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Natural Resource Stewardship and Science

Lyndon B. Johnson National Historical Park

Natural Resource Condition Assessment

Natural Resource Report NPS/SOPN/NRR—2016/1139



ON THE COVER

The Perdenales River running though the Ranch Unit of Lyndon B. Johnson NHP. Jason Lott

Lyndon B. Johnson National Historical Park

Natural Resource Condition Assessment

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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 Lyndon B. Johnson National Historical Park 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. The viewshed was considered to be in good condition while night sky and soundscape were in moderate condition.

The park's supporting physical environment resource topics included air quality, geology, groundwater, and surface water quality. The condition for each of these resources varied between good for geology and surface water quality, moderate for groundwater, and significant concern for air quality.

The biological integrity resources assessed included grasslands, riparian habitat, live oak, and exotic plants for vegetation and landbirds and White-tailed Deer & exotic Blackbuck Antelope for wildlife. The vegetation resources were in good to moderate condition, although exotic plants were considered to be of significant concern. The wildlife conditions were primarily good, except for landbirds, which were considered to be in good to moderate condition.

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We wish to thank Jeff Albright, program lead of the Natural Resource Condition Assessment Program, Water Resources Program Center, National Park Service, who provided programmatic insight and guidance on project development and review and Donna Shorrock, Intermountain Region Natural Resource Condition Assessment Coordinator for her assistance. The authors are grateful to the staff at the National Park Service Natural Resource Stewardship and Science Directorate for their technical expertise, guidance, and reviews of their respective subjects, especially Larry Martin with the Water Resources Division for providing information to develop the groundwater assessment. We would also like to express our gratitude and thanks to Lyndon B. Johnson National Historical Park staff, Dave Schafer, Chief of Interpretation and Resource Management for his assistance throughout the process of the NRCA and to Becca Renaud, Chief of Maintenance and John Peckne, Water Operator for their assistance with groundwater well information. To all those remaining who reviewed and commented on this report, thank you. Your contributions have increased its professional value.


NPS PHOTO

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.



NPS PHOTO

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/.



KIM STRUTHERS

A view of the rural setting surrounding the Sam Ealy Johnson, Sr.

Chapter 2: Introduction and Resource Setting

2.1. Introduction

2.1.1. Enabling Legislation/Executive Orders

Lyndon B. Johnson National Historical Park (NHP) was authorized by an act of Congress on December 2, 1969 (Public Law 91-134, NPS 2014). The park includes two separate districts within and to the west of Johnson City, Texas. It preserves the birthplace, boyhood home, ranch, and other historic sites and features associated with the life of Lyndon Baines Johnson, the 36th president of the United States (NPS 2014).

Park Purpose

The NHP was established "to protect the historic structures and Texas Hill Country landscapes linked to the ancestry, life, and legacy of President Johnson and provide opportunities for visitors to compellingly experience these places that shaped the personality, character, and political philosophy of Lyndon Johnson throughout his life and that served as the setting for a remote White House during his presidency" (NPS 2014).

Park Significance

Five significance statements have been identified for the NHP and include:

> *1. Lyndon B. Johnson conducted his official duties as president from his home on the LBJ Ranch for more than one-quarter of his presidency. Johnson used jet aircraft and other technological advancements to become the first American president to work "virtually" from the remote location of his Texas ranch.*
>
> *2. The historic setting of the Boyhood Home and Johnson Settlement areas in Johnson City, Texas, reflects President Lyndon B. Johnson's humble origins and the importance of community that influenced his policy agenda as president.*

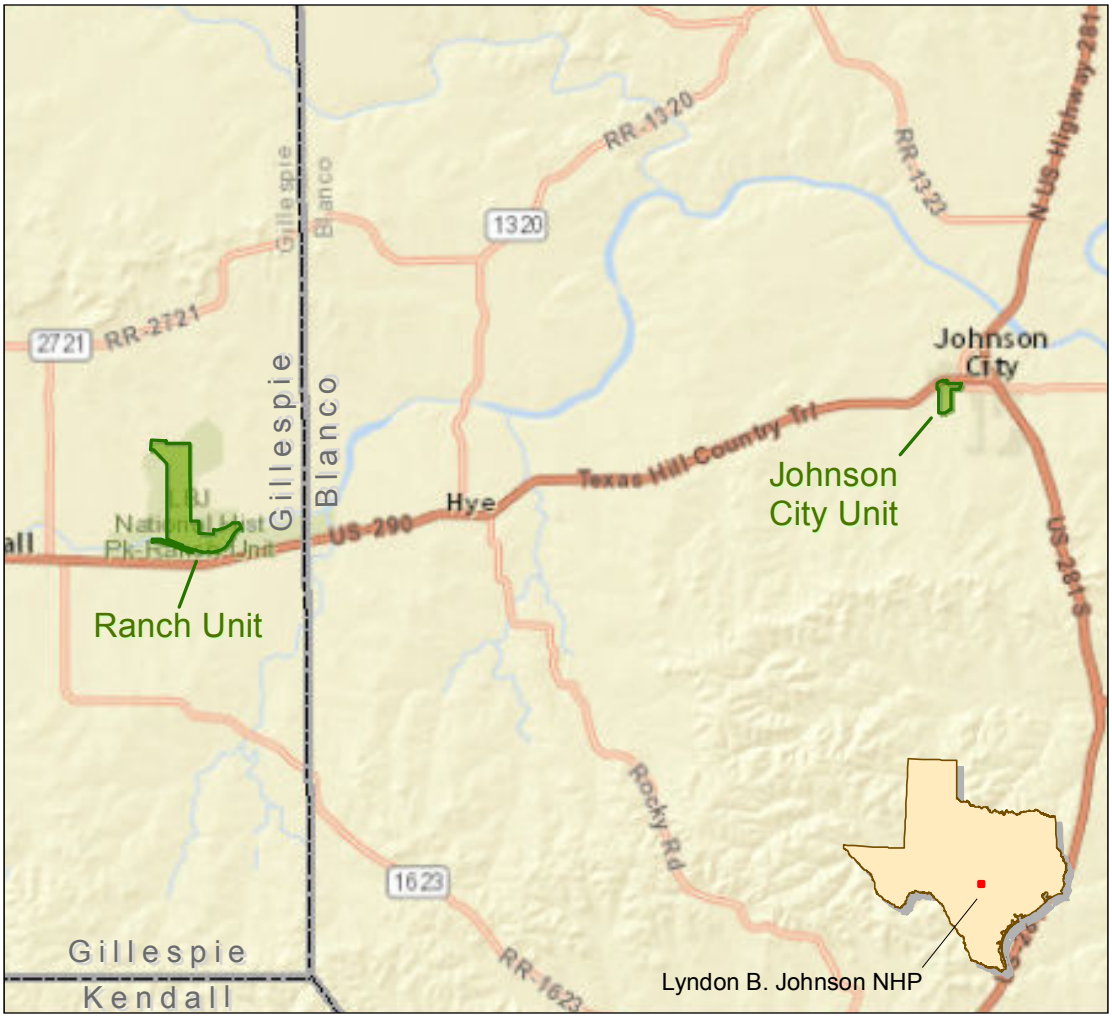


Figure 2.1.2-1. Setting of Lyndon B. Johnson NHP.

3. The site of the Texas White House, the LBJ Ranch is a physical manifestation of Lyndon B. Johnson's personal and political life, the site of his ancestral home place as well as a key aspect of his personal and public image.

4. Lyndon and Lady Bird Johnson's deep-rooted connection to the rural Texas Hill Country landscape shaped policies directed toward natural and historic conservation, and inspired the establishment of the park.

5. Lyndon B. Johnson National Historical Park, as part of a community of presidential sites, provides a setting to interpret the functions of the US presidency, the American political system, and President Johnson's significant legacy including his Great Society programs and the escalation of American involvement in the Vietnam War (NPS 2014).

2.1.2. Geographic Setting

The NHP is situated in the Texas Hill Country, approximately 80.5 km (50 mi) west of Austin and 104.6 km (65 mi) north of San Antonio (Figure 2.1.2-1). The NHP includes 273 hectares (674 acres) between the two districts. The area is characterized by hills covered with juniper and oak, with elevations ranging from 305-762 m (1,000-2,500 feet) above sea level. The Pedernales River weaves its way through farms, ranches, and small towns, creating a rural, small-town America feel.

Climate

Lyndon B. Johnson NHP 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

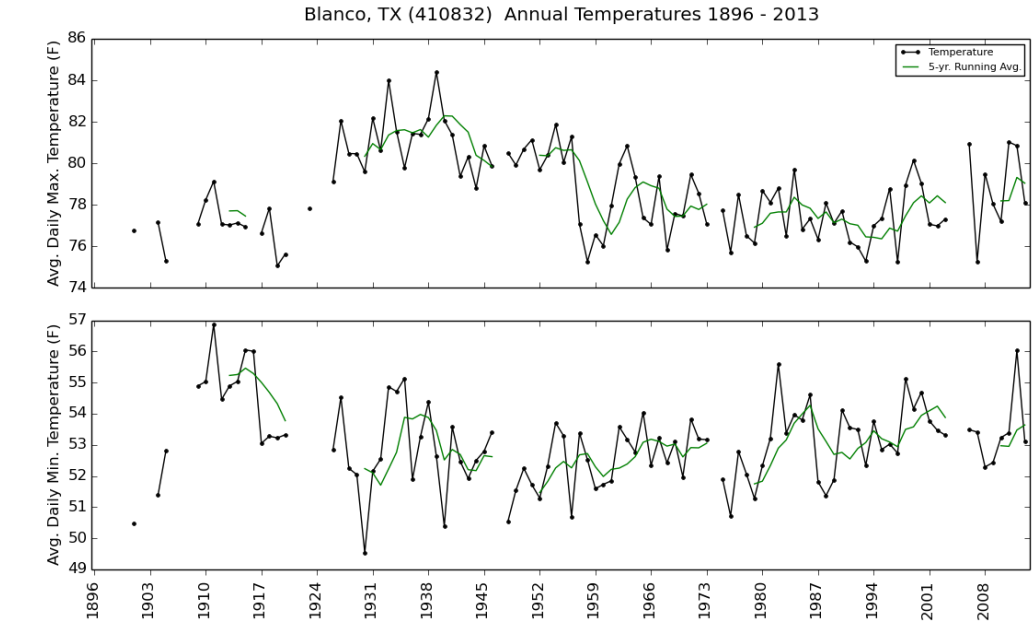


Figure 2.1.2-2. Trends in the average daily temperatures annually from 1896-2013, recorded at Blanco, TX (www.climateanalyzer.org).

and drier conditions on their leeward side. 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. Sharp winter freezes and frequent periods of prolonged drought have a strong influence on the success of crops in the region. The organisms that live in this area are adapted to surviving extreme climate conditions. In some cases, native plants take advantage of these climate extremes in order to colonize new areas. Drought can lead to massive local extinctions of annual forbs and grasses that have invaded stands of perennial species (Davey et al 2007). The Texas Forest Service maintains a weather station in the LBJ Ranch District., which uses the data for fire weather forecasts.

Temperature

The general temperature gradient in the Southern Plains is from cooler temperatures in the northwest to warmer temperatures in the southeast. The El Niño-Southern Oscillation (ENSO) causes inter-annual climate variations. El Niño conditions (warm ENSO phases) are associated with cooler, wetter conditions while La Niña conditions (cool ENSO phases) are associated with warmer, drier conditions (Davey et al. 2007). The mean annual temperature near Lyndon B. Johnson NHP is 65.ºF (18.7ºC). On average, the warmest month is August; the highest recorded temperature was 109°F in 1953. On average, the coolest month is January; the lowest recorded temperature was -5°F in 1949 (Figure 2.1.2-2).

Precipitation

Precipitation in the southern plains generally increases to the east, although localized higher precipitation amounts are also evident in the higher elevations of New Mexico. Precipitation in the southern plains generally peaks in mid- to late-summer, with some additional autumn maxima in central Texas. The mean annual rainfall is 30.2 in (76.7 cm), and the maximum average precipitation occurs in May. Precipitation maxima occur in spring and fall in response to frontal systems entering the region from the north that merge with unstable and moist air from the Gulf of Mexico. Annual precipitation can vary greatly with wet years receiving nearly 60 inches of rain, and dry years less than a quarter of that. (Figures 2.1.2.-3 and -4).

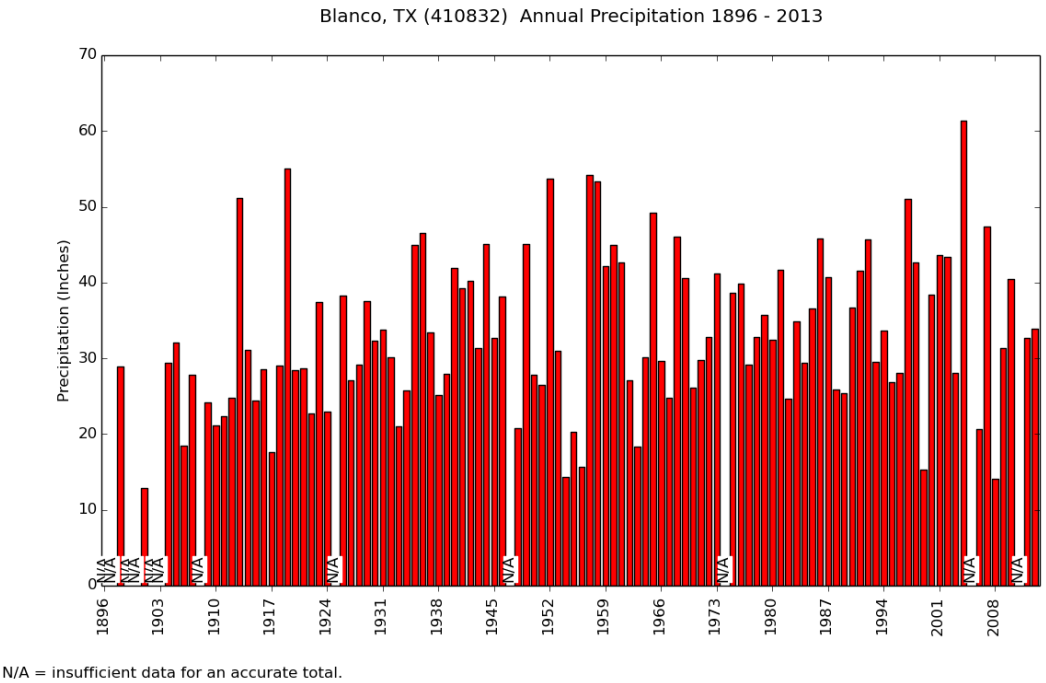


Figure 2.1.2-3. Annual precipitation, 1896-2013 (www.climateanalyzer.org).

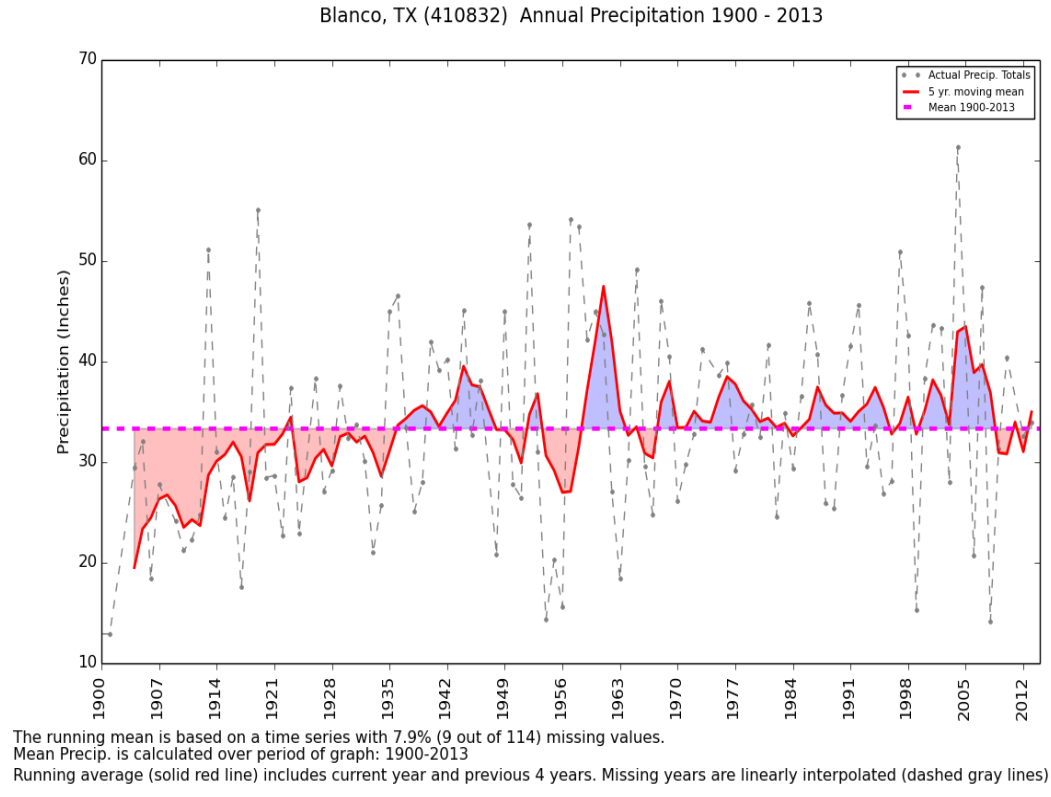


Figure 2.1.2-4. Annual precipitation compared to the mean, showing drought years since about 2006, and severe prolonged drought between 1900 and 1935 (www.climateanalyzer.org).

2.1.3. Visitation Statistics

Monthly visitation data for the NHP were available for 1979-2014. The months receiving the greatest average 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 75,932 (in 2005) to 579,200 (in 1973). The number of visitors in 2014 was 88,427 (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 NHP is located within the mixed grass prairie of the Great Plains region. The Pedernales River flows through the NHP and is a tributary of the Colorado River draining an area of approximately 3,316 km² (1,280 mi²)(Figure 2.2.1-1) (USGS 2014).

2.2.2. Resource Descriptions

Hydrology

The Pedernales River, which is a tributary to the Colorado River is a perennial, spring-fed stream that flows approximately 161 km (100 miles) through the Texas Hill Country, from west to east. It's the primary water feature in the park and has two dams along the stretch of river that flows along the sounth boundary of the Ranch Unit. Local tributaries relevant to the LBJ Ranch and Johnson City districts of the park include Wittington Creek and Town Creek, as well as a number of seasonal, unnamed washes and streams (Thornberry and Ehrlich 2008)

Geology

The park lies in an area of central Texas known as the Llano Uplift, which has the metamorphic core of an ancient mountain range, Paleozoic and Mesozoic sedimentary rocks, and recent alluvial, terrace, and colluvial deposits (Thornberry-Ehrlich 2008).

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 NHP 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

The central grassland region of North America is one of the largest contiguous grassland environments on earth (Lauenroth et al. 2008), and Lyndon B. Johnson NHP is located within the region generally classified as mixed grass prairie, but it is near and to the west of tallgrass prairie. The mixed grass prairie is considered a broad ecotone (separating the tallgrass prairie and shortgrass prairie; World Wildlife Fund and Hogan 2014). The vegetation at the park consists of a combination of common Texas Hill

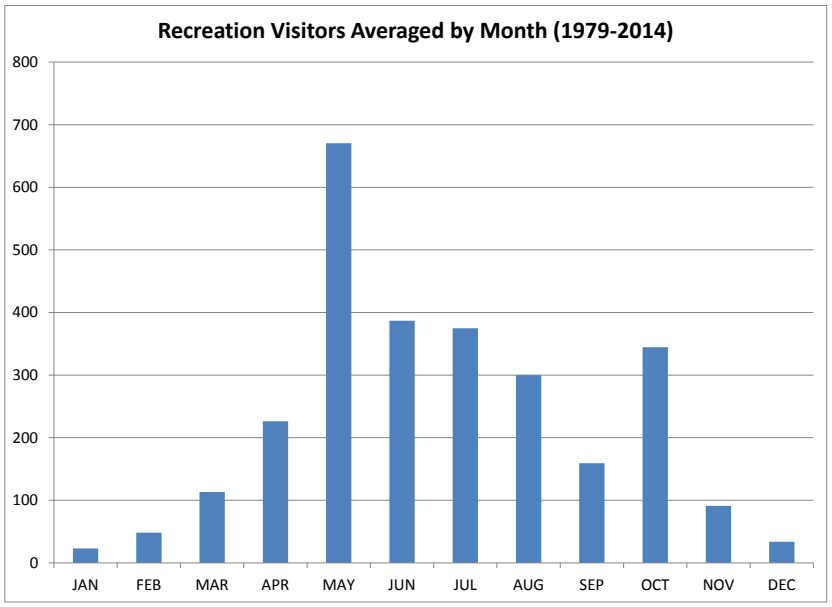


Figure 2.1.3-1. Average number of visitors to Lyndon B. Johnson NHP by month, 1979-2014.

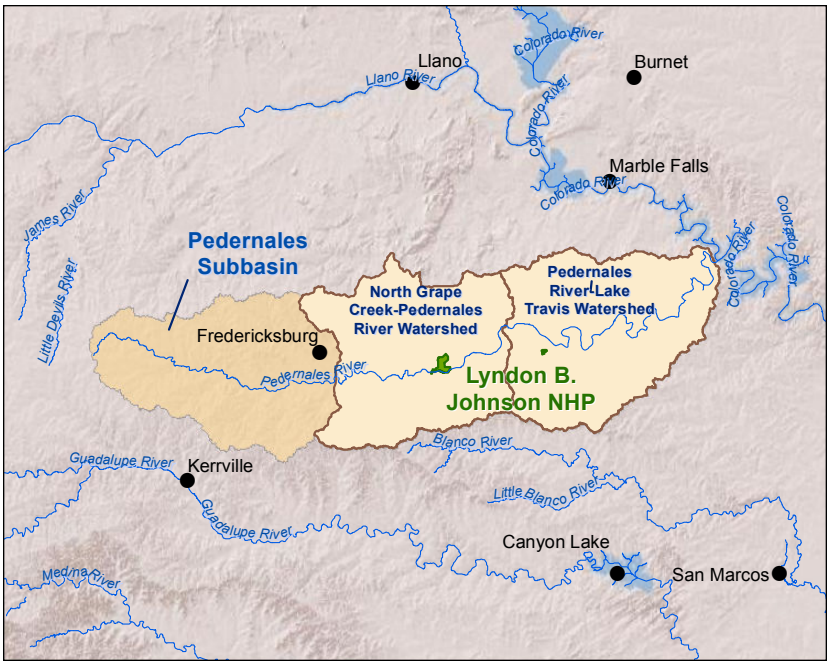


Figure 2.2.1-1. Lyndon B. Johnson NHP is located within the Pedernales Subbasin, which encompasses an area of 3,316 km² (1,280 mi ².

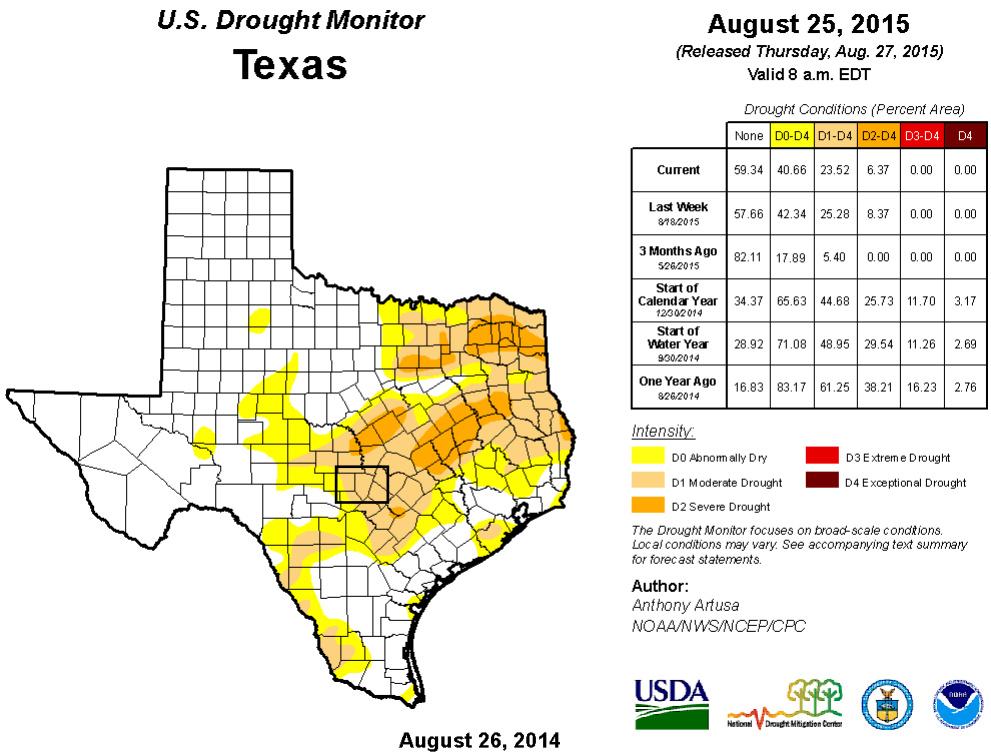


Figure 2.2.3-1. The U.S. Drought Monitor (http://droughtmonitor.unl.edu/Home/StateDroughtMonitor.aspx?TX, accessed August 9, 2015) for Texas indicates that several areas throughout the state were experiencing extreme - exceptional drought conditions in 2014 (bottom figure). Now, one year later, no areas in extreme drought. Boxes show the counties where the park districts are located.

Country native plants and non-native species influenced by agriculture (Cogan 2007). Trees and shrubs at the Historical Park account for much of the native vegetation.

Wildlife

Birds

There have been a total of 55 bird species recorded at Lyndon B. Johnson NHP by Rocky Mountain Bird Observatory to date. A larger number of species appear on the NPSpecies List for the park, but again, this list is based on Archer (2011), which is a checklist that includes the state park that is adjacent to the Ranch Unit of the Historical Park. There are 10 species of conservation concern on one or more of the conservation lists described in Section 4.11.

White-tailed Deer and Blackbuck Antelope

Lyndon B. Johnson NHP is home to both native white-tailed deer and non-native blackbuck antelope. White-tailed deer are said to be the most important big game animal in Texas, and nearly one-half of the state's annual harvest is attributed to the Texas Hill Country. Currently, deer at the Ranch Unit of the Historical Park occur in two herds, and blackbuck antelope occur in one herd. Deer also are present on the Johnson City Unit.

2.2.3. Resource Issues Overview

Drought

Drought is common in this region. In recent years (since about 2006), this area has experienced prolonged and extreme drought. (Figure 2.2.3-1).

Climate Change

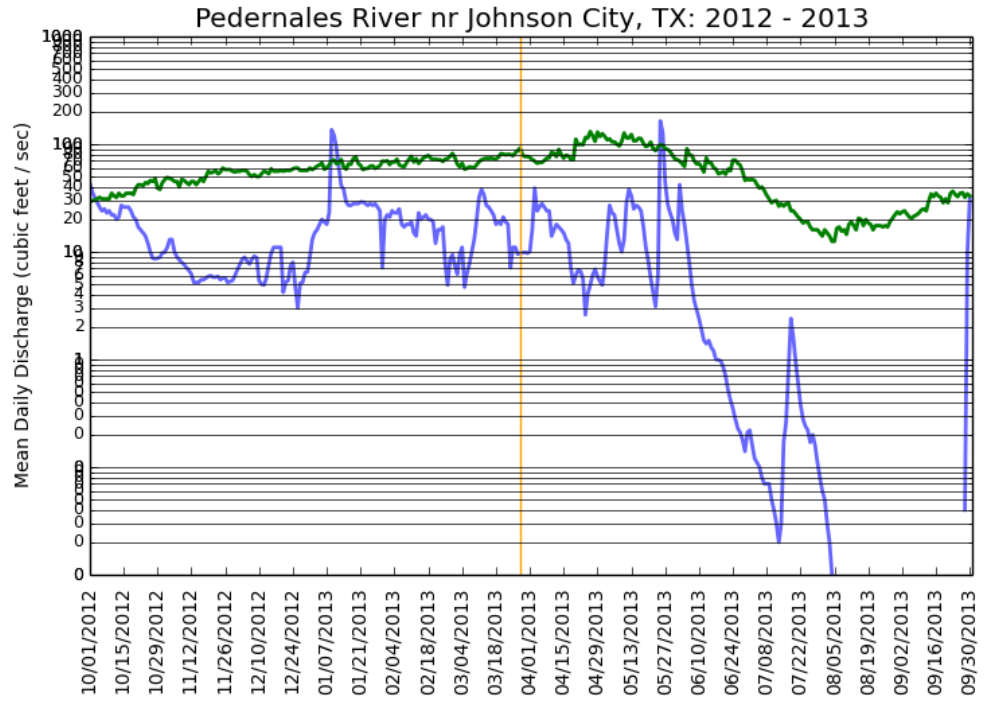


Figure 2.2.3-2. Flow of the Pedernales River October 2012 to October 2013 shows decreased flow compared to the historic median, and when the river dried up completely in August of 2013 (www.climateanalyzer.org).

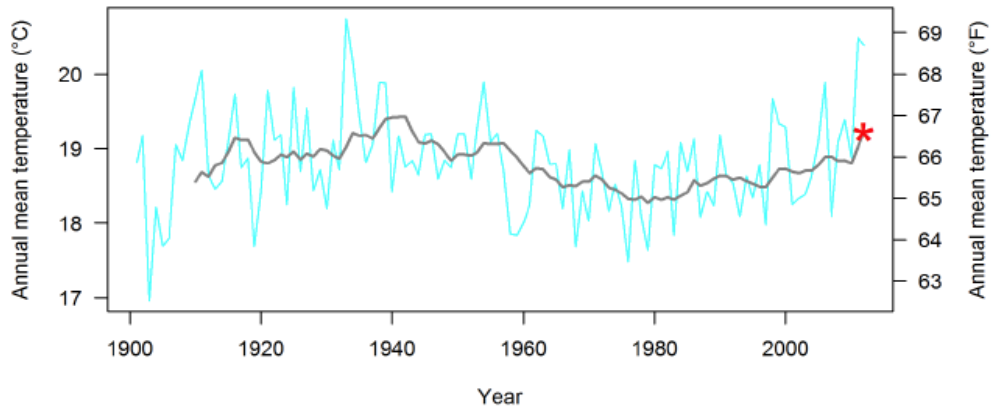


Figure 2.2.3-2. Time series used to characterize the historical range of variability and most recent percentile for annual mean temperature at Lyndon B. Johnson National Historical Park (including areas within 30-km [18.6-mi] of the park's boundary).

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).

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. Species extinctions may occur due to the inability to re-colonize in response to future climate changes (Davey et al. 2007). Warming temperatures and increased impacts of drought are likely to increase the stress on water resources, such as the Pedernales River (Figure 2.2.3-2), as well as on plants and wildlife.

Monahan and Fisichelli (2014) assessed the magnitude and direction of changes in climate for Lyndon B. Johnson NHP 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."
- 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 2.2.3-3.

The results indicate that recent climate conditions are within the HRV, but that future changes are likely (Monahan and Fisichelli 2014).

Resource Threats (NPS 2014)
Park staff identified a wide variety of resource threats during the development of their Foundation Document that was finalized in 2014. They are as follows (excerpted from NPS 2014):

- Drought has negatively impacted the landscape and structure condition.
- Texas Department of Transportation plans for State Highways 290 and 281 could impact the viewshed from the park and contribute to further development and traffic, and potentially impact air quality.
- Regular water quality testing is not conducted due to limited staffing.
- Housing and development is changing the viewshed and scenic vistas.
- Light pollution from surrounding development impacts nighttime viewsheds.
- Increasing population and suburban sprawl from Austin and San Antonio could impact the rural small-town character of the area.
- Reduced flow of water in the Pedernales River could increase damage from floods. Loss of the river would change the ability of visitors to experience the land as the Johnsons did.
- Overpopulation of white-tailed deer, hogs, and nonnative ungulates could overbrowse and add stress to the land, compete with cattle grazing, create disease risks for cattle, and change the landscape.
- Upstream development could have negative impacts on water quality in the river.
- Oak wilt could further change the landscape through the loss of oak trees.
- Drought and oak wilt could impact oaks.
- The Crider Motel property across the street disrupts the viewshed. The motel is dilapidated, and there is uncertainty as to what will happen with the property.
- Growth in Austin, Fredericksburg, San Antonio, and Marble Falls could result in encroachment. The site could be impacted by potential expansion of Texas State Highway 290.
- Invasive species (hogs) and pest issues on landscape.
- The long-term impacts of drought or climate change are unknown.
- There is a risk of flooding due to increased riparian vegetation on the south bank of the river that diverts floodwaters toward these structures.
- There is a risk of flood damage to the cemetery landscape.
- There are pest problems caused by skunks and other animals (list of threats were excerpted from NPS 2014).

2.3. Resource Stewardship

2.3.1. Management Directives and Planning Guidance

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

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 2011). The primary goals of the I&M Program are to:

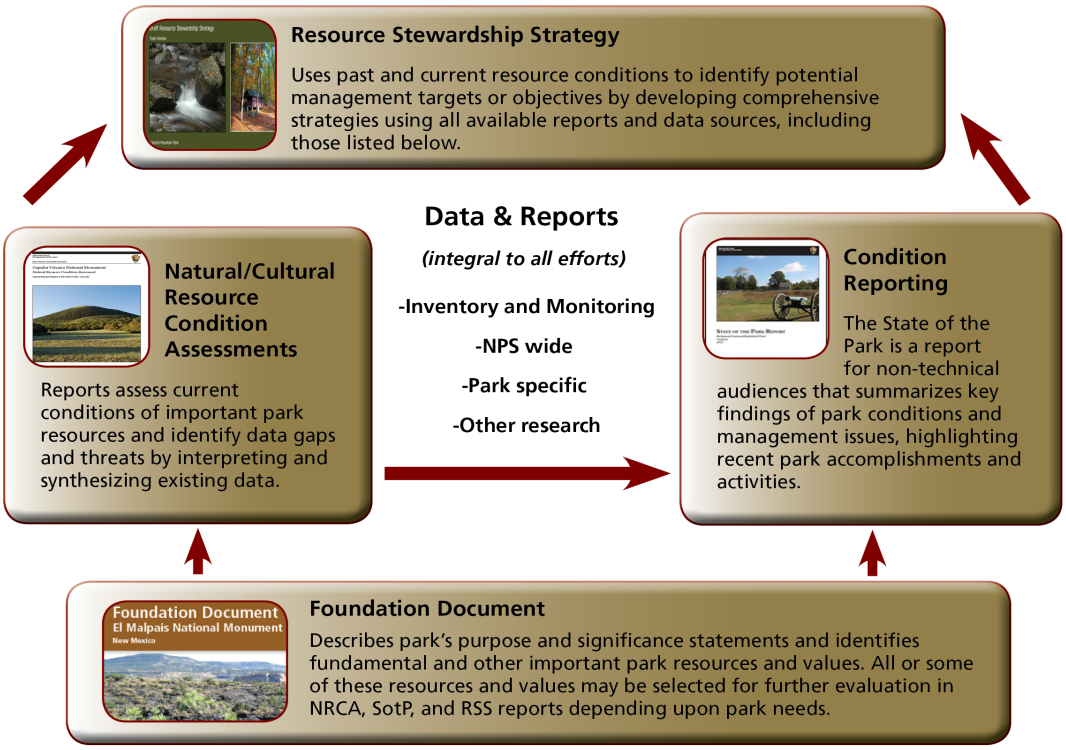


Figure 2.3.1-1. The diagram shows the relationship of NRCAs to other park planning reports.

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

To facilitate this effort, 270 parks with significant natural resources were organized into 32 regional networks. Lyndon B. Johnson NHP 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 the NHP. They also assist with surface water data collection.

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 was completed for the NHP in 2014.

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 Interpretation and Resource Management Dave Schafer, provided valuable information and assistance pertaining to resource topics. 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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KIM STRUTHERS

Pastoral view from porch of Sam Ealy Johnson, Sr. cabin.

Chapter 3: Study Scoping and Design

This NRCA is a collaborative project between the Lyndon B. Johnson NHP staff and the SOPN Network, all of the NPS. Stakeholders in this project include the National Historical Park'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 Historical Park natural resources that were identified and agreed upon by the project team during the scoping session. Project findings will aid National Historical Park 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 Historical Park 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 Historical Park 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 on 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 Historical Park data, reports, and spatial information from appropriate sources including: National Historical Park 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 Historical Park or controlled directly by National Historical Park management activities (e.g., viewshed condition). There are important stressors that impact key natural resource components in the National Historical Park but are not under NPS jurisdiction.

National Historical Park natural resource staff participated in on-site meetings and reviewed interim and final products. National Historical Park 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 Historical Park'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, 13 key National Historical Park 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 Historical Park, 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 Historical Park resources was unknown, an attempt was made to include a qualitative framework to provide some context for interpreting condition.

Table 3.2.1-1. Lyndon B. Johnson NHP 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 (2 Measures) • Sky Quality (1 Measure)
Soundscape	Full Assessment	• Audibility (1 Measure) • 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	• Geologic Resource Integrity
Surface Water Quality	Full Assessment	• Field Properties (5 measures) • *E. coli* (1 measure) • Nutrients (1 measure)
Groundwater	Full Assessment	• Groundwater Elevation (Change In Groundwater Elevation)
III. Biological Integrity		
Vegetation		
Riparian Habitat	Limited Assessment	• Vegetation (7 Measures) • Erosion/Deposition (3 Measures)
Restoration 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 measures) • Prevalence of Exotic Plants (3 measures)
Live Oak	Limited Assessment	• Occurrence and Severity of Oak Wilt Disease (3 measures)
Wildlife		
Landbirds	Full Assessment	• Species Occurrence (2 measures)
White-tailed Deer & Exotic Blackbuck Antelope	Limited Assessment	• Deer/Antelope Populations (Estimated # of Deer/ Antelope) • Impact On Park Resources (Damage To Vegetation)

3.2.2. Reporting Areas

The reporting area was treated as one unit and encompassed the entire acreage within the National Historical Park'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 Historical Park's boundary were assessed to determine overall condition within the National Historical Park (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 Historical Park to the reference condition(s) when possible.

Data Mining

Data and literature were found in multiple forms: NPS reports and monitoring plans (National Historical Park, 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 Historical Park, 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 Historical Park staff during the review of draft chapters. Additionally, continued contact with National Historical Park 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 Historical Park 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

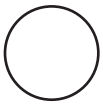
Condition Status		Trend in Condition		Confidence in Assessment	
	Warrants Significant Concern		Condition is Improving		High
	Warrants Moderate Concern		Condition is Unchanging		Medium
	Resource is in Good Condition		Condition is Deteriorating		Low
	An open (uncolored) circle indicates that current condition 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 Lyndon B. Johnson NHP NRCA.

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



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

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 Historical Park. 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 Historical Park 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 Lyndon B. Johnson NHP. 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	26	33
Night Sky	Sky Brightness (Anthropogenic Light Ratio, Zenith Sky Brightness, Maximum Vertical Illuminance)	40	39
	Sky Quality (Bortle Dark-Sky Scale)	41	44
Soundscape	Audibility	52	56
	Sound Levels	52	57
II. Supporting Environment			
Air Quality	Visibility	63	65
	Level of Ozone	64	65
	Atmospheric Wet Deposition in Total N and Total S	64	65
Geology	Geologic Resource Integrity	72	73
Surface Water	Field Properties	78	80
	E. coli	78	82
	Nutrients	78	82
Groundwater	Groundwater Elevation	86	89
III. Biological Integrity			
Vegetation			
Riparian Habitat	Vegetation	94	96
	Erosion/Deposition	95	98
Restoration Grasslands	Hydrology Soil/Site Stability and Hydrologic Function	108	114
	Biotic Integrity	108	115
Exotic Plants	Potential to Alter Native Plant Communities	128	137
	Prevalence of Exotic Plant	130	139

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
Wildlife			
Landbirds	Species Occurrence	148	154
White-tailed Deer & Exotic Blackbuck Antelope	Deer/Antelope Populations (estimated # of deer/ antelope)	164	165
	Impact on Park Resources (damage to vegetation)	164	166
Live Oak Treess	Occurrence & Severity of Oak Wilt Disease	170	171

4.1. Viewshed

Indicators/Measures

- Scenic and Historic Integrity (2 Measures)

Condition – Trend - Confidence



Good – Unknown - 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.

The LBJ Boyhood Home and Johnson Settlement is located within Johnson City, just off Main Street. Johnson Settlement is composed of 15 acres of restored buildings from the mid-19th to the early-20th century interpreted for the public and walking trails (NPS 2012a). The views are diverse including both views of town and rural/agricultural land that is part of the National Historical Park and adjacent to it.

The LBJ Ranch is west of Johnson City (approximately 14 miles). This is the location where LBJ's grandparents ran their 320-acre cattle ranch from 1867-1872 (NPS 2012b). The site includes historic buildings associated with the Johnson family, LBJ's presidency, and buildings and equipment associated with the working ranch. The views are pastoral and provide visitors with the experience of visiting the Johnson family ranch (Figure 4.1.1-1).



NINA CHAMBERS

Figure 4.1.1-1. Lyndon B. Johnson NHP, LBJ Ranch has pastoral views that retain the feel of a working ranch.

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 NHP 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 story of the NHP.

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 Lyndon B. Johnson NHP. 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. In the case of Lyndon B. Johnson NHP, there is so much overlap that we treat them together. We qualitatively assess how features on the landscape contribute (or not) to the scenic and historic integrity of the site.

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 (in an historic context) 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 those features that have a visual impact and contribute to the story of Lyndon B. Johnson NHP. 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).

We assess scenic and historic integrity by evaluating specific human-made 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 an historic context.
	Conspicuousness of non-contributing features	Non-contributing features that are more conspicuous tend to detract more from the scenic quality and/or the sense of place in an historic context.

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. For noncontributing features, we further assess the characteristics that make them more or less conspicuous; which influences the level of impact that they might have. We then supplement this assessment with a GIS-based map showing areas that are or are not visible from key vantage points. The GIS analysis provides spatial orientation of key features.

Viewshed Vantage Point

For this assessment we focused primarily on the views visible on the LBJ Ranch and used one main vantage point from which to assess the view. The vantage point we used was at the top of the airstrip near the tetrahedron-shaped wind indicator (Figure 4.1.2-1). This is near the highest point on the ranch and is the point from which most visitors view the surrounding landscape. As such, the view from this site plays a major role in how visitors perceive the NHP within the context of its surrounding landscape.

Ancillary Views

Other views at the NHP also contribute to the scenic and historic integrity, but are not vantage point "viewsheds" *per se*. These ancillary views include views of the historic buildings and the natural and pastoral settings of the Johnson Settlement that contribute to visitor experience (Figure 4.1.2-2).

These additional views were not included in the assessment with respect to applying our full measures of integrity, but still have important implications to NHP management.

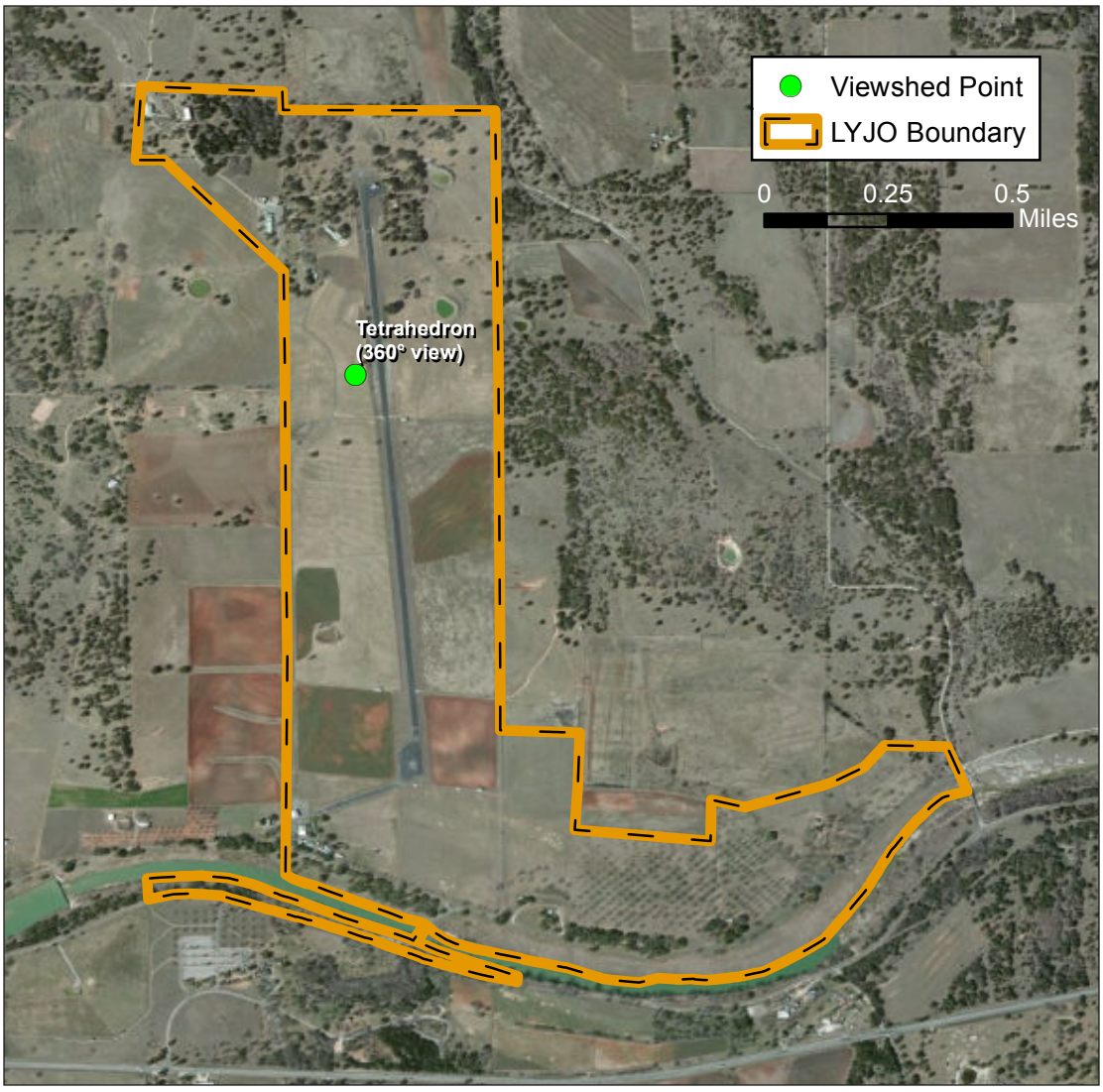


Figure 4.1.2-1. The location of the vantage point used in this assessment.

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Figure 4.1.2-2. Other important views of the park at Johnson Settlement, apart from vantage point, include historic buildings in natural and pastoral settings that contribute to a visitor's experience of sense of place.

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 4.1.2-3). 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 (Zube et al. 1982, Kaplan and Kaplan 1989, Sheppard 2001, Kearny et al. 2008, Han 2010). However, in the case of parks set aside for their historical significance, human-made structures that have historical significance add value to the historical context and contribute to the sense of place. Therefore, human-made features that are consistent with the historical context of the NHP are likewise considered consistent with the goals of scenic and historic integrity. Human-altered components of the landscape (e.g., roads, buildings, powerlines, and other features) that do not contribute to the historic context are often perceived as detracting from the scenic and historic character of the viewshed.

Despite this generalization for natural landscape preferences, studies have 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).



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

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 4.1.2-4). For this assessment, we have used the distance classes that have been recently used by the National Park Service:

- *Foreground* = 0-½ mile from vantage point
- *Middle ground* = ½-3 miles from vantage point
- *Background* = 3-60 miles from vantage point.

Over time, different agencies have adopted minor variations in the different specific distances use to define these zones, but the overall logic and intent has been consistent.

The foreground is the zone where visitors should be able to distinguish variation in texture and color, such as the relatively subtle variation among vegetation patches, or some level of distinguishing clusters of tree boughs. 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

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 4.1.2-4. An example of approximate distance classes used in this assessment.

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

Size

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

We considered the features on the landscape surrounding Lyndon B. Johnson NHP 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.

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

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 4.1.2-5). 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). For example, the Visual Resource Management Program of the BLM (BLM 1980) similarly places considerable focus on design techniques that minimize visual conflicts with features such as roads and power lines by aligning them with the natural contours of the landscape. Based on these characteristics of contrast, we considered the color of a feature in relative harmony with the landscape if it closely matched the surrounding environment, or if the color tended to be darker relative to the environment. We considered the shape of a feature in relative harmony with the landscape if it was not in marked contrast to the environment.

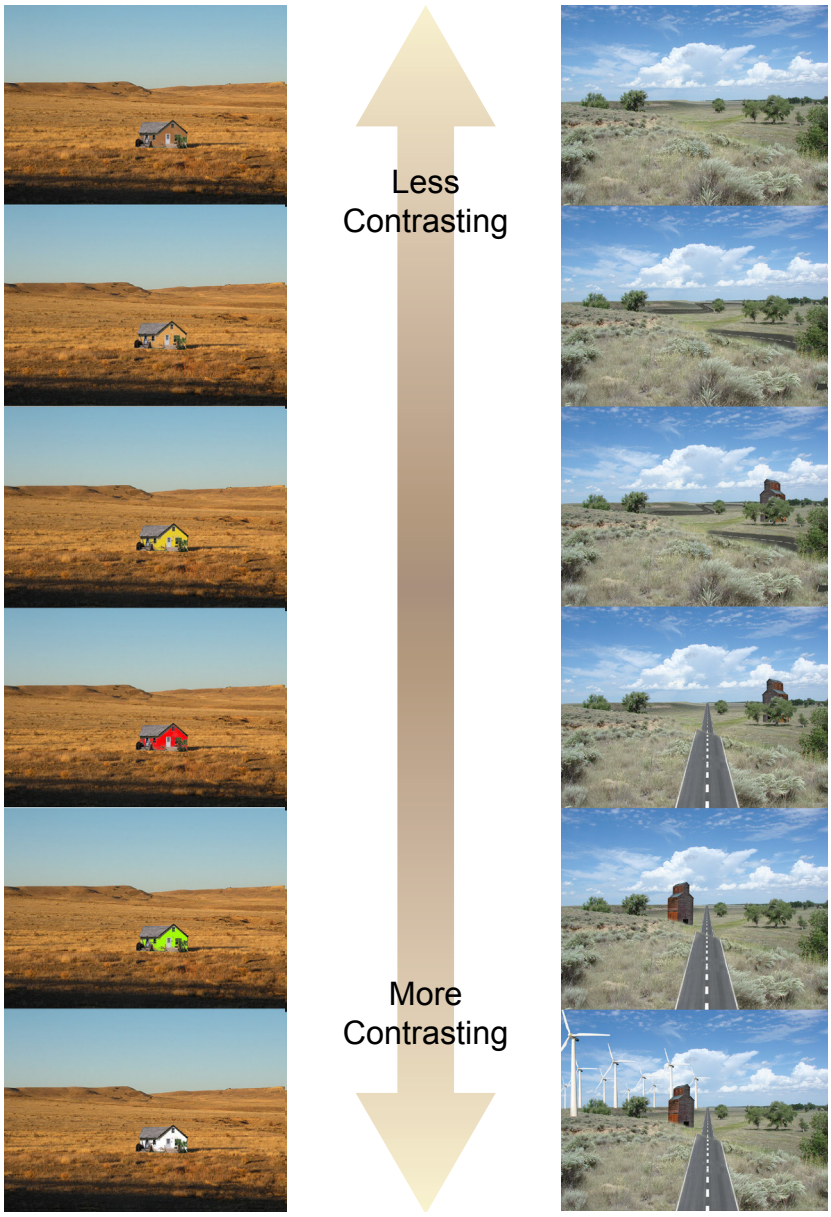


Figure 4.1.2-5. Graphic illustration of how color (left) and shape (right) can influence whether features are in harmony with the environment, or are in contrast.

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

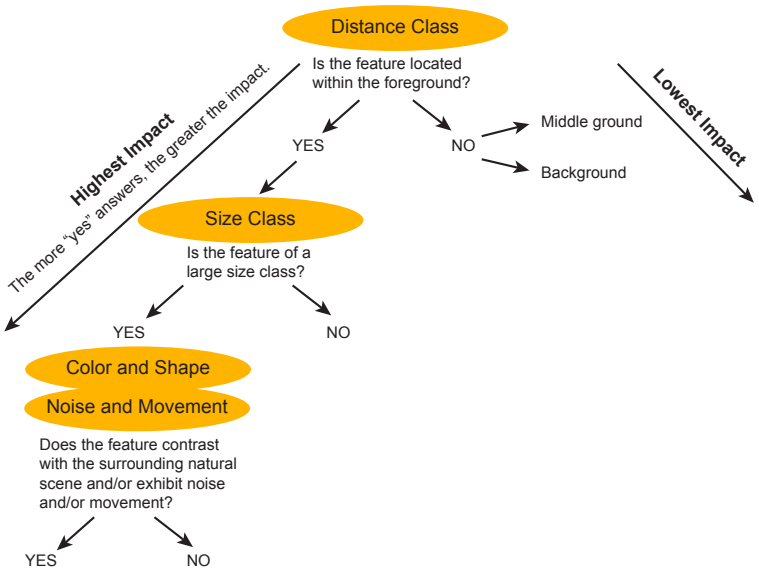


Figure 4.1.2-6. Conceptual framework for hierarchical relationship of characteristics that influence the conspicuousness of features within a viewshed.

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 Historical Park'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 4.1.2-6).

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 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 Lyndon B. Johnson NHP are all inter-related and are intended to provide information about how well the views maintain their scenic quality and their ability to evoke a sense of place in an historic context. As previously discussed, the scenic and historic integrity at the Historical Park overlap considerably.

From the historic perspective, the reference state is based on a particular period relevant to the site. The LBJ Boyhood Home Area period of significance is from 1913 through 1973, including when the Johnsons moved from the family ranch into the LBJ Boyhood home through the death of President Johnson in 1973 (NPS 2012a). The Johnson Settlement Area's period of significance is from 1864 through 1973, which reflects the time the property was held and occupied by the Johnson family (NPS 2012b).

Table 4.1.3-1. Qualitative reference condition classes used for scenic and historic integrity within the viewshed at Lyndon B. Johnson NHP.

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

Based on these reference periods, we use a qualitative reference state for the scenic and historic integrity of the viewshed (Table 4.1.3-1). Embedded within these reference conditions is both the intactness and conspicuousness of features that do not contribute to the scenic and historic integrity relative to that period.

4.1.4. Condition and Trend

Overall, the scenic and historic integrity of the viewshed at Lyndon B. Johnson NHP is in good condition. The landscape surrounding the site remains largely intact and the degree of conspicuous agricultural and rural development surrounding the park is minimal (Table 4.1.4-1; Figure 4.1.4-1).

Non-contributing features visible from the vantage point include primarily NPS features, such as visitor services and park roads. The visitor center near the airstrip (hangar) is mostly shielded by the large oak trees. A couple of the most prominent non-contributing features are the neighboring ranch buildings and powerlines to the southwest and west. Agricultural equipment, the airstrip, barns, and other buildings on site seen from the vantage point contribute to the scenic and historic integrity. It's interesting to note that the tower to the north is actually a contributing feature originally located directly behind the Texas White House, but the President and Mrs. Johnson insisted on moving the tower. The solution was to move the tower north of the Bus Barn, or at the time, north and west of the Dale Malechek house (I.W. "Stormy" Davis-Oral History Tapes 1977).

Ancillary views also contribute to the sense of place. Most of the views of and from the historic buildings and along the trail in the Johnson Settlement Area are well shielded from outside development (noncontributing features) and enhance the sense of place (Figure 4.1.4-2).

GIS-based Assessment

For our GIS-based analysis, we estimated the areas visible or not visible from the tetrahedron vantage point (Figure 4.1.4-3). It is important

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	Good	Views are mostly intact with few non-contributing features and the majority of features contributing to the scenic and historic quality, consistent with good condition.
	Conspicuousness of non-contributing features	Good	Non-contributing features that are most conspicuous include the tower to the north and the ranch buildings and powerlines to the southwest and west. These are relatively minor intrusions into the landscape, and consistent with good condition.



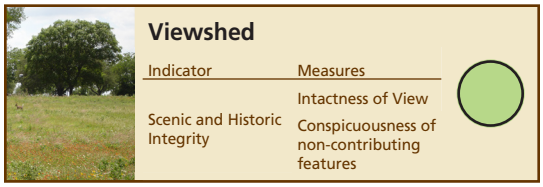
Figure 4.1.4-1. Panorama from the vantage point at LBJ Ranch.



Figure 4.1.4-2 Ancillary views (these from the trail at the Johnson Settlement Area) enhance sense of place.

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 intrusion into the landscape. The closest town to the LBJ Ranch is Johnson City (about 14 miles away), which has a population of about 1,716 people. The majority of housing density is related to town and the low-density farm and ranch houses around the sites (Tables 4.1.4-2 and 4.1.4-3 and Figures 4.1.4-4 and 4.1.4-5). This indicates good condition.



Overall Condition

Based on this assessment, we considered the viewshed condition at Lyndon B. Johnson NHP to be good. This condition represents the intact scenic and historic integrity of the views and relatively few or inconspicuous noncontributing intrusions.

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.

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.

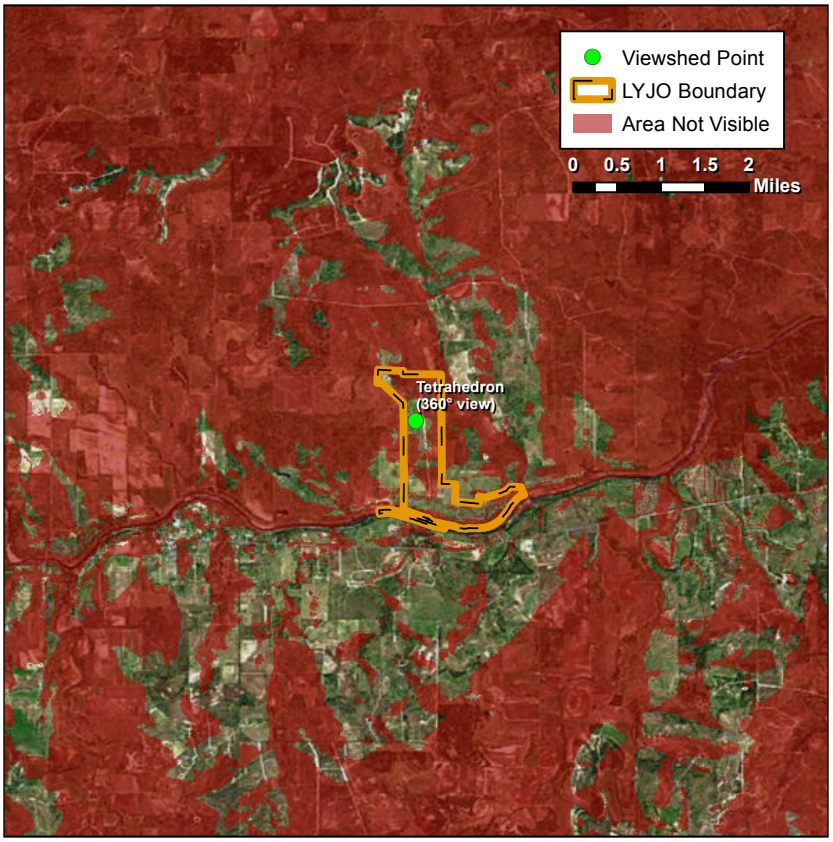


Figure 4.1.4-3. Area visible and not visible from the Tetrahedron vantage point based on GIS analysis.

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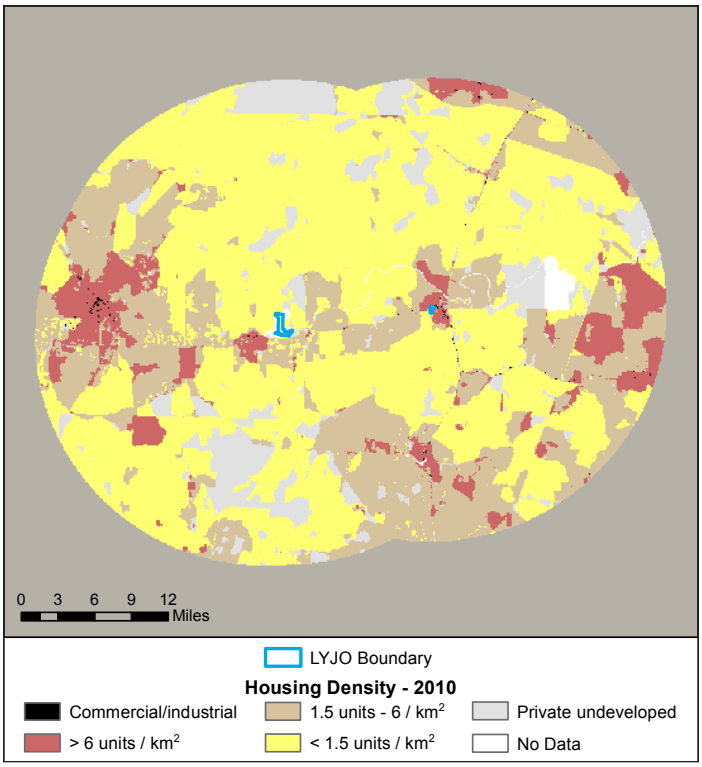


Figure 4.1.4-4. Housing density surrounding Lyndon B. Johnson NHP.

Table 4.1.4.2. Housing density surrounding Lyndon B. Johnson NHP.

All Areas

Density Class	Area (km²)	Percent
Private undeveloped	427	9.99%
< 1.5 units / square km	2,395	56.02%
1.5 - 6 units / square km	1,119	26.16%
> 6 units / square km	331	7.74%
Commercial / Industrial	3.76	0.09%
Total Area	**4,275.98**	

Visible Areas Only

Density Class	Area (km²)	Percent
Private undeveloped	3.72	3.60%
< 1.5 units / square km	50.29	48.61%
1.5 - 6 units / square km	35.95	34.75%
> 6 units / square km	13.34	12.89%
Commercial / Industrial	0.16	0.15%
Total Area	**103.46**	

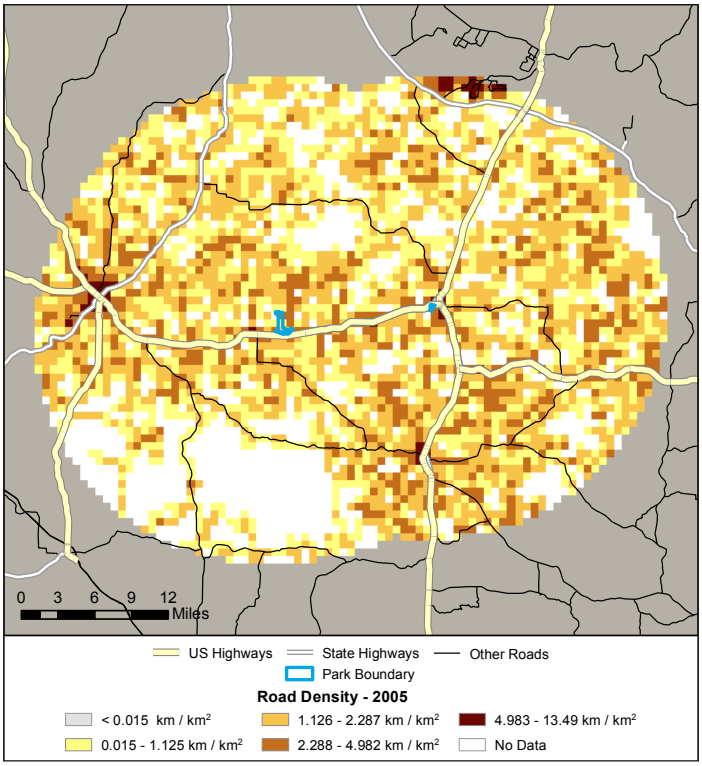


Figure 4.1.4-5. Road density surrounding Lyndon B. Johnson NHP.

Table 4.1.4.3. Road density surrounding Lyndon B. Johnson NHP.

All Areas

Density Class	Area (km²)	Percent
0.015 - 1.125	1,215	37.27%
1.126 - 2.287	1,360	41.72%
2.288 - 4.982	641	19.66%
4.983 - 13.49	44	1.35%
Total Area	**3,260**	

Visible Areas Only

Density Class	Area (km²)	Percent
0.015 - 1.125	30	36.59%
1.126 - 2.287	30	36.59%
2.288 - 4.982	21	25.61%
4.983 - 13.49	1	1.22%
Total Area	**82**	

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4.2. Night Sky

Indicators/Measures

- Sky Brightness (Anthropogenic Light Ratio, Zenith Sky Brightness, Maximum Vertical Illuminance)
- Sky Quality (Bortle Dark-Sky Scale)

Condition – Trend – Confidence



Moderate - Insufficient Data - High

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.

Lyndon B. Johnson National Historical Park (NHP) has a unique opportunity to interpret the night sky in the context of the space program. After the Soviets launched Sputnik I in 1957, President Kennedy aimed to re-establish American leadership by landing an astronaut on the moon by the end of the 1960s (Figure 4.2.1-1). President Kennedy was, in part, responding to urging from then



NASA

Figure 4.2.1-1. President and Mrs. Johnson watch the launch of Apollo 11 at the Kennedy Space Center July 16, 1969.

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

Senate majority leader Lyndon Johnson who raised the alarm regarding Sputnik and that the satellite launch signaled the race to control space. Kennedy put Vice President Johnson in charge of the space program (the National Aeronautics and Space Administration, NASA, was founded in 1958).

Johnson had the distinction of being instrumental in both the ramping up and the scaling back of the "space race." As President, he made the space program a high priority until the high costs of the Vietnam War and his Great Society programs forced him to cut NASA's budget. Under Johnson's administration, the 1967 Outer Space Treaty laid the foundation for international space law that is still in place today and has been ratified by all of the major space-going nations. The treaty outlaws nuclear weapons in space and bars national sovereignty over celestial objects (Wall 2013).

Protecting the night sky resources at Lyndon B. Johnson NHP benefits the natural resources, is important for visitor experience, has cultural and historical significance, and is important within the cultural context of the Historical Park.

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 the all-sky Anthropogenic Light Ratio (ALR) as 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).

Additional indicators and measures such as maximum vertical illuminance may be considered in an assessment of night sky conditions, but the ALR measure is the primary source for condition assessment.

We conducted a supplemental rapid assessment of the Historical Park's night sky condition on June 3, 2014 using a sky quality meter to measure sky brightness, and the Bortle Dark Sky Scale, a qualitative assessment commonly used by amateur astronomers to evaluate the sky quality for star gazing. This rapid assessment is supplementary and is intended only to illustrate the night sky condition.

Measure

Anthropogenic Light Ratio, Maximum Vertical Illuminance, and Zenith Sky Brightness

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. Ground-based measures were taken at Lyndon B. Johnson NHP on April 22, 2006.

CCD camera images assess brightness, including maximum sky brightness, minimum sky brightness, and two measures of integrated sky brightness—horizontal and vertical illuminance. The maximum sky brightness is typically found in the core of urban light domes (i.e., the semicircular-shaped light along the horizon caused by the scattering of urban light). The minimum sky brightness is typically found at or near the zenith (i.e., straight overhead). The integrated night sky brightness is calculated from both the entire celestial hemisphere as well as a measure of the integrated brightness masked at the apparent horizon to avoid site-to-site variations introduced by terrain and vegetation blocking. Vector measures of illuminance (horizontal and vertical) are important in describing the appearance of three-dimensional objects on the landscape and their relative visibility. Vertical illuminance is the integration of all light striking a vertical plane from the point of the observer. In light-polluted areas, maximum sky brightness and maximum vertical illuminance will often measure the same area of sky, typically at the core of urban light domes. Vertical illuminance is an important metric when discussing night sky quality as it is easily noticeable to park visitors (since humans are oriented vertically). Even with dark conditions overhead, high vertical illuminance can hinder or inhibit dark adaptation of the eyes and cast visible shadows on the landscape. This is also an important ecological indicator, as many wildlife species base behavior on visual cues along the horizon.

Sky brightness describes the amount of light in the night sky. One method of assessing sky brightness uses a Unihedron Sky Quality Meter (SQM) that samples the night sky in a broad spectrum band roughly corresponding to the entire human visual range. The SQM measures an aggregate average brightness for the entire sky that is skewed to zenith brightness over an 80 degree field of view (Moore 2012). Readings were taken at two locations within Lyndon B. Johnson NHP on June 3, 2014 approximately an hour after moonset.

Measure
Bortle Dark Sky Scale

The Bortle Dark Sky Scale (Appendix C) was proposed by John Bortle (Bortle 2001) based on 50 years of astronomical observations. Bortle's qualitative approach uses a nine-class scale that requires a basic knowledge of the night sky and no special equipment (Bortle 2001, Moore 2001, White et al. 2012, Table 4.2.2-2). The Bortle scale uses both stellar objects and familiar descriptors to distinguish among the different classes. Another advantage of the Bortle scale is that it is suitable for conditions ranging from the darkest skies to the brightest urban areas (Moore 2001, Figure 4.2.2-1).

4.2.3. Reference Conditions

The ideal night sky reference condition, regardless of how it's measured, is one devoid of any light pollution. However, results from night sky data collection throughout more than 90 national parks suggest that a pristine night sky is very rare (NPS 2010). For a summary of condition assessment categories for all night sky indicators, see Table 4.2.3-1.

