the inner channel were almost completely devoid of perennial riparian-wetland vegetation.

For Rock Creek, the woody species listed above are all characteristic riparian species for this region and indicate maintenance of appropriate soil moisture characteristics. Perennial herbaceous wetland species including rice cutgrass, scouring rush horsetail, and Emory's sedge were dominant or co-dominant along the banks and lower bar features over most of the reach, and they exhibited vigorous growth. Bushy knotweed, false indigo bush and redtop, which were locally common, are all wetland species as well. Bermudagrass and Johnsongrass are weedy, non-native and largely upland species that can invade disturbed sites, but they were not dominant and did not appear to indicate any drying of riparian soils. Based on these observations we consider this measure to be in proper functioning condition for Rock Creek.

For Guy Sandy Creek, the woody species listed above are all characteristic riparian species for this region and indicate maintenance of appropriate soil moisture characteristics. However, as described previously, the point bars, side channel bars and banks of the inner channel had scattered black willow shrubs, but these features were almost completely devoid of perennial herbaceous riparian-wetland vegetation. Therefore, we consider this measure to be functional-at risk for Guy Sandy Creek.

For Rock Creek, all of the woody species described above are common riparian trees for this region and have root masses capable of withstanding high streamflow events. The dominant herbaceous species, rice cutgrass, scouring rush horsetail and Emory's sedge, are all strongly rhizomatous wetland plants with root systems that anchor the streambanks and provide roughness to help dissipate the energy of larger flood events, therefore in proper functioning condition.

For the Guy Sandy Creek assessment reach, the riparian forest on the terrace/floodplain above the inner channel was composed of trees with root masses capable of withstanding high streamflow events. The tree roots provided adequate bank stabilization along the edges of the floodplain/terrace above the inner channel, and the lack of woody and perennial herbaceous wetland-riparian vegetation in the inner channel didn't appear to be adversely affecting overall channel stability, therefore, considered to be in proper functioning condition.

The woody and perennial herbaceous riparian-wetland vegetation exhibited high vigor along the entire Rock Creek assessment reach. Trees were robust, did not appear stressed, and were reproducing on appropriate bank and floodplain surfaces. Herbaceous wetland vegetation on the lower banks and bar features appeared healthy and formed the dense root mats needed to anchor soils against erosion and was considered to be in proper functioning condition.

The riparian tree community on the floodplain/terrace above the inner channel of Guy Sandy Creek was diverse and vigorous, and young trees were present to replace older trees over the long term. Although the point bars, side channel bars and banks of the inner channel were almost completely devoid of perennial riparian-wetland vegetation, this didn't appear to be adversely affecting overall channel stability. We considered this measure to be in proper functioning condition based on the vigor of the floodplain/terrace forest and the bank protection provided by the roots of the riparian trees.

For Rock Creek, the riparian-wetland vegetation on the banks clearly had the species composition, vigor, root masses and

cover to anchor the soil and dissipate energy during higher flows. We saw no signs of bank erosion other than in locations where it is expected to occur naturally, so we considered this measure to be in proper functioning condition.

Along Guy Sandy Creek, tree roots associated with the extensive riparian forest on the floodplain/terrace above the inner channel provided substantial protection against bank erosion. There was almost no perennial herbaceous riparian-wetland vegetation on the inner channel banks or point/side channel bars, most likely due to the coarseness of the alluvium and the lack of a persistent high water table. However, the combination of tree roots protecting the upper banks and the energy dissipation provided by the channel morphology and substrate appeared to be sufficient to dissipate flood energy without dramatic changes in the overall channel/floodplain form. For these reasons we considered this measure to be in proper functioning condition for Guy Sandy Creek.

Rock Creek and Guy Sandy Creek Erosion/ Deposition

We observed numerous bedrock outcrops and bed steps in the Rock Creek channel. Additionally, the large-scale sinuosity and the smaller-scale sinuosity established by the mid-channel, side-channel and point bars added to the ability of the riparian system to dissipate energy. In Guy Sandy Creek, the small-scale sinuosity of the inner channel established by sequential point bars aided in energy dissipation during rising flows. As flow increases and fills the inner channel, mobilization and migration of these un-vegetated bed forms likely takes place to some degree, adding to energy dissipation. Lastly, the large-scale sinuosity present at the valley scale is a constant contributor to energy dissipation at all flow levels. Consequently, we concluded that the channel and floodplain characteristics present in both drainages were adequate to dissipate the energy of larger flows and in proper functioning condition for Rock and Guy Sandy Creeks.

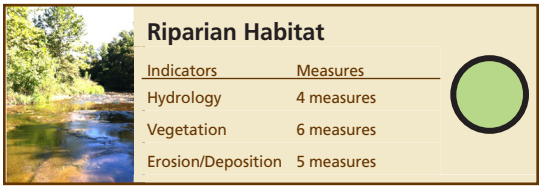
Woody and rhizomatous herbaceous riparian-wetland vegetation not only add stability to the channel banks and floodplain through anchoring, but also help to dissipate the energy of higher flows due to hydraulic roughness. While the Rock Creek channel is largely controlled by bedrock outcrops and bed steps, all of the alluvial mid-channel, side-channel and point bars that we observed were well vegetated with riparian-wetland species and were in proper functioning condition for Rock Creek. However, in Guy Sandy Creek the well-developed point bars in the inner channel were almost completely devoid of any wetland or riparian vegetation and, consequently, was rated as functional-at risk - nonfunctional.

In the Rock Creek drainage, large-scale sinuosity is controlled by bedrock at both the valley and channel scales, so lateral channel migration may only occur at a very slow rate. However, within the bedrock channel, some lateral migration occurred wherever sufficient alluvium was present to form mid- and side channel bars. In Guy Sandy Creek, evidence of natural lateral channel movement through the vegetated terraces was evident in the form of sequential, paired cutbank-point bar features coupled with a relatively constant channel width. Consequently, the measure was rated fully functioning for both Rock Creek and Guy Sandy Creek.

Vertical stability is a very important element in evaluating conditions of erosion and deposition in riparian systems. The Rock Creek and Guy Sandy Creek assessment reaches did not exhibit any attributes of vertically unstable riparian systems such as v-shaped channels, steep eroding banks, headcuts, or disconnection of the channel from the floodplain. As mentioned previously, Rock Creek has numerous bedrock outcrops along the banks and bedrock controlled steps and runs in the channel that provide strong vertical control (resistance to channel incision). Although Guy Sandy Creek is almost completely alluvial, we did observe shallow bedrock in the upper reaches in the National Recreation Area that establish vertical control there. In the lower portion of Guy Sandy Creek no bedrock control was visible but there were no signs of vertical instability and

consider this measure to be fully functional for both creeks.

The balance between the water and sediment being supplied by the watershed appeared to be in equilibrium for both creeks. In Rock Creek, we did not observe areas that appeared to be receiving large amounts of sediment from the watershed, nor did we observe any degree of degradation of the banks or adjoining uplands. In Guy Sandy Creek, the assessed reach was almost completely alluvial. The composition of this alluvial material, which is primarily arkosic sand and gravel, strongly suggested that it is mostly being supplied by the upper watershed, as the lithology does not match that of the creek banks. Despite this supply of sediment from the watershed, the inner channel has a continuous, stable, single-thread channel form with no signs of excessive erosion or sediment deposition. We found both drainages to be in balance with the water and sediment being supplied by the watershed and in proper functioning condition.



Overall Condition and Trend

Rock Creek is a perennial stream supplied by a variety of surface and ground water sources. It has a mostly bedrock channel bed, but it supports relatively diverse, soil-stabilizing woody and herbaceous riparian-wetland plant communities on the channel banks, point/side channel bars and floodplain surfaces. We considered all of the measures for this riparian system to be in Proper Functioning Condition. This rating suggests that adequate vegetation and/or landforms exist to dissipate streamflow energy during moderately large flood events, thereby reducing erosion, maintaining channel/floodplain forms, improving water quality, maintaining aquatic and riparian habitats, and supporting biodiversity.

Although we saw no imminent risks to the stability and function of the Rock Creek riparian system at this time, substantial reductions in groundwater inflows in the future could have a detrimental effect on the functionality of the riparian ecosystem. We also observed substantial amounts of algae in the channel, which may be associated with nutrient inputs from the watershed.

Despite the close proximity of the Guy Sandy Creek and Rock Creek watersheds, these drainages have markedly different geologic and hydrologic regimes. Unlike Rock Creek, Guy Sandy Creek is a primarily alluvial, ephemeral channel that only flows in response to large precipitation events. Other than a couple of pools in a very short stream segment near Highway 7 that had bedrock near the surface, the channel was completely dry during our site visit. There was no evidence of a persistent, shallow water table anywhere in the alluvial inner channel, and it appeared that the coarseness of the substrate and lack of water-holding capacity prevented establishment of most perennial riparian-wetland vegetation. We suspect that the healthy riparian forest on the floodplain/terrace deposits above the inner channel stems from the greater water-holding capacity of the much finer-grained soils there.

For these reasons, several of the measures for Guy Sandy Creek were in proper functioning condition for the riparian forest but not for perennial herbaceous riparian-wetland vegetation, which resulted in some mixed condition responses Additionally, the point bars of the inner channel were largely devoid of vegetation. Despite these mixed condition responses, the PFC Method required us to judge the condition of a riparian area against its "potential," which is defined as "the highest ecological status a riparian-wetland area can attain given no political, social or economic constraints" (Prichard et al. 1998). This is often referred to as the "potential natural community" of a riparian ecosystem. We concluded that the ephemeral nature of flow from the contributing watershed, the minimal (if any) connection to the Arbuckle-Simpson aquifer and the very poor water-holding capacity of the coarse alluvium in the inner channel limit the potential for establishment or maintenance of most

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

Indicators	Measures	Rock Creek Condition	Guy Sandy Creek Condition	Rationale
Hydrology	4 measures	Good	Good	All hydrology measures for both creeks were in good condition.
Vegetation	6 measures	Good	Good - Moderate	All of the vegetation measures were in good condition for Rock Creek. Three of the measures for Guy Sandy Creek were in good condition and the remaining three were in moderate condition, warranting a good-moderate condition rating.
Erosion/Deposition	5 measures	Good	Good	Overall, these measures were in good condition for both creeks, however, the point bars of Guy Sandy Creek's inner channel were largely devoid of vegetation, although this was not sufficient to warrant a degraded condition rating.

riparian-wetland vegetation there. However, despite these limitations, the combination of tree roots protecting the upper banks and the energy dissipation provided by the channel morphology and substrate appeared to be sufficient to dissipate flood energy without fundamental changes in the overall channel/floodplain form. For these reasons we concluded that the Guy Sandy Creek riparian area within the National Recreation Area was also in "Proper Functioning Condition." For a summary of the overall condition assessment ratings for each reach, refer to Table 4.8.4-2.

Level of Confidence/Key Uncertainties

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

4.8.5. Sources of Expertise

The National Park Service's Water Resources Division scientists, Michael Martin and Joel Wagner, and SOPN I&M Biologist, Tomye Folts-Zettner provided the expertise for this assessment.

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

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

Tomye Folt-Zettner is a biologist/botanist with the SOPN I&M and has her Masters in Natural Resource Management. She specializes in native and exotic vegetation and their ecosystems.

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4.9. Grasslands

Indicators/Measures

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

Condition – Trend - Confidence



Good – Improving - High

4.9.1. Background and Importance

Chickasaw National Recreation Area (NRA) lies in a zone where the eastern deciduous forest and western prairies converge. While not overly common on the landscape, true grasslands are an important component of the park's flora, which represent both environments, as well as a unique transition environment. Grasslands are primarily tall and mixed grass types, but areas where shallow soils predominate are occupied by a variety of shortgrass types (Hoagland and Johnson 2000).

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). Chickasaw NRA is located with the region generally classified as tallgrass prairie, a more productive system due to deeper, fertile soils and wetter climate. The species that characterize the archetypal tallgrass prairie are big bluestem (*Andropogon gerardii*), little bluestem (*Schizachyrium scoparium*), Indian grass (*Sorghastrum nutans*) and switchgrass (*Panicum virgatum*) (Salas et al 2010). Mixed grass and shortgrass steppe species may appear at more xeric sites and/or sites with shallower soils.

Grasslands at Chickasaw NRA

Chickasaw lies in a transition zone where the Eastern deciduous forest and the Western prairies meet at the juncture of the southern Osage Plains and the Arbuckle Mountains in south-central Oklahoma (Salas et al 2010). The resulting flora reflects the ecotonal nature of the intersection of these physiographic provinces in the unusual composition of grassland, woodland, and forest species. Although much of Chickasaw National Recreation Area is in the Arbuckle Mountains physiographic province, the northwestern portion of Chickasaw NRA is a transitional area to the low rolling hills of the redbed



Figure 4.9.1-1. An example of grasslands at Chickasaw NRA.

plains (Hoagland and Johnson 1999 as cited in Folts-Zettner et al 2011). The topography of the park is moderately rolling with several steep bluffs in the northern portion and level terrain on the upland areas in the southern portion. Grasslands (primarily *Schizachyrium scoparium–Sorghastrum nutans*) and oak forests cover a large portion of the upland areas, while riparian vegetation dominates the lowlands (Folts-Zettner et al 2011).

According to the 1997 Chickasaw NRA Fire Management Plan (FMP), there are no federally threatened or endangered plant species known to exist in the recreation area. The FMP also notes that grazing was allowed throughout much of the park until 1986, but continues today only within a fenced pasture containing reintroduced bison. Vegetation management using prescribed fire began in 1998 in an effort to restore habitat health (Chickasaw National Recreation Area 1997 and 1999 as cited in Folts-Zettner et al 2011) and was the only vegetation monitoring that took place prior to the Southern Plains Inventory and Monitoring Network (SOPN) and Fire Group's (SPFG) monitoring, which began in 2010.

Many of Chickasaw National Recreation Area's natural ecosystems have been altered by the activities of people and the introduction of nonnative species (NPS 2008). In fact, there is documentation that grasslands at Chickasaw NRA might once have been less common. While grasslands were historically documented (in 1871) in areas like the Upper Guy Sandy, Hoagland (2000) compared maps of land use in the late 19th century and found a substantial portion of today's grasslands in the Arbuckle District to be historical woodlands and forests cleared for agriculture. A mosaic of woodlands and grasslands characterized the transition area between the once prairie and the forested low mountains of eastern Oklahoma. Transitional "cross-timbers" (little bluestem grassland with scattered blackjack oak and post oak trees) is the native vegetation, and presently rangeland and pastureland comprise the predominant land cover (Salas et al 2010).

Post oak woodlands and savannahs were more prevalent prior to 1897, which is also when the occurrence of red cedars was first documented (Hoagland 2000). Since then, the condition of natural vegetation communities has been altered in Chickasaw National Recreation Area due to the spread of red cedar, the expansion of other woody plants, and the spread of nonnative plant species. Fires have also been suppressed, which has led to the decline of prairies in the recreation area. In recent years efforts have begun to restore Chickasaw National Recreation Area's prairie ecosystems with the application of prescribed burns and the clearing of red cedar (NPS 2008).

While Chickasaw NRA is situated within the broad categories of tall and mixed grass prairie, there is also considerable variation in grasslands throughout the NRA. In 2005, the SOPN initiated a vegetation mapping project at Chickasaw NRA by asking the U.S. Bureau of Reclamation's (BOR) Remote Sensing and Geographic Information Group (RSGIG) to undertake the mapping 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 270 national park units across the United States. This program uses a hierarchical classification scheme, the National Vegetation Classification Standard (http://science.nature.nps.gov/im/inventory/veg/index.cfm), as a basis for classifying vegetation.

RSGIG mapped a total of 16,235 acres (6,570 ha) comprising Chickasaw NRA and its environs. The area mapped within the Park boundary was 10,064 acres (4,073 ha). Nineteen map units were used to describe the landscape. Five of these units were un-vegetated or special use. Two map classes had a prominent grassland component (Salas et al 2010). The most frequently occurring map unit within the entire mapping area was Map Unit 2 Upland Post Oak communities with 289 polygons ranging in size from 0.1 acres (0.05 ha) to 554 acres (224 ha). The most abundant map unit in terms of area was also Map Unit 2, Upland Post Oak communities, covering

4,409 acres or about 45% of the project area (Salas et al 2010) (Figure 4.9.1-2)(Table 4.9.1-1). All map units were developed from a combination of an initial NVC vegetation classification provided by NatureServe with input from Park and Network biologists, Botanical Research Institute of Texas and BOR ecologists, fieldwork, and preliminary photo-interpretation (Salas et al 2010).

A few map units have a one to one relationship with the vegetation associations, but most have several associations as part of each map unit. This is largely due to the fact that many associations are defined by the understory vegetation which is often not visible from overhead (Salas et al 2010).

Hoagland & Johnson (2001) describe the park as being located in the Subtropical Humid climate zone (as cited in Folts-Zettner et al 2011), resulting in a warm continental climate. Summers are hot and humid, with an average maximum temperature June–August of (91°F [33°C]) and prevailing winds from the southwest. Winters are mild with an average minimum temperature December–February of (28°F [-2°C]). Snowfall is light and lasts only a few days, resulting in a relatively dry season. Average annual precipitation is 38 inches (97 cm), with 70% falling during the warm months predominately from thunderstorms (Folts-Zettner et al 2011).

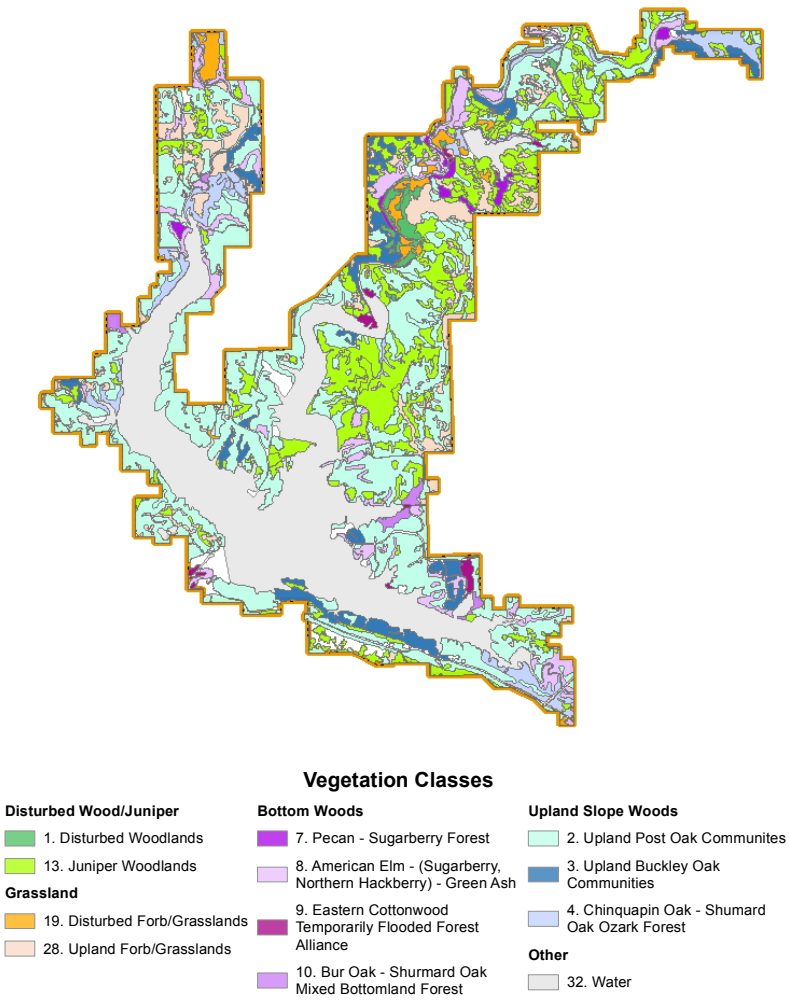


Figure 4.9.1-2. Vegetation map of Chickasaw NRA (from Salas et al 2010).

Historical Context - Bison

According to Chickasaw NRA's General Management Plan, draft Bison Management Plan, and Cultural Landscape Report, "Chickasaw National Recreation Area maintains a small herd of bison. The bison have been an important part of the cultural

Table 4.9.1-1. Properties of Vegetative Map Units

Map Unit	Classified Community Names (Vegetation Class)	Primary Class	Acres	Hectares
1	Disturbed Woodlands	Woodland	96.3	39
2	Upland Post Oak Communites	Woodland/Forest	4409.1	1784.3
3	Upland Buckley Oak Communities	Forest	550.7	222.9
4	Chinquapin Oak - Shumard Oak Ozark Forest	Forest	432.1	174.9
7	Pecan - Sugarberry Forest	Forest	68.6	27.7
8	American Elm - (Sugarberry, Northern Hackberry) - Green Ash Forest	Forest	687.2	278.1
9	Eastern Cottonwood Temporarily Flooded Forest Alliance	Forest	56.1	22.7
10	Bur Oak - Shumard Oak Mixed Bottomland Forest	Forest	62	25.1
13	Juniper Woodlands	Woodland/Forest	1835.5	742.8
19	Disturbed Forb/Grasslands	Grassland	340.8	137.9
28	Upland Forb/Grasslands	Grassland	1228.9	497.3

landscape and cultural experience since 1920, when three animals were brought to Platt National Park from the Wichita Mountains National Wildlife Refuge near Lawton, Oklahoma. The small herd, consisting of 6-10 bison, is managed as an interpretive exhibit that displays a snapshot of the past.

The bison herd has been in the Buffalo Pasture in the Platt National Park National Historic Landmark (Platt Historic District) since 1934. A "Bison Viewpoint" highway pullout adjacent to the east boundary fence along State Highway 177 provides an easily–accessible area for public viewing. The 1.9-mile Buffalo Pasture Trail along the pasture's perimeter is popular among visitors and is one of the park's most-used exercise trails. The trail is featured in the Platt Trail Blazers program to promote physical exercise and healthy living.

The Buffalo Pasture covers 84.5 acres and is predominantly covered with red cedar and hardwood trees. The invasion of eastern red cedar (Juniperus virginiana) into the formerly open grassland of the Buffalo Pasture is a result of the Civilian Conservation Corps (CCC) reforestation efforts in the 1930s and fire suppression in the Platt Historic District.

Cedar growth has shaded out forage plants and reduced the ability of the land to support the bison. If no action is taken, most preferred native grasses will continue to be gradually replaced by species better adapted to increased shade, soil compaction, and cooler temperatures. In general, the condition of the pasture will decline and the remaining grasslands will convert to additional red-cedar woodland. Cedar encroachment, pasture degradation due to overgrazing, and ongoing drought have severely impaired the grazing capacity for the bison herd. As a result, park staff has resorted to supplemental feeding of hay during most of the year, which requires staff time and resources.

The General Management Plan (2008) recommends 'The bison pasture would be restored to prairie and the bison herd maintained at an appropriate size. A study would be completed to determine the possibility of introducing bison from the Platt District to the Upper Guy Sandy'."

The park is, in fact, exploring relocating the bison to the Little Bluestem Prairie section of Guy Sandy while the current pasture is restored, then setting up a rotational grazing system in the future (Folts-Zettner, personal communication).

Conditions During Assessment

It is important to recognize that drought conditions occurred during two of the five year assessment period. During the summer of 2010 Chickasaw NRA was experiencing conditions that were considered in the mid-range of variability; whereas during 2011, they experienced extreme drought, followed by a year of severe drought before returning to moderate to mid-range conditions in 2013 and 2014 (Figure 4.9.1-3). We have tried to take these conditions into account in our interpretations, but the reader should be aware that such conditions may have a significant impact on our assessment.

4.9.2. Data and Methods

We considered three categories of measures/indicators for the assessment of grassland condition at Chickasaw NRA using a modified approach based on methods presented by Pellant et al. (2005). The three categories are: soil/site stability, hydrologic functioning, and biological integrity and 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-off, 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

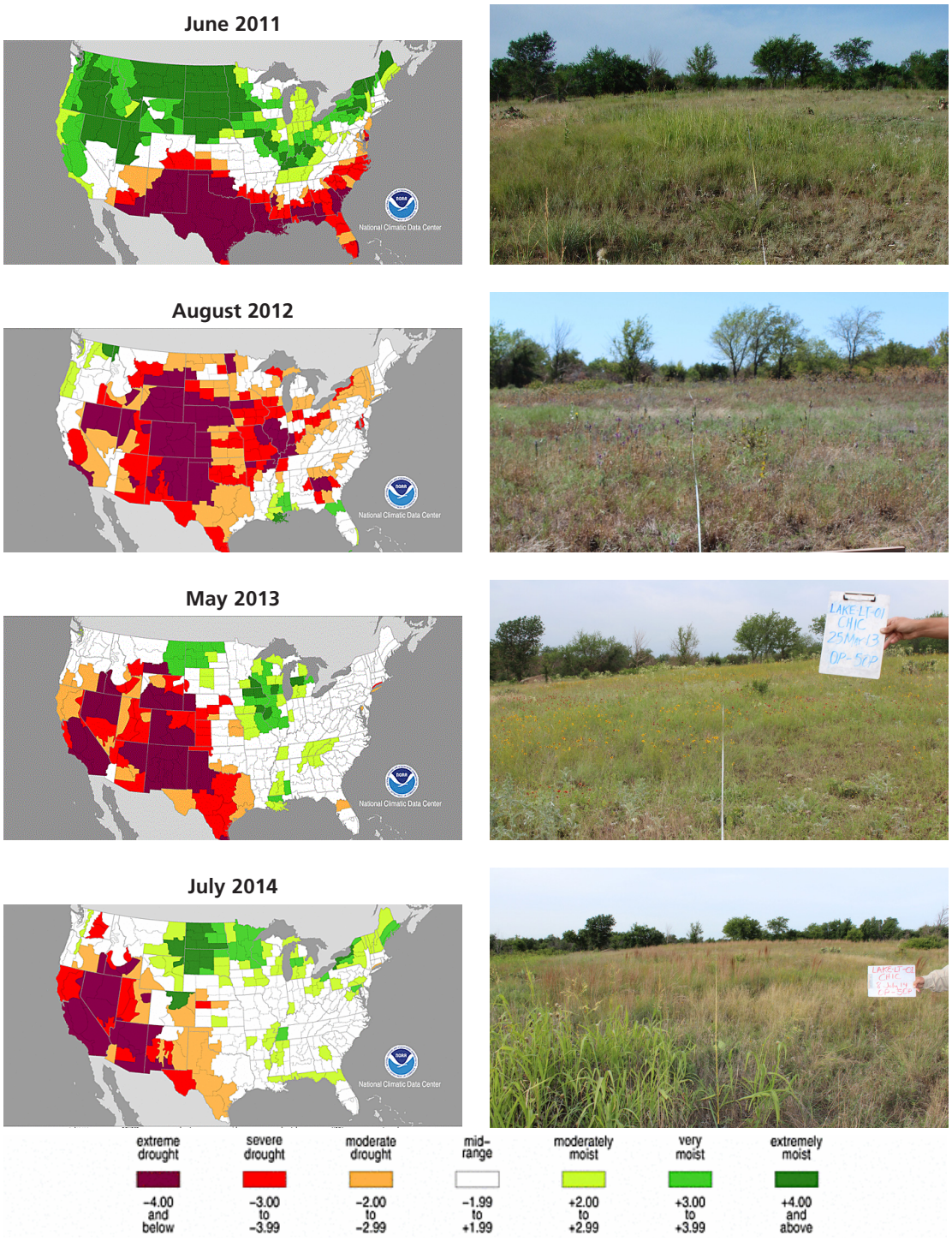


Figure 4.9.1-3. The Palmer Modified Drought Index for each of the four years for which data from Chickasaw NRA were available. Also shown to the right of each map are photos taken from a monitoring transect (LAKE-LT01) for the corresponding time period.

capacity when losses do occur. The biotic community includes plants, animals, and microorganisms occurring both above and below ground.

In combination, the measures from each of these categories provide the basis for this assessment. Note that we only looked at extant vegetation as the primary indicator for biotic integrity. We have summarized the measures for each of these groups below.

Please note that we relied primarily on SOPN fire and vegetation monitoring datasets to assess biotic integrity while the soil/ site stability/hydrologic function measures were assessed primarily through a site visit and rapid assessment in early July 2014 conducted by Dr. Fred Smeins of Texas A&M University

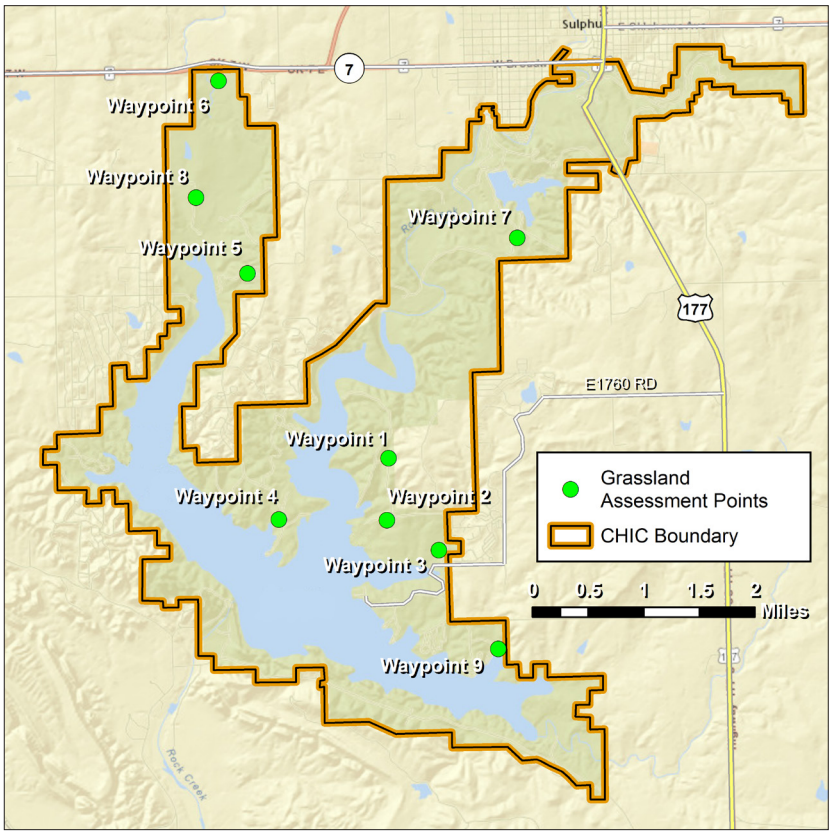


Figure 4.9.2-1. Location of grassland rapid assessment plots.

and Tomye Folts-Zettner, (Folts-Zettner, unpublished) who is the biologist with the Southern Plains I&M Network, and who had trained in the assessment methods with soil scientist, Pete Biggam, recently retired from the NPS' Geoscience and Restoration Branch. The rapid soil assessments consisted of evaluating nine selected sites at Chickasaw NRA (Figure 4.9.2-1).

The methodology for these assessments used an approach based on those described in the qualitative assessment protocol "Interpreting Indicators of Rangeland Health (Pellant et al 2005), in which Soil/Site Stability qualitative measures (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.

Assessment methods were modified from those outlined by Pellant et al (2005) as reference sheets that describe a standard for comparison were not available for the ecological site description types used in the assessment at Chickasaw NRA. Use of these reference sheets is required to conduct assessments of soil/ site stability/hydrologic function per the Pellant et al protocol. Therefore, our assessment is based upon best professional judgment that took the same site characteristics into account as would be using a reference sheet, but the reader should interpret these results with some caution.

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

These measures were used in conjunction with soil survey information and ecological site descriptions for the nine selected evaluation areas, each of which were approximately 3/4 to 1 acre in size. It is important to note that only the Soil/Site Stability qualitative measures were observed and documented on site, and these were what were used to perform the rapid soil assessments. The rapid soil assessment was used to determine the departure from the expected soil/site stability attributes.

The assessment for the biotic integrity of grasslands was made via a combination of a field assessment by grassland experts Fred Smeins (Texas A&M University) and SOPN Biologist Tomye Folts-Zettner, and using data collected as part of the Southern Plains Network's ongoing grassland monitoring. Criteria used for evaluating biotic integrity followed those established by SOPN staff with input from academic rangeland specialists and ecologists. Using the qualitative measures of rangeland health presented in (Pellent et al. 2005) as a starting point, this ad hoc scientific committee developed a suite of five measures of grassland biotic integrity that was deemed appropriate for this assessment. These measures are summarized in Table 4.9.2-1 and described in greater detail below.

Based on these measures, a rapid field assessment was conducted at multiple sites at Chickasaw NRA (Figure 4.9.2-1). Each site was qualitatively evaluated by the experts based on the measures developed. We then used data collected during the past five years

Table 4.9.2-1. Indicators and measures used to assess grasslands at Chickasaw NRA.

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

of monitoring to augment the opinions by our experts and to provide a more quantitative baseline for future assessment. These data were collected by the Southern Plains Inventory and Monitoring Network (SOPN) and the Southern Plains Fire Group, following Folts-Zettner et al (2011). Grassland monitoring data were collected in 2010-2014 along 23 transects (10 annually), each with five subplots, as part of this monitoring effort (Folts-Zettner et al 2012, 2013, 2014a, 2014b) (Figure 4.9.2-2). At each subplot, the percent cover was estimated for each species within a 1x2m quadrat.

Landscape-scale Diversity

The plant communities and alliances are generally expected to reflect local conditions of soils, moisture, disturbance, etc. As such, we would expect the diversity across

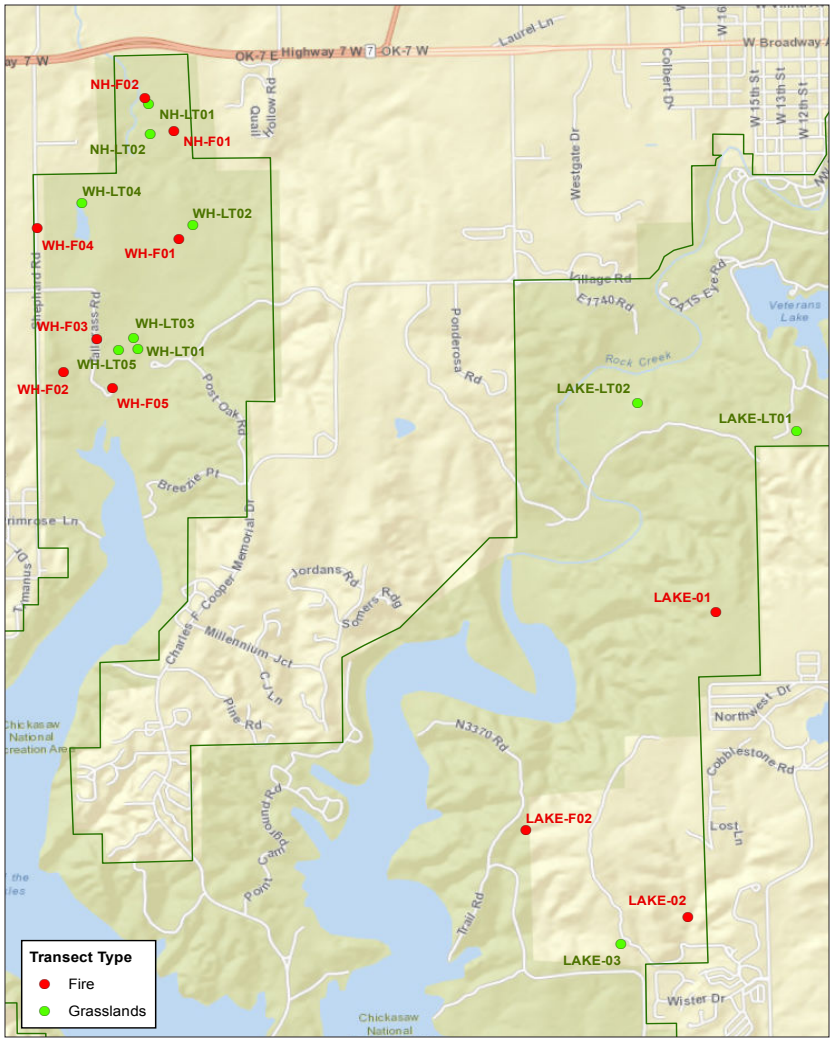


Figure 4.9.2-2. Location of long term grasslands monitoring and fire monitoring plots.

the Chickasaw NRA 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. To assess this, we compared the vegetation communities observed during the Chickasaw NRA vegetation mapping (Salas et al 2010) with soil types (NRCS 2014) and ecological sites (NRCS 2008).

Local Species Composition

The intent behind this measure is to see if the species composition is generally consistent with what might be expected for the site, given the local conditions (soils, disturbance, moisture, etc). We considered this from two perspectives. First, we examined the degree to which the local communities consisted of native vs exotic species. Details about which exotic species are present and their effect on the site are presented in greater detail in Chapter 4.11. Here we just provide an initial indication of the extent of invasion by exotic species by looking at the proportion of native and exotic species. Second, we looked at the species composition of the native species relative to what might be expected for that site. This was based on a combination of NRCS Ecological Site Descriptions and expert opinion. As we have done for other measures, this assessment is based primarily on percentage cover, rather than the number of individual species because most species are quite rare and cover provides a more realistic assessment of species abundance (i.e. dominance or lack thereof) on the landscape.

General Life Cycles Relative to Disturbance

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

Relative Proportion of Functional Groups

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

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

4.9.3. Reference Conditions

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

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

Biotic Integrity
Determining definitive quantitative reference conditions for grassland communities at Chickasaw NRA is somewhat problematic given the dynamic nature of these resources. Part of our consideration in choosing the measures we have used for biotic integrity is that they are moderately robust to the potentially substantial seasonal and annual variation that plant communities often exhibit. We began with a conceptual framework for assigning condition based on what might be expected for the site conditions at Chickasaw NRA (Table 4.9.3-2). We recognize, however, that seasonal and annual variation in such things as rainfall and disturbance can results in dramatic shifts in specific measurement that are still within an acceptable range of natural variation. In particular, the drought that has occurred at Chickasaw NRA in recent years (2011 - 2013) may have influenced some measures of biotic integrity.

Our measure of landscape-scale diversity focuses on whether or not the diversity of plant communities reflects to a reasonable extent the diversity in site characteristics. As such, we used the spatial pattern of soil types (NRCS 2014) and ecological sites (NRCS 2008) as a general reference for the extent and pattern of landscape diversity that might be expected.

For the remaining measures, we used a combination of the Natural Resources Conservation Service's ecological site descriptions (NRCS 2008) 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 Chickasaw NRA. It is important to note however, the values in the ecological site descriptions are typically only provided for what are considered the historic climax plant communities (HCPCs), and variations in the dynamics of those communities are presented only through qualitative descriptions and/or generalized state and transition models. Consequently we do not strictly adhere to the HCPCs as a reference condition in the sense that departures from that reference necessarily represent a degraded quality; rather as a general guide to be used in conjunction with expert opinion to determine resource condition.

4.9.4. Condition and Trend

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

Soil/Site Stability / Hydrologic Function
The results from Folts-Zettner's rapid assessment indicated that the overall current condition of the soil/site stability/hydrologic at Chickasaw NRA was good, with seven of

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

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

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

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

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

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



Figure 4.9.4-1. A grassland plot visited during drought conditions.

the nine sites scoring "none to slight" and the remaining two sites, "slight to moderate", noting that rankings describe departure from the optimal state. Both of these categories earn a "good" condition score for the purposes of our assessment. Indicators of potential erosion did occur at a few sites, but not significantly enough to impact site condition or to warrant downgrading the assessment score. Examples of these indicators are exposed soil (sites #1, 2, 7, and 9) and signs of rills and pedestalling (site #1). It should be noted that these characteristics were minor and showed signs of stabilizing and/ or improving. Therefore, the soil and hydrologic functions of the assessment sites were rated as good.

Biotic Integrity

Landscape-scale Diversity

The spatial patterns of plant community distribution generally coincide with that of the ecological sites and soils (Figure 4.9.4-2). Further, during the rapid assessment, our grassland experts seemed to think diversity among sites was adequate to high. The exception was at Site #6, a disturbed Johnson grass hayfield, densely populated by exotics. According to the experts, the condition of this site and others like it, would likely be improved by controlled grazing by livestock or bison. Thus, landscape-scale diversity was considered to be in reasonably good condition with no evidence for any degrading trend.

Local Species Composition

Although moisture levels had been more typical the year prior to the field assessment in 2014, species composition at local sites might have been affected by recent drought conditions from immediately preceding years and we have tried to take that into account in our assessment. As previously indicated, we do not have an expectation for species composition to match the species list for historic climax plan communities of the appropriate ecological site descriptions (NRCS 2008), although we did take these descriptions into account along with expert opinion.

Local species diversity was consistent among sites with all but one site in good condition. At these sites, there was a good mix of forbs and grasses, with occasional tree and shrub species in the overstory, such as oak, ash, hackberry and juniper. The condition of Site #6, the Johnson grass hay field, warranted "significant concern" as it was dominated by exotic species (Appendix D).

Chickasaw NRA is engaged in an active prescribed fire and vegetation management program. Beginning in 2010, large woodland areas in the park were manually cleared of juniper undergrowth, followed by prescribed fire. Grasslands are frequently burned (+ 3 yrs) to prevent woody encroachment. Many of these areas are included in this assessment and are now in good condition due to these ongoing forms of restoration and maintenance. As a result of condition of local species diversity being good at all sites with one exception, we considered the overall condition of this measure to be good.

Exotic vs Native Species -- 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).

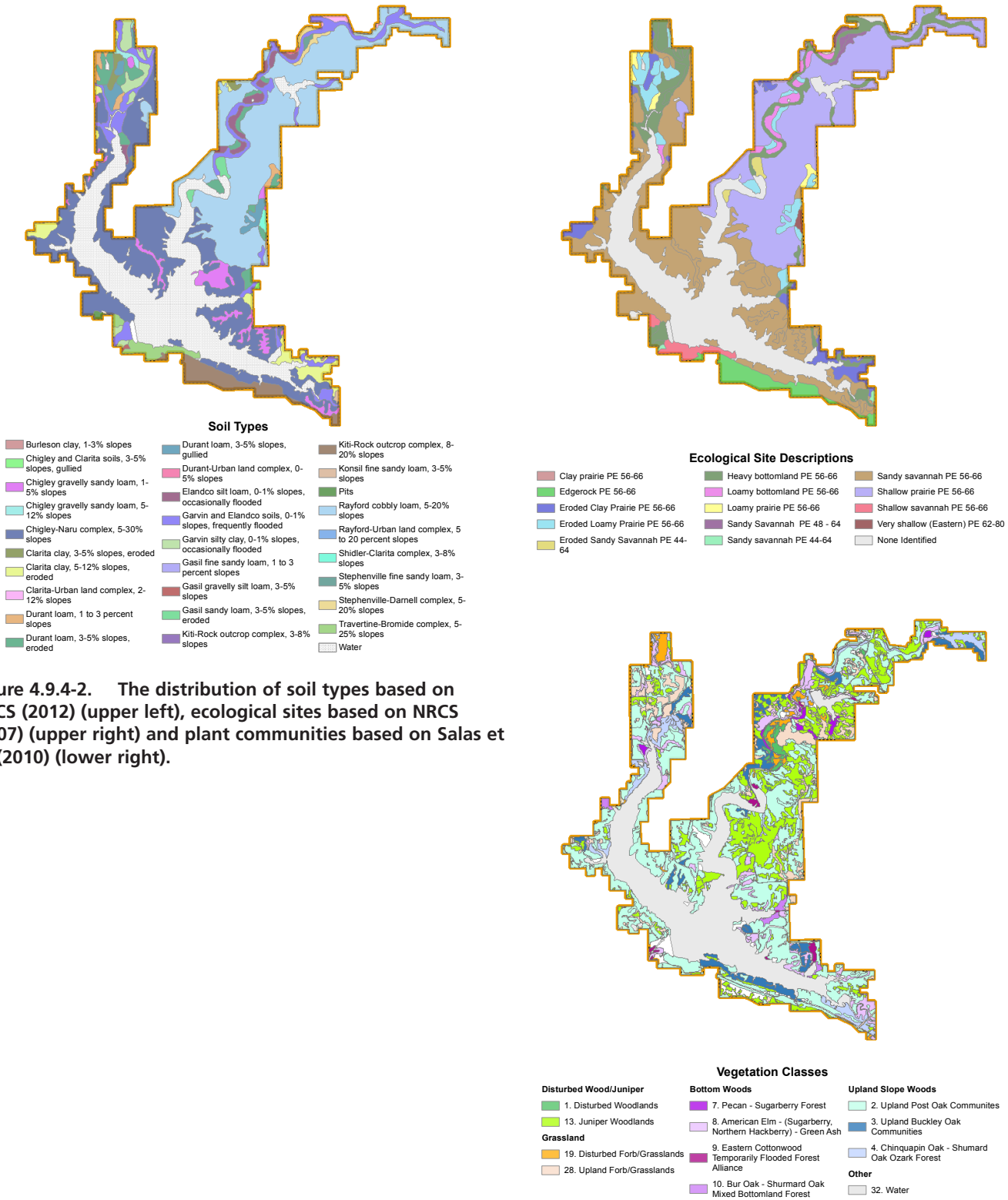


Figure 4.9.4-2. The distribution of soil types based on NRCS (2012) (upper left), ecological sites based on NRCS (2007) (upper right) and plant communities based on Salas et al. (2010) (lower right).

Table 4.9.4-2. The number and percentage of native and exotic species of each life form found on Chickasaw during the 2010-2014 grassland monitoring sampling.

