National Park Service
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Natural Resource Stewardship and Science

Natural Resource Condition Assessment

Tallgrass Prairie National Preserve

Natural Resource Report NPS/TAPR/NRR—2019/2043

ON THE COVER

Photograph across Fox Creek toward the Spring Hill Ranch, Tallgrass Prairie National Preserve

Photograph by Dave Jones, Colorado State University

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The National Park Service, Natural Resource Stewardship and Science office in Fort Collins, Colorado, publishes a range of reports that address natural resource topics. These reports are of interest and applicability to a broad audience in the National Park Service and others in natural resource management, including scientists, conservation and environmental constituencies, and the public.

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All manuscripts in the series receive the appropriate level of peer review to ensure that the information is scientifically credible, technically accurate, appropriately written for the intended audience, and designed and published in a professional manner.

This report received informal peer review by subject-matter experts who were not directly involved in the collection, analyses, or reporting of the data. Data in this report were collected using methods based on established, peer-reviewed protocols and were analyzed and interpreted within the guidelines of those protocols. Where quantitative data were unavailable, the authors used expert opinion of subject matter experts and reviewers to form conclusions.

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Executive Summary

The National Park Service (NPS) Natural Resource Condition Assessment (NRCA) Program administered by the NPS Water Resources Division evaluates current conditions for important natural resources and resource indicators using primarily existing information and data. NRCAs also report on trends in resource condition when possible, identify critical data gaps, and characterize a general level of confidence for study findings. This NRCA complements historic resource assessments, is multi-disciplinary in scope, employs a hierarchical indicator framework, identifies and develops reference conditions/values for comparison against current conditions, and emphasizes spatial evaluation of conditions and GIS products.

Created in 1996, Tallgrass Prairie National Preserve (TAPR) is a unique and highly successful partnership between The Nature Conservancy and the National Park Service. The purpose of TAPR is to preserve, protect, and interpret for the public, an example of a tallgrass prairie ecosystem; to preserve and protect the cultural resources found within the preserve; and to interpret for the public, the cultural resources and the social and cultural values represented within the preserve. The combination of historic elements and high-quality tallgrass prairie is unparalleled within the NPS. The rural nature of the surrounding area, expansive views and lack of wind energy development creates scenery with high natural and cultural quality. Preserve managers and NPS initiatives have made great strides since the preserve was created in 1996 and an active monitoring program supports preserve management. Introduction of bison in 2009 presented challenges to the preserve but the herd is thriving and multiple ecosystem and visitation benefits are occurring as a result of their presence.

The NRCA for Tallgrass Prairie National Preserve, Kansas began in 2012. This study employed a scoping process involving Colorado State University, preserve and NPS staff to discuss the NRCA framework, identify important preserve resources, and gather existing information and data. Indicators and measures for each resource were then identified and evaluated. Data and information were analyzed and synthesized to provide summaries and address condition, trend and confidence using a standardized but flexible framework.

A total of 19 focal resources were examined: six addressing landscape context – system and human dimensions, three addressing chemical and physical attributes, and ten addressing biological attributes. Landscape context – system and human dimensions included land cover and land use, night sky, soundscape, scenery, climate change and fire disturbance regime. Climate change and land cover/land use were not assigned a condition or trend—they provide important context to the preserve and many natural resources, and can be a source of stress and management concern. Some of the land cover and land use-related stressors at TAPR and in the larger region are related to the development of rural agricultural land and increases in population/housing over time. The trend in land development, coupled with a lack of significantly-sized and linked protected areas in the region, presents challenges and risks to the conservation of preserve natural resources, including dark night skies, natural sounds, scenery and air and water quality. There are opportunities to mitigate the effects of some local stressors through planning, management and mitigation. Stressors driven by more distant factors such as light pollution generated by urban centers, and increase in regional

transportation volumes affecting sights and sounds, and air quality issues in distant urban centers affecting prescribed burning are more difficult to mitigate. Collectively, this context supports resource planning and management within the preserve, and provides a foundation for collaborative conservation with other landowners in the surrounding area.

The supporting chemical and physical environment at the preserve includes its air quality, water quality and stream hydrology/geomorphology. The condition of these resources can a affect human dimensions of the preserve such as visibility and scenery as well as biological components such as stream biota. Air a quality warranted significant concern, while water quality and stream hydrology/geomorphology warranted moderate concern. Air quality and water quality in Fox Creek are significantly impacted by land uses outside the preserve boundary. Water quality in most streams evaluated have all or most of their watersheds within the preserve boundary. Both stream geomorphology and water quality appear to be significantly impacted by cattle grazing. Although trampling from cattle grazing appears to have a significant negative impact on the streams within the preserve, it is difficult to attribute stream bank and incision problems to current grazing management vs. historic overgrazing as recent as 2005.