Anthropogenic Light Ratio

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

Table 4.2.2-2. Bortle Dark Sky Scale.*

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

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

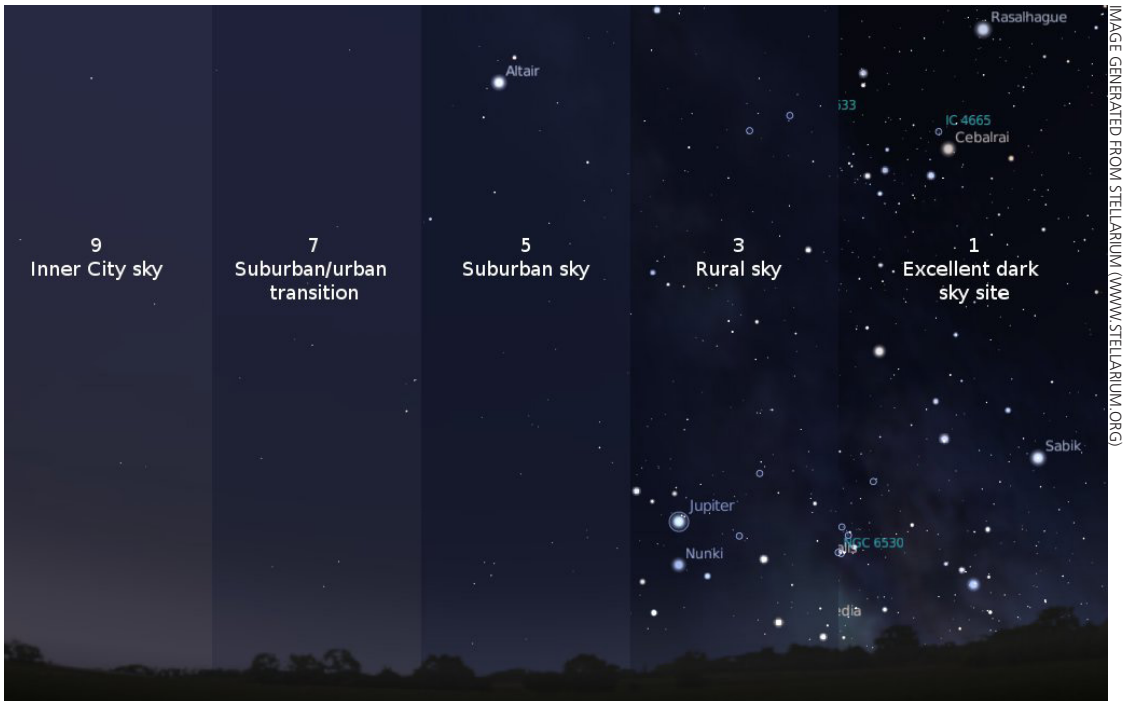


Figure 4.2.2-1. Composite image illustrating the range of night sky conditions based on the Bortle Dark Sky Scale.

from the night sky. 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).

Maximum Vertical Illuminance

The NPS Night Skies Division recommends a reference condition of 0.4 milli-Lux, since the average vertical illuminance experienced under the natural night sky on a moonless night is 0.4 milli-Lux (derived from Jensen et al. 2006, Garstang 1986, and unpublished NPS Night Skies Program data). No thresholds for condition rating have been set at this time. Vertical illuminance can also be expressed in a ratio to natural conditions, similar to ALR.

Zenith Sky Brightness

Reference conditions for night sky brightness can vary moderately based on the time of night (time after sunset), time of the month (phase of the moon), time of the year (the position of the Milky Way), and the activity of the sun which can increase "airglow"—a kind of faint aurora. For the *minimum* night sky brightness measure, the darkest part of a natural night sky is generally found near the zenith. A value of 22.0 magnitudes per square arc second (msa) is considered to represent a pristine sky, though it may vary naturally by more than +0.2 to -0.5 depending on natural conditions (Duriscoe 2013 [submitted]). Lower (brighter) values indicate increased light pollution and a departure from natural conditions. The astronomical magnitude scale is logarithmic, so a change of 2.50 magnitudes corresponds to a difference of l0x (100%); thus a 19.5 msa sky would be 10x brighter than natural conditions. *Minimum* night sky brightness values of 21.4 to 22.0 msa, are generally considered to represent

Table 4.2.3-1. Night sky condition class summary.

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

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

natural (unpolluted) conditions (Duriscoe et al. 2007).

The *maximum* night sky brightness is often found within the Milky Way of a natural sky. A typical measurement from the Sagittarius region of the Milky Way in a natural sky yields 19.2 msa. Other regions of the Milky Way are somewhat dimmer, or around 20.0-21.0 msa. A value brighter than 19.0 msa will result in impairment to human night vision and may be noticeable by casting faint shadows or causing glare. A value lower (brighter) than 17.0 represents very bright areas of the night sky and would significantly impair human night vision and cast obvious shadows. Values for the brightest portion of the sky are of interest to the NPS because they represent unnatural intrusions on the nightscape, will prevent human dark-adapt vision, and may have effects on wildlife (Duriscoe et al. 2007).

Bortle Dark Sky Scale

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

4.2.4. Condition and Trend

Data provided by the NPS Night Skies Program show an ALR of 1.01 indicating moderate condition (ground-based data have a 90% confidence level of ±8 nL, or ±0.1 ALR) (Figure 4.2.4-1). Maximum vertical illuminance was measured at 0.8 milli-Lux or 200% above average natural conditions, indicating the potential for inhibition of dark adaptation and disruption of natural ecological functions.

Ground-based SQM readings taken by the Natural Sounds and Night Sky Division in 2006 ranged between 21.38-21.45; the median SQM readings collected in 2014 were 21.38 and 21.43. Data were consistent between years and indicate moderate condition.

The qualitative Bortle Scale assessment estimated the night sky quality to class 5 in both 2006 and 2014 observations, consistent with a suburban sky, which indicates some cause for concern (Table 4.2.4-1).

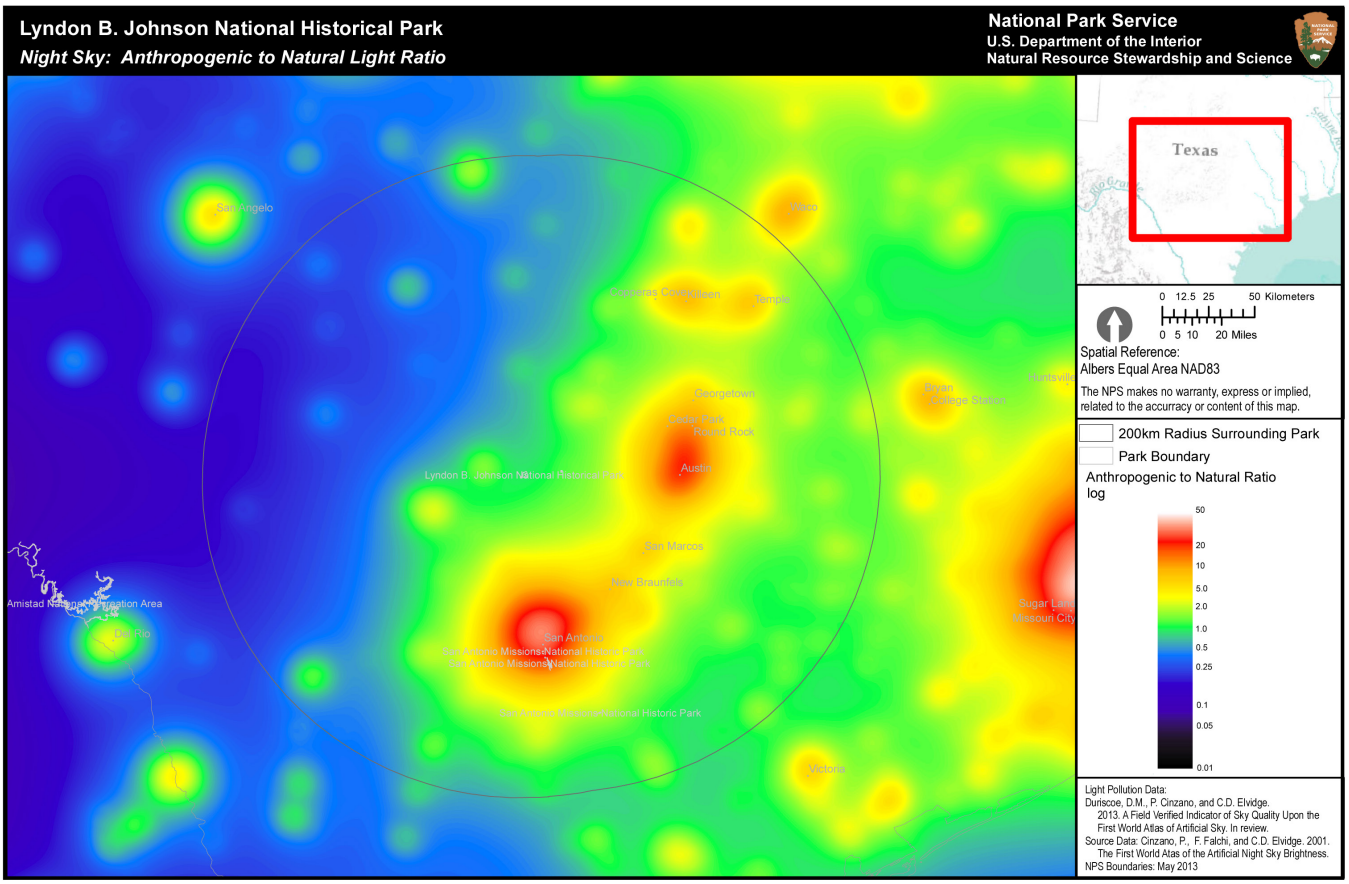
Local and Regional Context

Lyndon B. Johnson NHP is surrounded by a number of cities producing light domes that interfere with dark night skies. The Historical Park is just outside (less than 13 miles) the town of Johnson City (population 1,656); less than 20 miles east of Fredericksburg (population 10,530); and close to the larger cities of Austin (61 miles away, population 790,390) and San Antonio (77 miles away, population 1,327,407) (U.S. Census Bureau 2010). The light domes from these population centers do impact the night sky (Figure 4.2.4-2 and Figure 4.2.4-3). Other sources of artificial light include homes and ranch buildings on or near the Historical Park, although some of the light is buffered by vegetation and topography of the site. The Historical Park does intend to offer night sky interpretive programs and these plans should not be ruled out; bright constellations are still visible, and the history and context of the former president and the space program.



Overall Condition

Quantitative measures of sky brightness (all-sky anthropogenic light ratio and zenith sky brightness) and a qualitative assessment of sky quality (the Bortle Dark Sky Scale) were used to assess the condition of the night sky. These



NPS Natural Sounds & Night Skies Division and NPS Inventory and Monitoring Program MAS Group 20140109

Figure 4.2.4-1. ALR map for Lyndon B. Johnson NHP.

Table 4.2.4-1. Summary of night sky indicators and measures and assessment of night sky condition at Lyndon B. Johnson National Historical Park.

Indicator	Measure	Condition	Condition Rationale
Sky Brightness	Anthropogenic Light Ratio (1.01)	Moderate	This measure results from ground-based data collected by the NPS Night Sky Division. Specific thresholds for condition classes have been set by the NPS. In this case, the moderate condition likely resulted from the significant light domes of nearby cities. The confidence level in this assessment is high.
	Maximum Vertical Illuminance (0.8)	Moderate	This measure results from ground-based data collected by the NPS Night Sky Division. Specific thresholds for condition classes have not been set; however, condition is estimated as moderate. The measure reflects a rating of 200% above average natural conditions.
	Zenith Sky Brightness (21.38-21.45)	Moderate	Zenith sky brightness indicates moderate condition, based on the impact from light domes from nearby cities and towns, and more local point sources. Confidence level is high.
Sky Quality	Bortle Scale Class (5)	Significant Concern	Although star gazing at Lyndon B. Johnson NHP may be quite good as far as seeing constellations, the Milky Way, and other celestial bodies, the light domes from nearby towns were quite visible; a few point sources from homes, farm buildings and roads were also evident. Inside the Historical Park, the interfering light sources are mostly shielded by the topography and vegetation. Because this measure is qualitative, it has a low confidence level.

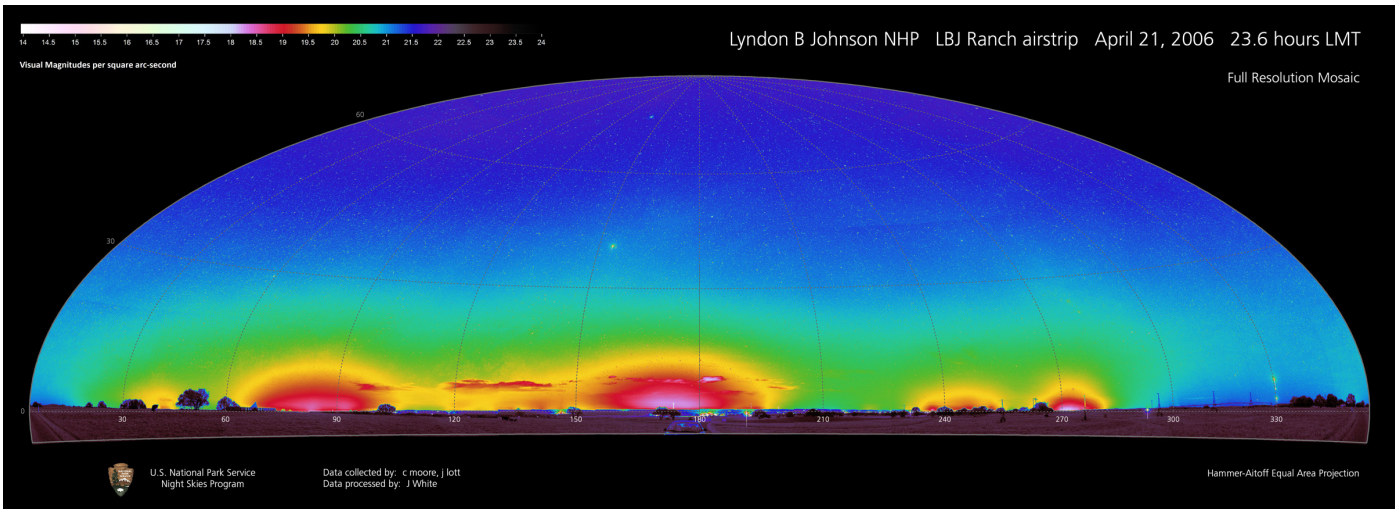


Figure 4.2.4-2. Panoramic all-sky ALR output at Lyndon B. Johnson NHP (April 2006) from the NPS Night Skies and Natural Sounds Division.

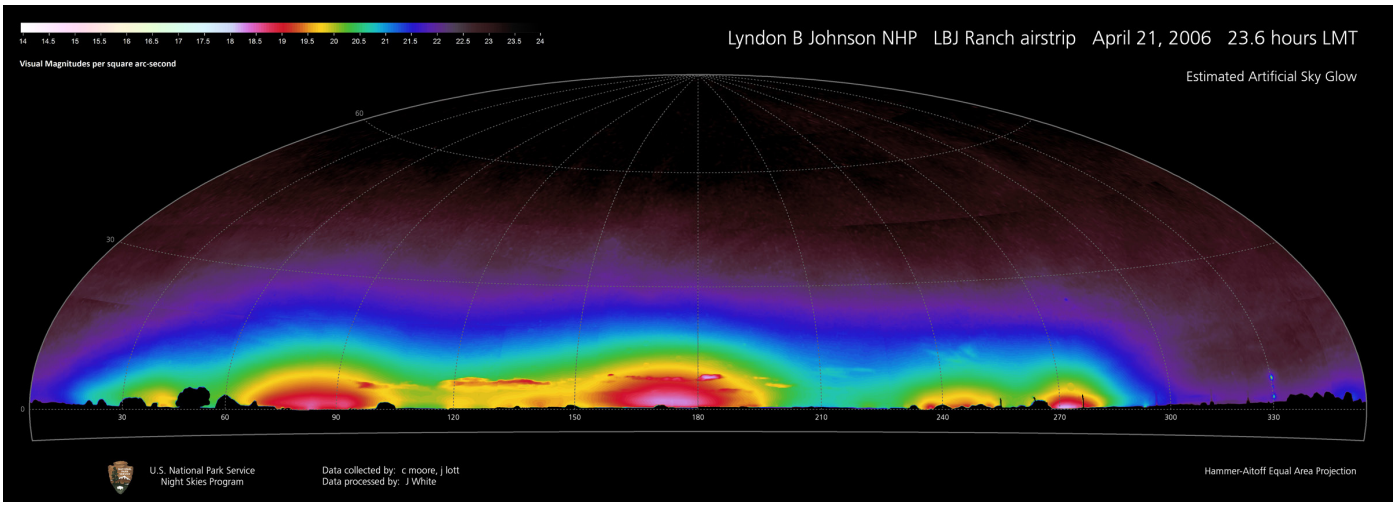


Figure 4.2.4-3. Panoramic all-sky anthropogenic light only (natural light removed). Taken at Lyndon B. Johnson NHP (April 2006) by the NPS Night Skies and Natural Sounds Division.

indicators are summarized and interpreted in Table 4.2.4-1. The overall condition of the Historical Park's night sky is moderate.

Uncertainties

The Bortle Dark Sky Scale estimates have inherent uncertainties and error. The principle drawback of the Bortle Scale is that it relies upon human visual observers. Differences in visual acuity, experience and knowledge, as well as time and effort expended can influence the estimates (Bortle 2001, Moore 2001). 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.

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.

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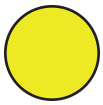
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4.3. Soundscape

Indicators/Measures

- Audibility (1 Measure)
- Sound Level (2 Measures)

Condition – Trend – Confidence



Moderate - Insufficient Data - Medium

4.3.1. Background and Importance

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

Visitors to national parks often indicate that an important reason for visiting the parks is to enjoy the relative quiet they can offer (Figure 4.3.1-1). 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). Despite this desire for quiet environments, anthropogenic noise continues to intrude upon natural areas and has become a source of concern in national parks (Lynch et al. 2011).

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



NPS / JASON LOTT

Figure 4.3.1-1. The peaceful setting of the Johnson Family Cemetery evokes a contemplative atmosphere and sense of dignity.

Documented responses of wildlife to noise include increased heart rate, startle responses, flight, disruption of behavior, and separation of mothers and young (Selye 1956, Clough 1982, USDA 1992, Anderssen et al. 1993, NPS 1994).

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

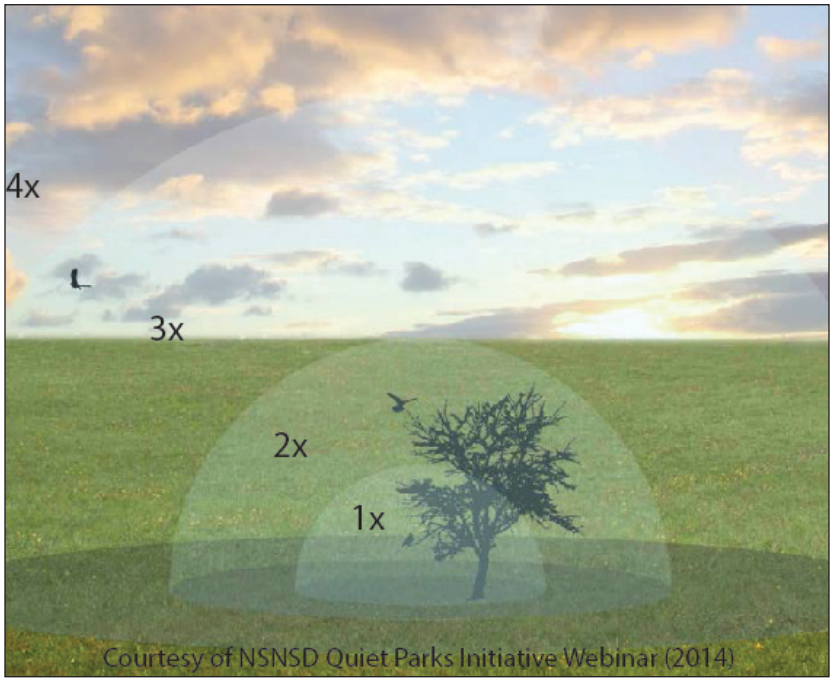


Figure 4.3.1-2. A 6 dBA reduction in sound would produce a 4x increase in listening area (NSNSD 2014).

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).

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

A formal soundscape assessment has not been conducted by NSNSD at Lyndon B. Johnson NHP. So for the purposes of this assessment,

we conducted brief, on-site listening sessions at four locations (described below) from June 3-4, 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 the Historic Zone and preservation subzones in both districts, which are described in Table 4.3.2-2.

Sam Ealy Johnson, Sr. Cabin
This location was located within the Settlement Area where President Johnson's ancestral connection to the Texas Hill Country began. The monitoring location was on the porch of the historic cabin with scenic views of the Bruckner Barn, landscape, and livestock. This site instills an historic sense of place.

Tetrahedron
This monitoring site was located within the Texas White House Complex along the airstrip where the tetrahedron is located between Bailey and Malechek Roads.

Johnson Family Cemetery
The Johnson Family Cemetery is located in the Johnson Family Farmhouse Complex representing his ancestral home where he was exposed to a rural lifestyle in the Texas Hill Country. The recording session occurred on a bench adjacent to the parking lot with a view of the cemetery.

Texas White House
This monitoring site was also located within the Texas White House Complex between the family home and the Pedernales River underneath a live oak, which was President Johnson's favorite tree (NPS 2010).

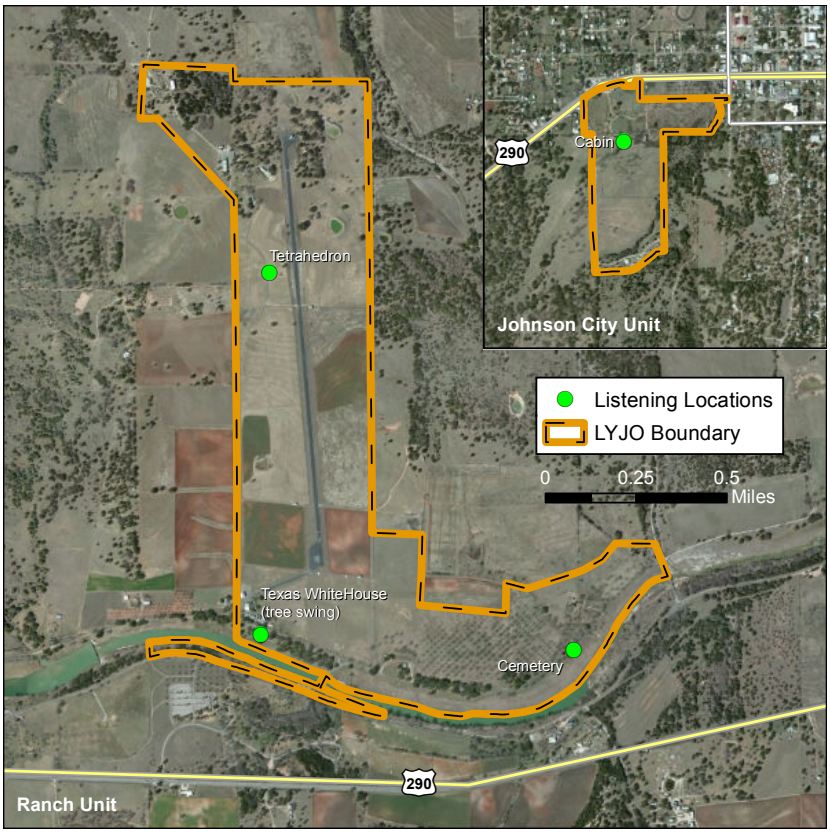


Figure 4.3.2-1. On-site acoustical monitoring locations.

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).

Table 4.3.2-1. Summary of on-site listening sessions at Lyndon B. Johnson NHP.

Location	Date	Time	Session Duration	Wind Speed and Direction[1]	Weather
Sam Ealy Johnson, Sr. Cabin	June 3, 2014	6:50-7:50 AM	60 minutes	1-3 mph	55-79° and Cloudy
	June 3, 2014	11:30-12:30 PM	60 minutes	8-12 mph	55-79° and Cloudy
	June 3, 2014	4:00-5:00 PM	60 minutes	8-12 mph	80-99° and Mostly Cloudy
Tetrahedron*	June 4, 2014	7:59-8:29 AM	30 minutes	8-12 mph	55-79° and Mostly Cloudy
	June 4, 2014	11:06-11:36 AM	30 minutes	8-12 mph	55-79° and Mostly Cloudy
Johnson Family Cemetery*	June 4, 2014	8:40-9:10 AM	30 minutes	8-12 mph	55-79° and Cloudy
	June 4, 2014	11:54-12:24 PM	30 minutes	>12 mph	55-79° and Mostly Cloudy
Texas White House*	June 4, 2014	9:45-10:15 AM	30 minutes	8-12 mph	55-79° and Cloudy
	June 4, 2014	12:40-1:10 PM	30 minutes	>12 mph	80-99° and Mostly Cloudy

*Apple IPad overheated during the afternoon Tetrahedron listening session and would not turn back on. Therefore, only morning and afternoon sessions were recorded within the LBJ Ranch District.

Table 4.3.2-2. Descriptions of each management zone, excerpted from NPS 2010, where on-site acoustical monitoring occurred.

Management Zone	Monitoring Location(s)	Description of Zone (excerpted from NPS 2010)
Johnson City District		
Historic Zone (Preservation Subzone)	Sam Ealy Johnson Sr. Cabin	The preservation subzone includes all historic structures integral to interpretation of the district. Properties within this subzone include the LBJ boyhood home and block and the historic structures and grounds at the settlement (Sam Ealy Johnson, Sr. cabin, Bruckner barn, James Polk Johnson barn, and the Cooler house).
LBJ Ranch District		
Historic Zone (Preservation Subzone)	Johnson Family Cemetery, Tetrahedron, and Texas White House	The preservation subzone includes the Texas White House and grounds, the Secret Service command post and yard, the LBJ birthplace and immediate grounds, and the cemetery (the National Park Service does not own the cemetery but maintains it). Also included in the preservation subzone are the ranch lands that are managed as they were from 1963 to 1973.

Table 4.3.2-3. Indicators and measures used to assess the soundscape condition.

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 cultural/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 4.3.2-3 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 on-site listening results.

Indicators/Measures
Audibility (% Time Audible)

During the on-site listening sessions, the observer listened for the designated period of time and identified all sound sources and their durations. This type of monitoring took full advantage of human binaural hearing capabilities 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 general categories (i.e., noise, natural, and cultural/recreational sounds), which are presented in Figure 4.3.2-2.

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.

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

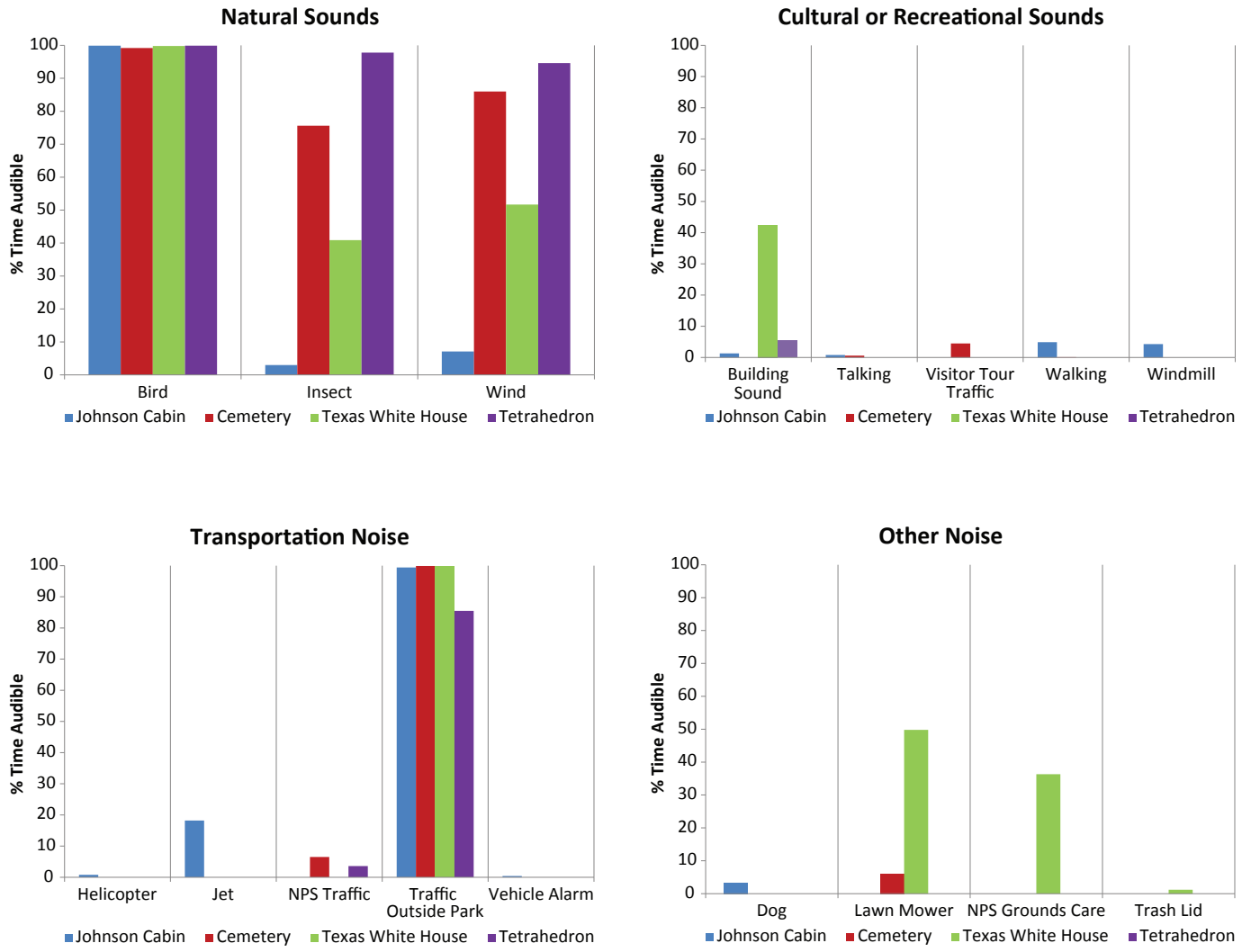


Figure 4.3.2-2. Percent time audibility of natural, cultural/recreational, and noise sound sources heard at on-site acoustical monitoring locations.

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 and frame the condition discussion.

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 Lyndon B. Johnson NHP. The sound model maps for existing, natural, and impact sound levels are included in Appendix D.

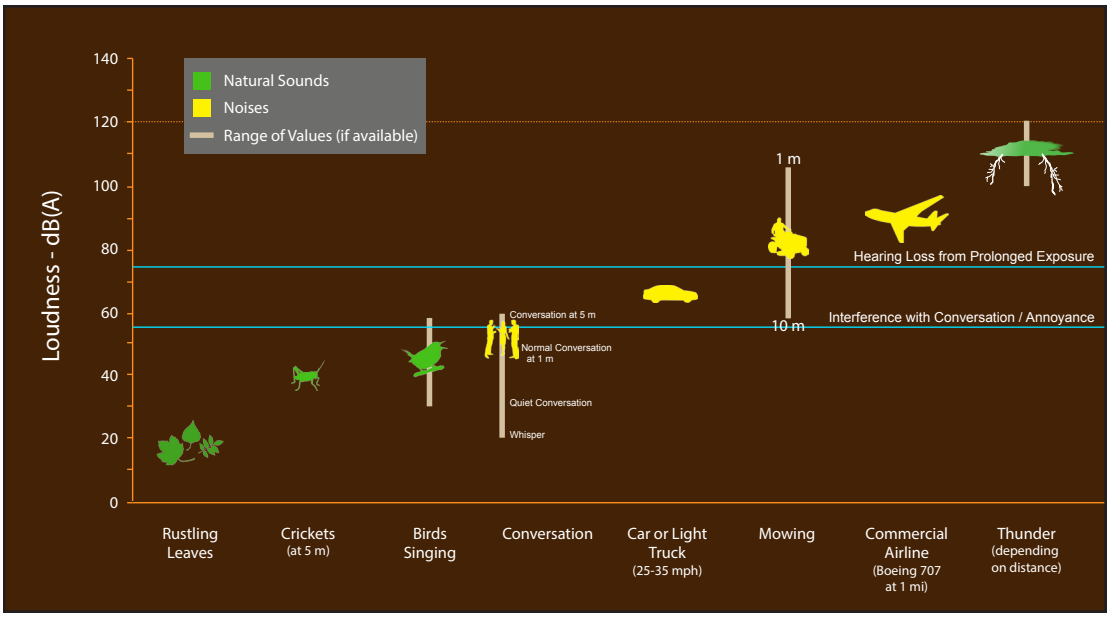


Figure 4.3.2-3. Reference dB(A) levels for qualitative sound level assessment at Lyndon B. Johnson NHP.

Context for Evaluating Sounds Heard During On-site Listening

Whether or not a given sound contributes to or detracts from the soundscape condition depends largely on whether or not that sound is appropriate for the context. The park's designated purpose includes protecting the historic structures and landscape that shaped President Johnson's life as well and provides "opportunities for visitors to compellingly experience these places that shaped the personality, character, and political philosophy of Lyndon Johnson" (p. 6) (NPS 2014). As such, sounds that contribute to the education and enjoyment of the visitors, even though they are not natural sounds, are considered appropriate to the park's soundscape.

If this were a wilderness setting, natural verses anthropogenic sounds might be a pertinent distinction for how a sound is perceived. However, the context and setting at LBJ NHP are quite different in that there are non-natural elements that contribute to the "sense of place." Thus, in addition to the natural sounds that comprise the natural setting, the visitor use sounds, such as interpretive tours of the Texas White House or visitor footfalls along the Johnson Settlement trail, also contribute to the condition of the soundscape. Thus, for the purposes of this assessment, we considered sounds that were consistent with the intended historic scene to contribute positively to the soundscape condition. In contrast, certain types of anthropogenic sounds, such as low flying aircraft, vehicles, or excessive human voices may detract from the "sense of place" of the park's context and can be perceived negatively as noise, detracting from the soundscape condition.

For these reasons, we separated sound types into two classes: (1) natural, cultural, and/or recreational-appropriate sounds, and (2) noise (any unwanted sound). The first class was considered as having a neutral or positive influence on soundscape condition; whereas excessive noise, especially in locations where noise is unexpected due to designated uses was considered to have a negative effect, contributing to a degraded soundscape condition.

Additionally, the locations where the sounds were heard, based upon the park's designated management zones, affected the soundscape condition. Each management zone "ensures that appropriate visitor use and park development occurs only where such activities would have the least impact on resources, and, where such activities already exist, not be expanded to inappropriate locations (NPS 2010)." These factors were taken into consideration throughout the assessment.

Table 4.3.3-1. Reference conditions used to assess the soundscape at Lyndon B. Johnson NHP.

Indicator	Measure	Good	Moderate	Significant Concern
Audibility	% Time Audible	Dominant sounds are consistent with NHP'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 areas.	A high percentage of the audible sounds heard are from noises such that the natural and/or historical sense of place 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..	Noises > 55 dB cause occasional interference with normal conversations although noises greater than approximately 65 dB are still quite rare.	Communication among interpreters and visitors is frequently interrupted by loud noises. 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%.

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 NHP 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 sounds heard were beginning to be inconsistent with NHP designated activities and if where 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 location. Significant concern was also 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, which are discussed below.

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 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 park 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 Lyndon B. Johnson NHP 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 NHP. 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 Lyndon B. Johnson NHP 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 natural sounds, including birds, insects, and wind and traffic noise originating from outside both park district boundaries. The loudest sounds heard originated from traffic outside the park's boundary and from grounds care within the LBJ Ranch Unit.

Audibility at Monitoring Locations

Sam Ealy Johnson Sr. Cabin

Both birds and traffic noise were heard over 99% of the time throughout all recording sessions. Jets were heard 18.2% of the time and only at the Same Ealy Johnson Sr. cabin listening location. The next highest percent time audible sound was from wind (7.1%). One unique sound heard at this location was related to visitor use. With the site's proximity to Johnson City, many joggers used the nature trail along with visitors walking through the park along the trail. The highest percent time audible recreation-related sound originated from walking (footsteps on the trail substrate), 4.9% of the time. Cultural landscape-related sounds were from the cabin settling/creaking and the adjacent windmill.

Tetrahedron

The tetrahedron monitoring location was the farthest removed of any of the monitoring sites from Texas State Highway 290 and as a result, traffic noise originating from the highway was heard 85.5% of the time. The predominant audible sounds were natural, including birds, insects, and wind 94.6-99.9% of the time.

Visitor traffic that originated within the park was recorded 5.5% of time.

Johnson Family Cemetery
Similar to the sounds heard at the Sam Ealy Johnson Sr. Cabin location, both birds and traffic noise were heard over 99% of the time throughout all recording sessions. The next highest percent time audible sounds included wind (86%) and insects (75.6%) followed by NPS traffic (6.5%), lawnmower originating from the State Park (6.1%), and visitor traffic (4.6%).

Texas White House
Once again, the highest percent time audible sounds originated from traffic along Texas State Highway 290 and from birds, occurred over 99% of the time. The other natural sounds, including wind and insects were less audible, representing 51.7% and 40.9% of the time, respectively. Cultural-related sounds were higher at this location (42.5%) than at any of the other sites and was primarily comprised of sounds originating from the flag and flagpole that is flown at the Texas White House. Noise associated with grounds care was also much higher at this location (both from within and outside the park) but occurred when no interpretive-led tours were being conducted so not considered disruptive to the visitor experience. The highest percent time audibility of grounds care noises was occured 49.8% of the time.

The overall percent time audibility of noises were heard at all monitoring locations was high, representing almost 100% time audibility, primarily due to traffic travelling along Texas State Highway 290 in both districts. Based on this, we considered this measure to be of significant concern.

Sound Levels at Monitoring Locations (on-site listening results)
The relative sound levels at the NHP were based on information presented in Figure 4.3.2-3. The loudest sounds heard originated from traffic noise along Texas State Highway 290 in both districts and was loud enough to mask natural sounds such as insects, especially at the Texas White House and Johnson Family Cemetery monitoring locations. The automobile noise along the state highway did not impact the acoustical environment at the Tetrahedron location due to the increased distance from the road and was also less intrusive and diruptive at the Johnson Settlement cabin.

Other sounds heard that were louder included noises from grounds care operations, both at the State Park across the river as well as at the Texas White House. Interestingly, traffic from park visitors and staff was very unobtrusive even though the proximity to the source of sound was very close. This was due to the fact that vehicles are travelling at much slower speeds thus quieter.

Access to the Johnson Settlement area required a short walk along a nature trail that created a sense of separation from the adjacent Johnson City and a strong sense of place of "stepping back in time" to experience the site during its original period of significance The sense of place was supported by the relatively quieter sound levels heard while monitoring from the cabin's porch. While traffic noise was very common, it was quieter and less disruptive compared to the cemetery and White House monitoring locations. The loudest sound heard at the cabin originated from jets.

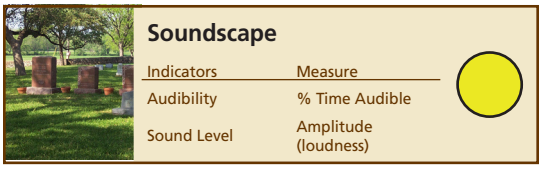
Overall, the sound levels heard were within levels that would rarely interrupt normal conversations at a 1 m distance, and as a result, was considered to be in good condition.

Sound Level for Monitoring Sites Based on Mennitt et al. (2013) Model
The modeled results for the natural ambient and existing sound levels across the entire NHP ranged from 34.0-36.6 dBA and 37.0-45.6 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 Lyndon B. Johnson NHP exceeds the higher level for the maximum existing sound level quartile.

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	Significant Concern	The highest percent time audibility of sounds heard at all monitoring locations originated from birds and traffic noise outside the park's districts. As a result we considered the percent time audibility measure to be of significant concern.
Sound Level	Amplitude (on-site monitoring)	Good	The loudest sounds heard originated from traffic noise along Texas State Highway 290 and from grounds care both within and outside park boundaries. Overall, most sounds heard would not have interrupted a normal conversation at 1 m. We considered this measure to be in good condition.
	Amplitude (Mennitt et al. 2013)	Significant Concern	The modeled impact sound level for the park ranged between 3.0-9.0 dBA. This range falls within the significant concern threshold for non-urban parks (Turina et al. 2013).

The difference between the existing and natural levels is 3.0-9.0 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 NHP is considered a non-urban park, which means that the modeled sound impact level is of significant concern.



Overall Condition and Trend

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

At all monitoring locations, natural sounds were very common but so was traffic noise, accounting for almost 100% audibility at three of the four locations. The noise was especially apparent at the family cemetery and Texas White House due to their proximity to the highway.

President Lyndon Johnson and Mrs. Johnson were deeply connected to their home and the landscape of the Texas Hill Country. This land and its rural character "offered a sense of tranquility and opportunities for rejuvenation" (NPS 2014). Unfortunately, as the area has become more developed so has traffic-related noise. The park's Foundation Document (NPS 2014) states that "increasing population and traffic throughout the area are impacting soundscapes by reducing quiet (p. 17)." The results from the rapid assessment confirmed the fact that traffic noise is one of the most common sounds heard within both park districts. Unfortunately, this is a source that originates from outside the park's jurisdiction.

After combining all measures, we considered the overall condition of the soundscape to be moderate, with an unknown trend.

Level of Confidence, Key Uncertainties, and/or Threats

This was a very brief assessment of the NHP'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 but according to NSNSD, the modeled results warrant a medium confidence level of sound impact.

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 Lyndon B. Johnson NHP'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 NHP, included in Appendix D. 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, Lyndon B. Johnson National Historical Park (park) 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, 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).



NPS PHOTO

Figure 4.4.1-1. Lyndon B. Johnson National Historical Park is a Class II airshed.



Figure 4.4.1-2. A cloudy day at Lyndon B. Johnson National Historical Park.

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 2011). Increases in nitrogen have been found to promote invasions of fast-growing annual grasses (e.g., cheatgrass) and exotic species (e.g., Russian thistle) at the expense of native species (Brooks 2003, Allen et al. 2009, Schwinning et al. 2005). Increased grasses can increase fire risk (Rao et al. 2010), with profound implications for biodiversity in non-fire adapted ecosystems. Nitrogen may also increase water use in plants like big sagebrush (Inouye 2006).

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

4.4.2. Data and Methods

The approach we used for assessing the condition of air quality within the park airshed was developed by the NPS-ARD for use in Natural Resource Condition Assessments (NPS-ARD 2011, 2010b). Interpolated values generated by NPS-ARD, averaged over five years were used to assess condition as there are no on-site or nearby representative monitors. 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 2011).

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 park 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 park. 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 (2011) for NRCAs and listed in Table 4.4.3-1.

Visibility

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

Ozone

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

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

Wet Deposition

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

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 2011

"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 park'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 Lyndon B. Johnson National Historical Park , but in considering the overall trend of visibility throughout national parks, NPS-ARD (2013) 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 moderate ozone condition rating.

Six ozone-sensitive plant species were found within the park (NPS-ARD 2006), and four are ozone bioindicators (Table 4.4.4-2) (Porter 2003).

An ozone risk assessment was conducted by Kohut (2007) for Southern Plains parks, including the Historical Park. The overall ozone ranking at the park was considered moderate, which is consistent with the current condition reported by NPS-ARD (2012f).

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 moderate-significant concern rating and the condition rating was moderate for total sulfur.

Sullivan et al. (2011a), studied the risk from acidification for acid pollutant exposure and ecosystem sensitivity for Southern Plains parks, including the Historical Park. 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

Table 4.4.4-1. Condition results for air quality indicators at Lyndon B. Johnson National Historical Park.

Data Span	Ozone	Visibility	Total N (kg/ha)	Total S (kg/ha)
2008-2012	Moderate (73.9)	Significant Concern (8.8)	Significant Concern (3.5)	Moderate (2.7)

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

Table 4.4.4-2. Ozone sensitive plants found at Lyndon B. Johnson National Historical Park (NPS-ARD 2006, Porter 2003).

Scientific Name	Common Name	Bioindicator
Artemisia ludoviciana	Silver wormwood	Yes
Cercis canadensis[1]	Redbud	Yes
Fraxinus pennsylvanica	Green Ash	No
Parthenocissus quinquefolia[1]	Virginia creeper	No
Platanus occidentalis	American sycamore	Yes
Sapium sebiferum[2]	Chinese tallowtree	Yes

[1]These species only were identified by Kohut (2007) as ozone sensitive.

[2]This is a non-native plant.

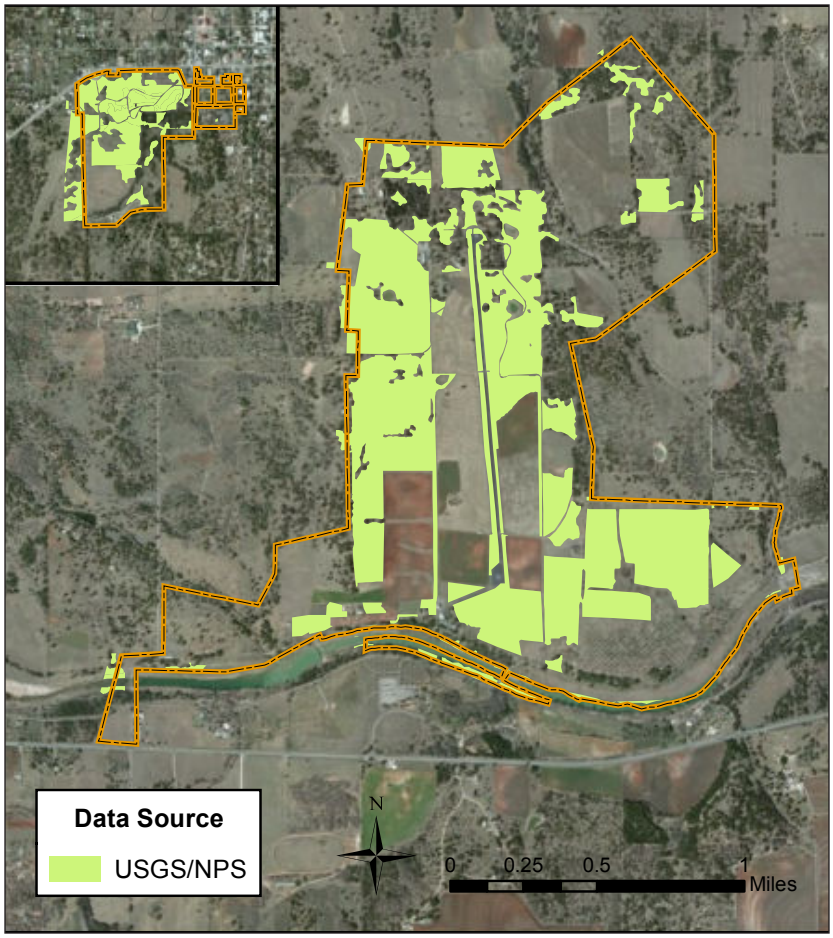


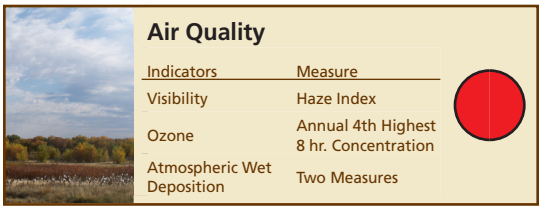
Figure 4.4.4-1. Locations of nitrogen sensitive vegetation at Lyndon B. Johnson National Historical Park.

terrestrial and aquatic ecosystems present at the park and their inherent sensitivity to the atmospherically deposited chemicals. These risk rankings for the Historical Park were considered moderate for acid pollutant exposure and very low for ecosystem sensitivity to acidification.

Sullivan et al. (2011b), also developed risk rankings for nutrient N pollutant exposure and ecosystem sensitivity to nutrient N enrichment, and were ranked as moderate for both at the park. As part of this nitrogen screening project, sensitive vegetation types were identified throughout the Historical Park 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 Historical Park, and an increase in nitrate concentrations. Neither trend was statistically significant.

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 Lyndon B. Johnson National Historical Park 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 park 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,

especially nitrogen deposition, on ecosystems at the Historical Park.

4.4.5. Sources of Expertise

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

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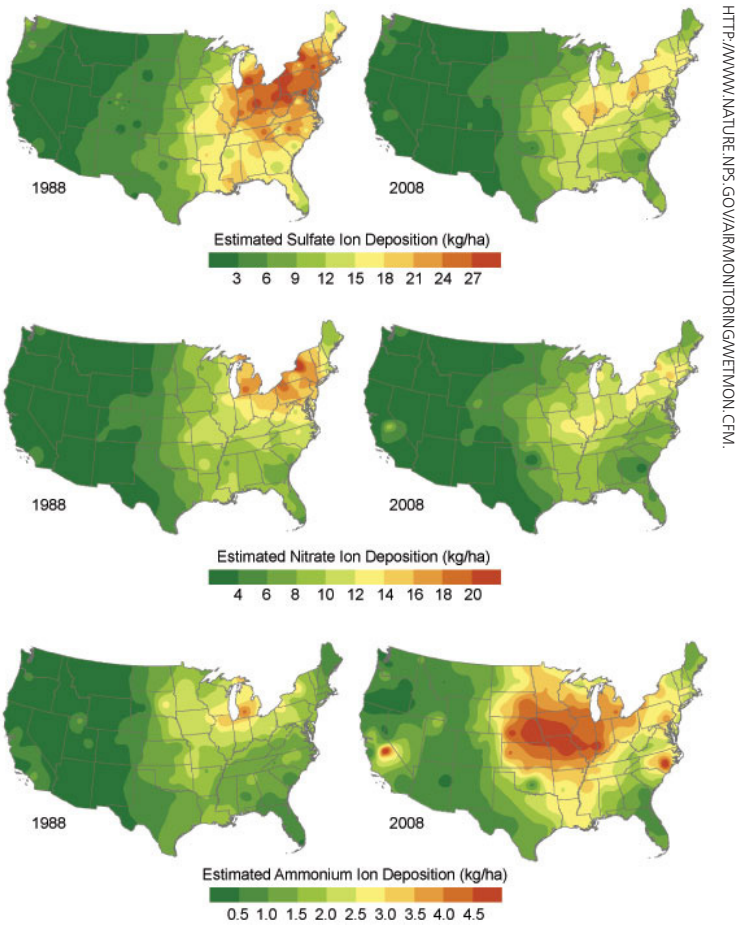


Figure 4.4.4-2. Change in wet deposition levels From 1988-2008 throughout the United States.

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 NHP was 8.8 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	Moderate	The estimated ozone level for 2008–2012 at the Historical Park was 73.9 parts per billion, therefore, the condition status warrants moderate concern based on NPS Air Resource Division benchmarks. There are six ozone-sensitive plants in the park, with four 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 3.5 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	Moderate	For 2008–2012, estimated wet sulfur deposition was 2.7 kilograms per hectare per year, therefore, the resource is in moderate condition based on NPS Air Resource Division benchmarks. No NPS-ARD trend information is available for sulphur.

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4.5. Geology

Indicators/Measures

- Geologic Resource Integrity

Condition – Trend – Confidence



Good - Insufficient Data - High

This section is extracted from the Geologic Resources Evaluation Report (Thornberry-Ehrlich 2008) for Lyndon B. Johnson National Historical Park. For more information, go to http://www.nature.nps.gov/geology/inventory

4.5.1. Background and Importance

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

Lyndon B. Johnson National Historical Park (NHP) commemorates the reconstructed birthplace, boyhood home and ranch of the 36th president, the Texas Hill Country ranch lifestyle, and also protects part of the Pedernales River drainage basin (Figure 4.5.1-1) (Thornberry-Ehrlich 2008).

The history of the area is heavily influenced by its geology. The gullies and ravines carved into the Edwards Plateau region made travel and farming difficult. Because of the local topography and hydrography of the Pedernales River, large 100- and 500-year floodplains cover much of the park today. The combination of climate and landform rendered this landscape rich in prairies and grasslands for cattle grazing (Thornberry-Ehrlich 2008).

The Johnson family, which can trace its Texas Hill Country lineage several generations back, was generous in donating land to the park. Today the ranch is preserved as a working



NPS

Figure 4.5.1-1. A portion of the Pedernales River flows along the southern boundary of Lyndon B. Johnson NHP.

ranch in the style of the 1960s, with about 100 to 125 head of whitefaced, registered Hereford cattle. In the Johnson Settlement, the park maintains a small herd of Longhorn cattle and horses. Grazing is highly regimented and closely monitored according to a livestock management and grazing program. There is strict control over livestock numbers at the park (Thornberry-Ehrlich 2008).

The ranch protects vital habitat and pasture land along the Pedernales River Valley near the community of Stonewall, Texas. Here the Pedernales River flows through Blanco and Gillespie counties as it heads eastward toward its confluence with the Colorado River. The river is part of the larger Colorado River basin, and situated near the boundary between the Edwards Plateau and Central Texas Uplift physiographic provinces. The province contains a collection of tablelands heavily dissected by canyons along entrenched streams. Local tributaries relevant to the two districts of the park include Wittington Creek and Town Creek, as well as a number of seasonal, unnamed washes and streams (Thornberry-Ehrlich 2008).

The park lies in an area of central Texas known as the Llano Uplift, which has the metamorphic core of an ancient mountain range, Paleozoic and Mesozoic sedimentary rocks, and recent alluvial, terrace, and colluvial deposits (Thornberry-Ehrlich 2008).

4.5.2. Data and Methods

This limited assessment summarizes the findings from a geologic resources evaluation report conducted by the National Park Service Geologic Resources Division (Thornberry-Ehrlich 2008). For more information about the Geologic Resources Division, visit http://www.nature.nps.gov/geology/.

4.5.3. Reference Conditions

The reference conditions by which geology condition was assessed are listed in Table 4.5.3-1.

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

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

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

Level of confidence is assessed depending on the level of information we have on which to base the condition assessment. A Geologic Resources Inventory Report produced by the NPS Geologic Resources Division, or similar report produced by the U.S. Geological Survey or state geologic survey specifically focused on a park's geology, results in a high confidence level for the assessment. A Geologic Resources Scoping Report (or the equivalent) provides a moderate level of confidence. If a Scoping Summary is all that is available and little is known or available about

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

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

the geologic resources, then a low confidence level is assigned.

4.5.4. Condition and Trend

Specific indicators and measures related to soil erosion are presented in section 4.9 on grasslands. Discussions on surface water (4.6) and groundwater (4.7) are presented in separate sections in this report. Based on the geologic scoping completed to date, a few areas of geologic concern have been identified. The condition of the park is considered to be good (T. Connors, NPS Geologist, pers. comm. July 2014).

The following discussion on geologic features, processes, and issues are excerpts summarized from the geologic resource evaluation report (Thornberry-Ehrlich 2008).

Geologic Features and Processes

Llano Uplift

The unique geology of the Llano Uplift (Figure 4.5.4-1) has sparked research interest among geologists. More local research would help resource managers at the park understand the relationships among various physical factors in the ecosystem.

"Llano" translates to "plain" in Spanish; the term "uplift" is a bit of a misnomer, since the area is not a topographic high. Instead, the term refers to the juxtaposition of Precambrian rocks uplifted relative to much younger Cretaceous limestone. The numerous fault blocks comprising the uplift are oriented southwest to northeast (Kier 1988, as cited in Thornberry-Ehrlich 2008). The relatively low-density granitic rocks of the locally thickened crust "float" on the denser rocks of the Earth's mantle (Reed 2005, as cited in Thornberry-Ehrlich 2008). The crust thickened during the orogenic collision and associated plutonism of the Grenville event.

The 1.5-billion-acre Llano Uplift—also known as the Central Mineral Region—of central Texas comprises igneous and metamorphic rocks as part of a long-lived collisional orogenic belt that formed during the Precambrian Grenville Orogeny (Kier 1988, Li et al. 2005, Mosher and Levine 2005, as cited in Thornberry-Ehrlich 2008). This belt formed along the southern margin

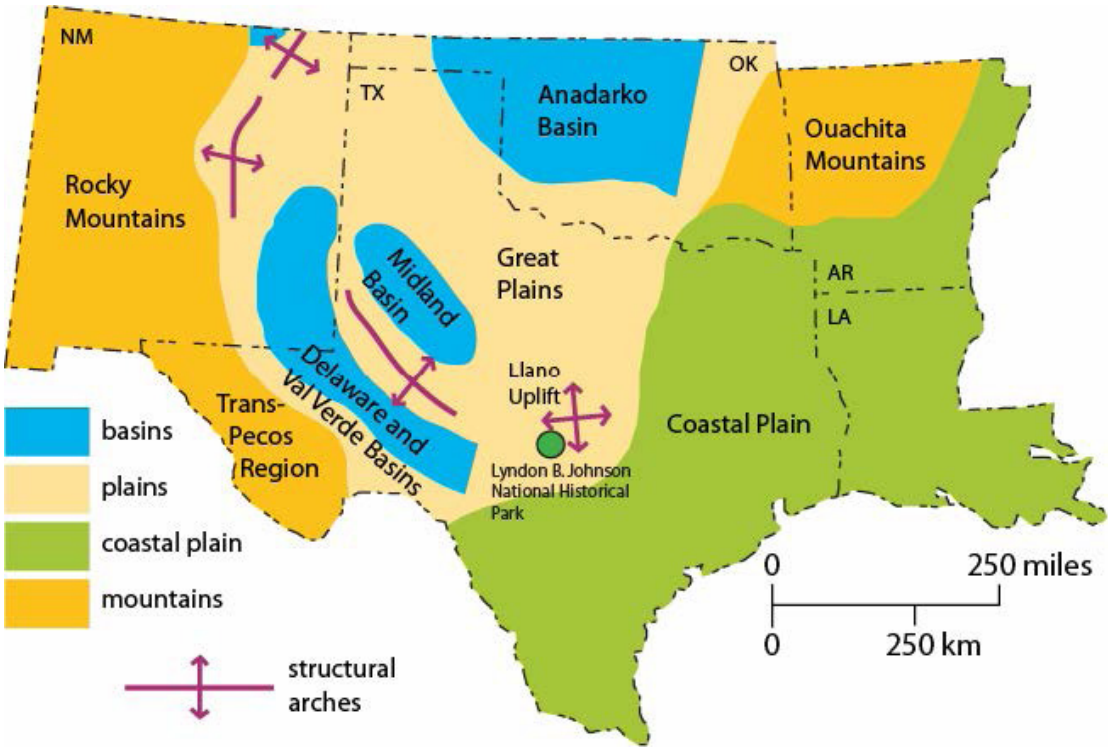


Figure 4.5.4-1. Map showing structural features in the area of Lyndon B. Johnson NHP (approximate location noted as green circle) near the Llano Uplift. Graphic created by Trista L. Thornberry-Ehrlich (Colorado State University) from information from the University of Texas at Austin http://www.lib.utexas.edu/geo/.

of the Laurentian (proto-North American) continent (Thornberry-Ehrlich 2008).

The uplift differs in structure, metamorphic grade, and rock assemblages between the eastern and western parts. The eastern part records the collision between a volcanic arc and the Laurentian continent, and the western part records continent-continent collision with one or more southern continental masses (possibly including the Amazon craton of South America; Tohver et al. 2002, Rivers 2004, Mosher and Levine 2005, as cited in Thornbery-Ehrlich 2008). These deformational events took place intermittently over 200 million years (Grimes and Copeland 2004, Rivers 2004, as cited in Thornbery-Ehrlich 2008).

According to the City of Llano, the Llano Uplift contains the only known specimens of the granite known as llanite (Figure 4.5.4-2). This brown granite contains visible crystals (phenocrysts) of sky-blue quartz and rusty-pink feldspar in a matrix of microscopic quartz, feldspar, biotite, and minor fluorite, magnetite, apatite, and zircon crystals. This unique rock typically occurs as dikes of ≈1,093 Ma age (Reed 2005, as cited in Thornbery-Ehrlich 2008). It is treasured as a decorative polished stone.



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Figure 4.5.4-2. Llanite is a brown granite with sky-blue quartz and pink feldspar crystals.

Gem quality topaz and some gold associated with pegmatite dikes are also present in the area. Gold is found either as native gold, or in association with sulfide minerals, such as pyrite, quartz veins, and quartz stringers, as well as residual soils and saprolite (Heylum 1985, as cited in Thornberry-Ehrlich 2008). Some small-scale mines in the area surrounding the park are the Heath, Central Texas, and Los Almagres mines. Many other small mines explored by early Spanish settlers in the 1700s are known only through local legends of buried treasures (Heylum 1985, as cited in Thornberry-Ehrlich 2008).

Paleontological Resources

Marine deposition throughout the Paleozoic resulted in the dolomite, limestone, calcite, and chert-rich units of the Ordovician Tanyard Formation, as well as the fossiliferous Gorman and Honeycut formations of the Ellenburger Group. Fossils include *Archaeosycphia* sp., *Ophileta* sp., *Orospira* sp., *Jeffersonia missouriensis*, *Hormotoma* sp., *Aphetoceras* cf. *A. subcostulatum*; various gastropods, nautiloids, siphuncles, cystid plates, trilobites, and brachiopods (Thornberry-Ehrlich 2008).

Geologic Issues

Geologic issues are those that may warrant attention from resource managers at Lyndon B. Johnson NHP as they are relevant for maintenance of facilities, mitigation of hazardous conditions, and protection of resources.

Hillslope Features and Processes

Slopes processes, such as landsliding, slumping, chemical weathering, block sliding, and slope creep, are constantly changing the landscape at the park. Runoff removes sediments exposed at the surface and carries them down streams and gullies. Bank erosion is a major factor leading to the introduction of heavy sediment loads to the riverine environment. Land use affects stream bank erosion rates. Cattle grazing reduces the amount of buffering and stabilizing vegetation in riparian zones along the rivers and streams. Fenced segments of rivers in grazed areas usually have better fish habitat (Nimick 1990, as cited in Thornberry-Ehrlich 2008). Erosion naturally diminishes higher areas and

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

Indicator of Condition	Measure	Condition	Rationale for Condition
Geologic Integrity	None	Good	With the exception of general erosion concerns, there are no real issues identified that impair the geological resources at the park. A geologic resource evaluation report was completed in 2008.

fills in the lower areas, distorting the historical context of the landscape (Thornberry-Ehrlich 2008). The function of the park as a working ranch requires careful management of the pasturelands necessary for cattle grazing. Erosion is removing these pasturelands, and overgrazed areas are especially at risk due to loss of stabilizing vegetation (Thornberry-Ehrlich 2008).



Overall Condition

In parks that do not have a geologic resource focus, that is, they do not have significant canyons or volcanoes or other prominent geologic features, no specific indicators or measures have been identified by which to assess geologic condition. In these cases, we use professional judgment and qualitative assessment of general geologic integrity to assign condition class and level of confidence. Table 4.5.4-1 clearly states how condition was assessed.

The condition of the geologic resources at Lyndon B. Johnson NHP is in good condition, with a high level of confidence.

4.5.5. Sources of Expertise

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

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4.6. Surface Water Quality

Indicators/Measures

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

Condition – Trend - Confidence



Good– Insufficient Data - High

4.6.1. Background and Importance

Lyndon B. Johnson National Historical Park (NHP) Ranch Unit is situated along the north bank of the Pedernales River, which is a tributary to the Colorado River (Figure 4.6.1-1). It's a perennial, spring-fed stream that flows approximately 161 km (100 miles) through the Texas Hill Country, draining an area of 3,372 km^2 (1,302 mi^2) throughout the Edwards Plateau. Local tributaries relevant to the LBJ Ranch and Johnson City districts of the park include Wittington Creek and Town Creek, as well as a number of seasonal, unnamed washes and streams (Thornberry and Ehrlich 2008). Historically, the water quality of the Pedernales River has been excellent, however, land use change, population growth, and agricultural activities have begun to impact the quality of this resource (EARDC 2007).

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, can shift species abundance and distributions, and alter nutrient cycles (USDI NPS 2008).

There are three water quality monitoring sites located in the NHP that are part of the Colorado River Watch Network (CRWN), which is a water quality monitoring program administered by the Lower Colorado River Authority. Two sites (170 and 173) are located along the Pedernales River in the LBJ Ranch Unit and one site (325) is located in the Johnson City Unit along Town Creek. Park staff at Lyndon B. Johnson NHP collect data at the Pedernales River sites and SOPN staff collects data at the Town Creek site. The



NPS / JASON LOTT

Figure 4.6.1-1
A scenic view along the Pedernales River, which flows along the LBJ Ranch.



Figure 4.6.2-1 Water quality parameters are monitored at three locations for Lyndon B. Johnson NHP.

Southern Plains Inventory and Monitoring Network (SOPN) currently collects core water quality parameters as identified in the Streams Monitoring in the Sonoran Desert and Southern Plains Networks summary protocol (Hubbard and Gwilliam nd) (Figure 4.6.2-1).

Data collection began on December 1, 1996 at sites 173 and 170 and has been continuous at site 170 but discontinued at site 173 on June 8, 2013. Data collection at site 325 began on October 5, 2004 to present day. Sites 173 and 170 have fewer observations in recent years than in earlier years, ranging from 15-25 readings per year before 2003 and 2-12 thereafter. Dissolved oxygen readings at Site 173 were discontinued after 4/1/12.

Indicators/Measures
Field Properties: temperature, specific conductance, pH, and dissolved oxygen

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. The field properties collected for the NHP included 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, and pH.

Statistical summaries of the four field properties are provided for all three monitoring sites in Table 4.6.2-1. Annual box-and-whisker plots of the field properties, which provide graphical overviews of the data, their distributions, and outliers, are presented for each location in Figures 4.6.2-2 to 4.6.2-5.

Indicators/Measures
E. coli (Abundance)

E. coli is a fecal coliform bacteria that is found in human and animal waste. It is used as an indicator for the presence of other disease-causing bacteria, viruses and protozoans that may be present in water with elevated levels of *E. coli*. *E. coli* levels are often used to determine whether fresh water is safe for recreational purposes.

E. coli was monitored monthly using the Coliscan Easygel© method for estimating abundance. Statistical summary for *E. coli* levels at all three sites are presented in Table 4.6.2-2 and in Figure 4.6.2-6.

Indicators/Measures
Nutrients (Nitrates)

Nitrogen is a nutrient necessary for growth of all living organisms, but excessive amounts of nitrates increase algae growth. The CRWN

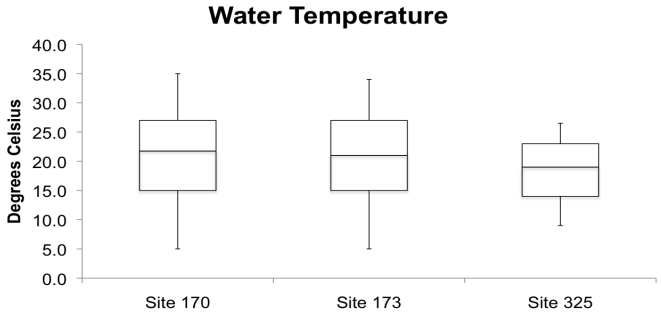


Figure 4.6.2-2. Water temperature annual plots for the three monitoring sites

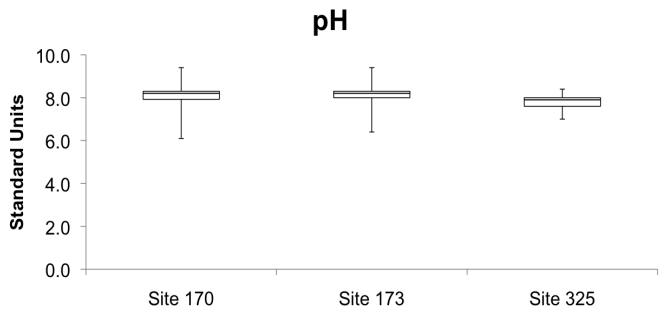


Figure 4.6.2-3. pH annual plots for the three monitoring sites

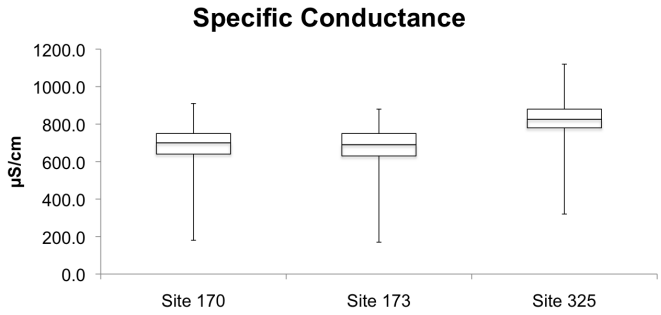


Figure 4.6.2-4. Specific conductance annual plots for the three monitoring sites

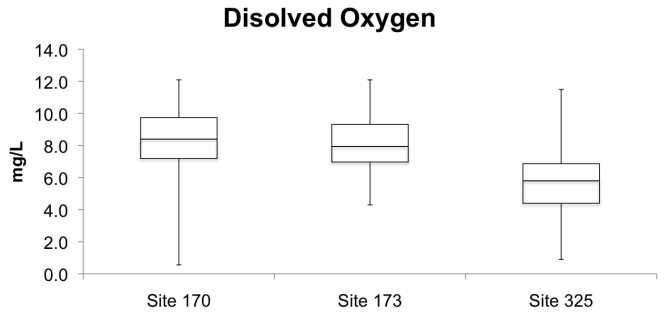


Figure 4.6.2-5. Dissolved oxygen annual plots for the three monitoring sites

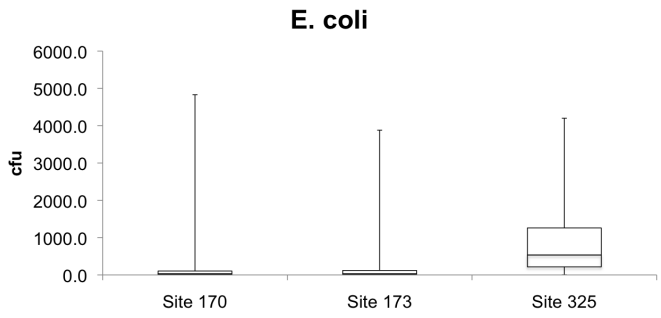


Figure 4.6.2-6. *E. coli* annual plots for the three monitoring sites

nitrogen tests measure nitrate (NO_3-N) and the statistical summary for nitrates levels at all three sites are presented in Table 4.6.2-1.

4.6.3. Reference Conditions

The water quality results were compared to the water quality standards/guidelines established by the Texas Commission on Environmental Quality Control Commission (TCEQ 2010, 2014, 2015a), which were reviewed by the EPA beginning in 2007 to determine compliance with standards set forth by the Clean Water Act.

TCEQ standards establish goals for the quality of waterbodies and were developed to maintain the quality of surface waters so that they support public health and enjoyment and protect aquatic life. The TCEQ guidance also identified appropriate uses for the Pedernales River, which included contact recreation, high-quality aquatic habitat, and public water supply (Kaiser and others, 1994 as cited in EARDC 2007). All available standards for the monitored water quality parameters are listed in Table 4.6.3-1.