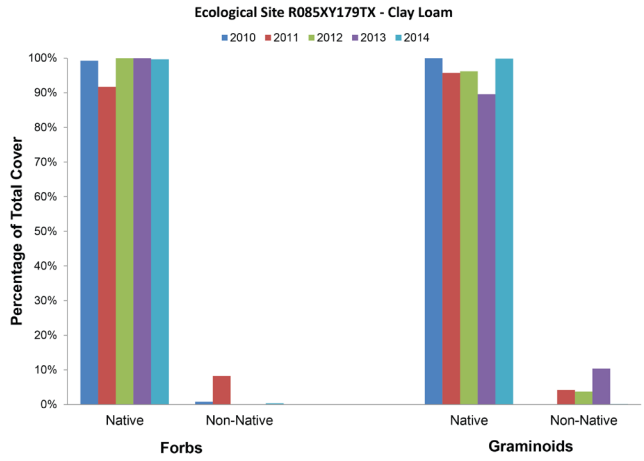
Life Form	Native	Exotic	Total	Percent Native
Forb	154	24	178	86.52%
Grass	56	10	67	83.58%
Shrub	3	0	3	100.00%
Subshrub	4	0	4	100.00%
Tree	24	1	25	96.00%
Vine	10	4	14	71.43%
Total	**251**	**39**	**291**	**86.25%**

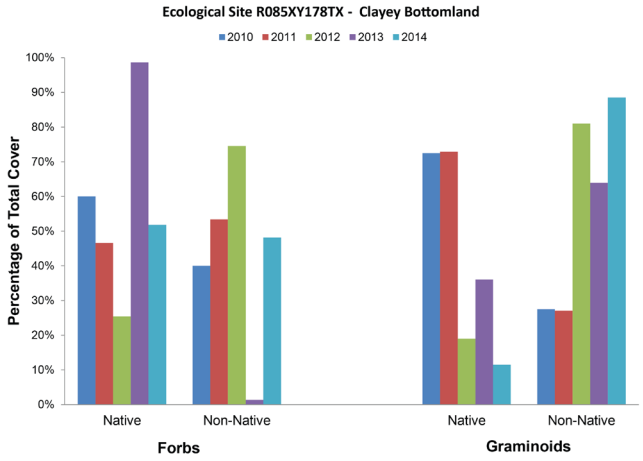
Table 4.9.4-3. The mean percentage of of native grasses and forbs on sample plots at Chickasaw NRA during the 2010-2014 grassland monitoring sampling.

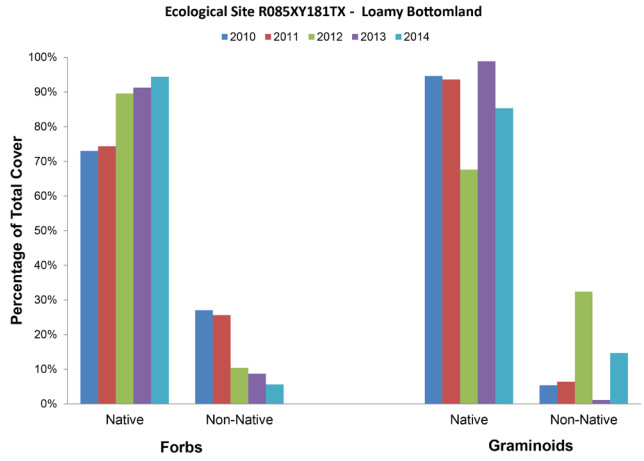
Ecolological Site No.	Ecological Site Name	Life Form	Mean % Native Cover
R085XY562TX	Sandy Loam*	Forb	92.9%
R085XY562TX	Sandy Loam*	Grass	100.0%
R085XY188TX	Stony Clay Loam	Forb	83.3%
R085XY188TX	Stony Clay Loam	Grass	88.1%
R085XY181TX	Loamy Bottomland	Forb	84.5%
R085XY181TX	Loamy Bottomland	Grass	88.0%
R085XY179TX	Clay Loam	Forb	98.1%
R085XY179TX	Clay Loam	Grass	96.3%
R085XY178TX	Clayey Bottomland	Forb	56.5%
R085XY178TX	Clayey Bottomland	Grass	42.4%
Total Mean % Cover Natives:		**Forb**	**83.1%**
*Sandy Loam Data 2014 only		**Grass**	**82.9%**

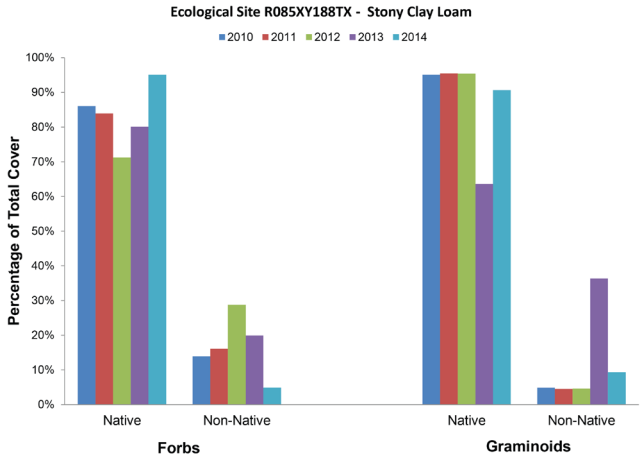
Based on five years (2010-2014) of grassland sampling, 251 of 291 (86%) of the total species we observed were native (Table 4.9.4-2). Of these, the proportion of native species was generally higher for forbs (87%) than grasses (84%). However, the number of species does not take into account how prevalent those species are on the landscape. Based on the percentage of cover, the abundance of native grasses and forbs on our sample plots were almost identical (Table 4.9.4-3). Exotic grasses and forbs were more prevalent at sites falling within the Clayey Bottomland ecological site (Table 4.9.4-3, Figure 4.9.4-3).

These results are based on grassland monitoring plots, which are located throughout the Recreation Area. 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 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 selected subsections in various communities of Chickasaw NRA at 150 m intervals (see grid layout in Chapter 4.10); thus does represent the overall NRA, but does not take into account native species.









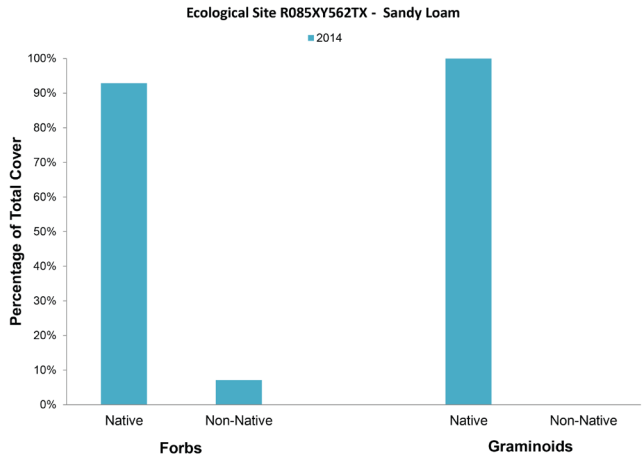


Figure 4.9.4-3. The percentage of native and exotic grasses and forbs for each ecological site sampled in 2010-2014.

General Life Cycles Relative to Disturbance

The proportion of annual, biennial and perennial species provides an indication of the stability of the site, and it is generally expected that the proportion of annual species at a given site would be higher immediately following a disturbance, but would shift toward an increased proportion of perennials as time passes since a disturbance. Data from our grassland monitoring samples indicated that grasses were most often perennial (Figure 4.9.4-4). Forbs were considerably more variable among sites and years (Table 4.9.4-4). Based on what is considered the historic climax plant communities (NRCS 2008), the proportion of perennial species was generally expected to be high for grasses and more variable for forbs.

As previously discussed, we did not have any expectation for the proportion of annuals, biennials, and perennials, to coincide exactly with historic climax plant communities, in

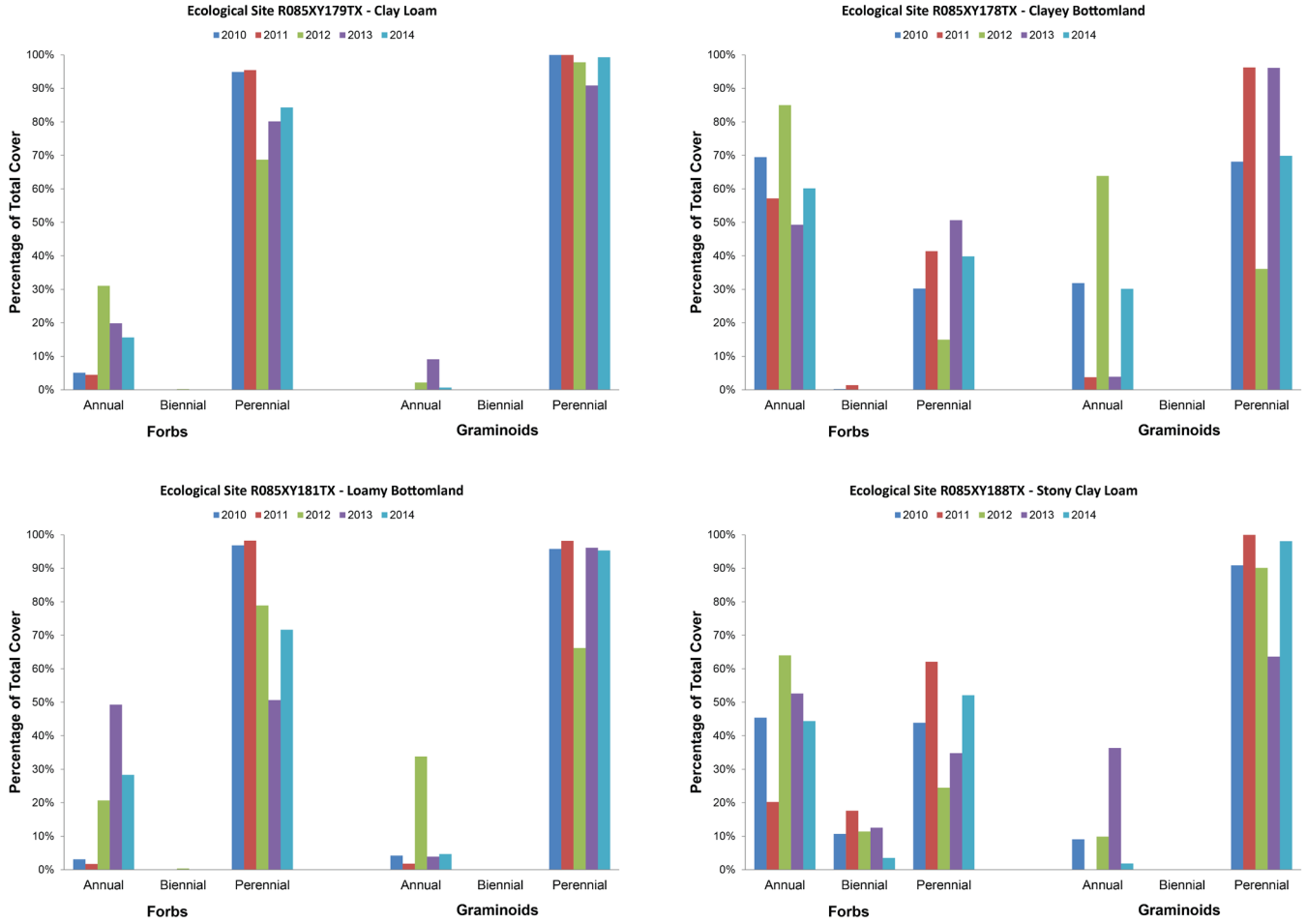


Figure 4.9.4-4. The percentage of annual, biennial, and perennial grasses and forbs for each ecological site sampled in 2010-2014

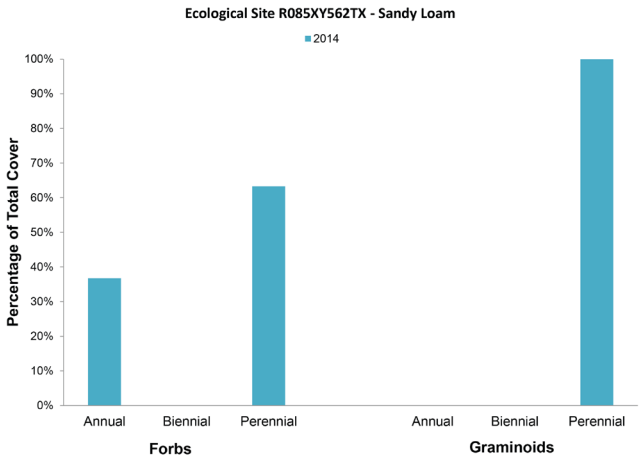
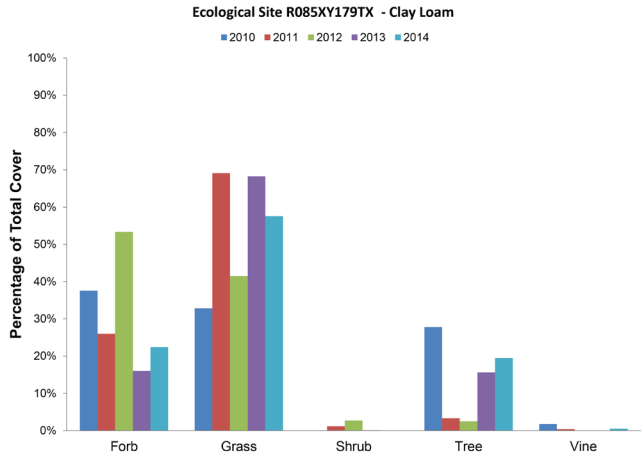
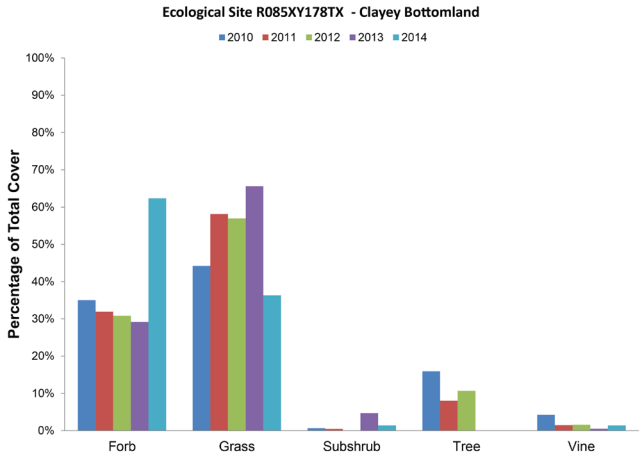


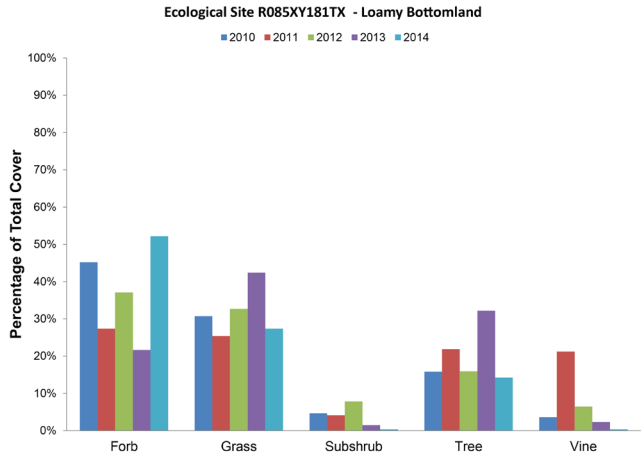
Table 4.9.4-4. The percentage of perennial grasses and forbs for each community type, 2010-2014

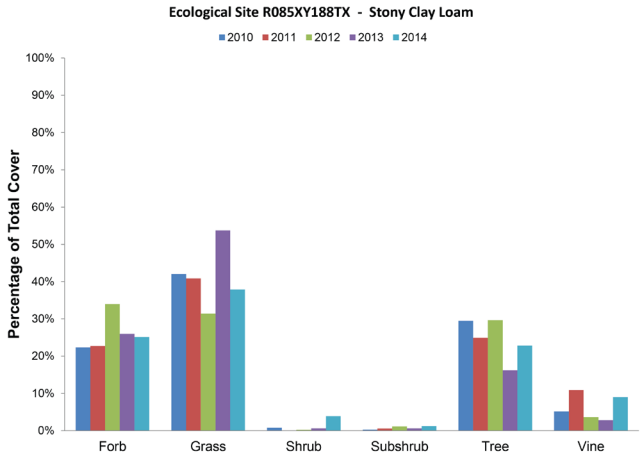
Ecolological Site No.	Ecological Site Name	Life Form	% Perennial 2010-2014
R085XY562TX	Sandy Loam*	Forb	63.3%
R085XY562TX	Sandy Loam*	Grass	100.0%
R085XY188TX	Stony Clay Loam	Forb	44.4%
R085XY188TX	Stony Clay Loam	Grass	88.3%
R085XY181TX	Loamy Bottomland	Forb	92.0%
R085XY181TX	Loamy Bottomland	Grass	89.6%
R085XY179TX	Clay Loam	Forb	82.0%
R085XY179TX	Clay Loam	Grass	97.1%
R085XY178TX	Clayey Bottomland	Forb	35.6%
R085XY178TX	Clayey Bottomland	Grass	76.1%
Total Mean % Cover Natives: *Sandy Loam Data 2014 only		**Forb** **Grass**	**63.5%** **90.2%**

part because of local site variability and not all sites are at a climax stage. At Chickasaw NRA, sites that exhibited relatively low proportion of perennials were sites that have experienced more recent disturbance either from clearing, burning, or both, and perhaps a more pronounced response to recent drought. Thus, it not surprising that we observe a higher proportion of annual species on these









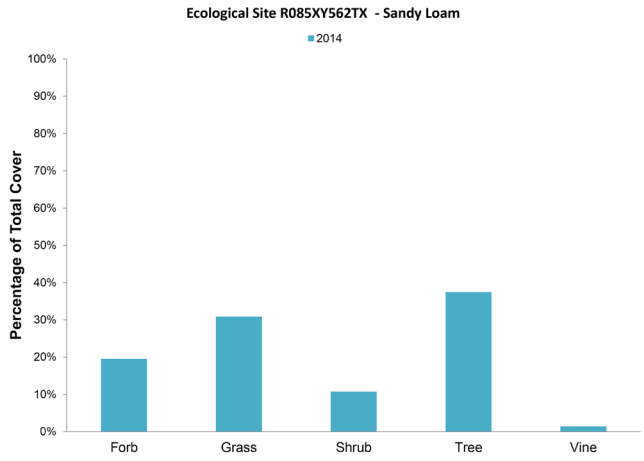


Figure 4.9.4-5. The percentage of lifeforms for each ecological site sampled in 2010-2014

sites. The time frames over which we might expect a shift toward increasing perennial species probably depends on the intensity and duration of the disturbance.

Given the ongoing, active vegetation management at the recreation area, the grassland experts did not express concern about the balance of perennials and annuals at most of the assessment sites. The exception to this was at Site #6, the Johnson grass field, where most of the annuals present were exotic. More typically, at other sites, they were native. Based on this assessment, we considered Chickasaw NRA to be in good condition overall with respect to this measure.

Relative Proportion of Functional Groups -

Similarly to our other measures, the proportion of functional groups and relative concern regarding this measure was highly variable among both rapid assessment sites and ecological sites (Table 4.9.4-5) and showed some annual variability among years (Figure 4.9.4-5). Some rapid assessment sites (e.g., all of the sandy loam sites – 2, 4, 5) were

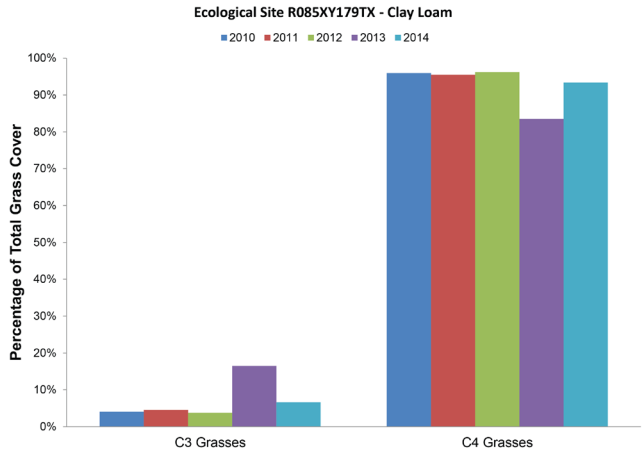
Table 4.9.4-5. The percentage of lifeforms for each community type, 2010-2014

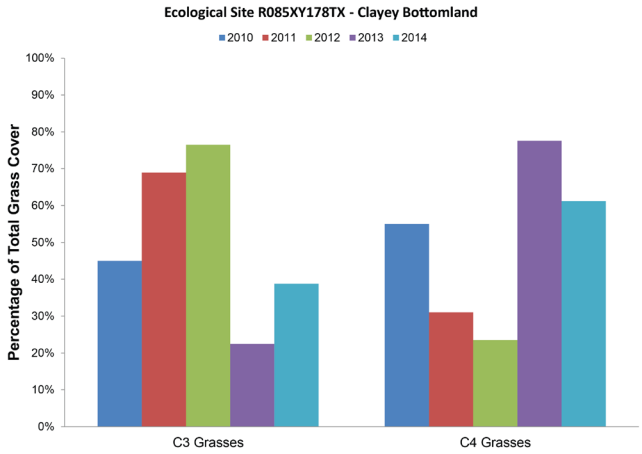
Eco Site Number	LifeForm	% Observed 2010-2014
R085XY179TX	Forb	30.01%
R085XY179TX	Grass	53.96%
R085XY179TX	Shrub	0.70%
R085XY179TX	Tree	14.81%
R085XY179TX	Vine	0.52%
R085XY178TX	Forb	34.55%
R085XY178TX	Grass	55.00%
R085XY178TX	Shrub	0.10%
R085XY178TX	Subshrub	0.12%
R085XY178TX	Tree	8.46%
R085XY178TX	Vine	1.77%
R085XY181TX	Forb	33.89%
R085XY181TX	Grass	30.98%
R085XY181TX	Shrub	4.55%
R085XY181TX	Tree	20.62%
R085XY181TX	Vine	9.96%
R085XY188TX	Forb	24.76%
R085XY188TX	Grass	41.84%
R085XY188TX	Shrub	0.72%
R085XY188TX	Subshrub	0.60%
R085XY188TX	Tree	25.51%
R085XY188TX	Vine	6.56%
R085XY562TX	Forb	19.52%
R085XY562TX	Grass	30.88%
R085XY562TX	Shrub	10.76%
R085XY562TX	Tree	37.45%
R085XY562TX	Vine	1.39%

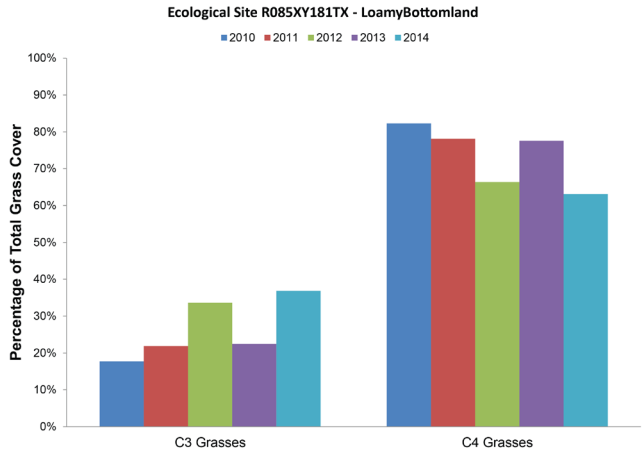
considered in good condition, whereas others were in "moderate condition" primarily due to the woody component being too high (#s 1, 3) or in one case, the site was dominated by cool season grasses (#9). The Johnson grass site (#6) was the only assessment site described as causing "significant concern" due to the lifeform composition not matching expectations of site potential.

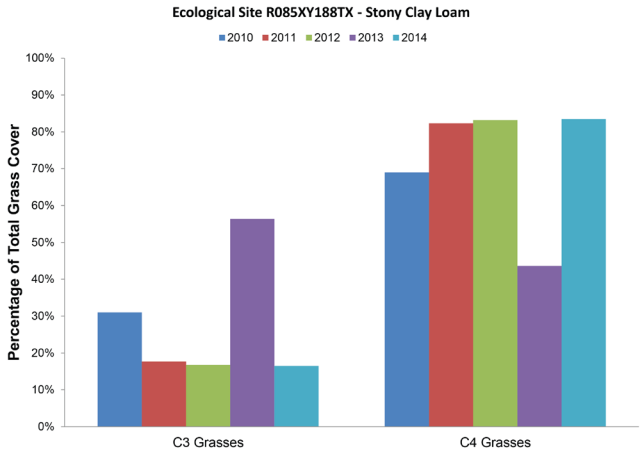
According to Dr. Smeins of Texas A&M, who was one of the grassland experts who conducted the field assessment at Chickasaw NRA in 2014, two invasive, woody species of great concern when managing grasslands in the Chickasaw NRA region are ashe juniper (Juniperus ashei) and Eastern Red Cedar (J. virginiana). Smeins in his trip report (Appendix D) notes that the Chickasaw NRA occurs within an admixture of elements of the Grand Prairie and the Northern Cross Timbers Major Land Resource Areas (MLRAs 85 and 84A, respectively) as defined by the USDA. The Grand Prairie is a tall/mid grass grassland with minimal woody vegetation over fine-textured Mollisol and Vertisol soils, while the Cross Timbers may vary from an open savannah with a tall/mid grass herbaceous layer matrix to a nearly closed canopy woodland of short-statured Post Oak and Blackjack Oak trees with a varied assortment of associated trees and shrubs (Hoagland and Johnson 2001 as cited in Smeins trip report). Much of the Prairie and Cross Timbers can succeed to woody plant dominance in the absence of fire and periodic droughts and these woody dominated communities might be considered the Climatic Climax Plant Community. Thus areas of high abundance of woody species are not considered to be the natural historic vegetation over much of the Prairie and Cross Timbers. Amounts of woody vegetation increases depending upon fire frequency and intensity, periodic droughts and grazing regime (Smeins 2004, DeSantos et al. 2010 as cited in Smeins trip report in Appendix D).Years of fire suppression and an altered grazing regimen, in addition to periods of drought, have created conditions ripe for woody encroachment, especially by these invasive junipers. Recommended treatment is mechanical removal of junipers, followed by a prescribed burn. Chickasaw NRA staff has been actively engaged with management of these species, and according to our grassland experts, results have been positive and progress is being made in restoring grassland communities…with much work and monitoring left to do. See Dr Smeins's full report in Appendix D for more details.

As previously mentioned, the National Recreation Area has been actively engaged in management options that might improve conditions (e.g., exotic plant control, prescribed burning, clearing of woody species), but in its current state, we consider this measure as being of moderate condition,









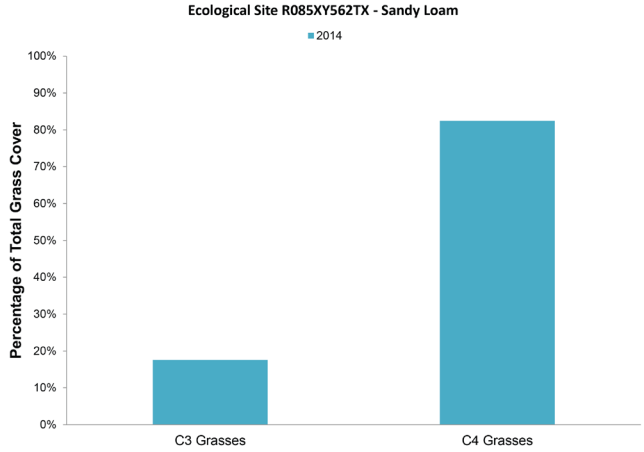


Figure 4.9.4-6. The percentage of C3 and C4 grasses ecological site sampled in 2010-2014

Table 4.9.4-6. The percentage cover of C3 and C4 grasses by community type at Chickasaw NRA during the 2010-2014 grassland monitoring sampling.

Eco Site Name	Eco Site Number	Percent C4 (vs C3)
Clay Loam	R085XY179TX	91.8%
Clayey Bottomland	R085XY178TX	49.0%
Loamy Bottomland	R085XY181TX	74.6%
Stony Clay Loam	R085XY188TX	70.0%
Sandy Loam	R085XY562TX	82.4%

reflecting the variation from good to significant concern.

Relative Proportion of C3 and C4 Species – Results from the SOPN monitoring data revealed C4 grasses to be far more prevalent than C3 grasses in four out of five ecological site types (Table 4.9.4-6). The ratio of C3 to C4 grasses varied considerably during years of SOPN monitoring (2010-2014), with the cover of C3 grasses spiking at the various ecological sites in different years (Figure 4.9.4-6). The rapid assessment sites were a bit more consistent with most (7 out of 9) sites having a good mix of C3 and C4 grasses. The exceptions were sites 6 and 9 where C3 grasses dominated.

Grasslands in this region are typically dominated by C4 grasses (Paruelo et al 1996, Epstein et al 1997). Sims et al (1978) found that C4 grasses comprise an average of 80% of above ground biomass in a grazed grassland site and 90% at ungrazed sites near Osage, OK (150 miles north of Chickasaw NRA); this is consistent with what Paruelo et al (1996) recorded at Osage where relative abundance of C4 grasses was 87%. At a Blackland Prairie, TX grassland site (108 miles southeast of Chickasaw NRA), Paruelo et al (1996) reported 71% relative abundance of C4 grasses. Given that distribution of grass type follows a gradient driven by temperature and precipitation, it is intuitive that average value of abundance of C4 grasses at Chickasaw NRA (74% across all sites) fell in between values of the surrounding sites.

Some of the variation in C3 to C4 ratios at Chickasaw NRA and over time may be explained by the different ecosites, and some may be explained by land use history, including restoration activities. The ecological site type that had a larger proportion of C3 grasses, clayey bottomland, is the same type where sites 6 and 9 were found. In general, these sites have been plowed to pasture and are currently invaded by Johnsongrass (Sorgum halapense). It is entirely possible that the fields were planted to Johnsongrass due to the even distribution of what is usually a patchy species. Some of the sites we evaluated in the bottomlands were adjacent to cedar eradication areas, which would have an effect. And finally, bottomland sites often have closed canopies, which will highly limit the species found (Folts-Zettner personal communication).

The experts did not express much concern over the balance of C3 and C4 grasses, since park management is aware of and actively restoring the sites where there is an imbalance. Therefore, we considered this measure as moderate to good, overall, with an improving trend, if restoration efforts are successful.

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

The Role of Fire in Grassland Condition at Chickasaw NRA

Historical records of fire frequencies for prairies of the southern Great Plains before settlement are generally nonexistent or unreliable because there are no trees to carry fire scars from which to estimate fire frequency (Ford and McPherson. 1996). Although fire is generally reported to play a prominent role in health and functioning of grasslands (e.g., Joern and Keeler 1995), this role likely varies substantially among grassland types. In particular, the role of fire as a primary determinant of grassland structure likely decreases strongly from tallgrass prairie to shortgrass steppe as a result of the gradient in productivity and fuel (Kucera 1981, Oesterheld et al. 1999, Scheintaub et al. 2009). In fact, grassland experts Drs. Alan Knapp and William Lauenroth (pers comm.) suggest that fire probably plays a much lesser role in maintaining a healthy prairie in the shortgrass steppe than other drivers such as herbivory and climate variation.

One of the perceived benefits of fire in grassland systems is the reduction of litter. In tallgrass prairie, litter removal increases soil temperature and light leading to increased productivity (Hulbert, 1988; Knapp and Seastedt, 1986). However, shortgrass steppe has minimal litter accumulation (Burke et al. 1998), and Scheintaub et al. (2009) reported a positive relationship between litter and productivity, suggesting that litter may facilitate, or at least not inhibit productivity as it does in tallgrass prairie. However, Scheintaub et al. (2009) also suggest that further research is needed on the relationship between litter and productivity in short grass steppe.

As documented in the Chickasaw NRA general management plan (NPS 2008), historically, fire periodically occurred in Chickasaw National Recreation Area. However, in more modern times, fires have been suppressed, resulting in a buildup of fuel and has led to the decline of prairies in the recreation area. The current fire management plan (NPS 2003c as

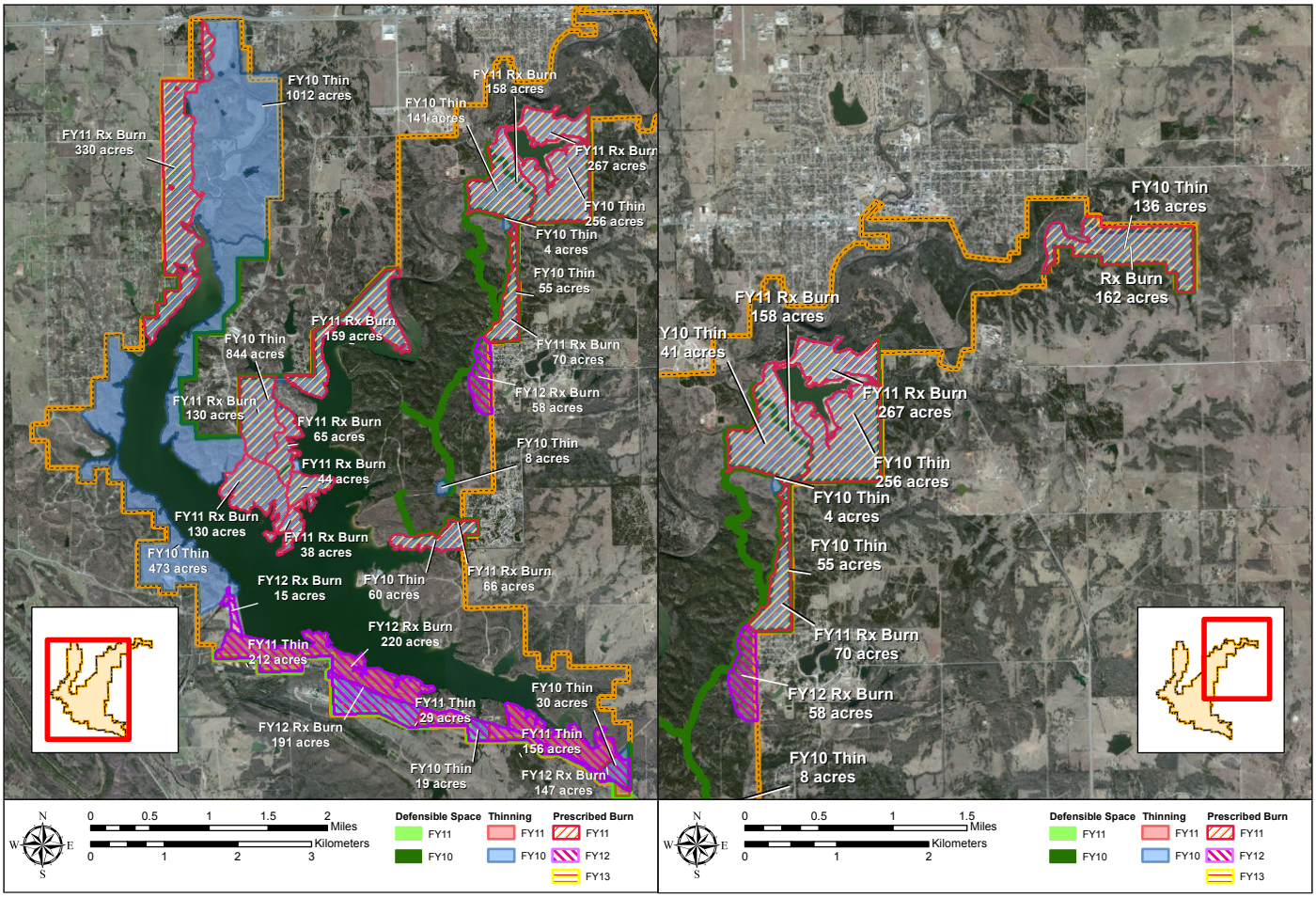


Figure 4.9.4-7. Wildland fires, prescribed fires and non-fire treatments at Chickasaw NRA, 2010-2013.

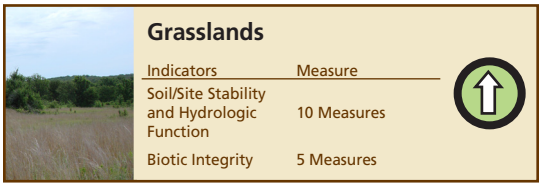
cited in NPS 2008) discusses and deals with these issues.

Chickasaw NRA currently has an active prescribed fire program. There have also been several incidents of wildfire (Figure 4.9.4-7). In recent years, efforts have begun to restore Chickasaw National Recreation Area's prairie ecosystems with the application of prescribed burns and the clearing of red cedar, which due largely to the suppression of fire, has rapidly spread throughout most of Chickasaw National Recreation Area.

Strategies: The absence of fire is also generally thought to have contributed to fuel accumulation, such that when fires do occur it is possible that they fires burn at a greater severity than they did historically, especially where shrubs have encroached.

Fire could also be an effective tool to control woody exotics. Nonsprouting species such as the invasive Ashe juniper are more susceptible to fire than the oaks that characterize the Cross Timbers region, which are easily top-killed with fire but resprout vigorously (Wright and Bailey 1980). Wink and Wright (1973) (as cited in Wright and Bailey 1980) have shown that hot fires can easily kill large juniper trees because of the volatility of the green material. Subsequent fires within 10 or 15 years have the potential to kill immature junipers, eliminating the potential local seed source of the non-sprouting species. Thus, with occasional fires, such areas could easily have been converted to grasslands, with occasional patches of juniper on rocky sites. Protection from fire has favored the re-establishment of dense stands of juniper (Wright and Bailey 1980). Management practices, including mechanical removal of junipers in combination with fire treatments, should be effective toward recreating a more natural fire regime.

However, whether fire has a positive, neutral or negative benefit on grassland condition will depend on several factors (season, frequency, potential for exotic plant response, etc) that will need to be considered carefully by Chickasaw NRA and fire management program. The uncertainty associated with the use of fire as a vegetation management tool might also warrant that such action be undertaken under an adaptive management framework including monitoring of the response.



Overall Condition

For assessing the condition of grasslands, we used a variety of indicators/measures that were not mutually exclusive but were intended to be different ways of capturing the essence of what we thought represented the condition of the Chickasaw NRA'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 4.9.4-7.

For many indicators and measures, condition was variable among sites, with the majority of sites in good to moderate ecological condition. Both monitoring and assessment sites that scored poorly with some consistency are what were described as clayey bottomland ecosite types. In some cases, these were converted hayfields and restoration is underway. Sites that performed well are actively managed, as well. Thus, based on the measures, data, expert opinion, and management activities, we consider the overall condition of the grasslands at Chickasaw NRA to be in good condition with an improving trend.

It should also be noted that the condition of grasslands is the result of a long history of land use and ecological conditions that began long before the establishment of Chickasaw as a national recreation area. Consequently, we do not consider the sites with grassland problems to be a result of NPS management; quite the contrary. Chickasaw NRA natural resource staff has been actively engaged in restoring areas in more degraded condition. Thus, we believe that many areas of the NRA would be in substantially worse condition if it were not for the efforts of Chickasaw NRA staff. We are also anticipating conditions to be improving as the region shifts from extreme drought conditions to more normal rainfall patterns and as Chickasaw NRA management continues to address exotic plants and restoration of native prairies.

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

Table 4.9.4-7. Summary of the grassland indicators and measures and their contributions to the overall assessment of grassland condition.

Indicator	Measure	Condition	Condition Rationale
Soil/Site Stability and Hydrologic Function	10 measures	Good	Departures from expected conditions for most measures of Soil/Site Stability and Hydrologic Function were minimal at most sites. Indicators of potential erosion did occur at a few sites, but not significantly enough to impact site condition or to warrant downgrading the assessment score. Therefore we assigned a good condition rating overall.
Biotic Integrity	5 measures	Good	For many indicators and measures of biotic integrity, condition was variable among sites, with the majority of sites in good to moderate ecological condition. The sites that scored poorly were converted hayfields and restoration is underway. We consider the overall condition of the grasslands at Chickasaw NRA to be in good condition with an improving trend.

include annual variability, the effect of drought conditions, and the potential success of ongoing management actions.

Annual variability in rainfall, temperatures, diseases, etc. can have a dramatic effect on some measures (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 measures, but this influence would also likely imply our assessment is a bit conservative. That is, conditions may have appeared even better had they been assessed under more typical rainfall period.

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. Fred Smeins is a professor at Texas A&M University, Department of Ecosystem Science and Management, College Station, Texas. Dr Smeins' research focuses on understanding the structure and dynamics of rangeland (grassland, wetland, savannah) ecosystems as influenced by herbivory, soil, fire and weather.

Tomye Folts-Zettner is the biologist/ vegetation specialist for the Southern Plains Inventory and Monitoring Network and has an in-depth knowledge of the vegetation of the Southern Plains.

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4.10. Exotic Plants

Indicators/Measures

- Potential to Alter Native Plant Communities (1 measure)
- Prevalence of Exotic Plants (3 measures)

Condition - Trend - Confidence



Significant Concern - Declining - 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. Approximately 4 - 19% of species introduced into the United States may become invasive (USFWS 2012).

Invasive species have been directly linked to the displacement of several native species of plants (Pimentel et al. 1999). Approximately 42% of threatened and endangered species are at risk primarily because of alien-invasive species (Pimentel et al. 2005). Exotic plants cause changes in ecosystem structure, alteration of nutrient cycles and soil chemistry, alteration of normal successional trajectory of a system (Ehrenfeld 2003, Emery 2012), negative impacts to agriculture (Pimentel 2009), and limitations on water availability (USFWS 2012) (Figure 4.10.1-1).

The spread of invasive species is one of the most environmentally serious global changes, causing economic and environmental damage in the United States and worldwide (UCSUSA 2008). Consequently, the dynamic relationships among plants, animals, soil, and water established over many thousands of years are at risk of being destroyed in a relatively brief period. For the National Park Service (NPS), the consequences of these invasions present a significant challenge to the management of the agency's natural resources "unimpaired for the enjoyment of future generations." National parks, like lands 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 anthropogenic pathways (e.g., weed seeds in restoration



NPS

Figure 4.10.1-1. Exotic plants threaten native wildflower displays.

planting mixes). Nonnative plants claim an estimated 4,600 acres per day on federal lands alone in the western United States, quadrupling their range from 1985-1995, claiming approximately 17 million acres (BLM 2011) and significantly altering local flora. For example, in Great Smoky Mountains National Park, over ¼ of the plants (27%) are non-native species. On the big island of Hawaii, 35% of the plants are non-native (Pimentel et al. 2005). Invasive plants are dominant on approximately 5% of the lands managed by the NPS (NPS 2009).

4.10.2. Data and Methods

In assessing the current condition and trend for exotic plants at Chickasaw NRA, we used two indicators. The first indicator, which has one measure, evaluates the overall impact an exotic plant has on the native plant communities throughout the recreation area. This indicator utilizes known natural history characteristics of exotic plant species in order to characterize their impact on natural ecosystems.

The second indicator, with three measures, was used to assess the prevalence of the exotic plant species on NPS lands. Data for the prevalence indicator and measures were collected by Southern Plains Inventory and Monitoring (SOPN) staff.

SOPN Annual Exotic Plants Monitoring

The SOPN's systematic monitoring program gathers information in a financially feasible means about the occurrence of exotic plants in select areas in NPS units that can be spatially represented and used for data analysis (Folts-Zettner et al. 2013). The protocol involves regular monitoring of blocks along high priority vectors (e.g., roads and trails) that have been identified based on their potential risk for invasion by exotic plants. The overall 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 4.10.2-1). Four distances classes per block are assessed in order provide information that may indicate that a given species has invaded interior habitats or whether it remained localized near the likely source of invasion (Folts-Zettner et al. 2013).

The standard sampling scheme uses a three-year rotating panel design, whereby an area is surveyed each year (a panel) for three years, then repeated. We utilized SOPN's annual monitoring data collected between 2012 - 2014 to report the most current condition of the recreation area's exotic plants (Folts-Zettner and Sosinski 2012a; 2013; 2014). Monitoring took place in mid June each year.

The SOPN monitored blocks along the paved Buckhorn and Cedar Blue Roads in 2012 (Panel 1), along Trails 1 and 3 and the Sewage Treatment Road in 2013 (Panel 2), and along the paved E1750 Road, and the unpaved West

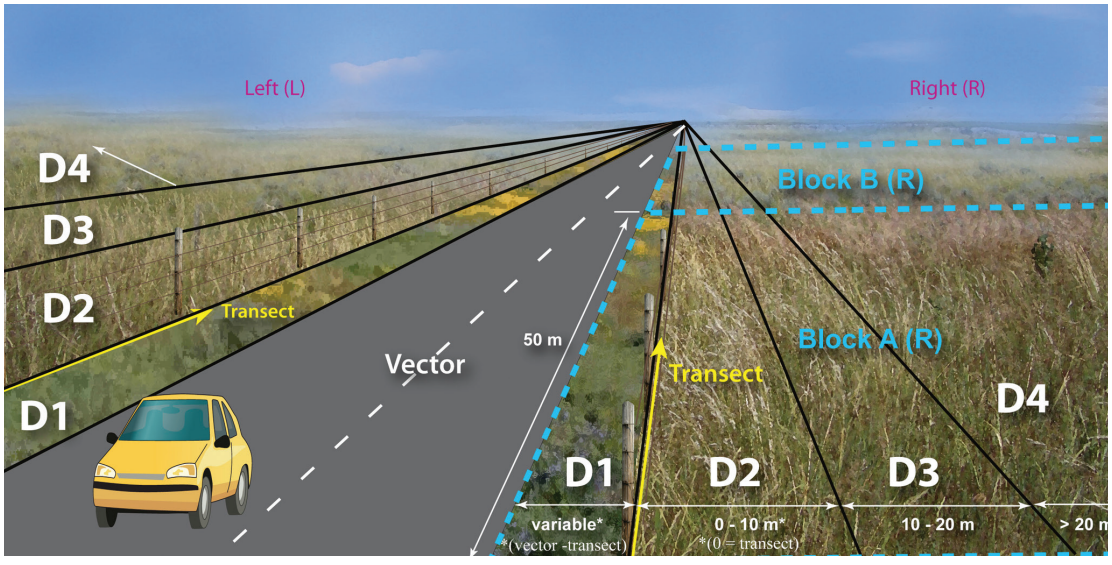


Figure 4.10.2-1. Fifty meter blocks are sampled on each side of a high-risk vector (e.g., road or trail).