The floral biological components examined included prairie vegetation and invasive exotic plants. The preserve is an excellent example of tallgrass prairie and one of the largest protected parcels in the historic range of the community. In some areas, enhanced management of prescribed fire and cattle grazing (especially since grazing rights were acquired), bison introduction, and prairie restoration projects in the Fox Creek bottomlands are likely increasing the heterogeneity of vegetation and overall habitat quality. However, challenges related to invasive plant management and fire regime contribute to moderate ratings and some declining trends.

The faunal biological components examined included aquatic macroinvertebrates, birds, bison, butterflies, fish, greater prairie-chicken, herptiles and the Topeka shiner. Half of the resources examined were found to be in good condition with an unchanging trend or no trend. Of the remaining four resources that warranted moderate concern, three are aquatic fauna that are being impacted by poor water quality, altered stream flows/hydrology and introduced warm-water species of fish. The bison reintroduction effort has been extremely successful. Although the herd is limited to occupying no more than 10% of the preserve, managers are hoping to use bison to achieve ecological restoration objectives as well as objectives related to bison herd health and genetics, herd size and demographics, and visitor experience.

The identification of data gaps during the course of the assessment is an important outcome of the NRCA. In some cases significant data gaps contributed to low confidence in the condition or trend assigned to a resource. Primary data gaps and uncertainties encountered were lack of recent survey data; uncertainties regarding reference conditions; availability of consistent, long-term data; and incomplete understanding of the ecology of rare resources. Findings from the NRCA will help preserve managers to develop near-term management priorities, engage in watershed or landscape-scale collaboration and education efforts, conduct preserve planning, and report program performance.

Ecosystem stressors impacting preserve resources and their management exist both inside and outside preserve boundaries. Altered disturbance regimes such as fire and flooding, conversion and fragmentation of natural habitats, spread of invasive exotic plants and animal species that threaten regional biological diversity, altered hydrology and channel degradation of streams, and water pollution appear to be significant stressors of biological resources. Other resources related to human dimensions and visitation appeared to be stressed or directly affected by changes in land uses and land cover, population and housing densities, and traffic. Climate change is estimated to contribute to the vulnerability of the Topeka shiner at the preserve. Many of the resources were found to have interrelated stressors, the most common being invasive plants and increased development and damage to streams and water quality by agricultural practices and grazing.

Regional and preserve-specific mitigation and adaptation strategies are needed to maintain or improve the condition of some resources over time. Success will require acknowledging a "dynamic change context" that manages widespread and volatile problems while confronting uncertainties, managing natural and cultural resources simultaneously and interdependently, developing broad disciplinary and interdisciplinary knowledge, and establishing connectivity across broad landscapes beyond preserve borders.

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 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*

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.

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

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[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-up 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.

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; 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.

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*

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 an 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.

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 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.

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)

Over the next several years, the NPS plans to fund an NRCA project for each of the approximately 270 parks served by the NPS I&M Program. For more information visit the NRCA Program website.

[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.

Chapter 2. Introduction and Resource Setting

2.1. Introduction

2.1.1. Enabling Legislation/Presidential Proclamation

Public Law 104-333 (110 Stat 4204) created Tallgrass Prairie National Preserve (TAPR) on November 12, 1996. The primary legislative intents of the preserve are 1) "to preserve, protect, and interpret for the public an example of a tallgrass prairie ecosystem on the Spring Hill Ranch, located in the Flint Hills of Kansas"; and 2) "to preserve and interpret for the public the historic and cultural values represented on the Spring Hill Ranch" (NPS 2008). Under the preserve legislation, the NPS cannot acquire more than a total 180 acres of the preserve. The preserve is a public/private partnership between The Nature Conservancy (TNC) and the National Park Service (NPS).

2.1.2. Preserve History[1]

The property that would become the preserve has a rich history. Human activity in the Kansas Flint Hills can be traced back about 10,000 years. Native American life was predominantly horticultural, with the development of settled villages by A.D. 1000. By A.D. 1500–1825, the introduction of the horse led to increases in bison hunting. In the area of the preserve, this period has clear association with specific American Indian peoples including the Wichita, Kansa, Osage, and Pawnee. Starting in 1825, a number of treaties were signed that surrendered traditional lands to the U.S. Government. Subsequent treaties, pressures from squatters and homesteaders, western expansion, disease, decimation of the bison, and increasing agriculture and grazing by livestock was in full force by the late 1870s, by which time nearly all of the original inhabitants of eastern Kansas were moved to the Indian Territory of Oklahoma.