4.6.4. Condition and Trend

Field Properties

Water Temperature

Water temperature was measured 241 times at Site 173 between 12/1/96 – 6/8/13 and ranged from 5.0° C to 34.0° C, with an average of 20.8° C. Water temperature was measured 246 times at Site 170 between 12/1/96 – 6/29/15 and ranged from 5.0° C to 35.0° C, with an average of 21.0° C. Water temperature was measured 77 times at Site 325 between

Table 4.6.2-1. Summary statistics for field properties and E. coli at the Pedernales River water quality monitoring sites.

Site Location	NPS Inventory and Monitoring Core Water Quality Parameters					
	Temperature (°C)	pH (SU)	Specific Conductance (µS/cm)	Disolved Oxygen (mg/L)	*E. coli* (CFU/100mL)	Nitrates (mg/L)
Site 173: Pedernales River at LBJ NHP Hodges Dam- RR 1623						
Number of observations	241	235	140	235	133	231
Minimum	5.0	6.4	170.0	4.3	0.0	0.25
Maximum	34.0	9.4	880.0	12.1	3880.0	4.00
Mean	20.8	8.1	688.6	8.2	241.1	1.17
Standard deviation	6.8	0.5	101.9	1.5	594.5	0.47
10%ile	11.0	7.4	580.0	6.4	0.0	1.00
25%ile	15.0	8.0	630.0	7.0	10.0	1.00
50%ile (Median)	21.0	8.2	690.0	8.0	30.0	1.00
75%ile	27.0	8.3	750.0	9.3	120.0	1.00
90%ile	29.0	8.6	820.0	10.1	633.1	2.00
Site 170: Pedernales River at LBJ NHP, PR49						
Number of observations	246	238	147	239	139	232
Minimum	5.0	6.1	180.0	0.6	0.0	0.25
Maximum	35.0	9.4	910.0	12.1	4830.0	4.00
Mean	21.0	8.0	689.8	8.3	205.6	1.15
Standard deviation	6.8	0.6	107.6	1.7	558.5	0.45
10%ile	11.5	7.4	570.0	6.4	0.0	1.00
25%ile	15.0	7.9	640.0	7.2	10.0	1.00
50%ile (Median)	21.8	8.2	700.0	8.4	30.0	1.00
75%ile	27.0	8.3	750.0	9.8	105.0	1.00
90%ile	29.0	8.5	820.0	10.2	640.0	2.00
Site 325: Town Creek at Johnson Settlement						
Number of observations	77	76	78	78	65	75
Minimum	9.0	7.0	320.0	0.9	0.0	1.00
Maximum	26.5	8.4	1120.0	11.5	4200.0	1.00
Mean	18.7	7.8	805.0	5.7	854.1	1.00
Standard deviation	5.1	0.3	132.0	1.9	837.0	0.00
10%ile	11.0	7.5	610.0	3.5	120.0	1.00
25%ile	14.0	7.6	780.0	4.4	216.5	1.00
50%ile (Median)	19.0	7.9	825.0	5.8	533.0	1.00
75%ile	23.0	8.0	880.0	6.9	1260.0	1.00
90%ile	25.0	8.2	930.0	8.3	1890.0	1.00

Note: Site 173 had a duplicate entry of the data recorded on 5/17/00 and Site 170 had a duplicate entry of the data recorded on 4/18/00. Both duplicate entries were removed from the calculations..

10/5/04 and 6/15/15 and ranged from 9.0° C to 26.5° C, with an average of 18.7° C. Median water temperatures ranged from 19.0° C at Site 325 to 21.8° C at site 170.

Site 173 exceeded the state's criterion for maximum water temperature (32.8.0°C) twice (7/18/97 & 7/4/01), 34.0°C and 33.0°C, respectively over the period of record. Site 170 exceeded the criterion three times (6/21/01, 7/8/01, 7/7/05) with readings of 34.0°C, 35.0°C, and 33.0°C, respectively over the period of record. Water temperature appeared to be increasing at Site 170 over this

same period of record. Expected seasonal trends are 22 -35°C May- October and 2-27°C November to April. Overall, this parameter was considered to be in good condition.

pH

pH levels were measured 235 times at Site 173 between 12/1/96-6/8/13 and ranged from 6.4 SU (7/16/99) to 9.4 SU (10/4/06). At Site 170, levels were measured 238 times between 12/1/96-6/29/15 and ranged from 6.1 SU (3/12/99) to 9.4 SU (10/4/06, 12/3/10). Site 325 had 76 measurements between 10/5/04-6/15/15 and ranged from 7.0 (11/4/04) to 8.4 (12/2/10). Median pH levels ranged from 7.9 SU (Site 325) to 8.2 SU (Site 170 & 173). pH appeared to be increasing at both river sites (170 & 173) and decreasing at the creek site (325). There was considerably more fluctuation in pH levels at the two Pedernales River sites than at Site 325. Exceedances of the state pH criterion have been relatively few in relation to the number of measurements and no exceedances have occurred over the last several years. We consider this parameter to be in good condition.

Specific Conductance

Specific conductance was measured 140 times at Site 173 between 10/19/00-6/8/13 and ranged from 170.0 to 880µS/cm; measured 147 times at Site 170 between 10/19/00-6/29/15 and ranged from 180 to 910µS/cm; and measured 78 times at Site 325 between 10/5/04-6/15/15 and ranged from 320 to 1120µS/cm. Median specific conductance values ranged from 690µS/cm (Site 173) to 825µS/cm (Site 325).

All sites exceeded the state's water quality maximum criterion (780µS/cm) numerous times over the period of observations but Site 325 recorded approximately twice the exceedances compared to the other two sites. Specific conductance at all sites appeared to be increasing over the period of record. Based on the number of exceedances, especially the more current measurements, we consider this parameter to be in moderate condition.

Dissolved Oxygen

Dissolved oxygen was measured 235 times at Site 173 between 12/1/96-4/1/12 and ranged from 4.3 to 12.1 mg/L; measured 239 times at Site 170 between 12/1/96-6/29/15 and ranged from 0.6 to 12.1 mg/L; and measured 78 times at Site 325 between 10/5/04-6/15/15 and ranged from 0.9 to 11.5 mg/L. Median dissolved oxygen ranged from 5.8 mg/L (Site 325) to 8.4 mg/L (Site 170). Site 170 had 8 observations below the state's water quality criterion of 5.0 mg/L and appeared to be declining over the period of observations. Site 173 had been steadily increasing over the period of record from 4.3 mg/L (12/1/96) to 12.1 mg/L (4/1/12). Site 325 has had over 20 observations that were below the state criterion (5.0 mg/L) and appeared to be declining over the period of record. Overall, especially with the most recent measurements meeting the state's criterion, we consider this parameter to be in good condition but closer attention to this particular parameter may be warranted.

Table 4.6.3-1. Surface water quality standards for the parameters monitored at Lyndon B. Johnson NHP (TCEQ/EPA 2015a; LCRA 2015).

Parameter	Standard Value
Water Temperature	91°F (32.8 °C) maximum
pH	6.5 - 9.0 SU
Dissolved Oxygen	5.0 mg/L (minimum) for summer and winter
E. coli	394 colony forming units per 100 milliliters in individual samples
Specific Conductivity	780 (µS/cm)
Nitrates	< 1.0mg/L

E. coli

E coli was measured 133 times at Site 173 between 4/24/98-6/8/13 and ranged from 0-3880 cfu/100mL; measured 139 times at Site 170 between 4/24/98-6/29/15 and ranged from 0-4830 cfu/100mL; and measured 65 times at Site 325 between 11/4/04-6/15/15 and ranged from 0-4200 cfu/100mL. Median E coli ranged from 30 cfu/100mL (Site 173 & 170) to 533 cfu/100mL (Site 325). Neither of the two river sites (173 & 170) have exceeded the EPA standard of 394 cfu/100mL since 11/2007. Site 325 has had greater fluctuation over the period of record and has exceeded

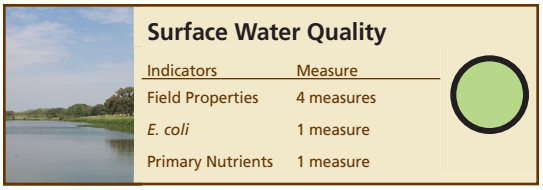
Table 4.6.4-1. Summary of the surface water quality indicators and their contributions to the overall condition.

Indicator of Condition	Measure	Condition	Rationale for Condition
Field Properties	4 Measures	Good	With a few exceptions, field properties met the state standards set forth by TCEQ and the EPA. While dissolved oxygen levels appeared to be decreasing and specific conductance levels appeared to be increasing, overall, the field properties measures were considered to be in good condition.
E. coli	1 Measure	Good	All sites appeared to have declining levels of *E coli* over the period of record. This parameter was considered to be in good condition.
Primary Nutrient	1 Measure	Good	Nitrate levels were often within the state's standard, especially in recent monitoring years. This parameter was considered to be in good condition.

the EPA standard more recently (5/2012 & 10/2014), however, all sites appeared to have declining levels of E coli over the period of record. We consider this parameter to be in good condition.

Nitrates

Nitrogen is an essential macronutrient for plant and animal life, but in excess, can interact with the biological and physical environment to reduce availability of high-quality aquatic habitat, altering the composition and species diversity of aquatic communities. Overall, the nitrate levels have been lower than the established standard, and no exceedances have occurred since January 2006 at Site 170 , since December 2005 at Site 173, and never at Site 325. This parameter is considered to be in good condition



Overall Condition

A summary of each indicator and its contribution to the overall water quality condition at Lyndon B. Johnson NHP is listed in Table 4.6.4-1. No segments of the Pedernales River or Town Creek are included on Texas' 303(d) impaired waterbodies list (TCEQ 2015b). While dissolved oxygen levels appeared to be decreasing and specific conductance levels appeared to be increasing, the overall water quality condition is still considered to be good.

Level of Confidence/Key Uncertainties/ Threats

The Pedernales River watershed drains a large area of land 3,372 km^2 (1,302 mi^2) (as cited in Thornberry and Ehrlich 2008) and a better understanding of the surface water movement within individual catchment areas may help with understanding the risk associated with potential contamination, especially after large storm events, which are common throughout this region. EARDC (2007) suggested routine monitoring of nutrients and phytoplankton chlorophyll to better understand potential eutrophication issues in the river. Thornberry and Ehrlich (2008) suggested the possibility of the park dams causing sediment loading that may trap stored contaminants. Extreme disturbance events, such as flooding, may release these contaminates into the river, potentially degrading the water quality condition. And finally, the park's Foundation Document (NPS 2014), states that the "Pedernales River water quality is "good" based on water testing, though there are some discharge issues upstream (NPS 2014)."

The water quality baseline analysis conducted by NPS (2001) indicated that surface waters within the study area, which included the region surrounding the park districts, appeared to be "generally of good quality with some impact from human activities, particularly numerous instances of high fecal-indicator bacteria concentrations in

the Pedernales River (p. 7)." NPS (2001) identified both potential natural sources of contaminants as erosion from flash floods, and potential anthropogenic sources of contaminants, including agricultural activities; stormwater runoff; municipal and industrial wastewater discharges; recreational use; and atmospheric deposition.

4.6.5. Sources of Expertise

SOPN conducts routine water quality monitoring at the NHP following CRWN's standardized procedures. These data are routinely entered into CRWN's data portal, which were used for the purposes of this assessment.

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4.7. Groundwater

Indicators/Measures

- Groundwater Elevation (Change in groundwater elevation)

Condition - Trend - Confidence



Moderate - Unknown - Medium

This section is comprised of groundwater assessment notes from Larry Martin with NPS Water Resources Division (2014a,b).

4.7.1. Background and Importance

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). It is the policy of the NPS to determine the quality of park surface and groundwater resources and avoid, whenever possible, the pollution or other types of degradation of park waters by human activities occurring within and outside of parks.

Occurrence and Movement of Groundwater in the Vicinity of Lyndon B. Johnson NHP Johnson City Unit

Most of the surface at the Johnson City Unit of the park is covered with Quaternary Alluvium (Figure 4.7.1-1). The alluvium overlies Glen Rose limestone, which overlies strata of the Ellenburger aquifer. The Ellenburger-San Saba aquifer includes the San Saba Limestone Member of the Cambrian-age Wilberns Formation and the Ellenburger Group of Ordivician and Cambrian age. The aquifer is composed of thick beds of cherty limestone and dolomite and is honeycombed with caverns (Follett 1973). However, there is little to no information available regarding the shallow groundwater underlying the park that is in the alluvium (Follett 1973).

Occurrence and Movement of Groundwater in the Vicinity of Lyndon B. Johnson NHP LBJ Ranch Unit

The general description of geology at the Ranch Unit is that of a limited area of Quaternary alluvium along the river, and the Hensell Sand Member at the surface near the river where the overlying Glen Rose Limestone has been eroded away. Farther back from the river, Glen Rose Limestone occurs at the surface. Underlying the Glen Rose limestone are strata comprising the Ellenburger aquifer, including the San Saba Limestone in which some of the park wells are finished (Figure 4.7.1-2) (LBG-Guyton Assoc. 2007; Martin 2014b).

Overall, the Pedernales River Valley contains fairly shallow aquifers where some fractured rocks supply water via seeps and springs (Thornberry and Ehrlich 2008). It is these aquifers that support the riparian vegetation throughout the park.

4.7.2. Data and Methods

Water use at Lyndon B. Johnson NHP

There are a total of eight active groundwater wells within the NHP, one of which (i.e.,

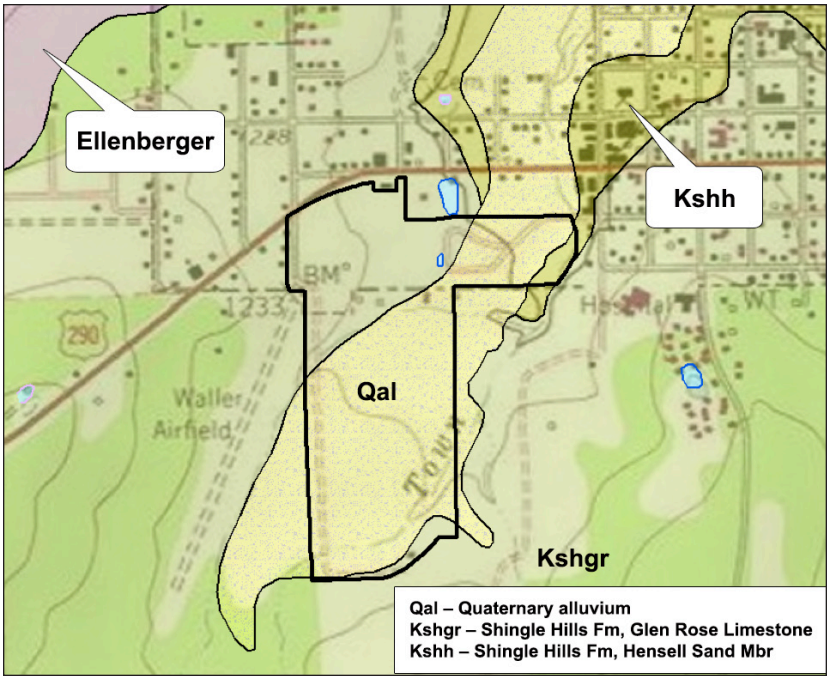


Figure 4.7.1-1. One of the park's wells in the Johnson City Unit is finished in the Quaternary alluvium (map created by NPS Geological Resources Division).

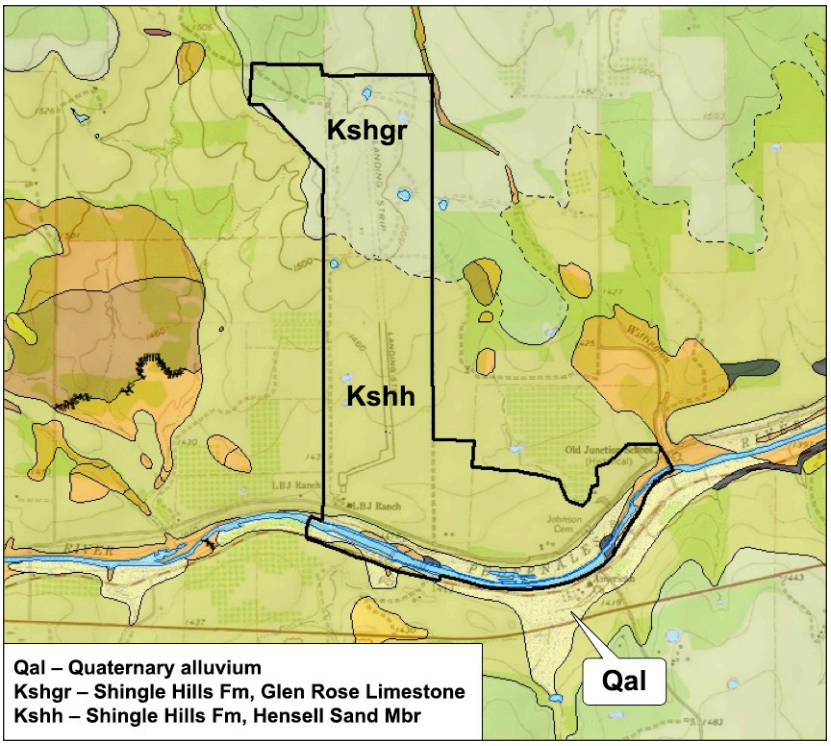


Figure 4.7.1-2. Park wells in the Ranch Unit are finished in different geologic strata and aquifers, depending upon their location (map created by NPS Geological Resources Division).

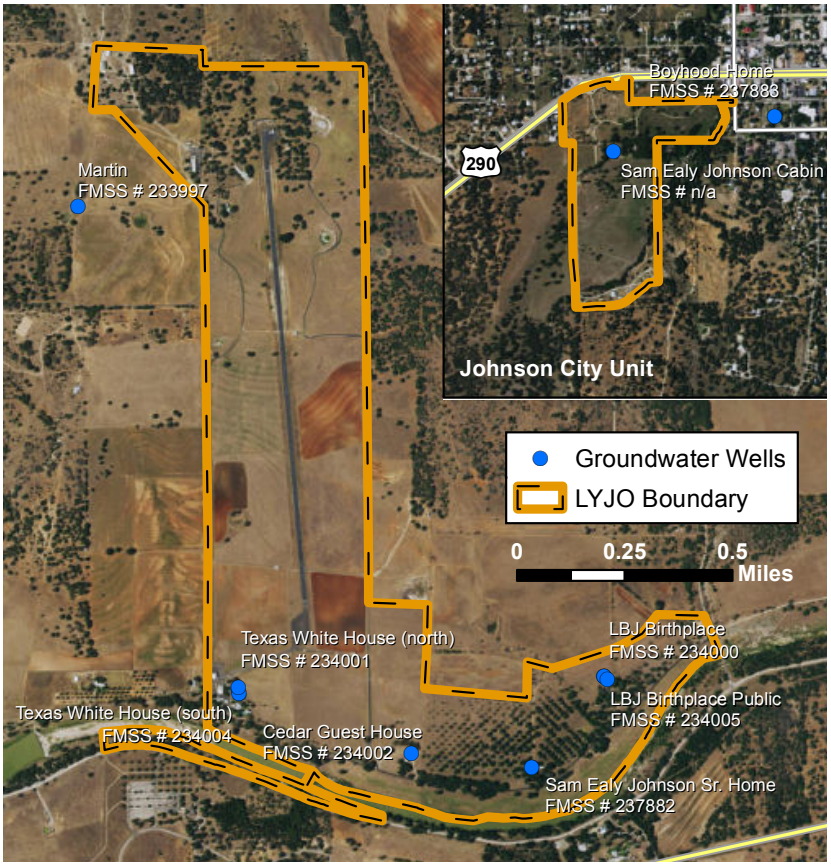


Figure 4.7.2-1. Locations of the park's groundwater wells, which were gps'd in 2014.

Martin well) is located outside the park's boundary (Figure 4.7.2-1). Water levels are not regularly monitored at the park but were measured in 2014 for the purposes of this assessment. Information pertaining to the wells are summarized in Table 4.7.2-1. According to Martin (2014b), there are no water rights dockets for the park at the Water Resources Division to supply additional information.

Johnson City Unit

There are two NPS wells located in the Johnson City unit. The Boyhood Home well is an irrigation well, and there is no record of this well in the Texas Water Department Board (TWDB) 2014 database (at least not listed under the name of NPS).

The well near the Sam Ealy Johnson Cabin has a Texas well number of 57-45-902, and the well owner is listed as City of Johnson City. The well is 30 feet deep and was originally a 10-foot diameter dug well. Apparently the well draws water from the Quaternary alluvium. It's unknown what aquifer the other well is finished in but likely the Ellenburger Limestone Aquifer. All water for public and staff consumption in the Johnson City Unit comes from the municipal water system (NPS 1983), which occurs in the Ellenburger-San Saba aquifer (Ashworth and Hopkins 1995).

LBJ Ranch Unit

There are five active NPS wells in the LBJ Ranch Unit, and one well is located outside the park's boundary. Only four of the park's wells are listed in the TWDB database (refer to Table 4.7.2-1).

Indicator/Measure

Groundwater Elevation (Change in groundwater elevation)

Since groundwater levels are not regularly monitored at the park, proxy wells containing regular water level measurements and finished within the same aquifers as the park's wells, were found in the TWDB (2014) well database. Martin (2014a,b) found two proxy wells, one for each district's groundwater assessment, and their locations are shown in Figure 4.7.2-2. No long-term water measurements

Table 4.7.2-1. Summary of active groundwater wells within Lyndon B. Johnson NHP.

Name and TWDB Well ID#	Aquifer (if known)	Well Depth (ft.)[1]	Depth of Water from Ground Surface (ft.)[2]	In TWDB Database?	Notes
Johnson City Unit					
Boyhood Home		250	n/a	No	Well is contaminated and only used for irrigation/fire protection purposes only (NPS 1983).
Sam Ealy Johnson Cabin	Quaternary alluvium	30	16.3	Yes (#57-45-902)	Well owner is listed as City of Johnson City in the TWDB. This well was hand dug in 1960 and is only used for fire protection/stock water since it's contaminated. It is listed as 32 feet deep in NPS (1983).

NPS (1983) states that all water for staff and public consumption at the Johnson City Unit comes from the municipal water system. No proxy wells were found finished in the same aquifers with well records to determine condition of groundwater within the Johnson City Unit.

LBJ Ranch Unit					
LBJ Birthplace Home	San Saba Limestone	120, 200	38.2, 23.75	Yes for both wells (#57-52-103 and #57-52-107)	Two wells are located at the home. The new well was drilled in 1972, and it's used for public water supply. Records reveal conflicting well depths reporting both 120 and 160 feet. The old well is contaminated and used for stock water (NPS 1983).
Sam Ealy Johnson Sr. Home		39	17.4	No	N/A
Cedar Guest House		150	23.8	No	N/A
Texas White House South			n/a	No	N/A
Texas White House North		240	28	No	This well was drilled in 1965 for domestic supply. Well depths are reported at both 240 and 280 feet.
Martin	San Saba Limestone	360	97.7	Yes (#57-43-903)	The first well was drilled in 1966 (Martin 1995), but a new one was drilled in 1995 within the same aquifer. The water table measured in 1995 was 64 feet below ground surface.

[1] Well information was derived from State of Texas (2000) well reports and from park records.

[2] Water levels were recorded by NPS maintenance in August 2014 and are listed in NPS (2014).

General Notes: Well #57-44-702 was also in the TWDB for NPS as an inactive well located north end of runway and drilled 250 ft. into the Welge Sandstone aquifer. Several additional wells are no longer in use throughout the park.

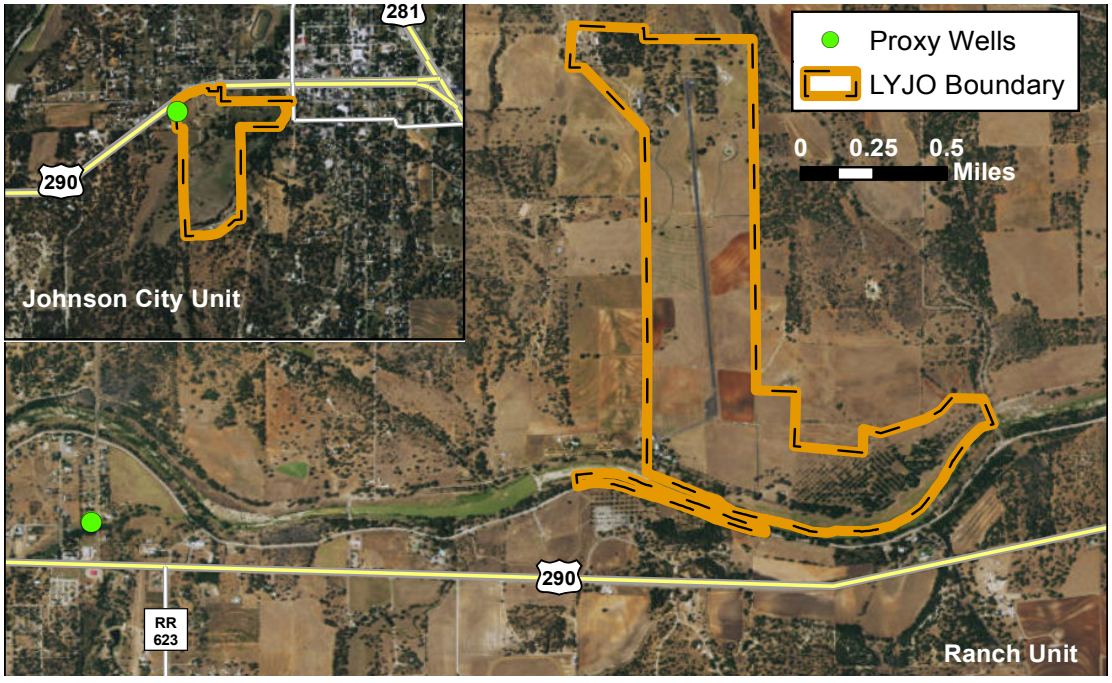


Figure 4.7.2-2. Locations of the proxy groundwater wells used for this assessment.

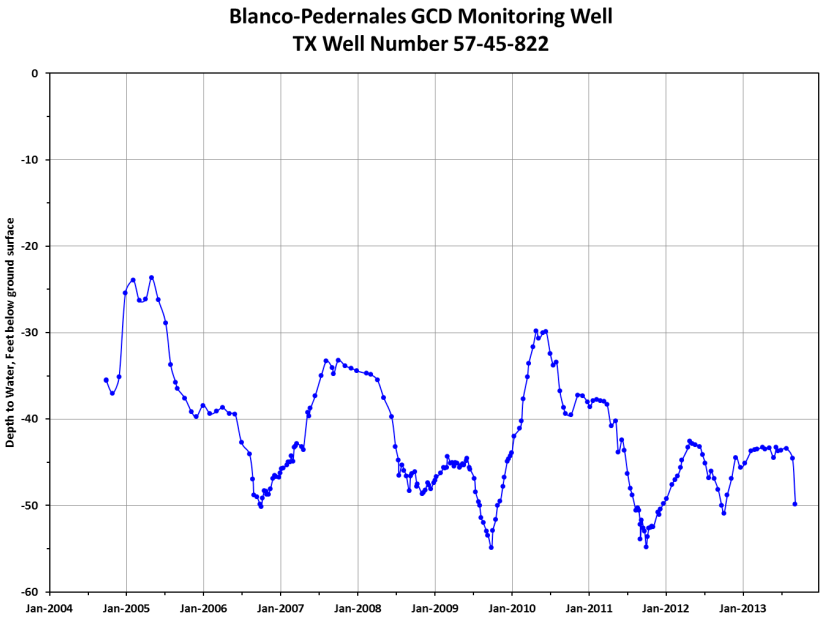


Figure 4.7.2-3. Depth to water level in State well # 57-45-822, which is located in the Ellenburger Limestone Aquifer, next to the Johnson City Unit.

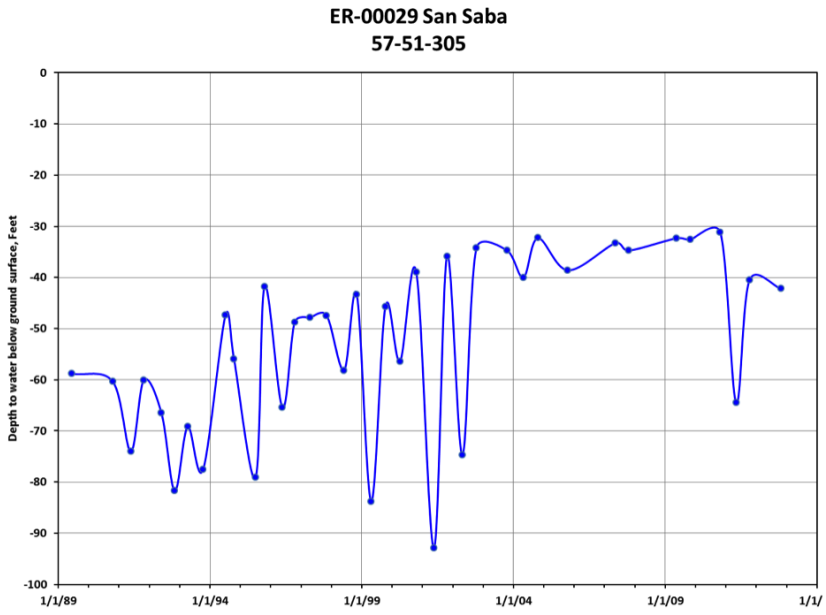


Figure 4.7.2-4. Depth to water level in State well # 57-51-305, which is located in the San Saba limestone and part of the Ellenburger limestone aquifer next to the Ranch Unit.

for wells finished in the Quaternary Alluvium were found, but the condition of this aquifer is discussed in general terms within the Condition and Trend section below.

Groundwater Conservation Districts (GCD) monitor wells within the Blanco-Pedernales GCD and the Hill Country Underground Water Conservation District (UWCD). Within a few blocks of the Johnson City Unit, there are 5-6 private wells, generally northeast of the park. These wells are mostly in the 100-200 foot range and are identified as being finished in the Ellenburger aquifer. However, only one well (Texas State well number #57-45-822), located in the Ellenburger limestone aquifer, is regularly monitored for groundwater level by the Blanco-Pedernales GCD. The well is near the northwest corner of the Johnson City Unit and is 464 feet deep. Figure 4.7.2-3 shows the depth to water measurements for this well from 2004-2013.

The Hill Country UWCD conducts bi-annual water level measurements at a private well (Texas State well #57-51-305) about 2 miles west of the LBJ Ranch. The well is 200 feet deep and is completed in the San Saba limestone (part of the Ellenburger aquifer). The. Figure 4.7.2-4 shows the water level measurements for this well from 1989-2013. The low points on the hydrograph were likely measurements that were made when the well was pumping or the well had been pumped recently (Martin 2014b).

4.7.3. Reference Conditions

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

4.7.4. Condition and Trend

The water level in the Ranch Unit proxy well (57-51-305) appeared to be generally rising from the early 1990s until 2010, then declined. Martin (2014b) suggested that the recent decline might be due to drought conditions, additional groundwater pumping or reduced recharge, and that the water level rise for the preceding two decades was unusual. Martin (2014b) was uncertain as to cause of the increase in water level and whether it was a local phenomenon or representative of increased water levels for a larger region. We have no site-specific data regarding groundwater trends at the park to make a determination as to the cause(s) of the increase.

The Hill Country Underground Water District projects no water supply needs for wells in the Ellenburger Aquifer through 2060. However, as shown in Figure 4.7.4-1, which is based on Ellenburger Aquifer

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

Condition Class	Description
Good	A good reference condition is one where groundwater level can withstand variability that reflects annual variation in environmental conditions (e.g., rainfall, evapotranspiration, pumping), but lacks an overall long-term decreasing water level trend. Natural systems, when well supported by the local water table, are generally resilient enough to maintain viability through natural variations in hydrology, including periods of drought*.
Moderate	A moderate condition is when groundwater levels fluctuate around a water table elevation that only provides marginal support for the resources and begins to decline overall. In this scenario, prolonged drought and/or excessive withdrawals begin to negatively impact the groundwater level.
Significant Concern	A significant concern condition is when water levels are so low that they are unable to rebound. A significant concern also occurs when no hydrologic support for natural systems, such as riparian habitat exists.

groundwater levels, cumulative rainfall over 10 months, Pedernales River flow, and the Palmer Hydrological Drought Index, drought conditions have just recently improved as were in emergency drought conditions as late as 2012(Hill Country UWCD 2012).

The water level in the Johnson City Unit proxy well (57-45-822) appeared to be generally declining based on measurements taken from 2004 until 2013. In recent years (2013), the Blanco-Pedernales Groundwater Conservation District, asked well owners to conserve their groundwater use due to declining aquifer levels in District monitor wells, decreasing flow in the Blanco and Pedernales Rivers, recent rainfall history, and extended weather forecasts (BCPGCD 2013). The District believes that the Ellenburger Aquifer as a whole should be able to meet future demands through 2060, but that areas adjacent to Johnson City may experience seasonal shortfalls if development of small acreage lots increases. These developments will rely upon the Ellenburger since the underlying Precambrian rocks are essentially void of groundwater (BPGCD 2008).

The Pedernales River and its associated aquifers (e.g., Quaternary Alluvium) are important resources of the park and interactions between surface water and groundwater is very important (LBG-Guyton Assoc. 2007). The Pedernales River is a major discharge and recharge feature of the Ellenburger aquifer system, and groundwater inflow contributes to the baseflow of the river and responds to variations in seasonal precipitation (Thornberry and Ehrlich 2008).

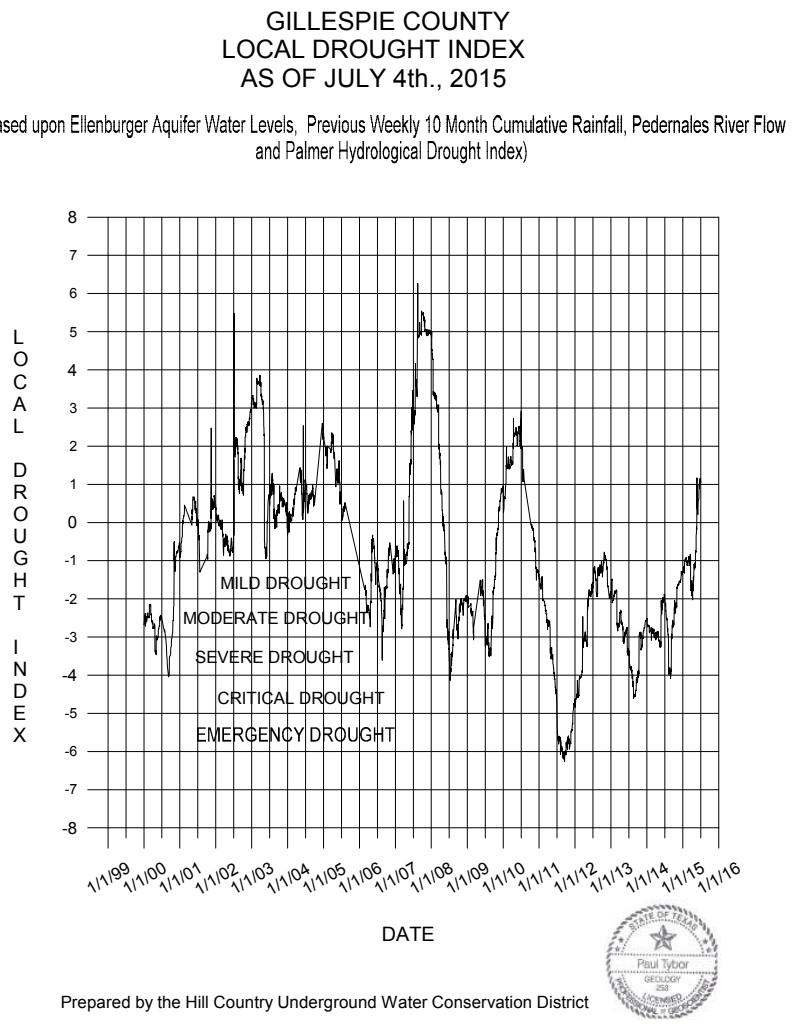


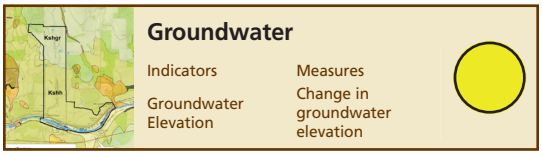
Figure 4.7.4-1. Gillespie County local drought index as of July 4th, 2015 (Hill Country UWCD 2015).

Gain/loss studies were conducted in the aquifer by USGS over 50+ years ago. Martin (2014b) states, "I would expect that the groundwater development and pumping has generally lowered the groundwater level, thereby reducing the rate of flow toward the river. In some areas, I would expect the

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

Indicator of Condition	Measure	Condition	Rationale for Condition
Groundwater Elevation	Change in Groundwater Elevation	Moderate	The aquifers that support park operations and the riparian habitat along the Pedernales River thus far have maintained viability through hydrologic variations. However, with the recent extreme drought conditions impacting groundwater levels and causing Blanco Pedernales Groundwater Conservation District to request conservative use, the groundwater condition is considered to be moderate at this time.

river has changed from a gaining reach to a losing reach." Obligate riparian species, such as willows, require this connection to groundwater (M. Martin, Hydrologist per. comm.), especially during drought events like the area has experienced is recent years.



Overall Condition/Trend

For assessing the condition of groundwater, we chose one indicator (groundwater elevation) (Table 4.7.4-1).

Based upon the review of the proxy well groundwater level measurements, and the very recent improvement to critical to emergency drought conditions, we consider the groundwater resource to be in moderate condition. While the The Hill Country Underground Water District shows the area no longer in drought conditions, the Texas Drought Monitor indicates abnormally dry conditions for both counties at present time (National Drought Mitigation Center 2015).

Key Uncertainties

At this time, the cause(s) for the groundwater level patterns are unknown. We don't know if it's a result of local phenomena or more regional. A better understanding of the groundwater dynamics and how nutrients and contaminants move through the hydrogeologic system is needed to provide better insight for management decisions. Consistent monitoring of selected parameters would establish baselines for comparison over time.

4.7.5. Source of Expertise

The groundwater assessment for the National Historical Park was based on information reported by Larry Martin for the purposes of this assessment (2014a,b). Larry Martin is a scientist with the NPS Water Resources Division.

Michael Martin, a hydrologist with the NPS Water Resources Division was also consulted for the purposes of this assessment.

4.7.6. Literature Cited

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4.8. Riparian Habitat

Indicators/Measures

- Vegetation (7 measures)
- Erosion/Deposition (2 measures)

Condition – Trend– Confidence



Moderate - Unchanging - High

This section was primarily developed from rapid field assessment notes recorded by Tomye Folts-Zettner, Biologist, Southern Plains Inventory and Monitoring Network (Folts-Zettner 2014).

4.8.1. Background and Importance

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

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

Setting

The Pedernales River is a tributary of the Colorado River and flows west to east for approximately 171 km (106 miles). The river drains a total area of 3,372 km^2 (1,302 mi$^{2)}$, with 46% of the area located upstream of Lyndon B. Johnson NHP (Figure 4.8.1-1). This area is characterized by rugged to rolling hills, thin soils, and limestone and granite bedrock. The large amount of exposed or shallow bedrock, along with poorly formed soils, makes the area very dry and prone to flash flooding.

According to Martin (2008), "the Pedernales watershed is located in a hydrologic province that may experience tropical and sub-tropical storms producing some of the highest rainfall rates in the United States. In addition to high rainfall, the river basin itself contributes to flooding with shallow bedrock and a relatively steep gradient channel of about 10.5 feet per mile (ACOE 1979 as cited in Martin 2008)." Eleven high flow events have been recorded beginning as early as 1869, with the record



Figure 4.8.1-1. The Pedernales River is a tributary of the Colorado River and flows west to east through Texas Hill Country and along the south boundary of Lyndon B. Johnson NHP.

flood occurring in 1952 (Martin 2008).The Pedernales River flows along the south side of President Lyndon B. Johnson's ranch where many of the historic structures and features are located within the 100- and 500-year floodplains (Martin 2008).

4.8.2. Data and Methods

The riparian habitat assessment was conducted by Tomye Folts-Zettner, Biologist with the Southern Plains Inventory and Monitoring Network on May 22, 2014. The 4 km (2.5 mile) stretch of the Pedernales River along the NHP Ranch Unit was evaluated as three separate reaches (Figure 4.8.2-1) due to an apparent inconsistency of geomorphic and vegetation characteristics. Reach one began from a point located at the western boundary to the Johnson Dam (just east of the Texas White House). Reach two was from the first dam to the Jordan Dam. And reach three was from the Jordan Dam to the eastern boundary. The assessment was conducted along the north bank of the river, adjacent to the park's boundary. The south bank was used for reference purposes since it was in a more naturalized vegetative state.

To complete this assessment, indicators and measures from "A User Guide to Assessing the Proper Functioning Condition and the Supporting Science for Lotic Areas" (Prichard et al. 1998) were used, however, the measures were primarily focused on vegetation characteristics. Although, some observations related to the erosional and depositional processes were included in the assessment as well.

Indicator
Vegetation (7 measures)

Most riparian habitats require some amount of vegetation to achieve functionality (Prichard et al. 1998). Different factors such as type, amount, and proportion of vegetation

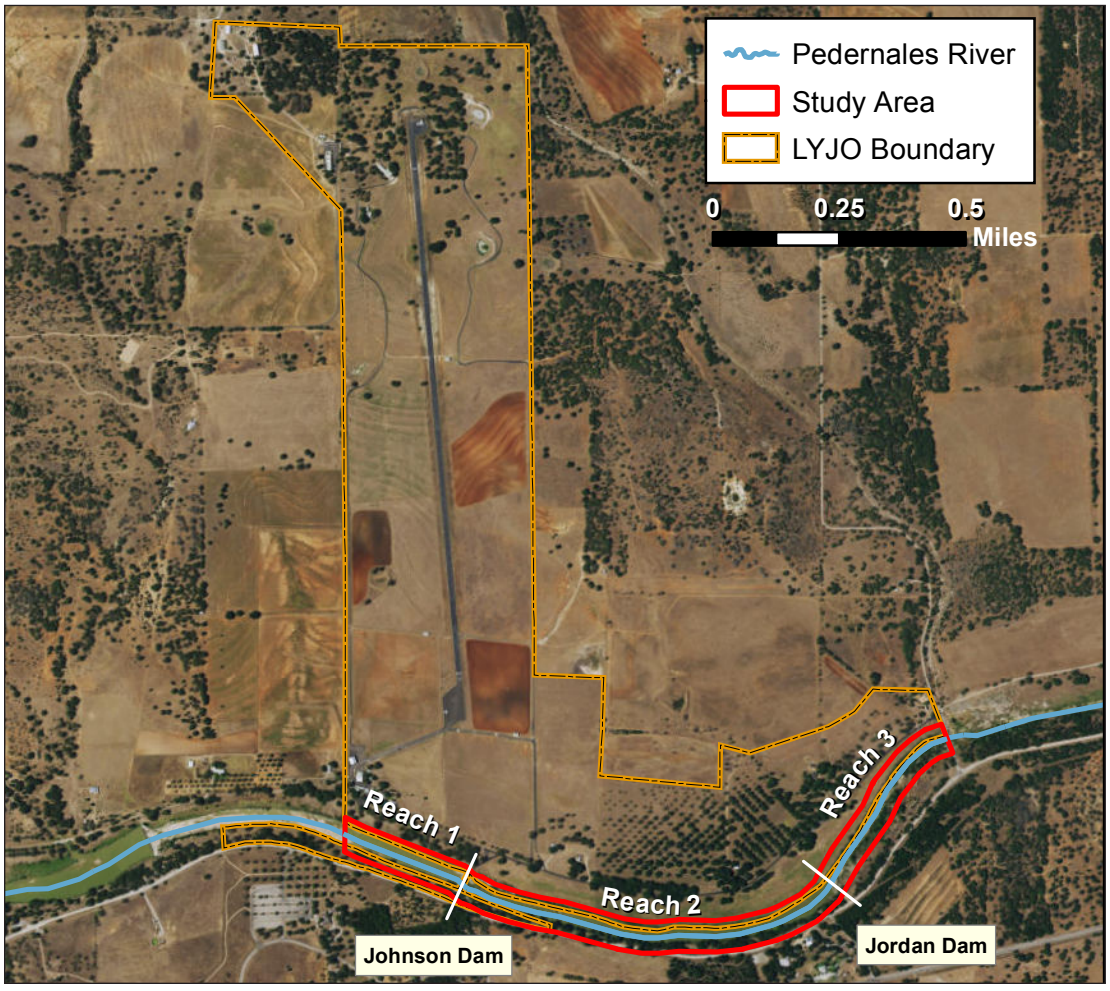


Figure 4.8.2-1 The 4 km (2.5 mi) stretch of Pedernales River, located within the Historical Park, was separated into three reaches for the 2014 riparian assessment.

contribute to a riparian area's condition. In order to accommodate periodic flooding, lateral distribution of vegetation is necessary. In addition, plants must be vigorous and able to maintain or recruit into the plant community to serve their various functions.

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

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

Measure: There is diverse composition of riparian wetland vegetation

Not all potential plant species need to be present within a riparian wetland system for the system to maintain itself, but there needs to be enough diversity for a riparian area to recover from flood events 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 have a water table near the ground surface or be inundated for at least 14 consecutive days during the growing season to persist. Different types of riparian wetland plants require different wetness regimes and vary in root depths. Wetland plants are divided into different categories (e.g., obligate, facultative wetland), 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 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 degrade aquatic habitat and 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 during moderately large flood events.

Measure: Riparian wetland plants exhibit high vigor

If plants are weakened or stressed, they are less able to withstand the erosive energy of flood flows, making the riparian-wetland area more susceptible to degradation. On the other hand, plants that exhibit vigor are usually more equipped to withstand higher flows without degradationor 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 riparian area's ability to dissipate energy, protect riverbanks from collapse, filter sediment, and aid floodplain development, which also dissipates energy during storms or high runoff. Some bank erosion is a natural part of river channel evolution, but excessive erosion usually indicates some failure in the system.

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

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

Table 4.8.3-1. The reference conditions used to determine the condition of the riparian habitat, primarily vegetation, at Lyndon B. Johnson NHP.

Good	Moderate	Significant Concern
A good or "properly functioning"condition is when a state of stability and resiliency allows a riparian area to hold together during higher flow events with a high degree of reliability. This resiliency allows an area to establish and maintain vegetative communities and channel/floodplain forms that create the structure necessary for fish and waterfowl habitat, to establish floodplains that help dissipate energy, and channel characteristics that help prevent streambank erosion.	A moderate concern or "functional – at risk" condition is when the riparian wetland area is in functional condition, but an existing soil, water, vegetation or watershed component is compromised, making it susceptible to degradation.	A significant concern or "nonfunctional" condition is when the riparian wetland area is not providing adequate vegetation or landform to dissipate stream energy associated with higher flows. Therefore, erosion is not reduced, habitat is not maintained and water quality degradation may be occurring. High flow events either deposit an inordinate amount of sediment or water flow results in excessive erosion, which can change the channel form and degrade desirable habitat.

Indicator
Erosion/Deposition (2 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. Areas with bank stability/instability or active erosion or intactness were noted throughout the assessment.

4.8.3. Reference Conditions

A riparian area needs to be in dynamic equilibrium with its streamflow forces and channel processes to be considered in "proper functioning (good) condition." This requires the system to maintain itself and/or recover after moderately 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 future degradation due to failure in one or more of the attributes (i.e., hydrology, vegetation, or erosion/depositional processes) are considered to be "functional – at risk" (moderate condition). Finally, riparian systems that do not provide adequate vegetation and landforms to dissipate the energy of higher flows and are subject to significant, erosion, deposition, or changes in channel/floodplain form and functionare considered to be in "nonfunctional" or significant concern condition. The reference conditions used to assess the riparian habitat, primarily from a vegetation perspective, are listed in Table 4.8.3-1.

4.8.4. Condition and Trend

The riparian habitat assessment results are presented in Table 4.8.4-1 for all three reaches along the Pedernales River.

For all three reaches, the adjacent floodplain was actively grazed and consisted of coastal Bermudagrass (*Cynodon dactylon*) and, to a lesser extent, K.R. bluestem (*Bothriochloa ischaemum var. songarica*). A narrow band (4+/- meter) of riparian vegetation was present and protected by electric fencing from grazing and trampling (Figure 4.8.4-1, left), which resulted from the restoration efforts of park staff per Martin (1999) recommendations for stabilizing the banks along the river.

The banks along reaches one and two appeared to be well vegetated with native and native-invasive plants, while the exotics Bermudagrass and Johnsongrass (*Sorghum halepense*) had invaded in areas. Switchgrass (*Panicum virgatum*), eastern gamagrass (*Tripsacum dactyloides*) and Canadian wildrye (*Elymus canadensis*) were present in limited quantities. Leadplant (*Amorpha fruticosa*) was frequently encountered shrub. Additional riparian grasses and forbs could be seen from the far bank, but the north banks were too steep to access to identify additional vegetation. There was no evidence of tree

Table 4.8.4-1. Assessment results for the riparian habitat condition assessment at Lyndon B. Johnson NHP (Folts-Zettner 2014 and pers. comm., August 2014).

Indicator/Measure	Reach 1	Reach 2	Reach 3
Vegetation			
Age class distribution vegetation	There was no evidence of tree recruitment and no trees were present on the bank.		There was recruitment of diverse woody vegetation.
Diverse vegetation composition	For all 3 reaches, the adjacent floodplain was actively grazed and consisted of exotic plants, coastal Bermudagrass (*Cynodon dactylon*) and, to a lesser extent, K.R. bluestem (*Bothriochloa ischaemum var. songarica*). A narrow band (4+/- meter) of riparian vegetation was protected by electric fencing from grazing and trampling. Reach 3 had better and more abundant native plant diversity, though still some invasive plants were found throughout the area.		
Soil moisture characteristics	Moist conditions were limited to the bank adjacent to the river.	No comments were notated.	Scouring rush (*Equisetum hyemale*) was present, and obligate wetland plants were observed from a distance but unidentified. The presence of these species implied moist soil.
Plants have root masses capable of withstanding high streamflow events	Plants with such root masses were limited; the *Baccharis* was holding the bank together, but may not be able to withstand a high flow event.		In this reach, plants with root masses capable of withstanding high streamflow events were present.
Vigorous plants	Plants were somewhat vigorous, although were more weedy and early successional species.		Plants were very vigorous and included Eastern gamagrass, Canada wildrye and switchgrass. Annual rabbitsfoot grass (*Polypogon monspeliensis*) had established in cracks of the bedrock in the river.
Vegetation cover	The banks appeared to be well vegetated with native and native-invasive plants, while the exotics Bermudagrass and Johnsongrass (*Sorghum halepense*) had invaded in areas. Switchgrass (*Panicum virgatum*), eastern gamagrass (*Tripsacum dactyloides*) and Canadian wildrye (*Elymus canadensis*) were present in limited quantities. Leadplant (*Amorpha fruticosa*) was common. Additional riparian grasses and forbs were present but unidentified.		Areas were well vegetated, but there was still a major component of Baccharis, but less plentiful than the upriver reaches. On the south bank not park land), there was one saltcedar (*Tamarix chinensis*) and one relatively small patch of giant cane (*Arundo donax*).
Plant communities produce coarse and/or large woody material	No coarse and/or large plants were present, which may not be significant for maintaining channel stability.		Mature trees of Sycamore (*Platanus occidentalis*), bald cypress (*Taxodium distichum*), and native Pecan (*Carya illinoiensis*), as well as many younger recruits, were present. A young black willow (*Salix nigra*) was also observed.
Erosion/Deposition			
Floodplain and channel characteristics	Reaches 1 and 2 have impoundments and cannot be assessed using a natural reference condition. Bank erosion and changes in morphology were observed. The banks were steep and showed evidence of undercutting. Active erosion was not visible from opposite bank due to thick growth of vegetation.		The original bedrock channel bed of the Pedernales River, with natural channel characteristics, was present. There was more slope to the bank along this reach. Game trails to the water were plentiful.
	A swale ran parallel to the river, capturing and redirecting runoff from upslope and serves as an overflow channel during flood events.		
Point bars	n/a		Gravel bars were present.

recruitment and no trees were present on the banks along reaches one and two.

The banks along reach three were well vegetated. There was still a major component of Roosevelt baccharis (*Baccharis neglecta*), but it was less plentiful than in the reaches one and two. Eastern gamagrass, Canada wildrye and switchgrass were plentiful. There were mature trees of Sycamore (*Platanus occidentalis*), bald cypress (*Taxodium distichum*), and native Pecan (*Carya illinoiensis*) as well as many younger recruits. A young black willow (*Salix nigra*) was also observed. Scouring rush (*Equisetum hyemale*)


NPS / TOMYE FOLTS-ZETTNER


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Figure 4.8.4-1. Grazed versus ungrazed vegetation (left) and north bank at bottom of reach two (right) along the Pedernales River.

was also present, and obligate wetland plants were observed from the far bank.

There were areas along reach three where Bermuda grass and Johnsongrass had invaded in patches, with silverleaf nightshade (*Solanum eleagnifolim*) being the most prevalent forb along this reach. On the south bank (across from the park's boundary), there was one saltcedar (*Tamarix chinensis*) and one relatively small patch of giant cane (*Arundo donax*) observed. Musk thistle (*Carduus nutans*) was found rarely on the north bank, but had invaded the south riparian area. Annual rabbitsfoot grass (*Polypogon monspeliensis*) had also established in cracks of the bedrock in the river.

Erosion/Deposition Condition

The banks along reaches one and two were steep and showed evidence of being undercut, however, active erosion was not visible from opposite bank due to thick growth of vegetation, primarily poverty weed /Roosevelt baccharis (*Baccharis neglecta*) (Figure 4.8.4-1, right). In these two reaches, the banks were destabilized likely by past land use practices. The swale that was present appeared to redirect natural waterflow patterns, preventing the establishment of a gently sloping riparian zone (which was mentioned to Tomye Folts-Zettner as being present during the White House years). Purportedly, during LBJ's time, no vegetation besides grass was allowed to establish and "block the view" (Figure 4.8.4-2), and at some point, erosion started undercutting the banks. With the current establishment of vegetation, the banks were somewhat more stable, but flooding may continue to erode the areas where erosion has already begun.

Along reach three, the original bedrock of the Pedernales was present, with its natural characteristics. There was more slope to the bank and gravel bars present. The vegetation that was present helped to stabilize the banks along this stretch of the river, however, the game trails to the water were plentiful.

Additional Studies

The maintenance of the Texas White House property is a character defining feature of its cultural landscape (NPS 2006b). The Texas White House Cultural Landscape report mentions that "the prairie and riparian areas have long disappeared in favor of the designed landscape, but wildflowers native to the area, some planted by Mrs. Johnson, and some growing from wind-borne seeds, provide evidence of the natural communities at the site before it underwent development (NPS 2006b, p. 44).

Lyndon B. Johnson had a deep connection to the Texas Hill Country and its features that helped support the lifestyle he and Mrs. Johnson chose to live, including ranching



The LBJ Ranch on the Pedernales River. Note the ice that has formed almost across the little lake.

Figure 4.8.4-2. A photo taken along the riverbank in front of the Texas White House, showing a lack of riparian vegetation.

and recreational activities. Some of the activities and practices conflicted with the natural elements that serve to maintain a more functional riparian system, one that has a better chance of withstanding high flow events.

Over the years, park staff have submitted several technical assistance requests, requested studies and consultations with subject matter experts to determine the best management practices for preserving both the integrity of the cultural landscape and its associated structures, as well as the integrity of a properly functioning riparian system (Martin 1999; Martin 2008; LCRA 2006; Middleton 2004; NPS 2000; CESU agreement with Dr. Fred Smeins as cited in NPS 2000).

Martin (2008) summarized the hydrologic-related issues for the park, many of which are integral to maintaining a functional riparian corridor. Martin observed that the natural conditions along the north bank of the Pedernales River had been heavily altered by previous management practices, essentially leaving no riparian vegetation, prior to the establishment of the park. Martin examined photographs from the significant historic period of 1963-1973 and observed that vegetation wasn't always completely absent along the north bank. He concluded that "while the whole suite of riparian benefits would not be achieved with the restoration of only a thin strip...the very important benefit of bank stabilization may be accomplished or at least increased" (Martin 2008). This area is prone to flooding and a function of intact riparian vegetation is to help minimize bank erosion during high flow events. Park staff did erect fencing to keep cattle from grazing, and as a result, a narrow strip of riparian vegetation has been restored.

Martin also evaluated the floodplains in relation to the historical structures and concluded that the flooding conditions did not appear to be extremely hazardous to the historic structures nor increased in frequency due to the presence of the Hodges Dam (Martin 2008). Additionally, Middleton (2004) concluded that channel migration of the river has changed minimally since 1955 and is primarily controlled by the dipping bedrock outcrop that slopes toward the school along reach three. Martin (2008) speculated that the trees along the south bank helped to dissipate river flow, but that "the highway bridge downstream of the school likely creates a substantial backwater effect during larger flows" (Martin 2008).

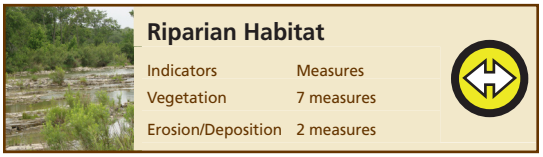
Table 4.8.4-2. Summary of the riparian habitat condition rationale.

Indicators	Measures	Condition	General Contribution of this Indicator or Measure to the Overall Resource Condition.
Riparian Vegetation	7 measures	Moderate	The condition of the measures to assess riparian vegetation were variable. The vegetation was in better condition in reach three than in reaches one and two. A thin strip of riparian vegetation has become established due to park efforts, but banks are still destabilized in areas due to limited types and amount of vegetation growing along the banks.
Erosion/ Deposition	2 measures	Moderate	The banks throughout reaches one and two have been destabilized, resulting in undercutting and erosion. Because of this, we consider the erosion/deposition processes to be in moderate condition.



NPS / B. CAREY

Figure 4.8.4-2. Vegetation regrowth along the electric fence and Pedernales River.



Overall Condition and Trend

Reaches one and two were comprised of man-made impoundments and there were areas of bank erosion and changes in channel and floodplain morphology that will not be recovered while in its present state. Reach three was in a more natural state, and is able to recover and maintain its natural form during higher flow events, and therefore, is in a more functional ecological condition than reaches one and two. Overall, Folts-Zettner (2014) considered the riparian system to be in moderate condition, primarily due to issues with erosion and considered the trend to be unchanging/stable. Condition rationale is summarized in Table 4.8.4-2.

Level of Confidence/Key Uncertainties

Southern Plains I&M biologist, Tomye Folts-Zettner, conducted the riparian assessment to evaluate the functional condition of the NHP's riparian habitat. Based on her expertise, we're confident that the findings accurately reflected the condition of the NHP's riparian habitat at the time of the assessment.

Threats

The park's Foundation Document (NPS 2014, p. 18) identifies the following threat to the riparian habitat, "the mandated and desired management actions for maintaining the cultural landscape along the Pedernales River (i.e., mowed grass down to the river) conflicts with needs for natural vegetation in the riparian areas. This vegetation would protect the north riverbank from erosion and flooding."

In 2002, park staff erected electric fencing to prevent cattle grazing on the river bottom pastures and altered riverbank mowing allowing riparian vegetation to regrow along the channel in an attempt to stabilize the bank (Figure 4.8.4-2). Also, staff have removed non-native plants, specifically musk thistle (*Carduus nutans*) using mechanical and chemical methods (NPS 2000). It's efforts like these that will help maintain the functionality of the riparian habitat, which in turn, will help preserve the cultural features that contribute to our nation's heritage.

4.8.5. Sources of Expertise

SOPN I&M Biologist, Tomye Folts-Zettner provided the expertise for this assessment. She has her Masters in Natural Resource Management and specializes in native and exotic vegetation and their ecosystems.

Technical assistance reports for the park were developed by NPS' Water Resources Division Michael Martin and were referenced for the purposes of this assessment. Mr. Martin is a hydrologist and has his Masters of Science in Watershed Science. Specialty areas include open channel flow, geomorphology, flood analysis, wetlands, and hydrology..

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4.9. Restoration Grasslands

Indicators/Measures

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

Condition – Trend - Confidence



Good – Improving - High

The vegetation at Lyndon B. Johnson NHP consists of a combination of common Texas Hill Country native plants and non-native species influenced by agriculture (Cogan 2007). Trees and shrubs at the Historical Park account for much of the native vegetation, while the grasslands were modified from their natural condition through seeding and irrigation. These altered grasslands (improved and unimproved pastures) and a restored grassland make up a significant proportion of the Historical Park and are an integral part of the cultural landscape (Figure 4.9.1-1).

Although both types of grassland areas are addressed in this section, the focus of the condition assessment is on the restoration grassland (Figure 4.9). The indicators and measures used for the restoration grassland were developed for use in relatively natural grasslands, so their use to assess condition in improved and unimproved pasture would not be appropriate. The improved and unimproved pastures are discussed below under Historic Context and in the Condition and Trend section.

4.9.1. Background and Importance

The central grassland region of North America is one of the largest contiguous grassland environments on earth (Lauenroth et al. 2008), and depending on which classification is used, there are at least three distinct grassland types: tallgrass prairie, mixed grass prairie, and shortgrass steppe (prairie). Lyndon B. Johnson NHP is located within the region generally classified as mixed grass prairie, but it is near and to the west of tallgrass prairie. The mixed grass prairie is considered a broad ecotone (separating the tallgrass prairie and shortgrass prairie; World Wildlife Fund and Hogan 2014). In the Central and Southern mixed grasslands region, from Nebraska to Texas, typical grasses may include little bluestem (*Schizachyrium scoparium*),



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Figure 4.9.1-1. Restoration grassland at Lyndon B. Johnson NHP.

Indiangrass (*Sorghastrum nutans*), and sideoats grama grass (*Bouteloua curtipendula*). Including its forb flora, the mixed grass prairie has the most diverse vegetation of the three grassland types.

Grasslands at Lyndon B. Johnson NHP

Grasslands at Lyndon B. Johnson NHP consist of an area of restored grassland within the Johnson City Unit and improved and unimproved pastures in both the Johnson City Unit and the Ranch Unit. These areas were depicted and described in a vegetation mapping project. The vegetation classification and mapping project was conducted at the Historical Park (Cogan 2007) as part of the USGS-NPS Vegetation Characterization Program, a cooperative effort by the U.S. Geological Survey (USGS) and the NPS to classify, describe, and map vegetation communities in more than 280 national park units across the United States. This program uses a hierarchical classification scheme, the National Vegetation Classification (NVC) Standard (http://biology.usgs.gov/npsveg/nvcs.html), as a basis for classifying vegetation. Cogan (2007) identified 22 map classes to describe the landscape (Figure 4.9.1-2). Among these were 11 NVC plant associations/alliances and one park special. The other 10 map classes were land use-land cover categories such as residential, agricultural business, and planted/cultivated. Five of the map classes are grasslands (Table 4.9.1-1), but two of the five classes have major exotic grass components. The exotic classes are Bermuda Grass Herbaceous Alliance and Silver Beardgrass-Johnsongrass Herbaceous Vegetation.

Precipitation at the Historical Park averages about 32 inches (81 cm) per year; May and September are the wettest months, and November, December, and January are the driest months (NPS, SOPN 2008). Snow and ice are rare, as typical winter temperatures are in the 50s°F (10°C). The climate is generally sunny and mild, except for during the summer when high humidities and high temperatures (100°F [38°C]) can occur.

Historic Context

Lyndon B. Johnson NHP tells the story of the 36th President by showing and interpreting

Table 4.9.1-1. The 11 different National Vegetation Classification (NVC) plant associations/alliances (and a Park Special) identified at Lyndon B. Johnson NHP (Cogan 2007) and their corresponding areas occupied. Shown in same order as Figure 4.9.1-2 legend.

NVC Common Name	NVC Plant Association/Alliance	Primary Class	Area (acres / hectares)	
Pecan-Sugar Hackberry Forest	*Carya illinoinesis - Celtis laevigata* Forest	Forest	14.4	5.8
Ashe Juniper Woodland Alliance	*Juniperus ashei* Woodland Alliance	Woodland	4.7	1.9
Plateau Live Oak / Little Bluestem Woodland	*Quercus fusiformis / Schizachyrium scoparium* Woodland	Woodland	53.0	21.5
Plateau Live Oak - Netleaf Hackberry Woodland	*Quercus fusiformis - Celtis reticulata* var. *reticulata* Woodland	Woodland	2.20	0.9
Honey Mesquite Woodland Alliance	*Prosopis glandulosa* Woodland Alliance	Woodland	10.5	4.3
Post Oak - Blackjack Oak Woodland Alliance	*Quercus stellata - Quercus marilandica* Woodland Alliance	Woodland	21.4	8.7
Sugar Hackberry Shrubland Stand (Park Special)	*Celtis laevigata* Shrubland Stand (Park Special)	Shrubland	1.73	0.7
Bermuda Grass Herbaceous Alliance	*Cynodon dactylon* Herbaceous Vegetation	Grassland	167.0	67.6
Hairy Grama - Sideoats Grama Herbaceous Vegetation	*Bouteloua hirsuta - Bouteloua curtipendula* Herbaceous Vegetation	Grassland	39.1	15.8
Restored Grassland Prairie	NA- No Scientific Name	Grassland	6.7	2.7
Silver Beardgrass - Johnsongrass Herbaceous Vegetation	*Bothriochloa laguroides - Sorghum halepense* Herbaceous Vegetation	Grassland	57.6	23.3
Switchgrass - Eastern Gammagrass Herbaceous Alliance	*Panicum virgatum - Tripsacum dactyloides* Herbaceous Alliance	Grassland	9.5	3.8

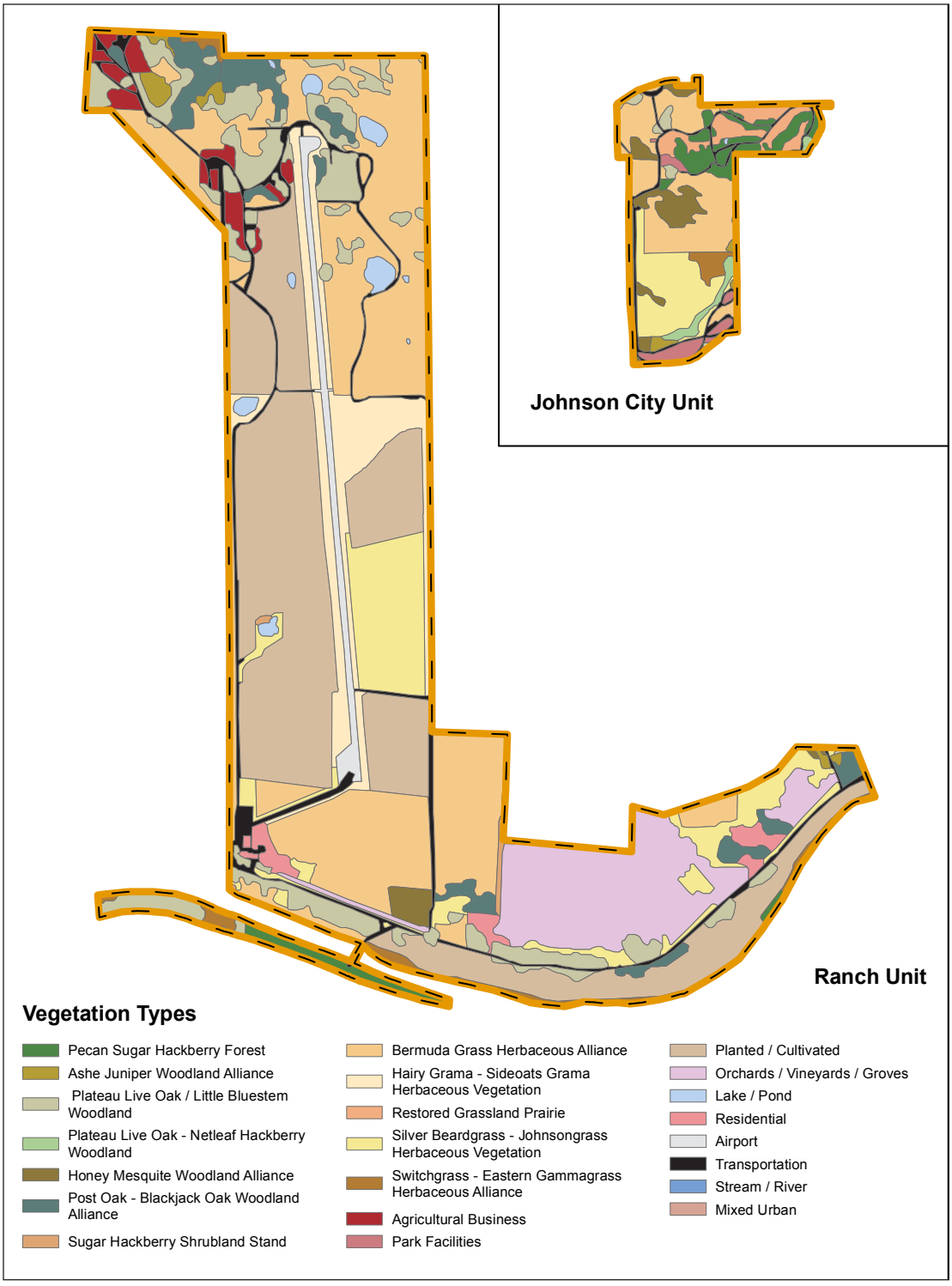


Figure 4.9.1-2. The 22 map classes identified by Cogan (2007) including the 11 plant associations/ and alliances used by the National Vegetation Classification (NVC) system.

the President's ancestral heritage, boyhood home, LBJ Ranch, and final resting place (NPS, SOPN 2008). Protecting and maintaining the natural environment and cultural heritage of the Texas Hill Country is one of the mission goals for the park (NPS, SOPN 2008). The predominant land use in the Pedernales River valley was and is ranching activities and orchards.

Most of the land within the Ranch Unit is a combination of improved pasture, unimproved pasture, and land that has not been reseeded and is being allowed to naturally revert to fallow cropland. These pastures are grazed by free-ranging Hereford cattle, as well as by native white-tailed deer and escaped, non-native blackbuck antelope (see Section 4.12 of the NRCA).Within

the Johnson City Unit are the restoration grassland, described below, and unimproved pasture. The unimproved pasture is actively grazed by both longhorn cattle and horses.