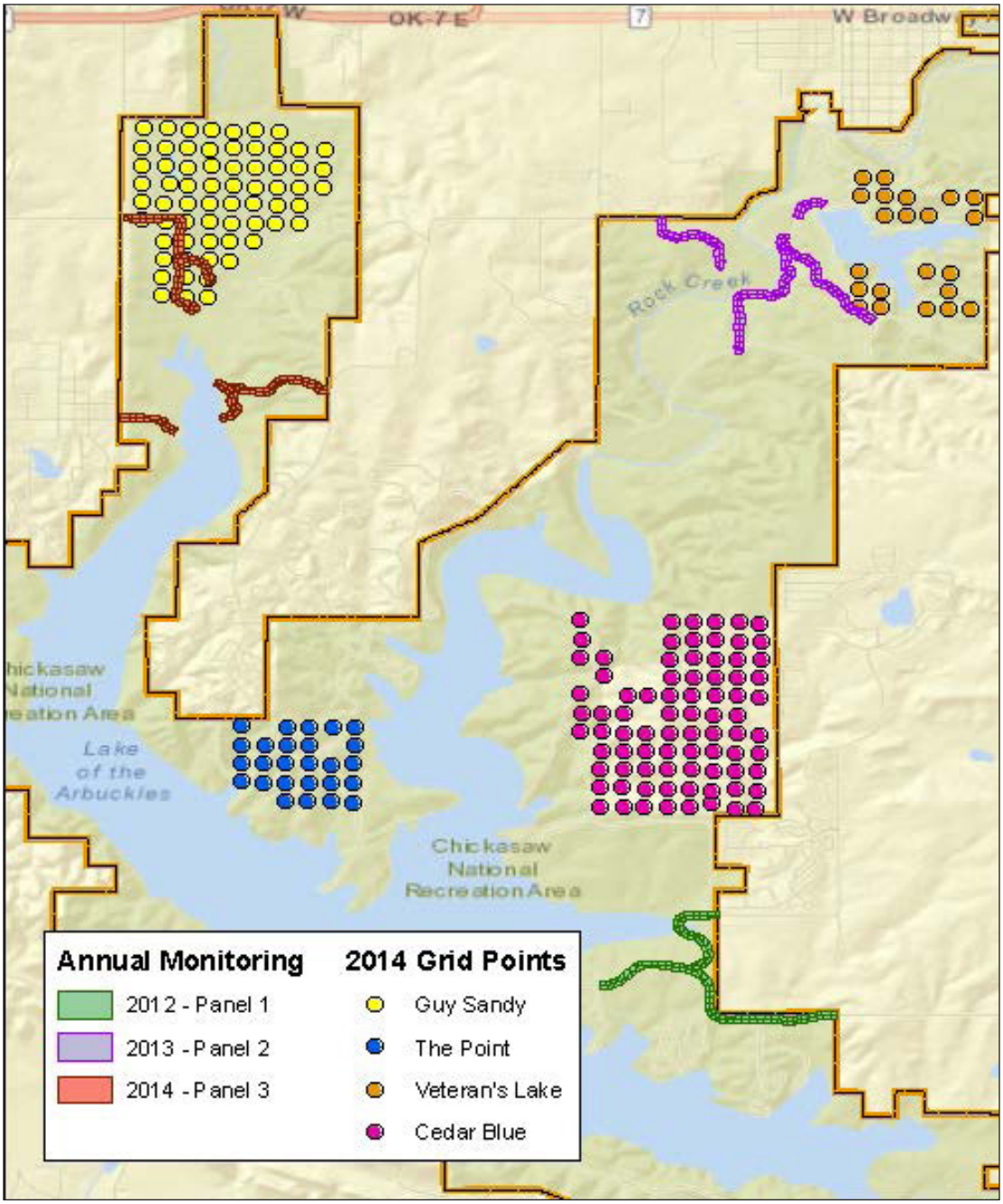


Figure 4.10.2-2. Areas within Chickasaw NRA surveyed during SOPN annual monitoring and during the one-time 2014 SOPN rapid assessment.

Guy Sandy, West Guy Sandy-Spur, East Guy Sandy and Breezy Point Roads in 2014 (Panel 3) (Figure 4.10.2-2).

The 2012-2014 vector monitoring was the second full panel rotation of sampling at Chickasaw. Monitoring along some of the same vectors also occurred in 2010-2011, as the 2009 vector was replaced with the higher priority vectors of the Buckhorn and Cedar Blue Roads in 2012 (Folts-Zettner and Sosinski 2012b). The Sewage Treatment Road was monitored in 2013 instead of the Trail Access Road , which was surveyed in 2010 (Sosinski, SOPN data manager, personal communication, 2014). Data from the 2010-2011 monitoring will be discussed in Section 4.11.4, Condition and Trend.

Other sources of information about exotic plant species found in Chickasaw NRA include the recreation area's vegetation classification and map (Salas et al. 2010), vegetation study (Hoagland et al. 2006), and the exotic species list maintained by the SOPN (Folts-Zettner 2014).

It is important to emphasize that SOPN's sampling approach does not provide a complete survey of exotic plants throughout the recreation area. Instead, it provides a repeated snapshot for limited areas with high potential (e.g., along roads or trails) for new invasions.

SOPN 2014 Rapid Assessment (one-time only)

In addition to the annual SOPN monitoring program, a one-time rapid assessment of exotic plant occurrence was conducted by SOPN staff in June 2014 (Horsley and Schafer 2014). The purpose of the rapid assessment was to collect information about the presence of exotic species in other areas of the recreation area for this condition assessment.

For the rapid assessment, a point grid was developed (Folts-Zettner, SOPN biologist, personal communication, 2014). Points are usually 150 meters apart, and exotic species were observed within a 10-meter diameter of that point. Data for occurrence and density of exotic species found in these supplemental plots were recorded in the same way as in the standard monitoring described in Folts-Zettner et al. (2013), but without utilizing distance classes as in the vector monitoring.

Because of the large size of Chickasaw NRA (10,062 acres), monitoring during the 2014 rapid assessment occurred in four areas (Figure 4.10.2-2) that represent the major environments found in the recreation area and that have had different types of treatment for exotic plant infestations (Folts-Zettner, SOPN biologist, personal communication, 2014). The Buckhorn area is woodland which has been cleared of *Juniperus virginiana* (eastern red cedar) and treated with prescribed fire. The Point area consists of cleared oak woodland. The Guy Sandy area is grassland near climax and has been treated with prescribed fire, and the Veteran Lake rapid assessment area is upland grassland habitat.

Both the SOPN annual monitoring locations and locations of the one-time rapid assessment that took place in 2014 are shown in Figure 4.10.2-2.

Indicator/Measure

Potential to Alter Native Plant Communities: Significance of Exotic Plant Impact)

The first indicator and measure, potential to alter native plant communities (significance of exotic plant impact), was derived from the Handbook for Ranking Exotic Plants for Management and Control (Hiebert and Stubbendieck 1993). The handbook's analytical approach provides NPS managers with scientific information that encompasses the full array of significant factors that measure the ecological impact of an exotic species.

For the purposes of this assessment, Hiebert and Stubbendieck's significance of exotic plant impact was modified to capture only the exotic plant's innate ability to become a pest. The innate ability for a species to become a pest section quantifies the characteristics, such as ability to reproduce vegetatively, the number of seeds per plant, germination requirements, and the plant's competitive ability, that preadapt it to become a problem.

The numerical ranking for this measure ranged between 0 - 50 possible points, with 50 representing the highest possibility of impacting and altering the native plant communities and zero being the lowest. We assigned the numerical rankings to the following categories:

- 40 - 50 = Highest Concern
- 35 - 39 = High Concern
- 30 - 34 = Medium Concern
- 0 - 29 = Low Concern

The significance of exotic plant impact rankings for each exotic species found during SOPN's annual (2012-2014) and 2014 rapid assessment monitoring at the NRA are reported in Table 4.10.2-1. Ten species were ranked as having the highest concern, with six additional species having high concern. Two of the species of high concern, *Carduus nutans* (nodding musk thistle) and *Onopordum acanthium* (Scotch thistle) are Oklahoma state noxious weeds (USDA-NRCS 2014).

Table 4.10.2-1. Significance of exotic plant impact ranking for species detected in SOPN 2012-2014 monitoring (Folts-Zettner and Sosinski 2012a, 2013, 2014) and the 2014 Rapid Assessment (Horsley and Schafer 2014), using a subset of criteria from Hiebert and Stubbendieck's (1993) Handbook for Ranking Exotic Plants for Management and Control.

Species	Common Name	Noxious	Ranking
Achillea millefolium	common yarrow		Medium
Aegilops cylindrica	jointed goatgrass		Medium
Bothriochloa ischaemum[1]	king ranch bluestem		Highest
Bromus catharticus	rescue brome		Low
Bromus inermis[1]	smooth brome		Highest
Bromus japonicus[1]	Japanese brome		High
Bromus lanceolatus	Mediterranean brome		Low
Bromus tectorum[1]	cheatgrass		Highest
Carduus nutans[1]	nodding musk thistle	X	High
Chenopodium album	lamb's quarters		Low
Conium maculatum[1]	poison hemlock		Highest
Convolvulus arvensis[1]	field bindweed		Highest
Coronilla varia[1]	purple crownvetch		Highest
Cynodon dactylon[1]	Bermudagrass		High
Datura stramonium	jimsonweed		Medium
Daucus carota	Queen Anne's lace		Medium
Echinochloa colona[1]	jungle ricegrass		High
Erodium cicutarium	redstem stork'sbill		Medium
Euphorbia spp.[1]	spurge		High
Kummerowia stipulacea	Korean lespedeza		Medium
Lactuca serriola	prickly lettuce		Medium
Lathyrus hirsutus	singletary pea		Low
Lespedeza cuneata[1]	sericea lespedeza		Highest
Lolium perenne[2]	perennial ryegrass		Low
Lonicera japonica[1]	Japanese honeysuckle		Highest
Medicago lupulina	black medik clover		Medium
Medicago minima	burr medick clover		Medium
Medicago sativa	alfalfa		Medium
Melilotus spp.	white/yellow sweet-clover		Low
Mentha spicata	spearmint		Medium
Onopordum acanthium[1]	Scotch thistle	X	High
Paspalum dilatatum	dallas grass		Low
Poa annua	annual bluegrass		Highest
Polygonum convolvulus	climbing buckwheat		Medium
Rumex crispus	curley dock		Medium
Sonchus asper	spiny sowthistle		Medium
Sorghum halepense[1]	Johnsongrass		Highest
Taraxacum officinale	dandelion		Medium
Torilis arvensis	spreading hedgeparsley		Medium
Tragopogon dubius	western salsify		Low
Trifolium arvense	rabbit footclover		Low
Trifolium dubium	small hop clover		Low
Vicia sativa	garden vetch		Low

[1] Species considered to be of highest or high concern using the significance of exotic plant impact, innate ability to become a pest measure (Hiebert and Stubbendieck 1993) are highlighted in the darker tone.

[2]Species of special concern (Folts-Zettner, SOPN biologist, personal communication, 2014) is highlighted in the lighter tone.

Euphorbia spp. include *Euphorbia davidii* and *Euphorbia dentata*.

Although it did not rank in the highest or high category for the significance of exotic plant impact using the Hiebert and Stubbendieck system, SOPN biologist Tomye Folts-Zettner (personal communication, 2014) identified *Lolium perenne* (perennial ryegrass) as a species of special concern in the recreation area. The species is especially competitive in the Chickasaw region. It can have a significant impact on native wildflowers, and has ability to form monocultures. These characteristics make its impact in the type of ecosystems found in the recreation area especially noteworthy. This species will be discuss further in Section 4.11.4.

Indicators/Measures

Prevalence of Exotic Plants (3 measures)

The prevalence of exotic plants includes three measures: extent, density, and distribution (Table 4.10.2-2). These measures describe how often, how many, and where respectively that exotic plant species were located during the annual and the 2014 rapid assessment monitoring.

Measure

Extent of Exotic Plants

Extent is a measure of the area (e.g., block in annual SOPN vector monitoring, or plot in 2014 rapid assessment monitoring) in which exotic species have been found. Extent is a proportional measure that indicates that an exotic species was identified a certain number of times. Extent is reported as the percentage of the surveyed blocks or plots that contained a specific exotic species, and is the frequency that blocks or plots contained exotic plant species. This measure only indicates whether the plant was found in the surveyed area, and does not include its density (e.g., number of plants found per block or plot) or where the block or plot was located. Extent is reported for all species identified during the SOPN 2012-2014 monitoring in Table 4.10.2-3, in Table 4.10.2-4 for the rapid assessment, and in Appendix E.

Table 4.10.2-2. Definitions of the three measures used for the prevalence of exotic plants indicator.

Measure	Description
Extent	*Answers how often.* A measure of the percent of surveyed park monitoring locations (blocks or plots) that has exotic species occurring in it.
Density	*Answers how many.* The number of exotic plants per unit of area (block or plot)
Distribution	*Answers where.* A measure of the location of exotic plant occurrence.

SOPN Annual Exotic Plants Monitoring

Thirty-six species of exotic plants were encountered during vector monitoring in 2012-2014 (Table 4.10.2-3), including 13 species of highest or high concern for their innate ability to become a pest plus *Lolium perenne*, the species of special concern. Only 1.4% of blocks did not contain exotic species.

Bromus japonicus (Japanese brome), a species of high exotic plant impact, was the most common exotic plant found along the vectors, and was detected in 73.6% of the blocks. It was especially prevalent along the vectors in the Guy Sandy area (West Hunting Area) where it was present in 98.4% of the blocks, and Trails 1 and 3 and the Sewage Treatment Road where it was in 89.8% of the units sampled.

Sorghum halepense (Johnsongrass), a species of highest concern, was found in 66.8% of the blocks, and was the second most common exotic plant encountered during vector monitoring.

A total of ten different species were found in more than 25% of the blocks, including six species of highest or high exotic plant impact. In addition to *Bromus japonicus* and *Sorghum halepense*, *Bothriochloa ischaemum* (king ranch bluestem) was present in 48.9% of the blocks, *Cynodon dactylon* (Bermudagrass) in 47.2%, *Lespedeza cuneata* (sericea lespedeza) in 36.3%, and *Bromus tectorum* (cheatgrass) in 27.4%. Additionally, *Lolium perenne*, a species of special concern, was documented in 22.9% of the blocks.

Seventeen species had limited extent along the vectors, being found in less than 5% of the

Table 4.10.2-3. Extent of exotic plant species detected in annual SOPN high priority monitoring blocks sampled in 2012-2014.

Species	No. Blocks	% (N=342)
Bromus japonicus[1]	262	73.2%
Sorghum halepense[1]	239	66.8%
Medicago minima	205	57.3%
Lactuca serriola	177	49.4%
Bothriochloa ischaemum[1]	175	48.9%
Cynodon dactylon[1]	169	47.2%
Lespedeza cuneata[1]	130	36.3%
Torilis arvensis	113	31.6%
Bromus tectorum[1]	98	27.4%
Achillea millefolium	94	26.3%
Melilotus spp.	84	23.5%
Lolium perenne[2]	82	22.9%
Sonchus asper	63	17.6%
Kummerowia stipulacea	61	17.0%
Bromus catharticus	33	9.2%
Tragopogon dubius	26	7.3%
Paspalum dilatatum	25	7.0%
Medicago lupulina	20	5.6%
Aegilops cylindrica	19	5.3%
Conium maculatum[1]	17	4.7%
Onopordum acanthium[1]	14	3.9%
Lathyrus hirsutus	12	3.4%
Daucus carota	10	2.8%
Euphorbia spp.[1]	10	2.8%
Lonicera japonica[1]	10	2.8%
Vicia sativa	7	2.0%
Medicago sativa	6	1.7%
Taraxacum officinale	6	1.7%
No plants detected	5	1.4%
Rumex crispus	5	1.4%
Erodium cicutarium	3	0.8%
Polygonum convolvulus	3	0.8%
Datura stramonium	2	0.6%
Poa annua[1]	2	0.6%
Bromus inermis[1]	1	0.3%
Bromus lanceolatus	1	0.3%
Coronilla varia[1]	1	0.3%

[1]Species considered to be of highest or high concern in (Table 4.10.2-1) are highlighted in the darker tone.

[2]Species of special concern (Table 4.10.2-1) is highlighted in the lighter tone.

Table 4.10.2-4. Extent of exotic plant species detected in SOPN rapid assessment plots sampled in 2014.

Species	No. Plots	% (N=194)
No plants detected	57	29.4%
Bromus japonicus[1]	51	26.3%
Lactuca serriola	47	24.2%
Sorghum halepense[1]	39	20.1%
Achillea millefolium	38	19.6%
Lespedeza cuneata[1]	35	18.0%
Torilis arvensis	33	17.0%
Melilotus spp.	20	10.3%
Sonchus asper	17	8.8%
Medicago minima	10	5.2%
Conium maculatum[1]	8	4.1%
Bothriochloa ischaemum[1]	7	3.6%
Euphorbia spp.[1]	5	2.6%
Carduus nutans[1]	5	2.6%
Bromus catharticus	3	1.5%
Coronilla varia[1]	3	1.5%
Tragopogon dubius	3	1.5%
Bromus tectorum[1]	2	1.0%
Chenopodium album	2	1.0%
Cynodon dactylon[1]	2	1.0%
Daucus carota	2	1.0%
Rumex crispus	2	1.0%
Trifolium arvense	2	1.0%
Trifolium dubium	2	1.0%
Convolvulus arvensis[1]	1	0.5%
Echinochloa colona[1]	1	0.5%
Kummerowia stipulacea	1	0.5%
Lathyrus hirsutus	1	0.5%
Medicago sativa	1	0.5%
Mentha spicata	1	0.5%
Paspalum dilatatum	1	0.5%

[1]Species considered to be of highest or high concern in (Table 4.10.2-1) are highlighted in the darker tone.

blocks. Seven of these species are of highest of high exotic plant impact: *Conium maculatum* (poison hemlock) (4.7% of the blocks), *Onopordum acanthium* (3.9%), *Euphorbia spp.* (spurge) (2.8%), *Lonicera japonica* (Japanese honeysuckle) (2.8%), *Poa annua* (annual bluegrass) (0.6%), *Bromus inermis* (smooth brome) (0.3%), and *Coronilla varia* (purple crownvetch) (0.3%).

SOPN 2014 Rapid Assessment

Thirty species were detected during the SOPN 2014 rapid assessment (Table 4.10.2-4), including 12 species of highest or high exotic plant impact. Altogether, exotic plant species were substantially less extent in the rapid assessment areas than along the vectors. Nearly 30% of the rapid assessment plots did not contain exotic plant species, and no species occurred in more than in 26.3% of the plots (*Bromus japonicus*).

Sorghum halepense and *Lespedeza cuneata*, both species with highest exotic plant impact rankings, were present in 20.1% and 18.0% of the plots, respectively. The other exotic plants with highest or high impact rankings had limited extent in the rapid assessment areas, and were found in 4.1% or less of the plots. *Lolium perenne*, the species of special concern, was not encountered during the rapid assessment.

Seven species not present along the high priority vectors were identified during the rapid assessment, including *Carduus nutans*, a species with high exotic plant impact and a Oklahoma state noxious weed, which was present in 2.6% of the plots. The other six species were found in 1% or less of the plots, including *Convolvulus arvensis* (field bindweed), a species of highest concern, and *Echinochloa colona* (jungle ricegrass), which is ranked as high ecological impact.

Measure

Density of Exotic Plants

The density measure is the number of exotic plants per unit of area (block or plot). During the annual SOPN monitoring and 2014 rapid assessment, the occurrence of each observed exotic species was assigned to one of five density classes, representing a range from not observed to a small number of individual plants to a continuous matrix within the block or plot.

These density classes are:

- 0 = Not observed
- 1 = 1-5 plants present
- 2 = Scattered in patches
- 3 = Scattered fairly evenly
- 4 = Forming a matrix (Folts-Zettner et al. 2013).

Density is reported for all species identified during the 2012-2014 annual monitoring in Table 4.10.2-5 and for all exotic species found during the 2014 one-time rapid assessment in Table 4.10.2-6.

The density of three species that have the highest or high concern for their impact to alter native plant communities and that have wide extents are shown in Figures 4.11.2-3 (*Sorghum halepense*), 4.11.2-4 (*Bothriochloa ischaemum*), and Figure 4.10.2-5 (*Bromus japonicus*). For the annual monitoring, these maps only show the densities of the plants in the distance class closest to the actual vector.

SOPN Annual Exotic Plants Monitoring

Exotic species were most often found in density class 2 (scattered patchy) during the 2012-2014 monitoring of high priority vectors (Table 4.10.2-5). In fact, some species were found nearly exclusively in scattered patchy densities, including *Bromus japonicus* (90.9%), *Bothriochloa ischaemum* (91.7%), *Medicago minima* (burr medick clover) (96.7%), and *Cynodon dactylon* (96.4%).

Six species were detected at evenly scattered densities (class 3) in the 2012-2014 monitoring, including five species of highest or high concern for their potential to alter native plant communities: *Bromus japonicus Sorghum halepense*, *Bothriochloa ischaemum, Cynodon dactylon* and *Bromus tectorum. Cynodon dactylon* formed the matrix in two blocks.

Species with high extent were also more likely to be found in at least density class 2, with the

Table 4.10.2-5. Density of exotic plants in SOPN 2012-2014 high priority vector blocks with the density class information in percentage of total occurrences recorded for each species.

Species	Number of Occurrences	Density Classes			
		Class 1 (%) 1-5 individuals	Class 2 (%) Scattered patchy	Class 3 (%) Scattered even	Class 4 (%) Matrix
Bromus japonicus[1]	483	5.0%	90.9%	4.1%	
Sorghum halepense[1]	453	17.4%	81.7%	0.9%	
Lactuca serriola	255	45.5%	54.5%		
Bothriochloa ischaemum[1]	252	5.6%	91.7%	2.8%	
Medicago minima	246	2.8%	96.7%	0.4%	
Cynodon dactylon[1]	220	0.9%	96.4%	1.8%	0.9%
Torilis arvensis	208	30.3%	69.7%		
Lespedeza cuneata[1]	195	23.1%	76.9%		
Achillea millefolium	161	29.8%	70.2%		
Bromus tectorum[1]	138	14.5%	84.8%	0.7%	
Melilotus spp.	114	36.0%	64.0%		
Sonchus asper	101	63.4%	36.6%		
Lolium perenne[2]	97	28.9%	71.1%		
Kummerowia stipulacea	63	17.5%	82.5%		
Bromus catharticus	38	47.4%	52.6%		
Tragopogon dubius	33	75.8%	24.2%		
Paspalum dilatatum	30	20.0%	80.0%		
Aegilops cylindrica	25	24.0%	76.0%		
Medicago lupulina	25	20.0%	80.0%		
Conium maculatum[1]	20	65.0%	35.0%		
Onopordum acanthium[1]	17	88.2%	11.8%		
Lathyrus hirsutus	16	31.3%	68.8%		
Lonicera japonica[1]	13	92.3%	7.7%		
Daucus carota	12	83.3%	16.7%		
Vicia sativa	11	81.8%	18.2%		
Taraxacum officinale	9	44.4%	55.6%		
Medicago sativa	8	87.5%	12.5%		
Rumex crispus	6	66.7%	33.3%		
Euphorbia spp.[1]	4	25.0%	75.0%		
Coronilla varia[1]	3		100.0%		
Erodium cicutarium	3	100.0%			
Poa annua[1]	3	66.7%	33.3%		
Polygonum convolvulus	3	100.0%			
Datura stramonium	2	50.0%	50.0%		
Bromus inermis[1]	1	100.0%			
Bromus lanceolatus	1		100.0%		

The number of occurrences includes those in all distance classes from the vector. Density classes are from (Folts-Zettner et al. 2011). Density class 0 measures are not reported in this table.

[1]Species considered to be of highest or high concern in (Table 4.10.2-1) are highlighted in the darker tone.

[2]Species of special concern (Table 4.10.2-1) is highlighted in the lighter tone.

Table 4.10.2-6. Density of exotic plants in SOPN 2014 rapid assessment plots, with the density class information in percentage of total occurrences recorded for each species.

Species	Number of Occurrences	Density Classes			
		Class 1 (%) 1-5 individuals	Class 2 (%) Scattered patchy	Class 3 (%) Scattered even	Class 4 (%) Matrix
Bromus japonicus[1]	53	17.0%	67.9%	15.1%	
Lactuca serriola	49	46.9%	53.1%		
Achillea millefolium	39	51.3%	46.2%	2.6%	
Sorghum halepense[1]	39	10.3%	64.1%	17.9%	7.7%
Lespedeza cuneata[1]	36	33.3%	66.7%		
Torilis arvensis	33	27.3%	72.7%		
Melilotus spp.	20	35.0%	65.0%		
Sonchus asper	17	47.1%	52.9%		
Medicago minima	10		70.0%	30.0%	
Conium maculatum[1]	8	62.5%	37.5%		
Bothriochloa ischaemum[1]	7	42.9%	42.9%	14.3%	
Carduus nutans[1]	5	60.0%	40.0%		
Euphorbia spp.[1]	5	80.0%	20.0%		
Bromus catharticus	3	33.3%	66.7%		
Coronilla varia[1]	3		66.7%	33.3%	
Tragopogon dubius	3	100.0%			
Bromus tectorum[1]	2	50.0%	50.0%		
Chenopodium album	2	50.0%		50.0%	
Cynodon dactylon[1]	2		100.0%		
Daucus carota	2	50.0%	50.0%		
Rumex crispus	2	100.0%			
Trifolium arvense	2		100.0%		
Trifolium dubium	2		50.0%	50.0%	
Convolvulus arvensis[1]	1	100.0%			
Echinochloa colona	1		100.0%		
Kummerowia stipulacea	1	100.0%			
Lathyrus hirsutus	1		100.0%		
Medicago sativa	1	100.0%			
Mentha spicata	1			100.0%	
Paspalum dilatatum	1	100.0%			

The number of occurrences includes those in all distance classes from the vector. Density classes are from (Folts-Zettner et al. 2011). Density class 0 measures are applicable for the rapid assessment.

[1]Species considered to be of highest or high concern in (Table 4.10.2-1) are highlighted in the darker tone.

exception of *Lactuca serriola* (prickly lettuce) whose occurrence was nearly evenly split between density classes 1 and 2.

SOPN 2014 Rapid Assessment

Exotic plant species also were mostly detected in density class 2 or higher during the 2014 rapid assessment (Table 4.10.2-6), although many more occurrences were in density class 1 (1-5 individuals) than were in blocks along the high priority vectors. However, there were also more occurrences in density class 3 (scattered even). For example, *Bromus japonicus* occurred in density class 3 15.1% of the time. And *Sorghum halepense* occurred in density class 3 17.9% of the time, and formed the matrix in three plots (7.7%).

Four species of very limited extent, *Chenopodium album* (lamb's quarters), *Coronilla varia*, *Mentha spicata* (spearmint)

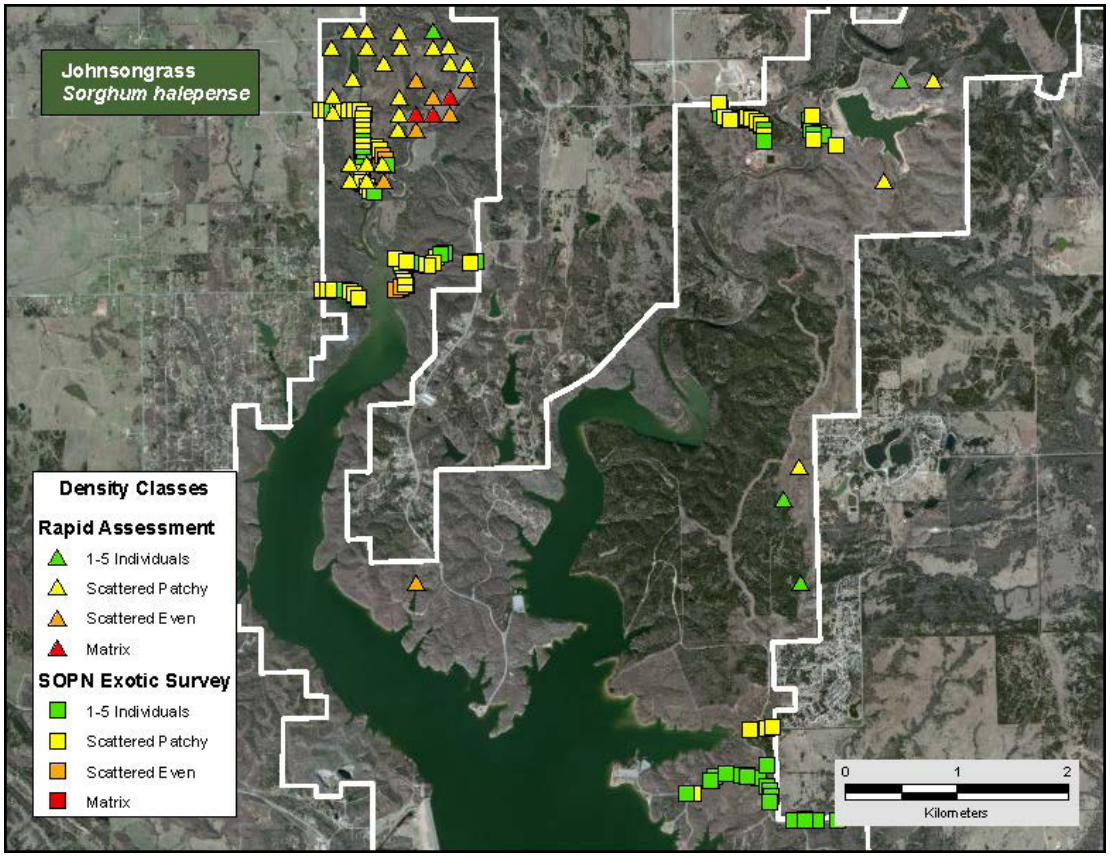


Figure 4.1.2-3. *Sorghum halepense* plant density based on surveys conducted during SOPN's 2012-2014 annual monitoring and SOPN's 2014 rapid assessment.

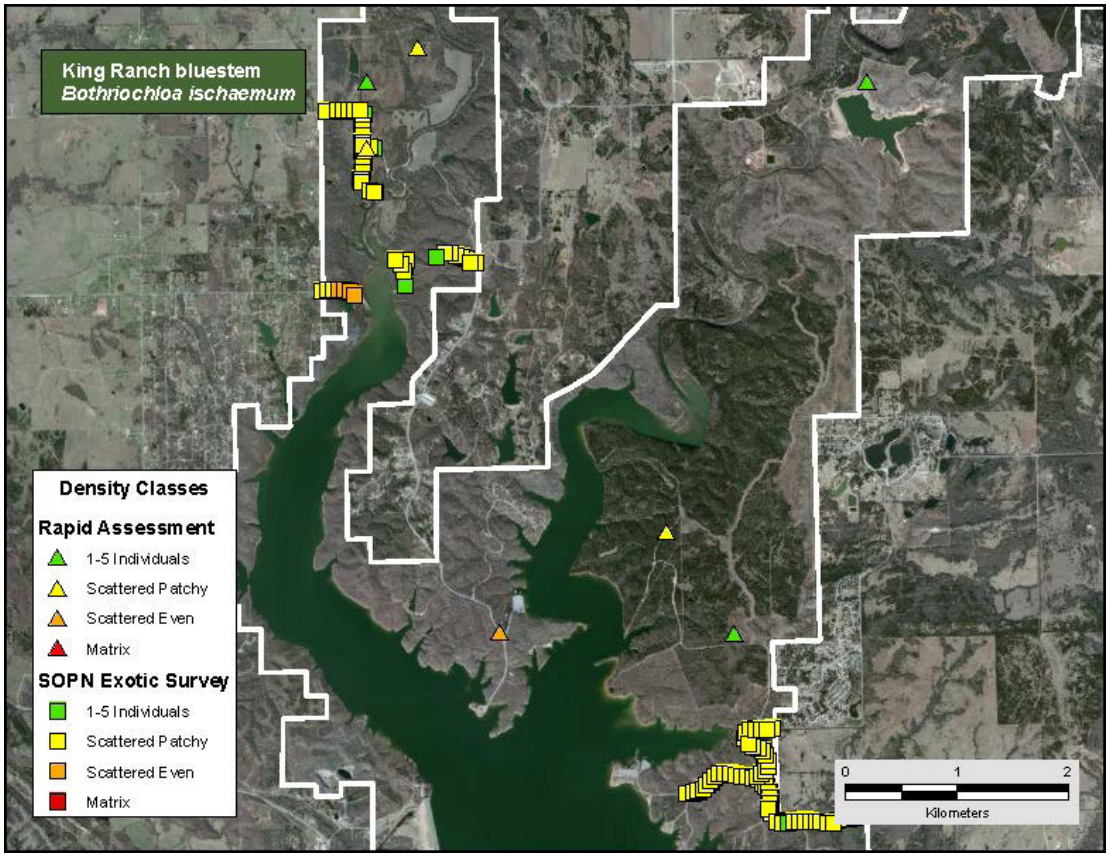


Figure 4.1.2-4. *Bothriochloa ischaemum* plant density based on surveys conducted during SOPN's 2012-2014 annual monitoring and SOPN's 2014 rapid assessment.

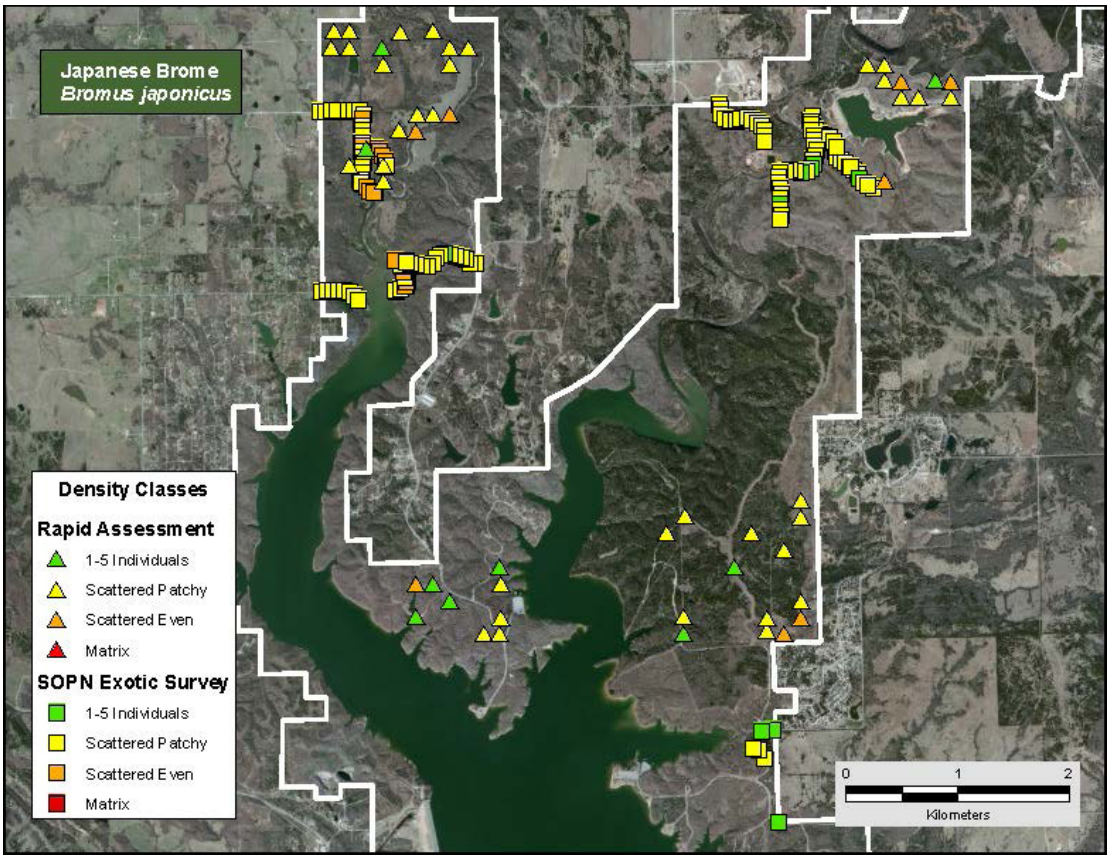


Figure 4.1.2-5. *Bromus japonicus* plant density based on surveys conducted during SOPN's 2012-2014 annual monitoring and SOPN's 2014 rapid assessment.

and *Trifolium dubium* (small hop clover) occurred in density class 3 in one block each.

Measure
Distribution of Exotic Plants

The distribution measure evaluates the occurrence of exotic plant species in different areas of the recreation area, including in different habitats and areas that have received different treatment for exotic plant infestations.

The distribution measure is the proportion of blocks or plots infested with exotic plants reported for each of the distinct areas surveyed in SOPN 2012-2014 vector monitoring (Table 4.10.2-7) and the 2014 rapid assessment (Table 4.10.2-8) (Horsley and Schafer 2014). This information shows whether the infestations of exotic species are widespread and found in multiple areas of the recreation area or restricted to certain areas.

Table 4.10.2-9 shows the number of different species found in along each of the vectors, and in the areas included in the 2014 rapid assessment.

SOPN Annual Exotic Plants Monitoring

Generally, the species with the greatest extent (e.g., found in more than 25% of the total blocks) also had the greatest distribution, and were found along all seven vectors. *Bothriochloa ischaemum* and *Bromus tectorum* were exceptions as they were absent along Trails 1 and 3 and the Sewage Treatment Road, although found in 48.9% and 27.4% of all the blocks monitored, respectively.

Bromus japonicus was particularly prevalent along the all the vectors, and was found in at least 82.5% of the blocks along each vector, except along the Cedar Blue and Buckhorn Roads were it was present in only 26.8% of the blocks.

Found along all seven vectors, *Sorghum halepense* was especially prevalent in the blocks along the Cedar Blue and Buckhorn Roads (88.4%), Sewage Treatment Road (85.7%), E1750 Road (93.8%), and the West Guy Sandy and Spur Roads (89.1%).

Table 4.10.2-7. Distribution of exotic plants found in Chickasaw NRA, with the proportion of infested blocks in each of the vectors surveyed during 2012-2014 SOPN monitoring.

Species	Cedar Blue & Buckhorn Rds (N=112)	Trail 3 (N=40)	Trail 1 (N=50)	Sewage Treatment Rd (N=24)	E1750 Rd (N=16)	W Guy Sandy & Spur Rds (N=48)	E Guy Sandy & Breezy Pt Rds (N=64)
Achillea millefolium	3.6%	45.0%	26.0%	25.0%	25.0%	43.8%	42.2%
Aegilops cylindrica		10.0%	18.0%	7.1%	6.3%	2.1%	3.1%
Bothriochloa ischaemum[1]	89.3%				87.5%	39.6%	65.6%
Bromus catharticus					25.0%	14.6%	34.4%
Bromus inermis[1]	0.9%						
Bromus japonicus[1]	26.8%	82.5%	90.0%	100.0%	100.0%	100.0%	96.9%
Bromus lanceolatus						2.1%	
Bromus tectorum[1]	47.3%				37.5%	37.5%	32.8%
Conium maculatum[1]						8.3%	20.3%
Coronilla varia[1]						2.1%	
Cynodon dactylon[1]	58.0%	2.5%	4.0%	100.0%	62.5%	16.7%	85.9%
Datura stramonium	1.8%						
Daucus carota						6.3%	10.9%
Erodium cicutarium	0.9%						3.1%
Euphorbia spp.[1]	0.9%				12.5%	4.2%	7.8%
Kummerowia stipulacea	39.3%				43.8%	6.3%	10.9%
Lactuca serriola	31.3%	30.0%	32.0%	64.3%	93.8%	85.4%	62.5%
Lathyrus hirsutus					12.5%	12.5%	6.3%
Lespedeza cuneata[1]	47.3%	15.0%	12.0%	17.9%	87.5%	64.6%	23.4%
Lolium perenne[2]		42.5%	22.0%	17.9%	6.3%	45.8%	40.6%
Lonicera japonica[1]	1.8%			7.1%	12.5%		6.3%
Medicago lupulina	3.6%	2.5%	6.0%	3.6%	12.5%	18.8%	
Medicago minima	74.1%	42.5%	18.0%	39.3%	93.8%	60.4%	64.1%
Medicago sativa					18.8%	4.2%	1.6%
Melilotus spp.	3.6%		2.0%	28.6%	31.3%	81.3%	37.5%
Onopordum acanthium[1]	12.5%						
Paspalum dilatatum	12.5%				37.5%	2.1%	6.3%
Poa annua[1]						2.1%	1.6%
Polygonum convolvulus					12.5%		1.6%
Rumex crispus					6.3%	6.3%	1.6%
Sonchus asper	3.6%				81.3%	58.3%	28.1%
Sorghum halepense[1]	88.4%	17.5%	24.0%	85.7%	93.8%	52.1%	89.1%
Taraxacum officinale	2.7%				6.3%	2.1%	1.6%
Torilis arvensis	10.7%	37.5%	70.0%	10.7%	68.8%	29.2%	23.4%
Tragopogon dubius		15.0%	8.0%		37.5%	18.8%	
Vicia sativa		12.5%	4.0%				

[1]Species considered to be of highest or high concern in (Table 4.10.2-1) are highlighted in the darker tone.

[2]Species of special concern (Table 4.10.2-1) are highlighted in the lighter tone.

Table 4.10.2-8. Distribution of exotic plants found in the rapid assessment areas in Chickasaw NRA, with the proportion of infested plots in each of the areas monitored during the 2014 rapid assessment.

Species	Cedar Blue (N=81)	Guy Sandy (N=65)	The Point (N=26)	Veterans Lake (N=22)
Achillea millefolium	8.6%	35.4%	34.6%	
Bothriochloa ischaemum[1]	2.5%	4.6%	3.8%	4.5%
Bromus catharticus	1.2%		3.8%	4.5%
Bromus japonicus[1]	17.3%	30.8%	34.6%	45.5%
Bromus tectorum[1]			3.8%	4.5%
Carduus nutans[1]	6.2%			
Chenopodium album	1.2%		3.8%	
Conium maculatum[1]		12.3%		
Convolvulus arvensis[1]		1.5%		
Coronilla varia[1]			11.5%	
Cynodon dactylon[1]		1.5%	3.8%	
Daucus carota		1.5%		4.5%
Echinochloa colona[1]		1.5%		
Euphorbia spp.[1]	2.5%	1.5%	7.7%	
Kummerowia stipulacea			3.8%	
Lactuca serriola	24.7%	10.8%	73.1%	13.6%
Lathyrus hirsutus		1.5%		
Lespedeza cuneata[1]	16.0%	20.0%	34.6%	4.5%
Medicago minima	1.2%	1.5%	7.7%	27.3%
Medicago sativa			3.8%	
Melilotus spp.	9.9%	10.8%	15.4%	4.5%
Mentha spicata			3.8%	
Paspalum dilatatum	1.2%			
Rumex crispus		3.1%		
Sonchus asper	8.6%	6.2%	23.1%	
Sorghum halepense[1]	3.7%	49.2%	3.8%	13.6%
Torilis arvensis	12.3%	13.8%	26.9%	36.4%
Tragopogon dubius	2.5%		3.8%	0.0%
Trifolium arvense		3.1%		
Trifolium dubium	1.2%	1.5%		

[1]Species considered to be of highest or high concern in (Table 4.10.2-1) are highlighted in the darker tone.

Medicago minima, *Lactuca serriola*, *Torilis arvensis* (spreading hedgeparsley) and *Achillea millefolium* (common yarrow), all ranked as medium for exotic plant impact, were also found along all seven vectors.

While found along the seven vectors, the occurrence of *Cynodon dactylon* was limited along Trails 1 and 3, where only 2.5% and 4.0% of the blocks respectively contained the species. *Lespedeza cuneata* was also found along each vector, but it was most prevalent along E1750 Road, where 87.5% of the blocks were infested.

Each vector contained at least 13 different exotic plant species. The vectors in the Guy Sandy (West Hunting) area had the most exotic plants species along them. Twenty-six exotic species were present along E1750 Road, 28 along West Guy Sandy and the Spur Roads, and 29 species were along the East Guy Sandy and Breezy Point Roads. The vectors in the vicinity of Veterans Lake were the least infested with exotic plant species: Trails 1 and

Table 4.10.2-9. Number of species found in each location during SOPN monitoring.

Location	Monitoring Type	# of Species
Cedar Blue & Buckhorn Rds	Vector	22
Trail 3	Vector	13
Trail 1	Vector	14
Sewage Treatment Rd	Vector	13
E1750 Rd	Vector	26
East Guy Sandy & Breezy Point Roads	Vector	29
West Guy Sandy and Spur Rds	Vector	28
Cedar Blue	Rapid Assess.	16
Guy Sandy	Rapid Assess.	20
The Point	Rapid Assess.	20
Veterans Lake	Rapid Assess.	13

3 had 13 and 14 different species respectively, and the Sewage Treatment Road also had 13 different exotic plant species found along it.

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As in the case of the vectors, exotic plant species with higher extent generally had a greater distribution. All but one species (*Achillea millefolium*) that occurred in more than 10% of the plots also occurred in all four rapid assessment areas. Similarly, with few exceptions, species with limited extent (less than 10%) occurred in just one or two rapid assessment areas. *Bothriochloa ischaemum* occurred in only 3.6% of the plots, but was found in all four rapid assessment areas. *Medicago minima* was also found in all four areas despite occurring in only 5.2% of the total plots. *Sonchus asper* (spiny sowthistle), *Bromus catharticus* and *Tragopogon dubius* (western salsify) were each found in three areas.