After 1873, millions of acres of newly opened public land were granted or sold to railroad companies to encourage commercial traffic and development. The railroads in turn sold excess land to raise capital to build new rail lines. The 1880s saw the boom of the cattle industry in the Flint Hills, a development integrally related to the availability of the railroad service. In some cases, small holdings were purchased and consolidated into large ranches. Much of the preserve and the historic ranch structures occupy lands that were part of the 7,000-acre Spring Hill Ranch and Stock Farm developed by Stephen Jones between 1878 and 1886. The ranch represented the transition from open-range ranching to the more specialized cattle industry which developed on enclosed ranches during the cattle industry's mature stage. The ranch and surrounding lands changed hands several times during the 20th century.

The preserve property was purchased by the National Parks Trust (NPT) in 1994; oil and gas development rights were retained in trust for 35 years. There had been gas production involving 25 wells that are currently inactive. In addition, a number of rights-of-way exist in the preserve. In March 1995, the NPT and Edward Bass signed a 35-year grazing lease. The lease involved approximately 10,000 acres or over 91% of the preserve, stipulating annual burns and the use of an

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1 Adapted from NPS (2008)

early intensive stocking regime on most of the area. The lease allowed for a termination of all or part of the lease through a buy-back provision (NPS 2008). The property was owned by the NPT when the preserve was created in 1996. Grazing rights to the 775-acre bottomland area were purchased from the lease in 2001. In September 2002, thirty-two acres were donated to the NPS by the National Park Trust. This area includes the Spring Hill Ranch house, barn, outbuildings, and Lower Fox Creek School. In April 2005 TNC became the primary land owner, bought back the grazing lease, and subsequently acquired mineral rights on the property in 2009. Heavy grazing by the lessee took place during the several years prior to the buyback, and the preserve is considered to still be recovering (personal comment Mike DeBacker, December 2012).

Together the NPS and TNC work to preserve the tallgrass prairie, while sharing in the story of ranching legacy, Native American history, and the diverse tallgrass prairie ecosystem. In addition to the prominent buildings, structures, and landscapes related to the ranching history of the property, a number of less prominent archaeological features have been identified on the property and the potential for more is high. The entire preserve was listed as a National Historic Landmark (NHL) in 1997 for its association with the cattlemen's empire of the late 19th century and with the transition from the open range to the enclosed holdings of the large cattle companies in the 1880s (NPS 2008).

2.1.3. Geographic Setting

Tallgrass Prairie National Preserve is located in northern Chase County, Kansas, a rural county with 2,790 residents (USCB 2010). Chase County sits approximately 80 miles from both Wichita, the most populous city in Kansas (382,368, USCB 2010), and Topeka, Kansas's fourth most populous city (127,473, USCB 2010). Strong City, population 485 (USCB 2010), borders the preserve on the southern side; further south is Cottonwood Falls (population 903; USCB 2010), the Chase County seat.

Tallgrass Prairie National Preserve contains approximately 10,900 acres of remnant tallgrass prairie, an ecosystem that once covered over 400,000 square miles (256 million acres) of the American Midwest. The preserve sits wholly within the high area of eastern Kansas known as the Flint Hills, a strip of the landscape extending from near the Nebraska border and running north-south to the Oklahoma border. This region of gently rolling landscape escaped the plow because the underlying geology is rocky and ill-suited for cultivation.

2.1.4. Preserve Significance

The preserve's *General Management Plan* (NPS 2000) describes the significance of the preserve:

- Of the 400,000 square miles (1,036,279 square km) of tallgrass prairie ecosystem that once covered North America, less than four percent remains; Tallgrass Prairie National Preserve represents a portion of this remnant.
- The landscape of the Tallgrass Prairie National Preserve contains a unique collection of natural and cultural features that tells the story of human interaction with the prairie environment, from pre-contact times to the present.
- The Spring Hill Ranch is an outstanding representation of the transition from the open range to the enclosed holdings of the large cattle companies of the 1880s.

- The Spring Hill Ranch Headquarters area contains outstanding examples of Second Empire and other 19th century architectural styles.
- Tallgrass Prairie National Preserve offers opportunities for extraordinary and inspirational scenic views of the Flint Hills prairie landscape.

The purpose of Tallgrass Prairie National Preserve (NPS 2000) is:

- To preserve, protect, and interpret for the public, an example of a tallgrass prairie ecosystem;
- To preserve and protect the cultural resources found within the preserve; and
- To interpret for the public, the cultural resources and the social and cultural values represented within the preserve.