Although the improved and unimproved pastures are an integral part of the landscape within the Historical Park, we would not expect them to function as and provide the same ecological values as native, intact grasslands. In addition, they are actively grazed. It is for these reasons that we did not include them with the sites assessed for the condition assessment. During the site visit for the rapid assessment, however, three locations (one in the Johnson City Unit and two in the Ranch Unit) in pastures were visited, and information from this site visit is presented in the Condition and Trend section.

The restoration grassland is an area about 12 acres (4.9 ha) in size at the settlement area. Simmons (2005) described it as a "former pecan orchard/pasture representative of a disturbed, mesic grassland on the Edwards Plateau, with a selection of early and mid-succesional native grasses...as well as colonies of invasive grasses." The goal of the restoration is to restore the site "to a late-successional, pre-European mixed-grass prairie but with isolated native trees to produce savanna architecture" (Simmons 2005). The 2005 *Prairie Restoration Management Plan*, prepared by Mark Simmons of the Lady Bird Johnson Wildflower Center, provides a target site description, restoration methods, and management recommendations. An earlier report also for the site, *Native Prairie Restoration and Monitoring on the Lyndon B. Johnson NHP*, by Fred Smeins (Smeins 2003), also provided a description of the site and a plan and actions for restoration. Restoration drill-seeding took place in 2010, just prior to the onset of drought. While some response was seen, especially by forbs, grass seedlings most likely did not survive.

Conditions During Assessment

It is important to recognize that a drought occurred during the time period of this assessment. This area of central Texas has been in moderate to extreme drought for approximately three of the last five years (over 2010-2014). Some rain fell in late winter-spring 2014 (prior to the field assessment), but not enough to ease the drought (Folts-Zettner 2014). Figure 4.9.1-3 shows that the park vicinity was in drought conditions for two of the four years (2011, extreme drought; 2014, moderate drought). Although not shown in the figure, the comparable map for 2013 indicates that moderate drought conditions also existed in that year. Additional rain fell during the fall-winter of 2014-2015, and soil moisture has improved (although reservoirs in the area have not yet been replenished; Folts-Zettner 2014). We have taken these conditions into account in our interpretations, but the reader should be aware that such conditions may have an important impact on our assessment.

It is also worth noting that the restoration grassland was burned in late February 2015. This was the first burn in the area in over a decade, and the area is in the process of "greening-up." All of the data used for the condition assessment, however, were recorded prior to the 2015 burn.

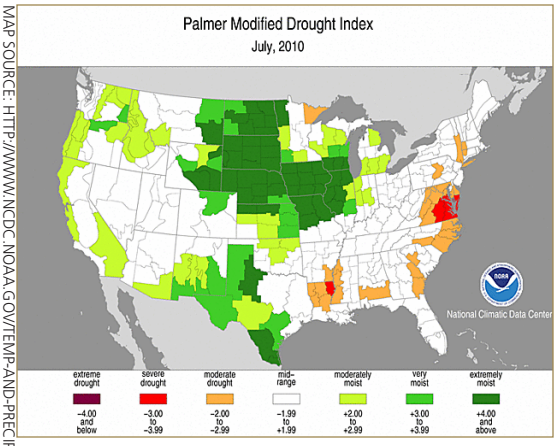
4.9.2. Data and Methods

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

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

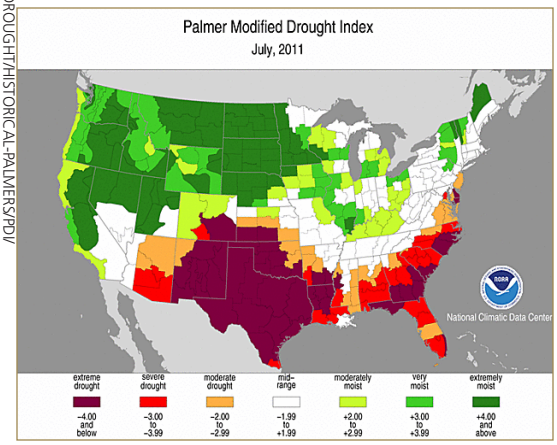
Hydrologic Function - The capacity of an area to capture, store, and safely release water from rainfall, run-off, and snowmelt (where relevant), to resist a reduction in this capacity, and to recover this capacity when a reduction does occur.

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



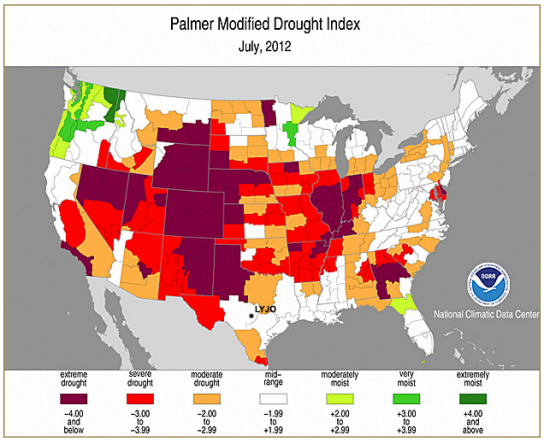


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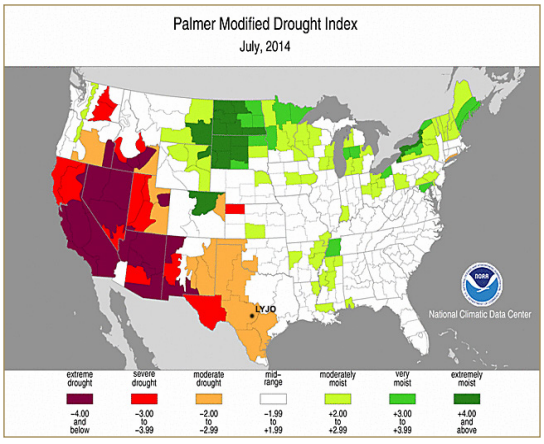


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MAP SOURCE: HTTP://WWW.NCDC.NOAA.GOV/TEMP-AND-PRECIP/DROUGHT/HISTORICAL-PALMERS/PDI/

Figure 4.9.1-3. The Palmer Modified Drought Index for each of the four years for which monitoring data from Lyndon B. Johnson NHP were available. Also shown to the right of the maps are photos taken from a monitoring transect (REST_LT02_0-50) during the corresponding time periods. All photos NPS. The location of the Historical Park is shown on the 2012 and 2014 maps.

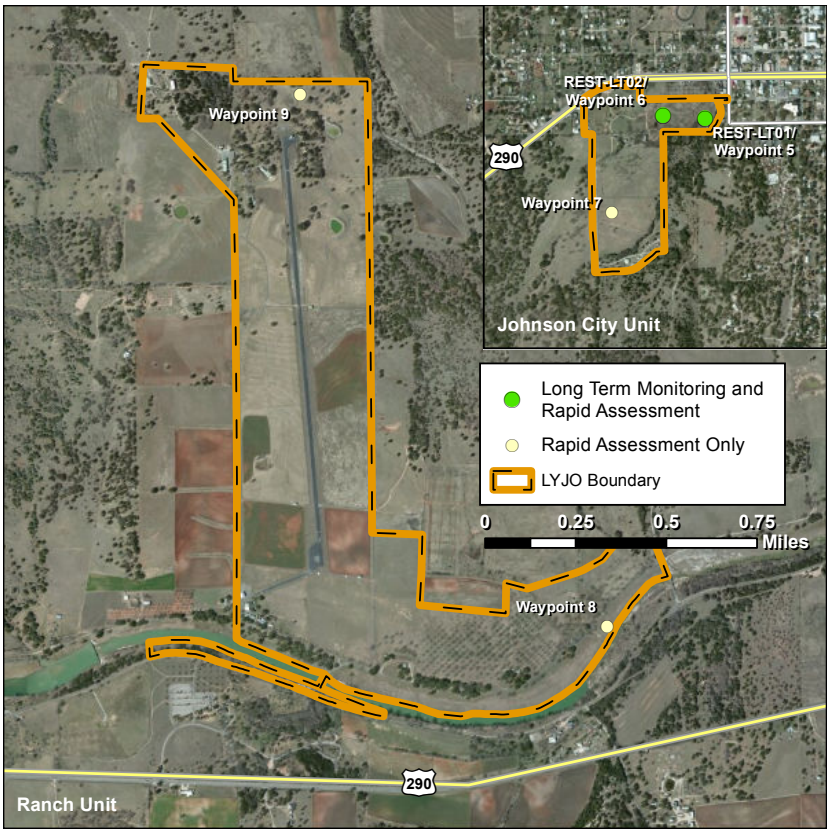


Figure 4.9.2-1. Location of Soil Rapid Assessment points and grassland monitoring plots at Lyndon B. Johnson NHP. General observations only were made at sites denoted by yellow dots.

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

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

The soil/site stability/hydrologic function measures were assessed primarily through a site visit and rapid assessment in May 2014 conducted by Tomye Folts-Zettner (Folts-Zettner 2014, Appendix E). Ms. Folts-Zettner is a botanist with SOPN and has a background in Natural Resource Management and Rangeland Ecology.

Indicator
Soil/Site Stability and Hydrologic Function

The rapid soil assessments consisted of evaluating two selected sites at the Historical Park (Figure 4.9.2-1, green points).

The methodology for these assessments used an approach based on those described in the qualitative assessment protocol *Interpreting Indicators of Rangeland Health* (Version 4.0; 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.

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 two selected evaluation areas, each of which were approximately 1/3 to 1/2 acre (0.13 to 0.2 ha) 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.

Indicator
Biotic Integrity

The assessment for the biotic integrity of grasslands was made via a combination of the rapid field assessment by SOPN botanist T. Folts-Zettner and data collected as part of the SOPN's ongoing grassland monitoring. The first task was to determine appropriate measures of grassland biotic integrity. Using the qualitative measures of rangeland health presented in Pellant et al. (2005) as a starting point, we developed a suite of five measures of grassland biotic integrity (summarized in Table 4.9.2-1 and described in greater detail below).

Based on these measures, the rapid field assessment was conducted at two sites in the restoration prairie at the Historical Park (green sites shown in Figure 4.9.2-1). We then used data collected during the past

Table 4.9.2-1. Indicators and measures used to assess grasslands at Lyndon B. Johnson NHP.

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 and/or biological soil crusts.
	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 complement 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 cool-season and warm-season species	The relative proportions of cool- and warm-season plants relative to what would be expected based on site characteristics.

four years of SOPN monitoring to augment the qualitative rapid assessment and provide a more quantitative baseline for future assessment. These data were collected by the SOPN and the Southern Plains Fire Group, following Folts-Zettner et al. (2011). Grassland monitoring data were collected in 2010-2012 and 2014 along two transects, each with five subplots, as part of this monitoring effort (Folts-Zettner et al. 2012, Folts-Zettner et al. 2013, Folts-Zettner et al. 2014; Figure 4.9.2-1). 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

the Historical Park 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 Historical Park vegetation mapping (Cogan 2007) with soil types (NRCS 2014a) and ecological sites (NRCS 2007).

Local Species Composition

The intent behind this measure is to see if the species composition is generally consistent with what might be expected for the site, given the local conditions (soils, disturbance, moisture, etc.). We considered this from two perspectives. First was the degree to which the local 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 Section 4.10. Here, we provide only 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 the site. This was based on a combination of NRCS Ecological Site Descriptions (ESDs) and professional judgement. As for other measures, this assessment is based primarily on percentage cover rather than the number of individual species; this is because most species are quite rare, and cover provides a more realistic assessment of species composition.

General Life Cycles Relative to Disturbance

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

Relative Proportion of Functional Groups

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

Relative Proportion of Cool-Season and Warm-Season Species

Mixed grass prairies typically have a high proportion of perennial 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 (e.g., cattle; Lauenroth et al. 2008). The proportion of cool-season and warm-season grasses can also dramatically influence how these grassland communities respond to climate change and levels of CO_2, although the nature of such response has been much debated (Wand et al. 1999).

4.9.3. Reference Conditions

Soil/Site Stability and Hydrologic Function

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

We considered the condition of grasslands as "good" if the current condition fell either within Pellant et al.'s (2005) "none to slight" or "slight to moderate" categories. The "moderate" ranking was assigned if the departure from optimal fell within Pellant et

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.

al.'s (2005) "moderate" class. And finally, we considered the condition of grasslands as "significant concern" if the departure from optimal fell within Pellant et al.'s (2005) "moderate to extreme" or "extreme to total" classes.

Biotic Integrity

Determining definitive quantitative reference conditions for grassland communities at Lyndon B. Johnson NHP 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 the Historical Park (Table 4.9.3-2). We recognize, however, that seasonal and annual variation in such things as rainfall and disturbance can result in dramatic shifts in specific measurement that are still within an acceptable range of natural variation. In particular, the drought conditions that have occurred in some recent years at the Historical Park may have dramatically 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 2014a) and ecological sites (NRCS 2007) 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 2014b) and professional experience as a general reference for plant community characteristics that might be expected given the soil types and ecological sites that occur at the Historical Park. It is important to note however, that 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, we use them as a general guide, in conjunction

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 complement 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 complement 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 complement 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 moderate 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 cool-season and warm-season species	Sites dominated by cool-season grasses at mixed grass sites traditionally dominated by warm-season grasses.	Higher than expected proportion of cool-season grasses given the ecological site and disturbance history.	Appropriate mix and natural variability of warm-season and cool-season grasses for the site (to maximize resilience).

with professional experience, to determine resource condition.

Finally, in this section on reference conditions, it is also important to refer to the discussion above under "Historic Context" (in Section 4.9.1). In our assessment of condition, we considered the past and present use of the land within the Historical Park. This consideration included past activities that moved the restoration grassland area and other grasslands (pastures) within the park away from a more natural grassland state.

4.9.4. Condition and Trend

Note that there are two main subsections in this Condition and Trend section. The first subsection addresses the grasslands at the Historical Park that are considered pastures; while they were briefly visited during the 2014 field assessment, they were not included in the overall condition assessment. The second subsection addresses the restoration grassland, which was the focus of the condition assessment.

Status of Grasslands (i.e., Pastures) not included in the Condition Assessment

The information presented in this subsection is based on the rapid field assessment/visit conducted by T. Folts-Zettner in May 2014 (Folts-Zettner 2014). The complete set of notes from the field visit is presented in Appendix E.

As of May 2014, the pastures on the Johnson City Unit were not overgrazed, but they were heavily invaded by exotic grasses and forbs. King Ranch bluestem (*Bothriochloa ischaemum*) and Kleburg bluestem (*Dichanthium annulatum*) were present, with King Ranch bluestem often the dominant grass. Any forbs present were annuals and usually either weedy, unpalatable natives (Texas broomweed [*Gutierrezia texana*]) or spiny exotics (Maltese starthistle [*Centaurea*

melitensis]). Woody invasion by native honey mesquite (*Prosopis glandulosa*) was obvious. These pastures generally appeared the same as other pastures within and outside of the park, so landscape-scale diversity was poor.

The Ranch pastures are about evenly divided between improved and unimproved pasture. The improved pastures were planted to a coastal selection of Bermuda grass (C*ynodon dactylon*), which is grazed and hayed. These pastures were irrigated up to the time of Lady Bird Johnson's death (in 2007), and have since persisted on rainfall. They were quite reduced in production but will improve with more plentiful rain. Other improved pastures have been used to grow feed grain, with grazing allowed following harvest. Several of these pastures have been taken out of production during the drought and are full of weedy annuals.

Remaining pasture at the Ranch Unit is composed of Bermuda grass that is maintained short by grazing or mowing. There are almost no native grasses present, and the forbs found are either weedy, annual natives with spines or toxins, or exotic, spiny species. Pasture along the riparian/road corridor is mowed to maintain the cultural scene, while the remainder is only grazed. Overall, there is little to no landscape-scale diversity, no biodiversity, poor functional group ratios, and limited cool-season grasses.

As previously noted, if these pasture areas had been assessed using the indicators and measures used for the restoration grassland, they would have rated as significant concern. However, it was not appropriate to use the same rating system for them due to their history and management.

Restoration Grasslands - Soil/Site Stability / Hydrologic Function

The information presented in the following sections is based on the grassland field assessment/visit conducted by T. Folts-Zettner in May 2014 (Folts-Zettner 2014) and the SOPN grassland monitoring data (2010-2012 and 2014), as described previously in the Data and Methods section.

The results from the rapid assessment indicated that the overall current condition of the soil/site stability/hydrologic function at the two sites at Lyndon B. Johnson NHP was good, with all but one of the 10 measures falling into the "none to slight" category (Table 4.9.4-1). Even the one "slight to moderate" measure fell under a "good" condition. It should be noted that some measures may be influenced by the drought conditions that have occurred in some recent years, which may be why both sites assessed

Table 4.9.4-1. The assessment of measures used to assess soil/site stability/hydrologic function at each of two rapid-assessment points at Lyndon B. Johnson NHP.

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

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

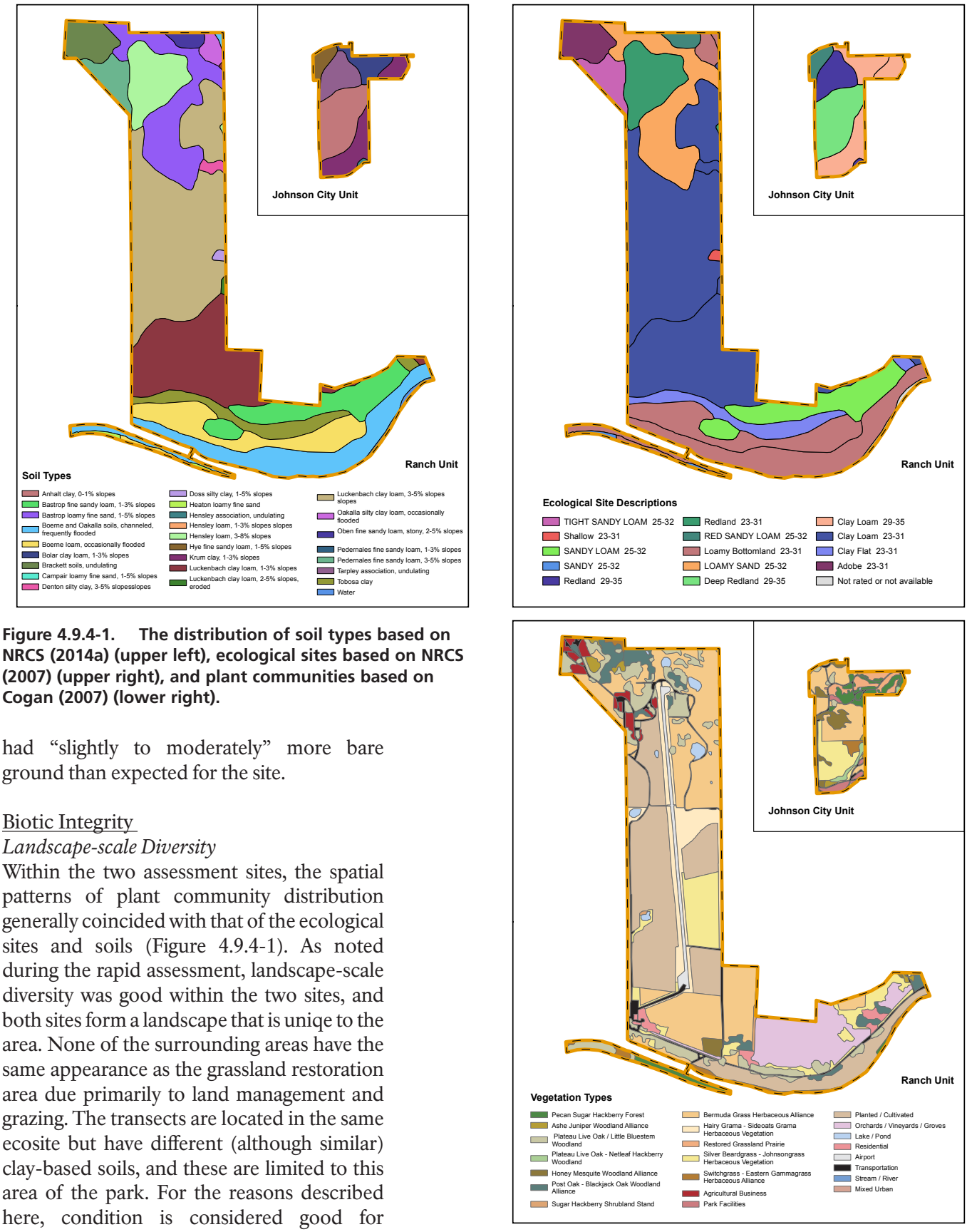


Figure 4.9.4-1. The distribution of soil types based on NRCS (2014a) (upper left), ecological sites based on NRCS (2007) (upper right), and plant communities based on Cogan (2007) (lower right).

had "slightly to moderately" more bare ground than expected for the site.

Biotic Integrity

Landscape-scale Diversity

Within the two assessment sites, the spatial patterns of plant community distribution generally coincided with that of the ecological sites and soils (Figure 4.9.4-1). As noted during the rapid assessment, landscape-scale diversity was good within the two sites, and both sites form a landscape that is uniqe to the area. None of the surrounding areas have the same appearance as the grassland restoration area due primarily to land management and grazing. The transects are located in the same ecosite but have different (although similar) clay-based soils, and these are limited to this area of the park. For the reasons described here, condition is considered good for this measure. There was no evidence for a degrading trend.

Table 4.9.4-2. The number and percentage of native and exotic species of each life form found on Lyndon B. Johnson NHP during the 2010-2012 and 2014 grassland monitoring sampling.

Life Form	Native	Exotic	Total	Percent Native
Grass	41	12	53	77%
Forb	108	6	114	95%
Subshrub	1	0	1	100%
Tree	5	0	5	100%
Vine	15	0	15	100%
TOTAL	170	18	188	90%

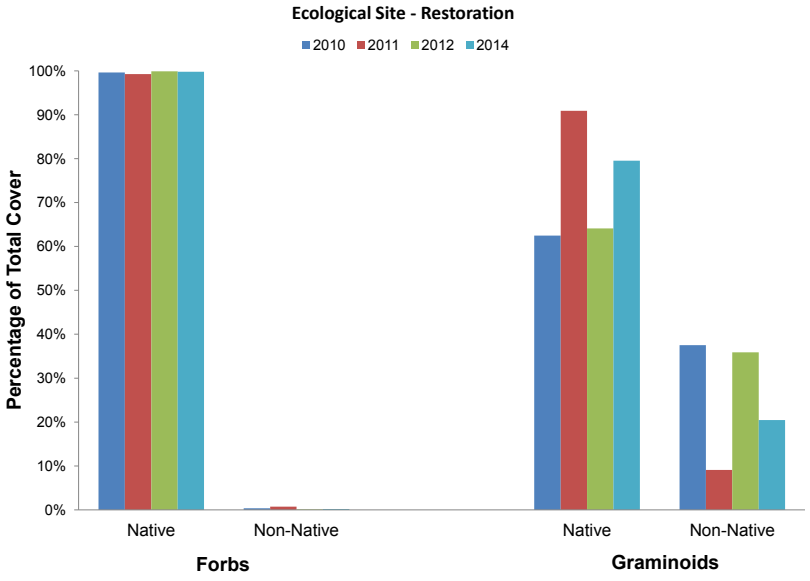


Figure 4.9.4-2. The percentage of total cover of native and exotic grasses and forbs for the restoration sites (two sites combined) sampled in 2010-2012 and 2014 at Lyndon B. Johnson NHP.

Local Species Composition

Species composition at local sites has probably been affected by ongoing drought conditions, and we have taken 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 plant communities of the appropriate ecological site descriptions (NRCS 2014), although we did take these descriptions into account.

Based on the rapid assessment, local species composition is considered to be good at both sites. At Site 1, there is an abundance of perennial forbs and cool-season grasses. However, there is more switchgrass (*Panicum virgatum*) than expected and less sideoats grama (*Bouteloua curtipendula*) and Indiangrass (*Sorghastrum nutans*) than expected. This, however, is probably a result of the drought during and prior to the rapid assessment and the over-grazing of Indiangrass several years before the assessment (Folts-Zettner 2014, Appendix E).

At Site 2, there is also a good presence of perennial forbs and cool-season grasses. There are more warm-season grasses present, such as little bluestem (*Schizachyrium scoparium*), and many large stands of switchgrass, but the presence of Indiangrass is lower than expected.

These results from the rapid assessment support a "good" condition for this aspect of this measure, but we also considered information from the annual grassland monitoring (described immediatley below).

Non-native 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).

Based on four years (2010-2012 and 2014) of grassland monitoring at the Historical Park, 170 of 188 (90%) 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 (95%) than grasses (77%). However, the number of species does not take into account how prevalent those species are on the landscape. Based on the percentage of cover, forbs on our sample plots were almost exclusively native species; grass cover, however, was approximately 40% non-native in two of the four monitoring years (Figure 4.9.4-2), but see the note below.

According to the rapid field assessment in May 2014, the condition of this measure is good. At both sites, annual species, especially forbs, were present and filling in areas of

bare ground caused by drought and the removal of trees and berms (conducted for grassland restoration). Most annuals within the landscape in these two sites were native.

Regarding the nearly 40% cover of non-native grasses in two of the years, the majority of the invasive grass was KR bluestem, which, through purposeful seeding along roadways and pastures, has become a major threat to native grasslands. However, native warm-season perennial grasses can out-compete KR during years with rain. During the drought, KR was quite robust while the natives were dormant; therefore, we observed higher percentages of this plant. However, during the time of the assessment in 2014, we had received rain and the natives were rapidly out-competing KR, both qualitatively and quantitatively. This factor, combined with burn efforts to control KR, supports the condition rating of "good."

These results are based on grassland monitoring plots and the rapid assessment sites. Two additional sources of information about exotics are the SOPN exotic monitoring transects and a supplementary exotic plant rapid assessment grid that was sampled in 2014. Both of these sources of information are presented in depth in Section 4.10 of this chapter. However, both of these sources of data focused exclusively on exotic species in order to gain a better understanding of their distribution and density, and therefore 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 they are not representative of grasslands in general.

General Life Cycles Relative to Disturbance

The proportion of annual, biennial, and perennial species provides an indication of the stability of a site. 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.

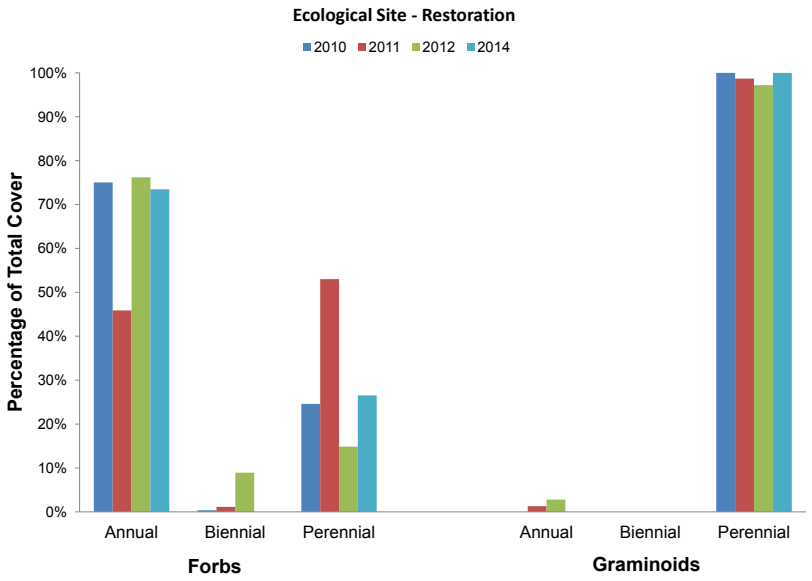


Figure 4.9.4-3. The percentage of annual, biennial, and perennial grasses and forbs for the restoration ecological sites (combined) in each year sampled.

Table 4.9.4-3. The percentage of perennial grass and forb species observed at both ecological sites (combined) on Lyndon B. Johnson NHP during the 2010-2012 and 2014 grassland monitoring sampling.

Ecological Site No.	Ecological Site Name	Life Form	% Perennials Observed 2010-2012 & 2014
1 and 2 combined	Restoration	Graminoid	99%
1 and 2 combined	Restoration	Forb	23%

Data from our grassland monitoring samples indicated that grasses were nearly all perennial (Figure 4.9.4-3). Forbs were more variable among years, but the majority in three of the four years were annuals (about 75%). Based on what is considered the historic climax plant communities (NRCS 2014b), the proportion of perennial species was generally expected to be high for grasses and more variable for forbs (Table 4.9.4-3). However, we did not expect the proportion of annuals, biennials, and perennials, to coincide exactly with historic climax plant communities, in part because of local site variability and the fact that these sites are not at climax stage.

A large number of annual forbs are to be expected in grasslands that have undergone frequent disturbance. This is the case in the restoration area that is a combination of early- and mid-successional microsites. This area

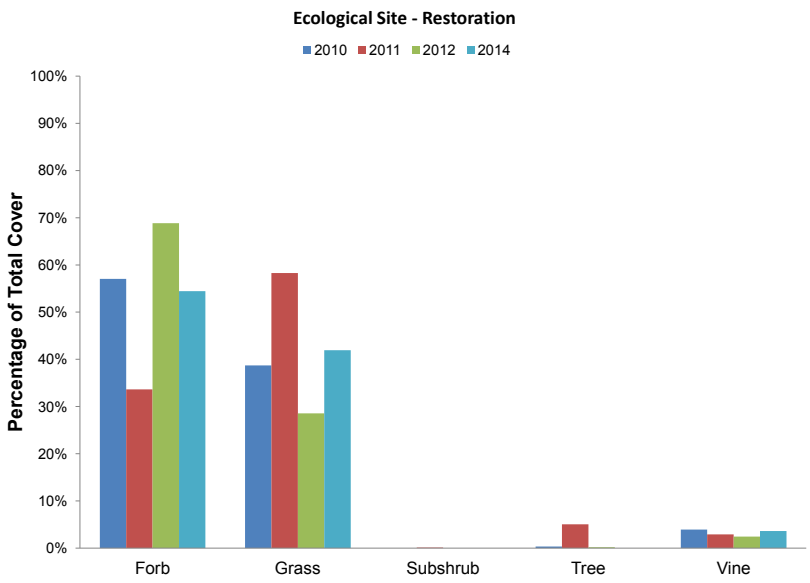


Figure 4.9.4-4. The percentage of life forms for the restoration ecological site samples (two sites combined) in 2010-2012 and 2014 at Lyndon B. Johnson NHP.

Table 4.9.4-4. The percentage cover of each life form observed at both ecological sites (combined) on Lyndon B. Johnson NHP during the 2010-2012 and 2014 grassland monitoring sampling.

Ecological Site Name	Life Form	Percent Observed 2010-2012 & 2014
Restoration	Graminoid	38%
	Forb	57%
	Subshrub	<1%
	Tree	<1%
	Vine	3%

has seen a period of over-grazing, several years of drought, and terrace-removal reseeded with a preponderance of annual forbs. It is expected that as the rains return and time since disturbance lengthens, greater numbers of perennial forbs will establish. Therefore, we do not find the current proportions of annuals, biennials, and perennials surprising.

In summary, there was little concern about this measure for the grasses, but the condition of this measure for forbs was more varied. Although the status is not surprising (for the reasons mentioned), we can not consider the proportion for forbs in good condition at this time. Therefore, based on the assessment, we considered the condition for this measure (considering both grasses and forbs) to be moderate to good, or moderate with a positive trend.

Relative Proportion of Functional Groups

Based on the annual grassland monitoring, the proportion of functional groups was somewhat variable among years, with more grasses than forbs occurring only in 2011 (Figure 4.9.4-4). Otherwise, forbs made up a greater percentage of cover (Table 4.9.4-4). Findings of the rapid field assessment indicated that the condition for this measure was good for both sites (Folts-Zettner 2014). At Site 1, there was a good mix of warm- and cool-season grasses and annual and perennial forbs. The presence of forbs may be greater than one would expect, but this may be a drought response (i.e., there was enough rain for forbs but not for grasses). Site 2 had more perennial grasses compared to Site 1, but some of the increase was due to dense stands of switchgrass (which was more abundant than desirable in some areas). Texas wintergrass (*Nasella leucotricha*), a perennial cool-season grass that is an important member of the landscape, was also responding well to rainfall. Also, in Site 2 there was a strong woody shrub component, made up mostly of Mustang grape (*Vitis mustangensis*) and dewberry (*Rubus aboriginum*), but there were also small junipers and mesquite saplings beginning to establish (Folts-Zettner 2014). A drop in the presence of woody species will probably occur in the future with use of prescribed burns. Based on the annual grassland monitoring alone, we might have considered the grasslands to be in moderate condition for this measure, but when taking its restoration status and the other factors discussed here into consideration, we considered it (marginally) good.

Relative Proportion of Cool-Season and Warm-Season Species

Results from the SOPN monitoring data indicated a predominace of warm-season grasses overall, but with the percent cover of cool-season and warm-season grasses being more similar in 2014 (Figure 4.9.4-5). The rapid assessment in 2014 found a strong component of cool-season grasses in both sites, mainly Texas wintergrass, Texas grama (*Bouteloua rigidiseta*), and Canada wildrye (*Elymus canadensis*). Warm-season grasses were dominated by switchgrass and the

exotic King Ranch bluestem (*Bothriochloa ischaemum* var. *songariucm*).

It is often the case that prairie sites are dominated by warm-season grasses in this region. The increase in cool-season grasses during 2014 is likely a direct result of the previous years of drought. The warm-season grasses were primarily dormant during the drought, and the amount of bare ground increased. Once the rains started in the fall of 2013, these bare areas were quickly colonized by annuals, some of which were grasses. The perennial cool-season Texas wintergrass proved very robust and persisted through the summer of 2014, while the perennial warm-season grasses began to recover. It is anticipated that the perennial warm-season grasses will again dominate the grasslands in 2015. The situation described here is a classic example of why it is important to have a mix of cool- and warm-season grasses to provide resilience to disturbance.

We considered this measure to be in good condition.

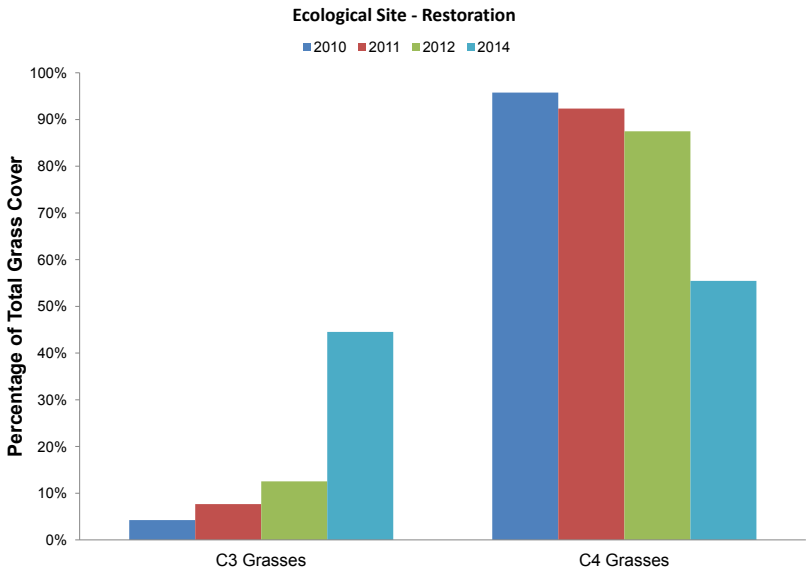


Figure 4.9.4-5. The percentage of cool-season (C3) and warm-season (C4) grasses for the restoration ecological sites (two sites) in 2010-2012 and 2014 at Lyndon B. Johnson NHP.

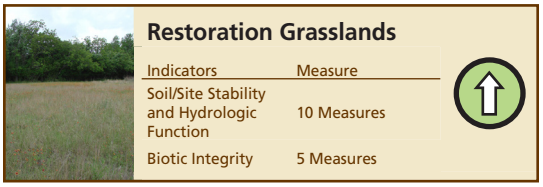
The Role of Fire in Grassland Condition at Lyndon B. Johnson NHP

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).

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. According to the ecological site descriptions (ESDs; NRCS 2014) for the restoration sites at the Historical Park, litter rates can range from 60-100%. The restoration area sites are within an area (Ecological Site: Clay Loam 29-35" PZ R081CY357TX) "where spring is reported as the principal fire season (Pyne, 1982). However, in the summer, when fuel loads accumulate and dry weather decreases fine fuel moisture, convection storms with their associated lighting suggest a peak of burning occurring every 7 to 35 years (Frost, 1998)" (taken from NRCS 2014).

The absence of fire is also generally thought to contribute to fuel accumulation, such that when fires do occur they may burn at a greater severity than they did historically, especially where shrubs have encroached. Whether fire has a positive, neutral, or negative effect on grassland condition at the Historical Park, however, will depend on several factors (e.g., season, frequency, potential for exotic plant response) that will need to be considered carefully by park staff and the fire management program. As mentioned in Section 4.9.1, the restoration grassland area did not experience a fire for more than a decade until it was burned in late February of 2015 (Folts-Zettner 2014). Managers at the Historical Park are also planning for future burns (Dave Schafer, Chief of Interpretation

and Resource Management, pers. comm.). The uncertainty associated with the use of fire as a vegetation management tool might also warrant that such action be undertaken using an adaptive management framework, including monitoring of the response.



Overall Condition

For assessing the condition of grasslands in the restoration area at Lyndon B. Johnson NHP, we used a variety of indicators/measures that were not mutually exclusive but were intended to be different ways to capture the essence of what we thought represented the condition of the restoration area's grasslands. Grassland condition can be assessed from many different angles, but we chose two main categories for this resource. A summary of how they contributed to the overall grassland condition is summarized in Table 4.9.4-5. Based on the measures and available data, we considered the overall condition of the restoration grasslands at the Historical Park to be in good condition (at the low end of the "good" scale) with an improving trend. In assessing condition, we took into account that the area is being restored from a degraded condition (i.e., heavily grazed, may have been plowed, portions placed into a pecan grove). If we had not taken these past activities into account, we may have held the restoration grasslands to a higher standard and found them to be in a lesser, moderate, condition.

For nearly all indicators and measures, condition was considered good. The moderate to extreme drought conditions that occurred in three of the years from 2010-2014 likely resulted in some of the observations reported here, such as a higher proportion of forbs than expected and a lower occurrence of desirable species such as sideoats grama and Indiangrass. The drought also exposed more bare soil than desirable and affected plant vigor. However, the sites assessed form a unique landscape in the area and at the Historical Park.

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 Lyndon B. Johnson NHP. However, the park continues to manage for the cultural landscape and continues to use the land largely as it was used at the time of Lyndon B. Johnson and his ancestors. Personnel at the Historical Park have worked to restore the 12 acres of mixed

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

Indicator	Measure	Overall Condition	Condition Rationale
Soil/Site Stability and Hydrologic Function	10 measures	Good	The overall good condition rating for this indicator reflects the condition ratings for the 10 measures. All 10 measures were considered to be in good condition. Nine of the ten measures had the highest rating ("none to slight"); one of the measures was in the "slight to moderate" category, but this category was still considered in good condition in accordance with the reference conditions.
Biotic Integrity	5 measures	Good	Similar to the measures of soils, measures of biotic integrity were consistently considered good. Four of the individual measures were considered to be in good condition, and the fifth was considered to be moderate to good (or moderate with an increasing trend). The vast majority of grassland species in the Restoration Grassland at Lyndon B. Johnson NHP are native (90%), and the percentage of total cover was dominated by native species (especially for forbs).

grass prairie in order to interpret the natural resources that originally drew Sam Johnson to locate his homestead there.

If the region continues to shift from drought conditions to more normal rainfall patterns, and as Historic Park management continues to address exotic plants and restoration of native prairies, we anticipate conditions to continue to improve for grasslands at Lyndon B. Johnson NHP.

Level of Confidence/Key Uncertainties

Overall, our confidence in this assessment is high, although as is generally the case, there are uncertainties. Some of the key uncertainties for the grassland assessment include annual variability, the effect of drought conditions, and the 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. This assessment was conducted largely 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 a more typical rainfall period.

4.9.5. Sources of Expertise

No outside experts were consulted for this assessment. Tomye Folts-Zetter, botanist with SOPN, conducted the on-site rapid assessment.

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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 – Insufficient data - Moderate

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

The spread of invasive species is one of the most environmentally serious global changes, causing economic and environmental damage in the United States and worldwide (UCSUSA 2008). Consequently, the dynamic relationships among plants, animals, soil, and water established over many thousands of years are at risk of being destroyed in a relatively brief period. For the National Park



NPS PHOTO

Figure 4.10.1-1. Native wildflower displays at Lyndon B. Johnson NHP may be imperiled by infestations of exotic plants.

Service (NPS), the consequences of these invasions present a significant challenge to the management of the agency's natural resources "unimpaired for the enjoyment of future generations." National parks, like land managed by other organizations, are deluged by new exotic species arriving through predictable (e.g., road, trail, and riparian corridors), sudden (e.g., long-distance dispersal through cargo containers and air freight), and unexpected anthropogenic pathways (e.g., weed seeds in restoration planting mixes). Nonnative plants claim an estimated 4,600 acres per day on federal lands alone in the Western United States, quadrupling their range from 1985-1995, claiming approximately 17 million acres (BLM 2011) and significantly altering local flora. For example, in Great Smoky Mountains National Park, over ¼ of the plants (27%) are non-native species. On the big island of Hawaii 35% of the plants are non-native (Pimentel et al. 2005). Invasive plants are dominant on approximately 5% of the lands managed by the NPS (NPS 2009).

The presence of exotic plants at Lyndon B. Johnson NHP may impair native wildflower populations. Sanders (2004) reports that the spread of exotic turf grasses may have reduced the display of wildflowers in areas within the Ranch Unit of the park. The park's General Management Plan indicates the park will maintain and encourage the growth of wildflowers as part of the continued legacy of Lady Bird Johnson (NPS 1999).

4.10.2. Data and Methods

In assessing current condition and trend for exotic plants at Lyndon B. Johnson NHP, 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 park. 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 park 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 park sites that can be spatially represented and used for data analysis (Folts-Zettner et al. 2013). The protocol involves regular monitoring of high priority vectors/blocks (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 a new area is surveyed each year (a panel) for three years. At the NHP, the sampling scheme was modified so the prairie restoration site along Settlement Trail prairie in the Johnson City Unit is the only area monitored in the NHP, which occurs in late May each year (Figure 4.10.2-2). The prairie restoration site is the only unmowed semi-natural site available for this monitoring (NPS 2012). Most of the park is managed for cattle grazing, and includes grazed pastures and hay fields (NPS 2014a). The objective of the prairie restoration project is to restore the site to a pre-European mixed grass prairie (Simmons 2005).

It is important to emphasize that SOPN's sampling approach does not provide a complete survey of exotic plants throughout the park. Instead, it provides a repeated snapshot for a limited area with high potential (e.g., along a trail) for new invasions.

We utilized SOPN's annual monitoring data collected between 2012 - 2014 to report

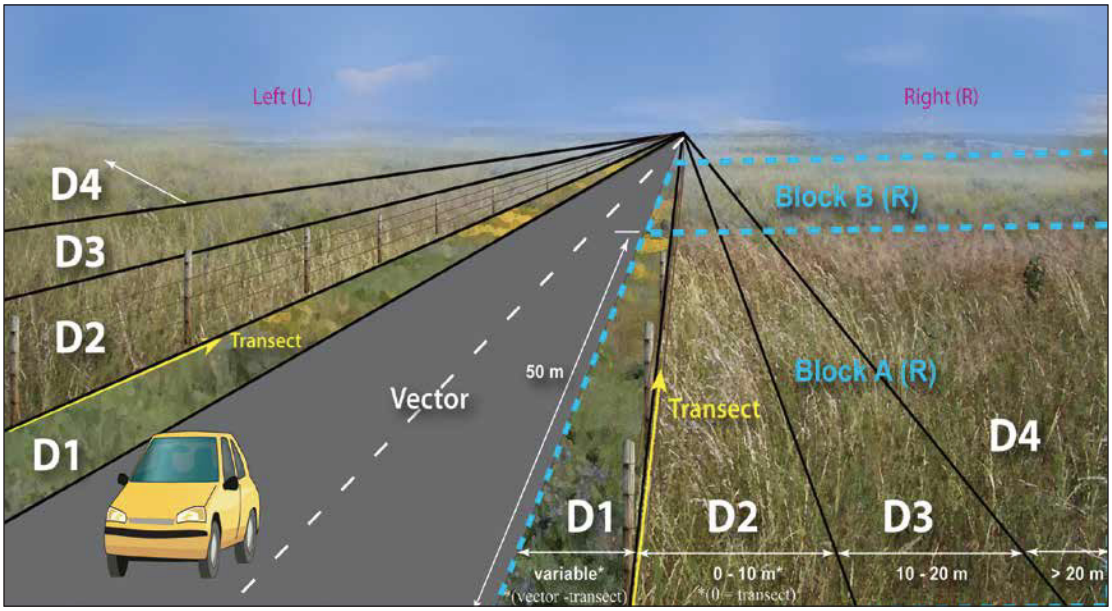


Figure 4.10.2-1. Fifty meter blocks are sampled on each side of a high-risk vector (e.g., roads and trails).

the most current condition of the park's exotic plants (Folts-Zettner and Sosinski 2012a; 2013; 2014). The SOPN has utilized this protocol to monitor the historical park since 2009, with the Settlement Trail being surveyed annually starting in 2010 (Folts-Zettner and Sosinski 2010a; 2010b; 2012a). Data from these past years are comparable to the current data. Other sources of information about exotic plant species found in Lyndon B. Johnson NHP include the park's vascular plant list (Sanders 2004), vegetation map (Cogan 2007), and the exotic species list maintained by the SOPN (Folts-Zettner 2014).

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 May 2014 (Horsley and Schafer 2014). The purpose of the rapid assessment is to collect information about the presence of exotic species in other areas of the historical park for the purposes of this condition assessment.

For the rapid assessment, a point grid is developed for the park (Folts-Zettner, SOPN biologist, personal communication, 2014). Points are usually 150 meters apart, and exotic species are 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 Folts-Zettner et al. (2013), but without utilizing distance classes as in the vector monitoring.

Monitoring during the 2014 rapid assessment was also limited to more natural areas of the Historical Park (Folts-Zettner, SOPN Biologist, personal communication, 2014). Two areas of the Johnson City Unit were assessed. Seven plots were monitored in the prairie restoration area, and eight plots were monitored in the "Back 40," which is a grazed pasture located at the south end of the unit.

In the LBJ Ranch Unit, approximately 14 miles west of the Johnson City Unit, two areas were monitored. Twenty-seven plots were located in a grazed pasture in the northern portion of the unit, and 23 plots were located in the riparian corridor along the Pedernales River. Riparian corridors are significant vectors for exotic plant introduction and dispersal (Folts-Zettner, SOPN Biologist, personal communication, 2014).

Both SOPN annual monitoring locations and plots for the one time rapid assessment that took place in 2014 are shown in Figure 4.10.2-2.

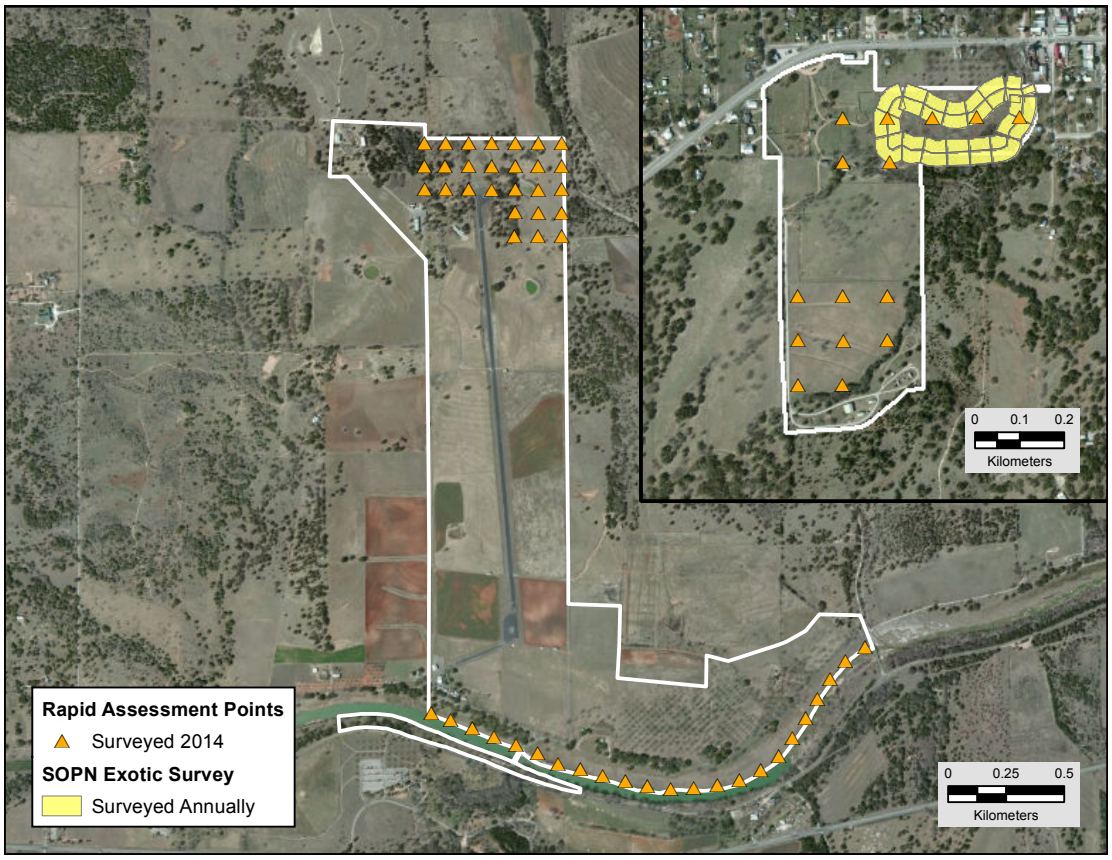


Figure 4.10.2-2. Areas within Lyndon Johnson NHP surveyed during SOPN annual monitoring and during the one time 2014 SOPN rapid assessment.

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 park 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 its 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 throughout the NHP 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 NHP are reported in Table 4.10.2-1. Nine species were ranked as having the highest concern, with three species having high concern.

Although they 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 two additional species of

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 Hiebert and Stubbendieck's (1993) Handbook for Ranking Exotic Plants for Management and Control.

Species	Common Name	Ranking
Bothriochloa ischaemum var songarica[1]	king ranch bluestem	Highest
Bromus catharticus	rescue brome	Low
Bromus japonicus[1]	Japanese brome	High
Bromus lanceolatus	Mediterranean brome	Low
Bromus tectorum[3]	cheatgrass	Highest
Capsella bursa-pastoris	shepardspurse	Low
Carduus nutans[1]	nodding musk thistle	High
Centaurea melitensis[1]	Malta starthistle	High
Conium maculatum[1]	poison hemlock	Highest
Cynodon dactylon[2]	Bermudagrass	Low
Daucus carota	Queen Anne's lace	Medium
Eragrostis barrelieri[1]	Mediterranean lovegrass	Highest
Erodium cicutarium	redstem stork's bill	Medium
Galium divaricatum	Lamarck's bedstraw	Low
Hordeum vulgare	cereal barley	Low
Lolium perenne ssp multiflorum	perennial rye grass	Low
Lonicera japonica[1]	Japanese honeysuckle	Highest
Marrubium vulgare	horehound	Medium
Medicago lupulina	black medick clover	Medium
Medicago minima	burr medick clover	Medium
Medicago polymorpha	burclover	Medium
Melilotus officinalis[2]	yellow sweetclover	Low
Mentha spicata	spearmint	Medium
Paspalum dilatatum	dallis grass	Low
Poa annua[1]	annual bluegrass	Highest
Poa pratensis[1]	Kentucky bluegrass	Highest
Rumex patientia	patience dock	Medium
Schedonorus arundinaceus[1]	tall fescue	Highest
Sherardia arvensis	blue fieldmadder	Low
Sonchus asper	spiny sowthistle	Medium
Sorghum halepense[1]	Johnsongrass	Highest
Stellaria media	common chickweed	Medium
Taraxacum officinale	dandelion	Medium
Torilis arvensis	spreading hedgeparsley	Medium
Torilis nodosa	knotted hedgeparsley	Medium
Verbascum thapsus	mullein	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) are highlighted in the lighter tone.

[1]The detections of *Bromus tectorum* may be due to a species misidentification as a result of phenology (e.g., seed heads not present) at the time of monitoring (Folts-Zettner, SOPN biologist, personal communication, 2014).

Three species, *Calyptocarpus vialis, Cyperus esculentus,* and *Euphorbia dentata*, about where there is a debate about their native or nonnative status (Folts-Zettner, SOPN Biologist, personal communication, 2014) that are included in the SOPN monitoring for exotic plant species, are not included in this assessment.

special concern at the historical park: *Cynodon dactylon* (Bermudagrass), and *Melilotus officinalis* (yellow sweetclover). These species have characteristics such as their abundance, impact on native wildflowers, and ability to form monocultures, and that make their impact in the type of ecosystems found in the park especially noteworthy. These species will be discuss further in Section 4.10.4.

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.

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.

Measure
Extent of Exotic Plants

Extent is 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, indicating that an exotic species was identified a certain number of times. The extent is the percentage of the surveyed blocks or plots that contained a specific exotic species, or the frequency that blocks 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) 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 G.

SOPN Annual Exotic Plants Monitoring

Exotic plants were detected in all blocks and some contained as many as twelve different exotic species. A total of 26 different species were identified (Table 4.10.2-3), with six species found in at least half the blocks. Eleven of the twelve species ranked as high or highest for their potential to alter native plant

Table 4.10.2-3. Extent of exotic plant species detected in annual SOPN high priority monitoring blocks along the Settlement Trail sampled in 2012-2014.

Species	No. Blocks	% (N=96)
Bothriochloa ischaemum[1]	89	92.71%
Sorghum halepense[1]	62	64.58%
Cynodon dactylon[2]	59	61.46%
Medicago lupulina	51	53.13%
Medicago minima	49	51.04%
Torilis arvensis	48	50.00%
Paspalum dilatatum	43	44.79%
Taraxacum officinale	31	32.29%
Bromus japonicus[2]	30	31.25%
Bromus tectorum[1]	20	20.83%
Bromus catharticus	16	16.67%
Lonicera japonica[1]	11	11.46%
Lolium perenne	9	9.38%
Poa annua[1]	8	8.33%
Hordeum vulgare	7	7.29%
Centaurea melitensis[1]	5	5.21%
Galium divaricatum	4	4.17%
Sherardia arvensis	3	3.13%
Torilis nodosa	3	3.13%
Daucus carota	2	2.08%
Poa pratensis[1]	2	2.08%
Carduus nutans[1]	1	1.04%
Eragrostis barrelieri[1]	1	1.04%
Marrubium vulgare	1	1.04%
Medicago polymorpha	1	1.04%
Sonchus asper	1	1.04%

[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.

communities (shown in Table 4.10.2-1) were found during monitoring.

Two species of highest concern were particularly widespread. *Bothriochloa ischaemum* (king ranch bluestem) was found in nearly 93% of the blocks. *Sorghum halepense* (Johnsongrass) was found in approximately 65% of the blocks. B*romus japonicus* (Japanese brome), a species of high concern, and *Cynodon dactylon*, of special concern, also had wide extent, and were found in approximately 61% and 31% of the blocks.

SOPN 2014 Rapid Assessment

Twenty-eight species were detected during the SOPN 2014 rapid assessment (Table 4.10.2-4), with only *Cynodon dactylon*, a species of special concern, being found in the majority (75%) of plots. Seven species of highest or high ecological concern were found during the rapid assessment, with *Bothriochloa ischaemum* found in 41.5% of the plots, *Carduus nutans* (nodding musk thistle) in 38.5% of the plots, *Bromus japonicus* in nearly 37% of the plots, and *Sorghum halepense* in 32.3% of the plots.

Many exotic plants found during the 2014 rapid assessment did not have a wide extent. Seventeen species (60.7%) were found in less than 10% of the plots, including eight species that were found in only one plot.

Table 4.10.2-4. Extent of exotic plant species detected in SOPN rapid assessment plots sampled in 2014.

Species	No. Plots	% (N=65)
Cynodon dactylon	49	75.38%
Bothriochloa ischaemum	27	41.54%
Carduus nutans	25	38.46%
Bromus catharticus	24	36.92%
Medicago minima	21	32.31%
Sorghum halepense	21	32.31%
Bromus japonicus	20	30.77%
Lolium perenne	16	24.62%
Marrubium vulgare	15	23.08%
Torilis arvensis	11	16.92%
Centaurea melitensis	7	10.77%
Conium maculatum	6	9.23%
Verbascum thapsus	5	7.69%
Sonchus asper	4	6.15%
Bromus lanceolatus	3	4.62%
Medicago lupulina	3	4.62%
Paspalum dilatatum	3	4.62%
Erodium cicutarium	2	3.08%
Rumex patientia	2	3.08%
Sherardia arvensis	2	3.08%
Capsella bursa-pastoris	1	1.54%
Daucus carota	1	1.54%
Melilotus officinalis	1	1.54%
Mentha spicata	1	1.54%
Schedonorus arundinaceus	1	1.54%
Stellaria media	1	1.54%
Taraxacum officinale	1	1.54%
Torilis nodosa	1	1.54%

[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.

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 and 2014 SOPN rapid assessment monitoring, 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 for that species.

These density classes are as follows:

- 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 SOPN 2012-2014 annual monitoring in Table 4.10.2-5 and for all exotic species identified during SOPN's 2014 one-time rapid assessment in Table 4.10.2-6.

The densities of the two species (*Bothriochloa ischaemum* and *Sorghum halepense)* that

Table 4.10.2-5. Density of exotic plants in SOPN 2012-2014 vector blocks along the Settlement Trail in Lyndon B. Johnson NHP, 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
Bothriochloa ischaemum[1]	134	11.19%	88.06%	0.75%	
Sorghum halepense[1]	111	34.23%	65.77%		
Cynodon dactylon[2]	71	4.23%	95.77%		
Medicago minima	65	10.77%	84.62%	4.62%	
Torilis arvensis	60	30.00%	70.00%		
Medicago lupulina	57	3.51%	96.49%		
Bromus japonicus[1]	53	18.87%	81.13%		
Paspalum dilatatum	53	15.09%	84.91%		
Taraxacum officinale	36	50.00%	50.00%		
Bromus tectorum[1]	31	12.90%	87.10%		
Bromus catharticus	22	36.36%	63.64%		
Lonicera japonica[1]	13	23.08%	76.92%		
Poa annua[1]	12	50.00%	50.00%		
Lolium perenne	11	63.64%	36.36%		
Hordeum vulgare	9	33.33%	66.67%		
Centaurea melitensis[1]	7	42.86%	57.14%		
Daucus carota	4	50.00%	50.00%		
Poa pratensis[1]	4		100.00%		
Sherardia arvensis	4		100.00%		
Torilis nodosa	4	25.00%	75.00%		
Galium divaricatum	2	100.00%			
Carduus nutans[1]	1	100.00%			
Eragrostis barrelieri[1]	1	100.00%			
Marrubium vulgare	1	100.00%			
Medicago polymorpha	1	100.00%			
Sonchus asper	1			100.00%	

The number of occurrences includes those in all distance classes from the vector. Density classes are from (Folts-Zettner et al. 2011). The prairie restoration site along the Settlement Trail is located in the Johnson City Unit. 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.

pose the highest concern for their impact to alter native plant communities and have wide extents are shown in Figures 4.10.2-3, and 4.10.2-4, respectively. For the annual monitoring, these maps show the densities of the plants in the distance class closest to the actual vector only. Density maps for the additional species are located in Appendix F).

SOPN Annual Exotic Plants Monitoring

Exotic species were most often found in density class 2 (scattered patchy) during the 2012-2014 SOPN monitoring of the prairie restoration site (Table 4.10.2-5).

Only four species were detected at evenly scattered densities (class 3) in the 2012-2014 monitoring, and only one of these species, *Bothriochloa ischaemum*, is of highest concern for its potential to alter native plant communities. No exotic species formed a matrix along the Settlement Trail vector.

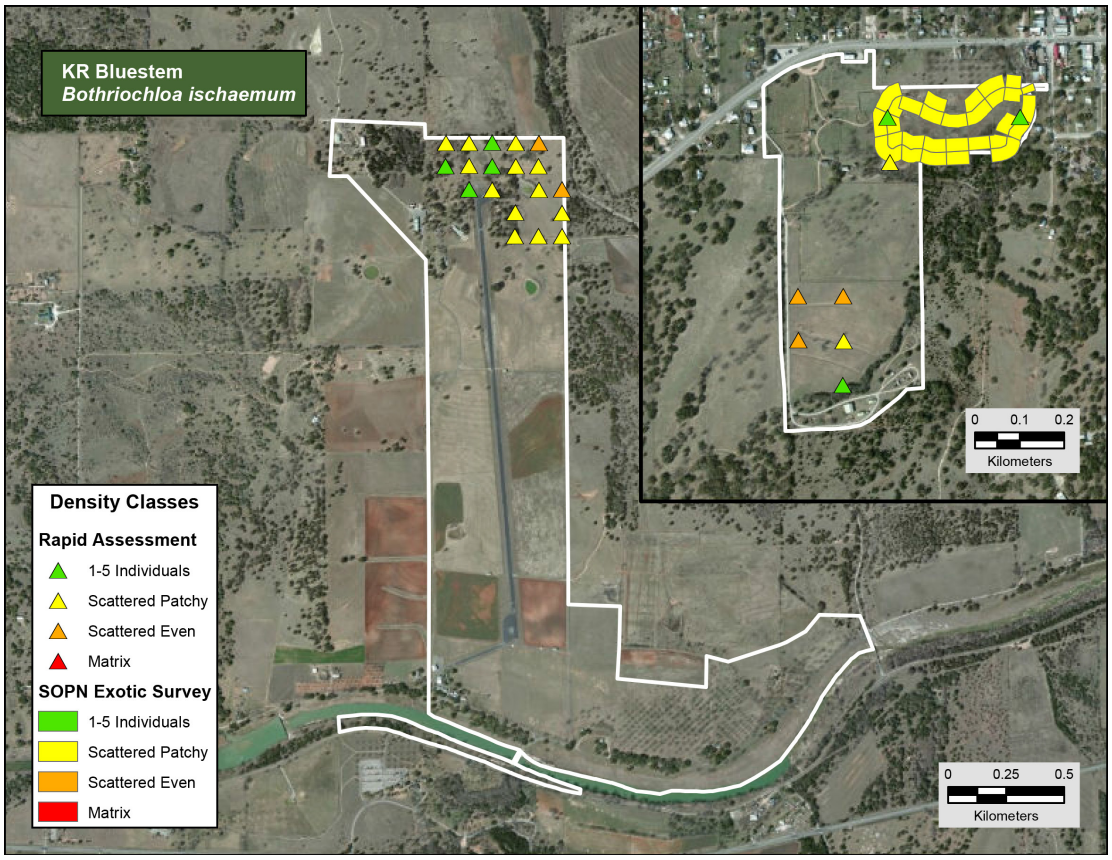


Figure 4.10.2-3. *Bothriocloa ischaemum* plant density based on surveys conducted during SOPN's 2012-2014 annual monitoring and SOPN's 2014 rapid assessment.

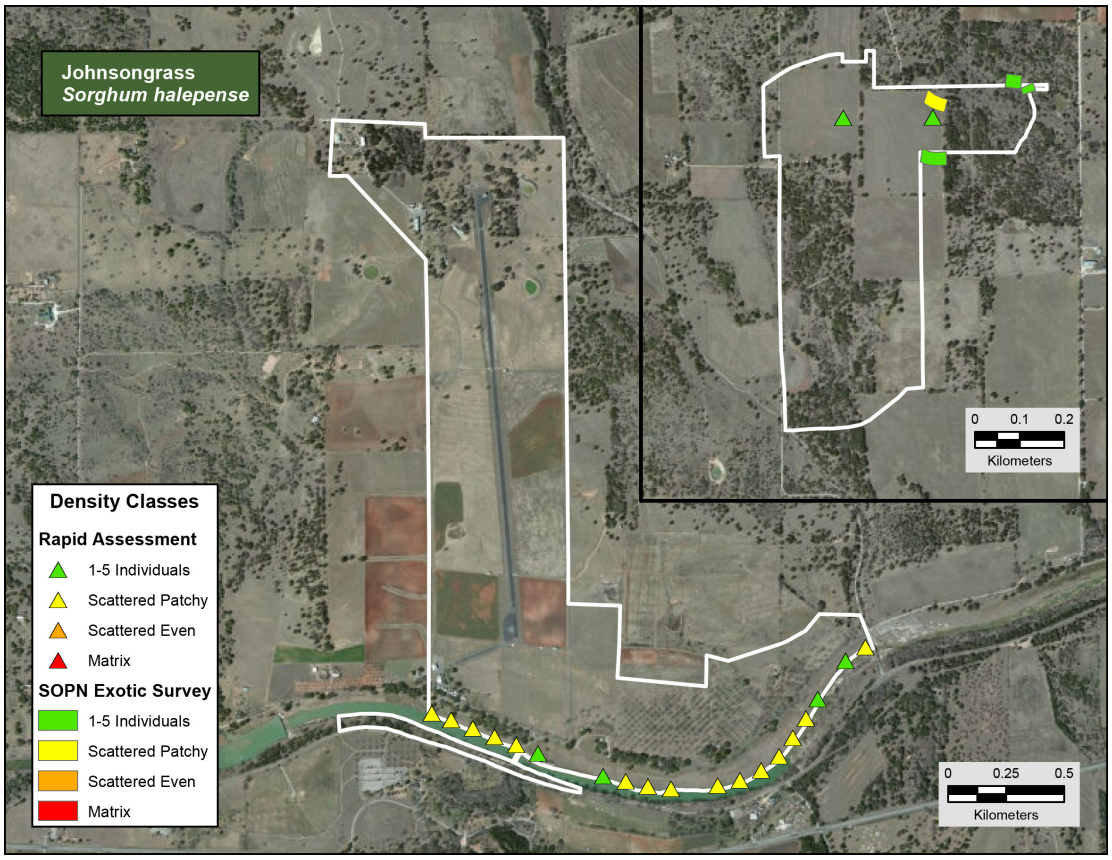


Figure 4.10.2-4. *Sorghum halepense* plant density based on surveys conducted during SOPN's 2012-2014 annual monitoring and SOPN's 2014 rapid assessment.

Table 4.10.2-6. Density of exotic plants in SOPN 2014 rapid assessment plots in Lyndon B. Johnson NHP, 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
Cynodon dactylon[2]	49	2.04%	51.02%	42.86%	4.08%
Bothriochloa ischaemum[1]	27	25.93%	55.56%	18.52%	
Carduus nutans[1]	25	76.00%	24.00%		
Bromus catharticus	24	29.17%	66.67%	4.17%	
Medicago minima	21	9.52%	80.95%	9.52%	
Sorghum halepense[1]	21	28.57%	71.43%		
Bromus japonicus[1]	20	15.00%	85.00%		
Lolium perenne	16	12.50%	81.25%	6.25%	
Marrubium vulgare	15	33.33%	53.33%	13.33%	
Torilis arvensis	11	36.36%	63.64%		
Centaurea melitensis[1]	7	28.57%	71.43%		
Conium maculatum[1]	6	83.33%	16.67%		
Verbascum thapsus	5	80.00%	20.00%		
Sonchus asper	4	100.00%			
Bromus lanceolatus	3	33.33%	66.67%		
Medicago lupulina	3	66.67%	33.33%		
Paspalum dilatatum	3	33.33%	66.67%		
Erodium cicutarium	2	50.00%	50.00%		
Rumex patientia	2	50.00%	50.00%		
Sherardia arvensis	2	50.00%	50.00%		
Capsella bursa-pastoris	1		100.00%		
Daucus carota	1	100.00%			
Melilotus officinalis[2]	1	100.00%			
Mentha spicata	1	100.00%			
Schedonorus arundinaceus[1]	1	100.00%			
Stellaria media[1]	1	100.00%			
Taraxacum officinale	1	100.00%			
Torilis nodosa	1	100.00%			

[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.

Most of the species that had extremely limited extent along the vector (e.g., found in only one block) were also found in a low density class (class 1; 1-5 plants per block), with the exception of *Sonchus asper* (spiny sowthistle) which occurred in only one block, but in density class 3 (scattered even).

SOPN 2014 Rapid Assessment

Exotic plant species were also mostly detected in density class 2 during SOPN's 2014 rapid assessment (Table 4.10.2-6). Six different species, *Bothriochloa ischaemum*, *Bromus catharticus* (rescue brome), *Cynodon dactylon*, *Lolium perenne* (perennial rye grass), *Marrubium vulgare* (horehound), and *Medicago minima* (burr medick clover), were surveyed at density class 3 or higher. *Cynodon dactylon* was recorded at density class 3 (scattered even) in 21 plots and formed a matrix in two plots. In 85% of the plots in which it was found, *Bromus japonicus*, a

Table 4.10.2-7. Distribution of exotic plants found in Lyndon B. Johnson NHP, with the proportion of infested plots in each of the four separate areas monitored during the SOPN rapid assessment (2014).

Species	Johnson City Unit		LBJ Ranch Unit	
	Restoration Site (N=7)	Back 40 (N=8)	Riparian (N=27)	North End (N=23)
Bothriochloa ischaemum[1]	42.86%	62.50%		70.37%
Bromus catharticus	28.57%	12.50%	47.83%	37.04%
Bromus japonicus[1]	14.29%	75.00%	47.83%	11.11%
Bromus lanceolatus			13.04%	
Capsella bursa-pastoris				3.70%
Carduus nutans[1]			30.43%	66.67%
Centaurea melitensis[1]	14.29%		4.35%	18.52%
Conium maculatum[1]			8.70%	14.81%
Cynodon dactylon[2]	71.43%		86.96%	88.89%
Daucus carota	14.29%			
Erodium cicutarium	14.29%			3.70%
Lolium perenne ssp multiflorum		25.00%	21.74%	33.33%
Marrubium vulgare				55.56%
Medicago lupulina	28.57%	12.50%		
Medicago minima	85.71%	75.00%		33.33%
Melilotus officinalis[2]			4.35%	
Mentha spicata				3.70%
Paspalum dilatatum	28.57%			3.70%
Rumex patientia			8.70%	
Schedonorus arundinaceus[1]			4.35%	
Sherardia arvensis				7.41%
Sonchus asper			13.04%	3.70%
Sorghum halepense[1]	28.57%		73.91%	
Stellaria media				3.70%
Taraxacum officinale	14.29%		21.74%	
Torilis arvensis	14.29%	25.00%	34.78%	
Torilis nodosa				3.70%
Verbascum thapsus			21.74%	

A total of 65 plots were monitored during SOPN's 2014 rapid assessment.