Additionally, species that were found in only one rapid assessment area usually had a very limited extent in that one area, and were found in less than 5% of the plots of that area. However, *Conium maculatum* was found in 12.3% of the plots in the Guy Sandy area, and *Coronilla varia* was found in 11.5% of the plots at The Point.

Some species were much more prevalent in one of the rapid assessment areas than they were in the other areas. For example, *Lactuca serriola* was present in only 24.5% of the total plots but was found in 73% of the plots at The Point. And *Sorghum halepense* was at found in nearly half (49.2%) of the plots in the Guy Sandy area, but in no more than 13.6% in the other three areas.

The Guy Sandy and The Point areas had the most exotic plant species with 20 exotic plant species each. Sixteen different species were present in the Cedar Blue area, and 12 species at Veterans Lake. Not only did the Veterans Lake area have the fewest number of species, but 45.5% of the plots there did not contain exotic plant species at all. Approximately 41% of the plots in the Cedar Blue area did not contain exotic plants, and 20% of the plots in the Guy Sandy area were free of exotic plants. At The Point, only 3.8% of the plots did not contain exotic plants.

4.10.3. Reference Conditions

Whenever an exotic plant is present that has the biological characteristics to alter native plant communities, there is cause for concern. However, early detection of these species provides managers with the necessary information to apply a rapid response management strategy before the exotic plant becomes established. If a rapid response is not implemented, the exotic plant may become established and potentially degrade the integrity of the native plant communities.

Our good, moderate, and significant concern reference conditions are based upon both an exotic plant's ability to alter native plant communities as well as its prevalence (i.e., extent, density, and distribution). A summary of the reference conditions is shown in Table 4.10.3-1.

A good reference condition is the capability for primary communities to be maintained. By this, we mean that ecological attributes (e.g., species composition, structure, etc.) and natural processes remain within the natural variation for the community type.

Table 4.10.3-1. Descriptions for determining condition based on exotic plant potential to alter native plant communities impact ranking and degree of prevalence.

Prevalence of Exotic Plant	Potential to Alter Native Plant Communities Impact Ranking			
	Low	Medium	High	Highest
Low	Good Condition[1]	Good Condition[1]	Moderate Condition	Significant Condition
Medium	Variable[1]	Moderate Condition	Significant Concern	Significant Concern
High	Variable[1]	Moderate Condition	Significant Concern	Significant Concern

[1]Species in these cells may warrant further consideration of condition on a case by case basis.

A moderate condition is assigned to exotic plant species that have been ranked as high concern but prevalence remains low, or when a plant has been assigned a medium impact ranking score and is found in medium to high prevalence.

A condition of significant concern is assigned when an exotic plant is ranked as highest for its ability to alter native plant communities, or ranked as highest and is found in at least at medium prevalence.

Further consideration of condition is warranted on a case by case basis, especially for species with low prevalence, or when a species' prevalence may be increasing. Given the early detection and rapid response model for the control of exotic plants, species with low prevalence may be considered to be in moderate condition even though they may have low or medium impact rankings. Further, species that scored low in the Hiebert and Stubbendieck's (1993) innate ability to become a pest ranking system, may be considered to be in moderate condition depending on the individual characteristics of a species, and the unique attributes of the NPS site, regardless of prevalence.

4.10.4. Condition and Trend

Forty-three exotic species were found within Chickasaw NRA during monitoring by the SOPN between 2012 and 2014 (Folts-Zettner and Sosinski 2012a; 2013; 2014, and Horsley and Schafer 2014). Altogether, 94 species of exotic plants (Appendix E) have been recorded in the recreation area (Folts-Zettner 2014).

Sixteen of the species found during SOPN's annual and one-time rapid assessment monitoring are considered to be the highest or high concern based upon their potential to alter native plant communities (Table 4.10.2-1). Combining the results of the significance of impact indicator with prevalence data from the three measures, twelve species are in the condition of significant concern (Table 4.10.4-1). Of these twelve species, *Bothriochloa ischaemum*, *Sorghum halepense*, *Bromus japonicus* and *Cynodon dactylon* were highly prevalent in the recreation area. Bromus tectorum and Lespedeza cuneata had medium prevalence. The other six species that were ranked at highest or high concern for their innate ability to become a pest were not prevalent in the NRA.

Nine species were determined to be in moderate condition based on the combination of their exotic plant impact ranking and prevalence in the park. One species, *Lolium perenne*, is of special concern.

<u>Condition of Significant Concern Species with High Prevalence</u>

Based on combining the two indicators with four measures, four species are in the condition of significant concern with high

Table 4.10.4-1. Exotic species found within Chickasaw NRA that are considered to have the most impact to native habitats throughout the recreation area based upon combined indicators and measures.

Scientific Name	Common Name	Rationale for Rating[1]
Condition of Significant Concern (with highest or high impact and high prevalence)		
Bothriochloa ischaemum	king ranch bluestem	King ranch bluestem was found along 48.9% of the vectors monitored in 2012-2014, but in only 3.6% of the rapid assessment plots. The density of the infestations were mostly at density class 2, scattered patchy. The species was also widely distributed, and found in all monitored areas except along Trails 1 and 3, and the Sewage Treatment Road. Ranked as highest concern for its ability to become a pest, this species' impact on native plant communities includes its great seed production and its thick basal growth that can displace native species and decrease plant and animal biodiversity. This grass can become a monoculture when left unmanaged. It also adds to fire threat by providing abundant fine fuel (Folts-Zettner and Sosinski 2012b).
Sorghum halepense	Johnsongrass	A highly invasive species that is very disruptive to natural ecosystems, Johnsongrass was ranked as highest concern for its innate ability to become a pest. *Sorghum halepense* was highly prevalent in the NRA, and was found in 66.8% of the vector blocks, and 20.1% of the rapid assessment plots. It occurred most often in density class 2, scattered patchy, although 17.9% of the rapid assessment plots were in density class 3, scattered even, and in 7.7% of the plots, Johnsongrass formed the matrix. The species also was widely distributed and found in all monitored areas. Johnsongrass has the capacity to colonize large areas, and once established, Johnsongrass persists in the landscape despite eradication efforts (Folts-Zettner and Sosinski 2012b).
Bromus japonicus	Japanese brome	With a high significance of exotic plant impact, Japanese brome was also highly prevalent in the recreation area. It was present in 73.2% of the vector blocks and 26.3% of the rapid assessment plots. It occurred predominately in density class 2, scattered patchy, although 15.1% of the rapid assessment plots were in density class 3, scattered even. *Bromus japonicus* also had wide distribution and found in along all vectors and in all rapid assessment plots. The species adds biomass to the ecosystem and outcompetes native cool season grasses.
Cynodon dactylon	Bermudagrass	This sod-forming grass has a tendency to form a monoculture and has a very adverse impact on native wildflower populations (Folts-Zettner, SOPN biologist, personal communication, 2014). It was found in nearly half (47.2%) of the blocks along the vectors, including in all the blocks along the Sewage Treatment Road, and 85.9% of the blocks along the West Guy Sandy and Spur Roads. It was present in only 1% of the rapid assessment plots.
Condition of Significant Concern (with highest or high impact and medium prevalence)		
Bromus tectorum	cheatgrass	Cheatgrass is a highly invasive plant that can have a significant adverse impacts on natural ecosystems. In Chickasaw NRA, it was found in 27.4% of the vector blocks, and 1% of the rapid assessment plots. It was not present along the Trails 1 and 3 vectors, and in the Cedar Blue and Guy Sandy rapid assessment areas. It was present in 47.3% of the blocks along the Buckhorn and Cedar Blue Roads.
Lespedeza cuneata	sericea lespedeza	Sericea lespedeza was present in 36.3% of the vector blocks and 18% of the rapid assessment plots. It was most prevalent along E1750 Road. This former agricultural species has the ability to form dense monocultures and outcompete and shade out native plants.
Condition of Significant Concern (with highest or high impact and lower prevalence)		
Bromus inermis	smooth brome	This highly invasive exotic brome was found in one block along the Cedar Blue Road during SOPN monitoring.
Conium maculatum	poison hemlock	Poison hemlock was found in 4.7% of the total high priority vector blocks, but only along the East Guy Sandy and Breezy Point Roads, and the West Guy Sandy and Spur Roads. During the rapid assessment, it was also only found in the Guy Sandy area where it was present in 12.3% of the plots. Folts-Zettner (SOPN biologist, personal communication, 2014) has observed that this species has the ability to invade and dominate an understory.
Convolvulus arvensis	field bindweed	*Convolvulus arvensis* was present in one rapid assessment plot in the Guy Sandy area. Field bindweed is extremely difficult to control once established.
Coronilla varia	purple crownvetch	Purple crownvetch was found in one block during annual SOPN monitoring, and in three rapid assessment plots. Ranked as highest for its potential to alter native plant communities, the species is used for erosion control on lands adjacent to the recreation area (Folts-Zettner, SOPN biologist, personal communication, 2014)

[1]The rationale is comprised of the four measures: a species' innate ability to become a pest, and the current extent, density and distribution of the exotic plant.

Table 4.10.4-1. Exotic species found within Chickasaw NRA that are considered to have the most impact to native habitats throughout the recreation area based upon combined indicators and measures (continued).

Scientific Name	Common Name	Rationale for Rating[1]
Lonicera japonica	Japanese honeysuckle	While not found in the 2014 rapid assessment, Japanese honeysuckle was found in 2.8% of the vector blocks. This plant is able to reproduce both vegetatively and by seed, has a great potential for dispersal, and is known to cause high impacts in natural areas. It is also difficult to control because of a strong root system and it can outcompete natives via underground competition.
Poa annua	annual bluegrass	*Poa annua* was found in one block along the Breezy Point Road and one block adjacent to the West Guy Sandy Road. This species was ranked in the highest category for its innate ability to become a pest, and is also extremely difficult to control.
Moderate Condition (with high impact and low prevalence)		
Carduus nutans	nodding musk thistle	Nodding musk thistle was located only during the rapid assessment of the Cedar Blue area where it was present in 5 (6.2%) plots. It was ranked as high for exotic plant impact.
Echinochloa colona	jungle ricegrass	*Echinochloa colona* was documented in one rapid assessment plot in the Guy Sandy area.
Euphorbia spp.	spurge	Spurge was ranked as having a high innate ability to become a pest, as it reproduces both vegetatively and by seed, is many-seeded, and has great potential for long-distance dispersal. It was detected in only 2.8% of the blocks along high priority vectors, and in 2.6% of the rapid assessment plots.
Onopordum acanthium	Scotch thistle	Scotch thistle is highly competitive with native plants and its presence can degrade native grasslands, wildlife habitat and recreation sites. It was present in 12.5% of the blocks along the Cedar Blue and Buckhorn Roads, usually in density class 1, 1-5 individuals.
Moderate Condition (with medium impact and high prevalence)		
Lactuca serriola	prickly lettuce	Prickly lettuce was present in 49.4% of the vector blocks and in 24.2% of the rapid assessment plots. The species was also widely dispersed being found along all vectors and in all rapid assessment areas. It occurred in density class 2, scattered patchy, more than half of the time. Prickly lettuce is very drought tolerant and produces abundant seeds.
Medicago minima	burr medick clover	Burr medick clover was found in 57.3% of the blocks along the high priority vectors and was also found in 5.2% of the rapid assessment plots. It usually occurred in density class 2, scattered patchy.
Moderate Condition (with medium impact and medium prevalence)		
Achillea millefolium	common yarrow	Common yarrow was found in 26.3% of the high priority vector blocks and in 19.6% of the rapid assessment plots. It was widely distributed and found along all seven monitored vectors and in all rapid assessment areas with the exception of Veterans Lake. It usually was present in density class 2, scattered patchy.
Sonchus asper	spiny sowthistle	Found in 17.6% of the vector blocks and 8.8% of the rapid assessment plots, spiny sowthistle has medium prevalence in Chickasaw. *Sonchus asper* was found along four of the vectors, and in three rapid assessment areas, and most often occurred in density class 1, 1-5 individuals. The species puts out abundant seeds that germinate only on disturbed ground.
Torilis arvensis	spreading hedgeparsley	Spreading hedgeparsley was present in 31.6% of the blocks monitored along high priority vectors, and in 17% of the rapid assessment plots, usually in density class 2, scattered patchy. The species was widespread and found along all vectors and in all rapid assessment areas. The seeds are easily spread by animals and people.
Species of Special Concern		
Lolium perenne	perennial ryegrass	While perennial ryegrass was ranked as low for its potential to alter native plant communities, it was designated a species of special concern (Folts-Zettner, SOPN biologist, personal communication, 2014) because its competitiveness in the Chickasaw area. It was found in 22.9% of the blocks along the high priority vectors, in density class 2, scattered patchy, more than 70% of the time. It was not detected during the rapid assessment.

[1]The rationale is comprised of the four measures: a species' innate ability to become a pest, and the current extent, density and distribution of the exotic plant.

prevalence. Of these four species, two, *Bothriochloa ischaemum* and *Sorghum halepense,* were ranked of highest concern for their innate ability to become a pest.

Bothriochloa ischaemum can dominate grassland communities, and reduce insect, landbird, and mammal diversity, and is difficult to manage (Institute for the Study of Invasive Species 2014). It had wide extent along the vectors being present in 48.9% of blocks. It was highly prevalent along the Buckhorn and Cedar Blue Roads where it was found in 89.3% of the blocks, and E1750 Road where it was in 87.5%. But the species was not found along Trails 1 and 3 or along the Sewage Treatment Road. The occurrence of king ranch bluestem in the interior was much more limited as it was found in only 3.6% of the rapid assessment plots. But it was widely distributed as it was found in all four rapid assessment areas. The species also was usually found in density class 2, scattered patchy.

Sorghum halepense was present in 66.8% of the blocks surveyed during vector monitoring, and in 20.1% of the plots visited during the 2014 rapid assessment. It was particularly prevalent along the Buckhorn and Cedar Blue Roads, Sewage Treatment Road, E1750 Roads, and the West Guy Sandy and Spur Roads where it occurred in more than 85% of the blocks. The species was less prevalent in the rapid assessment areas, except for the Guy Sandy area where it was in nearly half of the plots. Johnsongrass was also widely distributed as it was found along all vectors and in all rapid assessment areas.

The density of Johnsongrass was usually in density class 2, scattered patchy. But 17.9% of the rapid assessment plots were in density class 3, scattered even, and 7.7% were density class 4, matrix.

Johnsongrass is a highly invasive species that can outcompete native grasses. It reproduces both by seed and from rhizomatous roots, and grows well in disturbed sites (Institute for the Study of Invasive Species 2014). The species is also very difficult to eradicate. Johnsongrass is particularly prevalent in an old agriculture field in the Guy Sandy area (Folts-Zettner, SOPN biologist, personal communication, 2014).

Exotic bromes are well known to dramatically change the character of an ecosystem, including major shifts in community composition and structure (Knapp 1996), as well as substantial alteration of fire regimes (Whisenant 1990). In many cases these changes have become, for all practical purposes, irreversible (Knapp 1996). Exotic bromes also add biomass to the ecosystem, and outcompete other cool season grasses (Folts-Zettner, SOPN biologist, personal communication, 2014). Five species of bromes were found in Chickasaw during monitoring, including three species (*Bromus inermis*, B*romus japonicus* and *Bromus tectorum*) of highest or high concern for their significant of impact.

B*romus japonicus* is the only species of brome that was highly prevalent in the recreation area. It was found in 73.2% of the total vector blocks, but in more than 82% of blocks along vectors except the Cedar Blue and Buckhorn Roads where it was present in only 26.8% of the blocks. It was found in 26.3% of the rapid assessment plots. The species mostly occurred in density class 2, scattered patchy, but was also occurred in density class 3, scattered even, in 15.1% of the rapid assessment plots.

Cynodon dactylon is a very invasive grass that spreads by rhizomatous roots, and has an especially adverse impact on native wildflowers as it has a tendency to establish monocultures (Folts-Zettner, SOPN biologist, personal communication, 2014). It was prevalent along the vectors, being found in 47.2% of the blocks, and present along all the monitored vectors. Bermudagrass was particularly prevalent along the Sewage Treatment Road where it occurred in 100% of the blocks, and the West Guy Sandy and Spur Roads where it was present in 85.9% of the blocks. The extent of the species along Trails 1 and 3 was minimal, being found in 2.5% and 4.0% of the blocks, respectively. Bermudagrass occurred almost exclusively in density class 2, scattered patchy, or higher.

While *Cynodon dactylon* was prevalent along the vectors, there has been little spread of the species to the interior. Bermudagrass was detected in only 1% of the rapid assessment plots. It was found in one plot each in the Guy Sandy and The Point areas. The species is extremely difficult to control once established.

Condition of Significant Concern Species with Medium Prevalence

Bromus tectorum and *Lespedeza cuneata,* both ranked as highest for their potential to alter native plant communities, were found in medium prevalence in Chickasaw NRA.

From a standpoint of significance of impact to a park's native grassland community, *Bromus tectorum* is one of the highest exotic plant concerns (Folts-Zettner SOPN biologist, personal communication, 2014). B*romus tectorum* has most of the adverse impacts to native plant communities that exotic bromes have, and is especially competitive during periods of drought. Cheatgrass was found in nearly half the blocks along the Buckhorn and Cedar Blue Roads, and in approximately one third of the blocks of the vectors monitored in the Guy Sandy area (E1750, East Guy Sandy, Breezy Point, West Guy Sandy and Guy Sandy Spur Roads). The occurrence of *Bromus tectorum* was mostly limited to the vectors as it was found in only 1% of the rapid assessment plots.

Lespedeza cuneata was widely distributed in the recreation area and was found along all vectors in and in all rapid assessment areas. It usually occurred in density class 2, scattered patchy. Overall, it was present in 36.3% of the high priority vector blocks, but was most prevalent along E1750 Road where it occurred in 87.5% of the blocks. It was found in 18% of the rapid assessment plots.

Sericea lespedeza can shade out other plants, form dense monocultures and release allelopathic compounds that inhibit the germination of other species. (Colorado Noxious Weed Advisory Committee 2008). The species can quickly invade disturbed areas.

Condition of Significant Concern Species with Low Prevalence

Six species were ranked as the highest concern for their innate ability to become a pest, but had low prevalence in the recreation area. These species are *Bromus inermis*, *Conium maculatum, Convolvulus arvensis, Coronilla varia, Lonicera japonica* and *Poa annua*.

Bromus inermis was detected in one block along the Cedar Blue Road. Smooth brome presents the same ecological threat that other exotic bromes do, is very drought resistant, and a threat to grasslands.

Conium maculatum was found in 20.3% of the blocks along the West Guy Sandy and Spur Roads, and 8.3% of the blocks along the East Guy Sandy and Breezy Point Roads. It was also present in 12.3% of the rapid assessment plots in the Guy Sandy area. This species, especially its seeds, stems and roots, contains toxins and its presence can degrade wildlife habitat and cattle forage (USDA 2012). It reproduces abundantly by seeds, which have a high germination rate. The species prefers moist habitats, but can survive in drier areas. It may act as a pioneer species invading disturbed areas and displacing native species (TexasInvasives.org 2006).

Convolvulus arvensis was not identified along the vectors, but it was present in one rapid assessment plot in the Guy Sandy area. Once field bindweed gets established, it is very difficult to control and is highly competitive with native species.

Coronilla varia was found in one block along the Breezy Point Road during annual SOPN monitoring, and in three plots in The Point rapid assessment area, including one plot in which the plant occurred in density class 3, scattered even. This species reproduces by seeds and spreads by rhizomes. Purple crownvetch is used for erosion control on lands adjacent to the recreation area (Folts-Zettner SOPN biologist, personal communication, 2014). Park staff conducted control work once on this plant (Folts-Zettner SOPN biologist, personal communication, 2014).

Lonicera japonica is known to cause high impacts in natural areas and reproduces both vegetatively and by seed. It is difficult to control because of its strong root system. Japanese honeysuckle was not present in any of the rapid assessment plots, but was present in 2.8% of the vector blocks. While the extent of the species was low, it was present along four of the seven vectors.

Poa annua was only found in one block each along the Breezy Point and West Guy Sandy Roads. Given the extreme difficulty of controlling *Poa annua* invasions and its extremely high potential to alter native plant communities, the detections of this species is of especially significant concern.

Moderate Condition Species with High Impact and Low Prevalence

Carduus nutans, Echinochloa colona, *Euphorbia spp.* and *Onopordum acanthium* were ranked as high for their potential to alter native plant communities but had low prevalence in the recreation area. *Carduus nutans* and *Onopordum acanthium*, both species of exotic thistle, are also noxious plant species in Oklahoma.

Carduus nutans was not found along the vectors, but was present in 6.2% of the plots in the Cedar Blue rapid assessment area. This exotic thistle produces abundant seed, can outcompete native species, and is difficult to control.

Echinochloa colona was present only in one rapid assessment plot in the Guy Sandy area. Jungle ricegrass is an annual, and each plant produces thousands of seeds that can be dispersed great distances by animals.

While the nativity of *Euphorbia spp.* in Texas is in question, it is exotic in Oklahoma. It was present in 2.8% of the blocks along the high priority vectors, and in 2.6% of the rapid assessment plots. While the extent of the plant was low, it had relatively wide distribution, and was found along four vectors, and in three rapid assessment areas.

Onopordum acanthium was present in 3.9% of the blocks along the high priority vectors, but only along the Cedar Blue and Buckhorn Roads where it was found in 14 blocks. This exotic thistle reproduces only by seed, but is a prodigious seeder whose seeds remain viable in the soil for many years. Most of the infestations in the recreation area were in density class 1, 1-5 individuals per block.

Moderate Condition Species with Medium Impact and Medium Prevalence

Two species were prevalent in the park that were ranked according to Hiebert and Stubbendieck (1993) as having a medium potential to alter native plant communities: *Lactuca serriola* and *Medicago minima*.

Lactuca serriola was prevalent in the recreation, with high extent, low to medium density, and wide distribution. It occurred in 49.4% of the vector blocks, and was particularly prevalent along E1750 Road (93.8%) and East Guy Sandy and Breezy Point Roads (85.4%). It also occurred in more than 60% of the blocks along the Sewage Treatment Road and West Guy Sandy and Spur Roads. Prickly lettuce occurred in density class 2, scattered patchy, just over half of the time and was present in density class 1, 1-5 individuals, the rest of the time. Prickly lettuce was found in all rapid assessment areas, but was most prevalent at The Point where it was detected in 73% of the plots. Prickly lettuce prefers disturbed soils, and is very drought tolerant.

Medicago minima was also prevalent at Chickasaw. It was detected in 57.3% of vector blocks and in 5.2% of the rapid assessment plots. It was also widely distributed, and was found along all vectors and in all four rapid assessment areas. It was most prevalent along E1750 Road where it occurred in 93.8% of blocks. It was also present in 27.3% of plots in the Veterans Lake rapid assessment area. The species was almost always found in density class 2, scattered patchy, or higher. Burr medick clover thrives in disturbed areas.

Moderate Condition Species with Medium Impact and Medium Prevalence

A moderate condition ranking was indicated for three species (*Achillea millefolium*, *Sonchus asper*, and *Torilis arvensis*) with medium potential to alter native plant communities

that had medium prevalence in the recreation area.

Achillea millefolium was present in 26.3% of the vector blocks and was the species with the highest extent in the rapid assessment, being found in 19.6% of plots. Common yarrow was also widely dispersed, and found in adjacent to all vectors and in three of the four rapid assessment areas. It most often was present in density class 2, scattered patchy, but one rapid assessment plot was recorded as density class 3, scattered even. This species reproduces from both seeds and rhizomes, but is known to have limited ecological impact in natural areas.

Sonchus asper occurred in 17.6% of vector blocks and in 8.8% of rapid assessment plots. It was most prevalent along E1750 Road where it was present in 81.3% of the blocks. It also occurred in more than 50% of the blocks along the East Guy Sandy and Breezy Point Roads. Spiny sowthistle reproduces only by seed, but produces abundant seeds that are easily dispersed.

Torilis arvensis also had medium prevalence in the recreation area. It was present in 31.6% of the vector blocks and in 17% of the rapid assessment plots, occurring in density class 2, scattered patchy, approximately 70% of the time. It occurred in 70% of the blocks along Trail 3, and in 68.8% of the blocks along E1750 Road. Spreading hedgeparlsey also had wide distribution and was found in all monitored vectors and rapid assessment areas.

Species of Special Concern

SOPN biologist Tomye Folts-Zettner identified *Lolium perenne* as a species of special concern (personal communication, 2014). The species is especially competitive in the Chickasaw area, with potentially significant impact on native wildflowers and the ability to form monocultures. Perennial ryegrass is commonly used in lawns and for erosion control.

At Chickasaw NRA, *Lolium perenne* was found in 22.9% of the blocks along the high priority vectors. It had the greatest extent along the East Guy Sandy and Breezy Point Roads and the West Guy Sandy and Spur Roads where it was present in 45.8% and 40.6% of the blocks, respectively. The species was present along six of the seven monitored vectors, and usually found in density class 2, scattered patchy. It was not detected in the 2014 rapid assessment.

Trend

The rotating panel design of the SOPN monitoring protocol provides quantitative data on the occurrence of exotic plant infestations along high priority vectors that provides information on the trend of exotic plant species at Chickasaw NRA. Because the SOPN replaced the vector that was monitored in 2009 with a higher priority vector in 2012 (Folts-Zettner, SOPN biologist, personal communication, 2014), we limited this trend analysis to data collected in 2010-2011 (Folts-Zettner and Sosinski 2010; 2012a) and 2013-2014 (Folts-Zettner and Sosinski 2013; 2014) in order to compare data along the same vectors. However, one vector with ten blocks (Trail Access Road) that was monitored in 2010 was not resampled in 2013, and was replaced with the Sewage Treatment Road (28 blocks).

Table 4.10.4-2 shows the extent of exotic species found in SOPN monitoring in 2010-2011 and in 2013-2014. Extent, or proportion of infested blocks, was the only measure utilized for the trend determination.

Overall, the number of exotic plant species found along the vector increased from the first panel rotation (2010-2011) from 30 species to 34 species in the second rotation (2013-2014), including 11 species detected in the second rotation that were not present in 2010-2011. Seven species that were recorded in the first panel rotation were not found in the second rotation, including *Albizia julibrissin* (mimosa tree), *Eragrostis cilianensis* (stinkgrass), and *Melia azedarach* (Chinaberry) that were in 38.6%, 25.0% and 10.1% of the blocks, respectively in 2010-2011 (Folts-Zettner and Sosinski 2012b).

The extent of the 11 species with rankings as highest or high potential to alter native plant communities found in the monitored

Table 4.10.4-2. Extent of exotic plants found during 2010-2011 (first panel) and 2013-2014 (second panel) SOPN annual monitoring.

Species	2010-2011 (N=228)	2013-2014 (N=246)
Bromus japonicus[1]	75.0%	94.3%
Lactuca serriola	0.4%	57.7%
Sorghum halepense[1]	46.5%	56.9%
Medicago minima	22.4%	49.6%
Cynodon dactylon[1]	15.4%	42.3%
Torilis arvensis	44.3%	41.1%
Achillea millefolium	ND	36.6%
Lolium perenne[2]	26.3%	33.3%
Lespedeza cuneata[1]	32.9%	31.3%
Bothriochloa ischaemum[1]	24.1%	30.5%
Melilotus officinalis	28.9%	24.8%
Sonchus asper	ND	24.0%
Bromus tectorum[1]	10.1%	18.3%
Bromus catharticus	0.9%	13.4%
Tragopogon dubius	14.5%	10.6%
Aegilops cylindrica	ND	7.7%
Melilotus alba	35.5%	7.7%
Conium maculatum[1]	0.9%	6.9%
Kummerowia stipulacea	ND	6.9%
Medicago lupulina	35.1%	6.5%

Species	2010-2011 (N=228)	2013-2014 (N=246)
Lathyrus hirsutus	5.3%	4.9%
Paspalum dilatatum	ND	4.5%
Daucus carota	ND	4.1%
Euphorbia spp.[1]	3.5%	3.7%
Lonicera japonica[1]	12.7%	3.3%
Vicia sativa	ND	2.8%
Medicago sativa	2.6%	2.4%
Rumex crispus	ND	2.0%
Polygonum convolvulus	ND	1.2%
Taraxacum officinale	2.6%	1.2%
Erodium cicutarium	ND	0.8%
Poa annua[1]	ND	0.8%
Bromus lanceolatus	ND	0.4%
Coronilla varia[1]	0.4%	0.4%
Albizia julibrissin	38.6%	ND
Amaranthus retroflexus	1.8%	ND
Eragrostis cilianensis	25.0%	ND
Kochia scoparia	2.2%	ND
Lolium arundinaceum	0.4%	ND
Lolium pratense	0.9%	ND
Melia azedarach	10.1%	ND

ND = Not detected.

[1]Species considered to be of highest or high concern in (Table 4.10.2-1) are highlighted in the darker tone.

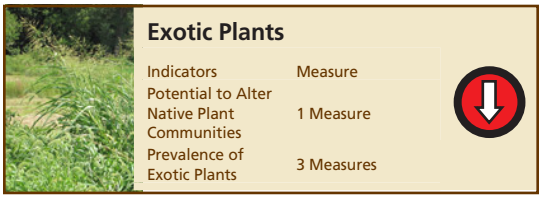
[2]Species of special concern (Table 4.10.2-1) are highlighted in the lighter tone.

Species not found in 2012-2014 monitoring were not ranked for exotic plant impact.

vectors either increased or were unchanged, with the exception of *Lonicera japonica*, which decreased from 12.7 to 3.3%. *Bromus japonicus* increased from 75.0% to 94.3%, *Sorghum halepense* from 46.5% to 56.9%, and *Cynodon dactylon* from 15.4% to 42.3%. *Lolium perenne,* the species of special concern, increased from 26.3% to 33.3%.

The extent of four other species increased significantly between the first and second rotations: *Lactuca serriola* from 0.4% to 57.7%, *Achillea millefolium* from not detected to 36.6%, *Sonchus asper* from not detected to 24% and *Medicago minima* from 22.4% to 49.6%.

Besides the seven species found in 2010-2011 monitoring that were not present in 2013-2014, the only species whose extent decreased significantly were *Melilotus alba* and *Medicago lupulina* (black medick clover) that decreased from 35.5% to 7.7%, and 35.1% to 6.5%, respectively.



Overall Condition and Trend

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

Table 4.10.4-3 Indicators, measures, and their contributions to the overall exotic plants condition rationale.

Indicator of Condition	Measure	Condition	Rationale for Condition.
Potential to Alter Native Plant Communities	Significance of Exotic Impact	Significant Concern	This measure is based on the premise that species with the highest innate ability to become a pest generally cause the most severe problems in natural ecosystems. Sixteen of the 43 species of exotic plants found during SOPN monitoring were ranked as having the highest or high innate ability to become a pest. Therefore, we consider this measure to be of significant concern.
Prevalence of Exotic Plants	Extent of Exotic	Significant Concern	Exotic plants were found in 98.6% of the blocks along high priority vectors. Thirty-six exotic species were found during monitoring between 2012-2014, including 10 species that were found in more than 25% of vector blocks. Thirty species were found during the 2014 rapid assessment, although the extent of exotic plants was less prevalent than in the vector monitoring. Exotic plants were not found in nearly 30% of plots, and individual species were found in less than 27% of the plots.
	Density of Exotic	Moderate	Most of the exotic species occurrences in Chickasaw NRA were in moderate to low densities in monitored parts of the park. Species were most often found in density class 2 (scattered patchy).
	Distribution of Exotic	Significant Concern	Exotic plants were found in widely distributed in the park, especially along the high priority vectors. Five species, including *Bromus japonicus* and *Sorghum halepense,* were found along all seven vectors and in all four rapid assessment areas.

Several factors contribute to an exotic's ability to threaten the integrity of a native ecosystem including its current extent, density, distribution and inherent ability to alter native plant communities. Thus, our measures for this resource were intended to capture different aspects of these contributing factors. A summary of how each measure and indicator contributed to the overall exotic plants condition assessment is in Table 4.10.4-3.

The potential for exotic species present in the NRA to alter native plant communities is of significant concern because 16 species (37% of the exotic species present) were ranked as highest or high for their significance of exotic plant impact based on their innate ability to become a pest.

Exotic plants also had a broad extent along the monitored vectors, with most monitored blocks infested. Only 1.4% of blocks along the high priority vectors did not contain exotic plants. The spread of exotic plants to the interior of the recreation area is not as extensive. Almost 30% of the rapid assessment plots did not contain exotic plants. Overall, the wide extent of exotic plants in the NRA, especially along the vectors, is of significant concern.

Exotic species mostly occurred in density class 2, scattered patchy, or density class 1, 1-5 individuals per block, with few records at density class 3, scattered even, or higher. These densities are at a level of moderate concern.

The distribution of exotic plant species was also at level of significant concern. Thirty-six of the 43 species found during 2012-2014 annual monitoring and the 2014 rapid assessment were found in multiple areas of the park. Five species were found in all areas monitored. Altogether, the prevalence

of exotic plants for the park is of significant concern.

By combining the four measures and evaluating the species individually, 12 exotic plant species were in a condition of significant concern, and nine species were in moderate condition (Table 4.10.4-1). One additional species, *Lolium perenne*, was designated of special concern.

The overall trend for the condition of exotic plants at the NRA was determined to be declining. The number of exotic species found in the recreation area increased from 30 to 34 from the first rotation (2010-2011) to the second rotation (2013-2014), including 11 species not present in the first rotation. The extent of most species increased also after the first rotation.

After analyzing all the available information about exotic plant species at Chickasaw NRA, we consider the overall condition for exotic plants to be of significant concern with a declining trend.

Level of Confidence/Key Uncertainties

The SOPN exotic plants monitoring program is designed to occur during a time of year when spring plants are still identifiable and rosettes are present for fall blooming plants. This strategic timing ensures the highest degree of detection. Further, with the three year rotation cycle, SOPN staff feel confident that they will identify new plants before they become established even if the plant is introduced right after the rotation cycle has been completed.

The 2014 rapid assessment provided a one-time snapshot of the condition of four areas that represent the major habitat types in the recreation area and that have had different types of treatment for exotic plant infestations.

A source of uncertainty in this assessment is what overall effect the recent drought has had on the condition of exotic plants, and especially the trend, at Chickasaw.

Another key uncertainty is the general variability in how a given exotic plant species will respond to localized conditions. What may be considered a non-threatening plant in one region may become a nuisance in a different region.

4.10.5. Sources of Expertise

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

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

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

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4.11. Breeding Landbirds

Indicators/Measures

- Species Occurrence (3 Measures)

Condition – Trend – Confidence



Good - Insufficient Data - Medium to 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). Birds have high body temperatures and rapid metabolisms, and they occupy high trophic levels. As such, changes in landbird populations may indicate 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 Southern Plains Network (SOPN) parks. The SOPN began annual monitoring of landbirds at Chickasaw NRA and the other SOPN parks in the spring (breeding season) of 2009.

Birds select habitat based on 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 in relating 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 are acknowledged in the agency's Organic Act: "to conserve . . . the wildlife therein . . . unimpaired for the enjoyment of future generations." Bird watching, in particular, is a popular, longstanding recreational pastime in the United States and forms the basis of a large and sustainable industry (Sekercioglu 2002).



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Figure 4.11.1-1 Northern Cardinal has been one of the species recorded in the highest numbers every year from 2009-2013 at Chickasaw NRA during RMBO surveys.

This section of the condition assessment addresses breeding landbirds at Chickasaw NRA, largely through the use of data from the annual network monitoring.

4.11.2. Data and Methods

In 2009, Rocky Mountain Bird Observatory (RMBO) began systematic surveys of birds at Chickasaw NRA as part of the SOPN Monitoring program. There are now five years of data for the park. Although these data will enable quantitative evaluation of trends in birds in the future (e.g., in occupancy), such analyses are only just now beginning to be explored (Rob Bennetts, SOPN, pers. comm.). Five years of data are about the minimum required to attempt such analyses, but additional years of data will render analyses more reliable. Therefore, for this assessment, we focus on species occurrence (presence/absence), focusing on what species are, or are not, observed at the Recreation Area.

The most recent data we have for occurrence of birds at the park 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 2009-2013 RMBO surveys at Chickasaw NRA (described below) to a 2003-2004 inventory for birds at the Recreation Area conducted by the Oklahoma Natural Heritage Inventory (ONHI; described below). This analysis compares information from 2003-2004 to 2009-2013- a relatively short time span.

Our analysis is not intended as a rigorous or quantitative comparison given the limitations of the available information; rather, it is intended as a crude qualitative indicator of major changes over time. To do this in the most meaningful way, we needed the sources to be as comparable as possible. 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 Recreation Area during other seasons. The 2003-2004 ONHI inventory was conducted between 20 May and 15 July 2003 (point counts); also, biologists spent several days in the spring of 2004 looking for species not detected in 2003. The RMBO surveys were conducted during the breeding season primarily in May. We focused our comparisons on those species for which Chickasaw NRA is within their normal breeding range. We made this determination based primarily on the Birds of North America (BNA) species accounts (Cornell Lab of Ornithology 2014). Given the potential for us to have made errors in determining whether the Recreation Area was within the normal breeding range from online and hard copy maps (GIS data were not available), we included for consideration species outside of their normal breeding range but within 100 miles of their breeding range edge. Unlike field guides that are often written by persons with general knowledge of birds, the BNA accounts for each species are written by persons that have extensive experience and knowledge working with that particular species. Consequently, these accounts constitute a comprehensive summary of our current knowledge for a given species (including range) written by experts for that species. Note that by "normal breeding range" we mean the area designated by the BNA accounts where a species is known to consistently breed. Some birds may breed in small numbers outside of these areas, however.

We further refined our comparisons to species for which reasonably suitable breeding habitat exists at the Recreation Area (since comparisons are based on the breeding season). We assigned each species to one of three breeding habitat classes (Table 4.11.2-1)

Table 4.11.2-1. Breeding habitat classes assigned to species reported to occur at Chickasaw NRA that are within or near their reported breeding ranges.

Breeding Habitat Class	Class Description
Exists	This class was assigned when the habitat at the Recreation Area is characteristic of habitats where a given species might be expected to breed.
Possibly Exists	This class was assigned when it was unlikely that the habitat at the Recreation Area 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 Recreation Area would support breeding by that species. This does not imply that the species would not occur at the Recreation Area in limited numbers or during other seasons, but rather that it would be unlikely to breed there.

based primarily on the input of avian expert Mr. Moez Ali (see Section 4.12.5, Sources of Expertise).

Spatial Context – Comparisons with Surrounding Region

We also evaluated species occurrence in a spatial context. Again, this is intended only as a qualitative indicator rather than a rigorous quantitate estimate (which will be possible in the future). For this assessment, we compared the recent RMBO surveys at the Recreation Area to those from Breeding Bird Surveys (BBSs; described below) conducted in similar habitats within the surrounding area; the regional surveys serve as a general spatial reference for species occurrence within the region. As with the temporal comparison, we focused our comparisons on those species for which the Recreation Area is within their normal breeding range, but we also considered species outside of but within 100 miles of their normal breeding range. The BBSs were the only available source of regional data for the Chickasaw NRA area.

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

Our intent for this context was to determine which species that occur at Chickasaw NRA are considered species of concern at either national, state, or local scales, to assess the current status (occurrence) of those species at the Recreation Area, and to evaluate the potential for the Recreation Area to play a role in their conservation. For the latter, we assigned each species of conservation concern to one of three classes representing the potential for the Recreation Area to play a role in its conservation during the breeding season (Table 4.11.2-2). This was based primarily on whether or not the park was within the normal breeding range of the species and the availability of breeding habitat at the park.

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

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

Potential for Conservation	Conservation Class Description
High	These are species for which the Recreation Area is within the normal breeding range or in proximity to the edge of that range. They are also species for which we considered the Recreation Area 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 Recreation Area in substantial numbers.
Moderate	These are the species for which the Recreation Area is within the normal breeding range or in proximity to the edge of that range, and for which there is some habitat at the Recreation Area that might support occurrence or even some breeding in limited numbers.
Low to None	These are the species that are either outside of their normal breeding range and/or for which the habitat at the Recreation Area is unlikely to support breeding. This does not preclude limited occurrences of the species, but the potential for the Recreation Area to play any significant role in its conservation during the breeding season is very limited.

One of the developments from the NABCI was the delineation of Bird Conservation Regions (BCRs) (U.S. North American Bird Conservation Initiative 2014). Bird Conservation Regions are ecologically distinct regions in North America with similar bird communities, habitats, and resource management issues (Figure 4.11.2-1). Chickasaw NRA lies within the Oaks and Prairies Unit (BCR-21) (Figure 4.11.2-2).

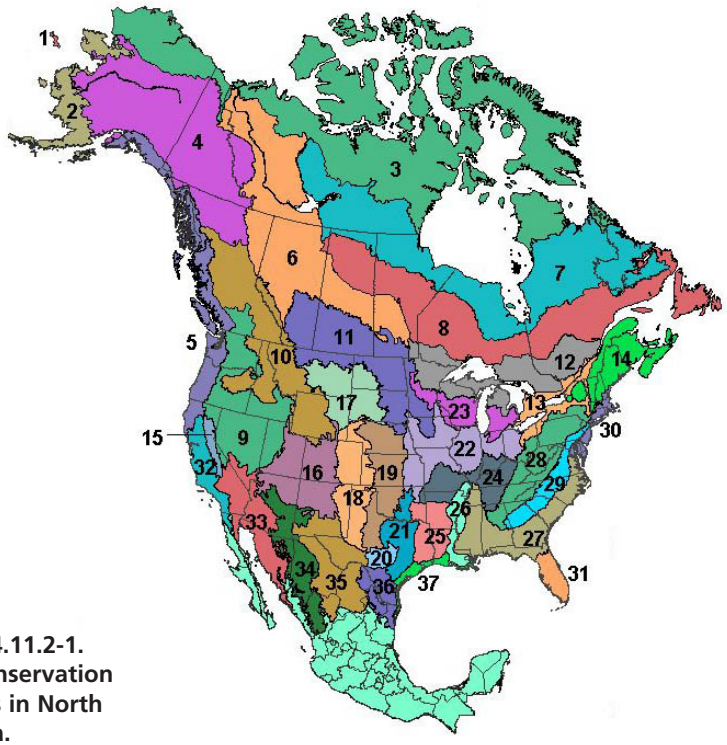


Figure 4.11.2-1. Bird Conservation Regions in North America.

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 F 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 as federally threatened or endangered through the Endangered Species Act (ODWC 2014).
- 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

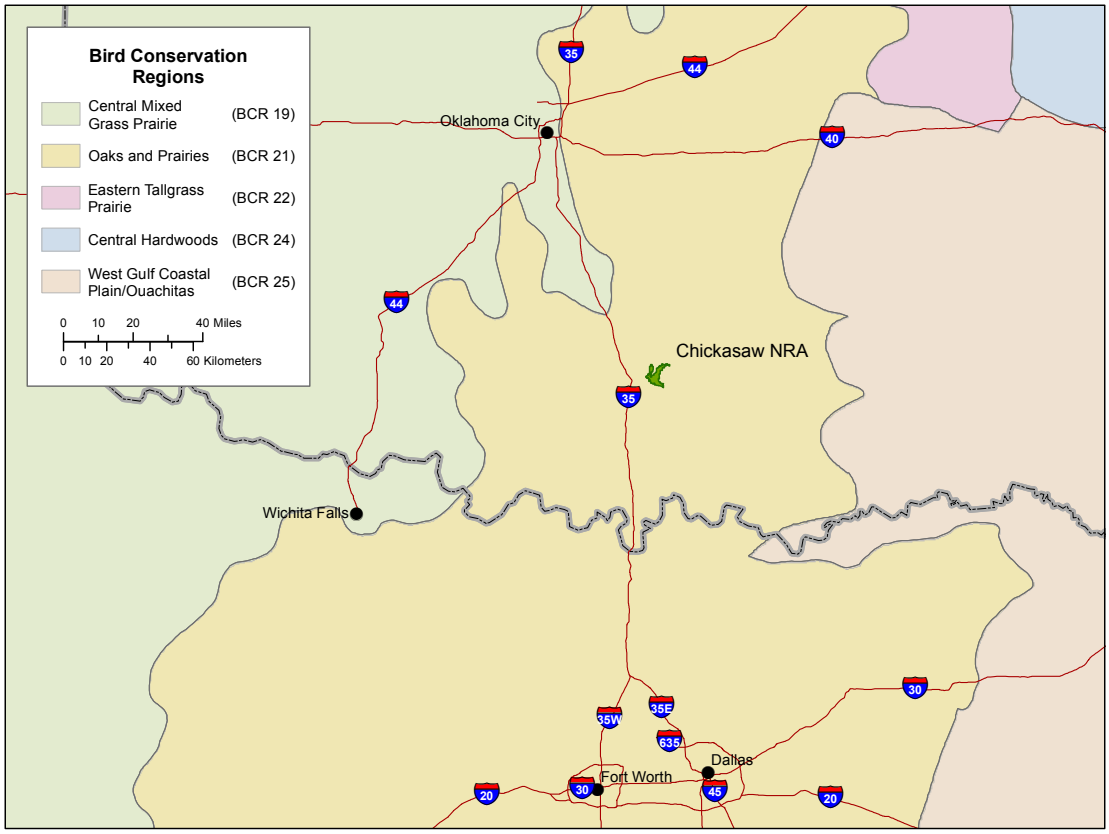


Figure 4.11.2-2. Bird Conservation Regions in the vicinity of Chickasaw NRA.