2.1.5. Visitation Statistics

Preserve visitors are a mixture of recreation and non-recreation travelers and local residents. Annual preserve recreation visitation has remained more or less stable since the preserve was created (Figure 2.1-1). Mean annual visitation for the five-year period ending 2012 was 20,529 recreation visitors. Monthly visitation is highest from May to October (Figure 2.1-2 and 2.1-3). Winter and spring visitation are higher during warmer years (NPS 2013).

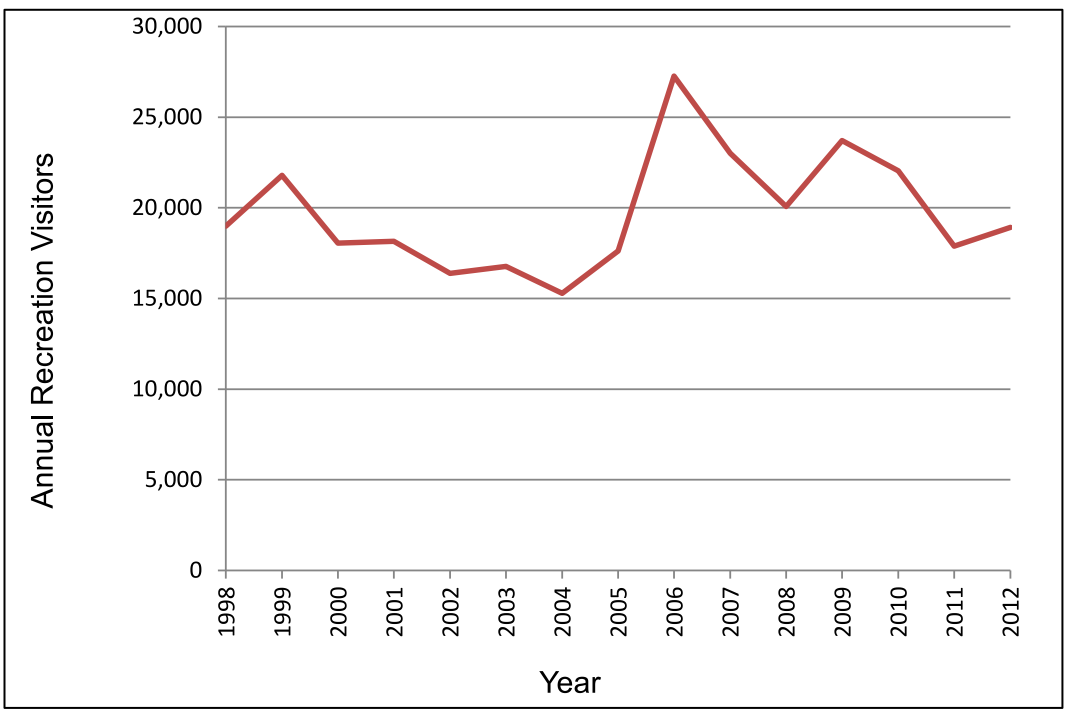


Figure 2.1-1. Annual TAPR recreation visitation for 1998–2012 (NPS 2013).