[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 of high concern, occurred in density class 2. *Melilotus officinalis*, a species of special concern, was detected in only one plot.

Measure

Distribution of Exotic Plants

The distribution measure evaluates the occurrence of exotic plant species in four disparate areas of the park. This measure is possible because SOPN's 2014 rapid assessment occurred in four separate semi-natural areas of the park. In the Johnson City Unit, the prairie restoration site and the back 40 -a grazed pasture, were surveyed. In the LBJ Ranch Unit, the riparian zone and the north end, another grazed pasture, were assessed. This measure is the proportion of plots infested with exotic plants reported for each of the areas surveyed in SOPN's 2014 rapid assessment (Table 4.10.2-7) (Horsley and Schafer 2014). This information shows

Table 4.10.2-8. Number of species found in each area during the rapid assessment.

Unit	Area	# of Species
Johnson City	Restoration Site	13
Johnson City	Back 40	7
LBJ Ranch	Riparian	16
LBJ Ranch	North End	18

whether the infestations of exotic species are widespread and found in multiple areas of the park or restricted to one of the two units, or to a particular ecosystem.

Two species, *Bromus catharticus* and *Bromus japonicus*, were found in all four surveyed areas. Six species were found in three areas, and eight occurred in two areas. Twelve of the exotic species detected during the 2014 rapid assessment were found in only one area, with eleven of these species found in the LBJ Ranch Unit. Six species were found only in north end of the Ranch Unit, and five other species were found only in the riparian zone of the Ranch Unit.

Further, the riparian zone and the north end pasture, both located in the LBJ Ranch Unit, have more species of exotic plants than in the Johnson City Unit (Table 4.10.2-8). Sixteen different exotic species were found in the riparian zone, and eighteen were in the north end pasture. These areas also appear to be a vector for exotic plant infestations as five species were found only in the riparian zone, including *Melilotus officinalis*, a species of special concern. Four species were present only in the north end pasture. However, most species that were found in only one area of the park also had a low extent within that area, typically occurring in less than 15 percent of the plots. *Marrubium vulgare* and *Verbascum thapsus* (mullein), found in the north end and riparian zone of the LBJ Ranch Unit, respectively were exceptions and found in 55.6% and 21.7% of the plots in their respective areas.

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). We apply these reference conditions only to the communities in the more natural areas (e.g., outside of the mowed hay fields and cultivated areas of the park, including riparian, woodland, and grassland communities) in the historical park. A summary of the reference conditions is shown in Table 4.10.3-1.

A good reference condition is the capability for primary communities in the more natural to be maintained. By this, we mean that the ecological attributes (e.g., species composition, structure, etc.) and natural processes remain within the natural variation for the community type.

A moderate condition is assigned to exotic plant species that have been ranked as high or highest 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 high or highest for its ability to alter native plant communities and is found at medium to high prevalence levels.

Further consideration of condition is warranted on a case by case basis, especially for species with low prevalence, and when the species' prevalence may be increasing. Given

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.

the early detection and rapid response model for the control of exotic plant species, 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 considered to be of moderate condition depending on the individual characteristics of a species, and the unique attributes of the park area, regardless of prevalence.

4.10.4. Condition and Trend

A total of 36 exotic species were found within Lyndon Johnson NHP in monitoring by the SOPN between 2012 and 2014. (Folts-Zettner and Sosinski 2012a; 2013; 2014, and Horsley and Schafer 2014). Altogether, 92 species of exotic plants (Appendix G) have been recorded in the park (Sanders 2004; Folts-Zettner 2014), excluding cultivated species reported in the park's vascular plant list (Sanders 2004).

Twelve 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, eleven species are in the condition of significant concern (Table 4.10.4-1). Of these eleven species, four species (*Bothriochloa ischaemum*, *Sorghum halepense, Bromus japonicus,* and *Carduus nutans*) are highly prevalent in the NHP. The other seven species were ranked at the highest concern for their innate ability to become a pest, but were not prevalent in the more natural areas of the park. Four additional species are in moderate condition, and two species are in the condition of special concern.

Condition of Significant Concern Species with High Prevalence

Based on combining the two indicators and four measures, four species are in the condition of significant concern. 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 is prevalent in all areas of grasslands monitored and was only absent from the riparian zone along the Pedernales River. This species has a wide extent and distribution in the park, and also was found in medium or higher densities in many areas. It can dominate grassland communities, and reduce insect, landbird, and mammal diversity, and is difficult to manage (Institute for the Study of Invasive Species 2014). Since 2010, king ranch bluestem has become more prevalent in the prairie restoration site.

Sorghum halepense was not found in the two grazed pastures that were monitored, but was abundant in both the prairie restoration site and in the riparian habitat. It is especially prevalent in the riparian zone

Table 4.10.4-1. Exotic species found within Lyndon B. Johnson National Historical Park that are considered to have the most impact to native habitats throughout the Historical Park based upon combined indicators and measures.

Scientific Name	Common Name	Rationale for Rating[1]
		Condition of Significant Concern (with high prevalence)
Bothriochloa ischaemum var songarica	king ranch bluestem	King ranch bluestem is the most abundant exotic plant in Lyndon B. Johnson NHP. It has wide extent as detected in both the vector monitoring along the Settlement Trail (92.7% in 2012-2014 blocks), and in the 2014 rapid assessment, occurring in 41.5% of the plots. The density of the infestations were mostly at density class 2, scattered patchy, although 18.5% of the plots in the rapid assessment were described as scattered even (density class 3). The species was also widely distributed, and found in all areas monitored during the rapid assessment, with the exception of the riparian habitat. Ranked as highest concern for its ability to become a pest, this species' impact on native plant communities includes its drought tolerance, its great seed production, a thick basal growth that can displace native species and decrease plant and animal biodiversity. Left unmanaged, this grass has the potential to become a monoculture. It also adds to fire threat by providing abundant fine fuel (Folts-Zettner and Sosinski 2012b).
Bromus japonicus	Japanese brome	With a high significance of exotic plant impact, Japanese brome is also prevalent in the park. It alters fire regime and outcompetes native cool season grasses.
Carduus nutans	nodding musk thistle	Nodding musk has a broad extent in the Ranch Unit. During the rapid assessment, it was detected in 30.4% of the riparian plots and in 66.7% of the plots in the north end pasture. Only one occurrence was detected during the 2012-2014 monitoring of the restoration site. It was ranked as high for exotic plant impact.
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* is also prevalent in the NHP. It was found in greater than 64% of the blocks in the prairie restoration site and in more than 32% of the rapid assessment plots. The species occurred at densities ranging from scattered patchy to evenly scattered. It was found in the restoration site and in the riparian area during the rapid assessment in nearly 74% of the plots. "The species has strong rhizomatous root system with the capacity to colonize large areas. Once established, Johnsongrass persists in the landscape despite eradication efforts, effectively displacing native grasses and forbs (Folts-Zettner and Sosinski 2012b).
		Condition of Significant Concern (with lower prevalence)
Bromus tectorum	cheatgrass	Cheatgrass is a highly invasive plant that can have a significant adverse impacts on natural ecosystems. It was found in 62.5% of the high priority vector plots in 2012, but was not detected in vector plots in 2013 and 2014, nor in the 2014 rapid assessment. The 2012 detection may be due to a species misidentification as a result of phenology (e.g., seed heads not present) at the time of monitoring (Folts-Zettner, SOPN biologist, personal communication, 2014).
Conium maculatum	poison hemlock	Poison hemlock was found in both the riparian and north end areas of the Ranch Unit, mostly in density class 1. It was also detected in 2011 SOPN monitoring of Johnson Settlement Trail vector (Folts-Zettner and Sosinski 2012b), but otherwise not found during sampling in the Johnson City Unit. Folts-Zettner (SOPN biologist, personal communication, 2014) has observed that this species has the ability to invade and dominate an understory.
Eragrostis barrelieri	Mediterranean lovegrass	This species was ranked as highest for its innate ability to become a pest, but was only detected in one block in the vector monitoring in 2013.
Lonicera japonica	Japanese honeysuckle	While not found in the 2014 rapid assessment, Japanese honeysuckle was found in 11.5% vector blocks, in mostly scattered patchy densities. 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 & can outcompete natives via underground competition (NatureServe 2014).
Poa annua	annual bluegrass	*Poa annua* was not detected in SOPN monitoring until 2014 when 25% of the blocks along the Settlement Trail were infested. This species was ranked in the highest category for its innate ability to become a pest, and is also extremely difficult to control.
Poa pratensis	Kentucky bluegrass	This species was ranked at the highest possible score for its innate ability to become a pest. It was only detected via SOPN monitoring in two blocks along the Settlement Trail in 2012.
Schedonorus arundinaceus	tall fescue	There was only one detection for this species in the riparian habitat during the rapid assessment in 2014. It is very invasive and very difficult to control.

Table 4.10.4-1. Exotic species found within Lyndon B. Johnson National Historical Park that are considered to have the most impact to native habitats throughout the Historical Park based upon combined indicators and measures (continued).

Scientific Name	Common Name	Rationale for Rating[1]
Moderate Condition (with high impact and low prevalence)		
Centaurea melitensis	Malta starthistle	This species was found in 5.2% of the vector blocks and in 10.8% of the rapid assessment plots. It is widely dispersed in the park, occurring in all surveyed areas except the Back 40 in the Johnson City Unit. However, it is common along the road on the west boundary of the Back 40 (Folts-Zettner, SOPN biologist, personal communication, 2014).
Moderate Condition (with moderate impact and high prevalence)		
Marrubium vulgare	horehound	Horehound reproduces only by seed, but the species produces abundant seed which are easily dispersed by animals and people. The species germinates in open areas and outcompetes native species. It was found in 55% of the plots in the north end pasture during the 2014 rapid assessment.
Medicago lupulina	black medick clover	This species is moderately competitive, and forms a dense low level of vegetation. In the park, it was found in more than 50% of the blocks along the Settlement Trail.
Medicago minima	burr medick clover	Burr medick clover was found in more than 50% of the blocks along the Settlement Trail and was also found in 32% of the rapid assessment plots. It usually occurred in density class 2, scattered patchy.
Torilis arvensis	spreading hedgeparsley	Spreading hedgeparsley was found in approximately 35% of the plots in the riparian area. Overall, it was found in 17% of the rapid assessment plots and in 50% of the blocks surveyed during vector monitoring. The seeds of this species are easily spread by animals and people.
Condition of Special Concern		
Cynodon dactylon	Bermudagrass	Bermudagrass is one of the most abundant exotic species found in the park. 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).
Melilotus officinalis	yellow sweetclover	*Melilotus officinalis* was only present in one rapid assessment plot. This species is beginning to naturalize in Texas, and is a threat to recovering prairie.

[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.

where it was found in nearly 74% of all plots. 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, making the infestations in the NHP of even greater concern.

Exotic bromes are well known to dramatically change the character of an ecosystem, including such changes as major shifts in community composition and structure (Knapp 1996) as well as substantially alter fire regimes (Whisenant 1990). In many cases these changes have become, for all practical purposes, irreversible (Knapp 1996).

B*romus japonicus* has many of the same adverse impacts to native plant communities that B*romus tectorum* (cheatgrass) has: it alters the fire regime, adds biomass to the ecosystem, and outcompetes other cool season grasses (Folts-Zettner, SOPN biologist, personal communication, 2014). It is prevalent throughout the NHP. It occurs in more than 30% of the blocks and plots surveyed, and usually in density class 2. The species also has a wide distribution, and was found in all four of the areas surveyed in the rapid assessment.

Carduus nutans has a high potential to alter native plant communities at the NHP. This exotic thistle produces abundant seed, can outcompete native species, and is difficult to control. While the species was not common in vector blocks at the restoration site, it occurred in significant extent in the Ranch Unit. Nodding musk thistle was found in 30.4% and 66.7% of plots in the riparian zone and north end pasture, respectively.

Condition of Significant Concern Species with Low Prevalence

Seven species were ranked as the highest concern for their innate ability to become a pest, but had low prevalence in the park. These species are *Bromus tectorum, Conium*

maculatum (poison hemlock), *Lonicera japonica* (Japanese honeysuckle), *Poa annua* (annual bluegrass), *Poa pratensis* (Kentucky bluegrass), *Eragrostis barrelieri* (Mediterranean lovegrass), and *Schedonorus arundinaceus* (tall fescue).

From a standpoint of significance of impact to the park's native grassland community, *Bromus tectorum* is one of the highest exotic plant concerns, especially for the prairie restoration site. Folts-Zettner (SOPN biologist, personal communication, 2014) states that the detections during vector monitoring may be a species misidentification due to phenology as the exotic bromes are difficult to distinguish when they do not have seed heads.

Conium maculatum was found in the LBJ Ranch Unit during the rapid assessment. It was also found in vector monitoring of the Settlement Trail in 2011 (Folts-Zettner and Sosinski 2012b), although it wasn't present there in 2012-2014, the time interval upon which this condition assessment is based. 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). Poison hemlock had a significant extent in the north end pasture, where it was detected in more than 14% of the plots, but in density class 1 (1 to 5 individuals) in all but one plot. Given this species' adverse impact on both cattle operations and wildlife habitat, controlling the spread of this plant while the infestation is limited may be more manageable.

Found in more than 11% of the vector blocks along the Settlement Trail, *Lonicera japonica* was not found in the 2014 rapid assessment. This plant 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.

Poa annua and *Poa pratensis* were only found during annual SOPN monitoring along the Settlement Trail vector. Kentucky bluegrass was detected in 6.25% of the blocks in 2012, but was not detected in 2013 or 2014. *Poa annua* was not detected prior to 2014, when 25% of the vector blocks were infested. The occurrences and/or absence of these Poa species between 2012-2014 may be drought-related (Folts-Zettner, SOPN biologist, personal communication, 2014).

Given the extreme difficulty of controlling *Poa annua* invasions and its extremely high potential to alter native plant communities, the detection of this species in 2014 is especially of significant concern. Likewise, any future occurrence of *Poa pratensis* would also be of significant concern.

Two species within the highest ranking for the significance of exotic plant impact were detected only in a single occurrence during monitoring. *Eragrostis barrelieri* was found in one block in 2013 along the Settlement Trail vector. *Schedonorus arundinaceus* was detected in only one plot in the riparian zone during the rapid assessment. The very low occurrences for these two species, based on early detection, provides an opportunity for effective control.

Moderate Condition Species with High Impact and Low Prevalence

Centaurea melitensis (Malta starthistle) was ranked as high for its innate ability to become a pest. While the species had a limited extent (found in 5.21% of the blocks along the Settlement Trail, and in 10.77% of the plots in the rapid assessment), it was distributed widely in both units of the park.

While it wasn't present in the Back 40 plots in the Johnson City Unit, Folts-Zettner (SOPN biologist, personal communication, 2014) has observed that it is common along the road on the west boundary of the area.

Moderate Condition Species with Moderate Impact and High to Medium Prevalence

Four species were prevalent in the park that were ranked according to Hiebert &

Stubbendieck (1993) as having a medium potential to alter native plant communities: *Marrubium vulgare*, *Medicago lupulina* (black medick clover), *Medicago minima*, and *Torilis arvensis* (spreading hedgeparsley).

Marrubium vulgare can outcompete native plants, and can form monocultures. While it reproduces only by seed, the burrs are easily spread by animals or humans. The species was found in 55% of the plots in the north end of the Johnson City Unit, in densities as great as class 3 (scattered even), but in only 23% of the plots assessed throughout all locations in the 2014 rapid assessment.

The two *Medicago* species were widely prevalent in the park. Each species occurred in more than 50% of the blocks along the Settlement Trail. *Medicago minima* was found in 32% of the rapid assessment plots, but *Medicago lupulina* was only found in 4.6% of plots. Both species usually occurred in density class 2, scattered patchy.

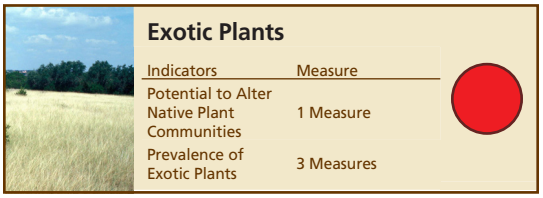
Torilis arvensis was found in half of the blocks along the Settlement Trail. While it was found in only 17% of the rapid assessment plots, it was found in 32% of the plots in the riparian area. Like *Marrubium vulgare*, the plant reproduces by seeds that are easily spread by animals or human activity.

Species of Special Concern

SOPN biologist Tomye Folts-Zettner identified two species of special concern, *Cynodon dactylon* and *Melilotus officinalis*, for the NHP based on characteristics of the species and unique attributes of the park (personal communication 2014), although these species were ranked low for their innate ability to become a pest.

Cynodon dactylon is particularly prevalent in the park. It was found in 92.7% of the blocks along the Settlement Trail, and occurred in 75 % of the rapid assessment plots. The species is very invasive lawn 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). Maintaining wildflower displays at the park is part of the NPS' effort to continue to legacy of Lady Bird Johnson (NPS 1999).

Melilotus officinalis was detected only once during surveying. It was found in the riparian area during the rapid assessment. While it is not currently problematic at the park, the species is becoming naturalized in Texas (Folts-Zettner, SOPN biologist, personal communication, 2014). The species is a threat to recovering as it invades open areas, and is competitive with native species (TexasInvasives.org 2008).



Overall Condition and Trend

For assessing the condition of exotic plants in the NHP, 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.

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, and a summary of how they contributed to the overall exotic plants condition assessment is summarized in Table 4.10.4-3.

The potential for exotic species present in the NHP to alter native plant communities is of significant concern because twelve species, one third 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 throughout the park, with all monitored blocks and plots infested. This wide extent of exotic plants in the NHP is also of significant

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. Eleven species of the 39 exotic plants found during SOPN monitoring were ranked as having the highest or high innate ability to become a pest. Two of these species were abundant. Therefore, this we consider this measure to be of significant concern.
Prevalence of Exotic Plants	Extent of Exotic	Significant Concern	Every site monitored (block or plot) by the SOPN between 2012-2014 contained exotic plants. Twenty-eight species were found during monitoring of the vector blocks. Blocks contained as many as 12 different exotic species. Six species were found in more than half the blocks. Thirteen exotic species were found in greater than 10% of vector blocks; four of these species are considered to be of highest concern for their potential to alter native plant communities. Thirty-two species were found during the 2014 rapid assessment, with one species occurring in more than half the plots. Eleven species were found in more than 10% of the plots, including four species of highest or high concern for innate ability to become a pest.
	Density of Exotic	Moderate	Most of the exotic species occurrences in Lyndon Johnson NHP were in moderate to low densities in monitored parts of the park. Only Bermuda grass was found to form a matrix in a monitored site, and did so in only two plots. Eight species were found in density class 3 (scattered even) or higher, but only in a total of 40 blocks and plots. Species were most often found in density class 2 (scattered patchy).
	Distribution of Exotic	Significant Concern	Exotic plants were found in all parts of the park. Two species were found in all four monitored areas, seven species were found in three of the monitored areas, eight occurred in two areas, and 14 in one area. Twelve species of exotic plants found during the rapid assessment were found in both the Johnson City and the Ranch Units.

concern. However, exotic species mostly occurred in densities that are at a level of moderate concern.

The distribution of exotic plant species was also at level of significant concern. Seventeen of the 28 species found during the 2014 rapid assessment were found in two or more areas of the park. Altogether, the prevalence of exotic plants for the park is of significant concern.

By combining the four measures and evaluating the species individually, eleven exotic plant species were in a condition of significant concern, and five species were in moderate condition (Table 4.10.4-1). Two additional species were of special concern.

It was not possible to determine an overall trend for the condition of exotic plants at the NHP since only the 13-acre prairie restoration site is monitored for exotic plants on a regular basis. Further, the 2014 rapid assessment only provided a limited perspective on the status of exotic plants in the park as a whole and was also limited to more natural areas.

Given that maintaining the cattle operation to reflect President Johnson's heritage and influence is part of the park's purpose, impact to native plant communities is likely unavoidable and has likely occurred prior to park establishment. Specifically, President Johnson planted 1,100 acres on his ranch with "improved" varieties of grass including king ranch bluestem and Bermuda grass (NPS 2014b).

After analyzing all the available information about exotic plant species at Lyndon B. Johnson NHP, we consider the overall condition for exotic plants to be of significant concern with an indeterminate trend due to insufficient data, but with a possibility that the trend is declining.

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. In addition with annual monitoring along the Settlement Trail in the prairie restoration site, SOPN staff feel confident that they will identify new plants before they become established there.

The greatest uncertainty related to the condition of exotic plant infestations at Lyndon Johnson NHP is the fact that the prairie restoration site along the Settlement Trail is the only site monitored on an annual basis. The fact that the park is mostly managed for cattle grazing in an altered system inherently limits the SOPN's ability to monitor for the presence of exotic plants in natural or semi-natural environments.

The 2014 rapid assessment provided a one-time snapshot of the condition of three other semi-natural areas of the park, including the riparian area along the Pedernales River. Given that riparian areas are well known vectors for exotic plant infestations, the lack of regular monitoring of that area decreases our certainty about the condition of exotic infestations for the park. Additionally, the north end pasture appears to be a vector for exotic plant infestation, but it is unknown whether the exotic plants are spreading from adjacent lands outside park boundaries or mowed hay fields inside the park, or the mechanism of spread.

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. Further, the fact that this NHP is a cultural landscape managed for cattle grazing may indicate that exotic plant species beneficial to cattle grazing may be less detrimental to the state of the park than they would be in an entirely natural landscape. However, that determination is outside the scope of this assessment.

4.10.5. Sources of Expertise

Surveys for exotic plants at Lyndon B. Johnson NHP 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 (2 Measures)

Condition – Trend – Confidence



Good to Moderate - Insufficient Data - Medium

4.11.1. Background and Importance

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

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

Perhaps the most compelling reason to monitor landbird communities in SOPN parks is that birds themselves are inherently valuable. The high aesthetic and spiritual values that humans place on native wildlife 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



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Figure 4.11.1-1 Red-winged Blackbird is a common species in riparian habitat at the National Historical Park.

large and sustainable industry (Sekercioglu 2002).

4.11.2. Data and Methods

In 2009, Rocky Mountain Bird Observatory (RMBO) began systematic surveys of birds at Lyndon B. Johnson NHP as part of the SOPN Monitoring program. Although these data will enable quantitative evaluation of trends in birds in the future (e.g., in occupancy), it is premature to use them in such a context at the present with only five years of data. Rather, for this assessment, we focus on species occurrence (presence/absence), focusing on what species are, or are not, observed at Lyndon B. Johnson NHP. The most recent, and only, data we have for occurrence of birds at the Historical Park are the RMBO surveys. With the use of additional data and information sources not limited to the park, we evaluated species occurrence in two contexts: (1) a spatial context (i.e., comparison with surrounding region), and (2) 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. It would have also been preferable to conduct an occurrence comparison in a temporal context (i.e., differences or changes in species occurrence over time), but with no survey data prior to 2009 at the Historical Park, this was not possible.

Indicators/Measures
Species Occurrence

Spatial Context – Comparisons with Surrounding Region

We evaluated landbird species occurrence in a spatial context. Our analysis is not intended as a rigorous or quantitative comparison given limitations of the available information; rather, it is intended as a crude qualitative indicator of major differences in species occurrence. To conduct the comparison 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 in the area during other seasons. The Breeding Bird Surveys (BBSs; described below), which were used for the spatial comparison, are also conducted during the breeding season.

For this assessment, we compared the recent RMBO surveys at the Historical Park to those from BBSs conducted in similar habitats within the surrounding area; the regional surveys serve as a general spatial reference for species occurrence within the region. We focused our comparisons on those species for which the Historical Park 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 Lyndon B. Johnson NHP area, although an area checklist was also used as supporting information (described under Secondary Data Sources).

We made the determination of whether the park was within a species' normal breeding range 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 this determination 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 Historical Park (since comparisons are based on the breeding season). We assigned each species to one of

Table 4.11.2-1. Breeding habitat classes assigned to species reported to occur at Lyndon B. Johnson NHP that are within or near their reported breeding ranges. These classes were also used in the spatial species comparison.

Breeding Habitat Class	Class Description
Exists	This class was assigned when the habitat at the Historical Park 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 Historical Park 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 Historical Park would support breeding by that species. This does not imply that the species would not occur at the Historical Park in limited numbers or during other seasons, but rather that it would be unlikely to breed there.

Table 4.11.2-2. Classes assigned to species of concern regarding the potential for Lyndon B. Johnson NHP to play a role in their conservation during the breeding season.

Potential for Conservation	Conservation Class Description
High	These are species for which the Historical Park is within the normal breeding range or in proximity to the edge of that range. They are also species for which we considered the Historical Park 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 Historical Park in substantial numbers.
Moderate	These are the species for which the Historical Park is within the normal breeding range or in proximity to the edge of that range, and for which there is some habitat at the Historical Park 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 Historical Park is unlikely to support breeding. This does not preclude limited occurrences of the species, but the potential for the Historical Park to play any significant role in its conservation during the breeding season is very limited.

three breeding habitat classes (Table 4.11.2-1) based primarily on the input of avian ecologist Mr. Moez Ali (see Section 4.11.5, Sources of Expertise).

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

Our intent for this context was to determine which species that occur at Lyndon B. Johnson NHP are considered species of concern at either national or local scales, to assess the current status (occurrence) of those species at the Historical Park, and to evaluate the potential for the Historical Park 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 Historical Park 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 Historical Park was within the normal breeding range of the species and the availability of breeding habitat at the Historical Park.

To develop a candidate list of 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

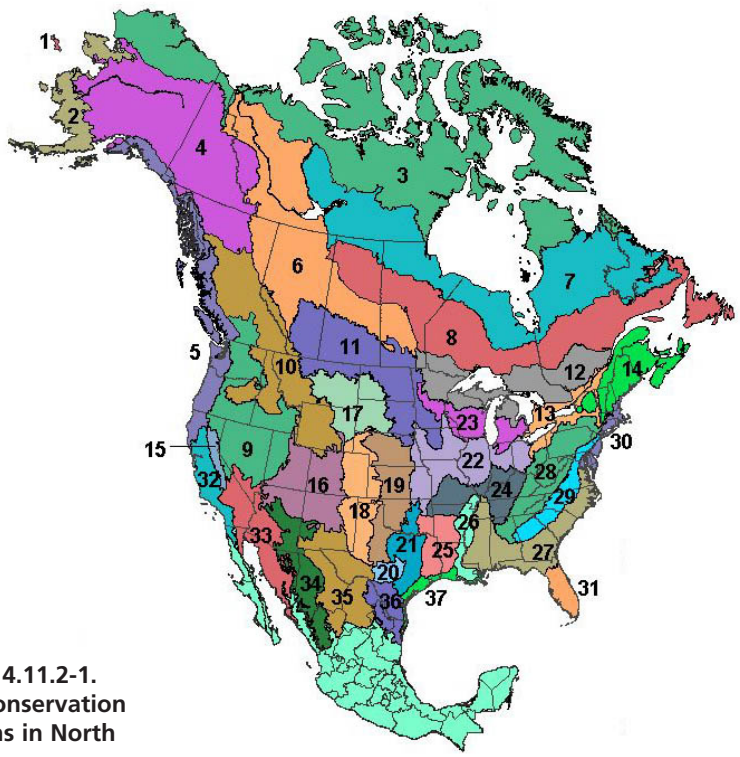


Figure 4.11.2-1. Bird Conservation Regions in North America.

of larger organizations. This has been, and continues to be, a source of confusion, and perhaps frustration, for managers that need to make sense of and apply the applicable information. In recognition of this, the U.S. North American Bird Conservation Initiative (NABCI) was started in 1999; it represents a coalition of government agencies, private organizations, and bird initiatives in the United States working to ensure the conservation of North America's native bird populations. Although there remain a number of sources at multiple geographic and administrative scales for information on species of concern, several of which are presented below, the NABCI has made great progress in developing a common biological framework for conservation planning and design.

One of the developments from the NABCI was the delineation of Bird Conservation Regions (BCRs) (U.S. North American Bird Conservation Initiative 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). Lyndon B. Johnson NHP lies within the Edwards Plateau Unit (BCR-20) (Figure 4.11.2-2).

Conservation Organizations Listing Species of Conservation Concern

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

- U.S. Fish & Wildlife Service: Under the Endangered Species Act, the U.S. Fish and Wildlife Service (USFWS) lists species as threatened, endangered, or candidates for listing.
- State of Texas: In 1973, the Texas Parks and Wildlife Department (TPWD) was authorized to develop a list of endangered and threatened animal species in the state. Legal protection of endangered and threatened animals is provided by laws and regulations contained in Chapters 67 and 68 of the Texas Parks and Wildlife Code and Sections 65.171-65.176 of Title 31 of the Texas Administrative Code (TPWD 2014a).
- USFWS: This agency also developed lists of birds of conservation concern according to: the Nation, USFWS Region, and BCR.
- The National Audubon Society (NAS) and American Bird Conservancy (ABC): These groups combined efforts to produce a "Watch List," based on, but not identical to, the Partners in Flight approach to species assessment (see below). The 2007 WatchList has two primary levels of concern: a "Red Watchlist," which identifies what these organizations consider as species of highest national concern; and a "Yellow WatchList," which is made up of species that are somewhat less critical.
- Partners in Flight (PIF): This is a cooperative effort among federal, state, and local government agencies, as well as private organizations. PIF has adopted BCRs as the geographic scale for updated regional bird conservation assessments. At the scale of the individual

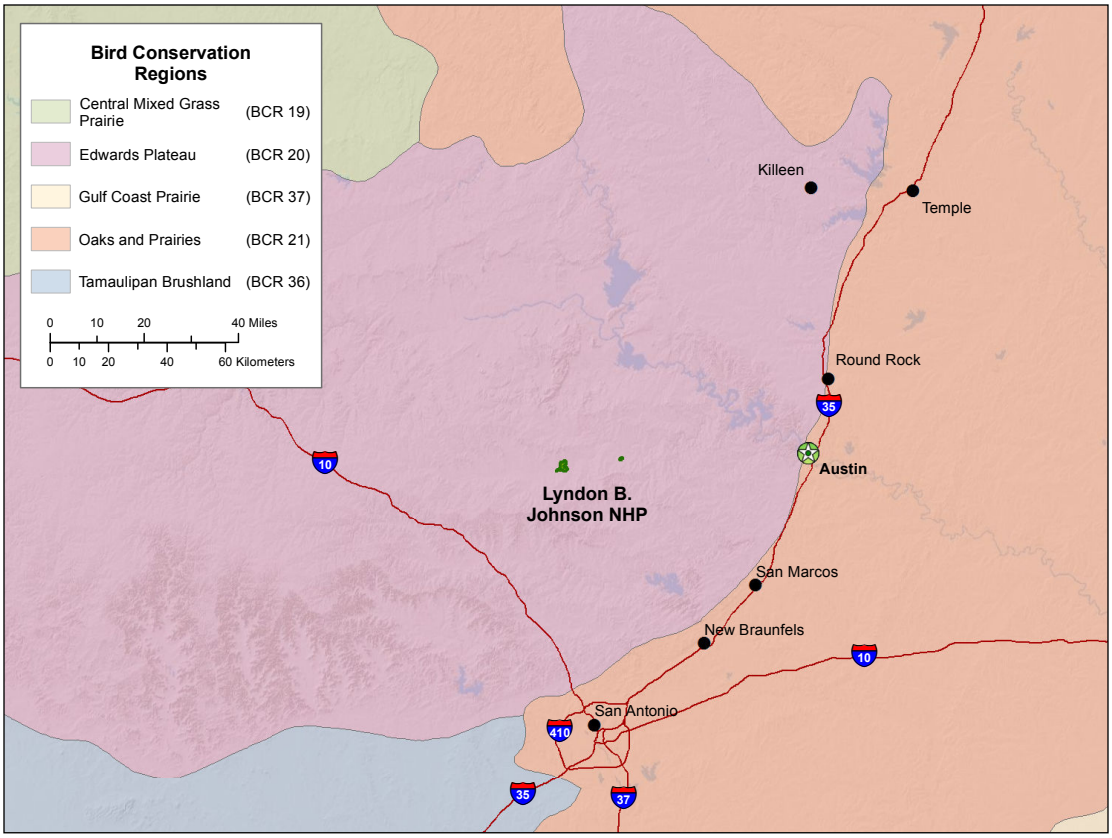


Figure 4.11.2-2. Bird Conservation Regions in the vicinity of Lyndon B. Johnson NHP.

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.

- Texas Species of Greatest Conservation Need: The State of Texas also designated species that, "due to limited distributions and/or declining populations, face the threat of extirpation or extinction but lack legal protection" (TPWD 2014b). The lists were developed for the TPWD's Texas Conservation Action Plan. Species are rated or ranked using a system developed by NatureServe.

Primary Data Sources

Data used as part of the condition assessment included: surveys conducted by RMBO at Lyndon B. Johnson NHP in 2009-2013; and results of Breeding Bird Surveys (BBSs) conducted in the general vicinity of the Historical Park over the approximate same time period (2009-2012). Again, no bird surveys prior to the RMBO surveys were available at the park for use in a temporal comparison of species occurrence. The NPSpecies List for the park (NPS 2014) and a checklist for Lyndon B. Johnson State Park and Historic Site and the Ranch Unit of the Historical Park (Archer 2011) were also reviewed and are mentioned in the report where applicable. Each source of information is described below.

RMBO Surveys at the Historical Park, 2009-2013

RMBO used point-transect surveys (Buckland et al. 2001) during the breeding season to estimate and monitor landbird population parameters at Lyndon B. Johnson NHP (Lock et al. 2014). One transect was in riparian habitat (bottomland grassland) with approximately 17 unique points (at the Ranch Unit), and the other transect/grid was in grassland (upland grassland) habitat with six unique points (at the Johnson City Unit). Each point was surveyed three times in each year, for a total of about 69 point visits per year (Figure 4.11.2-3) (Lock et al. 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

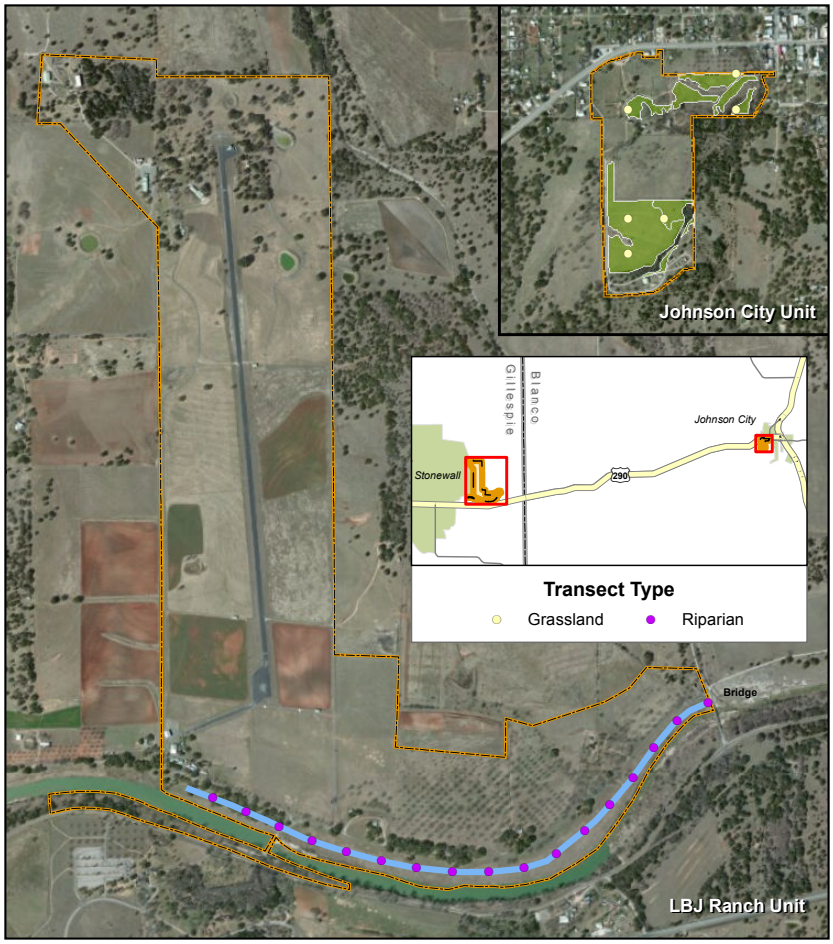


Figure 4.11.2-3. Survey points sampled by the Rocky Mountain Bird Observatory at Lyndon B. Johnson NHP in 2009-2013.

each bird or group detected. This protocol of spending six minutes per site is consistent with other efforts being conducted by RMBO. After counts were completed, observers used a handheld GPS (Global Positioning System) unit to locate successive survey points. While walking between points, observers noted only species that were not recorded during the count period; sometimes these represented species that had not been previously reported at the Historical Park.

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, 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 five hours to complete. There are several BBS routes in the general vicinity of the Historical Park, but only some of these routes are in habitat similar to that at the park. We chose three BBS routes for our comparison (83041, 83042, and 83325) (Figure 4.11.2-4). We compared species observed during the BBS sampling (2009-2012) to those observed during surveys at the Historical Park (RMBO data from 2009-2013). Note, however, that during the BBSs one route was sampled in 2009-2012, the second in 2009-2011, and the third in 2011 only; data were not yet available for 2013.

Secondary Data Sources

Check Lists

For the condition assessment, we obtained the NPSpecies List of bird species in the park (NPS 2014). However, although all of the birds listed had associated information on their occurrence at the park, all were noted as "in review." We found that this is because the list is based on Archer (2011)-- a checklist for Lyndon B. Johnson State Park and Historic Site and the Ranch Unit of the Historical Park produced by the Texas Parks and Wildlife Department (TPWD). The checklist was compiled by Dr. Stanley Archer of College Station, Texas, based on his observations from 1971-1987. The checklist was updated by individuals with the TPWD. Because the NPSpecies list is "in review," and the Archer (2011) checklist includes a larger area than just the Historical Park, we used these lists primarily on a case by case basis as supporting information for particular species.

4.11.3. Reference Conditions

The first bird monitoring/survey efforts at Lyndon B. Johnson NHP are the Inventory & Monitoring Program surveys by RMBO that began in 2009. These surveys were used to assess the condition of breeding landbirds at the Historical Site from an ecological perspective. However, in our assessment, we also considered the setting and purpose of the Historical Park. For example, if the park unit

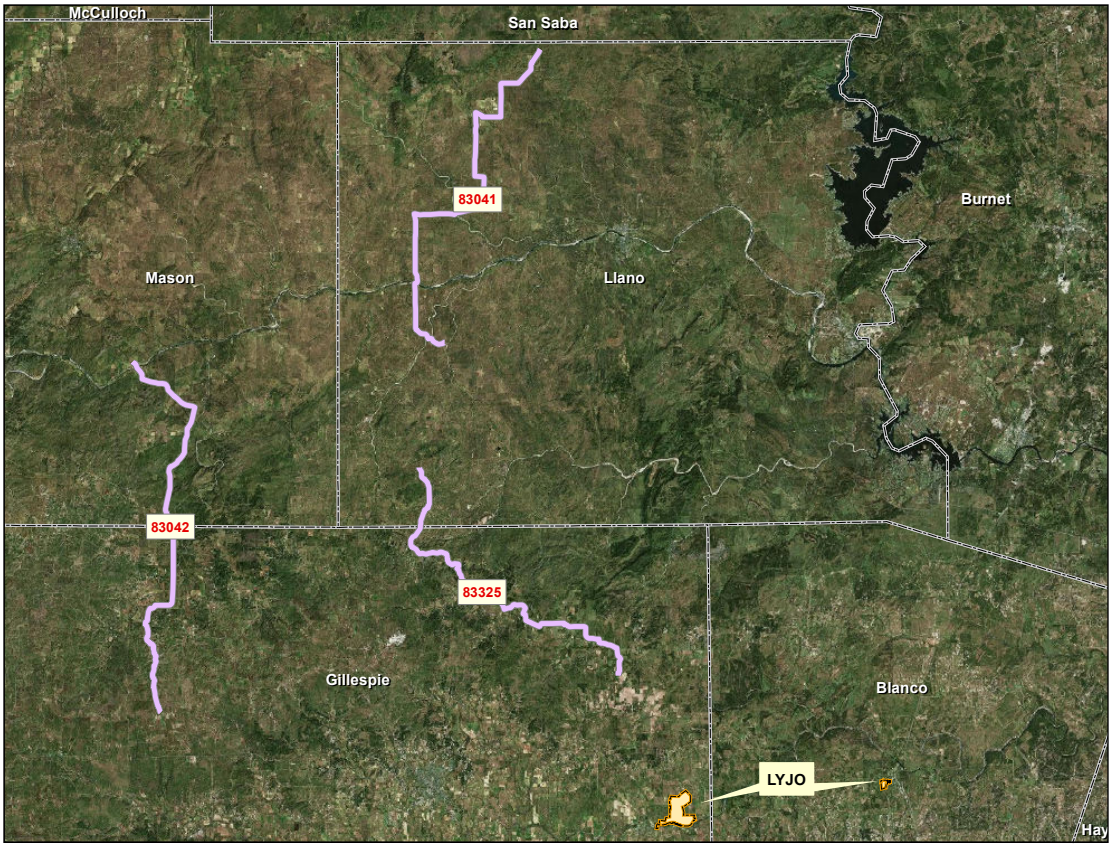


Figure 4.11.2-4. BBS routes (in purple; 83041, 83042, and 83325) in the general vicinity of the Historical Park that were used for the regional comparison of landbird species occurrence.

was in a primarily undeveloped landscape and had as its primary purpose the preservation of the natural resources within its boundaries, we might have relatively high expectations for the condition of biotic components such as breeding landbirds. Lyndon B. Johnson NHP was authorized to preserve historically significant properties associted with the life of Lyndon B. Johnson; the park preserves the birthplace, boyhood home, and ranch of the president, as well as other important features and structures. The LBJ Ranch District contains the ranch house, agricultural areas, including a pecan orchard and open space where cattle graze, and facilities such as the airstrip. Additionally, the Secret Service had the vegetation along the river maintained in a more open condition for security purposes. Expectations for bird species diversity and/or abundance might be lower in such a landscape compared to a more undisturbed or uninhabited environment.

Spatial Reference Condition for Species Occurrence

In a spatial context, we compared the species observed during recent RMBO surveys (2009-2013) at Lyndon B. Johnson NHP to BBSs in the general vicinity of the park (2009-2012); as noted previously, for the BBS data we chose routes located in habitats that appeared comparable to those at the Historical Park (riparian and grassland areas). Both surveys were conducted during the breeding season. 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). Table 4.11.3-1 summarizes the qualitative condition classes we assigned for the spatial indicator.

Reference Condition for Species of Concern

This aspect of the assessment is somewhat different than the spatial comparison in that the focus is on the avian species for which the Historical Park can play a role in their conservation. From the list of species detected at the Historical Park during recent RMBO surveys, we identified the species that occurred on one or more of the lists of species of conservation concern described in Section 4.11.2. Those considered as having

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

Occurrence Indicator	Significant Concern	Moderate Concern	Good
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 Historical Park 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 regional surveys and are within their normal breeding range and have breeding habitat at the Historical Park were not detected during recent RMBO surveys.	We considered condition to be good if all, or nearly all, birds that were detected during regional surveys and are within their normal breeding range and have breeding habitat at the Historical Park were detected during recent RMBO surveys.

the greatest potential for conservation at the Historical Park are those within their breeding range and for which breeding habitat exists at the park.

4.11.4. Condition and Trend

There have been a total of 55 bird species recorded at Lyndon B. Johnson NHP by RMBO to date (Appendix I). A larger number of species appear on the NPSpecies List for the park, but again, this list is based on Archer (2011), which is a checklist that includes the state park that is adjacent to the Ranch Unit of the Historical Park.

Species Comparisons to Surrounding Region (Spatial Context)

RMBO recorded 38 species at the Historical Park that were observed on the three BBS routes in 2009-2012. However, 35 species that were recorded during the BBSs were not detected during the 2009-2013 RMBO surveys (Table 4.11.4-1; the European Starling was also not detected by RMBO, but it is not addressed because it was introduced to the U.S.). All of the 35 species are either within their normal breeding ranges or within 100 miles of the edge of their breeding ranges. However, 15 of the species are in the "limited to none" breeding habitat class. Of the remaining 20 species, 14 are in the "exists" breeding habitat class, and six are in the "possibly exists" class. Many of the 20 species appear on the NPSpecies List/Archer (2011) List, although some are described as uncommon or rare during the spring (March-May). Of the 14 species in the "exists" habitat class, all but two are on the Archer (2011) list; four species are noted on Archer (2011) as common ("should be seen on 50% or more of trips in proper habitat and season") in the spring, and one is noted as abundant ("should be seen on 75% or more of trips in proper habitat and season") in the spring. Of the six "possibly exists" species, all species were either absent from the Archer (2011) list, noted as being uncommon or rare in the spring, or only present during winter. Note that Archer's (2011) spring time-frame is March-May, and RMBO sampled over several days in April each year.

A review of the BBS data for the five species for which breeding habitat exists at the Historical Park and the Archer (2011) List describes as common or abundant in the spring, only Painted Bunting and Purple Martin were recorded in relatively high numbers during the BBSs (339 total and 69 total, respectively).

Because there are several species that are within their normal breeding ranges and fall into the "exists" habitat class, yet they have not been detected by RMBO, we consider the condition of breeding landbirds to be moderate (based on the spatial comparison). It is possible that some of these species will be recorded during the annual surveys at the park in the future. However, it is also possible that some of these species have not been detected because of the agricultural nature of the Ranch Unit and the security measures which were taken that eliminated some components of the natural habitat.

Species of Conservation Concern

There are 10 species that have been detected at Lyndon B. Johnson NHP during 2009-

Table 4.11.4-1 Birds species detected during 2009-2012 BBSs in the vicinity of Lyndon B. Johnson NHP that were not detected at the Historical Park during the 2009-2013 RMBO point-count surveys. Species that appear on the NPSpecies List for the park / the Archer (2011) list are noted (only for the species in the top two breeding habitat classes).

Common Name	Range Status	Breeding Habitat Class:
Barred Owl	Year-round (edge)	Exists
Black-chinned Hummingbird [2, 3]	Breeding	Exists
Blue-gray Gnatcatcher [2]	Breeding	Exists
Eastern Meadowlark [2, 3]	Year-round	Exists
Eastern Wood-Pewee [2]	Breeding	Exists
House Finch [2]	Breeding	Exists
Indigo Bunting [2]	Breeding	Exists
Killdeer [2, 3]	Breeding and Wintering	Exists
Northern Bobwhite [2]	Breeding and Wintering	Exists
Painted Bunting [2, 3]	Breeding	Exists
Purple Martin [2, 3]	Breeding	Exists
White-eyed Vireo [2]	Breeding	Exists
Yellow-breasted Chat	Breeding	Exists
Yellow-throated Vireo [2]	Breeding	Exists
Bell's Vireo [2]	Breeding	Possibly Exists
Cassin's Sparrow	Breeding and Wintering	Possibly Exists
Cave Swallow	Outside Normal Breeding Range [1]	Possibly Exists
Dickcissel [2]	Peripheral Breeding Range	Possibly Exists
Rock Pigeon [2]	Year-round	Possibly Exists
Vermilion Flycatcher [2]	Breeding and Wintering	Possibly Exists
Black-throated Sparrow	Year-round (on edge)	Limited to None
Cactus Wren	Year-round	Limited to None
Canyon Towhee	Year-round	Limited to None
Chipping Sparrow	Year-round	Limited to None
Common Ground-Dove	Year-round	Limited to None
Common Raven	Year-round	Limited to None
Curve-billed Thrasher	Year-round (edge)	Limited to None
Golden-cheeked Warbler	Breeding	Limited to None
Golden-fronted Woodpecker	Year-round	Limited to None
Greater Roadrunner	Year-round	Limited to None
Inca Dove	Year-round	Limited to None
Pyrrhuloxia	Year-round	Limited to None
Rufous-crowned Sparrow	Year-round	Limited to None
Verdin	Year-round (near edge)	Limited to None
Western Scrub-Jay	Year-round (on edge)	Limited to None

[1] Outside Normal Breeding Range but within 100 miles of its breeding range edge.
[2] Species appears on the Archer (2011) list.
[3] Archer (2011) List notes species as either common or abundant during the spring (March-May).

Table 4.11.4-2. Summary of species detected during 2009-2013 RMBO surveys at Lyndon B. Johnson NHP 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]		State	
	USFWS	TP&W	National	Region 2	BCR 20	2007 Watch List	BCR 20		SGCN[5]	Comments
							CC	RC		
Carolina Chickadee									•	
Chimney Swift								•		
Field Sparrow								•	•	
Grasshopper Sparrow				• (a)					•	(a) = ammolegus subspecies only, which does not breed in Texas. Other listing applies.
Lark Sparrow								•	•	
Orchard Oriole					•			•	•	
Scissor-tailed Flycatcher									•	
Summer Tanager									•	
Wild Turkey									•	
Yellow-billed Cuckoo	PT (b)		• (b)	• (b)				•		(b) = listings with "b" are for the Western U.S. Distinct Population Segment, which occurs in areas including western and southern TX, but birds in the park do not appear to be included in this area (Hughes 1999; USFWS 2014b). Other listing is for entire species.

[1] **Federal Listed Species Codes**
T = Threatened PT= Proposed Threatened
E = Endangered

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

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

[4] **PIF NCS Categories**
CC = Continental Concern RC = Regional Concern

[5] **Species of Greatest Conservation Need**
in the Edwards Plateau region

2013 RMBO surveys that are listed as species of conservation concern on one or more of the lists described in Section 4.11.2 (Table 4.11.4-2). Orchard Oriole, with three listings, appeared on the greatest number of conservation lists.

- USFWS / Listed Species: There are no bird species listed by the USFWS as endangered or threatened that are known to occur at the Historical Park (USFWS 2014a; TPWD 2014a). One species is proposed as threatened (i.e., Yellow-billed Cuckoo), but the listing applies only to the Western U.S. Distinct Population Segment of the Yellow-billed Cuckoo. This sub-population occurs in areas of the west including western and southern Texas, but the birds at the Historical Site do not appear to fall into this area (Hughes 1999; USFWS 2014b).
- State of Texas / Listed Species: None of the species that have been recorded by RMBO during surveys at the Historical Park are listed as endangered or threatened by the state of Texas (TPWD 2014a).
- USFWS / Birds of Conservation Concern: Excluding two listings that do not apply (see Table 4.11.4-2 for details), there is one species that has been detected at the Historical Park that has been identified by the USFWS as having the greatest conservation need at the BCR geographic scale (U.S. Fish and Wildlife Service 2008)— Orchard Oriole.

Table 4.11.4-3. Species detected at Lyndon B. Johnson NHP during 2009-2013 surveys that have also been identified as species of concern on one or more watch list. Species are organized by whether they have high, moderate, or low potential for the Historical Park to contribute to their conservation. All species were also on the NPSpecies List for the park (NPS 2014).

Common Name	Range Status	Breeding Habitat Class
High Potential		
Carolina Chickadee [2]	Year-round	Exists
Chimney Swift [2]	Breeding	Exists
Orchard Oriole [2]	Breeding	Exists
Scissor-tailed Flycatcher [2]	Breeding	Exists
Summer Tanager [2]	Breeding	Exists
Yellow-billed Cuckoo [2]	Breeding	Exists
Moderate Potential [1]		
Field Sparrow [2]	Year-round	Possibly Exists
Grasshopper Sparrow	Year-round	Possibly Exists
Lark Sparrow	Year-round	Possibly Exists
Wild Turkey [2]	Year-round	Possibly Exists
Low to No Potential		
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[1] Species for which some breeding may occur, but the potential for the Historical Park to play a significant role in its conservation is limited (e.g., due to low quality or small area of breeding habitat).

[2] Archer (2011) List notes species as either common or abundant during the spring (March-May).

- NAS / ABC: There are no species that have been recorded by RMBO at the Historical Park that have been listed on the NAS/ABC 2007 WatchList.
- PIF: Five of the 10 birds in the table are listed by PIF in the RC category. None of the species are considered of Continental Concern.
- Texas Species of Greatest Conservation Need: Eight of the species detected at the Historical Park during the 2009-2013 RMBO surveys are considered Species of Greatest Conservation Need in the Edwards Plateau region of Texas (TPWD 2012).

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

For this summary, we emphasize species for which Lyndon B. Johnson NHP has the greatest potential to positively impact their conservation during the breeding season, based on their habitat and range. We do not mean to imply that other seasons are not important for the conservation of birds, they are. Rather, we have limited this assessment to the breeding season because that is the only season for which we have current 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 fully expect that other interpretations might be appropriate.

Of the 10 species listed by one or more organization as being of conservation concern, we believe that six have sufficient habitat at the Historical Park to be considered as having high conservation potential (Table 4.11.4-3). These are the species that are within their normal breeding range and sufficient habitat exists at the Historical Park to support breeding. All of these six species have been observed on recent (2009-2013) RMBO surveys in one or more years. Four of the species were observed in four or five of the years (Table 4.11.4-4). Scissor-tailed Flycatcher was observed in the highest

Table 4.11.4-4. The number of individuals of species with highest and moderate conservation potential detected at Lyndon B. Johnson NHP during recent RMBO surveys.

Species	Survey Year					Total
	2009	2010	2011	2012	2013	
High Potential						
Carolina Chickadee	2	6	2	5	0	15
Chimney Swift	2	0	0	0	0	2
Orchard Oriole	1	6	17	26	5	55
Scissor-tailed Flycatcher	22	25	28	17	11	103
Summer Tanager	4	9	3	33	19	68
Yellow-billed Cuckoo	1	0	2	0	0	3
Moderate Potential						
Field Sparrow	0	0	2	3	5	10
Grasshopper Sparrow	0	0	0	3	0	3
Lark Sparrow	1	0	22	3	0	26
Wild Turkey	3	5	0	1	1	10

numbers out of this group of species, followed by Summer Tanager and Orchard Oriole. Although Archer (2011) does not address only the Historical Park, and does not include the Johnson City Unit, this list notes each of the six species as being either common or abundant during the spring, which is also the period RMBO sampled.

Four species are considered to have moderate potential for the Historical Park to contribute to their conservation. These are the Field Sparrow, Grasshopper Sparrow, Lark Sparrow, and Wild Turkey.

In summary, all species of conservation concern that are within their normal breeding range and have "existing" breeding habitat at the Historical Park (i.e., high potential species) have been observed during recent (2009-2013) RMBO surveys, although two species have been observed in low numbers. Additionally, there are four species with moderate potential for conservation during the breeding season. Based on this, we consider the condition for species of conservation concern to be good.



Breeding Landbirds

Indicators: Species Occurrence
Measure: 2 Measures



Overall Condition

For assessing the condition of landbirds, we used one indicator with two measures that assessed landbird occurrence. This indicator is summarized in Table 4.11.4-5.

Although our assessment is based on a limited amount of data, including the absence of information to assess occurrence in a temporal context, we judged the overall condition of breeding landbirds at the Historical Park to be good to moderate.

Although RMBO recorded 38 species that were also observed on the three BBS routes, there were 35 species recorded during BBSs that RMBO did not record in 2009-2013. Fifteen of the 35 species, however, fall into the "limited to none" breeding habitat class. Of the remaining 20 species, 14 are in the "exists" breeding habitat class, and six are in the "possibly exists" class. Of the 14 species in the "exists" habitat class, five are noted by Archer (2011) as being either common or abundant during the spring. Out of these five species, only Painted Bunting and Purple Martin were recorded in relatively high numbers during the BBSs.

It is possible that some of these species will be recorded during annual surveys at the park in the future. However, as discussed previously, it is also possible that the agricultural nature

Table 4.11.4-5. Summary of the breeding landbirds indicator/measures and their contributions to the overall landbirds condition.

Indicator	Measure	Condition	Condition Rationale
Species Occurrence	Spatial Context	Moderate	In a comparison of 2009-2012 BBSs in the vicinity of the Historical Park to RMBO surveys within the Historical Park in 2009-2013, there were 35 species that were not observed by RMBO. However, only 14 of the species have characteristic breeding habitat at the park (i.e., fall into the "exists" breeding habitat class). Of the 14, only five were noted by Archer (2011) as being common or abundant during the spring, and only two of these were recorded in relatively high numbers in the BBSs. Based on this comparison, the condition of breeding landbirds is moderate. It should be noted, however, that this condition may not be a true concern for the park, because the agricultural nature of the Ranch Unit and past management of vegetation along the river for security purposes may help explain the absence of some of these bird species. No trend information is available at this time.
	Conservation Context	Good	There are 10 species that have been observed during 2009-2013 RMBO surveys that are listed by one or more organization as being of conservation concern. We believe that five of these species have high conservation potential at the Historical Park. These are species that are within their normal breeding range and sufficient habitat exists at the Historical Park to support breeding. All of these species have been observed on recent RMBO surveys (in one or more years), and four of the species were observed 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.

of the Ranch Unit and the vegetation removal measures that have been taken along the river have affected the habitat in some cases, making it less suitable for some species. From an ecological reference point, we would consider the condition based on the spatial comparison to be moderate. However, it is also important to take into account the purpose of the park to preserve the historic character, structures, and landscape.

We found six species that we believe have relatively high conservation potential at Lyndon B. Johnson NHP, with four of the species being observed in four or five of the years during RMBO surveys. Four additional species are considered to have moderate potential for the Historical Park to contribute to their conservation.

Based on the information presented here, we consider the overall condition of breeding landbirds at the Historical Park to be good to moderate. Unfortunately, we do not have sufficient data to justify a trend in that condition. 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 (i.e., five years of recent data only for the Historical Park) 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. Also, due to the lack of older bird occurrence data for the park, we could not conduct a temporal comparison of species occurrence.

We determined the breeding ranges primarily from the BNA species accounts and had to judge from online and hard copies whether or not the Historical Park 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 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 4.9.4-1 and 4.9.4-3. Mr. Ali will lead the annual landbird monitoring at the Historical Park in 2015 and has become the lead for field efforts for the landbird monitoring in the Chihuahuan Desert Network, Sonoran Desert Network, and Southern Plains Network.

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4.12. White-tailed Deer & Exotic Blackbuck Antelope

Indicators/Measures

- Deer/Antelope Populations (estimated # of deer/antelope)
- Impact on Park Resources (damage to vegetation)

Condition – Trend - Confidence



Moderate - Insufficient Data - Medium

4.12.1. Background and Importance

The white-tailed deer (*Odocoileus virginianus*) is one of a number of native mammal species that occurs at Lyndon B. Johnson National Historical Park (NHP; Figure 4.12.1-1). This deer species is present in most states in the U.S., and it is the most important big game animal in Texas (Davis and Schmidly 1997). The Edwards Plateau (also known as the Texas Hill Country), in which the Historical Park occurs, accounts for nearly 50% of the state's annual white-tailed deer harvest (Knight 2013).

Populations of white-tailed deer, as well as exotic blackbuck antelope (*Antelope cervicapra;* native to the Indian subcontinent), have increased in the vicinity of the Historical Park in recent years and have increased in number or expanded onto park lands (Munoz et al. 2007). There are concerns that the population of white-tailed deer is greater than the park can support. The presence of the exotic blackbuck is undesirable because it is non-native and exerts additional pressure on park resources. Although most exotic ungulates are found on ranches in the Texas Hill Country, many are not so confined and free-ranging herds of exotics can be seen (Traweek and Welch 1992). The Final General Management Plan and Environmental Impact Statement for Lyndon B. Johnson NHP (NPS 1999) notes that some exotic game species were kept on the LBJ Ranch for hunting during the historic period. However, it is unclear from the report whether or not these species included the blackbuck antelope.

The concept of carrying capacity is an important one in this assessment. "Carrying capacity" can be defined as balancing animal numbers to available vegetation, or a population level that avoids damage to



NPS

Figure 4.12.1-1. Female white-tailed deer.

the habitat (Armstrong and Young 2000). Carrying capacity varies from year to year and from location to location. Armstrong and Young (2000) describe two levels of carrying capacity in a management context:

- *"Optimum carrying capacity* is reached when deer are receiving a diet that promotes good antler production, body growth, and reproduction. When 50% or more of preferred browse is utilized, optimum carrying capacity is usually exceeded. Physical parameters of deer, including body weights and measurements of antlers can be used as a gauge of optimum carrying capacity. The addition of extra animals would degrade the physical quality of the herd."
- *"Maximum carrying capacity* is defined as the point at which the range is saturated with white-tailed deer and/or other animals and additional animals would trigger a die-off. If 50% or more of the available nutritionally poor browse is utilized, maximum carrying capacity is often exceeded. The effects of animal numbers on the habitat should be monitored to insure that overuse does not occur. There are obviously many stages between optimum and maximum carrying capacity."

Altough no information is available on the carrying capacity for white-tailed deer at the Ranch Unit of the Historical Park, it is an important concept to keep in mind.

Another important aspect of this discussion is the type of foods white-tailed deer and blackbuck antelope eat. There are three general types of vegetation found in the Edwards Plateau that ungulates eat- forbs, browse, and grass (Armstrong and Young 2000). Based on studies in the area, white-tailed deer prefer to eat broad-leaved herbaceous plants, also known as forbs, and leaves and twigs of woody plants, also called browse. Although not as reliable a source of food, deer like "mast," fruits and nuts of trees and shrubs, when available. White-tailed deer do not prefer to eat grass (they have physical issues digesting mature grasses), and only a small proportion of their food is grass (Armstrong and Young 2000). Although most exotic big game species in Texas prefer to eat forbs and browse also, they are able to eat grasses once the other foods are in low supply (Armstrong and Young 2000).

4.12.2. Data and Methods

This limited assessment is based primarily on a 2007 report on white-tailed deer at the Historical Park, and on information from park staff regarding the current occurrence of deer and blackbuck antelope at the park. Information on white-tailed deer carrying capacity and density were obtained from publications on the subject that appear in the literature cited section of this assessment. We used two indicators with one or two measures each to assess white-tailed deer (and blackbuck antelope) condition at the Historical Park.

Indicators/Measures
Deer/Antelope Population Level (2 measures)
Impact on Park Resources (1 measure)

Deer / Antelope Population Levels at the Historical Park

For this indicator, we used two measures: 1) the population of white-tailed deer at the Historical Park (measured by the number of deer counted), and 2) the population of blackbuck antelope at the Historical Park (measured by the number of antelope counted). The first measure was assessed using the results of a population assessment at the park in 2005 (i.e., Munoz et al. 2007) and an estimate of the number of deer in the park as of Fall, 2014 (made by Brian Perry, Chief Ranger at the Historical Park). The second measure was assessed using the same two sources of information for the blackbuck antelope.

Population Assessment by Munoz et al. (2007)

The report of Munoz et al. (2007), "Game Management Options for the Lyndon B. Johnson Rach," included population estimates (densities) for both white-tailed deer and blackbuck antelope. Road surveys along a standardized route (4.9 miles) were used to estimate deer and antelope densities within the Ranch Unit. A visual survey of

the entire unit, except for the residence area, was conducted; 88% of the Ranch Unit was surveyed (590 acres of the 674 total). The researchers also counted deer outside of the park in situations where deer/antelope could move between the Ranch Unit and adjacent property unimpeded.

A total of 17 surveys were conducted in March, July, and December of 2005. Surveys were conducted at night (8 surveys), at sunset (6 surveys), and at sunrise (3 surveys). Researchers began night surveys about one hour after sunset. All surveys lasted for approximately 45 minutes. For night surveys, two observers were in the back of a truck and used 200,000-candlepower hand-held spotlights. Observers made efforts to avoid the double counting of individual animals when they were visible from more than one location along the route.

2014 Crude Population Estimate

B. Perry, Chief Ranger at the Historical Park, estimated the number of white-tailed deer and the number of blackbuck antelope on the Ranch Unit using visual counts of deer and antelope herds. There are two herds of white-tailed deer and one group of antelope at the Ranch Unit. B. Perry also estimated the number of deer that may be found on the Johnson City Unit.

Impact on Park Resources

There is very little information available for this measure- the impact of deer and antelope on park vegetation. Munoz et al. (2007) established six vegetation exclosure plots to study the impacts of white-tailed deer and blackbuck antelope on native vegetation. They used a 1-m-diameter circle for each plot, and monitored the vegetation within and outside of the exclosure. Unfortunately, the work was still in progress at the time of writing of the 2007 report, and no follow-up information was located for use in this assessment.

Additionally, general information was obtained from park staff regarding the condition of vegetation in areas where deer and antelope occur in relatively high concentrations. This includes information regarding measures the park has taken to minimize damage from deer/antelope.

4.12.3. Reference Conditions

Because there are concerns that the white-tailed deer population at the Historical Park is too high, this assessment is made largely from the perspective of park resources. However, the assessment also takes into account the status and health of the deer themselves. Information on the average density of deer in the Texas Hill Country is provided immediately below.

4.12.4. Condition and Trend

Deer / Antelope Population Levels at the Historical Park

White-tailed Deer

Munoz et al. (2007) reported an approximate deer density at the Ranch Unit of 4.5 acres/deer in 2005. This figure was calculated by taking the effective area surveyed (590 acres) divided by the maximum number of deer counted during surveys (129, during a night-time survey). To put this number into a useful frame of reference, the average density of white-tailed deer in the Texas Hill Country was reported as 15 acres/deer (Armstrong and Young 2000). Therefore, the estimated density at the Historical Park in 2005 was higher than the estimated average in the region. However, Armstrong and Young (2000) reported some white-tailed deer densities in the Hill Country as great as 3 acres/deer.

The other source of information on white-tailed deer for the park is the crude visual estimate/count by B. Perry (Chief Ranger for the park). B. Perry estimated that approximately 400-500 deer were present on the Ranch Unit as of the fall of 2014. The deer appear to be separated into two herds, with the "North field herd" having about 100-150 deer, and the "Pecan and river bottom herd" having about 300-400 deer. He also estimated that about 20-30 deer may occur on the Johnson City Unit.

If we assumed that the two deer counting efforts occurred over the approximate same area, were made with the same amount of effort, and used the same methods, it would

appear that the number of white-tailed deer on the Ranch Unit has increased from 2005 (maximum count of 129) to 2014 (estimate of 400-500). However, it may not be appropriate to make these assumptions. The level of effort, at least, for the two estimates was not the same. Munoz et al. (2007) conducted 17 surveys to arrive at their estimate. Therefore, it is unclear based on the information here whether or not the number of white-tailed deer has increased since 2005. However, using the 2005 estimate of the deer population, the estimated density of deer at the Ranch Unit (4.5 acres/deer) was greater than the average density of deer in the Texas Hill Country from Armstrong and Young (2000; 15 acres/deer). Additionally, park staff believe that the deer population has increased in recent years (Dave Schafer, Chief of Interpretation and Resource Management, pers. comm.). Brian Perry (Chief Ranger) and Mark Tresselt (Gardener / MVO, Preservation Arborist) report that the deer do not look healthy, they are consuming vegetation they would not normally eat, and fawns have been observed abandoned and wasting away (pers. comm. with Historical Park staff). These are indications that the white-tailed deer population may be in excess of the land's carrying capactiy.

Blackbuck Antelope

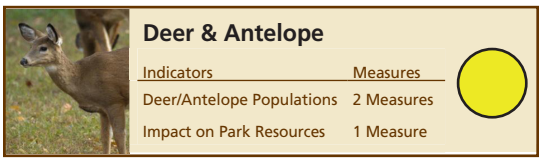
The blackbuck antelope density estimate for the Ranch Unit in 2005 was 5.8 acres/blackbuck (Munoz et al. 2007). This figure was calculated by taking the effective area surveyed (590 acres) divided by the maximum number of antelope counted during surveys (101, during a sunset survey). The estimated density of blackbucks was lower than the estimated density of deer at the park in 2005.

As with white-tailed deer, the other source of information on blackbuck antelope for the park is the crude visual estimate by park staff. B. Perry estimated that approximately 100 antelope are present on the Ranch Unit as of the fall of 2014. They occur almost entirely within the pecan orchard and river bottom. As discussed above for white-tailed deer, it may not be appropriate to compare the two estimates for blackbuck antelope. Although the numbers are very similar, it is unclear at this time whether or not the number of blackbuck antelope is larger or smaller than it was in 2005.

Impact on Park Resources

Although the Munoz et al. (2007) study included a vegetation monitoring component, few data were presented for use in this assessment. They indicated that vegetation cover was lower outside of the exclosure compared to inside of it, but they were not able to determine whether the source for the difference was deer/atelope.

The only other information available regarding impacts to vegetation are various general observations of park staff. Damage from deer has been observed at both of the Historical Parks's units. Dave Schafer (Chief of Interpretation and Resource Management) reported that shrubs and other vegetation around the Texas White House have been eaten by deer. This has required that newly planted trees be fenced off to prevent damage. Mark Tresselt (Gardener / MVO, Preservation Arborist) notes that deer cages protecting several significant plants are being pushed over from the deer. Also, in the past, browse lines on some vegetation were evident (D. Schafer, pers. comm.). Browse lines can be seen when ungulates have eaten leaves and twigs from shrubs and trees up to the height that they can reach. Browse lines may become increasingly higher as animals eventually rear up on their hind legs to get to the highest vegetation within their reach (Armstrong and Young 2000). A browse line is a visual indication of over-use of the habitat. Finally, during June 2011, the Hill Country Master Gardeners prepared a Texas White House Landscape Project that included measures for protecting the historic vegetation from deer (Mark Tresselt, Gardener / MVO, Preservation Arborist, pers. comm.).



Overall Condition and Trend

To assess the condition of white-tailed deer and blackbuck antelope, we used two indicators with three measures. The

Table 4.12.4-1. Summary of the white-tailed deer and blackbuck antelope indicators/measures and their contributions to the overall deer/antelope condition.