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]). We did not include the CS or RS species in our assessment.
- 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 the condition assessment include: surveys conducted by RMBO at Chickasaw NRA in 2009-2013; a bird inventory conducted by the ONHI in 2003 and 2004 (Kelly et al. 2004); and data collected from Breeding Bird Surveys (BBS) in the general vicinity of the Recreation Area. The NPSpecies list for the park (NPS 2014) was also reviewed and is mentioned in the report where applicable. Each of these data sources are described below.

RMBO Surveys at the Recreation Area in 2009-2013

RMBO used point-transect surveys (Buckland et al. 2001) during the breeding season to estimate and monitor landbird population parameters at Chickasaw NRA (Lock et al. 2014). A total of about 68 unique points in grassland habitat (upland grassland) were sampled three times per breeding season in 2009-2013 (Figure 4.11.2-3) (Lock et al.

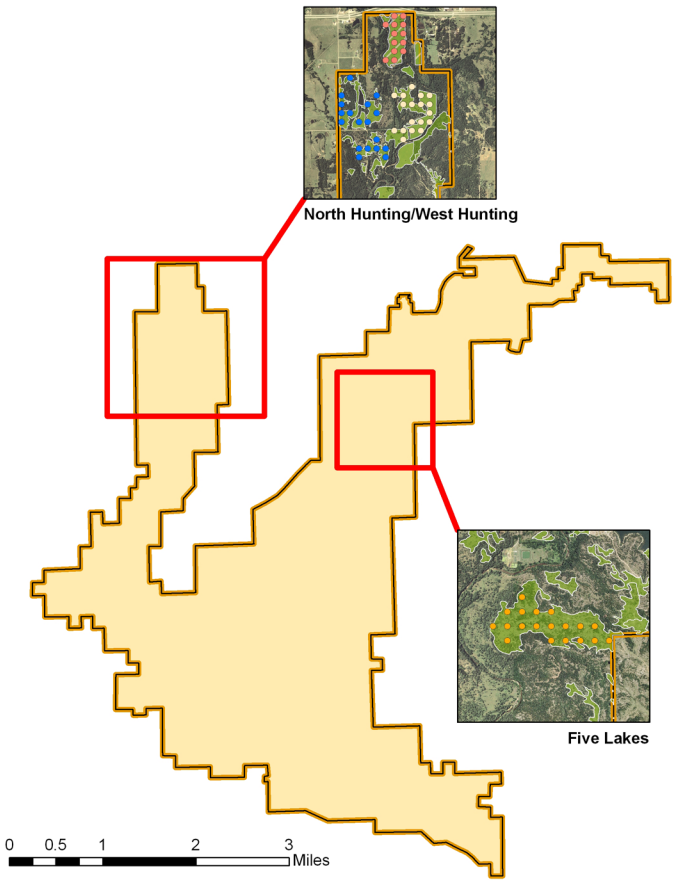


Figure 4.11.2-3. Areas sampled by the Rocky Mountain Bird Observatory at Chickasaw NRA in 2009-2013.

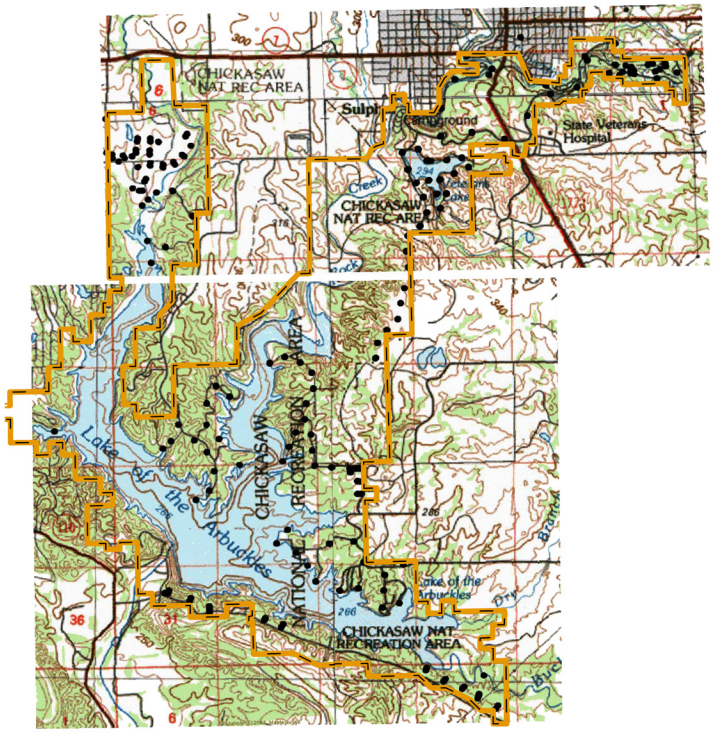


Figure 4.11.2-4. Map from Kelly et al. (2004) for Chickasaw NRA showing bird point counts (black dots) used in the ONHI inventory.

2014). All birds detected at a given point were recorded. Observers spent six minutes at each point along the transect or grid and used a rangefinder to estimate the linear distance to each bird or group detected. 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 species that were not recorded during the count period; sometimes these represented species that had not been previously reported for the park.

2003-2004 ONHI Inventory

In 2003, the Oklahoma Natural Heritage Inventory (ONHI) conducted an inventory for birds, as well as mammals and herpetofauna at the Recreation Area. The inventory's objective was to identify 90% of the vertebrates that inhabit the park; inventory progress was measured using pre-inventory lists of vertebrates thought to occur in Murray County or south-central Oklahoma (Kelly et al. 2004). Birds were surveyed using point-count surveys. Point counts for birds were conducted at 123 locations (Figure 4.11.2-4) within the Recreation Area between May 20 and July 15, 2003. Each point was visited one time, and each count, in which birds seen or heard were recorded, lasted eight minutes. In the spring of 2004, biologists also spent several days searching for species that were not detected the previous year.

A visual comparison of point-count survey locations from the ONHI work and RMBO work indicated there was some overlap in sampling locations (see Figures 4.12.2-3 and 4.12.2-4).

Regional Surveys- BBS Routes

Breeding Bird Surveys are conducted on over 4,100 survey routes located across the continental U.S. and Canada (Patuxent Wildlife Research Center 2014). 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 (39.4 kilometers [km]) long with stops at 0.5-mile (0.8-km) intervals. At each stop, a 3-minute point count is conducted. During the count,

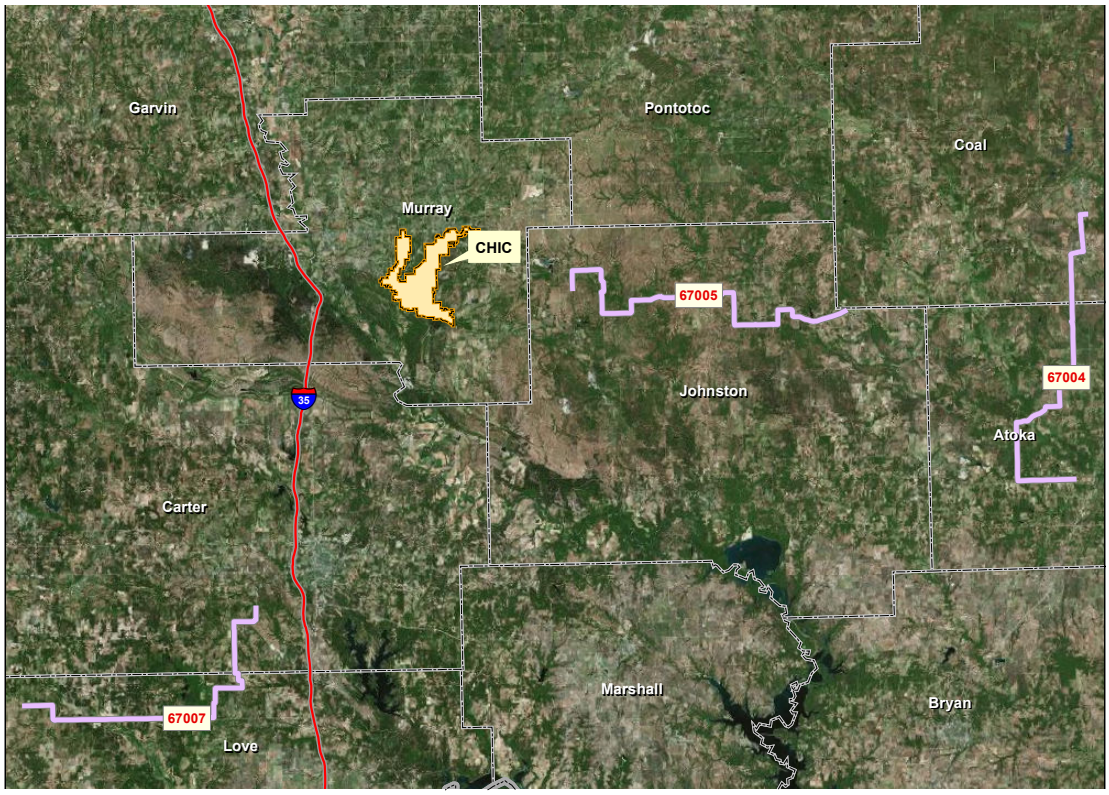


Figure 4.11.2-5. BBS routes (in purple) in the general vicinity of the Recreation Area used for the regional comparison of landbird species occurrence.

every bird seen within a 0.25-mile (0.4-km) radius or heard is recorded. Surveys start one-half hour before local sunrise and take about 5 hours to complete. There are several BBS routes in the general vicinity of Chickasaw NRA. For the spatial comparison of species occurrence, we used data from three routes that appeared to have habitat similar to that at the Recreation Area (Figure 4.11.2-5). We compared data from the three routes to 2009-2013 RMBO data at the park. We used BBS data from 2009-2013 when available (see Reference Conditions below).

Secondary Data Sources

The list of birds for the park from NPSpecies was also reviewed (NPS 2014; obtained from IRMA in August 2014). We used the list on a case by case basis as supporting information for particular species.

4.11.3. Reference Conditions

Temporal Reference Condition for Species Occurrence

The first bird monitoring or inventory effort at Chickasaw NRA was that made by ONHI in 2003-2004 (i.e., Kelly et al. 2004). A total of 84 species was recorded during the inventory (see Appendix G).

We compared the species list from the 2003-2004 survey/inventory to the list of species observed during the 2009-2013 RMBO surveys to see if there were any differences. Differences in the two lists may represent changes over time. Specifically, we looked at species that were not observed during 2009-2013 RMBO surveys that had been documented in 2003-2004. We "refined" the list of species where there were differences by excluding those species that were outside of their normal breeding range (and more than 100 miles from the edge of their normal breeding range). Although this analysis is a crude measure and only spans a relatively short time differential, it does potentially provide some insights as to major shifts that might have occurred at the Recreation Area. 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 the RMBO surveys (2009-2013) at Chickasaw NRA to those recorded during BBSs in the vicinity of the Recreation Area. BBS data for 2009-2013 were available

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

Occurrence Indicator	Significant Concern	Moderate Concern	Good
Temporal Context	We considered condition to be of significant concern if several species of birds that are within their normal breeding range and have existing habitat at the park were detected in the 2003-2004 surveys but not in recent RMBO surveys, particularly if those species had previously been considered common at the Recreation Area.	We considered condition to be of moderate concern if a few bird species that were detected during 2003-2004 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 2003-2004 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 Recreation Area were detected during regional surveys but not during recent RMBO surveys.	We considered condition to be of moderate concern if a few bird species that were detected during BBSs and that are within their normal breeding range and have breeding habitat at the Recreation Area 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 (BBSs) and that are within their normal breeding range and have breeding habitat at the Recreation Area were detected during recent RMBO surveys.

only for one route (67005). Data for the other routes were available for 2009 only (67007) and for 2004-2006 and 2008 (67004). As noted previously, for the BBS data we chose routes located in habitats roughly comparable to those at the Recreation Area. Both surveys were conducted during the breeding season. As in the temporal comparison, we refined the comparison by excluding species that are more than 100 miles from the edge of their normal breeding ranges.

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 Recreation Area can play a role in their conservation. From the list of species detected at the Recreation Area 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 Recreation Area are those within their breeding range and for which breeding habitat exists at the park. In our analysis, we also considered species that were not detected in recent RMBO surveys but were reported during the 2003-2004 ONHI inventory.

4.11.4. Condition and Trend

There have been a total of 122 bird species reported at Chickasaw NRA from the 2003-2004 ONHI inventory and/or the 2009-2013 RMBO point-count surveys (Appendix G). Two additional species are on the NPSpecies list of birds for the park (NPS 2014; but not on the lists from the two sets of surveys/inventories). Those two species are Black-capped Gnatcatcher and Boat-tailed Grackle.

Species Comparisons using 2003-2004 ONHI Inventory (Temporal Context)

A total of 84 species of birds were observed at Chickasaw NRA in the 2003-2004 ONHI surveys (Appendix G). Of these 84 species, nine (including the European Starling, a non-native species) were not observed on recent (2009-2013) RMBO surveys (Table 4.11.4-1). However, four of these nine species (designated with a "1" in the table) are primarily associated with wetlands, so they would not be expected to be observed during RMBO surveys that are conducted in upland grassland habitat at the park. Furthermore,

Table 4.11.4-1 Species reported in 2003-2004 by ONHI (Kelly et al. 2004) at Chickasaw NRA that were not observed during the 2009-2013 RMBO surveys. Also shown is the range status based on Birds of North America species accounts and breeding habitat class.

Common Name	Range Status	Breeding Habitat Class
Pied-billed Grebe [1]	Year-round	Exists
Yellow-crowned Night Heron [1]	Breeding	Limited to None
Swainson's Hawk	Outside Normal Breeding Range [2]	Possibly Exists
Spotted Sandpiper [1]	Outside Normal Breeding Range	Possibly Exists
Least Sandpiper [1]	Outside Normal Breeding Range	Limited to None
Eastern Screech Owl	Year-round	Exists
Great Horned Owl	Year-Round	Exists
European Starling (non-native)	Year-round	Possibly Exists
Prothonotary Warbler	Breeding	Possibly Exists

1 = Wetland species not expected to be observed on RMBO Surveys (although its occurrence/detection is possible).
2 = Outside Normal Breeding Range but within 100 miles of breeding range edge.

two of these four species are outside of (and more than 100 miles from) their normal breeding ranges. Of the other two species (out of the four), only Pied-billed Grebe is within its normal breeding range and in the "exists" habitat class.

Of the other four species listed in the table (excluding the European Starling), two are owls, which are within their normal breeding ranges and in the "exists" breeding habitat class. They have probably gone undetected to date because they are nocturnal. Also, only one Great Horned Owl and one Eastern Screech Owl were detected during the inventory, and these species were both incidental detections (observed outside of the point counts). The remaining two species, Swainson's Hawk and Prothonotary Warbler, are either within or within 100 miles of the normal breeding range, but fall into the "possibly exists" breeding habitat class. Also, Kelly et al. (2004) recorded only one individual of each of the species during their inventory.

A different set of species (38) was detected in the 2009-2013 surveys but not in the 2003-2004 inventory (e.g., Acadian Flycatcher, Baltimore Oriole, Blue Grosbeak, Common Yellowthroat, House Wren, and Red-tailed Hawk; see Appendix G).

From the comparison of species detected in 2003-2004 to 2009-2013, we do not have any particular concerns for species occurrence at the Recreation Area. The nine species not observed are not of concern at this time for the reasons described here. It is possible some or all of these species may be observed during future monitoring.

Species Comparisons to Surrounding Region (Spatial Context)

Ten species were detected during the BBSs that were not detected during the 2009-2013 RMBO surveys at Chickasaw NRA (Table 4.11.4-2). One species is non-native (European Starling) and is not discussed further. Of the remaining nine species, three were recorded at the Recreation Area during the 2003-2004 ONHI surveys (designated with a "1" in the table) and are also addressed in the temporal comparison. Three of the nine species are outside of their normal breeding ranges and/or in the "limited to none" breeding habitat class. Of the six remaining species that are within their normal breeding ranges (or within 100 miles of the ranges), only one falls into the "exists" breeding habitat class (Great Horned Owl). Five fall into the "possibly exists" breeding habitat class, meaning that while some breeding may occur in limited numbers, it is unlikely that the habitat at the Recreation Area would support consistent

Table 4.11.4-2 Birds species recorded during BBSs in the vicinity of Chickasaw NRA that were not detected at the Recreation Area during the 2009-2013 RMBO point-count surveys. Species that were detected during surveys by ONHI in 2003-2004 are noted (with a "1"). Three BBS routes (67004, 67005, and 67007) were used.

Common Name	Range Status	Breeding Habitat Class
Bell's Vireo	Breeding	Possibly Exists
Cassin's Sparrow	Outside Normal Breeding Range [3]	Possibly Exists
European Starling [1] (non-native species)	Year-round	Possibly Exists
Fish Crow	Outside Normal Breeding Range	Limited to None
Great Horned Owl [1]	Breeding	Exists
Loggerhead Shrike	Year-round	Possibly Exists
Prothonotary Warbler [1]	Breeding	Possibly Exists
Swainson's Hawk [1]	Outside Normal Breeding Range [3]	Possibly Exists
Lazuli Bunting [2]	Outside Normal Breeding Range	Exists
Yellow-crowned Night-Heron [2]	Breeding	Limited to None

1 = species recorded during the ONHI Inventory in 2003-2004.

2 = species recorded on BBS Route 67004 only with data from 2004-2006 and 2008 (data for 2009-2013 not available).

3 = Outside normal breeding range but within 100 miles of its breeding range edge.

or widespread breeding (this includes two of the species that were observed by ONHI). The five species in the "possibly exists" class are Bell's Vireo, Cassin's Sparrow, Loggerhead Shrike, Prothonotary Warbler, and Swainson's Hawk. All of these species were counted in small numbers in the BBSs, except for Bell's Vireo, which had a total count of 38 individuals. Also, all of the five species were either absent from the ONHI list and NPSpecies list or noted as uncommon on the NPSpecies list.

As mentioned, only the Great Horned Owl is within its normal breeding range and falls into the "exists" habitat class. This species was only observed one time (one individual) in one year of the BBSs. This species is also nocturnal, so it could easily be missed during RMBO daytime surveys.

Given their breeding ranges and breeding habitat classes, we do not have any particular concerns with this list of nine species. It is also possible that some of the species will be observed on RMBO surveys in the future. Therefore, based on the spatial comparison, the condition of breeding landbirds at the Recreation Area is good.

Species of Conservation Concern

There are 21 species that have been detected at Chickasaw NRA during 2009-2013 RMBO surveys (in one or more of those years) that are listed as species of conservation concern on one or more of the lists described in Section 4.12.2 and Appendix F (Table 4.11.4-3). Additionally, there are two species that were detected during the 2003-2004 surveys that are considered species of conservation concern, which are also addressed here.

- USFWS / Listed Species: There are no bird species listed by the USFWS as endangered or threatened that are known to occur at Chickasaw NRA (USFWS 2014). In western portions of the U.S., the USFWS proposed a sub-population of Yellow-billed Cuckoo as threatened in October 2013; the listing, however, does not apply to birds in Oklahoma (and we have not included the listing in the table).
- State of Oklahoma: There are no bird species that occur at the Recreation Area that are listed as endangered or threatened by the state of Oklahoma (ODWC 2014).

Table 4.11.4-3. Summary of species detected during 2009-2013 RMBO surveys (or 2003-2004 inventories only*) at Chickasaw NRA that are of conservation concern, as listed by government agencies and non-governmental organizations.

Common Name	Listed Species		Species of Conservation Concern Lists							
	Federal[1]	State[2]	US Fish & Wildlife Service			NAS/ ABC[3]	Partners in Flight National Conservation Strategy[4]		Oklahoma	Comments
	USFWS	ODWC	National	Region 2	BCR 21	2007 Watch List	BCR 21 CC	BCR 21 RC	SGCN	
Chimney Swift								•		
Common Nighthawk								•		
Dickcissel			•							
Eastern Meadowlark								•		
Field Sparrow								•		
Great Crested Flycatcher								•		
Hooded Warbler									•	
Lark Sparrow								•		
Little Blue Heron					•				•	
Louisiana Waterthrush									•	
Northern Bobwhite								•	•	
Olive-sided Flycatcher			•			•				
Orchard Oriole					•					
Painted Bunting			•	•		•		•	•	
Prothonotary Warbler *			•	•		•	•		•	
Red-headed Woodpecker			•	•	•	•	•	•	•	
Rufous Hummingbird			•							
Rufous-crowned Sparrow								•		
Scissor-tailed Flycatcher					•					
Snowy Egret									•	
Swainson's Hawk *			•			•			•	
Willow Flycatcher			•			•			•	
Yellow-billed Cuckoo								•		

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

[2] **State Listed Species Codes**
ST = Threatened SC = Special Concern
SE = Endangered

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

[4] **PIF NCS Categories**
CC = Continental Concern
RC = Regional Concern

- USFWS / Birds of Conservation Concern: There are 11 species that have been recorded at the Recreation Area that have been identified by the USFWS as having the greatest conservation need at a National, USFWS Regional, or BCR geographic scale (USFWS 2008). This includes two species that were not recorded during recent RMBO surveys but during the 2003-2004 ONHI inventory at the park.
- NAS / ABC: There are six species that occur or have occurred at Chickasaw NRA that have been listed on the NAS/ ABC 2007 WatchList. Four species observed during RMBO surveys (Olive-sided Flycatcher, Painted Bunting, Red-headed Woodpecker, and Willow Flycatcher) are on the Yellow List

because of population declines. Two additional species observed during the ONHI inventory (Swainson's Hawk and Prothonotary Warbler) are also on the Yellow List, the first because it is rare, and the second because its population is declining.

- PIF: Twelve of the 23 birds in Table 4.11.4-3 are listed by PIF as either CC or RC (recall we did not include the stewardship categories). This includes one species that was detected in the 2003/2004 inventory but not in recent RMBO surveys at the park. Eight of the 12 species are listed only by PIF and not by the other agencies or groups.
- Oklahoma Species of Greatest Conservation Need: Eight species that were detected at the Recreation Area during the 2009-2013 RMBO surveys (and two that were detected during the 2003-2004 inventory) are considered Species of Greatest Conservation Need by ODWC (ODWC 2011).

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

For this summary, we emphasize species for which Chickasaw NRA has the greatest potential to positively impact their conservation during the breeding season, based on their habitat and range. We do not mean to imply that other seasons are not important for the conservation of birds. Rather, we have limited this assessment to the breeding season because that is the only season for which we have current information. We also recognize that there is uncertainty and subjectivity in our assessment. Thus, we do not mean to imply that the classes we assigned are the only "correct" categories. Rather, this represents our interpretation from the available evidence, but we expect that other interpretations might be appropriate.

Of the 23 species listed by one or more organization as being of conservation concern (Table 4.11.4-3), we believe that twelve have sufficient habitat at the Recreation Area to be considered as having high conservation potential (Table 4.11.4-4). These are the species that are within their normal breeding range and sufficient habitat exists at the park to support breeding. All of these 12 species have been observed on recent (2009-2013) RMBO surveys. Furthermore, nine of the species have been observed in four or five of the years (Table 4.11.4-5). Several of the species, such as Field Sparrow, Painted Bunting, and Dickcissel, have been observed in relatively high numbers (795 total, 498 total, and 295 total, respectively).

Six species are considered to have moderate potential for the Recreation Area to contribute to their conservation. These are the Hooded Warbler, Lark Sparrow, Louisiana Waterthrush, Prothonotary Warbler, Rufous-crowned Sparrow, and Swainson's Hawk.

In summary, all species of conservation concern that are within their normal breeding range and have "existing" breeding habitat at the Recreation Area (i.e., high potential species) have been observed during recent (2009-2013) 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 with three measures that assessed landbird occurrence. This indicator is summarized in Table 4.11.4-6. Although our assessment is based on a limited amount of data (e.g., one year of point counts from the ONHI inventory), we found no justification to warrant concern for landbird occurrence at Chickasaw NRA at this time.

The temporal comparison found eight species (excluding the non-native European Starling) that were not detected during recent RMBO surveys. However, four of these species are primarily associated with wetlands, so they would not be expected to be observed during RMBO surveys in upland grassland habitat. Only two of the remaining four species are within their normal breeding ranges and fall into the "existing" habitat class. They are both owls (nocturnal), which have probably gone

Table 4.11.4-4. Species detected at Chickasaw NRA during 2009-2013 surveys (and/or 2003-2004 ONHI surveys) that have also been identified as species of conservation concern on one or more watch list. Species are organized by whether they have high, moderate, or low potential for the Recreation Area to contribute to their conservation.

Common Name	Detected During		Range Status	Breeding Habitat Class
	2009-2013 RMBO Surveys	2003-2004 ONHI Surveys		
High Potential				
Chimney Swift	•	•	Breeding	Exists
Common Nighthawk	•	•	Breeding	Exists
Dickcissel	•	•	Breeding	Exists
Eastern Meadowlark	•	•	Year-round	Exists
Field Sparrow	•	•	Year-round	Exists
Great Crested Flycatcher	•	•	Breeding	Exists
Northern Bobwhite	•	•	Breeding and Wintering	Exists
Orchard Oriole	•		Breeding	Exists
Painted Bunting	•	•	Breeding	Exists
Red-headed Woodpecker	•	•	Breeding and Wintering	Exists
Scissor-tailed Flycatcher	•	•	Breeding	Exists
Yellow-billed Cuckoo	•	•	Breeding	Exists
Moderate Potential [2]				
Hooded Warbler	•		Outside Normal Breeding Range [1]	Exists
Lark Sparrow	•	•	Breeding	Possibly Exists
Louisiana Waterthrush	•	•	Outside Normal Breeding Range [1]	Possibly Exists
Prothonotary Warbler		•	Breeding	Possibly Exists
Rufous-crowned Sparrow	•		Outside Normal Breeding Range [1]	Possibly Exists
Swainson's Hawk		•	Outside Normal Breeding Range [1]	Possibly Exists
Low to No Potential [3]				
Little Blue Heron	•	•	Breeding	Limited to None
Olive-sided Flycatcher	•		Outside Normal Breeding Range	Limited to None
Rufous Hummingbird	•		Outside Normal Breeding Range	Limited to None
Snowy Egret	•		Breeding	Limited to None
Willow Flycatcher	•		Outside Normal Breeding Range	Possibly Exists

[1] Outside Normal Breeding Range, but within 100 miles of breeding range edge.

2 Species for which some breeding may occur, but the potential for the Recreation Area to play a significant role in its conservation is limited (e.g., due to low quality or small area of breeding habitat).

[3] Species is in the lowest category of conservation potential, meaning that the Recreation Area is unlikely to play a significant role in its conservation.

undetected during RMBO surveys during the day (surveys begin 30 minutes before sunrise). The owls were observed during the ONHI surveys incidental to point count surveys. Furthermore, there were 38 species recorded in the 2009-2013 surveys but not in the 2003-2004 inventory.

Similarly, there was nothing particularly surprising or alarming when comparing species observed during recent RMBO surveys to the species observed during BBSs in the area surrounding the Recreation Area. Nine native species were recorded during the BBSs that were not detected during the RMBO surveys. Of the species that are within

Table 4.11.4-5. The number of individuals of species with highest conservation potential recorded at Chickasaw NRA during recent RMBO surveys.

Species	Survey Year					
	2009	2010	2011	2012	2013	Total
Chimney Swift	5	3	15	0	0	23
Common Nighthawk	1	0	0	0	3	4
Dickcissel	2	8	30	38	217	295
Eastern Meadowlark	3	9	0	5	132	149
Field Sparrow	106	75	288	179	147	795
Great Crested Flycatcher	27	25	49	55	36	192
Northern Bobwhite	11	1	7	6	6	31
Orchard Oriole	1	2	2	0	5	10
Painted Bunting	80	139	89	154	36	498
Red-headed Woodpecker	0	0	15	0	0	15
Scissor-tailed Flycatcher	3	15	6	11	11	46
Yellow-billed Cuckoo	24	33	14	18	2	91

Table 4.11.4-6. Summary of the breeding landbirds indicator/measures and their contributions to the overall landbirds condition.

Indicator	Measure	Condition	Condition Rationale
Species Occurrence	Temporal Context	Good	Eighty-nine percent of 84 species observed in the 2003-2004 bird inventory were observed in 2009-2013 RMBO bird surveys at the Recreation Area. There were eight species observed by ONHI that RMBO surveys did not detect. Half of these are associated with wetlands- habitat not surveyed in 2009-2013. Of the remaining species, only two were within their normal breeding ranges and fall into the "exists" habitat class; both species are owls (nocturnal), which have probably just gone undetected during RMBO surveys. Additionally, 38 species were observed in the 2009-2013 RMBO surveys but not in 2003-2004. In a temporal context, the condition of breeding landbirds at the Recreation Area is good. Data are available for a relatively small number of years, so no trend information is available at this time.
	Spatial Context	Good	In a comparison of RMBO surveys in the Recreation Area to BBSs in the surrounding region, there were nine species that were not observed at the park by RMBO in 2009-2013 (excluding one non-native species). Of the species within their normal breeding ranges, only one (Great Horned Owl) falls into the "exists" breeding habitat class. It is possible that this species may have gone undetected by RMBO's daytime surveys. Also, the species was only observed one time (one individual) during BBSs. Based on this comparison, the condition of breeding landbirds is good. We do not have sufficient data to justify a trend in the condition at this time.
	Conservation Context	Good	There are 23 species that have been observed during 2009-2013 and/or 2003-2004 surveys that are listed by one or more organization as being of conservation concern. We believe that 12 of these species have high conservation potential at the Recreation Area. These are species that are within their normal breeding ranges and sufficient habitat exists at the Recreation Area to support their breeding. All of these species have been observed on recent RMBO surveys (most in four or five years). Therefore, we consider the condition of species of conservation concern at the park to be good. We do not have sufficient data to justify a trend in the condition at this time.

their normal breeding ranges (or within 100 miles of the ranges), only one (Great Horned Owl) falls within the "exists" breeding habitat class. This species was only observed one time (one individual) in one year of the BBSs. This species is also nocturnal, so it could easily go undetected during RMBO daytime surveys. Therefore, based on the spatial comparison, the condition of breeding landbirds at the Recreation Area is good.

We found 12 species that we believe have high conservation potential at Chickasaw NRA, and all of them have been observed on recent RMBO surveys (some numerous times and in relatively high numbers).

Based on the information presented here, we consider the condition of breeding landbirds at the Recreation Area 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 (e.g., one-two years of prior data and limited BBS 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 online and hard copies whether or not the Recreation Area was within those ranges. We tried to account for this uncertainty by also including species that were on the edge of their ranges (i.e., less than 100 miles from the breeding range edge). Similarly, there is subjectivity in our assignment of breeding habitat classes. We based this judgement on avian expert Moez Ali (see below).

4.11.5. Sources of Expertise

Moez Ali, an avian expert, provided input on the breeding habitat classes for each species in Tables 4.12.4-1, 4.12.4-2, and 4.12.4-4. Mr. Ali will lead the annual landbird monitoring at the Recreation Area in 2015 and has become the lead for field efforts for the landbird monitoring in the Southern Plains Network, Chihuahuan Desert Network, and Sonoran Desert Network.

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4.12. Feral Mammals: Cats and Hogs

Indicators/Measures

- Species Occurrence: Presence/absence (2 Measures)

Condition – Trend - Confidence



Moderate to Significant - Insufficient Data - Moderate

4.12.1. Background and Importance

World-wide, the class of animals known as mammals is extremely diverse. Different mammal species are able to swim, fly, climb, burrow in the ground, live in trees, hop and run. Mammals also vary tremendously in size, from large members of the class, such as whales, to small members, such as shrews and some bats. An inventory of mammals at the Chickasaw National Recreation Area (NRA) was conducted by the Oklahoma Natural Heritage Inventory (ONHI) for the park in 2003-2004. During the inventory, Kelly et al. (2004) recorded a total of 23 mammal species, primarily native wildlife. However, the domestic (or feral) cat was also observed (Figure 4.12.1-1). Additionallly, although not recorded during the inventory, feral hogs are known to occur at the Recreation Area and have increased their distribution across the state in recent years (Stevens 2010).

"Feral" is defined as having escaped from domestication and become wild. Feral cats (*Felis catus*) and hogs (*Sus scrofa*) are undesirable species at the Recreation Area for several reasons. Feral cats are an issue for wildlife because they are predators of many small types of wildlife, they compete with native species (e.g., skunks, opossums, raccoons, and foxes) for food, and they may transmit disease (Wildlife Society 2011). A large proportion of the small animals they consume are native mammals, birds, amphibians, and reptiles (Kelly et al. 2004). Free-ranging domestic cats are estimated to kill more than one billion birds (Wildlife Society 2011, Loss et al. 2013) and 6.3-22.3 billion mammals every year in the U.S. (Loss et al. 2013).

Feral hogs are opportunistic omnivores who consume mainly plant material and invertebrates such as worms, insects, and insect larvae (Hamrick et al. 2011). The



PHOTO: NOEL OSBORN, CHICKASAW NRA

Figure 4.12.1-1. Feral cats in the Platt Historic District at Chickasaw NRA. Photo taken August 2014.

activities of feral hogs can lead to negative effects on habitat and wildlife, as well as domestic crops and livestock (Davis and Schmidly 1997). The hogs' extensive rooting, trampling, and wallowing activities disturb soil and vegetation, leading to damage to native plants, compaction of soils, and increased turbidity (excessive silt and particle suspension) in riparian areas (Hamrick et al. 2011). Reduced water quality from turbidity and bacterial contamination (from feces) can affect a variety of native aquatic life, such as fish, amphibians, and insect larvae. Feral hogs may also compete with wildlife, such as deer and turkey, for space and food items (e.g., mast [acorns]), as well as prey on native reptiles, amphibians, small mammals, bird eggs, and, occasionally, birds and newborn deer (Taylor 2003, Hamrick et al. 2011). The ancestors of feral hogs are European wild hogs (introduced in the U.S. for sport hunting) and domestic swine that escaped and established feral populations (Davis and Schmidly 1997). Stevens (2010) estimated that the state population of feral hogs in 2007 was as high as 500,000 individuals. Feral hogs are thought to occur in all 77 of Oklahoma's counties.

Note that mammal species that occur at Chickasaw NRA that are managed by the State of Oklahoma for hunting are discussed in detail in the Game Species section of this chapter of the condition assessment (except that we focus on feral hogs here).

4.12.2. Data and Methods

This limited assessment is based on the 2003-2004 ONHI inventory at the Recreation Area (Kelly et al. 2004) and information provided by Chickasaw NRA personnel (particularly Noel Osborn, Resources Manager). We also reviewed the NPSpecies list of mammals for the park (NPS 2014) and used Stevens (2010) for data about feral hog occurrence in the state and county.

We used one indicator/measure of condition--species occurrence: presence/absence.

Indicators/Measures
Species Occurrence: Presence/Absence

Species Occurrence: Presence/Absence
Because there are no recent data to assess current condition of feral cats and hogs, we used the 2003-2004 surveys and information from park personnel to address the occurrence of these two species at the Recreation Area. We also used Stevens (2010), which presents feral hog density estimates per county. It should be noted, however, that the population and density estimates from Stevens (2010) are not based on hog sampling in the field.

Primary Data Sources
In 2003, the ONHI conducted an inventory for mammals, as well as birds and herpetofauna, at the Recreation Area. The inventory's objective was to identify 90% of the vertebrates that inhabit the park; inventory progress was measured using pre-inventory lists of vertebrates thought to occur in Murray County or south-central Oklahoma (Kelly et al. 2004). Mammals were inventoried using mammal traps for small and medium-sized mammals, camera and track stations for large mammals, mist-nets for bats, and road cruising. In the spring of 2004, biologists also spent several days searching for species that were not detected the previous year.

No information in addition to that provided above is necessary for the other information sources used.

4.12.3. Reference Conditions

Reference conditions for this assessment are shown in Table 4.12.3-1. Although the criteria for judging condition are the same for feral cats and hogs (hence one row in the table), we determined condition for cats and hogs separately (i.e., we had two measures of species occurrence, one for cats and one for hogs).

4.12.4. Condition and Trend

Species Occurrence: Presence/Absence
Feral / Domestic Cats
The 2003-2004 ONHI inventory recorded seven feral/domestic cats (Kelly et al. 2004). The NPSpecies list for the park (NPS 2014) for mammals indicates that the feral/domestic cat is abundant in the park. Park personnel

Table 4.12.3-1. Reference conditions used to assess the current condition of feral cats and hogs at Chickasaw NRA. Conditions were determined separately for cats and hogs (i.e., there were two measures of species occurrence, one for cats and one for hogs).

Indicator/Measures	Significant Concern	Moderate Concern	Good
Species Occurrence: Presence / absence of Feral cats Species Occurrence: Presence / absence of Feral hogs	We consider condition to be of significant concern if feral cats/feral hogs occur at the Recreation Area in high enough numbers or concentrations that 1) they are causing substantial damage to park resources (e.g., killing wildlife, degrading habitat/water resources), posing serious public health concerns, and/or posing significant challenges to management (e.g., in staff time and effort), and/or 2) their numbers are increasing dramatically.	We consider condition to be of moderate concern if feral cats/feral hogs occur at the Recreation Area and 1) they are either causing resource damage (e.g., to wildlife or habitat), public health concerns, and/or management issues for park staff, and/or 2) their numbers are increasing such that they may cause damage or management issues in the near future.	We consider condition to be good if no feral cats/feral hogs occur at the Recreation Area, or if the numbers occurring are very low and there is no potential for an increase.

confirm this, indicating that feral cats residing in the park are thought to number in the hundreds (N. Osborn, Resources Manager, Chickasaw NRA, pers. com.), although no formal surveys have been conducted. Cats occur throughout the Platt Historic District, the section of the park adjacent to the town of Sulphur (Figure 4.12.4-1). Within the District, cats are most numerous along Rock Creek. Some members of the public feed the cats. Park staff educate the public on why they should not feed the cats, and staff can issue citations to people caught feeding them.

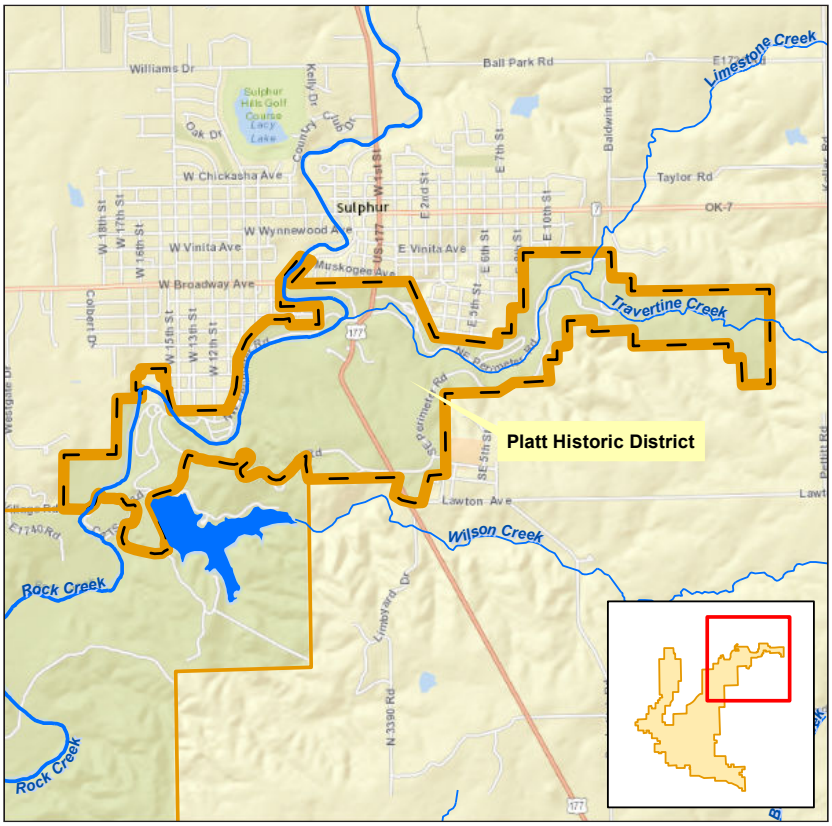


Figure 4.12.4-1. Feral cats occur in the Platt Historic District, especially along Rock Creek (which is shown in a heavy blue line). The inset map shows the location of the Historic District within the park.

As discussed previously, one of the concerns with the presence of feral cats is disease transmission. Park personnel are concerned with the large numbers of cats living along Rock Creek partially because they pose a risk to human health by increasing potential human exposure to diseases such as rabies or toxoplasmosis (N. Osborne, Resources Manager, Chickasaw NRA, pers. com.). Some cats captured in the past tested positive for rabies.

Toxoplasmosis is caused by a single-celled parasite called *Toxoplasma gondii*. In addition to being contracted by eating undercooked or contaminated meat or drinking contaminated water, the disease can be contracted through contact with cat feces containing the parasite (Centers for Disease Control and Prevention [CDC] 2014). This could occur by accidentally ingesting contaminated soil by not washing hands after handling dirt where infected cats have been, or by touching anything that has been in contact with cat feces that contain the parasite. Pregnant women and individuals with compromised immune systems may be

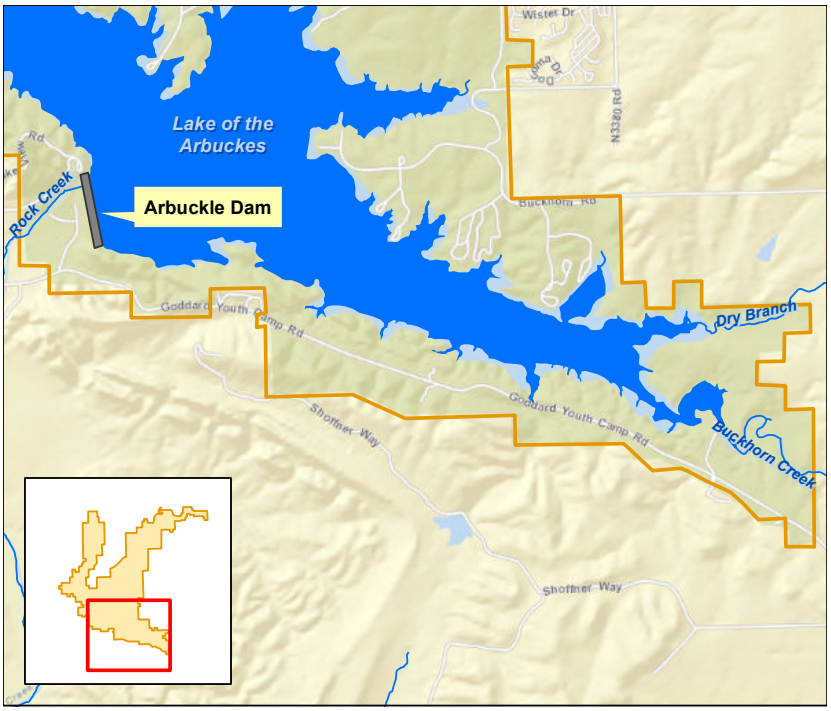


Figure 4.12.4-2. Feral hogs occur along the south and southeast side of Lake of the Arbuckles.

particularly at risk from toxoplasmosis (CDC 2014).

Management of feral cats at the Recreation Area poses a significant challenge. In addition to some members of the public feeding feral cats, live trapping of cats is not a viable option for the park because there are no shelters that take cats in Murray County, and trapping can put park personnel at risk for disease contraction or injuries (N. Osborn, Resources Manager, Chickasaw NRA, pers. com.).

Feral Hogs

The feral hog is not included on the NPSpecies list (NPS 2014), and it was not observed during the 2003-2004 inventory by ONHI (Kelly et al. 2004). However, feral hogs are known to exist in the Recreation Area. Although there are no estimates of the number of hogs in the park, they currently occur in the southern end of the park, primarily around the southeastern arm of Lake of the Arbuckles (the Buckhorn Creek arm), which includes the area east of the Arbuckle Dam along Goddard Youth Camp Road, as well as the area south of Buckhorn Road (N. Osborn, Resources Manager, Chickasaw NRA, pers. com.; Figure 4.12.4-2). Park personnel have observed disturbance to vegetation and soils from the hogs' rooting activities, and there have been a few incidents of cars and other vehicles hitting hogs. While there are no estimates of hog numbers for the Recreation Area, there are some older estimates for Murray County. Stevens (2010) estimated that in 2007 feral hogs in the portion of Murray County where the Recreation Area occurs were abundant-- having a density of more than 64 hogs per square mile. To the north of the park estimates fell into the moderate category (13-58 hogs per square mile). [There was only one other density category-- sparse (<13 hogs per square mile)].

There is presently no official plan for the management of feral hogs at the park. However, park staff are looking into impacts from hogs and options for control, and park staff periodically trap and shoot feral hogs (N. Osborn, Resources Manager, Chickasaw NRA, pers. com.). Hunting of feral hogs is allowed year-round at the Recreation Area, as well as throughout Oklahoma, provided hunting is in compliance with State regulations (Chickasaw NRA website, http://www.nps.gov/chic/planyourvisit/hunting.htm; Oklahoma Department of Wildlife Conservation [ODWC] 2014). Park staff have no data on the number of hogs taken annually within the Recreation Area, because hunters are not required to report such information.



Feral Mammals

Indicator	Measures
Species Occurrence	Two Measures



Overall Condition and Trend

For assessing the condition of feral mammals, we used one indicator with two measures. We assessed species occurrence for feral cats and species occurrence for feral hogs. This indicator is summarized in Table 4.12.4-1.

As described, both feral cats and feral hogs occur in the Recreation Area. Although there are no firm data available for the number of either species in the park, feral cats are thought to number in the hundreds and are concentrated in the northern portion of the park. Feral hogs are presently (2014) south and southeast of Lake of the Arbuckles, and

Table 4.12.4-1. Indicator and measures of feral mammal (feral cats and feral hogs) condition.