Indicator	Measure	Condition	Condition Rationale
White-tailed deer/ Blackbuck antelope population	Estimated number of deer	Moderate	In 2005, 129 deer were counted during a night-time survey at the Ranch Unit; this lead to an estimated density of 4.5 acres/deer at the unit. This estimated density was higher than the average density of 15 acres/deer in the Texas Hill Country (Armstrong and Young 2000) but lower than the greatest density reported for the region by Armstrong and Young (2000; 3 acres/deer). Staff at the Historical Park estimate that in Fall of 2014, there are approximately 400-500 deer on the Ranch Unit. If we assumed that the two deer counting efforts occurred over the same area, were made with the same amount of effort, and used the same methods, it would appear that the number of white-tailed deer on the Ranch Unit has increased from 2005 to 2014. However, it may not be appropriate to make these assumptions. However, park staff indicate that the number of deer do appear to have increased in recent years. For this reason and because the density estimated by Munoz et al. (2007) was high compared to the average deer density in the Hill Country, we conclude the deer population level is of moderate concern. Park staff have also observed deer in apparently poor health. The current trend is uncertain because additional information is needed.
	Estimated number of antelope	Moderate	In 2005, 101 antelope were counted during a sunset survey at the Ranch Unit; this lead to an estimated density of 5.8 acres/blackbuck at the unit. This estimated density was lower than the estimated deer density but higher than the average density of 15 acres/white-tailed deer in the Texas Hill Country (Armstrong and Young 2000). Staff at the Historical Park estimate that as of Fall 2014, there are approximately 100 antelope on the Ranch Unit. Although these estimates (from 2005 and 2014) are similar, it is unclear whether or not the population has increased or not. However, the species is exotic and places additional pressure on the Historical Park landscape. Therefore, we consider the condition to be of moderate concern, with an unknown trend.
Impact on park resources	Damage to vegetation	Moderate	Based on the information available, there appears to be some level of damage to plants at the Historical Park from deer/antelope foraging/ browsing. Park staff have reported that parts of shrubs and other vegetation around the Texas White House have been eaten by deer. This has required that newly planted trees and other significant vegetation be fenced off to prevent damage. Also, browse lines on vegetation have been observed in some places, indicating over-use of the habitat (Armstrong and Young 2000). Park staff have reported damage to vegetation at both park units. Although the extent of the damage is unclear, we consider this indicator/measure to be of moderate concern. The trend is unknown.

indicators/measures are summarized in Table 4.12.4-1. It would be desirable to have a current estimate of the deer (and antelope) population/density based on repeated, standardized surveys. It would also be desirable to have a white-tailed deer expert estimate the carrying capacity for white-tailed deer at the Historical Park. In the absence of such information at this time, we conclude that the white-tailed deer population is of moderate concern. We conclude the same for the blackbuck antelope population. Although the estimated numbers of blackbuck antelope are not as high as those for white-tailed deer, the species is non-native to the U.S. and puts additional pressure on the vegetation and native deer population of the Lyndon B. Johnson NHP landscape. Although there is a lack of data regarding the impact of deer/ antelope on park resources, Historical Park staff have described a number of observations and actions taken to minimize and prevent damage to desirable park vegetation.

Therefore, we consider condition for this measure to also warrant moderate concern.

We conclude that the overall condition based on these two indicators and three measures is of moderate concern. The trend is unknown.

4.12.5. Sources of Expertise

No outside experts were consulted for this topic. However, the assessment was based largely on the 2007 report, "Game Management Options for the Lyndon B. Johnson Ranch," by faculty and students in the Wildlife and Fisheries Sciences Department at Texas A&M University.

4.12.6. Literature Cited

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4.13. Live Oak Trees

Indicators/Measures

- Occurrence & Severity of Oak Wilt Disease (3 Measures)

Condition – Trend - Confidence



Moderate - Insufficient Data - Medium

4.13.1. Background and Importance

Texas live oak trees (or Escarpment live oak, *Quercus fusiformis*) are an important part of the landscape at the Lyndon B. Johnson NHP. The National Park Service (NPS; 1999) estimates that over 4,500 live oak and other trees grow within the Historical Park. Live oak trees are considered one of the "character-defining features" of the Texas White House complex (NPS 2006; Figure 4.13.1-1). The canopies of live oaks at the Texas White House are said to create a protected feeling and view along the Pedernales River, the picnic area, and around the ranch house. The large live oaks in the vicinity of the ranch house "dominate the landscape" (NPS 1999). In the Johnson family cemetery, the live oaks "impart a sense of peace and dignity" (NPS 1999). The live oak, a long-lived species, was also one of President Johnson's favorite trees.

The Texas live oak is sometimes considered a variety of the Southern live oak (*Quercus virginiana)*, but others consider it a separate species (e.g., Lady Bird Johnson Wildflower Center 2014). Texas live oaks are found in natural settings in central Texas and are the common live oak used in landscaping in the region (Lady Bird Johnson Wildflower Center 2014). Texas live oaks can grow to 40 feet in height, and they may have gnarled branches that can spread horizontally from the main trunk. Their leaves are evergreen, and they are more tolerant of drought than the Southern live oak. Although they do not grow as tall, they are very similar in appearance to Southern live oak. The largest known Texas live oak in the state occurs in Young County and is 48 feet tall and 361 inches (or 30 feet) in circumference (Texas A&M Forest Service 2014).



NPS PHOTO

Figure 4.13.1-1. Texas live oak trees (and their shadows) at the Texas White House at Lyndon B. Johnson NHP.

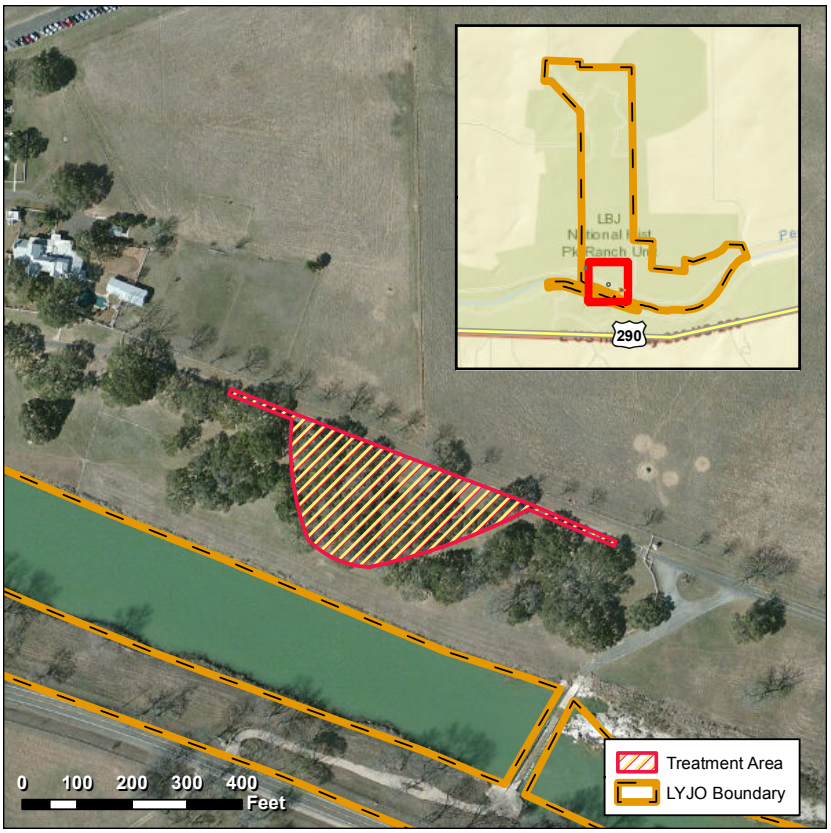


Figure 4.13.1-2. Oak wilt treatment area near the Pedernales River (Texas White House located on the left). In 2009, five trees within the treatment area showed signs of oak wilt disease.

In recent years, a small number of live oaks in the Historical Park were affected by a tree disease that is an issue for many species of oak. Oak wilt is caused by a fungus (*Ceratocystis fagacearum*) and is one of the most serious tree diseases in the eastern half of the U.S. (O'Brien et al. 2000). In central Texas, the disease is responsible for killing oaks in epidemic numbers (Appel et al. 2003). Once infected, Texas live oaks generally die within 1-6 months (O'Brien et al. 2000), after the fungus inhibits the tree's water-conducting system (Appel et al. 2003). Evidence of infection may be seen in the leaves (particularly in spring and fall), which may develop yellow, then brown, veins; other patterns of leaf damage may also occur. Affected leaves are dropped, giving the crown of the tree a progressively thinning appearance. Among the oaks, live oaks are intermediate in terms of susceptibility to the disease (Appel et al. 2003). However, because adjacent trees' root systems may become interconnected (facilitating spread of the fungus), live oaks may be more seriously affected. Severe drought conditions, which have occurred for several years in the vicinity of the Historical Park, can affect and weaken even the healthiest trees (and may make them more susceptible to diseases such as oak wilt).

Fifty-two live oaks along the Pedernales River at the Ranch Unit (known as the barbecue grounds oak grove) were treated in May 2009 for oak wilt disease (Urban Renewal 2009; Figure 4.13.1-2). At the time of treatment, five of the 52 trees were showing signs of the disease (Urban Renewal 2009). Treatment involved applying a chemical (Alamo, with active ingredient propiconazole) to each of the 52 trees to fight or ward off the fungus, and trenching the area (using both primary and secondary trenches) to isolate the roots of the treated trees. Chemical treatments were applied again to trees within the treatment/trenched area in 2011 and 2013. Live oaks in the affected area are monitored annually by Mark Tresselt (Gardener / MVO, Preservation Arborist with the Historical Park) and Robert Edmonson (Biologist, Texas A&M Forest Service).

4.13.2. Data and Methods

This limited assessment is based on information from staff at the Historical Park on the occurrence and treatment of oak wilt disease at the park (e.g., Urban Renewal 2009), and information from and observations of Tomye Folts-Zettner, a biologist with the Southern Plains Inventory and Monitoring Network specializing in vegetation (and an author of this report). Information on oak wilt disease was obtained from publications on the subject that appear in the literature cited section of this assessment. We used one indicator with three measures to assess live oak condition at the Historical Park.

Indicators/Measures

Occurrence & severity of oak wilt disease: 3 Measures

Occurrence & Severity of Oak Wilt Disease

For this indicator, we used three measures: 1) the approximate proportion and significance of live oak trees at the Historical Park affected by oak wilt disease; 2) the current status of the 52 trees treated for oak wilt disease in

2009; and 3) known spread (or containment) of oak wilt disease since 2009 to new trees in the vicinity of those treated or to live oak trees in other areas of the park. The first measure was assessed simply by determining the proportion of trees known to be affected by oak wilt and/or receiving treatment (52 trees) relative to the total number of live oaks at the Historical Park. The total number of live oaks is a rough estimate obtained from the 1999 Final General Management Plan and Environmental Impact Statement (NPS 1999). The other two measures were assessed using information from park staff.

4.13.3. Reference Conditions

Reference conditions for the live oaks at Lyndon B. Johnson NHP are shown in Table 4.13.3-1. In developing reference conditions and in assessing condition, we considered the important role that Texas live oaks play in the landscape and setting of the Historical Park. They have been described as one of the "character-defining features" of the Texas White House complex (NPS 2006).

4.13.4. Condition and Trend

Occurrence & Severity of Oak Wilt Disease

As noted above, we used three measures for this indicator, which are discussed, in turn, below.

Proportion and Significance of live oak trees at the Historical Park affected by oak wilt disease

Of all the live oak trees that grow on the two units of the Historical Park, only approximately 1.4% have been affected by oak wilt disease. This estimated percentage is an approximation; we calculated it as the proportion of trees affected by oak wilt (52 trees) relative to the total number of live oak trees reported to occur on the Historical Park (3,744 live oak trees). The figure of 3,744 comes from 1) the NPS (1999) statement that there are about 4,680 live oak and other trees (excluding pecan trees) in the park, and 2) T. Folts-Zettner's estimate that 80% of the trees in the park are live oaks. This figure is a rough approximation. Based on this measure, we consider the condition to be of moderate concern. Although only a small proportion (1.4%) of live oak trees at the Historical

Table 4.13.3-1. Reference conditions used to assess the current condition of live oaks using the indicator of occurrence and severity of oak wilt disease.

Occurrence Indicator	Significant Concern	Moderate Concern	Good
Proportion and significance of live oak trees affected by oak wilt disease	We considered condition to be of significant concern if the proportion of trees affected by oak wilt was greater than 20%. However, we also considered the significance of affected trees (e.g., based on location or size/age).The disease is very serious for live oaks, and live oaks are an important aspect of maintaining the park to the conditions of the 1960s-1970s.	We considered condition to be of moderate concern if the proportion of trees affected by oak wilt was approximately 10-20%. However, we also considered the significance of affected trees (e.g., based on location or size/age).	We considered condition to be good if the proportion of trees affected by oak wilt was small (up to 9%). However, we also considered the significance of affected trees (e.g., based on location or size/age).
Status of the 52 trees treated for oak wilt disease in 2009	If 18 or more of the treated trees died (more than 32.7%, about one-third), we considered condition to be of significant concern.	If more than a couple but fewer than 18 of the 52 treated trees died (i.e., 32.7%, about one-third), or if more than a few trees died and additional treated trees showed signs of the disease, we considered condition to be of moderate concern.	If only one or a few of the trees treated died, we considered condition to be good. At the time of treatment, Urban Renewal (2009) indicated one of the trees was likely to die.
Spread (or containment) of oak wilt disease since 2009 to new trees	If oak wilt spread to live oak trees outside of the 52 trees treated and trenched, we considered condition of be of significant concern.	N/A	If the 2009 treatment contained the oak wilt area to the 52 trees treated and trenched, we considered condition to be good.

Table 4.13.4-1. Indicator and measures of live oak condition.

Indicator of Condition	Measure	Condition	Rationale for Condition.
Occurrence & severity of oak wilt disease	Proportion and Significance of live oak trees affected by oak wilt disease	Moderate concern	Of all the live oak trees that grow on the two units of the Historical Park, only approximately 1.4% have been affected by oak wilt disease. Although overall this number is fairly small, we also considered the location and size of the trees affected. The trees are in the barbecue grove near the Texas White House. At this time, the trend appears unchanging.
	Status of the 52 trees treated for oak wilt disease in 2009	Significant concern	By Fall 2014, 19 (37%) of the 52 trees treated for oak wilt disease had died (more than one-third of those treated). Also, the remaining 33 trees are showing signs of being stressed by oak wilt disease, so there is the potential for additional trees out of the 52 to die. Three of the 19 trees were just recently found dead. For these reasons, we consider condition under this measure to be of significant concern. The tend is uncertain at this time..
	Spread (or containment) of oak wilt disease since 2009 to new trees	Good	There is no evidence that the disease has spread to trees outside of the treatment area (the 52 trees). There are also no signs of the disease occurring in new areas in either park unit. The trend at this time appears unchanging.

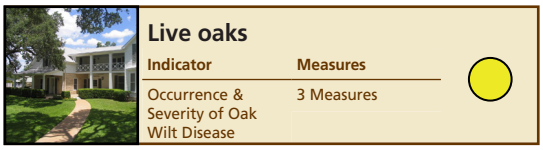
Park have been affected by the disease, those affected are in a high profile and significant area (close to the Texas White House and within the picnic/barbecue grove). The trend at this time appears unchanging.

Current status of the 52 trees treated for oak wilt disease in 2009

Since treatment in 2009, a total of 19 out of the original 52 treated trees (37%) have died from oak wilt disease. This includes two trees that may have died due to mechanical injury from installment of the trench line (M. Tresselt, Lyndon B. Johnson NHP, pers. comm.). This number includes the five trees that showed signs of the disease at the time of treatment. Sixteen of the 19 trees have been removed from the grove as of Fall 2014; three of the trees were just recently found dead (M. Tresselt, Lyndon B. Johnson NHP, pers. comm.). As of Fall 2014, 63% of the 52 treated trees remain alive. However, according to M. Tresselt, the remaining 33 trees within the trenched area are showing signs of being challenged by the oak wilt fungus. Therefore, we consider the condition based on this measure to be of significant concern. The trend is uncertain at this time.

Spread of oak wilt disease since 2009 to new trees

To date, it appears that the trench line around the trees in the treated area is holding (M. Tresselt, Lyndon B. Johnson NHP, pers. comm.). There has been no known spread of oak wilt disease since 2009 to new trees in the vicinity of those treated. Also, the disease has not appeared in trees in other areas of the park. For this reason, we consider the condition to be good for this measure.



Overall Condition and Trend

Based on the one indicator used with three measures, we consider the overall condition of live oak trees to be of moderate concern. The trend in the condition is not known at this time. The indicator and individual measures are summarized in Table 4.13.4-1: the first measure, proportion and significance of live oak trees at the Historical Park affected by oak wilt disease, was judged to be of moderate concern; the second measure, current status of the 52 trees treated for oak

wilt disease in 2009, was judged to be of significant concern; and the third measure, spread (or containment) of oak wilt disease since 2009 to new trees, was determined to be in good condition.

4.13.5. Sources of Expertise

This section was based on information provided by staff at the Historical Park and input provided by Tomye Folts-Zettner. Ms. Folts-Zettner is a biologist with SOPN specializing in vegetation, with a background in Natural Resource Management and Rangeland Ecology.

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JASON LOTT

A sweeping landscape view looking south from Bailey Road.

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 Lyndon B. Johnson National Historical Park's purpose, significance, and fundamental resource and value 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 Lyndon B. Johnson NHP is inextricably tied to its historic purpose, significance and fundamental resources and values (FRVs). 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 Historical Park's purpose, significance, and FRVs statements (NPS 2014). This provides a "snapshot" look at how each natural resource condition ties into the Historical Park's primary reasons for establishment.

Table 5.2-1. Summary of natural resource topic relevance (denoted by black dots) as it relates to Lyndon B. Johnson NHP's purpose, significance, and fundamental resources and values as identified in NPS (2014).

Natural Resource Condition Assessment Topics	Viewshed	Night Sky	Sound-scape	Air Quality	Geology	Water Quality	Ground-water	Riparian Habitat	Grassland	Exotic Plants	Landbird	Exotic Animals	Live Oak
I. Park Purpose													
Protect the historic structures and Texas Hill Country landscapes linked to the ancestry, life, and legacy of President Johnson and provide opportunities for visitors to compellingly experience these places that shaped the personality, character, and political philosophy of Lyndon Johnson throughout his life and that served as the setting for a remote White House during his presidency.	•	•		•	•	•		•	•	•		•	•
II. Park Significance													
Lyndon B. Johnson conducted his official duties as President from his home on the LBJ Ranch for more than one-quarter of his presidency. Johnson used jet aircraft and other technological advancements to become the first American president to work "virtually" from the remote location of his Texas ranch.	•		•										•
The historic setting of the Boyhood Home and Johnson Settlement areas in Johnson City, Texas, reflects President Lyndon B. Johnson's humble origins and the importance of community that influenced his policy agenda as president.	•	•	•	•				•	•	•		•	•
The site of the Texas White House, the LBJ Ranch is a physical manifestation of Lyndon B. Johnson's personal and political life, the site of his ancestral homeplace as well as a key aspect of his personal and public image.	•	•	•	•		•	•	•	•	•		•	•
Lyndon and Lady Bird Johnson's deep-rooted connection to the rural Texas Hill Country landscape shaped policies directed toward natural and historic conservation, and inspired the establishment of the park.	•	•	•	•	•	•	•	•	•	•	•	•	•
Lyndon B. Johnson National Historical Park, as part of a community of presidential sites, provides a setting to interpret the functions of the US presidency, the American political system, and President Johnson's significant legacy including his Great Society policies and the Vietnam war.	•												•
III. Fundamental Resources and Values													
36th President of the U.S. from the Hill Country of Texas.	•	•	•	•	•	•		•					•
Texas White House Complex	•	•	•	•	•	•		•	•	•		•	•
Connection to the Land	•	•	•	•	•	•	•	•	•	•	•	•	•
Boyhood Home Area	•	•	•	•						•			
Settlement Area	•	•	•	•	•	•	•	•	•		•	•	•
Johnson Family Farmhouse Complex	•		•	•	•		•	•	•	•	•	•	•
Working Ranch and Historic Herd	•	•	•	•		•	•	•	•	•	•	•	•
Collections and Archives													

Literature Cited: National Park Service. 2014. Foundation document Lyndon B. Johnson National Historical Park, Texas. 50 pages.

The resource condition highlights for each resource topic, if applicable, will be presented in the *State of the Park* resource brief (section 5.3). Condition findings relative to potential resource issues/data gaps, opportunities and management considerations will be presented in the resource narratives section 5.4.

5.3. State of the Park Reporting

As part of the stewardship of national parks for the American people, the NPS has begun to develop *State of the Park* reports to assess the overall status of each park's resources. The NPS will use the *State of the Park* report information to improve park priority setting and to synthesize and communicate complex park condition information to the public in a clear and simple way (NPS 2012).

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

- Provide to visitors and the American public a snapshot of the status and trend in the condition of a park's priority resources and values.
- Summarize and communicate complex scientific, scholarly, and park operations factual information and expert opinion using non-technical language and a visual format.
- 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 Historical Park'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

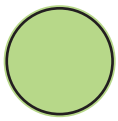
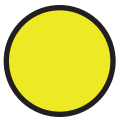
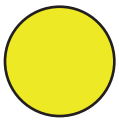
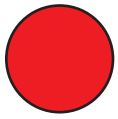
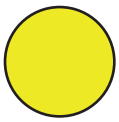
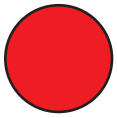
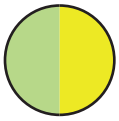
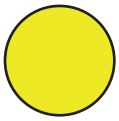
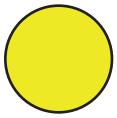
Priority Resource or Value	Condition Status/Trend	Summary of Overall Condition Rating
Natural Resources		
Viewshed		Viewshed condition is assessed based on scenic and historic integrity. The measures of integrity include intactness of view (that is, how much the viewshed has been altered from its reference 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 Lyndon B. Johnson NHP is in good condition, with a medium level of confidence. Insufficient data are available to determine trend.
Night Sky		Two indicators were used to assess the condition of night sky: sky brightness (measured by anthropogenic light ratio, zenith sky brightness, and maximum vertical illuminance) and sky quality (measured using the Bortle dark-sky scale). For each quantitative measure, condition of the night sky at Lyndon B. Johnson NHP was moderate, with a high 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 of significant concern 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 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. The level of ozone and the total sulfur measure for wet deposition were in moderate condition, whereas, wet deposition of total nitrogen and visibility were of significant concern. The overall condition rating for air quality was of significant concern.
Geology		We used one indicator, geologic resource integrity, to assess the condition of the geologic resources. Level of integrity (condition) is based on the extent of management issues or concerns evident in the park, and whether or not geologic resources and processes are within a natural range of state and function. Geologic resources are in good condition at Lyndon B. Johnson NHP, with a high level of confidence. Insufficient data are available to determine trend.
Surface Water		Three water quality indicators were used to assess water quality condition. Readings for the field properties, E. coli and nitrate levels were regularly within the Texas water quality standards and the water quality condition for the Pedernales River and Town Creek were considered to be in good condition.
Groundwater		One indicator, groundwater elevation, was used to assess the groundwater resource condition. Well records from wells that were finished in the same aquifers as the park's were used as proxies to assess current condition since no long-term water level measurements exist for the park. Due to recent extreme drought conditions, we consider the current groundwater condition to be moderate.
Riparian Habitat		The riparian resources and characteristics along the Pedernales River were assessed through a rapid assessment. The condition ratings for Rock Creek were good. Both the vegetation and erosion/deposition processes were considered to be in moderate condition.
Grasslands		We used three indicators, but combined two of them, to assess the restoration grassland condition at the Historical Park. The first and second indicators (combined into one indicator), soil/site stability and hydrologic function, had 10 measures, all of which were judged to be in good condition. The remaining indicator, biotic integrity, had five measures. Four of the individual five measures were considered to be in good condition, and the fifth was considered to be moderate to good (or moderate with an increasing trend). The overall condition of the restoration grassland at the Historical Park is good (at the low end of the "good" scale), with an increasing trend. It should be noted that in assessing condition, we took into account that the area is being restored from a degraded condition (e.g., heavily grazed, may have been plowed, portions placed into a pecan grove). If we had not taken these past activities into account, we may have held the restoration grasslands to a higher standard and found them to be in a lesser, moderate, condition at this time.

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
Exotic Plants		We used two indicators, potential to alter native plant communities and prevalence of exotic plants, to assess the condition of exotic plants at the park. 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. We do not have sufficient data to justify a trend in the condition at this time.
Breeding Landbirds		We used one indicator, species occurrence (presence/absence), in two separate contexts (or measures; spatial and conservation), to assess the condition of breeding landbirds at the Historical Park. No data were available for the park prior to 2009 to examine differences in species occurrence over time (a temporal context). We found the current condition to be moderate for the spatial context and good for the conservation context. The overall condition of breeding landbirds at the Historical Park is good to moderate. We do not have sufficient data to justify a trend in the condition at this time.
White-tailed Deer & Exotic Blackbuck Antelope		We used two indicators, with one or two measures each, to assess white-tailed deer and blackbuck antelope condition at the Historical Park. The first measure, white-tailed deer/ blackbuck antelope population levels, had two measures- one for the population of white-tailed deer and one for the population of blackbuck antelope at the Historical Park (each measured by the number of deer/antelope counted). The second measure, impact on park resources, was measured by observable damage to park vegetation. Each indicator/measure was determined to be of moderate concern. The overall condition of white-tailed deer and blackbuck antelope is of moderate concern. Adequate information does not exist to evaluate trends at this time.
Live Oak		We used one indicator, with three measures, to assess live oak condition at the Historical Park. The first measure, proportion and significance of live oak trees affected by oak wilt disease, was determined to be of moderate concern. The second measure, current status of 52 trees treated for oak wilt disease in 2009, was determined to be of significant concern. The third and final measure, spread of oak wilt disease since 2009 to new trees, was determined to be in good condition. Overall, the condition of live oak trees at the Historical Park are of moderate concern. Adequate information does not exist to evaluate trends 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. 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 Lyndon B. Johnson NHP. Visualizing this connection as part of the landscape is a critical part of the visitor experience.

The LBJ Boyhood Home and Johnson Settlement is located within Johnson City, just off Main Street. Johnson Settlement is composed of 15 acres of restored buildings from the early- and mid-20th century interpreted for the public and walking trails. The views are diverse including both views of town and rural/agricultural land that is part of the site and adjacent to it.

The LBJ Ranch is west of Johnson City (approximately 13 miles). This is the location where LBJ's grandparents ran their 320-acre cattle ranch from 1867-1872. The site includes historic buildings associated with the Johnson family, LBJ's presidency, and buildings and equipment associated with the working ranch. The views are pastoral and provide visitors with the experience of visiting the Johnson family ranch.

5.4.2. 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 NHP 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 viewshed at Lyndon B. Johnson NHP is in good condition. From the main vantage point in the LBJ Ranch unit, views are mostly intact with few non-contributing features and the majority of features contributing to the scenic and historic quality. Non-contributing features visible from the vantage point include primarily NPS

Table 5.4.2-1. Summary of overall viewshed condition, indicators and measures, and rationale for assigning condition assessment at Lyndon B. Johnson National Historical Park.

Viewshed			
Indicators of Condition	Specific Measures	Condition Status/Trend	Rationale
Scenic and Historic Integrity	Intactness of View		Views are mostly intact with few non-contributing features and the majority of features contributing to the scenic and historic quality, consistent with good condition.
	Conspicuousness of noncontributing features		Non-contributing features that are most conspicuous include the tower to the north and the ranch buildings and powerlines to the southwest and west. These are relatively minor intrusions into the landscape, and consistent with good condition.

features, such as visitor services and park roads. The visitor center near the airstrip (hangar) is mostly shielded by the large oak trees. One of the most prominent non-contributing features is the tower to the north, and neighboring ranch buildings and powerlines to the southwest and west. Agricultural equipment, the airstrip, barns, and other buildings on site seen from the vantage point contribute to the scenic and historic integrity. Most of the views of and from the historic buildings are well shielded from outside development (noncontributing features) and enhance the sense of place. Ancillary views along the trail in the Johnson Settlement Area also contribute to the sense of place. The landscape surrounding the site remains largely intact and the degree of conspicuous agricultural and rural development surrounding the park is minimal. Although there is insufficient data to determine trend, housing and road densities do not indicate an immediate threat; however, with the two units integrated in a developed landscape, there is potential for incursions into the viewshed.

5.4.3. Management and Project Considerations and Narrative

The 320-acre cattle ranch owned by Sam E. Johnson and Eliza Bunton Johnson existed in Johnson City at the present day Johnson Settlement. The cabin at the Johnson Settlement is the original cabin, restored by the National Park Service back to its 1850s appearance, when James Provost built the dog-trot cabin (Bearss 1971). In the book The Trail Drivers of Texas edited by J. Marvin Hunter, A.W. Capt—head drover for the Johnson family—wrote about the Johnson brothers explaining their "…headquarter pens and branding stall at the mouth of Williamson's Creek in Blanco County and headquarters at Johnson's Ranch on the Pedernales River, Johnson City, the county site of Blanco County" (Capt 1985). Additionally, the 1876 Blanco County Tax Roll shows that James Polk Johnson, a nephew of Sam Ealy Johnson, Sr., acquired the 320 acres of the Joseph Duel Survey, which was located in Blanco County, not in Gillespie. The Johnsons not only owned land belonging to the Joseph Duel Survey (Johnson City) but also the James Fentress land grant which lay north of the Joseph Duel Survey (Moursund 1981).

Currently, the area around Johnson City, Stonewall, and Fredericksburg is growing rapidly. Johnson City will continue to feel impact of urban development expanding westward from Austin and northward from San Antonio. Wineries and eateries continue to appear in Johnson City along with neighboring properties available for acquisition. Additionally, housing developments are being planned in previously undisturbed areas.

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. Noteworthy Highlights

Lyndon B. Johnson NHP has a unique opportunity to interpret the night sky in the context of the space program. After the Soviets launched Sputnik I in 1957, President Kennedy aimed to re-establish American leadership by landing an astronaut on the moon by the end of the 1960s. President Kennedy was, in part, responding to urging from then Senate majority leader Lyndon Johnson who raised the alarm regarding Sputnik and that the satellite launch signaled the race to control space. Kennedy put Vice President Johnson in charge of the space program (the National Aeronatuics and Space Administration, NASA, was founded in 1958).

Johnson had the distinction of being instrumental in both the ramping up and the scaling back of the "space race." As President, he made the space program a high priority until the high costs of the Vietnam War and his Great Society programs forced him to cut NASA's budget. Under Johnson's administration, the 1967 Outer Space Treaty laid the foundation for international space law that is still in place today and has been ratified by all of the major space-going nations. The treaty outlaws nuclear weapons in space and bars national sovereignty over celestial objects.

Table 5.5.1-1. Summary of overall night sky condition, indicators and measures, and rationale for assigning condition assessment at Lyndon B. Johnson National Historical Park.

Night Sky			
Indicators of Condition	Specific Measures	Condition Status/ Trend	Rationale
Sky Brightness	Anthropogenic Light Ratio (1.01)		This measure results from ground-based data collected by the NPS Night Sky Division. Specific thresholds for condition classes have been set by the NPS. In this case, the moderate condition likely resulted from the significant light domes of nearby cities. The confidence level in this assessment is high.
	Maximum Vertical Illuminance (0.8)		This measure results from ground-based data collected by the NPS Night Sky Division. Specific thresholds for condition classes have not been set; however, condition is estimated as moderate. The measure reflects a rating of 200% above average natural conditions.
	Zenith Sky Brightness (21.38-21.45)		Zenith sky brightness indicates moderate condition, based on the impact from light domes from nearby cities and towns, and more local point sources. Confidence level is high.
Sky Quality	Bortle Scale Class (5)		Although star gazing at Lyndon B. Johnson NHP may be quite good as far as seeing constellations, the Milky Way, and other celestial bodies, the light domes from nearby towns were quite visible; a few point sources from homes, farm buildings and roads were also evident. Inside the Historical Park, the interfering light sources are mostly shielded by the topography and vegetation. Because this measure is qualitative, it has a low confidence level.

5.5.2. 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.

Protecting the night sky resources at Lyndon B. Johnson NHP benefits the natural resources, is important for visitor experience, has cultural and historical significance, and is important within the cultural context of the Historical Park.

The overall condition of the Historical Park's night sky is moderate, with a high level of confidence. Although star gazing may be quite good as far as seeing constellations, the Milky Way, and other celestial bodies, the light domes from nearby towns were quite visible; a few point sources from homes, farm buildings, and roads were also evident. Inside the Historical Park, the interfering light sources are mostly shielded by the topography and vegetation.

5.5.3. Management and Project Considerations and Narrative

From 1973 to 2007, the park allowed visitation only at the Ranch during the day—with limited accessibility—due to Mrs. Johnson being in residence part of the time. For several years, in the 1990s and early 2000s, the park periodically hosted night sky star gazing events with the Austin Astronomical Society.

Under the 5.5.2 Section the park agrees with the importance of the Night Sky, working to educate the public, making this a higher priority. More people moving to Texas and urban areas—Austin and San Antonio—are growing outward toward the Hill Country. Currently, numerous wineries and vineyards are being established throughout Gillespie and Blanco Counties. The park is in the process of planning star viewing parties with the Hill Country Astronomers and Enchanted Rock State Park. The star party would be a chance to educate visitors, explaining their impact upon the night sky. The park has prioritized the purchase of eco-friendly light bulbs to limit night sky impact. Other options would be to speak to neighbors and ask them to consider using night friendly bulbs.

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. Noteworthy Highlights

Sounds originating from within Lyndon B. Johnson NHP are primarily natural, including birds, insects and wind. These sounds help to create a setting that is conducive to understanding President Johnson's strong connection to the land and surrounding environment. It's easy to understand why he cherished his home as its setting instills a sense of tranquility and peace.

5.6.2. 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 of significant concern due to the constant traffic noise heard along Texas State Highway 290. 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 significant concern based on the sound level impact. When combining all measures, we considered the soundscape to be in moderate condition.

5.6.3. Management and Project Considerations and Narrative

The rural and isolated Texas Hill Country setting that Lyndon Johnson was born into on August 27, 1908 has disappeared. With infrastructure growth after World War II created a necessity to build U.S. Highway 290 into a four-lane thoroughfare. The tour flow with the buses on the LBJ Ranch from 1973-2009 mitigated the amount of transportation noise on the LBJ Ranch, created by the NPS. The expansion of major cities in Texas created a desire to retreat to the Hill Country to enjoy nature. The increasing traffic flow on U.S. Hwy 290 will continue to impact the serene environment.

Table 5.6.2-1. Summary of overall soundscape condition, indicators and measures, and rationale for assigning condition assessment at Lyndon B. Johnson National Historical Park.

Soundscape			
Indicators of Condition	Specific Measures	Condition Status/Trend	Rationale
Audibility	% Time Audible		The highest percent time audibility of sounds heard at all monitoring locations originated from birds and traffic noise outside the park's districts. As a result we considered the percent time audibility measure to be of significant concern.
Sound Level	Amplitude (on-site monitoring)		The loudest sounds heard originated from traffic noise along Texas State Highway 190 and from grounds care both within and outside park boundaries. Overall, most sounds heard would not have interrupted a normal conversation at 1 m. We considered this measure to be in good condition.
	Amplitude (Mennitt et al. 2013)		The modeled impact sound level for the NHP ranged between 3.0-9.0 dBA. This range falls within the significant concern threshold for non-urban parks (Turina et al. 2013).

Under Section 5.6.3, park managers have assessed the importance of soundscape issues and will work with partners and employees to help them understand the importance of soundscapes. During the spring and fall seasons, special programs in the park could discuss the impacts sound makes upon a landscape. A program in the Johnson Settlement focusing upon the environment of the president's grandparents versus today would help visitors understand the impact of noise. Another program could weave sound into the interpretation, sounds of then and now. Park managers could meet with private tourism contractors and explain the importance of offering a pristine environment.

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. Currently, level of ozone and wet deposition of total sulfur were in moderate condition, Both visibility and wet deposition of nitrogen were of significant concern. No trends were reported for any of the measures since no monitoring station was located 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.

5.7.2. Management and Project Considerations and Narrative

The location of the park alongside a major highway, and in an area that receives pollutants from sources in Texas and Mexico (such as refineries and power plants). The increasing amount of car pollution resulting from the growth of traffic flow will increase the poor quality of air on the LBJ Ranch and the Johnson Settlement.

Table 5.7.1-1. Summary of overall air quality condition, indicators and measures, and rationale for assigning condition assessment at Lyndon B. Johnson National Historical Park.

Air Quality 			
Indicators of Condition	Specific Measures	Condition Status/Trend	Rationale
Visibility	Haze Index		For 2008–2012, estimated average visibility in the NHP was 8.8 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 Historical Park was 73.9 parts per billion, therefore, the condition status warrants moderate concern based on NPS Air Resource Division benchmarks. There are six ozone-sensitive plants in the park, with four 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 3.5 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 2.7 kilograms per hectare per year, therefore, the resource is in moderate condition based on NPS Air Resource Division benchmarks. No NPS-ARD trend information is available for sulphur.

Park managers appreciated the comments in Section 5.7.2 and will consider every option to improve the air quality. One of the options park managers discussed is the reduction of idling engines within the park boundaries. The park welcomes large amounts of tour buses that sit on the taxiway located by the ranch hangar and idle right before they leave the park.

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 unique geology of the Llano Uplift has sparked research interest among geologists. More local research would help resource managers at the park understand the relationships among various physical factors in the ecosystem.

According to the City of Llano, the Llano Uplift contains the only known specimens of the granite known as llanite. This brown granite contains visible crystals (phenocrysts) of sky-blue quartz and rusty-pink feldspar in a matrix of microscopic quartz, feldspar, biotite, and minor fluorite, magnetite, apatite, and zircon crystals. This unique rock typically occurs as dikes of ≈1,093 Ma age. It is treasured as a decorative polished stone.

Gem-quality topaz and some gold associated with pegmatite dikes are also present in the area. Gold is found either as native gold, or in association with sulfide minerals, such as pyrite, quartz veins, and quartz stringers, as well as residual soils and saprolite

5.8.2. Condition Rationale

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

Geologic resources are in good condition at Lyndon B. Johnson NHP, with a high level of confidence (a geologic resource evaluation report was completed in 2008). With the exception of general erosion concerns, there are no real issues identified that impair the geological resources at the park.

The history of the area is heavily influenced by its geology. The gullies and ravines carved into the Edwards Plateau region made travel and farming difficult. Because of the local topography and hydrography of the Pedernales River, large 100- and 500-year floodplains cover much

Table 5.8.1-1. Summary of overall geology condition, indicators and measures, and rationale for assigning condition assessment at Lyndon B. Johnson National Historical Park.

Geology 			
Indicators of Condition	Specific Measures	Condition Status/Trend	Rationale
Geologic Integrity	None		With the exception of general erosion concerns, there are no real issues identified that impair the geological resources at the park. A geologic resource evaluation report was completed in 2008.

of the park today. The combination of climate and landform rendered this landscape rich in prairies and grasslands for cattle grazing.

5.8.3. Management and Project Considerations and Narrative

Geologic issues that may warrant attention from resource managers include the interrelated impacts of riparian habitat degradation, erosion, and sedimentation associated with grazing cattle. The function of the park as a working ranch requires careful management of the pasturelands necessary for cattle grazing.

- Cattle/grazing management and protection of riparian areas. Cattle grazing reduces the amount of buffering and stabilizing vegetation in riparian zones along the rivers and streams.
- Erosion and sedimentation. Bank erosion is a major factor leading to the introduction of heavy sediment loads to the riverine environment. Land use affects stream bank erosion rates.

The Pedernales River is a beautiful tributary flowing right into the Lower Colorado River outside of Austin. During the years of highest historic significance—1963 to 1969—President Johnson considered the viewshed of the Pedernales River to be crucial in telling the story of his Hill Country roots. During his presidency, Johnson maintained the tract of riverbank adjacent to the Texas White House as ankle-high vegetation to appearing almost manicured in appearance. Photographs captured his Hereford cattle grazing in that section of riverbank. Contrary to that height, other sections of the riverbank comprised grasses growing as tall as the president himself (at least six feet tall). In recent years, the park has mowed various sections of the riverbank. Southern Plains Inventory and Monitoring Network employees encouraged park personnel to allow regrowth of key vegetation to stabilize the banks of the Pedernales.

In the best judgment of the park managers Section 5.8 and Section 5.11 are interrelated. The responses given in Section 5.8.3 revolves around the condition of the riverbank and riparian areas. The Edwards Plateau impacted many families who attempted farming—the Johnsons being one of those families. Park managers agree with monitoring the erosion and condition of the geology and riparian areas. Current park managers suggest replanting of key vegetation to stabilize the bank, along with the reduction of vegetation cutting along the bank level. Specialists suggested trimming some of the vegetation and using that to grow vegetation along the bank. Suggestions in this report will be considered by park managers along with the options of purchasing key seeds to rebuild the bank. Additionally, removal of exotic species will occur in order to maintain a healthy riverbank.

5.9. Surface Water Resource Brief and Narrative

The contents of sub-chapter 5.9 were designed to be placed into a stand-alone Surface Water 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. Noteworthy Highlights

The water quality of the Pedernales River has been in excellent condition historically and still is in very good condition today, preserving a dominant feature of the cultural landscape.

5.9.2. Condition Rationale

Lyndon B. Johnson NHP's surface water quality is monitored monthly by NPS staff. A total of four field parameters, E. coli, and nitrate levels are measured to monitor overall water quality condition. All of the parameters were regularly within Texas' water quality standards and the condition was considered good for the park. In general, the water quality has been good throughout the region historically as well.

5.9.3. Management and Project Considerations and Narrative

In the past the park's Visitor and Resource Protection division conducted water quality testing along the Pedernales River.

Table 5.9.1-1. Summary of overall surface water quality condition, indicators and measures, and rationale for assigning condition assessment at Lyndon B. Johnson National Historical Park.

Surface Water			
Indicators of Condition	Specific Measures	Condition Status/Trend	Rationale
Field Properties	4 Measures		With a few exceptions, field properties met the state standards set forth by TCEQ and the EPA. While dissolved oxygen levels appeared to be decreasing and specific conductance levels appeared to be increasing, overall, the field properties measures were considered to be in good condition.
E. coli	1 Measure		All sites appeared to have declining levels of *E coli* over the period of record. This parameter was considered to be in good condition.
Primary Nutrient	1 Measure		Nitrate levels were often within the state's standard, especially in recent monitoring years. This parameter was considered to be in good condition.

5.10. Groundwater 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. Condition Rationale

For assessing the condition of groundwater, we chose one indicator , groundwater elevation. The aquifers that support park operations and the riparian habitat along the Pedernales River thus far have maintained viability through hydrologic variations. However, with the recent extreme drought conditions impacting groundwater levels and causing Blanco Pedernales Groundwater Conservation District to request conservative use of the resource, the groundwater condition is considered to be in moderate condition at this time.

5.10.2. Management and Project Considerations and Narrative

Park managers will seriously consider any suggestions the writers of the chapter have regarding our groundwater conditions. The park could cut back on using sprinklers as often to water the grounds of the Texas White House. The park's Environmental Compliance Committee conducted discussions to consider using artificial turf for the front yard of the Texas White House.

Table 5.10.1-1. Summary of overall groundwater condition, indicators and measures, and rationale for assigning condition assessment at Lyndon B. Johnson National Historical Park.

Groundwater			
Indicators of Condition	Specific Measures	Condition Status/Trend	Rationale for Resource Condition
Groundwater Elevation	Change in Groundwater Elevation		The aquifers that support park operations and the riparian habitat along the Pedernales River thus far have maintained viability through hydrologic variations. However, with the recent extreme drought conditions impacting groundwater levels and causing Blanco Pedernales Groundwater Conservation District to request conservative use, the groundwater condition is considered to be moderate at this time.

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 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.

5.11.1. Noteworthy Highlights

Park staff have actively managed livestock grazing along the Pedernales River bottom. This has resulted in the establishment of a riparian buffer zone that not only protects exacerbated erosion along the riverbank but also helps to maintain the excellent water quality of the river.

5.11.2. Condition Rationale

The riparian habitat along the Pedernales River was assessed for its current condition of vegetation and erosion/deposition processes. The Pedernales River is spring fed and perennial and has a mostly bedrock channel bed that controls much of the river's channel. The reach along the north bank and LBJ Ranch includes two historically significant dams that affect the riparian habitat. There are areas of bank erosion further to the west, but the vegetation and riverbanks are in a more natural state the further downstream (to the east). Overall, the riparian system was considered to be in moderate condition.

5.11.3. Management and Project Considerations and Narrative

The Pedernales River is a beautiful tributary flowing right into the Lower Colorado River outside of Austin. During the years of highest historic significance—1963 to 1969—President Johnson considered the viewshed of the Pedernales River to be crucial in telling the story of his Hill Country roots. During his presidency, Johnson maintained the tract of riverbank adjacent to the Texas White House as ankle-high vegetation to appearing almost manicured in appearance. Photographs captured his Hereford cattle grazing in that section of riverbank. Contrary to that height, other sections of the riverbank comprised grasses growing as tall as the president himself (at least six feet tall). In recent years, the park has mowed various sections of the riverbank. Southern Plains Inventory and Monitoring Network employees encouraged park personnel to allow regrowth of key vegetation to stabilize the banks of the Pedernales.

In the best judgment of the park managers Section 5.8 and Section 5.11 are interrelated. The responses given in Section 5.8.3 revolves around the condition of the riverbank and riparian

Table 5.12.1-1. Summary of overall riparian habitat condition, indicators and measures, and rationale for assigning condition ratings at Lyndon B. Johnson National Historical Park.

Riparian Habitat			
Indicators of Condition	Specific Measures	Condition Status/Trend	Rationale
Riparian Vegetation	7 measures		The condition of the measures to assess riparian vegetation were variable. The vegetation was in better condition in reach three than in reaches one and two. A thin strip of riparian vegetation has become established due to park efforts, but banks are still destabilized in areas due to limited types and amount of vegetation growing along the banks.
Erosion/Deposition	1 measure		The banks throughout reaches one and two have been destabilized, resulting in undercutting and erosion. Because of this, we consider the erosion/deposition processes to be in moderate condition.

areas. The Edwards Plateau impacted many families who attempted farming—the Johnsons being one of those families. Park managers agree with monitoring the erosion and condition of the geology and riparian areas. Current park managers suggest replanting of key vegetation to stabilize the bank, along with the reduction of vegetation cutting along the bank level. Specialists suggested trimming some of the vegetation and using that to grow vegetation along the bank. Suggestions in this report will be considered by park managers along with the options of purchasing key seeds to rebuild the bank. Additionally, removal of exotic species will occur in order to maintain a healthy riverbank.

5.12. Restoration Grasslands Resource Brief and Narrative

The contents of sub-chapter 5.12 were designed to be placed into a stand-alone Restoration 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

Lyndon B. Johnson NHP is located within a region generally classified as mixed grass prairie, but it is near and to the west of the tallgrass prairie region. Vegetation at the Historical Park consists of a combination of common Texas Hill Country native plants and non-native species influenced by agricultural activities. The grasslands, in particular, were modified from their natural condition through seeding and irrigation. Today, these grasslands consist of improved and unimproved pastures and a restoration grassland. These areas account for a substantial proportion of the Historical Park and are a vital part of the cultural landscape. Protecting and maintaining the natural environment and cultural heritage of the Texas Hill Country is one of the mission goals for the park. The predominant land use in the Pedernales River valley was and is ranching activities and orchards. The restored grassland is located within the Johnson City Unit, and it was the focus of this condition assessment. Although the improved and unimproved pastures were not the focus of the condition assessment, they are included in the condition assessment discussion.

5.12.2. Condition Rationale:

To assess the condition of grasslands in the restoration area at Lyndon B. Johnson NHP, we used a variety of indicators/measures that were not mutually exclusive but were intended to be different ways to capture the essence of what we thought represented the condition of the restoration area's grasslands. Three indicators, with a total of 15 measures, were used. For nearly all measures, condition was considered good. The vast majority of grassland species in the restoration grassland are native (90%), and the percentage of total cover was dominated by

Table 5.12.2-1. Summary of overall restoration grasslands condition, indicators and measures, and rationale for assigning condition assessment at Lyndon B. Johnson National Historical Park.

Restoration Grasslands 			
Indicators of Condition	Specific Measures	Condition Status/Trend	Rationale
Soil/Site Stability and Hydrologic Function	10 measures		The overall good condition rating for this indicator reflects the condition ratings for the 10 measures. All 10 measures were considered to be in good condition. Nine of the ten measures had the highest rating ("none to slight"); one of the measures was in the "slight to moderate" category, but this category was still considered in good condition in accordance with the reference conditions.
Biotic Integrity	5 measures		Similar to the measures of soils, measures of biotic integrity were consistently considered good. Four of the individual measures were considered to be in good condition, and the fifth was considered to be moderate to good (or moderate with an increasing trend). The vast majority of grassland species in the Restoration Grassland at Lyndon B. Johnson NHP are native (90%), and the percentage of total cover was dominated by native species (especially for forbs).

native species (especially for forbs). In addition, the condition of the grasslands is anticipated to improve with time.

The first and second indicators (combined into one indicator), soil/site stability and hydrologic function, had 10 measures. All 10 measures were considered to be in good condition. Nine of the ten measures had the highest rating ("none to slight"); one of the measures was in the "slight to moderate" category, but this category was still considered in good condition in accordance with the reference conditions. The remaining indicator, biotic integrity, had five measures. Four of the individual five measures were considered to be in good condition, and the fifth (general life cycles relative to disturbance) was considered to be moderate to good (or moderate with an increasing trend). The condition under this indicator was good.

The overall condition of the restoration grassland at the Historical Park is good (at the low end of the "good" scale), with an increasing trend. It should be noted that in assessing condition, we took into account that the area is being restored from a degraded condition (e.g., heavily grazed, may have been plowed, portions placed into a pecan grove). If we had not taken these past activities into account, we may have held the restoration grasslands to a higher standard and found them to be in a lesser, moderate, condition at this time. Personnel at the Historical Park have worked to restore the 12 acres of mixed grass prairie in order to interpret the natural resources that originally drew Sam Johnson to locate his homestead there.

Additionally, the moderate to extreme drought conditions that occurred in three of the years from 2010-2014 likely resulted in some of the observations recorded during the annual grassland monitoring and the 2014 rapid field assessment upon which the condition assessment is based (e.g., a higher proportion of forbs than expected and a lower occurrence of desirable species, such as sideoats grama and Indiangrass). The drought also exposed more bare soil than desirable and affected plant vigor. However, the restoration grasslands form a unique landscape in the area and at the Historical Park. If the region continues to shift from drought conditions to more normal rainfall patterns, and as Historic Park management continues to address exotic plants and restoration of native prairies, we anticipate conditions to continue to improve for grasslands at Lyndon B. Johnson NHP.

5.12.3. Management and Project Considerations and Narrative

The prairie in the Johnson Settlement is in a transition stage. Park managers, along with help from SOPN specialists, have worked to begin a transformative process. The prescribed burn in the prairie last year (2015) has been an overwhelming success and was an important step. The next step is combatting the Johnsongrass. In January 2016, the maintenance division will mow the prairie down to a considerable short height in order to combat the Johnsongrass and foster growth of grass and wildflowers. After the mowing is complete the IPM team—Clint Herriman and Alex Shane—will use Outrider herbicide to treat the Johnsongrass. Park managers are hopeful this will be a one-two punch to work on the Johnsongrass. The next burn of the prairie is planned for 2017.

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 Lyndon B. Johnson National Historical Park 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). Twelve of the 36 exotic plant species (33%) found during SOPN monitoring and the 2014 rapid assessment were ranked as either highest or high for their significance of exotic plant impact. Thirteen

Table 5.13.1-1. Summary of overall exotic plants condition, indicators and measures, and rationale for assigning condition assessment at Lyndon B. Johnson National Historical Park.

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. Eleven species of the 39 exotic plants found during SOPN monitoring were ranked as having the highest or high innate ability to become a pest. Two of these species were abundant. Therefore, this we consider this measure to be of significant concern.
Prevalence of Exotic Plants	Extent of Exotic		Every site monitored (block or plot) by the SOPN between 2012-2014 contained exotic plants. Twenty-eight species were found during monitoring of the vector blocks. Blocks contained as many as 12 different exotic species. Six species were found in more than half the blocks. Thirteen exotic species were found in greater than 10% of vector blocks; four of these species are considered to be of highest concern for their potential to alter native plant communities. Thirty-two species were found during the 2014 rapid assessment, with one species occurring in more than half the plots. Eleven species were found in more than 10% of the plots, including four species of highest or high concern for innate ability to become a pest.
	Density of Exotic		Most of the exotic species occurrences in Lyndon Johnson NHP were in moderate to low densities in monitored parts of the park. Only Bermuda grass was found to form a matrix in a monitored site, and did so in only two plots. Eight species were found in density class 3 (scattered even) or higher, but only in a total of 40 blocks and plots. Species were most often found in density class 2 (scattered patchy).
	Distribution of Exotic		Exotic plants were found in all parts of the park. Two species were found in all four monitored areas, seven species were found in three of the monitored areas, eight occurred in two areas, and 14 in one area. Twelve species of exotic plants found during the rapid assessment were found in both the Johnson City and the Ranch Units.

additional species (36%) 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 is of significant concern (Table 5.13.1-1). 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, and were found in every block or plot sampled. Individual species were found in as many as 92% of the blocks sampled in annual monitoring and 75% of the one-time rapid assessment plots. Individual blocks contained as many as 12 different species. Hence, the extent of exotic plants in the historical park is of significant concern (Table 5.13.1-1). 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 (Table 5.13.1-1). They are found in all areas of the park that were surveyed, including 17 species that were found in two or more of the four surveyed areas. Further, by combining the four measures and evaluating the species on an individual basis, eleven exotic plant species were in a condition of significant concern, and five species were in moderate condition. Two additional species were of special concern.

5.13.2. Management and Project Considerations and Narrative

Park managers agree on the importance of managing exotic plant species in the park. The Gulf Coast Exotic Plant Management Team no longer exists but park managers advocate for the creation of a new exotic plant management team. Using the data given to the park by the NRCA, the IPM team, along with other divisions will work to target these exotic species. The first phase involves research. Research will hopefully show the best possible way to eradicate the exotic species. In the past, Jason Lott worked by acquiring seeds to replant sections of the LBJ Ranch along with the Johnson Settlement in Johnson City. Park managers will work with the Settlement project and tie in the exotic plants. In order to combat some of these problem plants the park plans to reach out to local Boy Scout groups for assistance. Other options include working with parks in San Antonio and Big Thicket in order to have groups come to work on exotic plant eradication. The park purchased a weed wrench to pull mesquite in the Johnson Settlement.

While Lyndon B. Johnson National Historical Park is a cultural landscape whose purpose is telling the life story of President Johnson, exotic plant species still can have an adverse impact on the integrity of park resources. Some exotic plant species (such as Bermudagrass) may be compatible with the cattle operation at LBJ Ranch, but others (such as nodding musk thistle and poison hemlock) degrade pastures used as cattle forage, in addition to having a significant impact on the natural to semi-natural ecosystems found in the park. Further, infestations of exotic species that may not have been present during the time period of significance in the 1960s for the cattle operation may impair the park's ability to represent President Johnson's heritage. Additionally, exotic plant infestations in the prairie restoration site along the Settlement Trail are impediments to the park reaching its objective of restoring the site to represent the natural prairie vegetation of the Texas Hill Country at the time of arrival of the Johnson family. The park contains many examples of native plant communities including a variety of woodlands, shrublands and herbaceous vegetation (Cogan 2007). The 2007 Vegetation Map of the park identified 14 unique plant assemblages in the park in riparian, prairie and savanna habitats (Cogan 2007). Taken together, management of exotic plant species is an integral aspect of preserving and protecting the natural resources of the park.

The park contains exotic species that are well established, e.g., species such as King Ranch bluestem and Bermudagrass that President Johnson planted (NPS 2014), and species that may be more recent arrivals. More recent arrivals may include the five species (*Bromus tectorum*, Mentha spicata, Poa pratensis, Rumex patientia, and Schedonorus arundinaceus) detected

in 2012-2014 SOPN monitoring that were not previously documented by the SOPN (Folts-Zettner 2014) and/or species that have low prevalence in the park, especially species such as Melilotus officinalis that are highly invasive.

Species that are prevalent in the park such as King Ranch bluestem and Johnsongrass present different management challenges than species that have limited occurrence in the park. For prevalent species, infestations in the prairie restoration site or in especially vulnerable zones such as the riparian ecosystem may have more ecological significance, and may be of greater ecological concern, than infestations in other less natural parts of the park. Further, the species such as *Conium maculatum*, *Lonicera japonica*, and *Schedonorus arundinaceus* 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 (Table 5.13.2-1) may warrant greater attention than other species.

Control of exotic plant species is also necessary to preserve the historic character of the LBJ Ranch (NPS 1991-1992) and the prairie restoration site, which is being restored for interpretive purposes to represent the environment of the Texas Hill Country (Sanders 2005) when the Johnson ancestors first arrived. Specifically, the presence of exotic species such as Carduus nutans, Centaurea melitensis and Conium maculatum in pastures and hay fields is not historically accurate as these species degrade lands used for ranching (NPS 1991-1992).

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 on park lands. At the historical park, annual monitoring along the Settlement Trail since 2010 has provided an extensive data set on the exotic plant species found that 13-acre site. For example, monitoring data shows that *Poa pratensis*, Kentucky bluegrass, a species of highest potential for exotic plant impact was not detected prior to 2014 when it was detected in 25% of the plots (Folts-Zettner and Sosinski 2014). 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.

Additionally, the 2014 exotic plants rapid assessment provided a one-time measurement of exotic plants found in other more natural areas of the park, including in the riparian area along Pedernales River and in the north end pasture in the LBJ Ranch Unit. Both these areas have significant infestations of exotic plant species, with more exotic plant species recorded than in the areas surveyed in the Johnson City Unit. Eighteen different exotic species were found in the riparian zone, and nineteen were in the north end pasture. These areas appear to be a vector for exotic plant infestations as five species were found only in the riparian zone and four species only in the north end pasture. Early detection followed by control efforts while these infestations are small or localized may prevent these exotic plant species from spreading to other areas of the park, or prevent the species from becoming more prevalent than their current limited extent.

The majority of the exotic species with highest or high exotic plant impact found in the historical park also are difficult to control (Table 5.13.2-1). Fifteen of the eighteen 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 either species with a highest or high potential to alter native plant communities or were designated species of special concern by

Table 5.13.2-1. Feasibility of management, ease of control ranking for species detected in SOPN 2012 -2014 monitoring (Folts-Zettner and Sosinski 2012, 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
Cynodon dactylon[2]	Bermudagrass	Extremely Difficult
Erodium cicutarium	redstem stork's bill	Extremely Difficult
Medicago minima[1]	burr medick clover	Extremely Difficult
Rumex patientia	patience dock	Extremely Difficult
Poa annua[1]	annual bluegrass	Extremely Difficult
Schedonorus arundinaceus[1]	Kentucky fescue	Extremely Difficult
Bothriochloa ischaemum var songarica[1]	king ranch bluestem	Difficult
Bromus catharticus	rescue brome	Difficult
Bromus japonicus[1]	Japanese brome	Difficult
Bromus tectorum[1,3]	Cheatgrass	Difficult
Carduus nutans[1]	nodding musk thistle	Difficult
Centaurea melitensis[1]	Malta starthistle	Difficult
Conium maculatum[1]	poison hemlock	Difficult
Eragrostis barrelieri[1]	Mediterranean lovegrass	Difficult
Lonicera japonica[1]	Japanese honeysuckle	Difficult
Melilotus officinalis[2]	yellow sweetclover	Difficult
Mentha spicata[1]	spearmint	Difficult
Sorghum halepense[1]	Johnsongrass	Difficult
Stellaria media	common chickweed	Difficult
Bromus lanceolatus	Mediterranean brome	Medium
Capsella bursa-pastoris	shepardspurse	Medium
Hordeum vulgare	cereal barley	Medium
Marrubium vulgare	horehound	Medium
Medicago lupulina	black medik clover	Medium
Paspalum dilatatum	dallis grass	Medium
Poa pratensis[1]	Kentucky bluegrass	Medium
Sonchus asper	spiny sowthistle	Medium
Taraxacum officinale	dandelion	Medium
Verbascum thapsus	mullein	Medium
Daucus carota	Queen Anne's lace	Easily Controlled
Galium divaricatum	Lamarck's bedstraw	Easily Controlled
Lolium perenne ssp multiflorum	perennial rye grass	Easily Controlled
Medicago polymorpha	burclover	Easily Controlled
Sherardia arvensis	blue fieldmadder	Easily Controlled
Torilis arvensis	spreading hedgeparsley	Easily Controlled
Torilis nodosa	knotted hedgeparsley	Easily Controlled

[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.

[3]The detections of *Bromus tectorum* may be due to a species misidentification as a result of phenology (e.g., seed heads not present) at the time of monitoring (Folts-Zettner, SOPN biologist, personal communication, 2014).

Three species, *Calyptocarpus vialis, Cyperus esculentus,* and *Euphorbia dentata*, about where there is a debate about their native or nonnative status (Folts-Zettner, SOPN Biologist, personal communication, 2014) that are included in the SOPN monitoring for exotic plant species, are not included in this assessment.

Tomye Folts-Zettner, SOPN biologist (personal communication 2014). Indeed the various characteristics that make impact of an exotic plant to natural plant ecosystems significant such as competitive ability, 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.

Given the data from the 2014 rapid asssessment, both the riparian area and north end pasture may benefit from regular surveys for exotic plant species since they are the areas that contained the highest number of exotic plant species. Nine additional exotic plant species were found as a result of adding these locations to the rapid assessment. The Pedernales River held special significance to President Johnson, and the riparian area is an integral component of the interpretive experience for park visitors. President Johnson said, "And through the years, when time would permit, here is where I would always return, to the Pedernales River, the scenes of my childhood" (NPS 2002). Similarly, the Long-Range Interpretive Plan (2002) also identifies the river corridor as an area to view native wildflowers and reflect on the historical legacy of President Johnson. The Pedernales riverfront was also the showplace and entertainment area for the Texas White House, and the river is visible from the house (National Park Service 2006).

5.14. Breeding Landbirds Resource Brief and Narrative

The contents of sub-chapter 5.14 were designed to be placed into a stand-alone Breeding 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 55 bird species have been recorded at Lyndon B. Johnson NHP during annual RMBO surveys (2009-2013). Ten of the species are considered species of conservation concern by one or more organization. Six of these 10 species have high conservation potential at the Recreation Area, because they are within their normal breeding ranges and breeding habitat exists for them at the park. Four of the species, such as Scissor-tailed Flycatcher and Summer Tanager, have been observed in four or five of the survey years. Four 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 overall condition of breeding landbirds at the Historical Park, assessed using one indicator, species occurrence (presence/absence), is good to moderate. We evaluated species occurrence using two measures/contexts (spatial and conservation contexts), one in moderate and the

Table 5.14.2-1. Summary of overall landbirds condition, indicators and measures, and rationale for assigning condition assessment at Lyndon B. Johnson National Historical Park.

Breeding Landbirds			
Indicators of Condition	Specific Measures	Condition Status/Trend	Rationale
Species Occurrence	Spatial Context		In a comparison of 2009-2012 BBSs in the vicinity of the Historical Park to RMBO surveys within the Historical Park in 2009-2013, there were 35 species that were not observed by RMBO. However, only 14 of the species have characteristic breeding habitat at the park (i.e., fall into the "exists" breeding habitat class). Of the 14, only five were noted by Archer (2011) as being common or abundant during the spring, and only two of these were recorded in relatively high numbers in the BBSs. Based on this comparison, the condition of breeding landbirds is moderate. It should be noted, however, that this condition may not be a true concern for the park, because the agricultural nature of the Ranch Unit and past management of vegetation along the river for security purposes may help explain the absence of some of these bird species. No trend information is available at this time.
	Conservation Context		There are 10 species that have been observed during 2009-2013 RMBO surveys that are listed by one or more organization as being of conservation concern. We believe that five of these species have high conservation potential at the Historical Park. These are species that are within their normal breeding range and sufficient habitat exists at the Historical Park to support breeding. All of these species have been observed on recent RMBO surveys (in one or more years), and four of the species were observed 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.

other in good condition. Our assessment was not based on extensive data (five years of recent RMBO data and four years of Breeding Bird Survey data), and no data were available for the park prior to 2009 to examine differences in species occurrence over time. The spatial comparison revealed that, although RMBO recorded 38 species that were also recorded on the BBS routes, there were an additional 35 species that RMBO did not observe at the park. However, only 14 of the 35 species fall into the "exists" breeding habitat class, in which the habitat at the Historical Park is characteristic of the habitat(s) where the species would be expected to breed. The Archer (2011) checklist for the Lyndon B. Johnson State Park and Historic Site (adjacent to the Historical Park) and the Ranch Unit of the Historical Park lists only five of the 14 species as common or abundant in the parks during the spring. We considered species occurrence based on this comparison to be moderate. Ten species that have been recorded at the Historical Park by RMBO are listed by one or more organization as being of conservation concern. Of these, six are considered to have high conservation potential at the park; these are species that are within their normal breeding ranges and sufficient habitat exists at the park to support their breeding. All of these species have been observed during recent surveys at the park, and four have been observed in four or five of the survey years. Using this measure, we considered the condition of landbirds at the park to be good. Adequate information does not exist at this time to evaluate trends in the condition.

5.14.3. Management and Project Considerations and Narrative

The Texas Hill Country is an excellent place to sit and enjoy a variety of birds. Whenever she was at the LBJ Ranch, Lady Bird Johnson took opportunities to bird-watch from her dining room inside the Texas White House. The soundscape study in the NRCA showed that a bulk of the noise around the Texas White House came from land birds.

Rebuilding the riparian zone along the Pedernales River will improve the habitat for the birds who need the river. Park employees noted an occurrence of grackles behind the Texas White House. Guidance will be appreciated as to how the park can mitigate these birds. Consideration towards a special bird tour, led by park interpreters, tying into Lady Bird Johnson's love of bird-watching and the ranch environment as a key environment for certain species. Another option is handing out bird-watching guides to visitors as they drive the LBJ Ranch.

5.15. White-tailed Deer & Exotic Blackbuck Antelope Resource Brief and Narrative

The contents of sub-chapter 5.15 were designed to be placed into a stand-alone White-tailed Deer & Exotic Blackbuck Antelope 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

Lyndon B. Johnson NHP is home to both native white-tailed deer and non-native blackbuck antelope. White-tailed deer are said to be the most important big game animal in Texas, and

Table 5.15.2-1. Summary of overall exotic animals condition, indicators and measures, and rationale for assigning condition assessment at Lyndon B. Johnson National Historical Park.

White-tailed Deer & Exotic Blackbuck Antelope 			
Indicators of Condition	Specific Measures	Condition Status/Trend	Rationale
White-tailed deer/ Blackbuck antelope population	Estimated number of deer		In 2005, 129 deer were counted during a night-time survey at the Ranch Unit; this lead to an estimated density of 4.5 acres/deer at the unit. This estimated density was higher than the average density of 15 acres/deer in the Texas Hill Country (Armstrong and Young 2000) but lower than the greatest density reported for the region by Armstrong and Young (2000; 3 acres/deer). Staff at the Historical Park estimate that in Fall of 2014, there are approximately 400-500 deer on the Ranch Unit. If we assumed that the two deer counting efforts occurred over the same area, were made with the same amount of effort, and used the same methods, it would appear that the number of white-tailed deer on the Ranch Unit has increased from 2005 to 2014. However, it may not be appropriate to make these assumptions. However, park staff indicate that the number of deer do appear to have increased in recent years. For this reason and because the density estimated by Munoz et al. (2007) was high compared to the average deer density in the Hill Country, we conclude the deer population level is of moderate concern. Park staff have also observed deer in apparently poor health. The current trend is uncertain because additional information is needed.
	Estimated number of antelope		In 2005, 101 antelope were counted during a sunset survey at the Ranch Unit; this lead to an estimated density of 5.8 acres/blackbuck at the unit. This estimated density was lower than the estimated deer density but higher than the average density of 15 acres/white-tailed deer in the Texas Hill Country (Armstrong and Young 2000). Staff at the Historical Park estimate that as of Fall 2014, there are approximately 100 antelope on the Ranch Unit. Although these estimates (from 2005 and 2014) are similar, it is unclear whether or not the population has increased or not. However, the species is exotic and places additional pressure on the Historical Park landscape. Therefore, we consider the condition to be of moderate concern, with an unknown trend.
Impact on park resources	Damage to vegetation		Based on the information available, there appears to be some level of damage to plants at the Historical Park from deer/antelope foraging/browsing. Park staff have reported that parts of shrubs and other vegetation around the Texas White House have been eaten by deer. This has required that newly planted trees and other significant vegetation be fenced off to prevent damage. Also, browse lines on vegetation have been observed in some places, indicating over-use of the habitat (Armstrong and Young 2000). Park staff have reported damage to vegetation at both park units. Although the extent of the damage is unclear, we consider this indicator/measure to be of moderate concern. The trend is unknown.

nearly one-half of the state's annual harvest is attributed to the Texas Hill Country (also known as the Edwards Plateau). The average density of white-tailed deer in the Texas Hill Country was reported as 15 acres/deer (Armstrong and Young 2000), with densities in some locations as great as 3 acres/deer. The populations of these species at the Historical Park were estimated in 2005 by Texas A&M University researchers. Currently, deer at the Ranch Unit of the Historical Park occur in two herds, and blackbuck antelope occur in one herd. Deer also are present on the Johnson City Unit. There are no firm estimates for population numbers at the present time, but park staff have estimated the number of deer/antelope in each herd. Park staff have also observed damage to vegetation at the park and must take measures to protect new plantings and those of particular significance from feeding deer. They have also observed deer in poor condition and abandoned/starving fawns.

5.15.2. Condition Rationale

Two indicators and three measures were used to assess the condition of white-tailed deer and blackbuck antelope at the Historical Park. It would have been desirable to have both a current estimate of the deer (and antelope) population/density based on standardized surveys and an estimate of the carrying capacity for white-tailed deer at the Historical Park. However, based on the available information, we concluded that the condition of white-tailed deer/ blackbuck antelope at the park is of moderate concern. Adequate information does not exist to evaluate trends in the condition.