Indicator	Measure of Condition	Condition	Rationale for Condition.
Species occurrence:	Presence / absence of feral cats	Significant concern	We considered condition to be of significant concern because feral cats are known to occur in the park in relatively high numbers in the Platt Historic District, especially along Rock Creek, where they are posing concerns for staff and public health and significant challenges for park managers. Also, feral cats may increase risk of diseases for native wildlife. Although no information is available specifically at the park, feral/domestic cats have the potential to kill a large number of small, native wildlife species. There are no hard data available on the number of feral cats in the park, but park staff estimate that cats number in the hundreds. There is no information on whether their numbers are increasing. Dealing with the issue of feral cats in the Recreation Area is difficult because of the logistics (e.g., once trapped, there are no shelters in the county that take cats), the activities of some members of the public to feed them, and the overall sensitivity of the issue.
Species occurrence:	Presence / absence of feral hogs	Moderate concern	We considered condition to be of moderate concern because feral hogs are known to occur in the park, and they are causing at least some level of damage to park resources. They presently occur in the southern portion of the Recreation Area south and southeast of Lake of the Arbuckles. Park personnel report that there is visible disturbance to soils and vegetation, and there have been a few incidents of cars/vehicles hitting hogs. There are no data available for the number of feral hogs in the park, but hogs were reported as abundant in the vicinity of the park in 2007 by Stevens (2010). Park staff are looking into impacts from the hogs and options for controlling them, and staff periodically trap and shoot hogs. They do not want the hogs to expand to other portions of the park or to increase in number. Public hunting of hogs is allowed in the Recreation Area in compliance with ODWC regulations.

park staff do not want their distribution to increase. Hogs are causing some disturbance to soils and vegetation, and cats pose health concerns as well as the potential to kill small, native species of wildlife. Both species, but particularly feral cats, present challenges to managers. We judged the overall condition of feral mammals at the Recreation Area to be of moderate to significant concern. That for feral cats is of significant concern, while that for feral hogs is of moderate concern. We do not have sufficient information to justify a trend in condition.

4.12.5. Sources of Expertise

No experts were consulted for this resource topic.

4.12.6. Literature Cited

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4.13. Game Species

Indicators/Measures

- None

Condition – Trend – Confidence



Unknown - Unknown - Low

4.13.1. Background and Importance

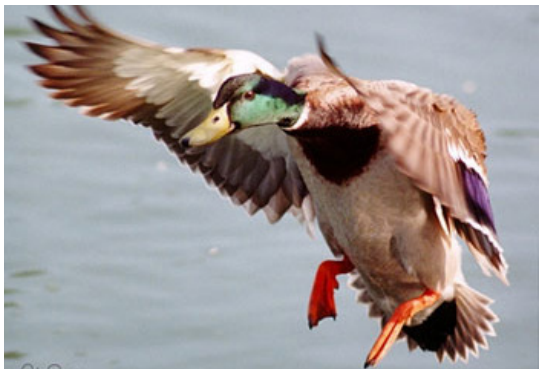
Chickasaw National Recreation Area (NRA) is a distinct wildlife management area of the Oklahoma Department of Wildlife Conservation and covers 4,500 acres. Hunters must have a valid Oklahoma hunting license and abide by state hunting regulations.

A variety of game species are open to hunt including upland game (deer), upland game birds (dove, turkey, bobwhite quail), waterfowl (ducks and geese), and small game and furbearers (fox squirrel, cottontail rabbit, coyote, raccoon, and bobcat; Figure 4.13.1-1).

Hunting is permitted in Chickasaw NRA as stipulated under the enabling legislation (P.L. 94-235, §3). The legislation provides for the designation of zones and periods when no hunting is permitted for reasons of public safety, administration, wildlife management, or public use and enjoyment. Not all of the NRA is open to hunting. All developed areas of the park are closed, and some areas are restricted to archery and shotgun only (Figure 4.13.1-2). While new federal law allows people to legally possess firearms in the park, the discharge of firearms is prohibited unless for the specific purpose of lawful harvest of game animals. Federal law continues to prohibit possession of firearms in designated federal facilities of the park such as the visitor centers, offices, ranger stations, maintenance buildings, and other park facilities and buildings.

4.13.2. Data and Methods

This limited assessment primarily summarizes the findings from existing information available from the park and the Oklahoma Department of Wildlife Conservation.









ALL PHOTOS: USFWS

Figure 4.13.1-1. Some of the game species that can be hunted at Chickasaw National Recreation Area include (clockwise from upper left): mallard duck, coyote, wild turkey, and white-tailed deer.

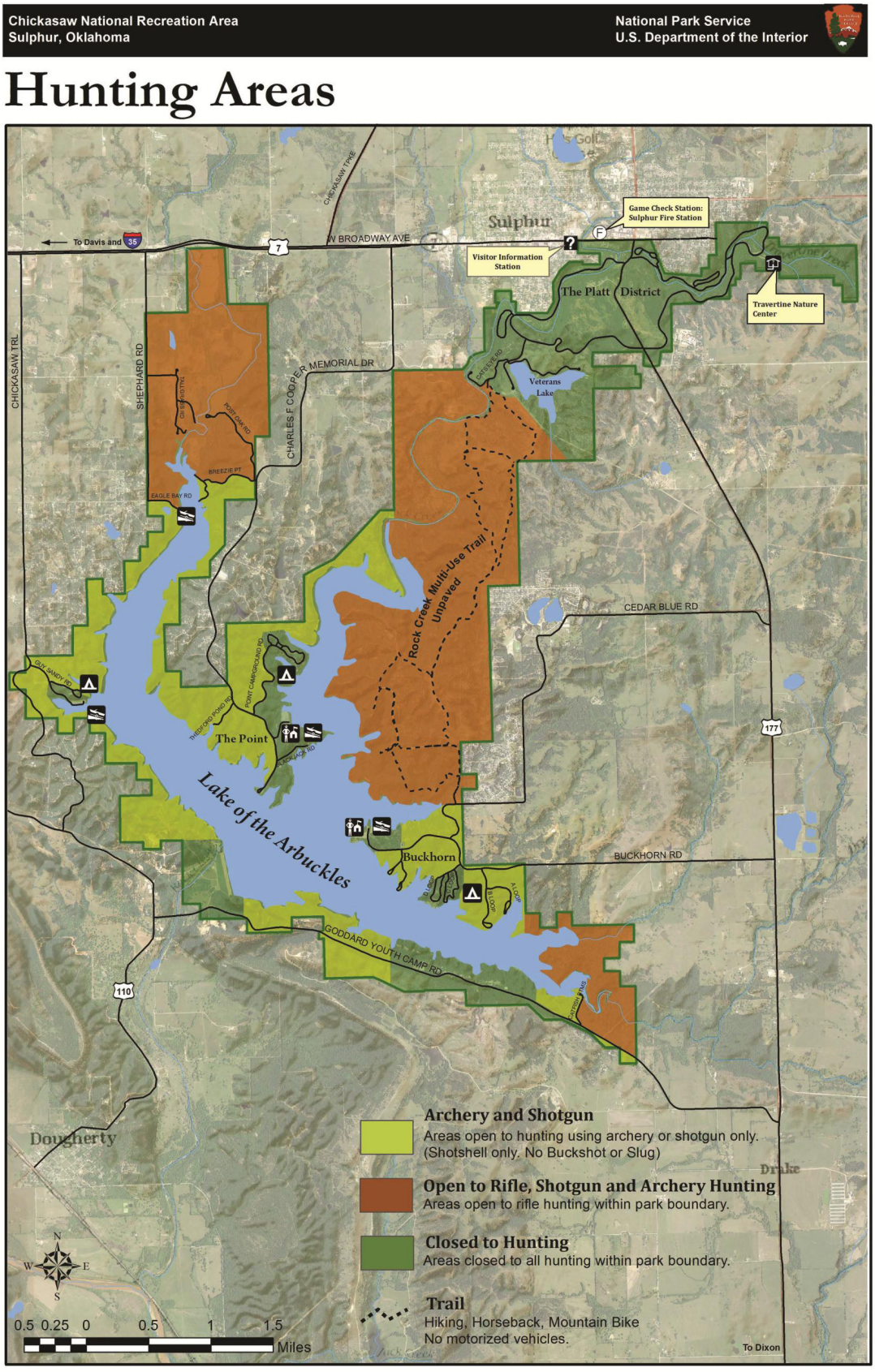


Figure 4.13.1-2. Map of designated hunting areas within Chickasaw NRA.

4.13.3. Reference Conditions

No reference conditions have been described for game species. The general management plan (NPS 2008) states a desired condition for hunting as continuing high-quality public opportunities to hunt native species in natural habitats and in natural concentrations. A management goal for deer has been the improvement of the age structure of the herd and the maintenance of a healthy population (Clark 2013).

4.13.4. Condition and Trend

No specific indicators and measures have been identified (at this point) by which to evaluate condition and trend of game species. The following discussion provides an overview of game species hunted in Chickasaw NRA.

Habitat

The NRA represents the eastern-most extent of the eastern deciduous forests and mixes with the western prairie ecosystems. The vegetation is a complex mix of oaks (*Quercus* spp.) and other deciduous trees occurring along the drainages and some upland areas. An active invasion of juniper (*Juniperus* spp.) is occurring in many of the upland areas and has been addressed by an active fire control program (Salas et al. 2010). The overstory is largely composed of post oak (*Quercus stellata*), blackjack oak (*Q. marilandica*), and black hickory (*Carya texana*). The understory is made up of little bluestem (*Schizachyrium scoparium*), big bluestem (*Andropogon gerardii*), and other species. The tallgrass prairie component of the NRA includes a mixture of big bluestem (*Andropogon gerardii*), little bluestem (*Schizachyrium scoparium*), Indian grass (*Sorghastrum nutans*), switch grass (*Panicum virgatum*), and silver beard grass (*Bothriochloa saccharoides*), buffalo grass (*Buchloë dactyloides*), blue grama (*Bouteloua gracilis*), and side oats grama (*Bouteloua curtipendula*). Grazing and herbivory have removed much of the tallgrass species, leaving primarily short grasses (Salas et al. 2010).

Upland Game

White-tailed deer (*Odocoileus virginianus*) are the main upland game species at Chickasaw NRA. Annual spotlight surveys are conducted in the NRA to help natural resource managers monitor trends in deer population numbers and demographic characteristics (Clark 2013). Since the inception of the surveys (piloted in 1999), survey methods have been applied inconsistently, so no trend information is available (Clark 2013). For a healthy age structure, Adams (2013) suggests a doe to buck ratio between 1 and 2 and a fawn to doe ratio of 0.5. In 2013, the doe to buck ratio was 2.6 and the fawn to doe ratio was 0.3 (Clark 2013; Table 4.13.4-1). In 2013, Clark estimated the demographics of deer in the NRA to consist of 23% bucks, 60% does, and 17% fawns. More data will be needed to detect trends in the deer population and identify potential management concerns.

Masters et al. (2013) describe carrying capacity for white-tailed deer in Oklahoma to range between 1/15 acres on highly productive sites to 1/125 acres on low-productivity sites. The average across the state is about 1/35 acres, but this number varies greatly by location and is also impacted by surrounding land use, hunting pressure, amount of suitable habitat, and other factors. The density of deer in

Table 4.13.4-1. Estimated doe:buck and fawn:doe ratios resulting from annual surveys conducted 1999-2013 (Clark 2013).*

Year	Doe:Buck	Fawn:Doe
1999	6.8	0.5
2001	3.6	0.5
2002	3.7	0.8
2003	2.9	0.7
2004	2.1	0.6
2005	ND	ND
2006	3.7	0.6
2007	3.9	0.5
2008	3.2	0.5
2009	2.3	0.55
2010	3.2	0.36
2011	ND	ND
2012	2	0.4
2013	2.6	0.3

ND=no data

*results may not be directly comparable year-to-year; these are the results of annual surveys that used inconsistent methods

Table 4.13.4-2. Chickasaw Wildlife Management Area deer harvest (1999-2013).

	Archery		Rifle		Muzzle-loader/ Primitive		Total		
Year	Bucks	Does	Bucks	Does	Bucks	Does	Bucks	Does	TOTAL
2013	6	2	13	8	6	2	25	12	**37**
2012	1	2	0	3		3	1	8	**9**
2011	0	6	4	11	1	7	5	24	**29**
2010	0	1	0	5	0	1	0	7	**7**
2009	0	0	1	0	0	2	1	2	**3**
2008	3	7	21	16	4	4	28	27	**55**
2007	1	3	21	8	6	4	28	15	**43**
2006	7	4	19	16	5	7	31	27	**58**
2005	5	2	12	16	8	7	25	25	**50**
2004	6	8	11	10	16	5	33	23	**56**
2003	8	5	31	18	7	9	46	32	**78**
2002	10	12	11	9	14	8	35	29	**64**
2001	3	1	10	7	2	6	15	14	**29**
2000	5	6	11	9	3	5	19	20	**39**
1999	6	2	7	8	8	4	21	14	**35**

Source: Oklahoma Department of Wildlife Conservation (2014)

Chickasaw NRA in 2013 is estimated at 1/17.5 acres (Clark 2013).

Deer harvest totals across years is another method for estimating population fluctuations Table 4.13.4-2 presents harvest data from 1999-2013 for Chickasaw Wildlife Management Area collected by the Oklahoma Department of Wildlife Conservation (ODWC 2014). There is quite a bit of fluctuation among years; unfortunately, there is no interpretation for these data, such as correlations of low harvest years to years of drought or other factors.

Upland Game Birds

Northern bobwhite quail (*Colinus virginianus*), Rio Grande wild turkeys (*Meleagris gallopavo intermedia*), rock doves (*Columba livia*), and mourning doves (*Zenaida macroura*) are year-round residents (Kelly et al. 2004). Turkey has a spring season (April-May) with a limit of one tom, and a fall season (October-January) with a limit of one per hunter. Quail season is from November -mid-February with a limit of 10/day.

Quail populations have generally been declining since the 1960s due primarily to habitat loss and fragmentation, along with a combination of predation, competition, and disease (ODWC 2010). The state has been working with the Natural Resource Conservation Service and private landowners to restore quail habitat throughout the state.

Waterfowl

Canada geese (*Branta canadensis*), wood duck (*Aix sponsa*), and mallards (*Anas platyrhynchos*) are year-round residents (Kelly et al. 2004) of the NRA. Oklahoma is in the southern portion of the Central Flyway and provides wintering range for many ducks and geese. Hunting opportunities are primarily from November through January. Annual harvest limits are set federally by the U.S. Fish and Wildlife Service (USFWS), states, and flyway councils based on monitoring data (USFWS 2014).

Small Game and Furbearers

Cottontails (*Sylvilagus floridanus*) are present and can be found across the NRA (Kelly 2013). Fox squirrel (*Sciurus niger*), coyote (*Canis latrans*), bobcat (*Lynx rufus*), and raccoon (*Procyon lotor*) are also available and hunted as small game or for their fur.

Table 4.13.4-3. Indicator, measure, and rationale for condition of game species.

Indicator of Condition	Measure	Condition	Rationale for Condition
None identified	None	Unknown	Because no indicators or measures for condition have been identified, and little local information is available regarding population sizes, carrying capcity, or habitat condition, we cannot know the condition related to game species.

Management Concerns

Chickasaw NRA provides a wide range of recreation opportunities including swimming, boating, fishing, hiking, observing nature, camping, picnicking, and hunting. Game species populations at the NRA are impacted by habitat condition (impacted by drought, invasive species, fragmentation, and other sources of degradation), hunting pressure, regional population health (such as density, wildlife diseases), and competition for resources. Chickasaw NRA staff will work with the Oklahoma Department of Wildlife Conservation to monitor wildlife populations, enforce state and federal regulations, ensure harvest levels are sustainable, and ensure visitor safety. Species-specific surveys will be conducted and continued, and population trends will be analyzed (NPS 2008).



Overall Condition

Due to no reference conditions being identified, and no indicators or measures, condition of game species at Chickasaw NRA is unknown at this time (Table 4.13.4-3).

4.13.5. Sources of Expertise

The National Park Service allows hunting on some park units, but hunting is managed by state agencies. No experts were consulted for this resource topic.

4.13.6. Literature Cited

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MARK BRUNSON

The park's General Management Plan (2008) recommends "The bison pasture (shown here) would be restored to prairie and the bison herd maintained at an appropriate size.

Chapter 5: Discussion of Natural Resource Condition Assessment Findings and Considerations for Park Planning

5.1. Introduction

The primary purpose of the Natural Resource Condition Assessment (NRCA) Chapter 5 is to provide a "big picture" - broader application of resource condition findings (Albright 2010). We will fulfill this purpose by:

- creating a framework that connects the natural resource findings to Chickasaw National Recreation's purpose and significance statements,
- delivering completed *State of the Park* natural resource condition summary tables and resource briefs for each of the topics assessed; and
- providing resource narratives for each assessed topic, highlighting potential management and project considerations, if applicable.

These Chapter 5 reporting pieces are *value added* products that can be used by park managers for a variety of resource planning and comprehensive park management purposes (Jeff Albright, NRCA Program Coordinator, pers. comm. August 23, 2013). Additionally, efficiencies are gained by providing these "ready to use products" because they deliver information to park staff that directly meet other reporting requirements, such as those for the *State of the Park* report.

5.2. Connecting Natural Resource Condition Assessment Findings to Park Purpose, Significance, and Fundamental Resources & Values

Managing the natural resources at Chickasaw NRA is inextricably tied to its purpose and significance. It is most often within this interdisciplinary perspective that managers consider potential actions and alternatives when addressing resource issues or needs. As such, we have created a table (Table 5.2-1) where natural resource topic relevance is presented within a framework of the NRA's purpose and significance statements (NPS 2008). This provides a "snapshot" look at how each natural resource condition ties into the NRA's primary reasons for establishment.

The resource condition highlights for each resource topic, if applicable, will be presented in the *State of the Park* resource brief (section 5.3). Condition findings relative to potential resource issues/data gaps, opportunities and

Table 5.2-1. Summary of natural resource topic relevance (denoted by black dots) as it relates to Chickasaw National Recreation Area's purpose and significance statements identified in the park's General Management Plan (NPS 2008).

Natural Resource Condition Assessment Topics	Viewshed	Night Sky	Sound-scape	Air Quality	Geology	Water Quality	Ground-water	Riparian Habitat	Grassland	Exotic Plants	Landbird	Feral Mammals	Game Species
I. Park Purpose													
Protect the springs and waters					•	•	•	•					
Preserve areas of archeological or ethnological interest							•						
Provide outdoor recreation	•	•	•			•	•				•		•
Protect scenic, scientific, natural, and historic values	•	•	•	•	•	•	•	•	•	•	•	•	•
Memorialize the Chickasaw Indian Nation													
II. Park Significance													
Mineral and fresh water from one of the most complex geological and hydrological features in the United States.					•	•	•						
Intact 1933-1940 era rustic design Civilian Conservation Corp cultural landscape of the proposed Platt National Park Historic District	•												
Outdoor recreational opportunities	•	•	•			•	•				•		•
Transition zone where the eastern deciduous forest meets the western prairies									•	•			
History of Chickasaw National Recreation Area exemplifies the evolution of the American conservation movement and the national park system.						•	•						

Literature Cited: National Park Service. 2008. General Management Plan Chickasaw National Recreation Area. 52 pages.

management considerations will be presented in the resource narratives section 5.4.

5.3. State of the Park Reporting

As part of the stewardship of national parks for the American people, the NPS has begun to develop *State of the Park* reports to assess the overall status of each park's resources. The NPS will use the *State of the Park* report information to improve park priority setting and to synthesize and communicate complex park condition information to the public in a clear and simple way (NPS 2012).

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

- Provide to visitors and the American public a snapshot of the status and trend in the condition of a park's priority resources and values.
- Summarize and communicate complex scientific, scholarly, and park operations factual information and expert opinion using non-technical language and a visual format.
- Highlight park stewardship activities and accomplishments to maintain or improve the State of the Park.
- Identify key issues and challenges facing the park to help inform park management planning.

The format for relevant state of the park content in sections 5.4-5.16 will integrate resource condition findings into the required format for the national recreation area's *State of the Park* report, such that relevant pieces can easily be used for such reports. This includes an overall natural resource summary table showing the resource topic condition and rationale for overall condition ratings. A summary of the Status and Trend symbols for condition ratings can be found in Chapter 3, Table 3.2.3-1. We then present each natural resource topic individually, including all indicators and/or measures by which resource topics were assessed. Finally, a resource brief summarizing the condition rationale, will follow the condition table and include any significant condition highlights.

Table 5.3-1 *State of the Park* Natural Resource Summary Table

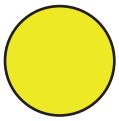
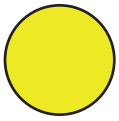
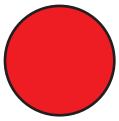
Priority Resource or Value	Condition Status/Trend	Summary of Overall Condition Rating
Natural Resources		
Viewshed		Viewshed condition is assessed based on scenic and historic integrity. The measures of integrity include intactness of view (that is, how much the viewshed has been altered from its reference state) and the conspicuousness of noncontributing factors (that is, how obvious the features are that are inconsistent with the scenic and historic integrity of the site).The viewshed at Chickasaw NRA is in moderate condition, with a medium level of confidence. Insufficient data are available to determine trend.
Night Sky		One indicator, sky brightness, was used to assess the condition of the night sky. Sky brightness was measured by the anthropogenic light ratio, modeled by the Natural Sounds and Night Sky Division. The overall condition of Chickasaw NRA's night sky is moderate, with a medium level of confidence. Insufficient data are available to determine trend.
Soundscape		We used two indicators and three measures to assess soundscape condition. The percent time audibility of noises was in good to moderate condition and the sound level indicator varied between the on-site monitoring measure, which was considered good, and the national sound model measure, which was of moderate to significant concern. Overall, the soundscape condition was considered to be in moderate condition.
Air Quality		The air quality assessment included visibility, ozone, and wet deposition for total nitrogen and total sulfur, all of which were of significant concern based upon NPS Air Resources Division reference criteria.
Geology		We used five indicators, travertine deposits, Vanoss Formation, paleontological resources, seismic risk, and disturbed lands, to assess the condition of geology in Chickasaw NRA. The condition for the travertine deposits is unknown. The condition of the Vanoss Formation is good. Paleontological resources are in unknown condition. Siesmic risk and disturbed lands are in a condition of significant concern. Overall, the condition of geology is moderate, with a stable trend, except for seismic risk.
Surface Water Quality		Two indicators were used to assess water quality condition. Most of the monitored parameters were within state water quality standards. However, given the fact that Lake of the Arbuckles is listed on Oklahoma's 303(d) list due to dissolved oxygen levels, even though the park and state are working together to change the standard, the water quality condition at Chickasaw NRA is moderate.
Groundwater and Springs		We used three indicators to assess the condition of springflow, streamflow, and groundwater head for both freshwater and mineral-water resources. Because decreasing trends were observed in artesian well discharge, discharge of two mineral springs, and low (dry-weather) flows of Rock Creek, we assigned an overall condition class of significant concern for the park's groundwater resources.
Riparian Habitat		Both Rock Creek and Guy Sandy Creek riparian resources including hydrology, vegetation, and erosion/deposition characteristics were assessed. The condition ratings for Rock Creek were good. All indicators and measures for Guy Sandy Creek were good except for three of the vegetation measures, which were considered to be in good to moderate condition. The overall condition rating for riparian habitat at the NRA was considered to be in good condition.

Table 5.3-1 State of the Park Natural Resource Summary Table (continued)

Priority Resource or Value	Condition Status/Trend	Summary of Overall Condition Rating
Grasslands		Grasslands at Chickasaw NRA are located within the transition zone where the Eastern deciduous forest and the Western prairies meet. For the grassland indicators and measures, condition was variable among sites, with the majority of sites in good to moderate ecological condition. Historic land uses have contributed to some degradation of grassland condition, especially in converted hayfields where restoration is underway. However, park staff have been actively engaged in restoring these areas, and the resulting outlook is for continued improvement.
Exotic Plants		We used two indicators, potential to alter native plant communities and prevalence of exotic plants, to assess the condition of exotic plants in the recreation area. The condition for the significance of exotic plant impact measure was of significant concern. Two of the measures for prevalence of exotic plants (extent and distribution) were of significant concern, and the third (density) was of moderate concern. Overall, the condition of exotic plants is of significant concern. The trend is declining.
Breeding Landbirds		We used one indicator, species occurrence (presence/absence), in three separate contexts (or measures; temporal, spatial, and conservation), to assess the condition of breeding landbirds at the Recreation Area. For each measure, we found the current condition of breeding landbirds to be good. We do not have sufficient data to justify a trend in the condition at this time.
Feral Mammals		We used one indicator, species occurrence, to assess the condition of feral mammals at the Recreation Area. We evaluated species occurrence using two measures, presence/absence of feral cats and presence/absence of feral hogs, which were determined to be of significant concern and moderate concern, respectively. The overall condition of feral mammals is of moderate to significant concern. Adequate information does not exist to evaluate trends in the condition.
Game Species		Due to no reference condition being identified, and no indicators or measures, condition and trend of game species at Chickasaw NRA is unknown at this time.

5.4. Viewshed Resource Brief and Narrative

The contents of sub-chapter 5.4 were designed to be placed into a stand-alone Viewshed resource brief at a later date. The final resource brief will follow NPS Graphic Identity Program (http://www.nps.gov/hfc/services/identity/) format and layout policy standards, and include the contact information of at least one NPS employee as a point contact for the public.

5.4.1. Condition Rationale

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

The scenic and historic integrity of the viewsheds at Chickasaw NRA are in moderate condition. The landscape surrounding the site remains somewhat intact, though noncontributing features do exist. Two vantage points were used to assess condition. From the Veteran's Lake vantage point the development along the northeastern views are conspicuous because their light coloring makes them stand out against the dark vegetation. Similarly, the tower in the western view stands out because its shape is in such contrast to the surroundings. The park trail is prominent, of course, but is an expected part of the experience, and its smooth, contoured lines make it blend in better. From Bromide Hill, homes and other developments are relatively conspicuous due to their light coloring (light colored, reflective rooftops) and the contrast they represent in the context of the deciduous forest vegetation. Although there are insufficient data to assess trend, housing and road density suggest there is a relatively high level of development along the borders of the park that are impacting the viewshed.

5.4.2. Noteworthy Highlights

From a cultural and historical perspective, the views are not just about the scenery, but an important way to better understand the connection between natural and cultural resources at Chickasaw NRA. Visualizing this connection as part of the landscape is a critical part of the visitor experience.

The cultural landscape focuses on the Civilian Conservation Corps (CCC) era (1933-1940) when rustic buildings, trails, and other infrastructure were erected; the Platt Historic District of the NRA is one of the most intact examples from that period.

Table 5.4.2-1. Summary of overall viewshed condition, indicators and measures, and rationale for assigning condition assessment at Chickasaw National Recreation Area.

Viewshed 			
Indicators of Condition	Specific Measures	Condition Status/Trend	Rationale
Scenic and Historic Integrity	Intactness of View		Views are somewhat intact, though non-contributing features do exist, consistent with moderate condition.
	Conspicuousness of non-contributing features		Non-contributing features are somewhat inconspicuous; consistent with moderate condition conditions.

5.5. Night Sky Resource Brief and Narrative

The contents of sub-chapter 5.5 were designed to be placed into a stand-alone Night Sky resource brief at a later date. The final resource brief will follow NPS Graphic Identity Program (http://www.nps.gov/hfc/services/identity/) format and layout policy standards, and include the contact information of at least one NPS employee as a point contact for the public.

5.5.1. Condition Rationale

Natural dark skies are a valued resource within the NPS, reflected in NPS management policies that highlight the importance of a natural photic environment to ecosystem function, and the importance of the natural lightscape for aesthetics. The value 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. Natural light intensity varies during the daynight (diurnal) cycle, the lunar cycle, and the seasonal cycle. Organisms have evolved to respond to these periodic changes in light levels in ways that control or modulate movement, feeding, mating, emergence, seasonal breeding, migration, hibernation, and dormancy. Plants also respond to light levels by flowering, vegetative growth, and their direction of growth

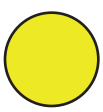
Chickasaw National Recreation Area (NRA) is a park where people come to enjoy the lakes and springs. Campgrounds offer an opportunity for people to enjoy the night sky, especially around the lakes where there is more sky visible and less interference from vegetation. Protecting the night sky resources benefits the natural resources and is important for visitor experience.

Condition of the NRA's night sky is moderate, based on the modeled ALR data and the significant influence from nearby light domes. No ground-based data are available.

5.5.2. Management and Project Considerations and Narrative

Although little can be done to minimize the impact of nearby city lights creating light domes, the park can improve local infrastructure around boat ramps, kiosks, and campgrounds to encourage dark night skies.

Table 5.5.1-1. Summary of overall night sky condition, indicators and measures, and rationale for assigning condition assessment at Chickasaw National Recreation Area.

Night Sky			
Indicators of Condition	Specific Measures	Condition Status/ Trend	Rationale
Sky Brightness	Anthropogenic Light Ratio (1.39)		This measure results from modeling data provided by the NPS Night Sky Program. Specific thresholds for condition classes have been set by the NPS. In this case, the moderate condition likely resulted from the light domes of nearby cities. No ground-based measurement has been collected, therefore, the confidence level in this assessment is medium.

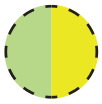
5.6. Soundscape Resource Brief and Narrative

The contents of sub-chapter 5.6 were designed to be placed into a stand-alone Soundscape resource brief at a later date. The final resource brief will follow NPS Graphic Identity Program (http://www.nps.gov/hfc/services/identity/) format and layout policy standards, and include the contact information of at least one NPS employee as a point contact for the public.

5.6.1. Condition Rationale

Soundscape condition was assessed at four locations using audibility and sound levels as indicators of condition. The percent time audibility of sounds was good, except for the constant automobile noise heard at the Rock Creek Trail morning session location. The most common sounds heard at all monitoring locations were natural and this measure was considered to be in good to moderate condition. While the sound levels of noises heard on-site were relatively low and considered to be in good condition, the sound levels modeled by Mennitt et al. (2013) suggested a moderate to significant concern sound level based on the sound level impact. When combining all measures, we considered the soundscape to be in moderate condition.

Table 5.6.2-1. Summary of overall soundscape condition, indicators and measures, and rationale for assigning condition assessment at Chickasaw National Recreation Area.

Soundscape			
Indicators of Condition	Specific Measures	Condition Status/Trend	Rationale
Audibility	% Time Audible		The percent time audibility of sounds was good except for the constant automobile noise heard at the Rock Creek Trail morning session location. While other noises were heard, many were within the expected range of sounds given the locations, such as boating and camping-related noises at Buckhorn Campground. The most common sounds heard at all monitoring locations were natural. Overall we consider the percent time audibility measure to be in good to moderate condition.
Sound Level	Amplitude (on-site monitoring)		The loudest sounds heard were within the recreational-based zones, especially at Buckhorn Campground where boats and jet skis produced the loudest sounds. While auto noise was heard 99% of the time at the morning session monitoring location along Rock Creek, it was very low and likely a result of the morning quiet not masking the constant sound. Overall, most sounds heard would not have interrupted a normal conversation at 1 m. We consider this measure to be in good condition.
	Amplitude (Mennitt et al. (2013) modeled sound level impact)		The modeled impact sound level for the National Recreation Area ranged between 1.6-5.9 dBA. This range is between the moderate to significant concern thresholds for non-urban parks (Turina et al. 2013).

5.7. Air Quality Resource Brief and Narrative

The contents of sub-chapter 5.7 were designed to be placed into a stand-alone Air Quality resource brief at a later date. The final resource brief will follow NPS Graphic Identity Program (http://www.nps.gov/hfc/services/identity/) format and layout policy standards, and include the contact information of at least one NPS employee as a point contact for the public.

5.7.1. Condition Rationale

We used four measures to assess air quality condition including ozone levels, visibility, and wet deposition of sulfur and nitrogen. All indicators and measures were of significant concern based on NPS Air Resources Division reference conditions. No trends were reported for any of the measures since no monitoring station was within the required distance from the park. Like most airsheds, the park's air quality is largely influenced by activities and operations that occur outside its boundaries, and the future of its air quality condition is ultimately dependent on local, regional, and national planning.

Table 5.7.1-1. Summary of overall air quality condition, indicators and measures, and rationale for assigning condition assessment at Chickasaw National Recreation Area.

Air Quality 			
Indicators of Condition	Specific Measures	Condition Status/Trend	Rationale
Visibility	Haze Index		For 2008–2012, estimated average visibility in the Recreation Area was 10.1 deciviews above natural conditions, therefore, the condition status warrants significant concern based on NPS Air Resource Division benchmarks. No trend information is available because there are not sufficient on-site or nearby visibility monitor stations.
Level of Ozone	Annual 4th-Highest 8-hour Concentration		The estimated ozone level for 2008–2012 at the Recreation Area was 76.6 parts per billion, therefore, the condition status warrants significant concern based on NPS Air Resource Division benchmarks. There are 13 ozone-sensitive plants in the NRA, with eight representing bioindicators. No trend information is available because there are not sufficient on-site or nearby ozone monitor stations.
Atmospheric Wet Deposition in Total N and total S	Total N in kg/ha/yr		For 2008–2012, estimated wet nitrogen deposition was 4.8 kilograms per hectare per year, therefore, the condition status warrants significant concern based on NPS Air Resource Division benchmarks. No NPS-ARD trend information is available for nitrogen.
	Total S in kg/ha/yr		For 2008–2012, estimated wet sulfur deposition was 3.1 kilograms per hectare per year, therefore, the resource is in significant condition based on NPS Air Resource Division benchmarks. No NPS-ARD trend information is available for sulfur.

5.8. Geology Resource Brief and Narrative

The contents of sub-chapter 5.8 were designed to be placed into a stand-alone Geology resource brief at a later date. The final resource brief will follow NPS Graphic Identity Program (http://www.nps.gov/hfc/services/identity/) format and layout policy standards, and include the contact information of at least one NPS employee as a point contact for the public.

5.8.1. Noteworthy Highlights:

The geology of Chickasaw NRA is an integral part of the site's significance, especially given the mineral and freshwater springs of the Platt Historic District. The complex geologic history of the region produced the Arbuckle-Simpson Aquifer, which is the source of the springs, and is also a source of drinking water in the region (Graham 2015).

5.8.2. Condition Rationale:

The condition of geology at Chickasaw National Recreation Area is moderate. We evaluated geology using five indicators, with one measure each. The travertine deposit indicator was in unknown condition since travertine deposits have not been mapped. The condition of the Vanoss Formation is good since it is in natural condition in the park. Paleontological resources are in unknown condition since they are not being monitored for the impacts of human activities, which may include collecting. The number of seismic occurrences is currently in good condition. but Oklahoma has experienced a sharp increase in earthquakes in recent years suspected to result from the injection of wastewater from oil and gas production in deep

Table 5.8.1-1. Summary of overall geology condition, indicators and measures, and rationale for assigning condition assessment at Chickasaw National Recreation Area.

Geology			
Indicators of Condition	Specific Measures	Condition Status/Trend	Rationale
Travertine Deposits	Travertine Intactness		With the exception of modifications to springs and Travertine Creek by the CCC, the travertine deposits in Chickasaw NRA remain in natural condition. Future deposition of travertine is dependent on future flow from freshwater springs. The travertine deposits in the NRA have not been mapped.
Vanoss Formation	Vanoss Formation Intactness		The Vanoss Formation is in natural condition in Chickasaw NRA. While some risk of rock fall at Bromide Hill exists, the conglomerate unit is generally resistant to erosion.
Paleontological Resources	Fossil Intactness		Fossils within Chickasaw are not experiencing accelerated erosion due to climatic factors. The recreation area's freeze-thaw index has decreased with warmer temperatures. However, fossil localities within Chickasaw are not being monitored for impacts of human activities, which may include fossil collecting.
Seismic Actvity	Presence/Absence		Oklahoma has experienced a sharp increase in earthquakes in the last 5 to 7 years, which are suspected to result from wastewater injection in deep wells. Chickasaw is in the area of potentially induced earthquakes, which are likely to occur on preexisting faults. Several major faults cut across the region, but no earthquakes have occurred in the park to date.
Disturbed Lands	Abandoned Mineral Land Prioritization Ranking		The two AML sites in Chickasaw NRA were ranked as high priority for mitigation by the NPS AML program because of their hazards and easy access for visitation.

wells (Oklahoma Geological Survey 2015). Future earthquake rates may depend on regulatory and economic factors (Petersen et al. 2015). Chickasaw NRA has two AML sites both ranked as high priority for mitigation by the NPS (Burghardt et al. 2014), making the condition for disturbed lands to be of significant concern.

5.8.3. Management and Project Considerations and Narrative

It appears that climate change may be decreasing the freeze-thaw index for the recreation area, which would theoretically expose fossils to less weathering and erosion due to freeze-thaw processes. However, fossil sites are not monitored and fossil collecting may be occurring within park boundaries (Noel Osborn, personal communication, 2015), so periodic monitoring may help inform the condition of this resource.

Chickasaw NRA contains only two AML sites; however, both sites are identified as high priority for mitigation by the NPS AML program because they present hazards and are easily accessible (Burghardt et al. 2014). The sites are gilsonite quarries that are easily accessible to the public and have highwall hazards, and one site has a deep pool that presents a drowning hazard (NPS 2015). Mitigation at the sites may include fencing to restrict access, and a mechanism to drain water from the West Site is also needed (NPS 2015), with an estimated cost of $140,000 in 2013 dollars for both sites (Burghardt et al. 2014).

While an excellent 1:24,000 geologic map of the region exists (Blome et al. 2013), important features such as travertine deposits have not been mapped and fossil localities have not been identified. Mapping of these resources would provide baseline information from which potential management objectives could be identified.

5.9. Surface Water Quality Brief and Narrative

The contents of sub-chapter 5.9 were designed to be placed into a stand-alone Surface Water Quality resource brief at a later date. The final resource brief will follow NPS Graphic Identity Program (http://www.nps.gov/hfc/services/identity/) format and layout policy standards, and include the contact information of at least one NPS employee as a point contact for the public.

5.9.1. Condition Rationale

Chickasaw NRA's surface water quality is monitored by park staff. A total of five field parameters and *E. coli* levels are regularly measured to monitor overall water quality condition. All of the parameters, except for dissolved oxygen in Lake of the Arbuckles, were within Oklahoma State's water quality standards. Lake of the Arbuckles is listed on Oklahoma's (2014) 303(d) impaired waterbodies list and until it is removed, which park staff are actively working with Oklahoma Water Resources Board to amend the criterion, the water quality condition at Chickasaw NRA is considered to be of significant concern..

5.9.2. Management and Project Considerations and Narrative

Continuing to monitor water quality parameters regularly to avoid or mitigate human activities that cause contamination of water resources will help the park continue to be proactive as issues arise. While water quantity was not selected as a topic for assessment, submitting a technical assistance request to NPS Water Resources Division to determine discharge rating curves for those segments with stage and discharge data will provide baseline information upon which further investigations can be built if needed.

Table 5.9.1-1. Summary of overall surface water quality condition, indicators and measures, and rationale for assigning condition assessment at Chickasaw National Recreation Area.

Surface Water Quality and Quantity			
Indicators of Condition	Specific Measures	Condition Status/Trend	Rationale
Field Properties	5 Measures		With a few exceptions, most of the field properties were within state standards, however, low dissolved oxygen levels in Lake of the Arbuckles does not meet the state's current standard. The low dissolved oxygen may be an inherent characteristic of the reservoir, but until a total maximum daily load is identified and the lake is removed from the state's 303(d) list of impaired waterbodies, we consider this measure to be of significant concern.
E. coli	1 Measure		Based on 2013 data only, we consider E. coli levels to be in good condition. However, high levels of E. coli have been detected over many of the monitoring years. Porter et al. (2010) reported that samples collected at Little Niagara and Bear Falls swimming areas exceeded the criterion more than 25% of the time but that levels appeared to be decreasing over time.

5.10. Groundwater and Springs Resource Brief and Narrative

The contents of sub-chapter 5.10 were designed to be placed into a stand-alone Groundwater resource brief at a later date. The final resource brief will follow NPS Graphic Identity Program (http://www.nps.gov/hfc/services/identity/) format and layout policy standards, and include the contact information of at least one NPS employee as a point contact for the public.

5.10.1. Noteworthy Highlights

The Platt Historic District of Chickasaw National Recreation Area, named Sulphur Springs Reservation in 1902 and Platt National Park in 1906, was established to protect the unique freshwater and mineral springs along Travertine and Rock Creeks. Groundwater provides base flow to Travertine and Rock Creeks, which supply water to Lake of the Arbuckles. Today, visitors come to the Platt District for recreational purposes-to swim in Travertine Creek, visit the springs, hike, picnic, and camp.

Springs and streams in the Platt District are supplied by water from the Arbuckle-Simpson aquifer. Although most groundwater discharge from the aquifer is to springs and streams, some groundwater discharge is to water wells. Average annual reported groundwater use from the eastern Arbuckle- Simpson aquifer from 1964 through 2008 was 4,299 acre-ft, of which about 2,000 acre-ft/year was withdrawn in the vicinity of the Platt District.

Table 5.10.1-1. Summary of overall groundwater condition, indicators and measures, and rationale for assigning condition assessment at Lake Meredith National Recreation Area.

Groundwater and Springs			
Indicators of Condition	Specific Measures	Condition Status/Trend	Rationale
Springflow	Freshwater Discharge		Hydrographs of Antelope and Buffalo Springs discharge from 2004-2015 show a correlation with seasonal precipitation, but no long-term trends.
	Mineral Water Discharge		Hydrographs of Pavilion, Hillside, and Black Sulphur Springs discharge from 2004 to 2015 indicates a possible long-term decline in spring discharge of Pavilion and Hillside Springs (Significant Concern/Decreasing) and a possible increase in spring discharge of Black Sulphur Spring. (Overall Moderate/ Decreasing)
Streamflow	Freshwater Discharge		The period of record for the Travertine Creek streamgage is too short for computing base flow and for determining long-term trends.
	Mineral Water Discharge		The Rock Creek streamgage, located in the southwest area of the Platt District, has recorded streamflow since 1989. Daily mean discharge from 1989 to 2015, indicates a downward trend in low flows.
Groundwater Head	Freshwater Groundwater Level		Freshwater: Groundwater levels in 2 observation wells correlate with seasonal changes in precipitation and with Antelope and Buffalo Spring discharge, but no long-term trends.
	Mineral Water Artesian Well Discharge		Mineral: Discharge measurements from Vendome Well #2 show a continued long-term decline.

Considerably less water is being withdrawn from the aquifer today than in the past. A substantial amount of groundwater was discharged from unregulated flowing artesian wells in the vicinity of the Platt District and the City of Sulphur, where more than 40 flowing artesian were drilled since 1889. Discharge from flowing artesian wells peaked in the 1930s. In 1937, discharge from 16 of the larger wells was estimated to be 33,070 acre-ft/year.

By 1937, the mineral springs discharged about one-fifth as much water as they did in 1906, and 14 of the original 27 mineral springs ceased to flow. The depletion of flow in mineral springs most likely resulted from a gradual lowering in the hydraulic head of the Arbuckle-Simpson aquifer caused by many years of uncontrolled flowing artesian wells.

5.10.2. Condition Rationale

The groundwater system has degraded since 1906, but has reached a somewhat stable state since monitoring began in 1988. The condition of groundwater resources is assessed for long-term declines in springflow, streamflow, and groundwater head since 1988. We used three indicators, each with two measures, to assess the current condition and trend for groundwater resources at Chickasaw NRA. The indicators evaluate the condition of the recreation area's springflow, streamflow, and groundwater head.

These indicators were measured separately for freshwater and mineral-water resources. Freshwater springs (Antelope and Buffalo), streams (Travertine Creek), and groundwater in the observation wells represent water from the freshwater system, which was recharged east of the park less than 60 years ago. Mineral springs (Pavilion, Hillside, and Black Sulphur), groundwater discharging to Rock Creek as base flow, and artesian well discharge represent groundwater in the mineral-water system. Groundwater in the mineral-water system is a mix of water from the freshwater system and saline water that originates from a deeper, older system than the freshwater system.

Because long-term declines were observed in artesian well discharge, discharge of two mineral springs, and low (dry-weather) flows of Rock Creek, we assigned an overall condition class of significant concern for the park's groundwater resources.

5.10.3. Management and Project Considerations and Narrative

Chickasaw National Recreation Area is taking several measures to protect the water resources of the Platt District. The NRA is working with the City of Sulphur, quarries, and other current and future significant groundwater users in the aquifer to prevent negative impacts to the park's water resources. Together with the Bureau of Reclamation and the Chickasaw Nation, the NRA is working with the City of Sulphur to move toward using surface water from Lake of the Arbuckles instead of groundwater. The NRA is also working on educating the community on the importance of conserving water. The NRA is reducing its own groundwater use by restricting the flow from Vendome Well. In addition, the NRA is planning to install a re-circulating pump in the historic 12th Street Fountain in order to reduce its use of City water. Chickasaw NRA will continue to establish partnerships with other Federal and State agencies, Tribes, and non-governmental entities to facilitate cooperative regional strategies to protect the Arbuckle-Simpson aquifer. NRA staff will continue to monitor spring and stream discharge to identify baseline conditions, natural variation, and long-term trends. The NPS Water Rights Division will continue to represent and protect the park's water rights and water-related resources from the effects of groundwater development in the Arbuckle-Simpson aquifer.

5.11. Riparian Habitat Resource Brief and Narrative

The contents of sub-chapter 5.11 were designed to be placed into a stand-alone Riparian Habitat resource brief at a later date. The final resource brief will follow NPS Graphic Identity Riparian Habitat (http://www.nps.gov/hfc/services/identity/) format and layout policy standards, and include the contact information of at least one NPS employee as a point contact for the public.

5.11.1. Condition Rationale

Riparian habitat along Rock and Guy Sandy Creeks were assessed for current condition. Rock Creek is a perennial stream supplied by a variety of surface and ground water sources and has a mostly bedrock channel bed. It supports relatively diverse, soil-stabilizing woody and herbaceous riparian-wetland plant communities on the channel banks, point/side channel bars and floodplain surfaces. We considered all of the measures for Rock Creek's riparian system to be in good condition.

Several of the measures for Guy Sandy Creek were in proper functioning condition for the riparian forest but not for perennial herbaceous riparian-wetland vegetation, which resulted in some mixed condition responses Additionally, the point bars of the inner channel were largely devoid of vegetation. The ephemeral nature of flow from the contributing watershed, the minimal (if any) connection to the Arbuckle- Simpson aquifer and the very poor water-holding capacity of the coarse alluvium in the inner channel appeared to limit the potential for establishment or maintenance of most riparian-wetland vegetation. However, despite these limitations, the combination of tree roots protecting the upper banks and the energy dissipation provided by the channel morphology appeared to be sufficient to dissipate flood energy without fundamental changes in the overall channel/ floodplain form and was rated being in overall good condition.

Table 5.11.1-1. Summary of overall riparian habitat condition, indicators and measures, and rationale for assigning condition ratings at Chickasaw National Recreation Area.

Riparian Habitat 				
Indicators of Condition	Specific Measures	Rock Creek Condition Status/Trend	Guy Sandy Creek Condition Status/Trend	Rationale
Hydrology	4 measures			All hydrology measures for both creeks were in good condition.
Vegetation	6 measures			All of the vegetation measures were in good condition for Rock Creek. Three of the measures for Guy Sandy Creek were in good condition and the remaining three were in moderate condition, warranting a good-moderate condition rating.
Erosion/Deposition	5 measures			Overall, these measures were in good condition for both creeks, however, the point bars of Guy Sandy Creek's inner channel were largely devoid of vegetation, although this was not sufficient to warrant a degraded condition rating.

5.12. Grasslands Resource Brief and Narrative

The contents of sub-chapter 5.12 were designed to be placed into a stand-alone Grasslands resource brief at a later date. The final resource brief will follow NPS Graphic Identity Program (http://www.nps.gov/hfc/services/identity/) format and layout policy standards, and include the contact information of at least one NPS employee as a point contact for the public.

5.12.1. Noteworthy Highlights

It should be noted that the condition of grasslands is the result of a long history of land use and ecological conditions that began long before the establishment of Chickasaw as a national recreation area. Consequently, we do not consider the sites with grassland problems to be a result of NPS management; quite the contrary. Chickasaw NRA natural resource staff has been actively engaged in restoring areas in more degraded condition. Thus, we believe that many areas of the NRA would be in substantially worse condition if it were not for the efforts of CHIC staff.

5.12.2. Condition Rationale

For many indicators and measures, condition was variable among sites, with the majority of sites in good to moderate ecological condition. Both monitoring and assessment sites that scored poorly with some consistency are what were described as clayey bottomland ecosite types. In some cases, these were converted hayfields and restoration is underway. Sites that are in better condition are actively managed by the park. Thus, based on the measures, data, expert opinion, and management activities, we consider the overall condition of the grasslands at Chickasaw NRA to be in good condition with an improving trend as the region shifts from extreme drought conditions to more normal rainfall patterns and as park management continues to address exotic plants and restoration of native prairies.

Table 5.12.2-1. Summary of overall grasslands condition, indicators and measures, and rationale for assigning condition assessment at Chickasaw National Recreation Area.

Grasslands 			
Indicators of Condition	Specific Measures	Condition Status/Trend	Rationale
Soil/Site Stability and Hydrologic Function	10 measures		Departures from expected conditions for most measures of Soil/Site Stability and Hydrologic Function were minimal at most sites. Indicators of potential erosion did occur at a few sites, but not significantly enough to impact site condition or to warrant downgrading the assessment score. Therefore we assigned a good condition rating overall.
Biotic Integrity	5 measures		For many indicators and measures of biotic integrity, condition was variable among sites, with the majority of sites in good to moderate ecological condition. The sites that scored poorly were converted hayfields and restoration is underway. We consider the overall condition of the grasslands at Chickasaw NRA to be in good condition with an improving trend.

5.13. Exotic Plants Resource Brief and Narrative

The contents of sub-chapter 5.13 were designed to be placed into a stand-alone Exotic Plants resource brief at a later date. The final resource brief will follow NPS Graphic Identity Program (http://www.nps.gov/hfc/services/identity/) format and layout policy standards, and include the contact information of at least one NPS employee as a point contact for the public.

5.13.1. Condition Rationale

The condition of exotic plants at Chickasaw National Recreation Area is of significant concern. We evaluated exotic plants using two indicators, with four measures. The significance of exotic plant impact measure for the potential to alter native plant communities indicator examined species' innate ability to become a pest. This measure utilized the ranking system from the Handbook for Ranking Exotic Plants (Heibert and Stubbendieck 1993). Sixteen of the 43 exotic plant species (37%) found during SOPN monitoring and the 2014 rapid assessment were ranked as either highest or high for their significance of exotic plant impact. Sixteen additional species (37%) were of medium concern. Based on the fact that the majority of exotic plant species found in the park are at medium to highest concern for their innate ability to become a pest, we found the condition for this indicator of significant concern. The prevalence of exotic plants indicator had three measures: extent (how often an exotic species was detected during monitoring), density (how many individuals of exotic plant species found per sampling unit) and distribution (where the exotic plants were found). Exotic plants had a wide extent. They were found in more than 98% of the blocks monitored in annual surveying between

Table 5.13.1-1. Summary of overall exotic plants condition, indicators and measures, and rationale for assigning condition assessment at Chickasaw National Recreation Area.

Exotic Plants			
Indicators of Condition	Specific Measures	Condition Status/Trend	Rationale
Potential to Alter Native Plant Communities	Significance of Exotic Impact		This measure is based on the premise that species with the highest innate ability to become a pest generally cause the most severe problems in natural ecosystems. Sixteen of the 43 species of exotic plants found during SOPN monitoring were ranked as having the highest or high innate ability to become a pest. Therefore, we consider this measure to be of significant concern.
Prevalence of Exotic Plants	Extent of Exotic		Exotic plants were found in 98.6% of the blocks along high priority vectors. Thirty-six exotic species were found during monitoring between 2012-2014, including 10 species that were found in more than 25% of vector blocks. Thirty species were found during the 2014 rapid assessment, although the extent of exotic plants was less prevalent than in the vector monitoring. Exotic plants were not found in nearly 30% of plots, and individual species were found in less than 27% of the plots.
	Density of Exotic		Most of the exotic species occurrences in Chickasaw NRA were in moderate to low densities in monitored parts of the park. Species were most often found in density class 2 (scattered patchy).
	Distribution of Exotic		Exotic plants were found in widely distributed in the park, especially along the high priority vectors. Five species, including *Bromus japonicus* and *Sorghum halepense,* were found along all seven vectors and in all four rapid assessment areas.

2012-2014, and in 70% of the plots sampled in the 2014 rapid assessment. Individual species were found in as many as 73% of the blocks sampled in annual monitoring and 26% of the one-time rapid assessment plots. Hence, the extent of exotic plants in the recreation area is of significant concern. Exotic plants were found mostly in medium to low densities in the park indicating a moderate level of concern for this measure. The distribution of exotic plants is also of significant concern. They are found in all areas of the park that were surveyed, including 18 species that were found in more than half of the combined surveyed rapid assessment areas and high priority vectors. Further, by combining the four measures and evaluating the species on an individual basis, 12 exotic plant species were in a condition of significant concern, and nine species were in moderate condition. One additional species was designated as of special concern.

5.13.2. Management and Project Considerations and Narrative

Chickasaw National Recreation Area is located in the transition zone in which eastern deciduous forest meets the western prairie, resulting in a rich array of diverse native vegetation in habitats ranging from oak woodland to juniper woodland, and from wetland to upland grassland (Salas et al. 2010). Probably more than 600 species of vascular plants are found in Chickasaw (Hoagland 2006). The same environmental characteristics that make the recreation area suitable habitat for eastern and western native plant species provide environments that favor exotic plants that are typically found in more western and more eastern areas. For example, Bromus tectorum (cheatgrass) is typically found in the west, and Lathyrus hirsutus (singletary pea) is usually found in the east. Both exotic species are found in Chickasaw.

Chickasaw is at further risk of exotic plant infestations because it is surrounded by urban and suburban development and contains numerous streams and drainage systems that can serve as vectors for the spread of exotic plant species (Folts-Zettner and Sosinski 2012a,b). It also experiences a great deal of recreational use which can also lead to the introduction of exotic plants, and contains lands that were formerly used for agriculture (Folts-Zettner, SOPN biologist, personal communication, 2014).

As a result of its habitat characteristics, location in the east-to-west transition zone, and risk factors for exotic plant infestations, Chickasaw contains a large number of exotic plant species that are especially prevalent along vectors (park roads and trails). Forty-three exotic plant species were found during SOPN monitoring in 2012-2014, the most exotic species found in park units found during monitoring in the Southern Plains Network.

Exotic plant species have an adverse impact on the integrity of park resources. They change the ecosystem structure, alter nutrient cycles and soil chemistry, alter the normal successional trajectory of a system (Ehrenfeld 2003, Emery 2012), and limit water availability (USFWS 2012). As a result, management of exotic plant species is an integral aspect of preserving and protecting the natural resources of an NPS unit. Three-quarters of the exotic plants found in the recreation area have at least medium impact on native plant communities, including 35% that were ranked as having highest or high potential to impact native plant communities using the Heibert and Stubbendieck (1993) system.

Chickasaw contains exotic species that are well established, e.g., species such as Sorghum halepense (Johnsongrass) and Bromus japonicas (Japanese brome), and species that may be more recent arrivals or experiencing a renewed period of spreading. More recent arrivals may include the eight species, including Bromus inermis (smooth brome), Carduus nutans (nodding musk thistle), Conium maculatum (poison hemlock), and Onopordum acanthium (Scotch thistle), detected in 2012-2014 SOPN monitoring that were not previously documented by the network (Folts-Zettner 2014).

Species that are prevalent in the park such as Bothriochloa ischaemum (King Ranch bluestem) and Johnsongrass present different management challenges than species that have limited occurrence in the park. For prevalent species, infestations in restoration sites or in especially vulnerable sites such as riparian zones may have more ecological significance, and may be of greater ecological concern, than infestations in other areas. Given that exotic plant species were significantly more prevalent along the vectors than in the interior of the park sampled in the rapid assessment, treatment of exotic species along vectors may be an effective way to prevent infestations in other areas of the recreation site. Further, the species such as poison hemlock, Lonicera japonica (Japanese honeysuckle), and Lespedeza cuneata (sericea lespedeza) that have the greatest potential to alter native plant communities, and/or have a low feasibility of control of management, ease of control ranking (Heibert and Stubbendieck 1993) such as Poa annua (annual bluegrass) and Coronilla varia (purple crownvetch) (Table 5.12.2-1) may warrant greater attention than other species.

Prevention and early detection of new infestations are integral aspects of successful invasive exotic plant management. While there is a need for long-term suppression programs to address high-impact species that are already prevalent, management agencies tend to direct resources toward control of weed species that are already major problems, and not much toward the prevention, early detection, and or even early containment of new exotic plants (Radosevich 2007). The SOPN annual monitoring program is an outstanding tool that managers can use to detect small or new infestations of exotic plants at NPS sites. At the recreation area, annual monitoring along high priority vectors since 2010 has provided an extensive data set on the exotic plant species found along those park roads and trails. For example, monitoring data shows that Bromus inermis (smooth brome), a species of highest potential to alter native plant communities, was only detected in one block along the Cedar Blue Road (Folts-Zettner and Sosinski 2012a,b) during 2012-2014 monitoring. Data such as this can provide managers with tools to plan strategies for control of high priority exotic plant species before they get well established or potentially spread to other park areas. Early detection followed by control efforts while infestations are small or localized may prevent exotic plant species from spreading, or prevent the species from becoming more prevalent than their current limited extent.

Further, the 2014 exotic plants rapid assessment provided a one-time measurement of exotic plants found in areas that represent that major habitats of the recreation area (woodland and grassland) and that have received different treatments for exotic plants infestations. In general, exotic plant species were significantly less extent in the rapid assessment areas than along the vectors.

The majority of the exotic species with highest or high exotic plant impact found in the recreation area also are difficult to control (Table 5.15.2-1). Fifteen of the 16 species ranked as extremely difficult or difficult for feasibility of control or management, ease of control, using the Hiebert and Stubbendieck (1993) ranking system, are species with a highest or high potential to alter native plant communities. Indeed, the various characteristics that make the impact of an exotic plant to natural plant ecosystems significant such as vegetative reproduction, potential for long distance dispersal and prolific seed production, also make a plant inherently difficult to control. Given the correlation between a species innate ability to become a pest and the difficulty of controlling the species, the early detection rapid response model for the control of exotic plant infestations becomes an especially powerful management tool.

Table 5.13.2-1. Feasibility of management, ease of control ranking for species detected in SOPN 2012-2014 monitoring (Folts-Zettner and Sosinski 2012a, 2013, 2014) and the 2014 Rapid Assessment (Horsley and Schafer 2014), using a subset of Hiebert and Stubbendieck's (1993) Handbook for Ranking Exotic Plants for Management and Control.

Species	Common Name	Feasibility of Management Ranking
Convolvulus arvensis[1]	field bindweed	Extremely Difficult (6)
Coronilla varia[1]	purple crownvetch	Extremely Difficult (11)
Cynodon dactylon[1]	Bermudagrass	Extremely Difficult (11)
Erodium cicutarium	redstem stork'sbill	Extremely Difficult (11)
Euphorbia spp.[1]	spurge	Extremely Difficult (11)
Lespedeza cuneata[1]	sericea lespedeza	Extremely Difficult (11)
Medicago minima	burr medick clover	Extremely Difficult (15)
Poa annua[1]	annual bluegrass	Extremely Difficult (11)
Achillea millefolium	common yarrow	Difficult (20)
Bothriochloa ischaemum[1]	king ranch bluestem	Difficult (16)
Bromus catharticus	rescue brome	Difficult (16)
Bromus inermis[1]	smooth brome	Difficult (20)
Bromus japonicus[1]	Japanese brome	Difficult (21)
Bromus tectorum[1]	cheatgrass	Difficult (16)
Carduus nutans[1]	nodding musk thistle	Difficult (16)
Conium maculatum[1]	poison hemlock	Difficult (16)
Datura stramonium	jimsonweed	Difficult (21)
Echinochloa colona[1]	jungle ricegrass	Difficult (20)
Lonicera japonica[1]	Japanese honeysuckle	Difficult (21)
Melilotus spp.	white/yellow sweet-clover	Difficult (21)
Mentha spicata	spearmint	Difficult (25)
Rumex crispus	curley dock	Difficult (16)
Sorghum halepense[1]	Johnsongrass	Difficult (21)
Aegilops cylindrica	jointed goatgrass	Medium (31)
Bromus lanceolatus	Mediterranean brome	Medium (28)
Kummerowia stipulacea	Korean lespedeza	Medium (26)
Lactuca serriola	prickly lettuce	Medium (32)
Medicago lupulina	black medik clover	Medium (35)
Onopordum acanthium[1]	Scotch thistle	Medium (26)
Paspalum dilatatum	dallas grass	Medium (30)
Polygonum convolvulus	climbing buckwheat	Medium (30)
Sonchus asper	spiny sowthistle	Medium (35)
Taraxacum officinale	dandelion	Medium (35)
Tragopogon dubius	western salsify	Medium (31)
Chenopodium album	lamb's quarters	Easily Controlled (50)
Daucus carota	Queen Anne's lace	Easily Controlled (45)
Lathyrus hirsutus	singletary pea	Easily Controlled (55)
Lolium perenne[2]	perennial ryegrass	Easily Controlled (40)
Medicago sativa	alfalfa	Easily Controlled (40)
Torilis arvensis	spreading hedgeparsley	Easily Controlled (45)
Trifolium arvense	rabbit footclover	Easily Controlled (50)
Trifolium dubium	small hop clover	Easily Controlled (50)

[1] Species considered to be of highest or high concern using the significance of exotic plant impact, innate ability to become a pest measure (Hiebert and Stubbendieck 1993) are highlighted in the darker tone.

[2]Species of special concern (Folts-Zettner, SOPN biologist, personal communication, 2014) are highlighted in the lighter tone.

5.14. Landbirds Resource Brief and Narrative

The contents of sub-chapter 5.14 were designed to be placed into a stand-alone Landbirds resource brief at a later date. The final resource brief will follow NPS Graphic Identity Program (http://www.nps.gov/hfc/services/identity/) format and layout policy standards, and include the contact information of at least one NPS employee as a point contact for the public.

5.14.1. Noteworthy Highlights:

Approximately 124 bird species have been reported to occur at the Recreation Area (see Appendix G), with 113 of the species observed during the 2009-2013 RMBO surveys. Twenty-three of the species are considered species of conservation concern by one or more organization. Twelve of these 23 species have high conservation potential at the Recreation

Table 5.14.2-1. Summary of overall landbirds condition, indicators and measures, and rationale for assigning condition assessment at Chickasaw National Recreation Area.

Breeding Landbirds			
Indicators of Condition	Specific Measures	Condition Status/Trend	Rationale
Species Occurrence	Temporal Context		Eighty-nine percent of 84 species observed in the 2003-2004 bird inventory were observed in 2009-2013 RMBO bird surveys at the Recreation Area. There were eight species observed by ONHI that RMBO surveys did not detect. Half of these are associated with wetlands- habitat not surveyed in 2009-2013. Of the remaining species, only two were within their normal breeding ranges and fall into the "exists" habitat class; both species are owls (nocturnal), which have probably just gone undetected during RMBO surveys. Additionally, 38 species were observed in the 2009-2013 RMBO surveys but not in 2003-2004. In a temporal context, the condition of breeding landbirds at the Recreation Area is good. Data are available for a relatively small number of years, so no trend information is available at this time.
	Spatial Context		In a comparison of RMBO surveys in the Recreation Area to BBSs in the surrounding region, there were nine species that were not observed at the park by RMBO in 2009-2013 (excluding one non-native species). Of the species within their normal breeding ranges, only one (Great Horned Owl) falls into the "exists" breeding habitat class. It is possible that this species may have gone undetected by RMBO's daytime surveys. Also, the species was only observed one time (one individual) during BBSs. Based on this comparison, the condition of breeding landbirds is good. We do not have sufficient data to justify a trend in the condition at this time.
	Conservation Context		There are 23 species that have been observed during 2009-2013 and/or 2003-2004 surveys that are listed by one or more organization as being of conservation concern. We believe that 12 of these species have high conservation potential at the Recreation Area. These are species that are within their normal breeding ranges and sufficient habitat exists at the Recreation Area to support their breeding. All of these species have been observed on recent RMBO surveys (most in four or five years). Therefore, we consider the condition of species of conservation concern at the park to be good. We do not have sufficient data to justify a trend in the condition at this time.

Area, because they are within their normal breeding ranges and breeding habitat exists for them at the park. Several of the species, such as Field Sparrow, Painted Bunting, Dickcissel, and Great Crested Flycatcher, have been observed in relatively high numbers during RMBO surveys. Six additional species are considered to have moderate potential for the park to contribute to their conservation during the breeding season.

5.14.2. Condition Rationale:

The condition of breeding landbirds at the Recreation Area, assessed using one indicator, species occurrence (presence/absence), is good. We evaluated species occurrence using three measures/contexts (temporal, spatial, and conservation contexts), all of which were determined to be in good condition. Although our assessment was not based on extensive data (five years of recent RMBO data [2009-2013], one season of point count data in 2003, and BBS data for three routes, only one of which had data for 2009-2013), we found no justification to warrant concern for landbird species occurrence at this time. The temporal comparison found eight species that were not detected during recent RMBO surveys, but only two of the species (excluding one wetland-dependent species that would not be expected during RMBO surveys of upland grassland habitats [Pied-billed Grebe]) are within their normal breeding ranges and fall into the "exists" breeding habitat class, in which the habitat at the Recreation Area is characteristic of the habitat(s) where the species would be expected to breed. These two species are owls (nocturnal), and it would not be surprising for RMBO surveys during the day to miss them. Also, 38 different species were observed in recent RMBO surveys but not in the older inventory. The spatial comparison found that nine species were observed during surveys in the vicinity of the park but not during RMBO surveys. Of the species within their normal breeding ranges (or within 100 miles of the ranges), only one, Great Horned Owl, falls within the "exists" breeding habitat class. As mentioned above, this species may simply have gone undetected so far because it is nocturnal. Twenty-three species that have been recorded at the Recreation Area are listed by one or more organization as being of conservation concern. Of these, 12 are considered to have high conservation potential at the park; these are species that are within their normal breeding range, and sufficient habitat exists at the park to support their breeding. All of these species have been observed during recent surveys at the park (in one or more years), with some being observed in relatively high numbers. The condition of landbirds at the Recreation Area is good. Adequate information does not exist at this time to evaluate trends in the condition.

5.15. Feral Mammals Resource Brief and Narrative

The contents of sub-chapter 5.15 were designed to be placed into a stand-alone Feral Mammals resource brief at a later date. The final resource brief will follow NPS Graphic Identity Program (http://www.nps.gov/hfc/services/identity/) format and layout policy standards, and include the contact information of at least one NPS employee as a point contact for the public.

5.15.1. Noteworthy Highlights

Two species of feral mammals are known to occur at the Recreation Area, although population estimates based on sampling are unavailable for either species. Feral hogs occur in the southern portion of the park and feral cats occur in the northern portion of the park. Both species can cause damage to park resources, hogs especially through their rooting activities, and cats through their preying on small mammals, birds, and herpetofauna. Feral mammals may also harbor and transmit diseases. Both species present challenges for park management, but this is especially the case for feral cats, which are concentrated in the Platt Historic District where they may number in the hundreds.

5.15.2. Condition Rationale

The condition of feral mammals at the Recreation Area, assessed using one indicator (species occurrence), is significant to moderate. Adequate information does not exist to evaluate trends in the condition. We evaluated species occurrence using two measures, presence/absence of feral cats and presence/absence of feral hogs, which were determined to be of significant concern and moderate concern, respectively.

Table 5.15.2-1. Summary of overall feral mammals condition, indicators and measures, and rationale for assigning condition assessment at Chickasaw National Recreation Area.

Feral Mammals			
Indicators of Condition	Specific Measures	Condition Status/Trend	Rationale
Species occurrence:	Presence / absence of feral cats		We considered condition to be of significant concern because feral cats are known to occur in the park in relatively high numbers in the Platt Historic District, especially along Rock Creek, where they are posing concerns for staff and public health and significant challenges for park managers. Also, feral cats may increase risk of diseases for native wildlife. Although no information is available specifically at the park, feral/domestic cats have the potential to kill a large number of small, native wildlife species. There are no hard data available on the number of feral cats in the park, but park staff estimate that cats number in the hundreds. There is no information on whether their numbers are increasing. Dealing with the issue of feral cats in the Recreation Area is difficult because of the logistics (e.g., once trapped, there are no shelters in the county that take cats), the activities of some members of the public to feed them, and the overall sensitivity of the issue.
Species occurrence:	Presence / absence of feral hogs		We considered condition to be of moderate concern because feral hogs are known to occur in the park, and they are causing at least some level of damage to park resources. They presently occur in the southern portion of the Recreation Area, south and southeast of Lake of the Arbuckles. Park personnel report that there is visible disturbance to soils and vegetation. There are no data available for the number of feral hogs in the park, but hogs were reported as abundant in the vicinity of the park in 2007 by Stevens (2010). Park staff are looking into impacts from the hogs and options for controlling them. They do not want the hogs to expand to other portions of the park or to increase in number. Public hunting of hogs is allowed in the Recreation Area in compliance with ODWC regulations.

Feral cats occur throughout the Platt Historic District, but they are most numerous along Rock Creek. Although no population estimates are available from sampling, based on general observations, park personnel believe that cats number in the hundreds. The presence of feral cats is of concern because they are predators of many small types of wildlife (e.g., small mammals, birds, amphibians, and reptiles), they compete with native species (e.g., skunks, opossums, raccoons, and foxes) for food, and they may transmit disease (Wildlife Society 2011). Feral/free-ranging domestic cats are estimated to kill more than one billion birds (Wildlife Society 2011, Loss et al. 2013) and 6.3-22.3 billion mammals every year in the U.S. (Loss et al. 2013). Among the diseases that feral cats may carry are rabies and toxoplasmosis. Some cats captured in the Recreation Area tested positive for rabies. Diseases are a concern for both the public and wildlife. Management of feral cats at the Recreation Area poses a significant challenge. In addition to some members of the public feeding feral cats, live trapping of cats is not a viable option for the park because there are no shelters that take cats in Murray County, and trapping may expose park personnel to diseases and injuries. Feral cats at the Recreation Area are of significant concern.

Feral hogs are known to exist in the Recreation Area in the southern end of the park, primarily around the southeastern arm of Lake of the Arbuckles (which includes the area east of the Arbuckle Dam along Goddard Youth Camp Road, as well as the area south of Buckhorn Road). There are no estimates of the number of hogs in the park, but park personnel have observed disturbance to vegetation and soils from the hogs' rooting activities, and there have been a few incidents of cars and other vehicles hitting hogs. Hog density estimates for Murray County in 2007 indicated that hogs were abundant (having a density of more than 64 hogs per square mile) in the vicinity of the park (Stevens 2010). Hunting of feral hogs is generally allowed year-round at the Recreation Area (as well as throughout Oklahoma), provided hunting is in compliance with State regulations. Because feral hogs are causing damage to natural resources and pose challenges to management, we judged their condition to be of moderate concern.

5.15.3. Management and Project Considerations and Narrative

The park might consider conducting a survey of the number of feral cats in the Platt Historic District. Obtaining an estimate of the number of cats might assist in the justification for management of the cats. Also, it would be worth exploring whether live trapped cats at the park could be taken to animal shelters in other adjacent counties. N. Osborn of Chickasaw NRA indicated that the park is looking into impacts from the hogs and options for control. It might also be beneficial to institute a request that hunters voluntarily report on the location, date, and number of feral hogs they remove through hunting. This information might be very useful in monitoring the hogs and their impacts.

5.16. Game Species Resource Brief and Narrative

The contents of sub-chapter 516 were designed to be placed into a stand-alone Game Species resource brief at a later date. The final resource brief will follow NPS Graphic Identity Program (http://www.nps.gov/hfc/services/identity/) format and layout policy standards, and include the contact information of at least one NPS employee as a point contact for the public.

5.16.1. Condition Rationale

Chickasaw NRA provides a wide range of recreation opportunities including swimming, boating, fishing, hiking, observing nature, camping, picnicking, and hunting. Hunting is permitted in Chickasaw NRA as stipulated under the enabling legislation (P.L. 94-235, §3). A variety of game species are open to hunt including upland game (deer), upland game birds (dove, turkey, bobwhite quail), waterfowl (ducks and geese), and small game and furbearers (fox squirrel, cottontail rabbit, coyote, raccoon, and bobcat).

Due to no reference condition being identified, and no indicators or measures, condition and trend of game species at Chickasaw NRA is unknown at this time. Because little local information is available regarding population sizes, carrying capacity, or habitat condition, and there is no reference or desired condition established by the park, we cannot know the condition related to game species.

5.16.2. Management Concerns

Game species populations at the NRA are impacted by habitat condition (impacted by drought, invasive species, fragmentation, and other sources of degradation), hunting pressure, regional population health (such as density, wildlife diseases), and competition for resources. Chickasaw NRA staff will work with the Oklahoma Department of Wildlife Conservation to monitor wildlife populations, enforce state and federal regulations, ensure harvest levels are sustainable, and ensure visitor safety. Species-specific surveys will be conducted and continued, and population trends will be analyzed

Table 5.16.2-1. Summary of overall game species condition, indicators and measures, and rationale for assigning condition assessment at Chickasaw National Recreation Area.

Game Species			
Indicators of Condition	Specific Measures	Condition Status/Trend	Rationale
None identified	None		Because no indicators or measures for condition have been identified, and little local information is available regarding population sizes, carrying capcity, or habitat condition, we cannot know the condition related to game species.

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Appendix A: Team Members and Subject Matter Experts

Table A.1. Chickasaw National Recreation Area NRCA Project Team Members

Chickasaw NRA NRCA Project Team
Jeff Albright, NPS Water Resources Division's Coordinator of the NRCA Series
Donna Shorrock, NPS Intermountain Region Natural Resource Condition Assessment Coordinator
Rob Bennetts, NPS Southern Plains Inventory and Monitoring Network Program Manager
Nina Chambers, Northern Rockies Conservation Cooperative, Writer/Editor
Allyson Mathis, Utah State University, Writer
Tomye Folts-Zettner, NPS Southern Plains Inventory and Monitoring Network Biologist
Bruce Noble, NPS Chickasaw National Recreation Area Former Superintendent
Noel Osborn, NPS Chickasaw National Recreation Area Chief of Resource Management
Heidi Sosinski, NPS Southern Plains Inventory and Monitoring Network Data Manager
Kim Struthers, Utah State University, Writer/Editor
Patty Valentine-Darby, University of West Florida, Biologist and Writer/Editor
William Wright, NPS Chickasaw National Recreation Area Superintendent

Table A.2. Chickasaw National Recreation Area NRCA Subject Matter Experts

Subject Matter Expert	Topic	Project Deliverables
Colleen Flanagan Pritz, National Park Service Air Resources Division Ecologist	Air Quality	Reviewed assessment
Michael Martin, National Park Service Water Resources Division Hydrologist	Riparian Habitat	Provided expert opinion on condition of riparian habitat during 2014 field visit and submitted report, which condition assessment was based
Joel Wagner, National Park Service Water Resources Division Wetlands Program Leader	Riparian Habitat	Provided expert opinion on condition of riparian habitat during 2014 field visit and submitted report. which condition assessment was based
Mark E. Meyer, National Park Service Air Resources Division PLA Renewable Energy Visual Resource Specialist	Viewshed	Reviewed assessment
Jeremy White, National Park Service Natural Sounds and Night Skies Division Physical Scientist	Night Sky	Reviewed assessment
John E. Burghardt, Geologist and Coordinator: NPS Abandoned Mineral Lands and Mining Claim Validity Programs - National Park Service Geologic Resources Division	Geology	Reviewed Abandoned Mineral Lands of the geology assessment
Tim Connors, Geologist, National Park Service Natural Resource Stewardship and Science - Geologic Resources Division	Geology	Reviewed assessment
Vincent L. Santucci, Senior Geologist / Paleontologist / Washington Liaison, National Park Service - Geologic Resources Division	Geology	Reviewed paleontology section of geology assessment
Justin S. Tweet, National Park Service	Geology	Reviewed paleontology section of geology assessment
Pete Penoyer and Jennifer Back, National Park Service Water Resources Division	Surface Water Quality	Provided consultation and guidance with the framing of surface water quality condition assessment
Dr. Fred E. Smeins, Rangeland Ecologist for the Ecosystem Science and Management Department at Texas A&M University in College Station, Texas	Grasslands	Provided expert opinion on condition of grasslands during June 2014 field visit and submitted report

Table A.2. Chickasaw's NRA NRCA Subject Matter Experts (cont.)

Authors Who Served as Subject Matter Experts	Topic	Project Deliverables
Noel Osborn National Park Service Chickasaw National Recreation Area Chief of Resource Management	Groundwater, Springs and Geology	Served as subject matter expert for groundwater and geology assessments. Reviewed all draft assessment topics and drafted groundwater and springs assessment
Tomye Folts-Zettner National Park Service Southern Plains Inventory and Monitoring Network Biologist/ Botanist	All	Provided expert opinion during grassland and riparian habitat rapid assessments and reviewed grasslands and exotic plants assessments. Reviewed entire document.
Heidi Sosinski, National Park Service Southern Plains Inventory and Monitoring Network Data Manager	All	Viewshed analyses, maps, graphs, and remaining graphics

Appendix B: Viewshed Analysis Steps

The process Heidi Sosinski used to complete Chickasaw NRA's viewshed analyses is listed below.

Downloaded 1/3 arc second national elevation dataset (NED) grid (roughly equivalent to a 30 m digital elevation model [DEM]) from The National Map Seamless Server (http://seamless.usgs.gov/). The x and y values for the NED are in arc seconds while the z data are in meters. Projected NED into NAD83 UTM 13 to get all data in meters.

Downloaded Chickasaw NRA 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 Bromide Hill and Veterans Lake.

Used Edit > Create New Feature tool to create 5 observation points. Saved file as obs_point.shp.

Added field named "OFFSETA" (type = double) to shapefile and set value to 1.68 for each respective record in the attribute table. The value in the field "OFFSETA" represents an observer height of 1.68m (~5'6")

Ran Viewshed Analysis using ESRI Spatial Analyst Viewshed Tool.
Using the Viewshed Tool in ESRI's ArcGIS 10, Spatial Analyst Toolbox, ran viewsheds using the following inputs.

- Input raster = 1/3 arc second NED modified to include area tree cover.
- Input point observer feature = obs_point.shp.

After the viewshed analyses were complete, housing and road density data were obtained and modified to depict past, present, and future densities around the National Recreation Area. These datasets were created by the NPS's Natural Resource Program Center by compiling and analyzing landscape-scale US Census Bureau data that linked measurable attributes of landscape (i.e., road density, population and housing density, etc.) to resources within natural resource based parks. This resulted in the creation of a dataset titled NPScape (Budde et al. 2009; Gross et al. 2009). The following modifications were made to NPScape data for purposes of this assessment:

Downloaded spatial data from Internet.
Downloaded Recreation Area-specific NPScape data from the NPScape website (http://science.nature.nps.gov/im/monitor/npscape/index.cfm).

Simplified NPScape Housing Density Projections.
Converted Chickasaw NRA 30 km housing density projection rasters to polygon shape files.

Combined classes to reduce number of original classes to five (Table B.1).

Table B.1. The original classes from NPScape and new classes assigned to housing densities for this assessment of the viewshed at Chickasaw NRA

Original Class	New Class
Private undeveloped	Private undeveloped
<1.5 units/km^2	<1.5 units/km^2
1.5–3 units/km^2	1.5–6 units/km^2
4–6 units/km^2	
7–12 units/km^2	> 6 units / km^2
13–24 units/km^2	
25–49 units/km^2	
50–145 units/km^2	
146–494 units/km^2	
495–1234 units/km^2	
Commercial / Industrial	Commercial / Industrial

Appendix C: Soundscape Models

Mennitt et al. (2013) with the NPS NSNSD developed a geospatial sound model by mapping sound pressure levels on a continental U.S. scale. The model included biological, climatic, geophysical, and anthropogenic factors to assess expected sound pressure levels for natural and existing conditions. The model suggested that the area within and surrounding Chickasaw National Recreation Area had a natural L_{50} dBA average of 37.0 (Figure D-3) and an existing L_{50} dBA average of 40.4 (Figure D-1) (Emma Lynch, Acoustical Resource Specialist, NPS Natural Sounds and Night Skies Division, pers. comm., Excel spreadsheet). The L_{50} represents the sound level reported that is exceeded 50 percent of the stated time period.

The impact of anthropogenic sound sources to the national recreation's soundscape, which is the existing L_{50} dBA minus natural L_{50} dBA, was estimated to be an average of 3.4 dBA (Figure D-2). According to Mennitt et al. (2013), "an impact of 3dB suggests that anthropogenic noise is noticeable at least 50% of the hour or more." As NSNSD's predictive soundscape model continues to be developed and refined, it is intended to help park staff anticipate impacts by projecting future developments that have the potential to degrade the soundscape.

Mennitt, D., K. Fristrup, K. Sherrill, and L. Nelson. 2013. Mapping sound pressure levels on continental scales using a geospatial sound model. Proceedings from Internoise Conference, Innsbruck, Austria, September 15-18, 2013. 11pp.

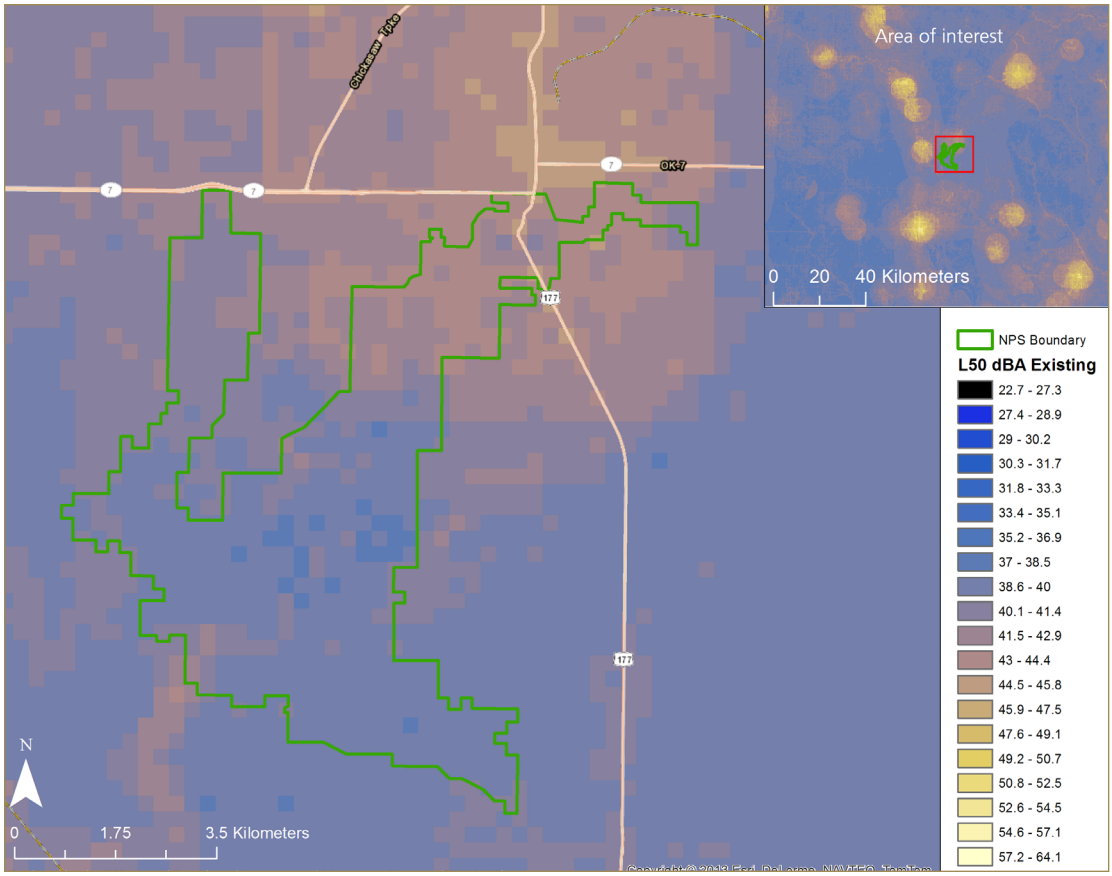


Figure D-1. Existing CONUS soundscape model zoomed to Chickasaw National Recreation Area.

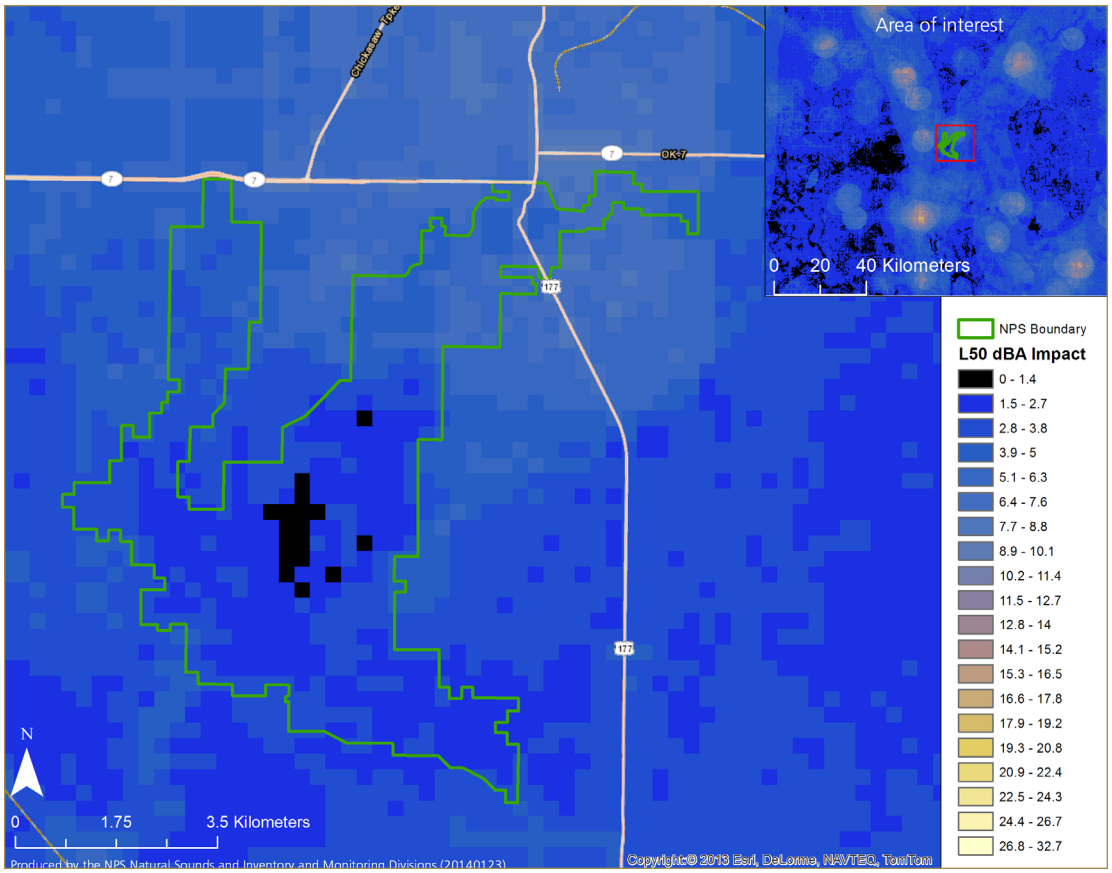


Figure D-2. Impact between existing and natural CONUS soundscape models zoomed to Chickasaw National Recreation Area.

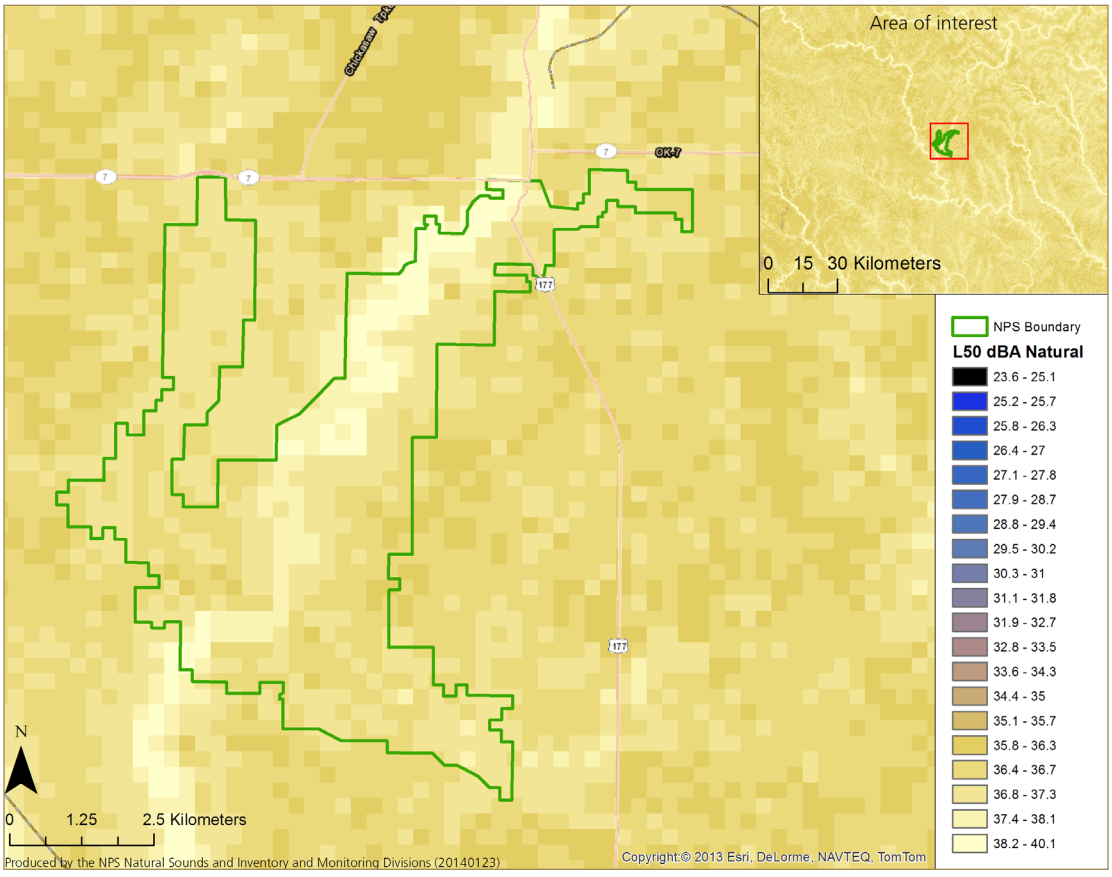


Figure D-3. Natural CONUS soundscape model zoomed to Chickasaw National Recreation Area.