The first indicator, white-tailed deer/blackbuck antelope population levels, was assessed using two measures- one for the population of white-tailed deer and one for the population of blackbuck antelope at the Historical Park. In 2005, 129 deer were counted during a night-time survey at the Ranch Unit (Munoz et al. 2007); this was the maximum number of deer counted during a number of individual surveys. This number led to an estimated density of 4.5 acres/deer at the unit. This estimated density was higher than the average density of 15 acres/deer in the Texas Hill Country (Armstrong and Young 2000) but lower than the greatest density reported for the region (3 acres/deer). Staff at the Historical Park estimate that in Fall 2014, there are approximately 400-500 deer on the Ranch Unit. If we assumed that the two deer counting efforts were comparable, which may not be appropriate, it would appear that the number of white-tailed deer on the Ranch Unit has increased from 2005 to 2014. Even if it cannot be concluded that deer have increased based on this comparison, park staff indicate that the number of deer do appear to have increased in recent years. For this reason and because the density estimated by Munoz et al. (2007) was high compared to the average deer density in the Hill Country, we conclude the deer population level is of moderate concern. Also, park staff have reported that some deer appear unhealthy, and young have been observed abandoned and/or starving. In 2005, 101 blackbuck antelope were counted during a sunset survey at the Ranch Unit, which led to a density estimate of 5.8 acres/blackbuck at the unit. This estimated density was lower than the estimated deer density but higher than the average density of 15 acres/white-tailed deer in the Texas Hill Country. In Fall 2014, staff at the Historical Park estimated the blackbuck herd to be about 100 antelope on the Ranch Unit. Although these estimates are similar, it is not clear whether the population level has changed. However, because the species is exotic and its population places additional pressure on the Historical Park landscape (i.e., native deer and vegetation), we consider the condition to be of moderate concern.

Although there is a lack of data regarding the impact of deer/antelope on park resources, Historical Park staff have described a number of observations regarding damage to park vegetation (third measure). This includes: shrubs and other vegetation around the Texas White House have been eaten by deer, and damage has occurred to plants at the Johnson City Unit; newly planted trees and other plants of significance have been fenced off to prevent damage; some fencing to protect vegetation has been pushed over by deer; and browse lines (which can be seen when ungulates have eaten leaves and twigs from shrubs and trees up to the

height that they can reach) have been observed in some areas and indicate over-use of the habitat. Additionally, Munoz et al. (2007) indicated that vegetation cover was lower outside of experimental exclosures at the Historical Park compared to inside exclosures. Although the overall extent of vegetation damage is unclear, we consider this indicator/measure to be of moderate concern.

5.15.3. Management and Project Considerations and Narrative

Just as the song "Home on the Range" describes deer and antelope, President Johnson ensured he would fulfill that song on his ranch and surrounding ranches. President and Mrs. Johnson had blackbuck antelope on surrounding tracts of land but "English Park" did have blackbuck antelope and Nilgai antelope (Malechek 1979). Ranch foreman Dale Malechek mentioned in several oral histories the whitetail and antelope populations existing on the LBJ Ranch and other Johnson owned or leased ranches. Research is still in progress regarding the timing of blackbuck antelope introduction to the LBJ Ranch, and how President Johnson got these animals.

In 2005, Texas A&M University began a project studying the whitetail deer and blackbuck antelope on the LBJ Ranch. In 2007, the group from A&M presented recommendations to the park regarding the game on the LBJ Ranch. The park took the results and moved about 100 blackbuck antelope and some whitetail deer onto Johnson property. By the time the Texas White House opened for tours in 2008 the park had removed the majority of the blackbuck antelope from the LBJ Ranch. Today as visitors drive the LBJ Ranch they normally do not see blackbuck antelope on park property. In 2016, park managers plan to replicate the 2005 study. Park employees will take a year to monitor the whitetail deer population—at sunrise, throughout the day, sunset and during the night—along with fencing off transects in order to measure grazing height.

5.16. Live Oak Resource Brief and Narrative

The contents of sub-chapter 5.16 were designed to be placed into a stand-alone Live Oak 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. Noteworthy Highlights

Texas live oak trees (also known as Escarpment live oak) are an important part of the landscape at the Lyndon B. Johnson NHP. Live oak trees are considered one of the "character-defining features" of the Texas White House complex. The canopies of live oaks create a protected feeling and view along the Pedernales River, the picnic area, and around the ranch house. The live oak is a long-lived species, and the large live oaks in the vicinity of the ranch house "dominate the landscape." In recent years, some live oaks at the Historical Park have been affected by a tree disease called oak wilt, which is caused by a fungus (*Ceratocystis fagacearum*). A number of trees at the Ranch Unit were treated for the disease in 2009 and subsequent years. Some of the trees died and have been removed.

5.16.2. Condition Rationale

One indicator with three measures was used to assess the condition of live oak trees at the Historical Park. The indicator used was occurrence and severity of oak wilt disease. Based on the available information, we concluded that the overall condition of live oak trees is of moderate concern. Adequate information does not exist to evaluate overall trends in the condition.

The first measure used to assess condition was the proportion and significance of live oak trees affected by oak wilt disease. The estimated proportion is based on the number of trees known to be affected by oak wilt (52 trees) relative to the total number of live oak trees estimated to occur on the Historical Park (3,744 live oak trees). We estimated that 1.4% of the live oaks

Table 5.16.2-1. Summary of overall live oak condition, indicators and measures, and rationale for assigning condition assessment at Lyndon B. Johnson National Historical Park.

Live Oak			
Indicators of Condition	Specific Measures	Condition Status/Trend	Rationale
Occurrence & severity of oak wilt disease	Proportion and Significance of live oak trees affected by oak wilt disease		Of all the live oak trees that grow on the two units of the Historical Park, only approximately 1.4% have been affected by oak wilt disease. Although overall this number is fairly small, we also considered the location and size of the trees affected. The trees are in the barbecue grove near the Texas White House. At this time, the trend appears unchanging.
	Status of the 52 trees treated for oak wilt disease in 2009		By Fall 2014, 19 (37%) of the 52 trees treated for oak wilt disease had died (more than one-third of those treated). Also, the remaining 33 trees are showing signs of being stressed by oak wilt disease, so there is the potential for additional trees out of the 52 to die. Three of the 19 trees were just recently found dead. For these reasons, we consider condition under this measure to be of significant concern. The tend is uncertain at this time..
	Spread (or containment) of oak wilt disease since 2009 to new trees		There is no evidence that the disease has spread to trees outside of the treatment area (the 52 trees). There are also no signs of the disease occurring in new areas in either park unit. The trend at this time appears unchanging.

have been affected by oak wilt disease to date. Although this number is fairly small, we also considered the location of the trees affected. The trees are in the barbecue/picnic area grove near the Texas White House, a high profile and significant area of the park. Based on this measure, we consider the condition to be of moderate concern. Although uncertain, the trend at this time appears unchanging. The second measure used to assess condition was the current status of 52 trees treated for oak wilt disease in 2009. Since initial treatment in 2009, 19 of the 52 trees (or 37%) have died. Sixteen of the 19 trees have been removed from the grove as of Fall 2014, and the remaining three trees were just recently found dead. More than one-third of those treated have died, and the remaining 33 trees are showing signs of being stressed by oak wilt disease. For these reasons, we consider condition under this measure to be of significant concern. The trend is uncertain at this time. The third measure used was the spread of oak wilt disease since 2009 to new trees. To date, there is no evidence that the disease has spread to trees outside of the 2009 treatment area in the barbecue grove (i.e., outside of the 52 treated trees). Also, there are no signs of the disease occurring in live oak trees in other areas of either park unit. For this reason, we consider the condition to be good for this measure. Although uncertain, the trend at this time appears unchanging.

5.16.3. Management and Project Considerations and Narrative

Since the discovery of oak wilt on the LBJ Ranch the park has heightened awareness about the threat of oak wilt to the park's live oak trees. Park managers are still waiting to see the full impact of the disease. In 2015 the maintenance division planted new live oaks in the barbecue grove while the park monitors the other oaks on the property. The park hired a crew to come and remove the ball moss from all the oak trees on the LBJ Ranch. Working with the landscape gardener, park managers will continue to monitor the oak trees.

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Appendix A: Team Members and Subject Matter Experts

Table A.1. Lyndon B. Johnson National Historical Park NRCA Project Team Members

Lyndon B. Johnson NHS NRCA Project Team
Jeff Albright, NPS Water Resources Division's Coordinator of the NRCA Series
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Dave Schafer, NPS Lyndon B. Johnson National Historical Park Chief of Interpretation and Resource Management
Donna Shorrock, NPS Intermountain Region Natural Resource Condition Assessment Coordinator
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
Russ Whitlock, NPS Lyndon B. Johnson National Historical Park Superintendent

Table A.2. Lyndon B. Johnson National Historical Park NRCA Subject Matter Experts

Subject Matter Expert	Topic	Project Deliverables
Alexander Shane, National Park Service Lyndon B. Johnson NHP Park Ranger Interpretation and Resource Management	All	Reviewed assessment
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
Colleen Flanagan Pritz, National Park Service Air Resources Division Ecologist	Air Quality	Reviewed assessment
Vincent L. Santucci, Senior Geologist / Paleontologist / Washington Liaison, National Park Service - Geologic Resources Division	Geology	Reviewed 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
Larry Martin, National Park Service Water Resources Division Hydrologist	Groundwater	Provided groundwater information for assessment.
Rebecca Renaud, National Park Service Lyndon B. Johnson National Historical Park Chief of Maintenance	Groundwater	Provided groundwater information for assessment.
John Peckne, National Park Service Lyndon B. Johnson National Historical Park Water Operator / Maintenance Division	Groundwater	Provided groundwater level information for assessment.
Joel Wagner, NPS Water Resources Division, Wetlands Program Leader	Riparian Habitat	Reviewed riparian habitat section.
Michael Martin, NPS Water Resources Division Hydrologist	Riparian Habitat	Reviewed riparian habitat section
Brian Perry, National Park Service Lyndon B. Johnson National Historical Park Supervisory Law Enforcement Ranger	Deer and Blackbuck antelope	Provided information about deer and Blackbuck antelope in the park.
Iris Neffendorf, Lyndon B. Johnson State Park and Historic Site Park Superintendent	Deer and Blackbuck antelope	Provided information about deer and Blackbuck antelope in the park.

Authors Who Served as Subject Matter Experts	Topic	Project Deliverables
Tomye Folts-Zettner National Park Service Southern Plains Inventory and Monitoring Network Biologist/ Botanist	All	Provided expert opinion and assistance on grasslands, riparian habitat and exotic plants. Reviewed entrie assessment.
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 Lyndon B. Johnson NHP'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 Lyndon B. Johnson NHP 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 layer for the observation point at the Tetrahedron.

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 Historical Park. 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 Historical Park-specific NPScape data from the NPScape website (http://science.nature.nps.gov/im/monitor/npscape/index.cfm).

Simplified NPScape Housing Density Projections.
Converted Lyndon B. Johnson NHP 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 Lyndon B. Johnson NHP

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: Bortle Dark-Sky Scale

Key for the Summer Sky— Latitudes 30° to 50° N

The Milky Way is not visible and sky glow extends above 35 degrees. Little to no dark adaptation is possible. Ground texture is easily seen, and artificial light dominates the landscape. Visible constellations are limited to the very brightest if any. The sky has a uniform washed out appearance.[1]

If this describes your nighttime environment, continue below

If the nighttime environment appears darker than this description, jump to the next section

Sky appears nearly completely washed out, and is luminous. Dark adaptation is not possible, ground is brightly illuminated and fewer than 200 stars are visible. Only the most major constellations are identifiable. For instance, the entire keystone of Hercules or the five stars of Delphinus are not completely visible.

this is accurate **Bortle Class 9** if darker—proceed below

Constellations are visible but may be missing key stars, sky background has a uniform washed out glow with light domes reaching 60 degrees above the horizon. Stars such as the tip of Sagitta or epsilon Lyrae are not visible. If clouds are present they are brilliantly lit.

this is accurate **Bortle Class 8** if darker—proceed below

Brighter constellations are easily seen in full, yet sky background has greyish or yellow background. Milky Way may be just barely seen near the zenith. The Scutum and Cygnus star clouds are not visible.If clouds are present they are brilliantly lit. Ground texture is still visible.

this is accurate **Bortle Class 7**

The Milky Way is visible but discontinuous, and lost to light domes near the horizon. Fine details and structure are not easily visible, if at all. Ground texture is still visible, and shadows are cast from light pollution. Light domes are clearly visible along the horizon and appear brighter than any portion of the visible Milky Way.[2]

If this describes your nighttime environment, continue below

If the nighttime environment appears darker than this description, jump to the next section

The Milky Way is just visible overhead, but is not continuous and is diminished to obvious skyglow. Cygnus ,Scutum, and Sagittarius star fields just visible. If clouds present they are illuminated and reflecting light. Ground texture is seen with difficulty.

this is accurate **Bortle Class 6** if darker—proceed below

Milky Way is faintly present, but may have occasional gaps and is lost to skyglow near the horizon. Great rift in Cygnus is just visible. Any clouds present are brighter than the background sky and reflect light back. Zodiacal light may be glimpsed, but is difficult to see amidst the light pollution. Ground texture is not visible but forms are easily seen.

this is accurate **Bortle Class 5** if darker—proceed below

Milky Way is evident from horizon to horizon, but fine details are lost. Clouds are just brighter than background sky, but appear dark at zenith. Light domes are much brighter than brightest part of Milky Way and extend to up to 15 degrees above the horizon. Zodiacal light is evident in west after sunset or in east before dawn. Deep sky objects such as the M13 globular cluster and Northern Coal Sac are visible.

this is accurate **Bortle Class 4**

The Milky Way has a defined outline with visible structure and detail. Very few light domes are visible just along the horizon and do not cast shadows. You may see color in the Zodical light when compared to bluish-white color of the Milky Way. Scattered clouds appear dark against the night sky except those clouds just above light domes.[3]

If this describes your nighttime environment, continue below

Milky Way appears complex with visible outline, however some light pollution is still evident along the horizon. Light domes only slightly brighter than brightest part of the Milky Way. Zodiacal light easily seen, but band and gegenschein difficult or absent. Many summer globular clusters and emission nebulae are visible with the naked eye despite distracting light domes along the horizon. Venus casts an obvious shadow.

this is accurate **Bortle Class 3** if darker—proceed below

Very few light domes are visible; with none extending above 5 degrees and fainter than the Milky Way. Airglow is often visible, and character in its brightness may be seen. Ground is mostly dark. The Zodiacal band (away from the Milky Way and at least 45 degrees above the horizon) and gegenschein are visible. The rift in the Cygnus star cloud is visible. The Prancing Horse in Sagittarius and Fingers of Ophiuchus dark nebulae are visible, extending to Antares. Jupiter and Milky Way cast barely visible shadows.

this is accurate **Bortle Class 2** if darker—proceed below

The Milky Way is intricate, marbled, and veined with Sagittarius region of the Milky Way casting obvious shadows. Milky Way appears 40 degrees wide in some parts with a convoluted outline. The horizon completely free of light domes, though some distant light domes may be visible from mountain tops. Transparency and seeing are excellent (among the best of the year) with very low airglow. Many objects such as M81 or the Helix nebula are visible with the naked eye. Zodical light is striking as a complete band. Any clouds are very difficult to see.

this is accurate **Bortle Class 1**

The Bortle Dark-Sky Scale is a qualitative scale developed by John Bortle and published in Sky & Telescope Magaine in 2001. It provides a useful complement to quantitative measures. The National Park Service is testing this dichotomous key for use by professional and citizen scientists. Some knowledge of the night sky and visual observational techniques are required to properly implement this assessment.

note 1) At least 5 minutes of dark adaptation is required to properly differentiate Class 7,8 & 9 skies.

note 2) At least 10 minutes of dark adaptation is required to properly differentiate Class 4, 5 & 6 skies.

note 3) 20 to 120 minutes of dark adaptation is required to properly differentiate Class 1, 2 & 3 skies.

Developed by Jeremy White, Dan Duriscoe, and Chad Moore of the NPS Natural Sounds & Night Skies Division, www.nature.nps.gov/night

August 2, 2012

Appendix D: 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 Lyndon B. Johnson NHP had a natural L50 dBA average of 34.9 (Figure D-3) and an existing L50 dBA average of 39.5 (Figure D-1) (Emma Lynch, Acoustical Resource Specialist, NPS Natural Sounds and Night Skies Division, pers. comm., Excel spreadsheet). The L50 represents the sound level reported that is exceeded 50 percent of the stated time period.

The impact of anthropogenic sound sources to the national monument's soundscape, which is the existing L50 dBA minus natural L50 dBA, was estimated to be an average of 4.6 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." This implies that based upon the model, the existing impact of anthropogenic noise to the national monument's soundscape warrants concern.

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.

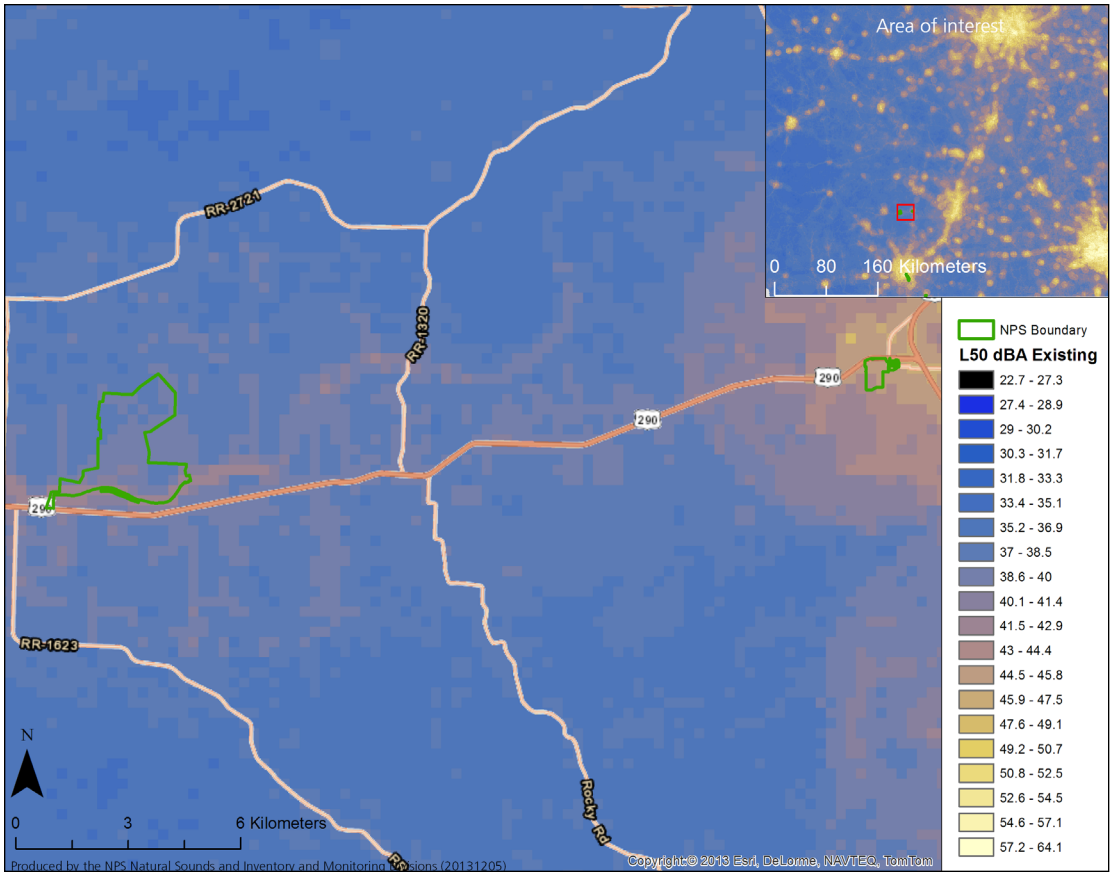


Figure D-1. Existing CONUS soundscape model zoomed to Lyndon B. Johnson National Historical Park.

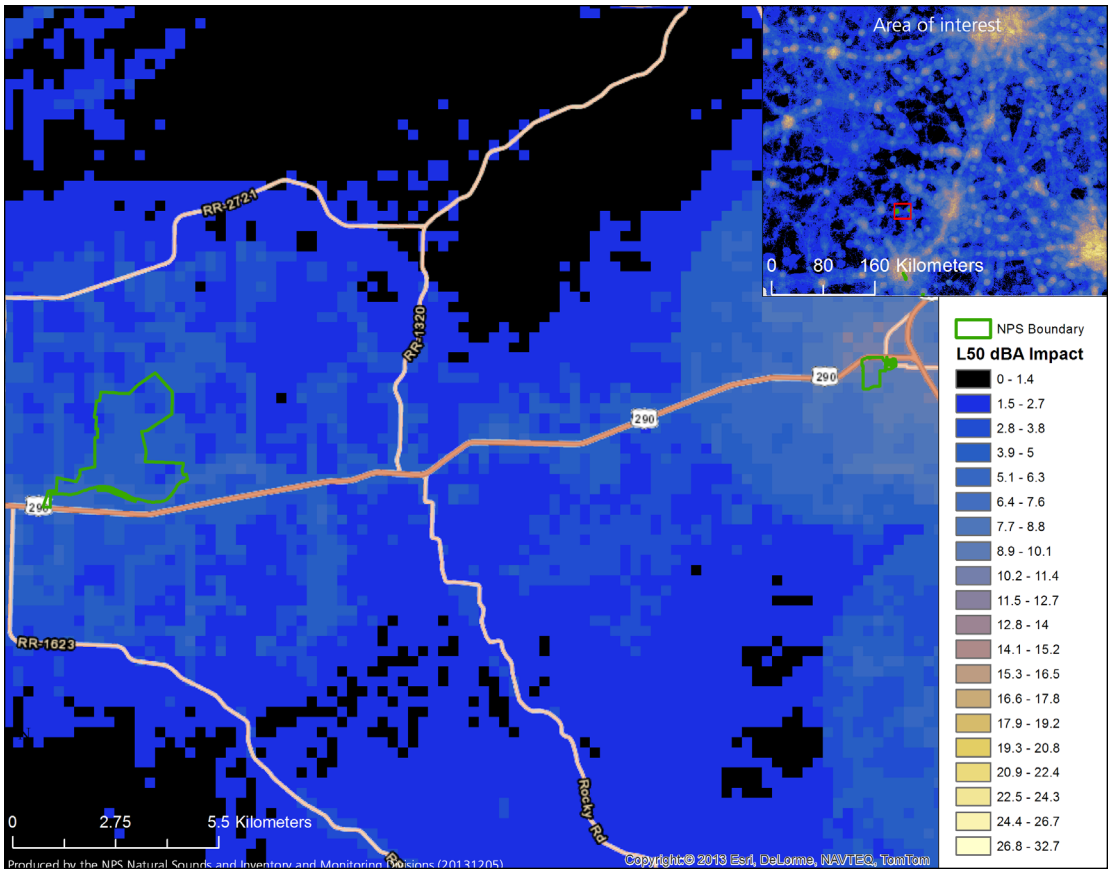


Figure D-2. Impact between existing and natural CONUS soundscape models zoomed to Lyndon B. Johnson National Historical Park.

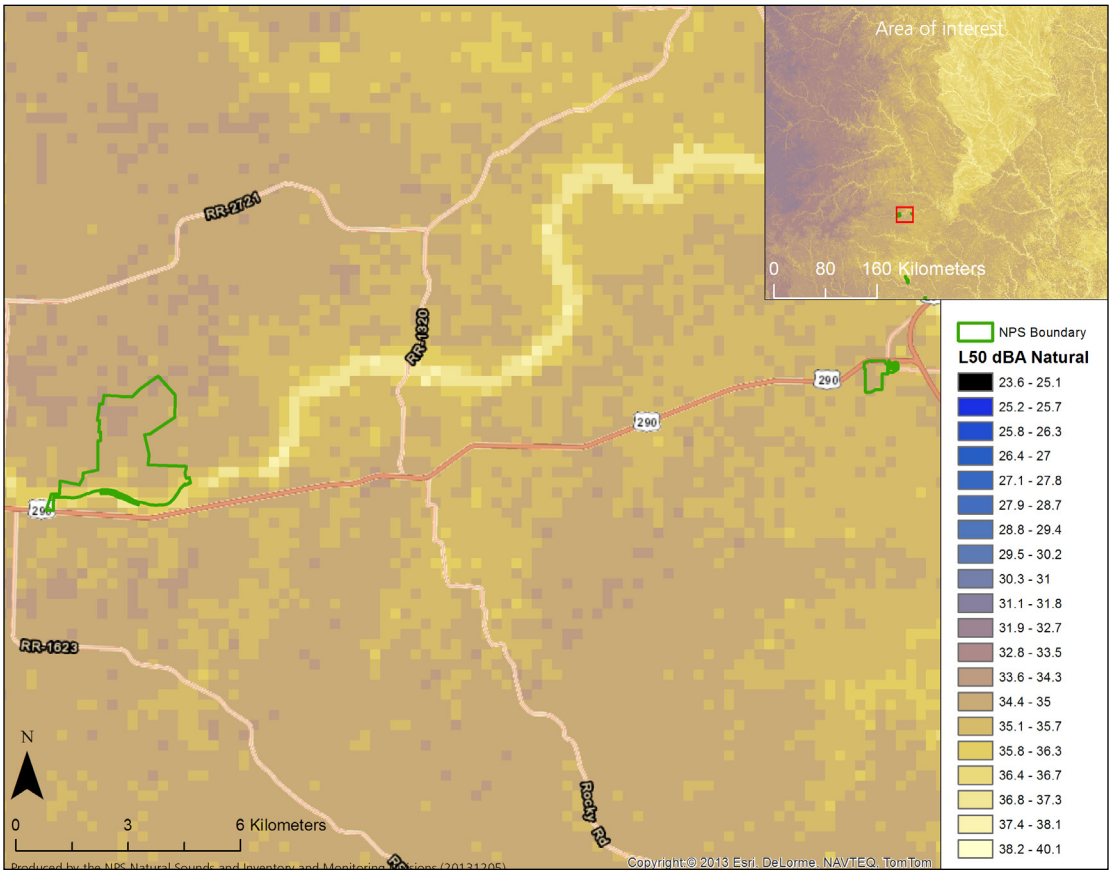


Figure D-3. Natural CONUS soundscape model zoomed to Lyndon B. Johnson National Historical Park.

Appendix E: Grassland and Soil Assessment - May 21 and 22, 2014

General Comments

This area of central Texas has been in moderate to extreme drought for at least three years. Some rain fell in late winter-spring 2014, prior to the assessment, but not enough to ease the drought. Better rains have fallen during the fall-winter 2014/15 and soil moisture has improved tremendously, although reservoirs have not been replenished yet. The restoration prairie was burned in late February of 2015 and green-up is currently taking place. This burn, the first in over a decade, should do a wonderful job at rejuvenating the prairie, as spring rains continue to fall.

Site #1 – Restoration area – East end

Waypoint # 5

Landscape-scale Diversity: Good. This site and Site 2 form a landscape unique to the area; no surrounding areas look anything like this.

Species Composition: Good. There is too much switchgrass (*Panicum virgatum*) and not enough side oats grama (*Bouteloua curtipendula*) and Indiangrass (*Sorghastrum nutans*), but this is likely a result of 1) 3rd year of extreme drought, and 2) Indiangrass grazed out 4-5 years ago. Lots of perennial forbs and cool season grasses in this site.

Annual Species Response: Good. Annual species, especially forbs, are present and filling in areas of bare ground caused by drought and removal of trees and berms. Most annuals within the landscape are native.

Functional Group Proportion: Good in general. Good mix of warm and cool grasses, annual and perennial forbs. May be more forbs present than one would expect to see, but suspect this is a drought response – enough recent rain for forbs but not enough for grasses.

Warm- vs cool-season: Good. Strong component of cool-season grasses this year, mainly Texas wintergrass (*Nasella leucotricha*), Texas grama (*Bouteloua rigidiseta*), and Canada wildrye (*Elymus Canadensis*). Warm season grasses in this area dominated by switchgrass (*Panicum virgatum*) and the exotic K.R. bluestem (*Bothriochloa ischaemum* var. *songaricum*).

Soils: The long-term drought has exposed more bare soil than one would like to see. It has also affected plant vigor, resulting in more decadence and less reproduction. There remains a lot of litter present to protect the soils from erosion, and overall, the soil is very stable at this time. NONE-SLIGHT

Site #2 – Restoration area – West end

Waypoint # 6

Landscape-scale Diversity: Good. See above

Species Composition: Good. See above. There are more warm-season grasses, such as little bluestem (*Schizachyrium scoparium*), present, and many large stands of switchgrass, but still lacking Indiangrass. There is still a good presence of perennial forbs and cool-season grasses.

Annual Species Response: Good. See above.

Functional Group Proportion: Good. More perennial grasses than Site 1, but some of that increase is due to dense stands of switchgrass, which are overtaking some areas. There is also a great response from Texas wintergrass (*Nasella leucotricha*), a perennial cool-season grass that is an important part of the landscape. There is a strong woody shrub component in this area of the prairie, mainly Mustang grape (*Vitis mustangensis*) and dewberry (*Rubus aboriginum*), although there are also small junipers and mesquite saplings beginning to establish.

Warm- vs cool-season: Good. See above.

Soils: see above. NONE-SLIGHT

Comments On Other Areas Not Included In Assessment

The remainder of the grasslands at the Johnson City unit are unimproved pasture that are actively grazed by both longhorn cattle and horses. The Ranch unit is a combination of improved pasture, unimproved pasture, and go-back land that has not been reseeded. These pastures are grazed by free-ranging Hereford cattle and also utilized by both native and escaped exotic deer. Because these areas are actively grazed, they should not be included in the assessment, but do need to be addressed.

The Johnson City pastures are not overgrazed, but they are heavily invaded by exotic grasses and forbs. KR bluestem (*Bothriochloa ischaemum*) and Kleburg bluestem (*Dichanthium annulatum*) are present, with the KR oftentimes being the dominant grass. Any forbs present are annuals and usually either weedy unpalatable natives (Texas broomweed, *Gutierrezia texana*) or spiny exotics (Maltese starthistle - *Centaurea melitensis*). Woody invasion by native honey mesquite (*Prosopis glandulosa*) is obvious. These pastures generally appear homogeneous to other pastures both within and without the park boundary, so landscape-scale diversity is poor.

The Ranch pastures are about evenly divided between improved and unimproved pasture. The improved pastures were planted to a coastal selection of Bermudagrass (*Cynodon dactylon*) which was grazed and hayed. These pastures were irrigated up to the time of Lady Bird's death and have since had to live on the lack of rain during a drought. They are quite reduced in production but will improve with rain. Other improved pastures have been used to grow feed grain, with grazing allowed following harvest. Several of these pastures have been taken out of production during the drought and are full of weedy annuals.

The remaining pasture is composed of Bermuda grass that is kept grazed and/or mowed short. There are almost no native grasses present and what forbs are found are either weedy annual natives with spines or toxins and exotic spiny species. Pasture along the riparian/road corridor is mowed to maintain the cultural scene, while the remainder is only grazed. Overall, there is little to no landscape-scale diversity, no biodiversity, poor functional group ratios, and limited cool-season grasses.

Appendix F: Maps of the Known Distribution of Exotic Plant Species At Lyndon B. Johnson NHP

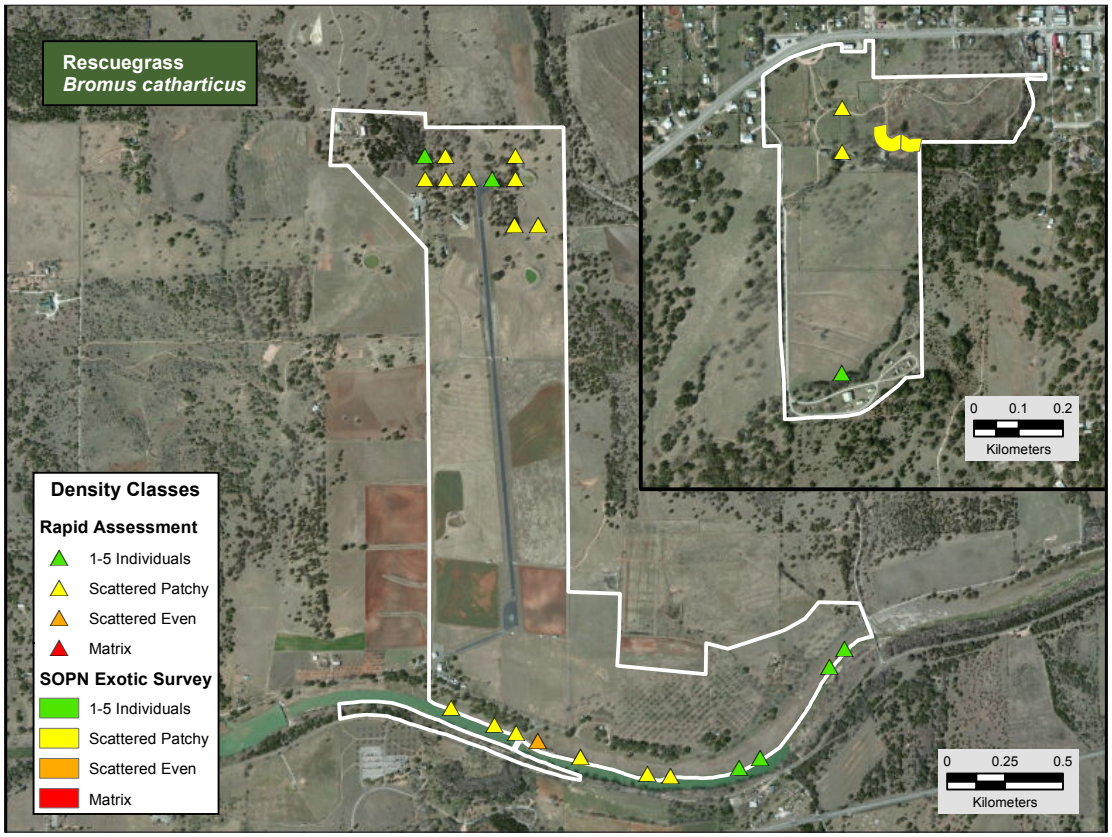


Figure F-1. Rescuegrass (*Bromus catharticus*)

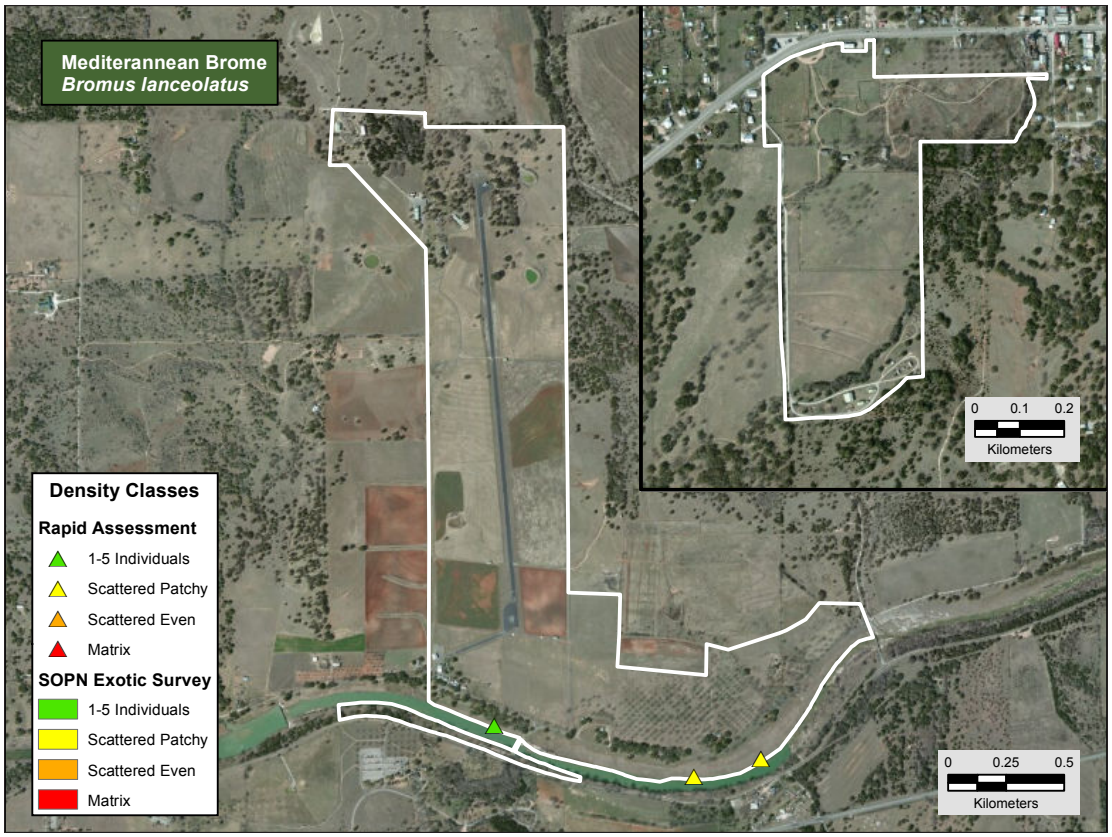


Figure F-2. Mediterannean Brome (*Bromus lanceolatus*)

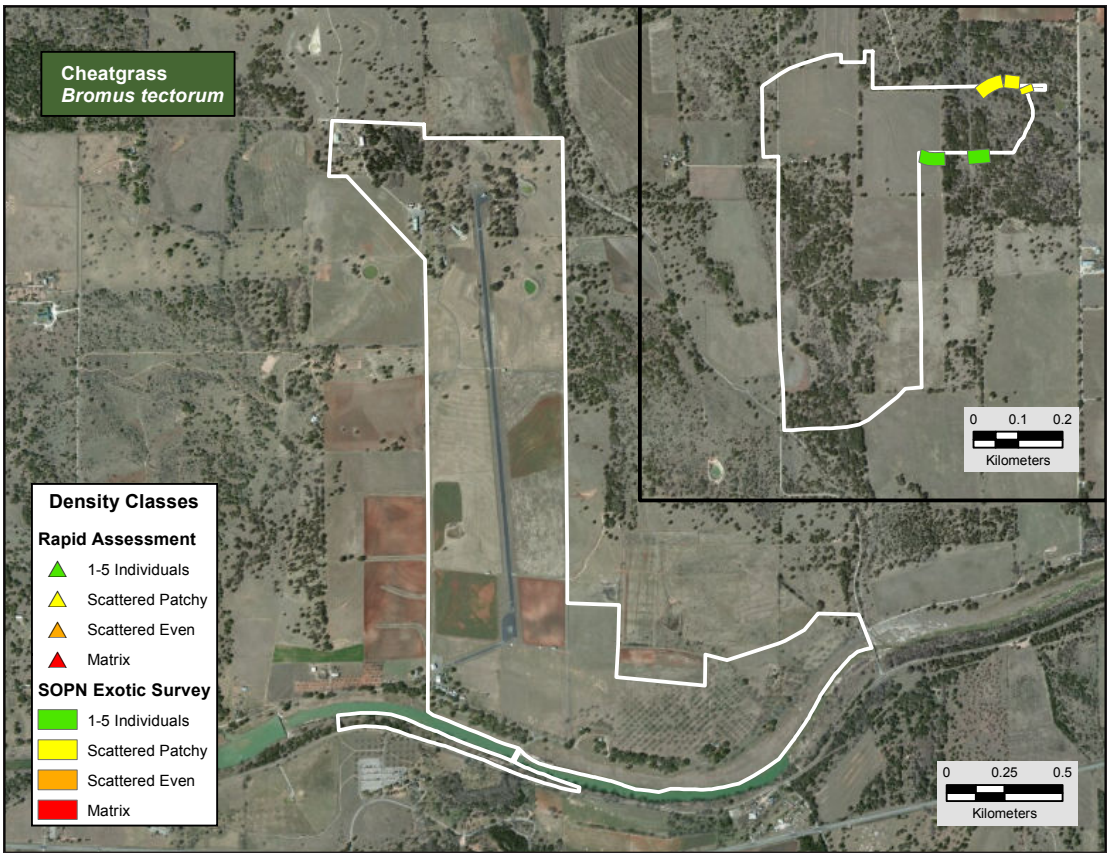


Figure F-3. Cheatgrass (*Bromus tectorum*)

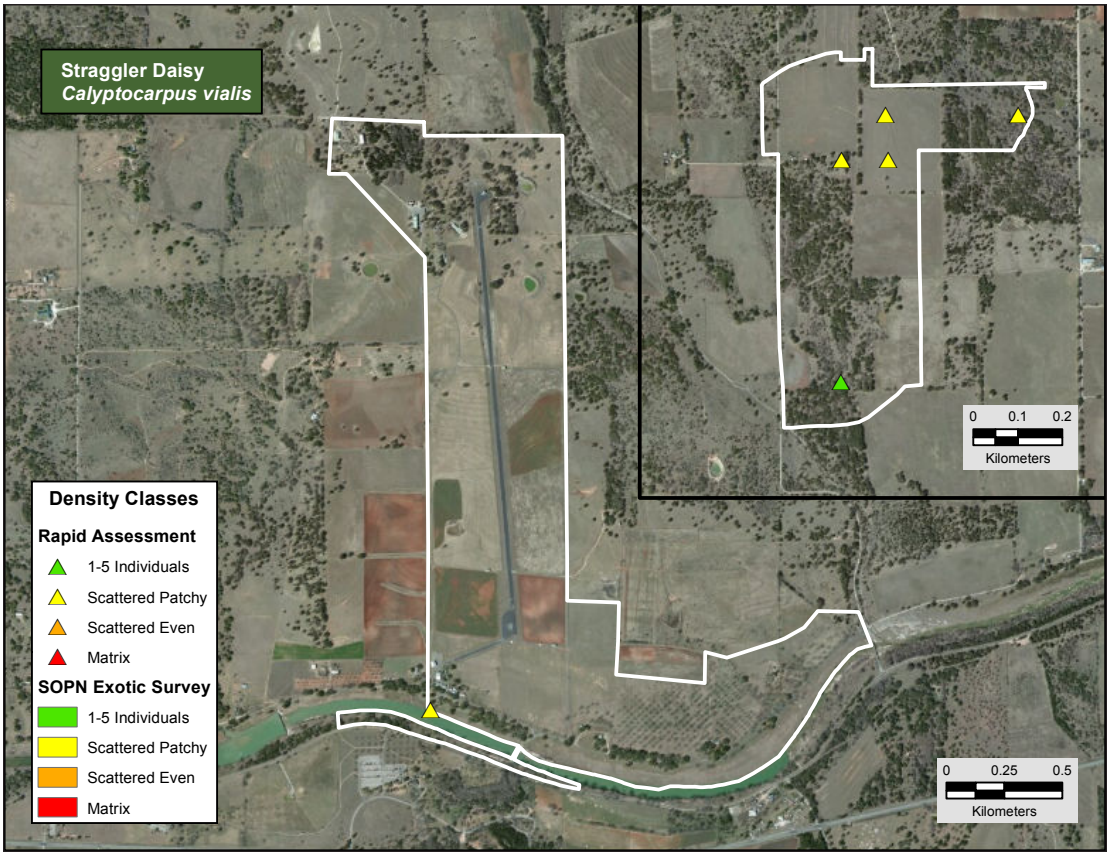


Figure F-4. Straggler Daisy (*Calyptocarpus vialis*)

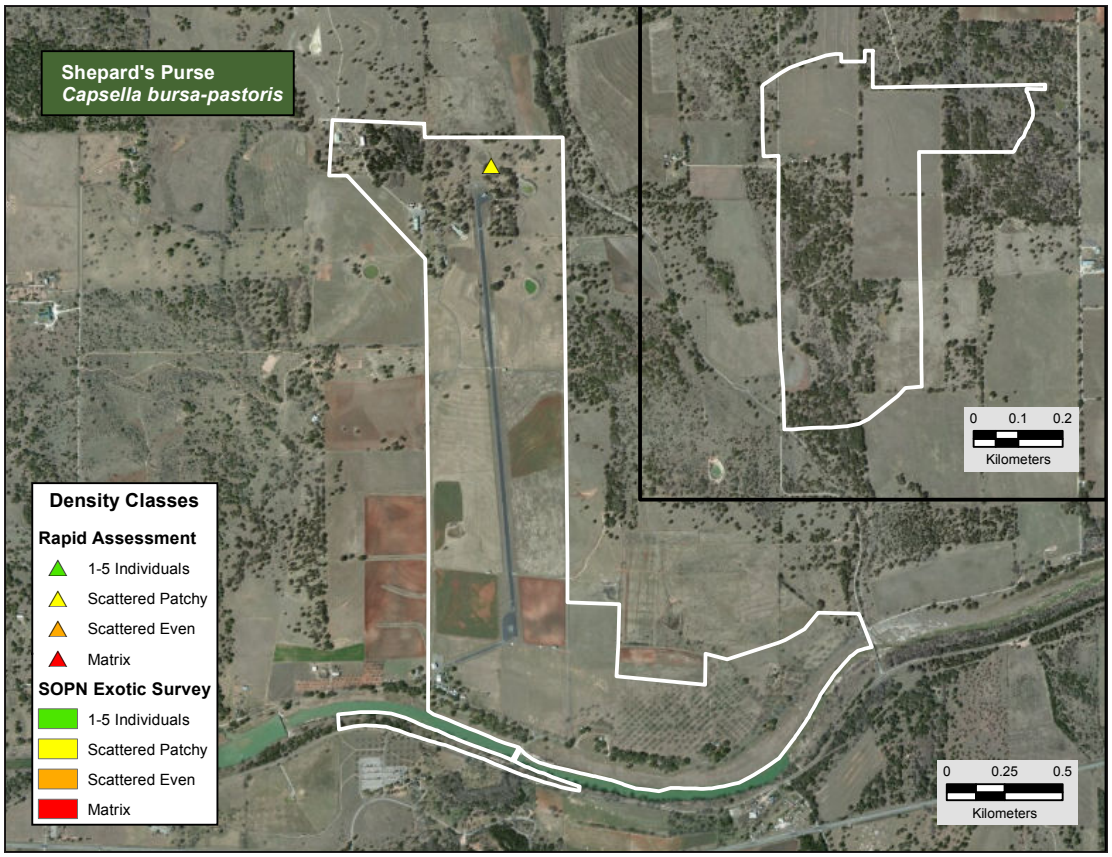


Figure F-5. Shepard's Purse (*Capsella bursa-pastoris*)

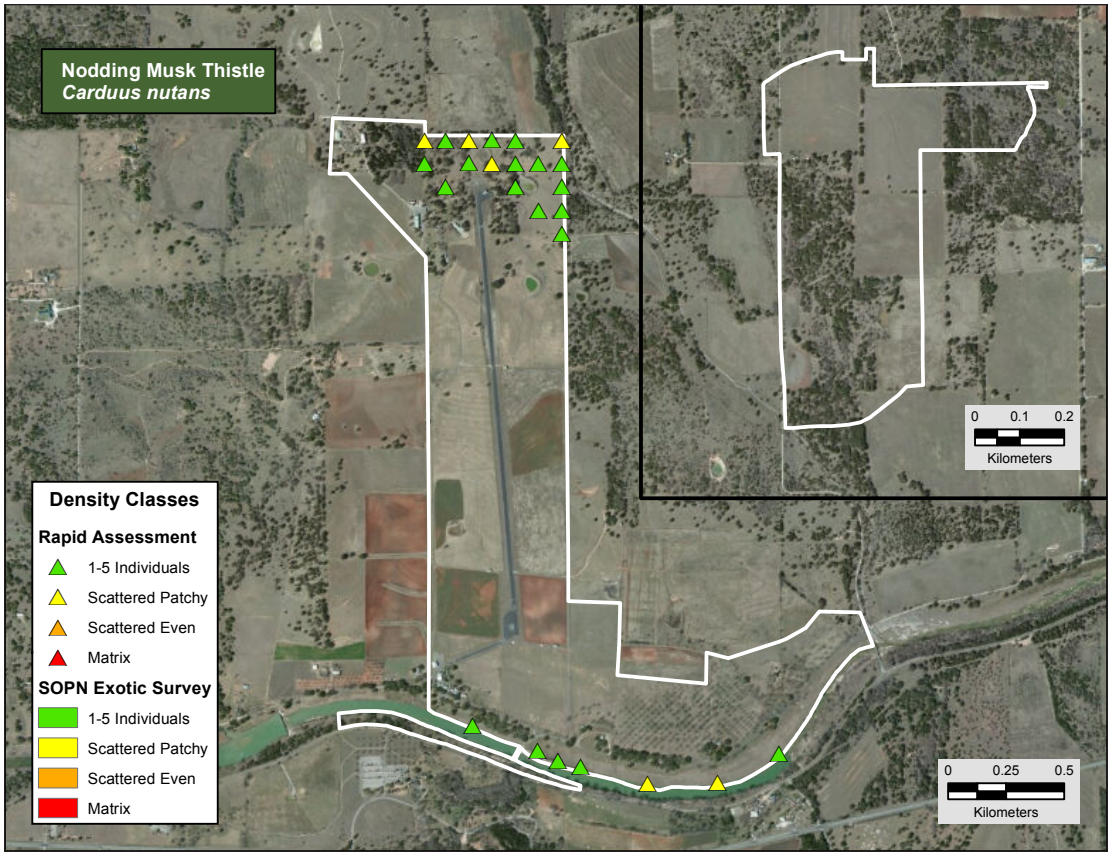


Figure F-6. Nodding Musk Thistle (*Carduus nutans*)

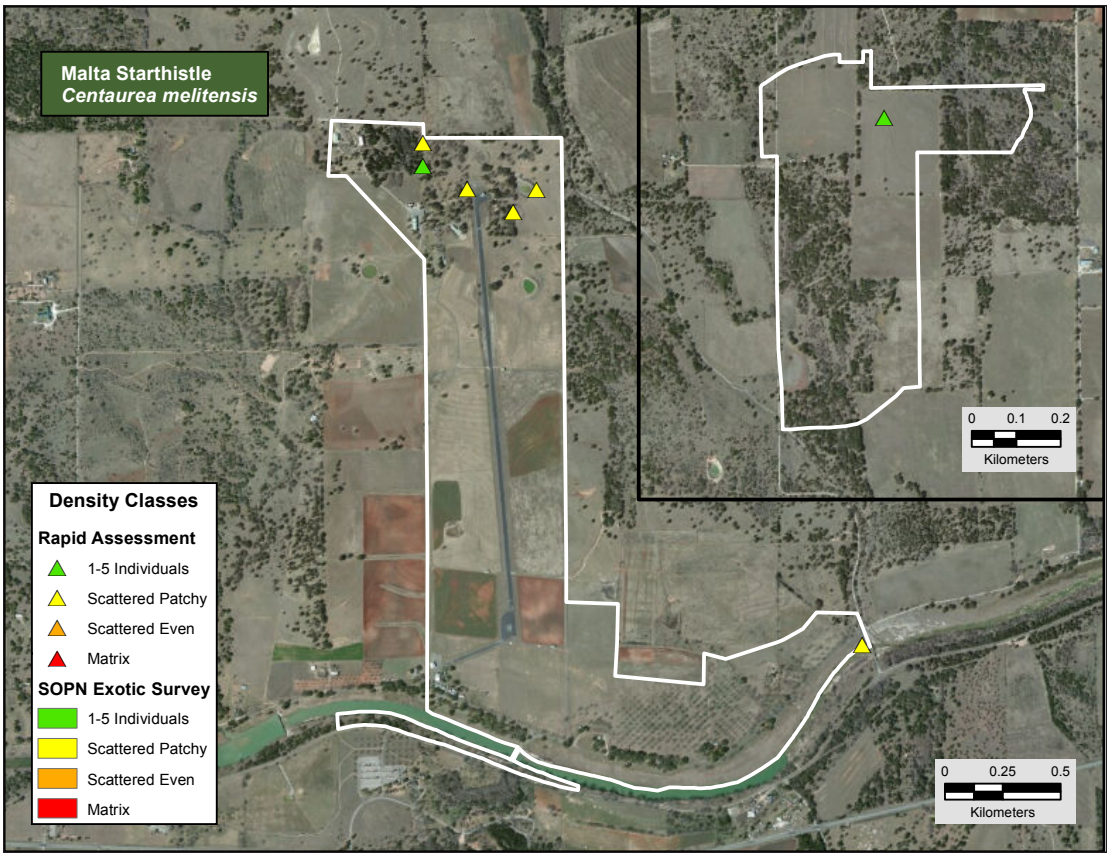


Figure F-7. Malta Starthistle (*Centaurea melitensis)*

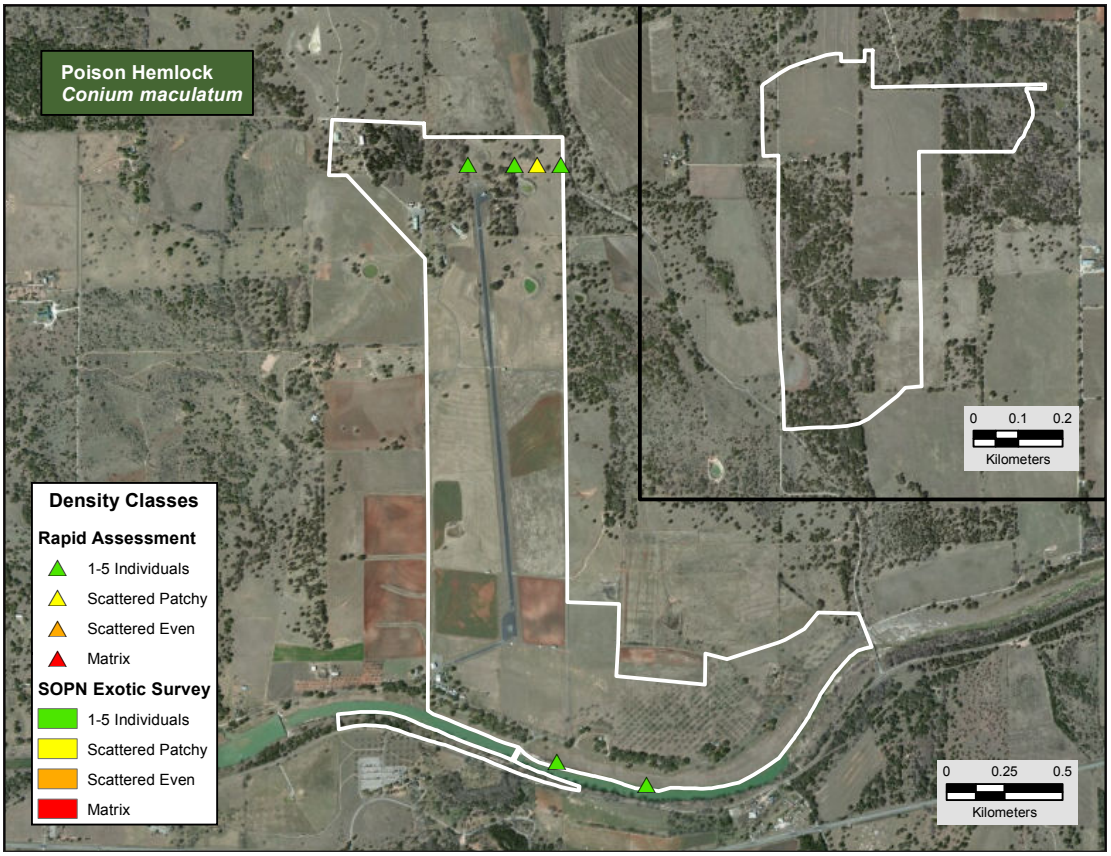


Figure F-8. Poison Hemlock (*Conium maculatum)*

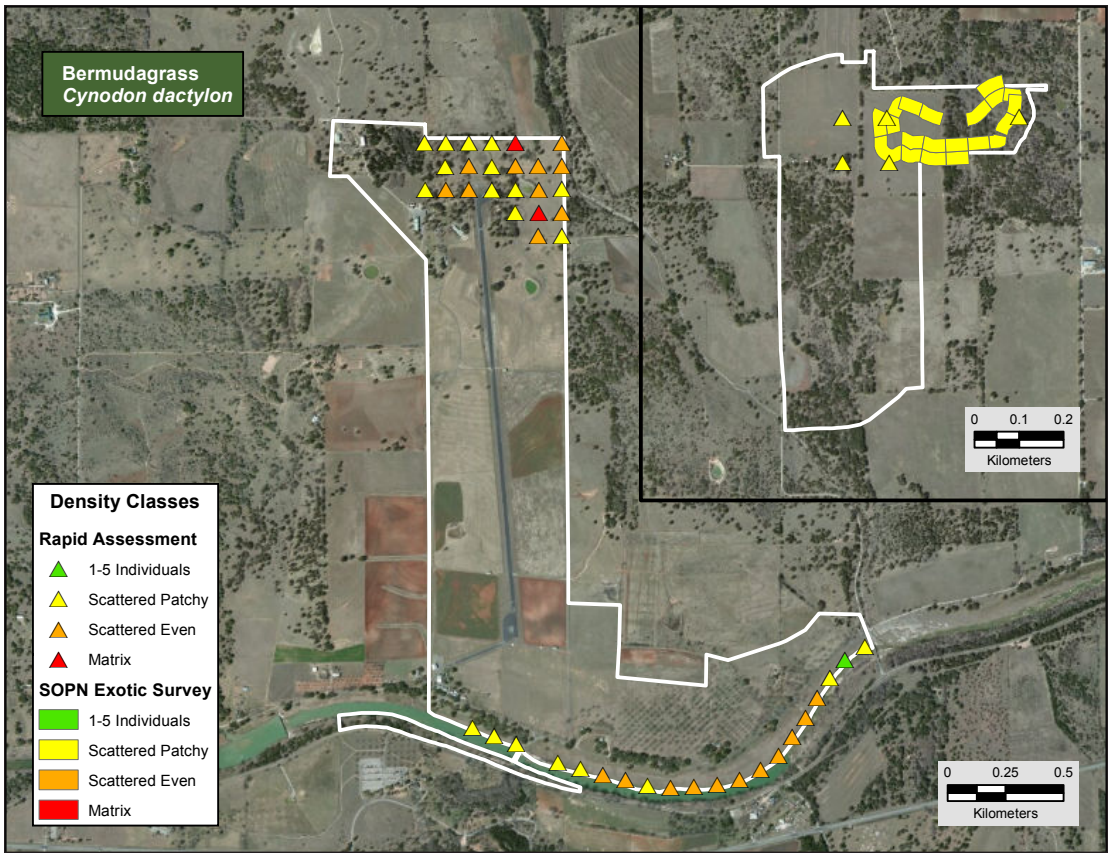


Figure F-9. Bermudagrass (*Cynodon dactylon*)

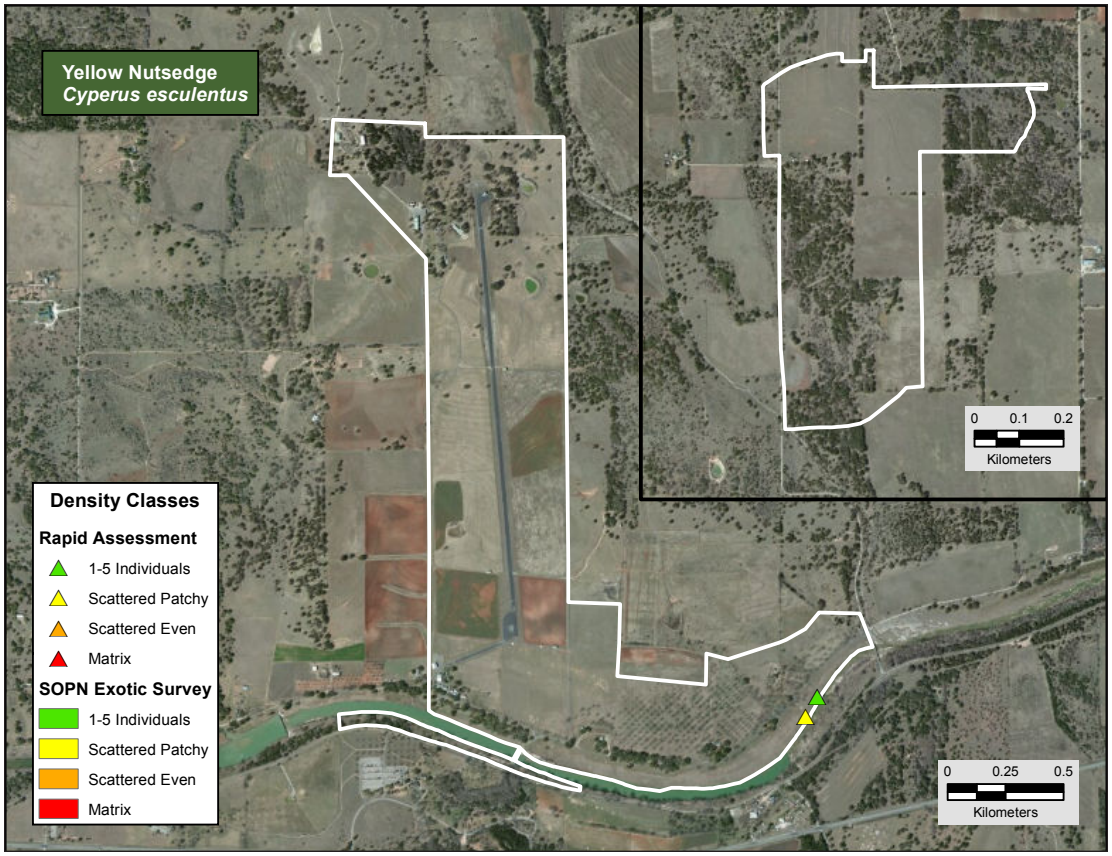


Figure F-10. Yellow Nutsedge (*Cyperus esculentus*)

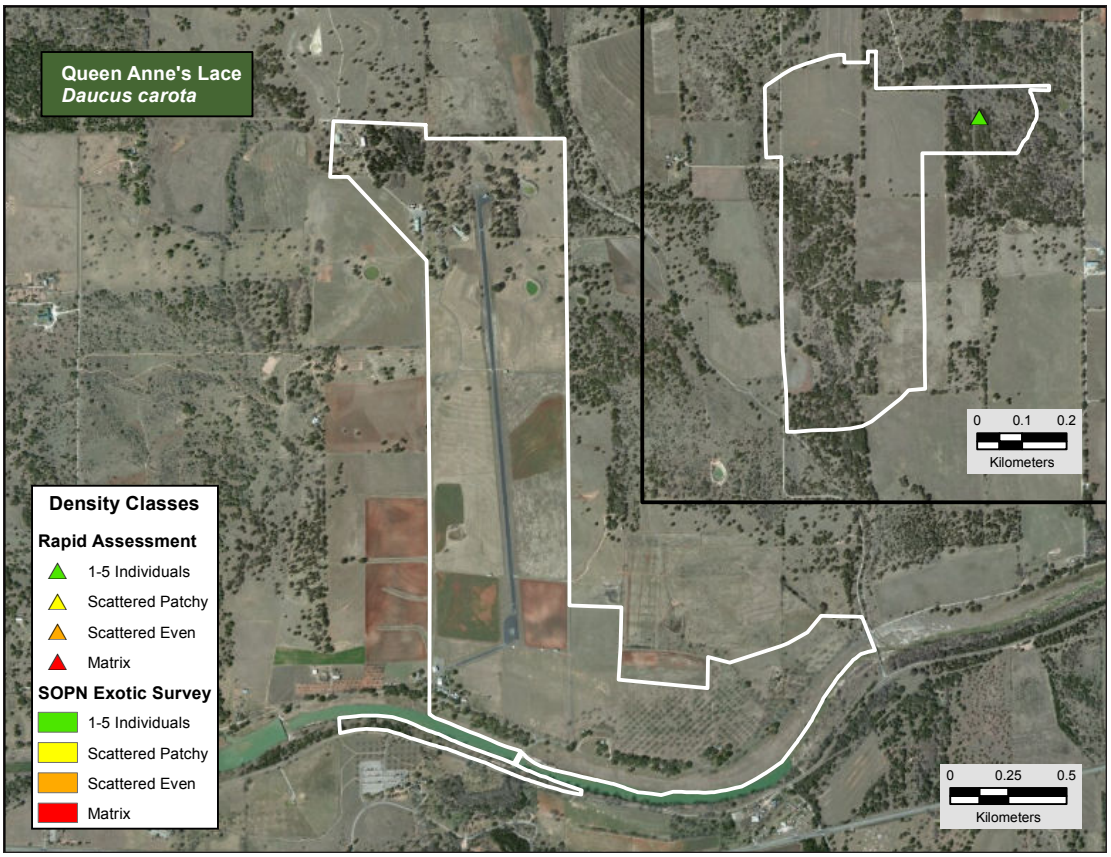


Figure F-11.
Queen Anne's Lace
(*Daucus carota)*

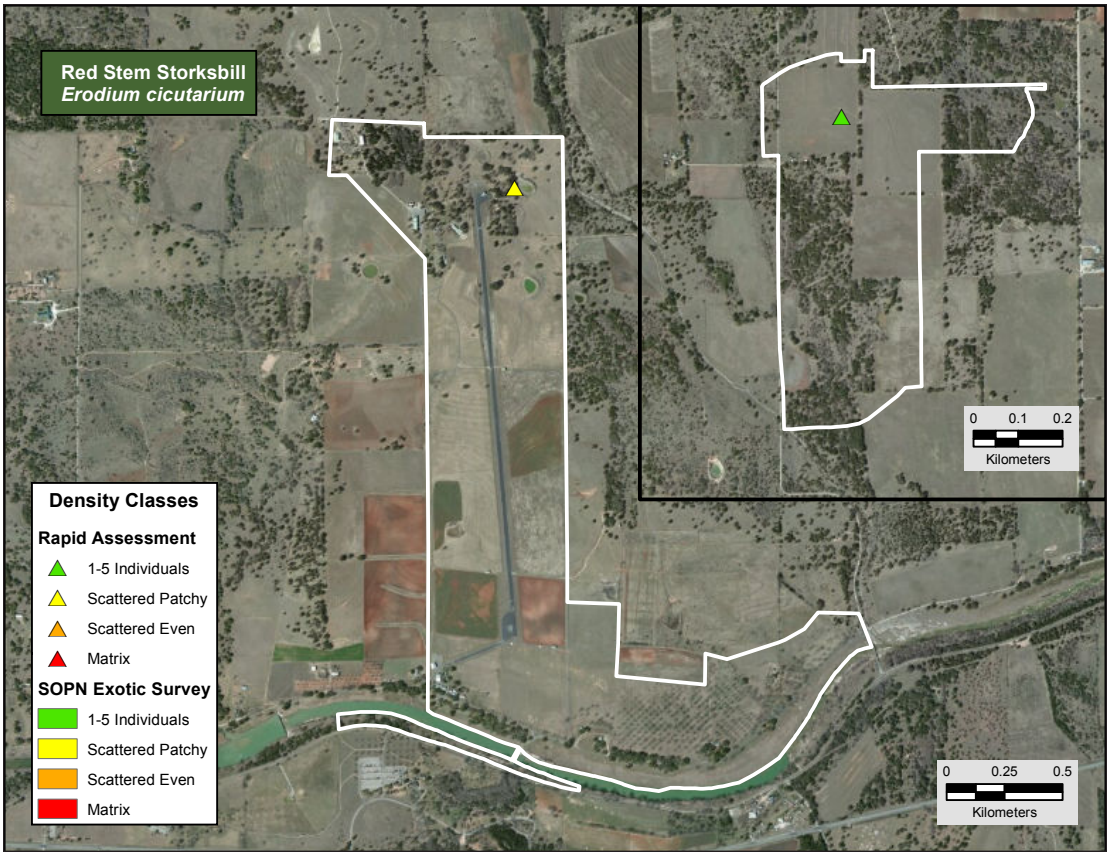


Figure F-12.
Red Stem Storksbill
(*Erodium cicutarium)*

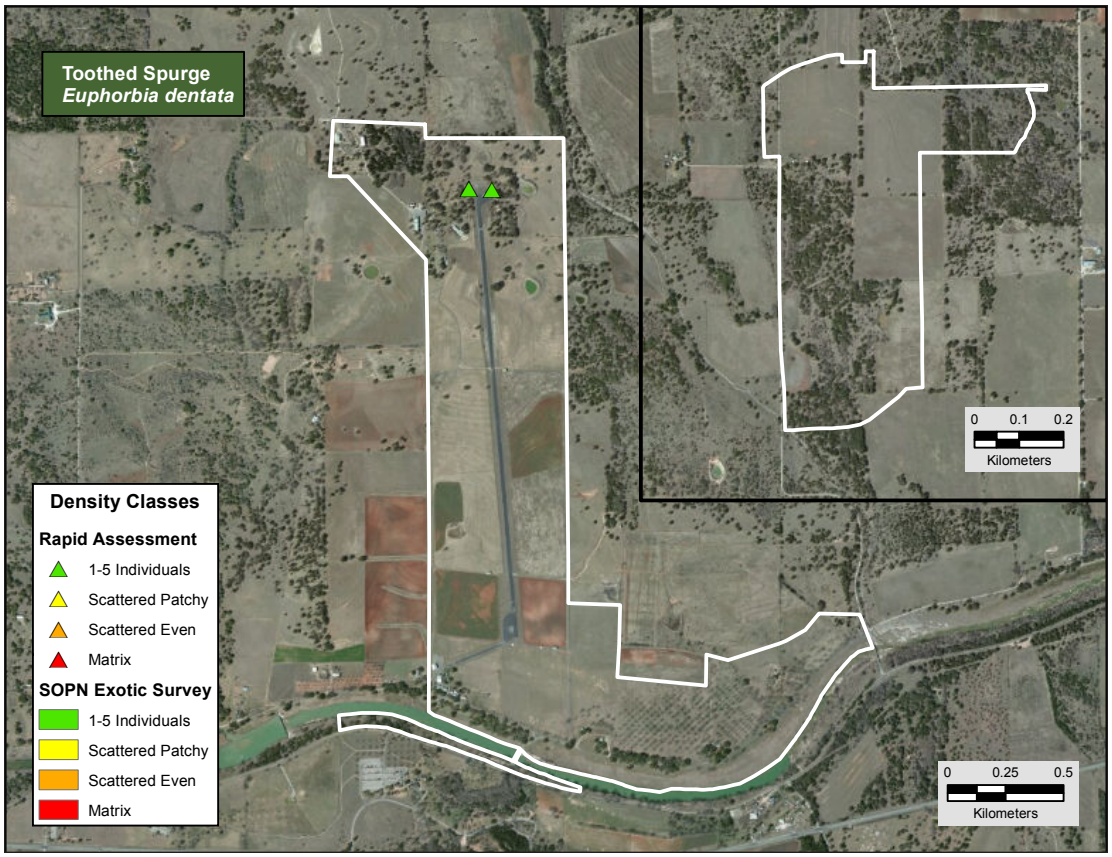


Figure F-13.
Toothed Spurge
(*Eupatorium dentata*)