Appendix D: Chickasaw NRA Grassland Vegetation and Soils Assessment - July 8-10, 2015

Part 1: Overview Assessment by Fred E. Smeins

This section was written by Fred E. Smeins, a rangeland ecologist for the Ecosystem Science and Management Department at Texas A&M University in College Station, Texas

Introduction

A two day field observational survey of nine sites on the Chickasaw Natural Recreational Area (NPS) was conducted to assess the current condition of the vegetation of these sites within the Area. This report contains two components of the assessment. First a general historical and ecological characterization of the vegetation will be presented to relate current vegetation condition of the Area to the historical and current regional context. Second a qualitative field assessment is presented of the current condition of the vegetation/environment and management applications on the nine sites.

General Vegetation of the Chichasaw NRA Region

The Chickasaw NRA occurs within an admixture of elements of the Grand Prairie and the Northern Cross Timbers Major Land Resource Areas (MLRAs 85 and 84A, respectively) as defined by the USDA. The Grand Prairie is a tall/mid grass grassland with minimal woody vegetation over fine-textured Mollisol and Vertisol soils, while the Cross Timbers may vary from an open savannah with a tall/mid grass herbaceous layer matrix to a nearly closed canopy woodland of short-statured Post Oak and Blackjack Oak trees with a varied assortment of associated trees and shrubs (Hoagland and Johnson 2001). Cross Timbers occur primarily over coarse-textured sandy Alfisols. Both the Prairies and the Cross Timbers may have significant amounts of woody vegetation increases depending upon fire frequency and intensity, periodic droughts and grazing regime (Smeins 2004, DeSantos et al. 2010). In both instances the most insidious encroaching woody species are Eastern Red Cedar and Ashe Juniper.

Assessment of the native vegetation of these Rangeland areas is typically determined by using the Natural Resources Conservation Service Ecological Site Description procedure. For Rangeland they use as the baseline for comparison of vegetation condition the prevailing vegetation that occurred on the landscape at the time of European settlement under the natural fire regime and free-roaming ungulate grazing conditions which would generally be an open canopy savannah/woodland or open prairie grassland. This community for any give Ecological Site is referred to as the Historic Climax Plant Community. Much the Prairie and Cross Timbers can succeed to woody plant dominance in the absence of fire and periodic droughts and these woody dominated communities might be considered the Climatic Climax Plant Community. Thus areas of high abundance of woody species are not considered to be the natural historic vegetation over much of the Prairie and Cross Timbers.

This is not to suggest that no areas of closed woodland existed at the time of settlement. Early accounts indicate that the landscape contained a mix of open savannahs and closed, thicketized woodlands. When the first Europeans described the region between 1840 and 1860, they noted places where travel was little influenced by the woody vegetation, while elsewhere it nearly prevented passage.

> Marcy (1866) observed:
> "At six different points that I have passed through it (Cross Timbers), I have found it characterized by the same peculiarities; the trees, consisting principally of post-oak and blackjack, standing at such intervals that wagons can without difficulty pass between them in any direction. The soil is thin, sandy and poorly watered."
>
> On the contrary, Gregg (1844) suggests,
> Most of the timber appears to be kept small by the continual inroads of the "burning prairies"; for, being almost killed almost annually, it is constantly replaced by scions of undergrowth; so it becomes more and more dense every reproduction. In some places, however, the oaks are of considerable size, and able to withstand the conflagrations. The underwood is so matted in many places with grapevines, green-briars, etc., as to form almost impenetrable "roughs" which serve as hiding-places for wild beasts.
>
> Washington Irving (1886) agrees:
> "I shall not easily forget the mortal toil and vexations of the flesh and spirit, that we underwent occasionally, in our wanderings through the Cross Timbers. It was like struggling through forests of cast iron."

Reintroduction of periodic fire to reclaim areas that have, or are tending to have a high abundance of woody plants is a management tool that can be used to return these areas to their more natural state. Depending upon the condition of the herbaceous component of these plant communities, grazing by livestock, or perhaps bison, and possibly goats, can be used to maintain or improve the range condition of these herbaceous communities but, of course, this must be done through knowledgeable application of controlled grazing.

Fortunately the flora and vegetation of much of the Chickasaw NRA is in a relatively natural condition that permits the use of prescribed fire and controlled grazing to manage for plant communities that are ecologically healthy and productive, and to maintain a high diversity of the flora and fauna natural to the communities and the landscape. These tools are already in use, or being considered, and should receive continued support for their application. As stated by Stotts et al. (2007) conservation criteria have not been developed for the Cross Timbers and conversion of open savannas and grasslands to closed canopy woodlands is a threat to the biodiversity of this ecoregion. The Chickasaw NRA provides an opportunity to provide criteria and procedures for reversing this threat to biodiversity.

There are areas on the property that have had significant alteration or destruction of their natural communities. Past agricultural use for crops or tame pasture or overgrazing of the natural vegetation has created generally abnormal plant assemblages, sometimes with invasive exotic species. Opportunities exist to restore these areas to native vegetation and programs should be developed to pursue this activity. Interns (Kaitlin O'Brien and Chelsea Blakely) working at the Chickasaw NRA during the summer of 2014 prepared an initial document to develop a plan and procedure for restoration of several areas on the NRA and it would be highly desirable to use this document as a starting place to begin restoration activities.

Assessment Of Nine Selected Sites

(Details of local and landscape scale species composition, functional-types, diversity and representative photographs were prepared for each site as part of this report)

Site #1-Waypoint #1

This Shallow Prairie Ecological Site is in relatively good vegetation condition. It has a good mix of native grasses and forbs that can serve as a source for improvement of the vegetation condition if woody species, particularly Eastern Red Cedar and Ashe Juniper, are reduced

or removed. Several standing dead skeletons of junipers occur across the area as apparent evidence of previous fires on the site. Any activity used to remove the woody species should be done with caution since patches of the invasive Johnsongrass and KR Bluestem occur on or near the site and any soil disturbance may favor increase in their abundance.

Site #2-Waypoint #2
Vegetation on this Sandy Savannah Ecological Site has relatively good native plant diversity but relative species abundances indicate it is in a low to mid-successional state. Recent mechanical removal of Junipers, followed by a prescribed burn, have positioned the area to begin succession toward a late-successional savannah state. Oak tree density of smaller diameter trees is high and as they grow they will begin to close the woody canopy. This should be monitored and it may be desirable in the future to selectively remove some of those trees as they move into large size classes. Continued periodic burning, and caution to inspect for any invasive exotic species that might ingress, should be a continuing management strategy.

Site #3-Waypoint #3
This Clayey Bottomland Ecological Site was recently cleared and burned. This has opened the woody canopy and allowed the herbaceous species to express themselves. Several desirable grasses and forbs are present and continued periodic burns should increase their abundance. Caution should be applied to monitor and control exotic invasive species that occur on the site and that may ingress from adjacent areas.

Site #4-Waypoint #4
Another Sandy Savannah Ecological Site that has recently been mechanically cleared of juniper and burned. Generally in good condition and appears to have the potential to continue to move to a more species diverse mix and higher successional state. Johnsongrass and KR bluestem are present and may respond to opening of the woody canopy and should be carefully monitored and controlled if necessary.

Site #5-Waypoint #5
A good condition Post Oak woodland occurs on this Sandy Savannah Ecological Site. Some juniper does exist but is currently not a problem. Overall the woody and herbaceous plant composition is of high diversity, healthy and exhibits good structural organization for a community on this site. This area in time is likely to continue development toward a closed canopy woodland and eventually this would lead to reduced diversity. A periodic, low intensity fire would tend to hold this community in its current state if that is what is preferred. The site should be routinely monitored for juniper encroachment since that is very likely to occur.

Site #6-Waypoint #6
An established Johnsongrass/legume hayfield exist on this Clayey Bottomland Ecological Site. It would desirable to restore this productive site to a native tallgrass grassland/savannah but it would be very expensive and labor intensive to do so. As is it is a poor representative of the natural vegetation that could potentially occur on the site. A possible beginning to transition to a more native grassland would be to periodically heavily stock the area with cattle, if they can be obtained from a nearby rancher. Cattle readily consume Johnsongrass and with heavy use the species may be reduced to levels that some inter seeding with natives could be attempted. To return the site to natives by killing the Johnsongrass with herbicides, cultivation, site preparation and reseeding is a long, often unpredictable and costly exercise. However, restoration of native grassland on this site is more feasible than upland areas due to the better moisture and nutrient regime of this bottomland site.

Site #7-Waypoint #7
This Stony Clay Loam Ecological Site is a near excellent condition native -grassland/savannah. It has a great diversity of grasses, forbs and shrubs. Continuation of the periodic burns would be necessary; in its absence woody species will increase at the expense of the grassland composition and diversity. Monitoring of the site for exotic invasive species is essential and control of them before they have an opportunity to spread.

Site #8-Waypoint #8
The plant community on this Eroded Loamy Prairie this Site is excellent is in near excellent condition. Continued periodic burning is necessary to retard woody encroachment and monitoring for exotic invasive species is essential.

Site #9-Waypoint #9
This is a Clayey Bottomland Ecological Site. This frequently flooded mostly closed canopy bottomland forested site has a relatively open understory of forbs, grasses and sedges. No specific management is necessary but a periodic ground fire may be clean-up procedure and would rejuvenate the understory. Monitoring of exotic invasive species should occur and control any that establish before they spread.

Summary Observations

Much of the Chickasaw NRA is in relatively good condition as regards the natural vegetation. Ongoing management with prescribed burning should continue and be expanded, for woody plant control, to other areas if resources permit. Opportunities exist to integrate burning and grazing (by livestock or bison) across several areas on the NRA, but many issues have to be considered. Fencing, water source availability, source of livestock i.e. are there willing nearby ranchers who would agree to provide animals for some periodic grazing on the NRA, how to move the animals, etc. All these things and more would have to be developed in to a management plan with logistics and cost determined before proceeding. A point to be made is that in many areas the vegetation is in sufficiently good condition to support a designed, monitored and controlled grazing system and in many instances the vegetation would likely have a favorable response to low frequency, low intensity grazing by large ungulates. Also, in combination with fire, goats can be effective for woody plant control but again some of the same issues arise as with cattle in terms of how to manage the animals. With the vegetation in the shape that it is in and with continued, and perhaps some enhanced management added, the Chickasaw NRA could be a focal point for biodiversity conservation in the region.

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Part 2: Detailed Assessment Notes by Dr. Fred Smeins and Tomye Folts-Zettner

General Info: During the time period of January 2011 – May 2013, the area in and around CHIC was in a drought status, with 26 of those months classified as Severe. For the past year, however, moisture has been classified as normal. CHIC has engaged in an active prescribed fire and vegetation management program. Beginning in 2010, large woodland areas in the park were manually cleared of Juniper undergrowth, followed by prescribed fire. Grasslands are frequently burned (+ 3 yrs) to prevent woody encroachment. Many of these areas are included in this assessment.

SITE #1 – DISTURBED Woodland - Cedar Blue – Waypoint #1 GOOD

General Notes: This area has not been cleared of juniper but is comprised of areas of woody growth with grassland openings. There are large dead junipers throughout.

ESD: Shallow Prairie (used Stony Clay Loam R085XY188TX) Soil: Rayford Cobbly Loam

Landscape-scale Diversity: Excellent site diversity, although this type of habitat exists throughout the park. **GOOD**

Local-scale Diversity: Excellent diversity of grasses and forbs. Dominant trees are eastern and ashe juniper (*Juniperus virginiana* and *J. asheii)*. Shumard oak (*Quercus shumardii)*, and post oak (*Quercus stellate)*, although other desirable species exist in smaller quantity. There exists a great mix of native grasses and forbs that indicate great site potential if clearing did occur. The list of species present is too great to include. Invasive/exotics include the junipers, plains prickly pear (*Opuntia macrorhiza)*, Johnsongrass (*Sorghum halepense)*, and K.R. bluestem (*Bothriochloa ischaemum)*. **GOOD**

Disturbance Response: There is limited sign of disturbance so this is difficult to determine, but from the generous mix of annual species still present in the community, one can expect an excellent response to disturbance. **GOOD**

Functional Groups: Good mix of functional groups, although woody component too high. Trees > warm-season grasses > cool-season grasses > forbs = shrub/subshrub. **MODERATE CONCERN**

C3 vs C4: Very good balance should insure resilience of site. **GOOD**

Soils: (The Reference Conditions were unavailable) Scattered small areas of exposed soil/rock – primarily below areas of juniper encroachment – showed signs of rills and pedestalling to a limited degree. This is likely to be expected for the site, given the slope. **NONE - SLIGHT**

Site #2 – Post Oak UPLANDS Cedar Blue – Waypoint #2 GOOD

General Notes: This area was manually cleared of junipers in 2010/2011 followed with a prescribed burn. Assessment based on current condition but trend is towards improvement.

ESD: Sandy Savannah (used Sandy Loam R085XY562TX) Chigley-Naru complex

Landscape-scale Diversity: Not as many diverse sites as Site #1. Topography less steep and soils deeper. These recently cleared areas are numerous in the park but few have been cleared long enough to exhibit maturity. **GOOD**

Local-scale Diversity: Good diversity throughout site. Many early successional species but perennials are developing well. Large carex and dichanthelium component. Species too numerous to list. Post oak (*Quercus stellaa)*, and black hickory (*Juglans nigra)* are dominant trees. There has been some fire-kill of trees. Exotics found primarily along edge of roadway and is mainly prickly lettuce (*Lactuca serriola)*. **GOOD**

Disturbance Response: Excellent response to disturbance by primarily native species. Annuals and cool season perennials colonizing well while warm-season perennials gain ground. **GOOD**

Functional Groups: 60% woody, 40% herbaceous. Currently out of balance due to disturbance but progressing in a positive manner. Cool-season grasses > all forbs > warm-season grasses > trees > shrubs **GOOD**

C3 vs C4: Cool-season currently dominating but warm-season grasses are establishing and spreading. We are currently seeing a disturbance response. **GOOD**

Soils: (No Reference Condition Sheet available.) This site is moderately sloped. Soils are loose and were heavily disturbed but are now stabilizing. Approx. 70% litter cover of bare ground with movement of smaller bits. Vegetation is holding soil better now. **NONE - SLIGHT**

SITE #3 – Oak BOTTOMLANDS Cedar Blue – Waypoint #3 GOOD

General Notes: Site heavily dissected with stable drainages. Cleared and burned in 2011 right up to bottomland woods. Lots of downed wood hazards. Exploration of site limited.

ESD: Heavy Bottomland (used Clayey Bottomland R085XY178TX) Soil: Garvin and Elandco

Landscape-scale Diversity: This is currently a hardwood bottomland community that is being opened up along its edges. The site diversity is good, and several drainages in this area exhibit similar communities. **GOOD**

Local-scale Diversity: Local diversity is good and improving with clearing. The overstory is composed of post oak (*Quercus stellata)*, Shumard oak (*Quercus shumardii)*, blackjack oak (*Quercus marilandica)*, chinquapin oak (*Quercus muhlenbergia)*, winged elm (*Ulmus alata)*, and red mulberry (*Morus rubra)*. Grasses found were broadleaved uniola (*Chasmanthium latifolium)*, Canadian wild rye (*Elymus Canadensis)*, indiangrass (*Sorghastrum nutans)*, little bluestem (*Schizachyrium scoparium)*, various rosette grasses (*Dichanthelium species)*, bushy bluestem (*Andropogon glomeratus)*, and various sedges (*Carex* species*)*. There was a wide variety of forbs and shrubs. Exotics include Johnsongrass (*Sorghum halepense)*, musk thistle (*Carduus nutans)*, rescue grass (*Bromus catharticus)*, and prickly lettuce (*Lactuca serriola)*. **GOOD**

Disturbance Response: Plenty of annuals that have filled in the open areas while perennials take hold. **GOOD**

Functional Groups: Currently out of balance due to disturbance but improving well. Trees > cool-deadon grasses > warm-season grasses > shrub > forb. There are more exotics at this site than Site #2 **MODERATE CONCERN**

C3 vs C4: Cool-seasons currently dominate, but warm-season grasses establishing well. **GOOD**

Soils: (no Reference Sheet available) Although previously disturbed, the soils here are quite stable. Water flow patterns are what is expected for the site. Bare ground is minimal. **NONE - SLIGHT**

SITE #4 – Post oak UPLAND - Point – Waypoint #4 GOOD

General Notes: Juniper understory manually removed in 2011, followed by a prescribed burn. West-facing aspect.

ESD: Sandy Savannah (Sandy Loam R085XY562TX) Chigley-Naru Complex

Landscape-scale Diversity: Improving site diversity. Great amounts of brush clearing throughout the park has resulted in communities that currently appear similar. It remains to be seen how various sites progress and the development and distribution of communities. **GOOD**

Local-scale Diversity: Good and getting better. Again, this site is in transition from a shrub-invaded woods to a more open woods/savannah. Canopy cover is still approx. 60%, dominated by post oak (*Quercus stellata)* and including other oak species, ash and hackberry. Grasses include indiangrass (*Sorghastrum nutans)*, big blustem (*Andropogon gerardii)*, sideoats grama (*Bouteloua curtipendula)*, little bluestem (*Schizachyrium scoparium)*, knotroot bristlegrass (*Setaria parviflora)*, purpletop (*Tridens flavus)*, silver bluestem (*Bothriochloa laguroides)*, several species of rosette grass (*Dichanthelium species)*, Texas winter grass (*Nasella leucotricha)*, broadleaved uniola (*Chasmanthium latifolium)*, and bushy bluestem (*Andropogon glomeratus)*. Numerous species of annual and perennial forbs are present. Exotics include Johnsongrass (*Sorghum halepense)* and K.R. bluestem (*Bothriochloa ischaemum)*. **GOOD**

Disturbance Response: Good. Dominant annual is common ragweed (*Ambrosia artemisifolia)* although other species exist. **GOOD**

Functional Groups: Currently not meeting optimum proportions, but an obvious positive trend toward potential. Warm-season grasses = cool-season grasses > trees > forbs > shrubs. **GOOD**

C3 vs C4: 50/50 mixture of C3 and C4, so nearing optimum proporation. **GOOD**

Soils: (No Reference Sheet available). Gently sloping site with high litter rate (+ 90%). No evidence of erosion whatsoever. **NONE - SLIGHT**

SITE #5 – Post oak UPLAND – Guy Sandy east – Waypoint #5 GOOD

General Notes: This post oak upland has not been cleared of juniper, but is also not heavily invaded.

ESD: Sandy savannah (Sandy Loam R085XY562TX) Chigley-Naru Complex

Landscape-scale Diversity: Great example of a mature post oak forest. 60% canopy and good mix of harwoods. Not terribly invaded by junipers though present. **GOOD**

Local-scale Diversity: Wonderful mix of grasses and more perennial forbs than other sites. Gives an idea of the potential of recently cleared sites. Dominated by post oak (*Quercus stellate)* with winged elm (*Ulmus alata)*, shumard oak (*Quercus shumardii)*, Texas ash (*Fraxinus*

texensis), blackjack oak (*Quercus marilandica)*, hackberry (*Celtis laevigata)*, Texas hickory (*Carya texana)*. Tall- and mid-grasses. Exotics include rescuegrass (*Bromus cathartica)* and sheep sorrel (*Oxalis stricta)*. **GOOD**

Disturbance Response: Long time since any disturbance, so fewer annuals in the community. **GOOD**

Functional Groups: Good balance of functional groups. Matches what would be expected well. Warm-season grasses > trees > cool-season grasses > forbs > shrubs. **GOOD**

C3 vs C4: Excellent. C4 dominated with good cohort of C3s. **GOOD**

Soils: (No Reference Sheet available). Soils appear quite stable with no evidence of erosion or displacement. Litter + 90%. **GOOD**

SITE #6 – Disturbed GRASSLAND – restoration - Waypoint #6
SIGNIFICANT CONCERN

General Notes: This is an old Johnsongrass hay field that the park is trying (unsuccessfully) to restore. Several years of herbicide treatment have been unsuccessful at reducing the Johnsongrass. Plans have been in place for a prescribed burn, but conditions have never been right for this burn to take place.

ESD: Heavy bottomland (Clayey Bottomland R085XY178TX) Garvin Silty Clay

Landscape-scale Diversity: There are several of these abandoned hay fields in this section of the park; all are full of Johnsongrass and other exotics. **SIGNIFICANT CONCERN**

Local-scale Diversity: Dominated by exotics, although there are diverse grass and forb seedlings in the understory of the agricultural clover cover-crop, when present. The exotic Johnsongrass (*Sorghum halepense)* is the dominant grass, while other species of concern include Japanese brome (*Bromus japonicas)*, sow thistle (*Sonchus asper)* and sheep sorrel (*oxalis stricta)*. **SIGNIFICANT CONCERN**

Disturbance Response: If the perennial Johnsongrass is discounted, native and exotic annuals form the most common vegetation. Therefore, annual response is excellent but made up primarily of exotics. **SIGNIFICANT CONCERN**

Functional Groups: C4 grass = C3 forbs >> C3 grass >>> trees. This area is converted and abandoned land and does not reflect what the community should be. **SIGNIFICANT CONCERN**

C3 vs C4: The C4 Johnsongrass dominates, with a C3 agricultural clover as a co-dominant. While the balance may be correct, the fact these both are exotics negate any benefits. **SIGNIFICANT CONCERN**

Soils: (No Reference Sheet available). The vegetation and thatch was so thick that the soil is not exposed anywhere. This leads one to assume that there is no soil loss occurring, but a true assessment was not able to be performed. There is a question whether a plow pan may exist in this area and should be investigated. Assumption of **SLIGHT - MODERATE**

SITE #7 – Upland GRASSLAND – Veteran's Lake - Waypoint #7 GOOD
General Notes: This area receives periodic prescribed burns.

ESD: Shallow Prairie (Stony Clay Loam R085XY188TX) Rayford Cobbly Loam

Landscape-scale Diversity: Excellent. There are a few other similar areas in the park that are moving along the same trajectory. **GOOD**

Local-scale Diversity: "As good as it gets." Highly diverse in all functional groups. Grasses dominated by little bluestem (*Schizachyrium scoparium)* and sideoats grama (*Bouteloua gracilis)*, although excellent mix of species, including big bluestem (*Andropogon gerardii)*. Wide variety of native perennial forbs although annuals present also. Shrubs include roughleaf dogwood (*Cornus drummondii)*, numerous sumac species (*Rhus* species*)*, redbud (*Cercis Canadensis)*, elbow bush (*Forestieria pubescens)*, plum (*Prunus angustifoia)*, and others. Exotics present in limited distribution include K.R. blustem (*Bothriochloa ischaemum)*, sheep sorrel (*Oxalis stricta)*. Biotic crust is well distributed. **GOOD**

Disturbance Response: Other than periodic burns, this area has received no major disturbance in a while. There are annual forbs present throughout, although in low numbers. Response t any future disturbance should be good. **GOOD**

Functional Groups: warm-season midgrass > cool-season midgrass > forbs > warm-season tall grass > shrub/subshrub > trees. Excellent balance **GOOD**

C3 vs C4: Excellent balance make this grassland very resilient. **GOOD**

Soils: (No Reference Sheet available). Most soil stability parameters are well met. Bare ground is 5-10% greater than expected and litter reduced as much, likely caused by the preceding years of drought. Biotic soil crust is well distributed and stabilizing soils and there is naturally occurring rocks and gravel adding to the stability. **NONE-SLIGHT**

SITE #8 – Upland GRASSLAND – Guy Sandy - Waypoint #8 GOOD
General Notes: This area undergoes frequent prescribed burns.

ESD: Eroded Loamy Prairie (Clay Loam R085XY179TX) Durant Loam

Landscape-scale Diversity: This site is a late successional grassland and would score at 85-90% on a Rangelands Assessment. This is the only area in the park that has reached this development. **GOOD**

Local-scale Diversity: Diversity is quite good, although it would be better if the grasses were grazed to limit the density. Little bluestem (*Schizachytium scoparium)* is the dominant grass, but the whole suite of desirable grasses exist throughout the site. Excellent variety of perennial forbs include late successional species such as prairie coneflower (*Echinacea angustifolia)* and western indigo (*Indigofera minuata)*. Shrubs are not as diverse as Site #7 and are dominated by several sumac species (*Rhus* species*)*. Exotics are slightly more prevalent and include Johnsongrass (*Sorghum halepense)* and K.R. bluestem (*Bothriochloa ischaemum)*. **GOOD**

Disturbance Response: There are annual forbs throughout the site but in limited numbers. It has been several years since the last disturbance (prescribed burn), but it can be assumed that annual response would be good. **GOOD**

Functional Groups: Excellent. Warm-season grass > cool-season grass > forbs > shrubs > trees. **GOOD**

C3 vs C4: Excellent mix and distribution to impart resilience. **GOOD**

Soils: (No reference Sheet available). This is classified as erodible and there are some old areas of disturbance, but these have stabilized for the most part and are well vegetated. Otherwise this site is highly stable and functioning as it should. **NONE - SLIGHT**

SITE #9 – Eastern Cottonwood BOTTOMLAND – Buckhorn - Waypoint #9 GOOD

General Notes: This site was assessed near the mouth of Lake of the Arbuckles. It is next to a campground but appears to have received little impact from this area.

ESD: Heavy Bottomland (Clayey Bottomland R085XY178TX) Garvin-Elandco

Landscape-scale Diversity: Typical of a forested bottomland. These areas are scattered throughout the park but are generally limited in extent. **GOOD**

Local-scale Diversity: Good for the limited diversity found in these habitats (*as opposed to grasslands)*. The locally uncommon smooth Soloman's seal (*Polygonatum biflorum)* is found throughout the area. Sycamore (*Platanus occidentalis)* dominate the canopy along the drainage, bounded by hackberry (*Celtis occidentalis)* and Texas ash (*Fraxinus texensis)*. Numerous sedges (*Carex species)* and woodland grasses including broadleaved uniola (*Chasmanthium latifolium)*, Virginian wild rye (*Elymus virginicus)* and woodland brome (*Bromus pubescens)*. Exotics include white sweet clover (*Melilotus alba)*, sericea lespedeza (*Lespedeza cuneata)* and Johnsongrass (*Sorghum halepense)*. **GOOD**

Disturbance Response: This area is frequently flooded, thus frequently disturbed. Annuals are prevalent but probably less abundant than normal since it has been some time since the last inundation. **GOOD**

Functional Groups: Cool-season grasses dominate so the habitat may be out of balance. Although the park has entered a more normal precipitation regime, the past years of drought may have impacted the floodway in this area. Trees > grass >> vines > forbs. **MODERATE CONCERN**

C3 vs C4: C3 dominates this habitat, with few C4 species present. See Functional Group discussion above. **MODERATE CONCERN**

Soils: (No Reference Sheet available). There is an elevated amount of bare ground (30%), therefore less litter. Soils appear quite stable with no sign of active erosion. **SLIGHT - MODERATE**

Appendix E: Exotic Plant Species at Chickasaw NRA

The following table lists exotic species that are and have been documented within Chickasaw (Folts-Zettner 2014). Only the species recorded during SOPN monitoring 2012-2014, including the 2014 rapid assessment, were ranked for significance of impact (e.g., the species' innate ability to become a pest), and for feasibility of management using the Handbook for Ranking Exotic Plants for Management and Control (Hiebert and Stubbendieck 1993). Other species that have been documented in the park were not ranked because they were not found during recent monitoring.

Scientific Name	Common Name	2012-2014 Survey[1] (N=358)	2014 Assess.[2] (N=194)	Noxious[3]	Significance of Impact[4]	Feasibility of Management[5]
Abutilon theophrasti	velvetleaf					
Achillea millefolium	common yarrow	26.3%	19.6%		Medium (34)	Difficult (20)
Aegilops cylindrica	jointed goat grass	5.3%	ND		Medium (30)	Medium (31)
Agrostis gigantea	redtop bentgrass					
Albizia julibrissin	mimosa tree					
Amaranthus retroflexus	redroot pigweed					
Arenaria serpyllifolia	thymeleaf sandwort					
Asparagus officinalis	garden asparagus					
Bothriochloa ischaemum	king ranch bluestem	48.9%	3.6%		Highest (41)	Difficult (16)
Bromus catharticus	rescue brome	9.2%	1.5%		Low (25)	Difficult (16)
Bromus inermis[6]	smooth brome	0.3%	ND		Highest (46)	Difficult (20)
Bromus japonicus	Japanese brome	73.2%	26.3%		High (35)	Difficult (21)
Bromus lanceolatus[6]	Mediterranean brome	0.3%	ND		Low (19)	Medium (28)
Bromus tectorum	cheatgrass	27.4%	1.0%		Highest (41)	Difficult (16)
Broussonetia papyrifera	paper mulberry					
Buglossoides arvensis	corn gromwell					
Capsella bursa-pastoris	shepard's purse					
Carduus nutans[6]	nodding musk thistle	ND	2.6%	X	High (39)	Difficult (16)
Cerastium glomeratum	sticky chickweed					
Chenopodium album[6]	common lambsquarters	ND	1.0%		Low (27)	Easily Controlled (50)
Chenopodium ambrosioides	Mexican tea					
Clematis terniflora	leatherleaf clematis					
Conium maculatum[6]	poison hemlock	4.7%	4.1%		Highest (41)	Difficult (16)
Convolvulus arvensis	field bindweed	ND	0.5%		Highest (46)	Extremely Difficult (6)
Coronilla varia	purple crownvetch	0.3%	1.5%		Highest (41)	Extremely Difficult (11)
Cynodon dactylon	Bermudagrass	47.2%	1.0%		High (39)	Extremely Difficult (11)
Cyperus esculentus	yellow nutgrass					
Datura stramonium	jimsonweed	0.6%	ND		Medium (32)	Difficult (21)
Daucus carota[6]	Queen Anne's lace	2.8%	1.0%		Medium (34)	Easily Controlled (45)
Digitaria sanguinalis	hairy crab grass					

Scientific Name	Common Name	2012-2014 Survey[1] (N=358)	2014 Assess.[2] (N=194)	Noxious[3]	Significance of Impact[4]	Feasibility of Management[5]
Echinochloa colona	Jungle ricegrass	ND	0.5%		High (35)	Difficult (20)
Echinochloa crus-galli	barnyardgrass					
Eragrostis cilianensis	stinkgrass					
Erodium cicutarium	redstem stork'sbill	0.8%	ND		Medium (31)	Extremely Difficult (11)
Erysimum repandum	bushy wallflower					
Euphorbia spp.[7]	spurge	2.8%	2.6%		High (37)	Extremely Difficult (11)
Holosteum umbellatum	jagged chickweed					
Iris germanica	German iris					
Iris sanguinea	Japanese iris					
Jasminum nudiflorum	winter jasmine					
Kummerowia stipulacea	Korean lespedeza	17.0%	0.5%		Medium (30)	Medium (26)
Lactuca serriola	prickly lettuce	49.4%	24.2%		Medium (34)	Medium (32)
Lamium amplexicaule	henbit					
Lathyrus hirsutus	singletary pea	3.4%	0.5%		Low (25)	Easily Controlled (55)
Lespedeza cuneata	sericea lespedeza	36.3%	18.0%		Highest (44)	Extremely Difficult (11)
Ligustrum vulgare	European privet					
Lolium perenne[8]	perennial ryegrass	22.9%	ND		Low (26)	Easily Controlled (40)
Lolium pratense	meadow fescue					
Lonicera japonica	Japanese honeysuckle	2.8%	ND		Highest (48)	Difficult (21)
Lonicera maackii	Amur honeysuckle bush					
Lycium barbarum	matrimony vine					
Marrubium vulgare	horehound					
Medicago lupulina	black medik clover	5.6%	ND		Medium (30)	Medium (35)
Medicago minima	burr medick clover	57.3%	5.2%		Medium (32)	Extremely Difficult (15)
Medicago sativa	alfalfa	1.7%	0.5%		Medium (31)	Easily Controlled (40)
Melia azedarach	chinaberry					
Melilotus spp.[7]	white/yellow sweet-clover	23.5%	10.3%		Low (29)	Difficult (21)
Mentha spicata	spearmint	ND	0.5%		Medium (33)	Difficult (25)
Nepeta cataria	catnip					
Onopordum acanthium[6]	Scotch thistle	3.9%	ND	X	High (37)	Medium (26)
Ornithogalum umbellatum	Pyrenees Star of Bethlehem					
Parthenium hysterophorus	ragweed parthenium					
Paspalum dilatatum	dallas grass	7.0%	0.5%		Low (29)	Medium (30)
Pennisetum glaucum	pearl millet					
Plantago lanceolata	buckhorn plaintain					
Poa annua	annual bluegrass	0.6%	ND		Highest (46)	Extremely Difficult (11)
Poa pratensis	Kentucky bluegrass					
Polygonum convolvulus	climbing buckwheat	0.8%	ND		Medium (30)	Medium (30)
Polygonum hydropiper	marshpepper knotweed					

Scientific Name	Common Name	2012-2014 Survey[1] (N=358)	2014 Assess.[2] (N=194)	Noxious[3]	Significance of Impact[4]	Feasibility of Management[5]
Potentilla recta	roughfruit cinquefoil					
Prunus mahaleb	Mahaleb cherry					
Rumex crispus	curley dock	1.4%	1.0%		Medium (30)	Difficult (16)
Rumex pulcher	fiddle dock					
Saponaria officinalis	bouncingbet					
Sida abutifolia	prostrate sida					
Sinapis arvensis	charlock mustard					
Sisymbrium altissimum	tumble mustard					
Sonchus asper	spiny sowthistle	17.6%	8.8%		Medium (33)	Medium (35)
Sorghum halepense	Johnsongrass	66.8%	20.1%		Highest (45)	Difficult (21)
Stellaria media	common chickweed					
Tamarix chinensis	Chinese saltcedar					
Taraxacum officinale	dandelion	1.7%	ND		Medium (34)	Medium (35)
Torilis arvensis	spreading hedgeparsley	31.6%	17.0%		Medium (31)	Easily Controlled (45)
Tragopogon dubius	western salsify	7.3%	1.5%		Low (25)	Medium (31)
Tribulus terrestris	puncturevine					
Trifolium arvense[6]	rabbit footclover	ND	1.0%		Low (23)	Easily Controlled (50)
Trifolium campestre	big-hop field clover	ND	1.0%		Low (23)	Easily Controlled (50)
Trifolium dubium	small hop clover					
Triticum aestivum	common wheat					
Typha angustifolia	narrowleaf cattail					
Verbascum thapsus	mullein					
Veronica agrestis	green field speedwell					
Vicia sativa	garden vetch	2.0%	ND		Low (29)	Easily Controlled (50)
Vinca minor	common periwinkle					

ND = Not Detected.

[1]Data from monitoring of the SOPN Annual Exotic Plant monitoring along high priority vectors 2012 - 2014 (Folts-Zettner and Sosinski 2012b; 2013; 2014).

[2]Data from the SOPN 2014 Rapid Assessment (Horsley and Schafer 2014).

[3]Noxious = Oklahoma state noxious status (USDA-NRCS 2014).

[4]Significance of Impact measures the species potential to alter native plant communities. This measure was derived the Handbook for Ranking Exotic Plants for Management and Control (Hiebert and Stubbendieck 1993). Significance of Exotic Plant Impact, Innate Ability of Species to Become a Pest is a numerical ranking between 0 and 50. The numerical rankings were assigned into the following categories: 40 - 50 = Highest Concern; 35 - 39 = High Concern; 30 - 34 = Medium Concern; 0 - 29 = Low Concern. Numbers in parentheses after the descriptive ranking are the actual assigned numeric scores. Species that are potentially native were not ranked. Rankings by Kimberly Struthers, Allyson Mathis and Tomye Folts-Zettner.

[5]Feasibility of Management was derived from the Handbook for Ranking Exotic Plants for Management and Control (Hiebert and Stubbendieck 1993). Species were ranked for this measure excluding some ranking elements (A, Abundance in Park, and B4, Abundance and proximity of propagules near park) in order to evaluate management feasibility independent of population numbers for the exotic species. The measure is a numeric ranking between 0 and 75, with lower values indicating that an infestation of this species is difficult to manage. The numerical rankings were assigned into the following categories: 0 - 15 = Extremely Difficult; 16 - 25 = Difficult; 26 - 35 = Medium; 36 - 75 = Easily Controlled. Numbers in parentheses after the descriptive ranking are the actual assigned numeric scores. Species that are potentially native were not ranked. Rankings by Kimberly Struthers, Allyson Mathis and Tomye Folts-Zettner.

[6]Species found during SOPN monitoring 2012-2014 (Folts-Zettner and Sosinski 2012b; 2013; 2014) not previously reported in SOPN exotic species data for the park (Folts-Zettner 2014).

[7]*Euphorbia davidii* and Euphorbia *dentata* were found in 2012-2014 SOPN monitoring, but were treated together in this assessment. *Melilotus alba* and *Melilotus officinalis* were found in 2012-2014 SOPN monitoring, but were treated together in this assessment.

[8]Species of special concern (Folts-Zettner, personal communication, 2014).

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Appendix F: 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 4.12.2, Data and Methods, of the breeding landbirds chapter. This appendix contains some of the same, but additional, information as that section of the report.

One component of the landbird condition assessment was to assess species occurrence in a conservation context. We compared the list of species that occur at Chickasaw National Recreation Area (NRA) (i.e., those detected during Rocky Mountain Bird Observatory [RMBO] surveys at the Recreation Area during 2009-2013) to lists of species of conservation concern developed by several organizations. There have been a number of such organizations that focus on the conservation of bird species. Such organizations may differ, however, in the criteria they use to identify and/or prioritize species of concern based on the mission and goals of their organization. They also range in geographic scale from global organizations such as the International Union for Conservation of Nature (IUCN), who maintains a "Red List of Threatened Species," to local organizations or chapters of larger organizations. This has been, and continues to be, a source of confusion and perhaps frustration for managers that need to make sense of and apply the applicable information. In recognition of this, the U.S. North American Bird Conservation Initiative (NABCI) was started in 1999; it represents a coalition of government agencies, private organizations, and bird initiatives in the U.S. working to ensure the conservation of North America's native bird populations. Although there remain a number of sources at multiple geographic and administrative scales for information on species of concern, the NABCI has made great progress in developing a common biological framework for conservation planning and design.

One of the developments from the NABCI was the delineation of Bird Conservation Regions (BCRs) (U.S. North American Bird Conservation Initiative 2014). Bird Conservation Regions 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.

F.1. Conservation Organizations Listing Species of Conservation Concern

Below we present a summary 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 2014).

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 IUCNs "Red List" (not presented here), thus, can essentially be considered as a list of globally threatened birds that occur in the United States (Butcher et al. 2007). The Yellow WatchList is made up of species that are somewhat less critical, but serves as an early warning list of birds that have the potential of being elevated to the Red WatchList. Species on this list can be there either because their populations are declining or because they are considered rare.

Partners in Flight

Partners in Flight is a cooperative effort among federal, state, and local government agencies, as well as private organizations. One of its primary goals, relative to listing species of conservation concern, is to develop a scientifically based process for identifying and finding solutions to risks and threats to landbird populations. Their approach to identifying and assessing species of conservation concern is based on biological criteria to evaluate different components of vulnerability (Panjabi et al. 2005). Each species is evaluated for six components of vulnerability: population size, breeding distribution, non-breeding distribution, threats to breeding, threats to non-breeding, and population trend. The specific process is presented in detail in the species assessment handbook (Panjabi et al. 2005).

The PIF assessments are conducted at multiple scales. At the broadest scale, the North American Landbird Conservation Plan (Rich et al. 2004) identifies what PIF considers "Continental Watch List Species" and "Continental Stewardship Species." Continental Watch List Species are those that are most vulnerable at the continental scale, due to a combination of small and declining populations, limited distributions, and high threats throughout their ranges (Panjabi et al. 2005). Continental Stewardship Species are defined as those species that have a

disproportionately high percentage of their world population within a single Avifaunal Biome during either the breeding season or the non-migratory portion of the non-breeding season.

More recently, PIF has adopted BCRs, the common planning unit under the NABCI, as the geographic scale for updated regional bird conservation assessments. These assessments are available via an online database (http://www.rmbo.org/pif/pifdb.html) maintained by RMBO. At the scale of the individual BCRs, these same principles of concern (sensu Continental Watch List Species) or stewardship (sensu Continental Stewardship Species) are applied at the BCR scale. The intention of this approach is to emphasize conservation of species where it is most relevant, as well as the recognition that some species may be experiencing dramatic declines locally even if they are not of high concern nationally, etc. There are two categories (concern and stewardship) each for Continental and Regional levels. The details of the criteria for inclusion in each can be found in Panjabi et al. (2005), and a general summary is as follows. Note that in the Chapter 4 analysis, we did not use the two stewardship categories.

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 State of Oklahoma also designated species of greatest conservation need. 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. The list used for Chickasaw NRA was for BCR 21.

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Appendix G: Chickasaw National Recreation Area Bird List

Listed below is the full list of species reported to occur or that have occurred at Chickasaw NRA according to the sources noted (Rocky Mountain Bird Observatory [RMBO] surveys, Oklahoma Natural Heritage Inventory [ONHI] surveys, and the NPSpecies List for the park [National Park Service 2014]).

Common Name	2009-2013 Surveys (RMBO)	ONHI Surveys (Kelly et al. 2004) 2003-2004	Park Species List (NPSpecies)
Acadian Flycatcher	X		
American Coot	X		
American Crow	X	X	X
American Goldfinch	X	X	X
American Robin	X	X	X
Baltimore Oriole	X		
Barn Swallow	X	X	X
Barred Owl	X	X	X
Belted Kingfisher	X	X	X
Bewick's Wren	X	X	X
Black Vulture	X	X	X
Black-and-white Warbler	X	X	X
Black-capped Gnatcatcher			X
Black-crowned Night-Heron	X		X
Blue Grosbeak	X		
Blue Jay	X	X	X
Blue-gray Gnatcatcher	X	X	
Boat-tailed Grackle			X
Brewer's Blackbird	X		
Broad-Winged Hawk	X		
Brown Thrasher	X	X	X
Brown-headed Cowbird	X	X	X
Canada Goose	X	X	X
Carolina Chickadee	X	X	X
Carolina Wren	X	X	X
Cattle Egret	X	X	X
Cedar Waxwing	X		
Chimney Swift	X	X	X
Chipping Sparrow	X		
Chuck-will's-widow	X	X	X
Cliff Swallow	X	X	X
Common Grackle	X	X	X
Common Nighthawk	X	X	X
Common Yellowthroat	X		
Cooper's Hawk	X	X	X
Dickcissel	X	X	X
Downy Woodpecker	X	X	X

Common Name	2009-2013 Surveys (RMBO)	ONHI Surveys (Kelly et al. 2004) 2003-2004	Park Species List (NPSpecies)
Eastern Bluebird	X	X	X
Eastern Kingbird	X		
Eastern Meadowlark	X	X	X
Eastern Phoebe	X	X	X
Eastern Screech-Owl		X	X
Eastern Wood-Pewee	X	X	X
Eurasian Collared-Dove	X		
European Starling		X	X
Field Sparrow	X	X	X
Franklin's Gull	X		
Grasshopper Sparrow	X		
Gray Catbird	X	X	X
Gray Flycatcher	X		
Great Blue Heron	X	X	X
Great Crested Flycatcher	X	X	X
Great Egret	X	X	X
Great Horned Owl		X	X
Greater Roadrunner	X	X	X
Great-tailed Grackle	X	X	
Green Heron	X	X	X
Hairy Woodpecker	X	X	X
Hooded Warbler	X		
House Finch	X		
House Sparrow	X	X	X
House Wren	X		
Indigo Bunting	X	X	X
Killdeer	X	X	X
Lark Sparrow	X	X	X
Least Flycatcher	X		
Least Sandpiper		X	X
Lincoln's Sparrow	X		
Little Blue Heron	X	X	X
Louisiana Waterthrush	X	X	X
Mallard	X		
Mississippi Kite	X	X	X
Mourning Dove	X	X	X
Northern Bobwhite	X	X	X
Northern Cardinal	X	X	X
Northern Flicker	X	X	X
Northern Mockingbird	X	X	X
Northern Parula	X	X	X
Northern Rough-winged Swallow	X	X	X
Olive-sided Flycatcher	X		
Orchard Oriole	X		
Painted Bunting	X	X	X

Common Name	2009-2013 Surveys (RMBO)	ONHI Surveys (Kelly et al. 2004) 2003-2004	Park Species List (NPSpecies)
Pied-billed Grebe		X	X
Pileated Woodpecker	X	X	X
Prothonotary Warbler		X	X
Purple Martin	X	X	X
Red-bellied Woodpecker	X	X	X
Red-eyed Vireo	X	X	X
Red-headed Woodpecker	X	X	X
Red-shouldered Hawk	X	X	X
Red-tailed Hawk	X		
Red-winged Blackbird	X	X	X
Ring-necked Pheasant	X		
Rock Pigeon	X	X	X
Ruby-throated Hummingbird	X	X	X
Rufous Hummingbird	X		
Rufous-crowned Sparrow	X		
Scissor-tailed Flycatcher	X	X	X
Snowy Egret	X		
Song Sparrow	X		
Spotted Sandpiper		X	X
Summer Tanager	X	X	X
Swainson's Hawk		X	X
Swainson's Thrush	X	X	X
Tree Swallow	X		
Tufted Titmouse	X	X	X
Turkey Vulture	X	X	X
Vesper Sparrow	X		
Warbling Vireo	X		
Western Kingbird	X	X	X
White-breasted Nuthatch	X	X	X
White-crowned Sparrow	X		
White-eyed Vireo	X	X	X
Wild Turkey	X	X	X
Willow Flycatcher	X		
Wilson's Warbler	X		
Wood Duck	X	X	X
Yellow Warbler	X	X	X
Yellow-billed Cuckoo	X	X	X
Yellow-breasted Chat	X		
Yellow-crowned Night Heron		X	
Yellow-rumped Warbler	X		
Yellow-throated Vireo	X		
Yellow-throated Warbler	X	X	X

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