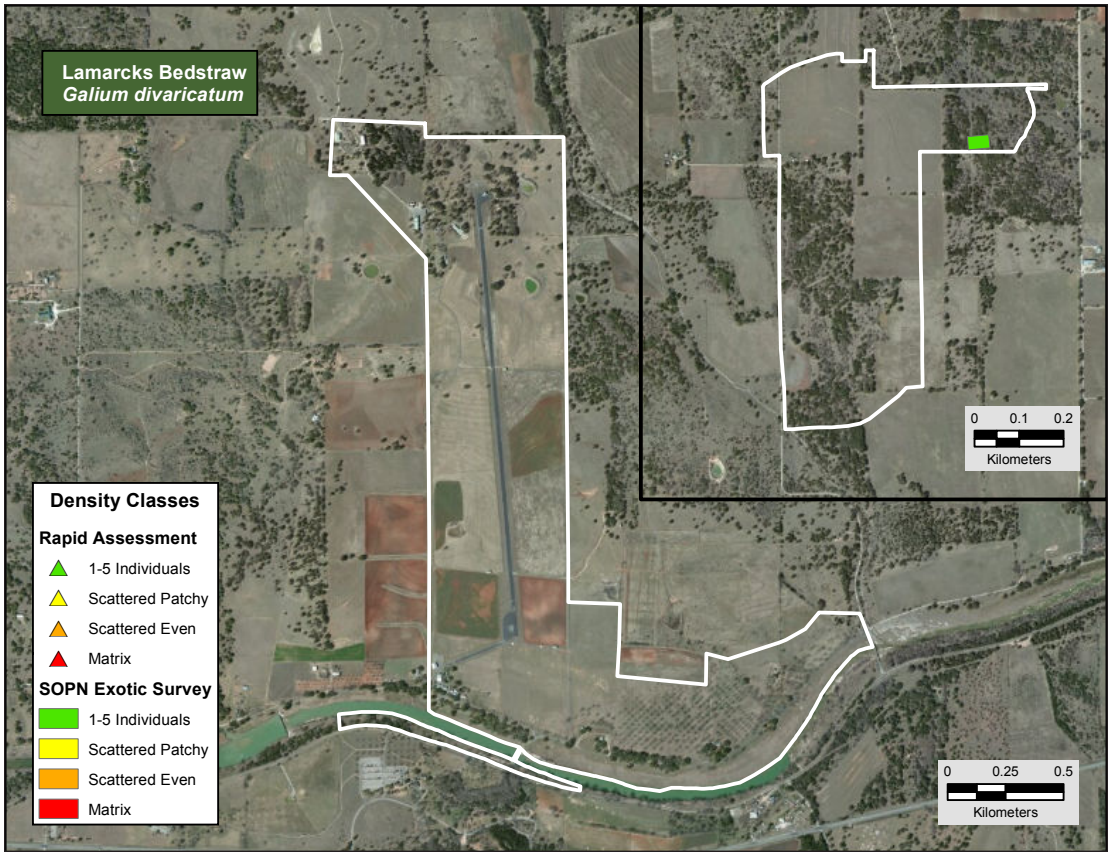


Figure F-14.
Lamarcks Bedstraw
(*Galium divaricatum*)

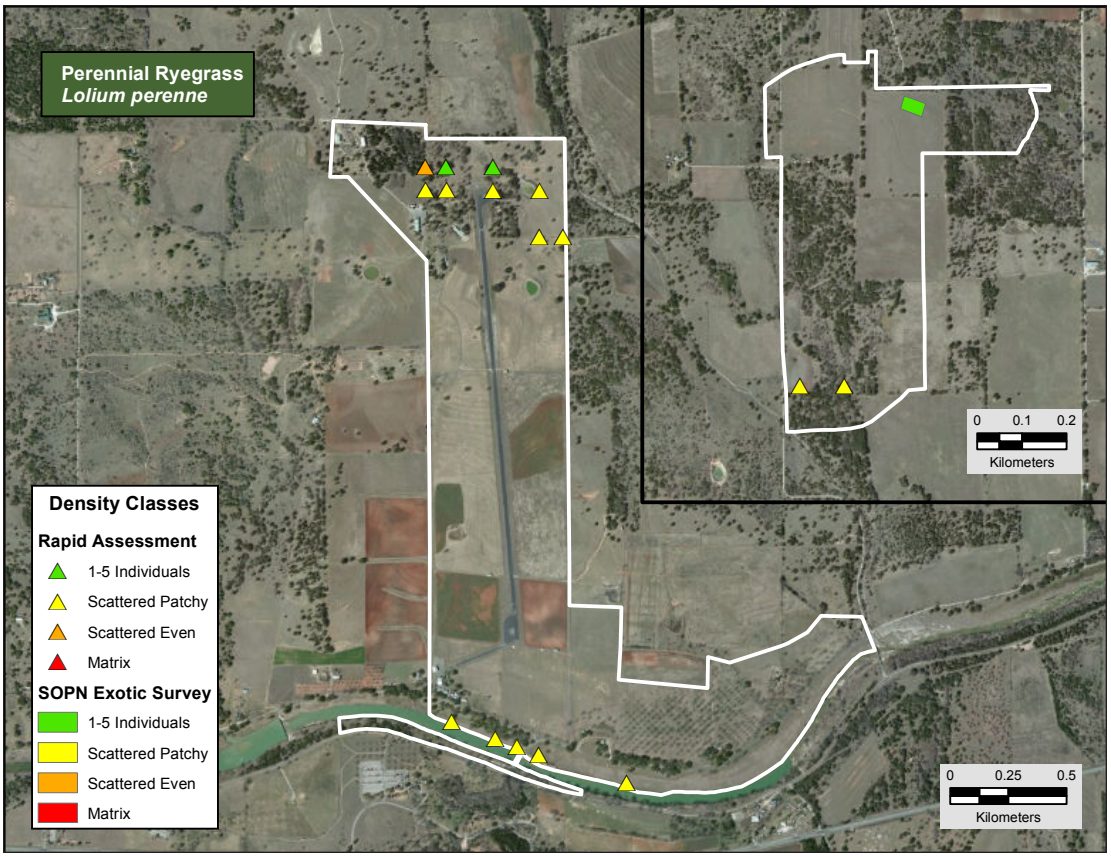


Figure F-15. Perennial Ryegrass (*Lolium perenne*)

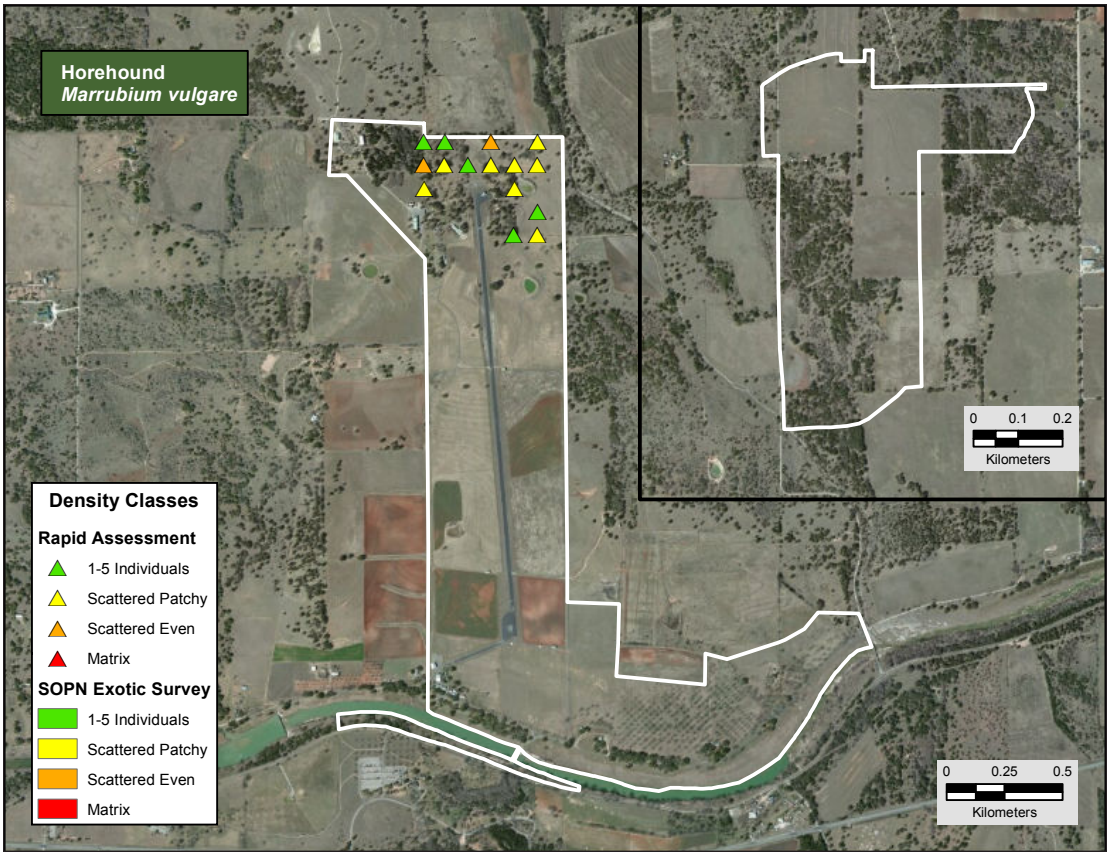


Figure F-16. Horehound (*Marrubium vulgare*)

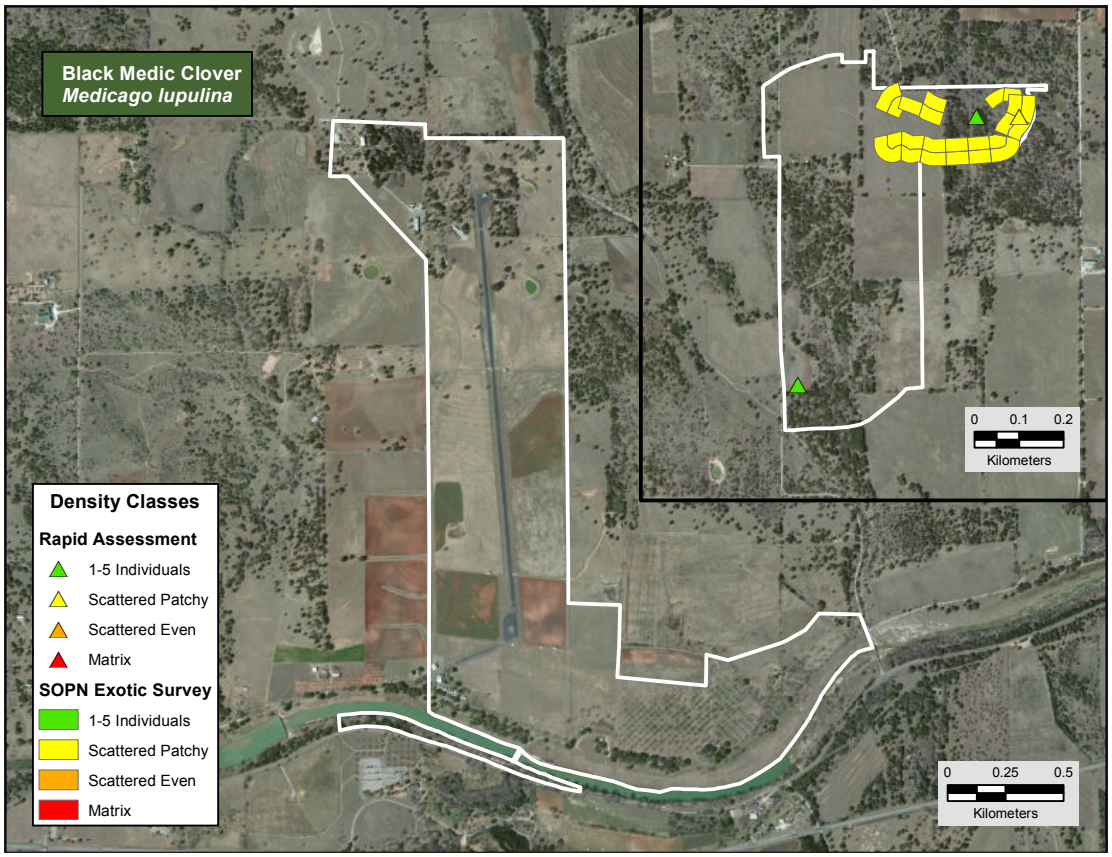


Figure F-17.
Black Medic Clover
(*Medicago lupulina*)

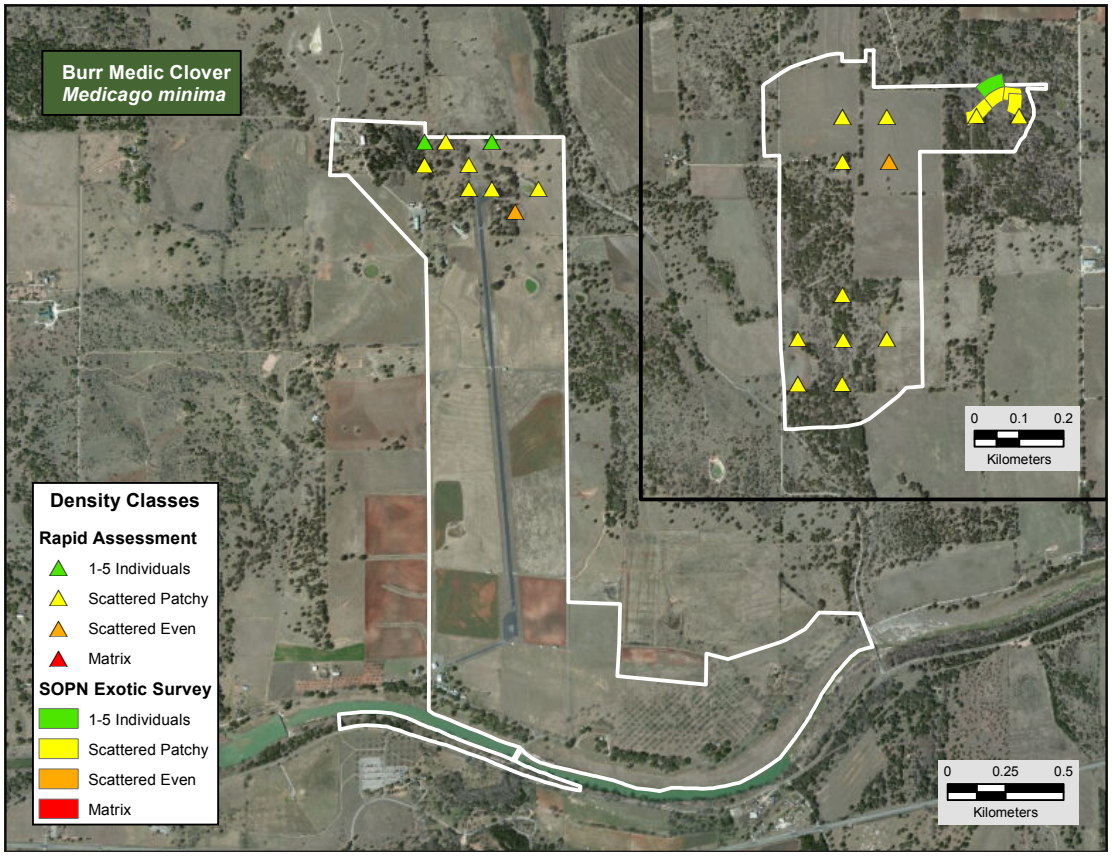


Figure F-18.
Burr Medic Clover
(*Medicago minima*)

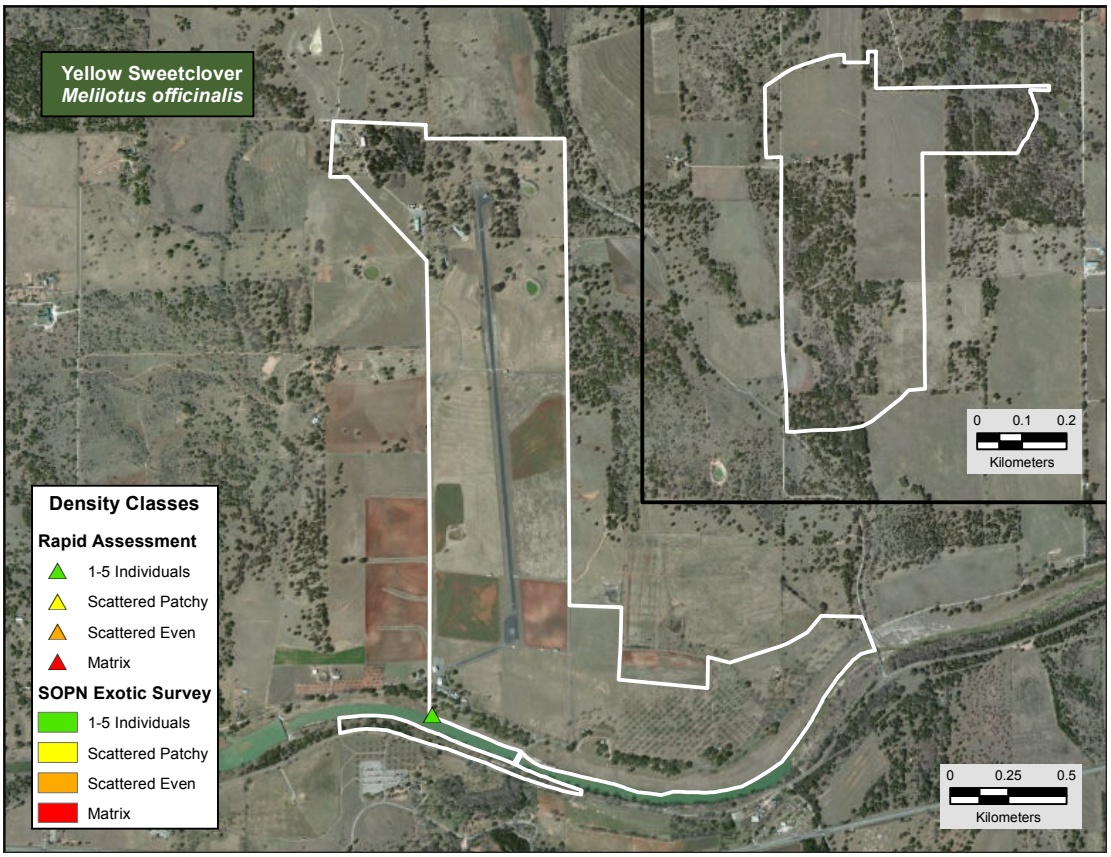


Figure F-19. Yellow Sweetclover (*Meliotus officinalis)*

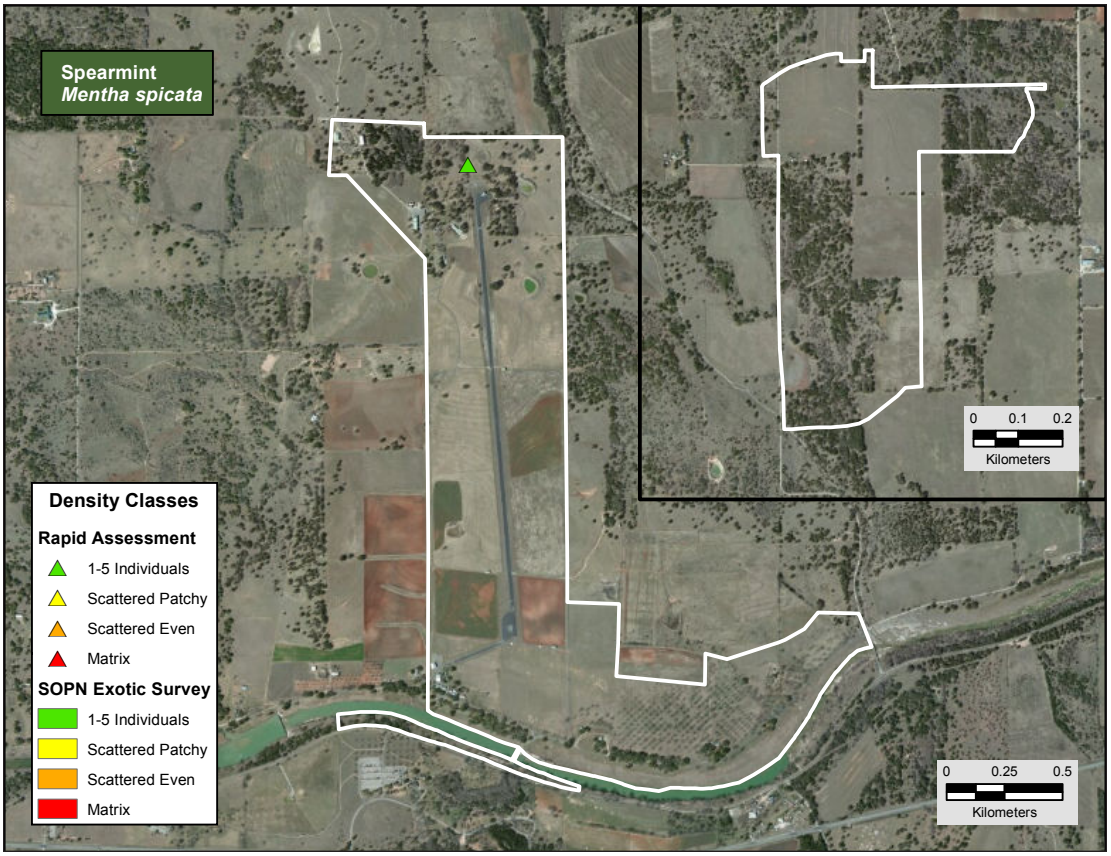


Figure F-20. Spearmint (*Mentha spicata)*

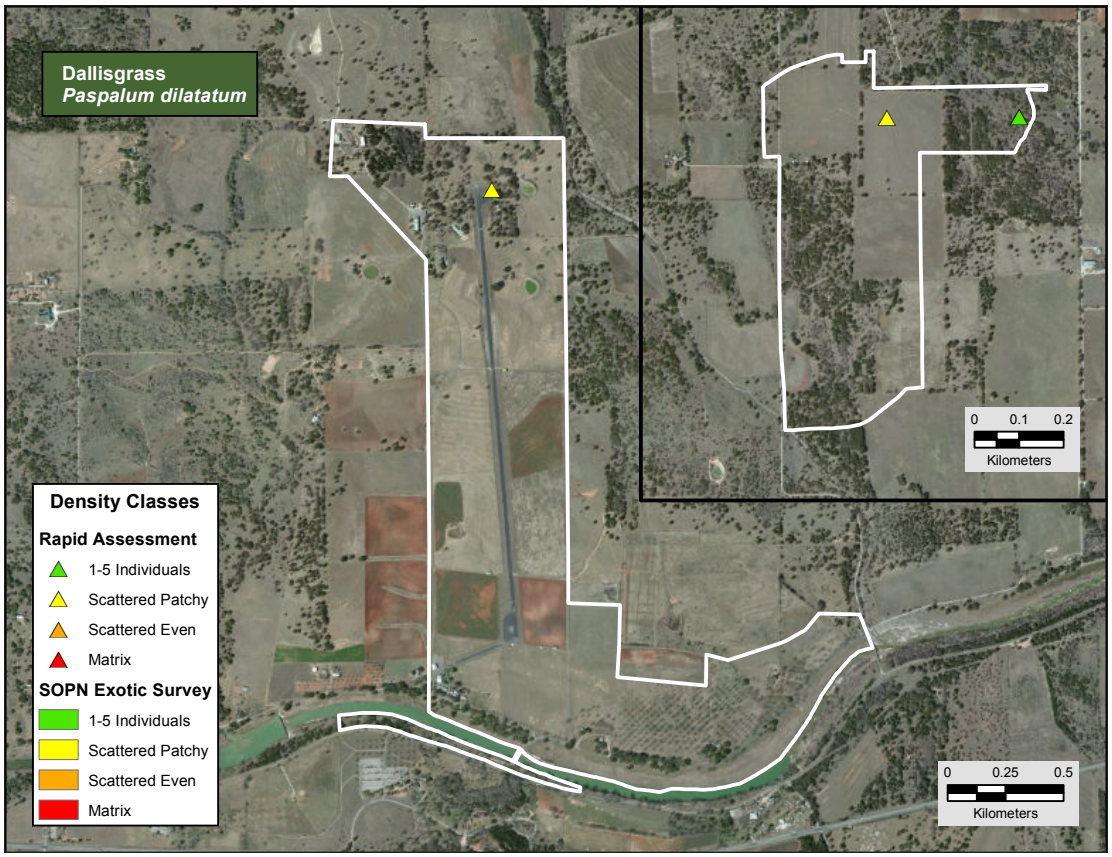


Figure F-21. Dallisgrass (*Paspalum dilatatum)*

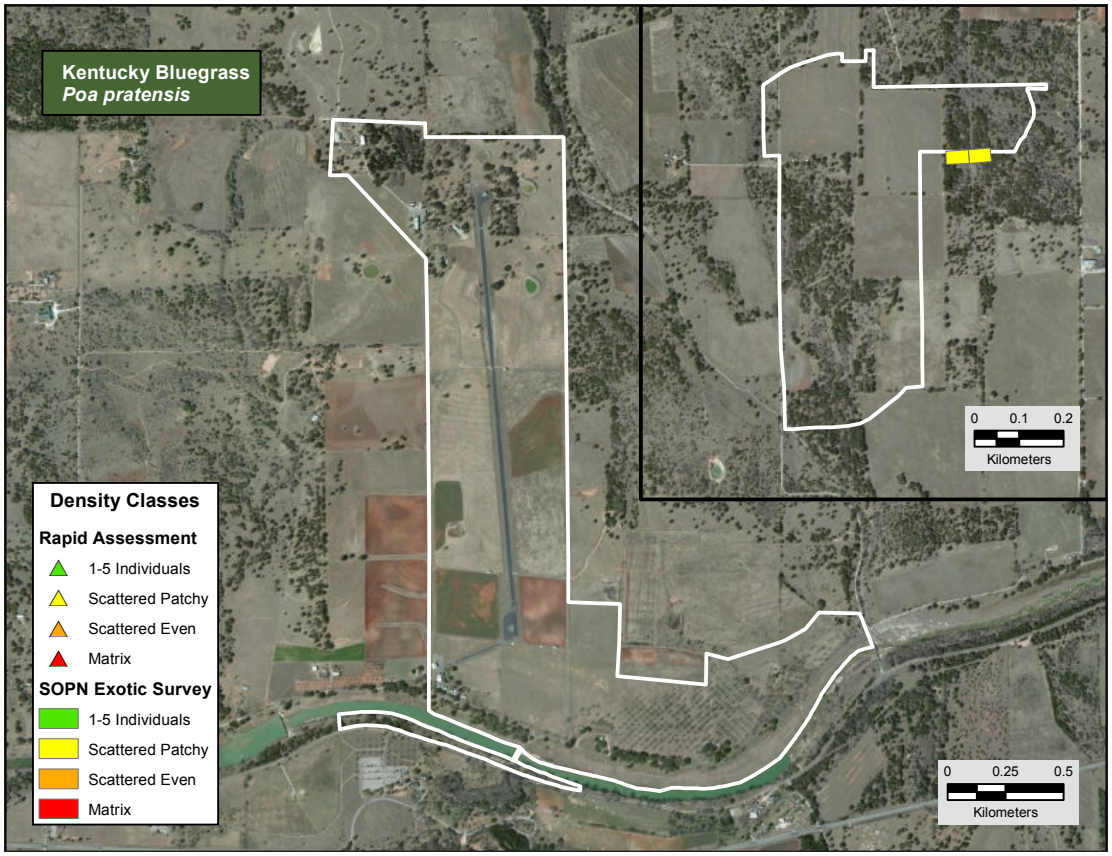


Figure F-22. Kentucky Bluegrass (*Poa pratensis)*

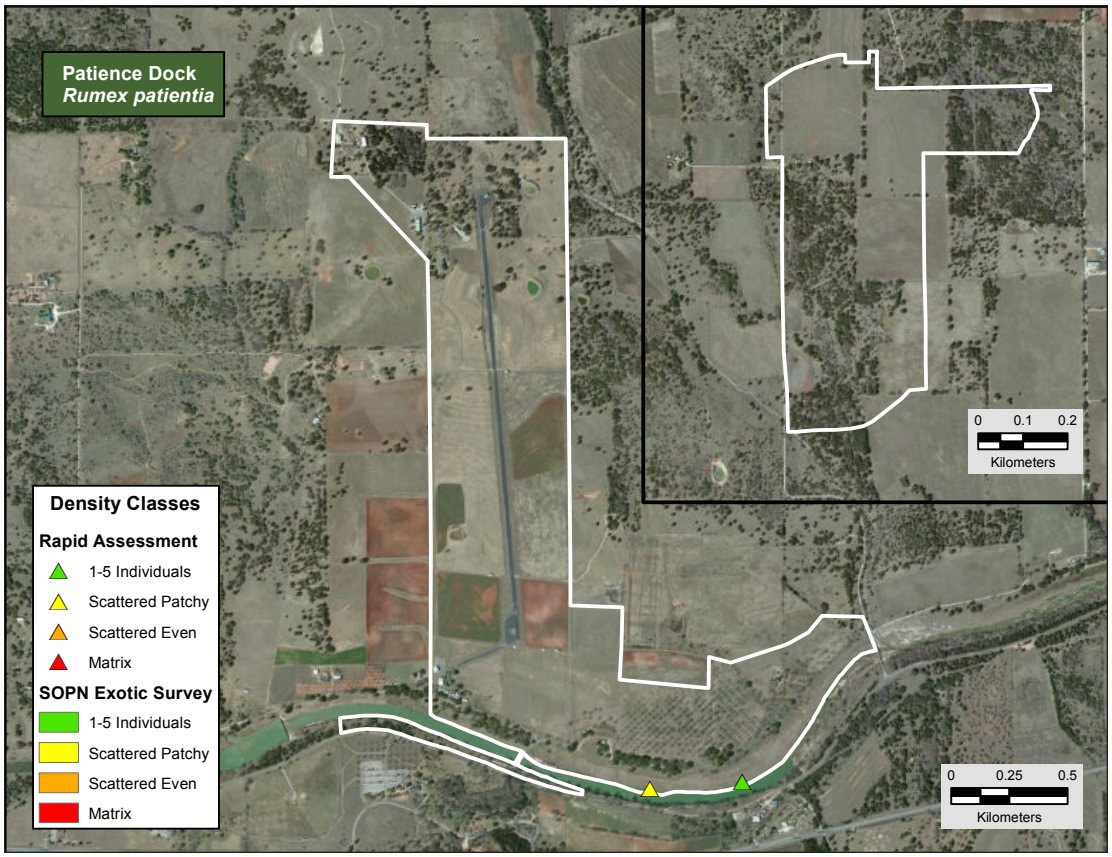


Figure F-23 Patience Dock (*Rumex patientia)*

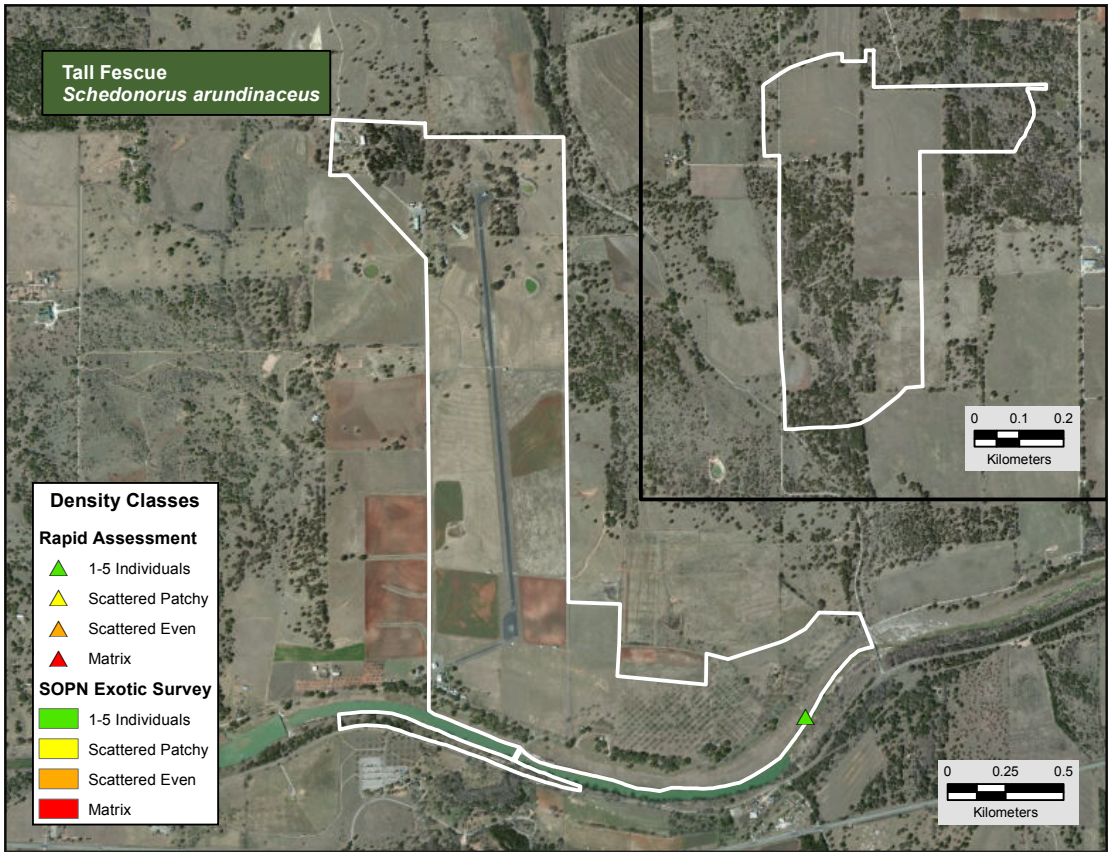


Figure F-24. Tall Fescue (*Schedonorus arundinaceus)*

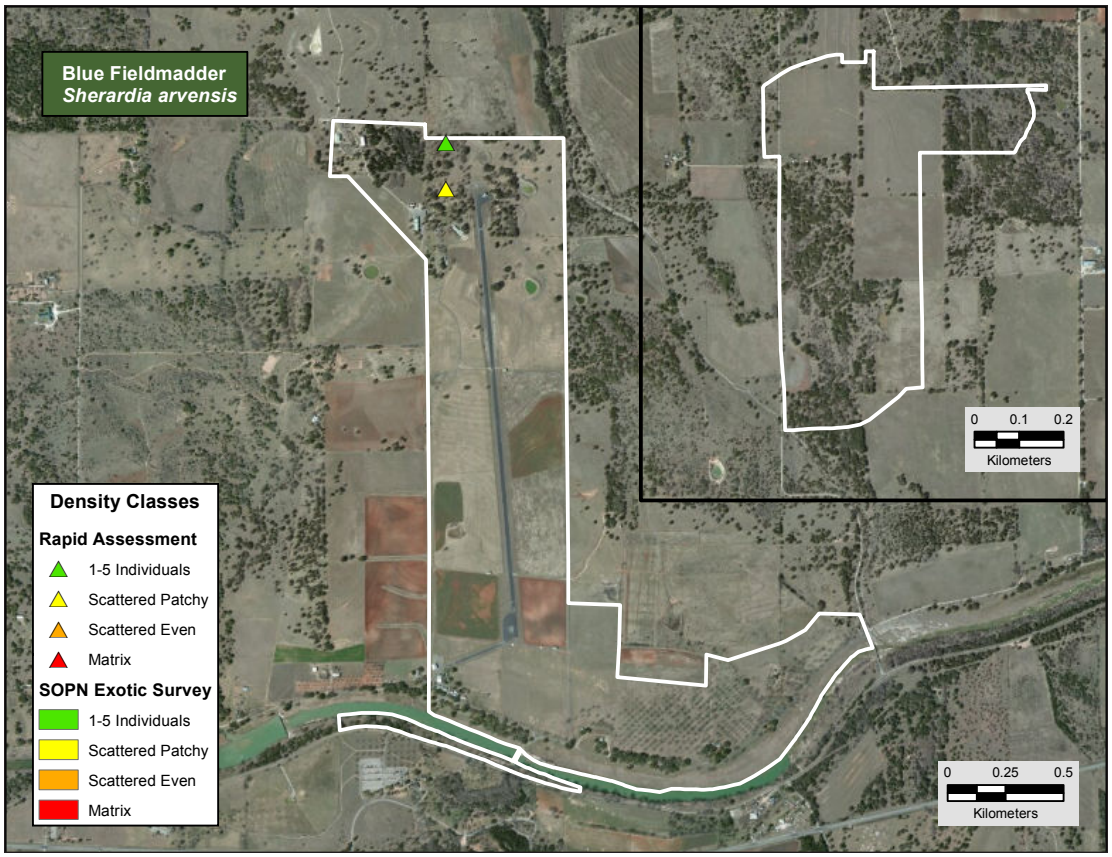


Figure F-25.
Blue Fieldmadder
(*Sherardia arvensis*)

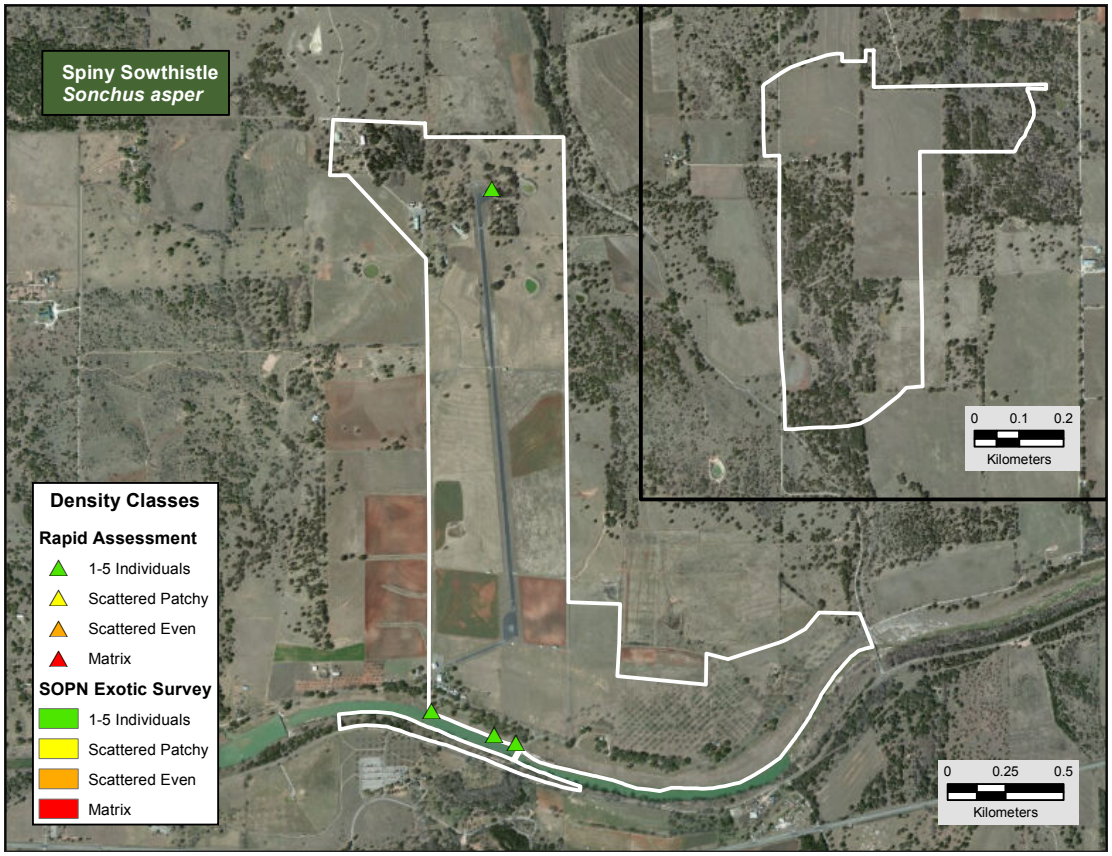


Figure F-26.
Spiny Sowthistle
(*Sonchus asper*)

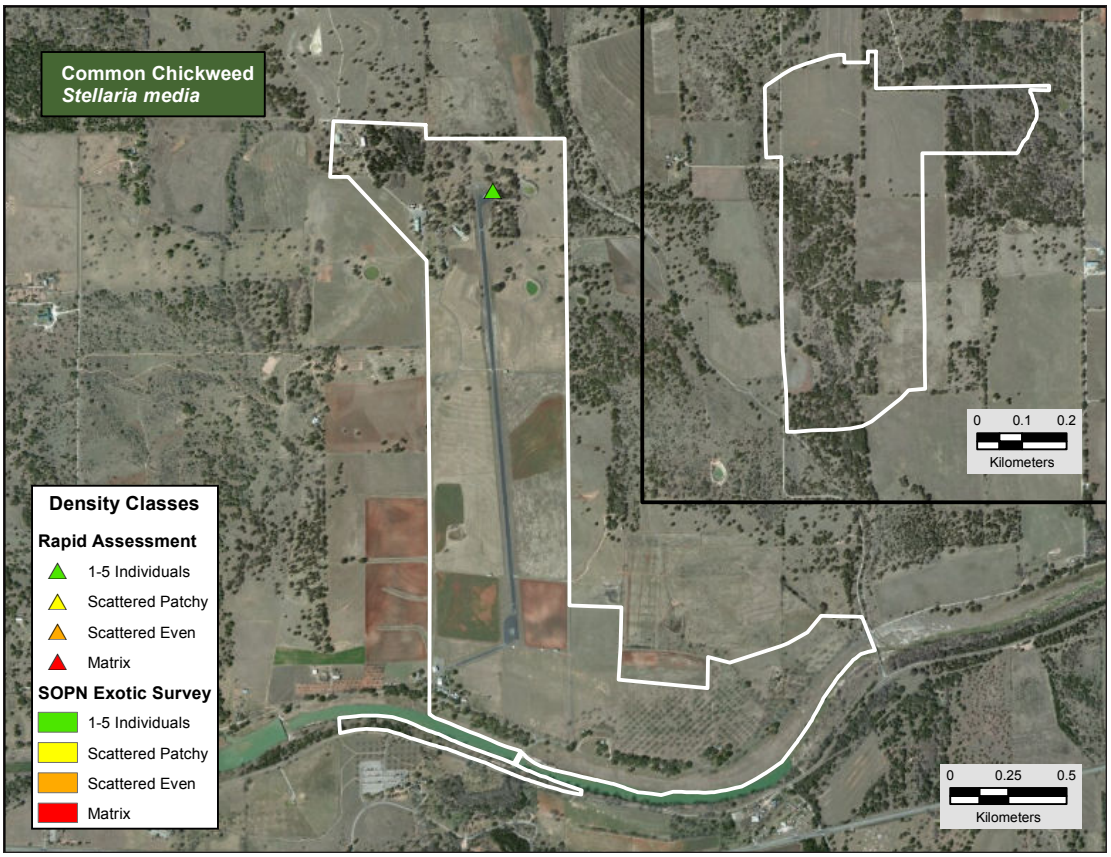


Figure F-27. Common Chickweed (*Stellaria media)*

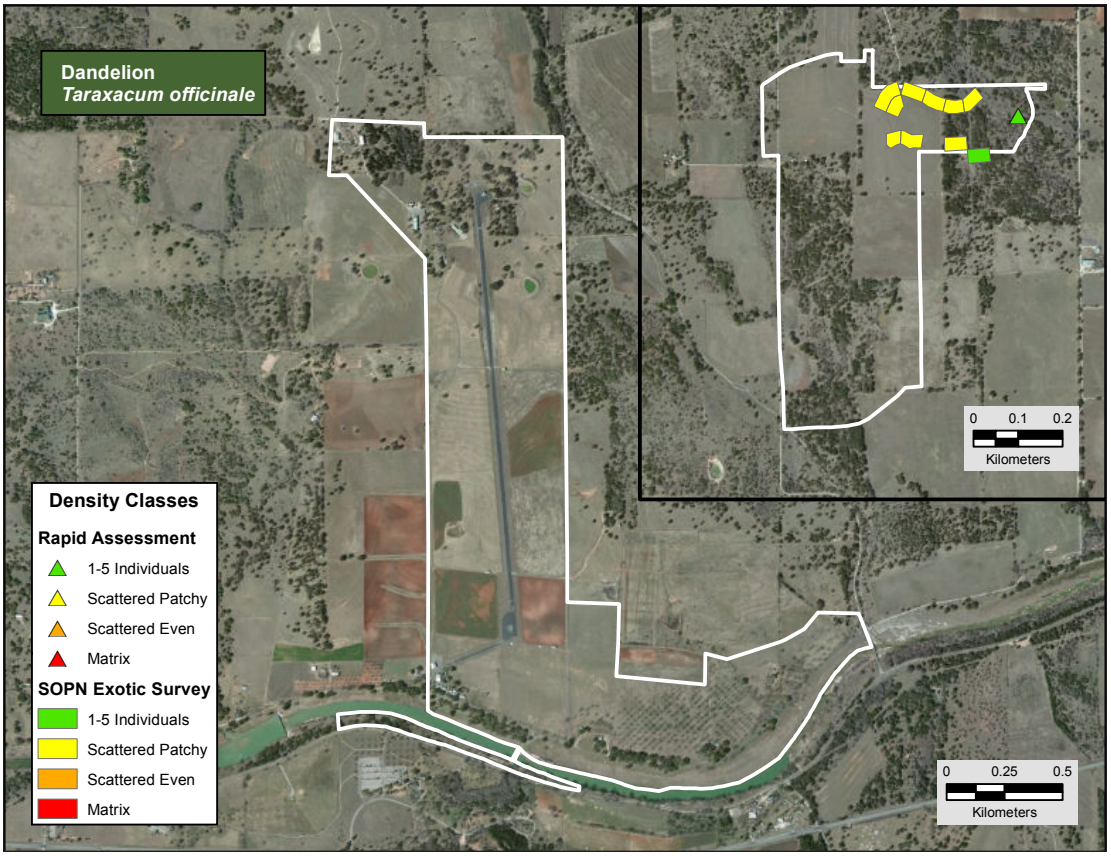


Figure F-28. Dandelion (*Taraxacum offcinale)*

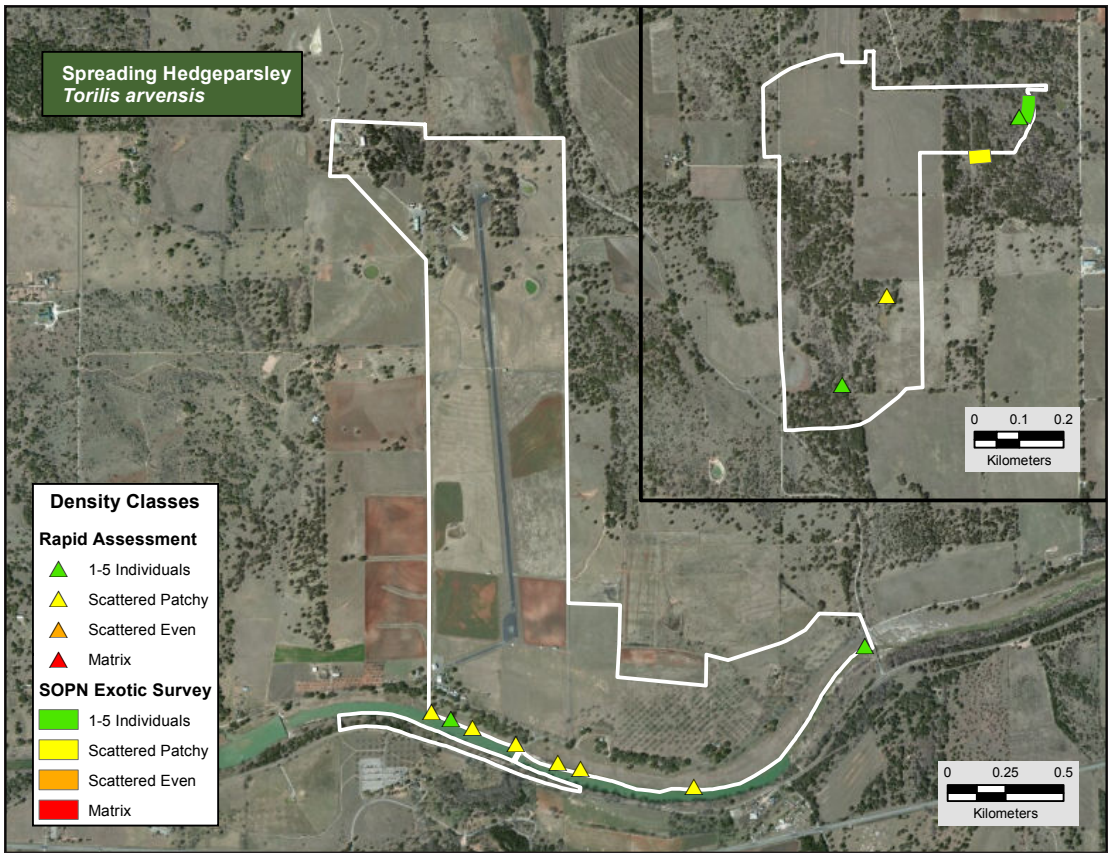


Figure F-29. Spreading Hedgeparsley (*Torilis arvensis)*

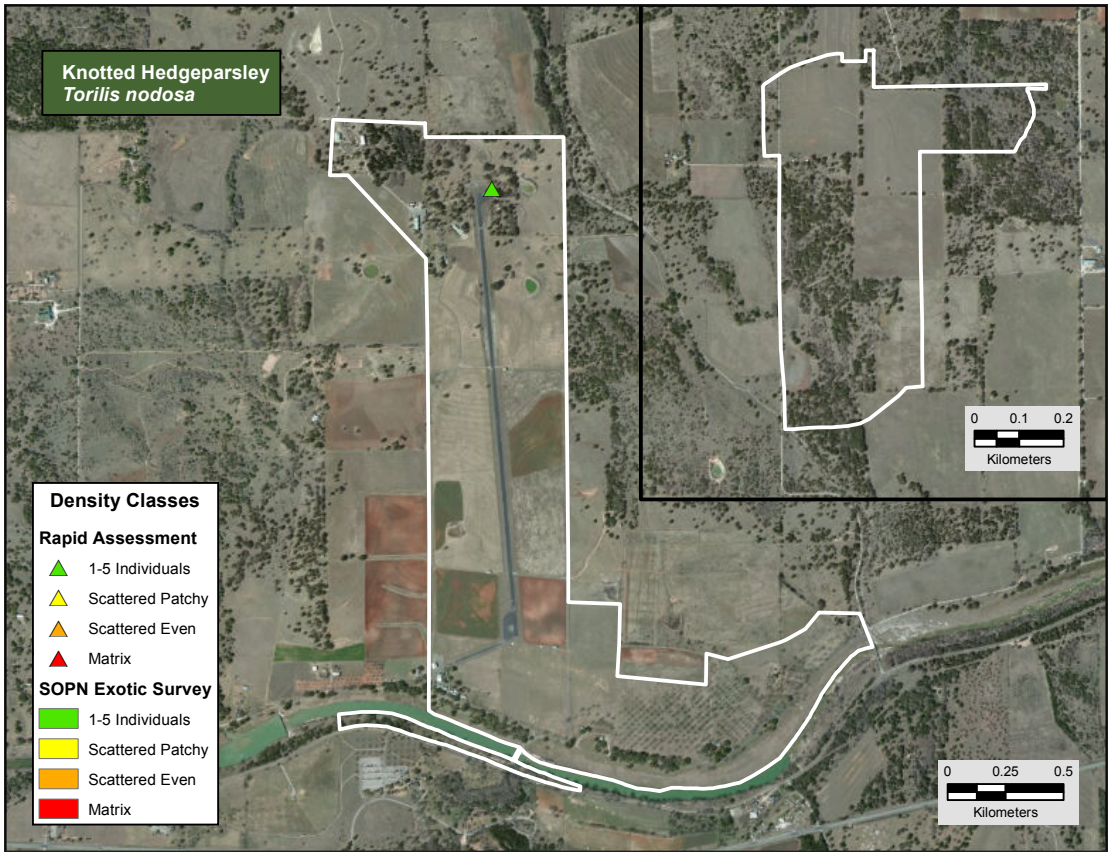


Figure F-30. Knotted Hedgeparsley (*Torilis nodosa)*

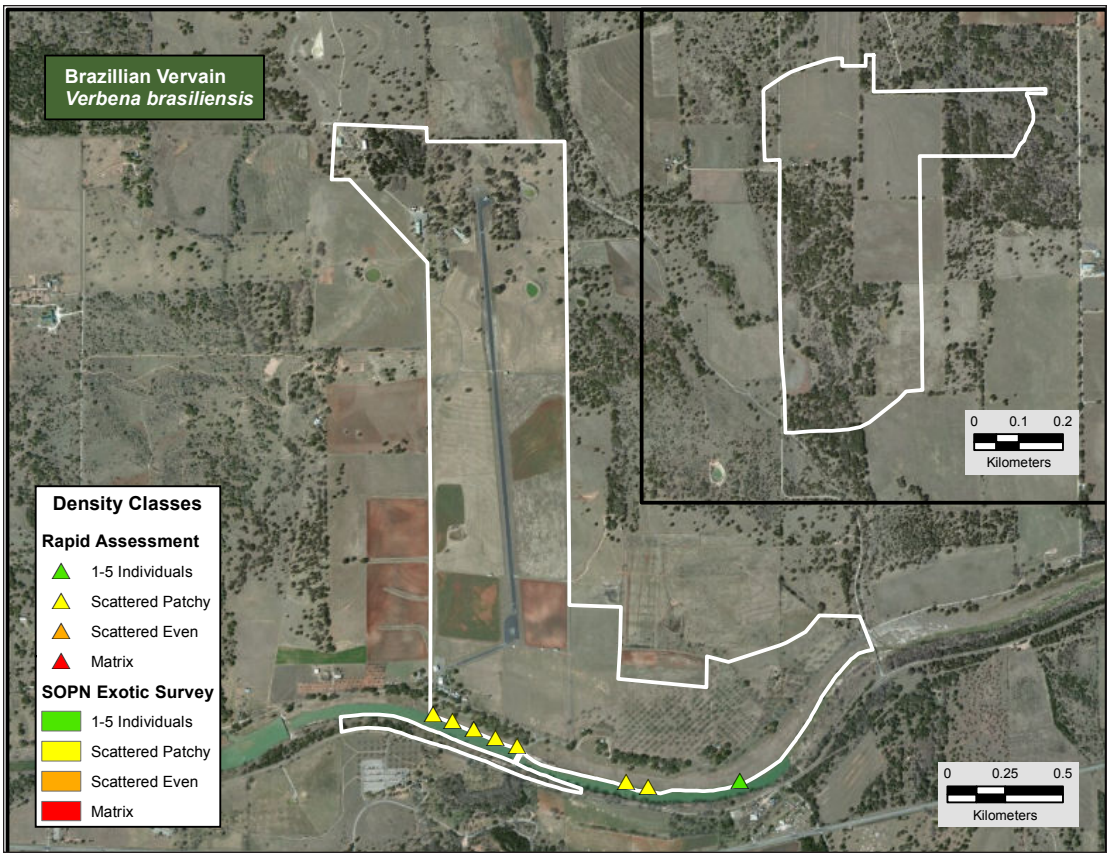


Figure F-31. Brazillian Vervain (*Verbena brasiliensis*)

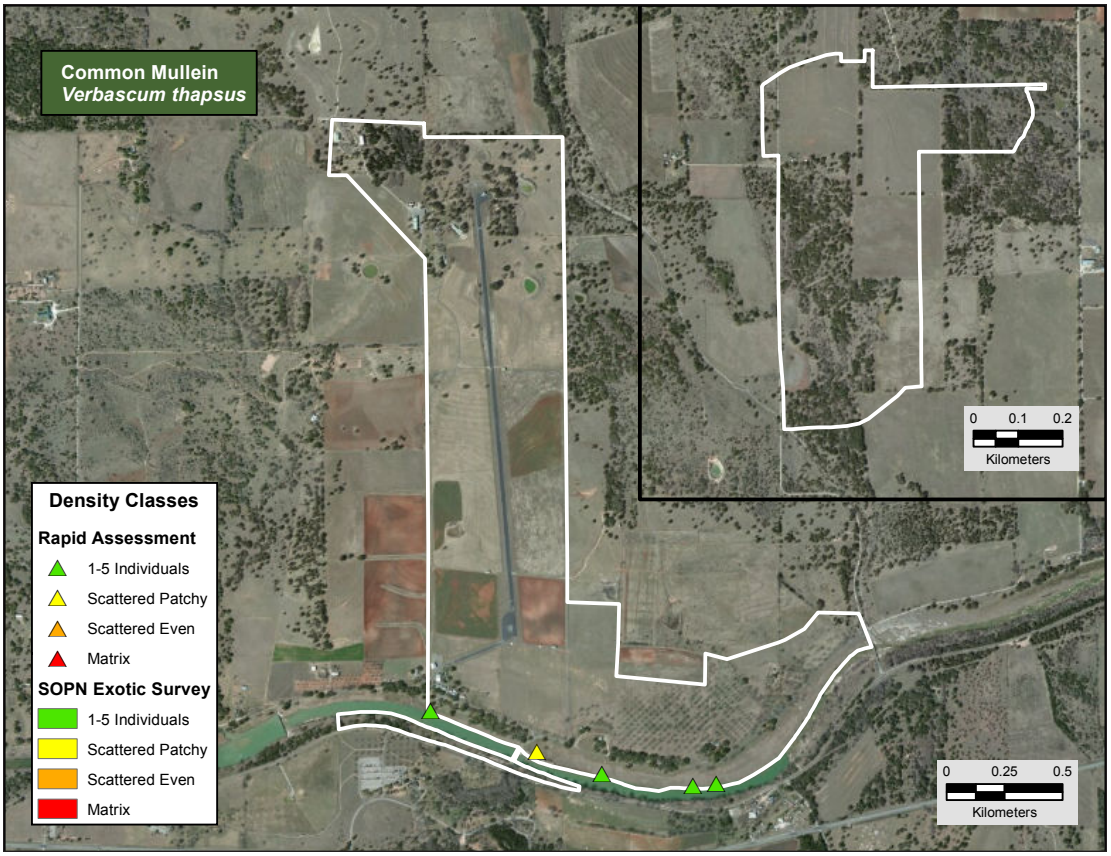


Figure F-32. Common Mullein (*Verbascum thapsus*)

Appendix G: Exotic Plant Species at Lyndon B. Johnson NHP

The following table lists exotic species that are and have been documented within Lyndon B. Johnson NHP (Folts-Zettner, T. 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 (Sanders 2004) were not ranked because they have not been documented in recent monitoring.

Scientific Name	Common Name	2012-2014 Survey[1] (N=96)	2014 Assess.[2] (N=65)	Noxious[3]	Significance of Impact[4]	Feasibility of Management[5]
Allium ampeloprasum	broadleaf wild leak					
Arenaria serpyllifolia	thymeleaf sandwort					
Arundo donax	giant reed			X		
Avena sativa	common oat					
Bothriochloa ischaemum var songarica	king ranch bluestem	92.71%	41.54%		Highest (41)	Difficult (16)
Brassica nigra	black mustard					
Bromus catharticus	rescue brome	16.67%	36.92%		Low (25)	Difficult (16)
Bromus japonicus	Japanese brome	31.25%	30.77%		High (35)	Difficult (21)
Bromus lanceolatus	Mediterranean brome	ND	4.62%		Low (19)	Medium (28)
Bromus tectorum[6,7]	cheatgrass	20.83%	ND		Highest (41)	Difficult (16)
Buglossoides arvensis	corn gromwell					
Calyptocarpus vialis[8]	straggler daisy	22.92%	9.23%		Potentially Native	
Capsella bursa-pastoris	shepardspurse	ND	1.54%		Low (24)	Medium (35)
Carduus nutans	nodding musk thistle	1.04%	38.46%		High (39)	Difficult (16)
Carduus tenuiflorus	Italian thistle					
Centaurea melitensis	Malta starthistle	5.21%	10.77%		High (36)	Difficult (21)
Cerastium glomeratum	sticky chickweed					
Chenopodium album	common lambsquarters					
Chenopodium ambrosioides	Mexican tea					
Conium maculatum	poison hemlock	ND	9.23%		Highest (41)	Difficult (16)
Convolvulus arvensis	field bindweed					
Cynodon dactylon[9]	Bermudagrass	61.46%	75.38%		Low (29)	Extremely Difficult (11)
Cyperus esculentus[8]	yellow nutsedge	1.04%	3.08%		Potentially Native	
Cyperus rotundus	cocograss					
Daucus carota	Queen Anne's lace	2.08%	1.54%		Medium (34)	Easily Controlled (45)
Desmazeria rigida	ferngrass					
Dichanthium annulatum	Kleburg bluestem					
Digitaria ciliaris	smooth crabgrass					
Echinochloa colona	jungle ricegrass					
Echinochloa crus-galli	barnyardgrass					

Scientific Name	Common Name	2012-2014 Survey[1] (N=96)	2014 Assess.[2] (N=65)	Noxious[3]	Significance of Impact[4]	Feasibility of Management[5]
Elaeagnus pungens	thorny olive					
Eragrostis barrelieri	Mediterranean lovegrass	1.04%	ND		Highest (40)	Difficult (20)
Eragrostis cilianensis	stinkgrass					
Erodium cicutarium	redstem stork's bill	ND	3.08%		Medium (31)	Extremely Difficult (11)
Euphorbia dentata[8]	toothed spurge	ND	3.08%		Potentially Native	
Facelis retusa	annual trampweed					
Fatoua villosa	hairy crabweed					
Galium divaricatum	Lamarck's bedstraw	4.17%	ND		Low (24)	Easily Controlled (45)
Gamochaeta antillana	delicate everlasting					
Hemerocallis fulva	orange daylily					
Hordeum murinum	mouse barley					
Hordeum vulgare	cereal barley	7.29%	ND		Low (19)	Medium (35)
Lactuca serriola	prickly lettuce					
Lamium amplexicaule	henbit					
Lathyrus hirsutus	singletary pea					
Leonurus sibiricus	honeyweed					
Ligustrum japonicum	Japanese privet					
Ligustrum lucidum	glossy privet					
Ligustrum sinense	Chinese privet					
Lolium perenne ssp multiflorum	perennial rye grass					
Lonicera japonica	Japanese honeysuckle	11.46%	ND		Highest (48)	Difficult (21)
Malva parviflora	small-whorl mallow					
Marrubium vulgare	horehound	1.04%	23.08%		Medium (33)	Medium (26)
Medicago lupulina	black medik clover	53.14%	4.62%		Medium (30)	Medium (35)
Medicago minima	burr medick clover	51.04%	32.31%		Medium (32)	Extremely Difficult (15)
Medicago polymorpha	burclover	1.04%	ND		Medium (32)	Easily Controlled (45)
Melia azedarach	chinaberry					
Melilotus officinalis[9]	yellow sweetclover	ND	1.54%		Medium (29)	Difficult (21)
Mentha spicata[6]	spearmint	ND	1.54%		Medium (33)	Difficult (25)
Mirabilis jalapa	common four-o'clock					
Morus alba	white mulberry					
Nandina domestica	heavenly bamboo					
Panicum coloratum	kleingrass					
Paspalum dilatatum	dallis grass	44.79%	4.62%		Low (29)	Medium (30)
Paspalum urvillei	Vasey grass					
Poa annua	annual bluegrass	8.33%	ND		Highest (46)	Extremely Difficult (11)
Poa pratensis[6]	Kentucky bluegrass	2.08%	ND		Highest (50)	Medium (26)
Polycarpon tetraphyllum	fourleaf manyseed					
Polypogon monspeliensis	annual rabbitsfoot grass					
Pseudognaphalium luteoalbum	Jersey cudweed					
Ricinus communis	castor bean					

Scientific Name	Common Name	2012-2014 Survey[1] (N=96)	2014 Assess.[2] (N=65)	Noxious[3]	Significance of Impact[4]	Feasibility of Management[5]
Rumex patientia[6]	patience dock	ND	3.08%		Medium (32)	Extremely Difficult (15)
Rumex pulcher	fiddle dock					
Schedonorus arundinaceus[6]	tall fescue	ND	1.54%		Highest (46)	Extremely Difficult (11)
Sherardia arvensis	blue fieldmadder	3.13%	3.08%		Low (21)	Easily Controlled (55)
Sida abutifolia	prostrate sida					
Sisymbrium irio	London rocket					
Sisymbrium officinale	hedgemustard					
Sonchus asper	spiny sowthistle	1.04%	6.15%		Medium (33)	Medium (35)
Sonchus oleraceus	common sowthistle					
Sorghum halepense	Johnsongrass	64.58%	32.31%		Highest (45)	Difficult (21)
Stellaria media	common chickweed	ND	1.54%		Medium (30)	Difficult (25)
Taraxacum officinale	dandelion	32.29%	1.54%		Medium (34)	Medium (35)
Torilis arvensis	spreading hedgeparsley	50.00%	16.92%		Medium (31)	Easily Controlled (45)
Torilis nodosa	knotted hedgeparsley	3.13%	1.54%		Medium (31)	Easily Controlled (45)
Triadica sebifera	Chinese tallow tree			X		
Trifolium repens	ladino clover					
Verbascum thapsus	mullein	ND	7.69%		Low (24)	Medium (26)
Veronica arvensis	corn speedwell					
Vicia sativa ssp nigra	garden vetch					
Vicia villosa	hairy vetch					

ND = Not Detected.

[1]Data from SOPN monitoring of the SOPN Annual Exotic Plant monitoring along the Settlement Trail in the prairie restoration area in the Johnson City Unit, 2012 - 2014 (Folts-Zettner and Sosinski 2012b; 2013; 2014).

[2]Data from the SOPN 2014 Rapid Assessment (Horsley and Schafer 2014).

[3]Noxious = Texas state noxious status (USDA-NRCS 2014, and Texas Department of Agriculture 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 populations 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]The detections of *Bromus tectorum* may be due to a species misidentification as a result of phenology (e.g., seed heads not present) at the time of monitoring (Folts-Zettner, SOPN biologist, personal communication, 2014).

[8]Three species, *Calyptocarpus vialis, Cyperus esculentus,* and *Euphorbia dentata*, about where there is a debate about their native or nonnative status (Folts-Zettner, SOPN Biologist, personal communication, 2014) that are included in the SOPN monitoring for exotic plant species, are not included in this assessment.

[9]Species of special concern (Folts-Zettner, personal communication, 2014)

Cultivated exotic species reported by Sanders (2004) were not included in this table because this condition assessment focused on the more natural areas of the park assessed during SOPN monitoring.

G.1. Literature Cited

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Appendix H: Background on Bird Species of Conservation Concern Lists

This appendix provides background information on the organizations and efforts to determine species of birds that are in need of conservation. The information presented here supports Section 4.11.2, Data and Methods, of the breeding landbirds chapter. This appendix contains some of the same, but additional, information as that section of the report.

One component of the landbird condition assessment was to assess species occurrence in a conservation context. We compared the list of species that occur at Lyndon B. Johnson National Historical Park (NHP) (i.e., those detected during Rocky Mountain Bird Observatory [RMBO] surveys at the Historical Park 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.

H.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 Texas

In 1973, the Texas Parks and Wildlife Department (TPWD) was authorized to

develop a list of endangered and threatened animal species in the state. Legal protection of endangered and threatened animals is provided by laws and regulations contained in Chapters 67 and 68 of the Texas Parks and Wildlife Code and Sections 65.171-65.176 of Title 31 of the Texas Administrative Code (TPWD 2014a).

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.

Texas Species of Greatest Conservation Need

The State of Texas also designated species that, "due to limited distributions and/or declining populations, face the threat of extirpation or extinction but lack legal protection" (TPWD 2014b). The lists were developed for the TPWD's Texas Conservation Action Plan (TPWD 2012). Species are rated or ranked using a system developed by NatureServe, and lists are available for each of 11 ecoregions in the state.

H.2. Literature Cited

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Appendix I: Lyndon B. Johnson National Historical Park Bird List (Based on RMBO Surveys)

Listed below is the full list of species recorded during Rocky Mountain Bird Observatory (RMBO) surveys in 2009-2013 at Lyndon B. Johnson National Historical Park (NHP). Species not also occurring on the NPSpecies List for the park (NPS 2014) or the Archer List (2011) are indicated. See Section 4.11 for a description of the two lists.

Common Name	
American Crow	Great Crested Flycatcher
American Robin	Great-tailed Grackle
Ash-throated Flycatcher [1]	Green Heron
Barn Swallow	Hairy Woodpecker
Bewick's Wren	House Sparrow
Black Vulture	Ladder-backed Woodpecker
Black-crested Titmouse	Lark Sparrow
Blue Grosbeak	Lesser Goldfinch
Blue Jay	Mourning Dove
Brown-headed Cowbird	Northern Cardinal
Bullock's Oriole	Northern Flicker
Carolina Chickadee	Northern Mockingbird
Carolina Wren	Orchard Oriole
Cattle Egret	Osprey
Chihuahuan Raven	Red-eyed Vireo
Chimney Swift	Red-tailed Hawk
Cliff Swallow	Red-winged Blackbird
Common Grackle	Scissor-tailed Flycatcher
Crested Caracara	Summer Tanager
Double-crested Cormorant	Turkey Vulture
Downy Woodpecker	Vesper Sparrow
Eastern Bluebird	Western Kingbird
Eastern Kingbird	White-crowned Sparrow
Eastern Phoebe	White-winged Dove
Eurasian Collared-Dove	Wild Turkey
Field Sparrow	Yellow-billed Cuckoo
Grasshopper Sparrow	Yellow-rumped Warbler
Great Blue Heron	

[1] Species does not appear on the Archer (2011) List or the NPSpecies List.

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