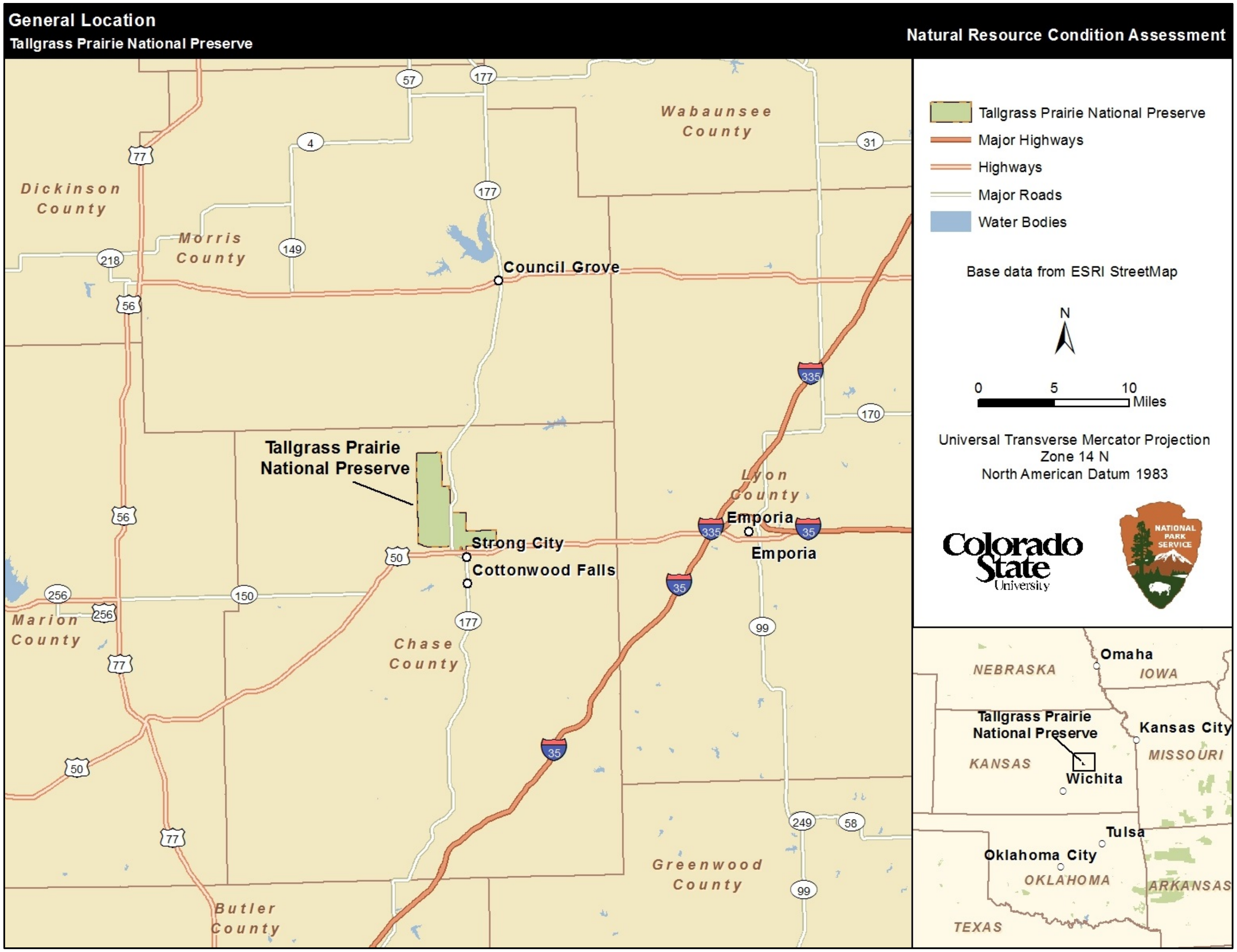


Figure 2.1-2. General location of Tallgrass Prairie National Preserve.

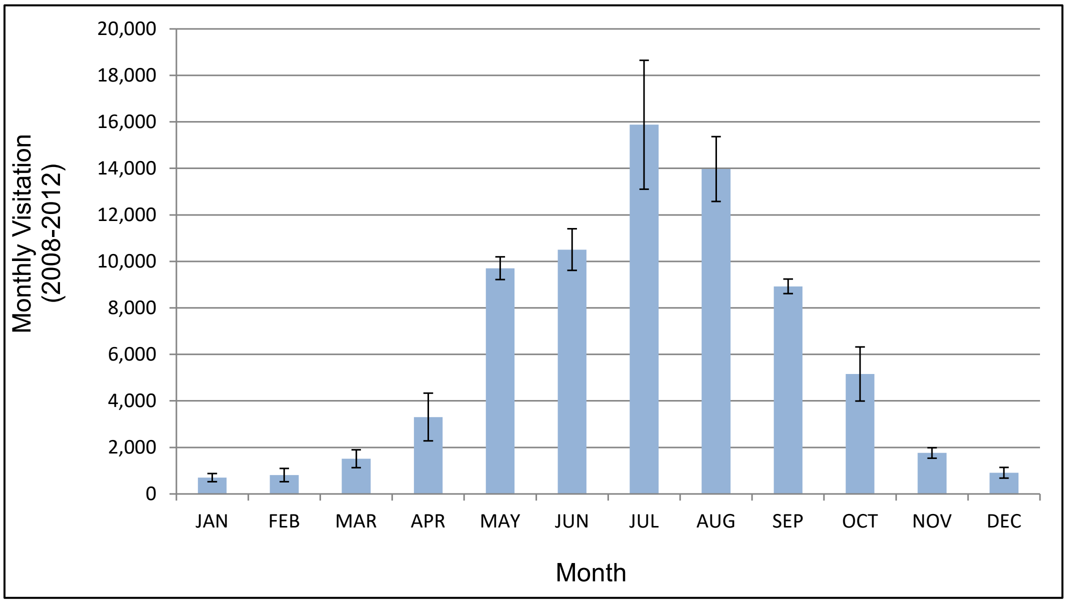


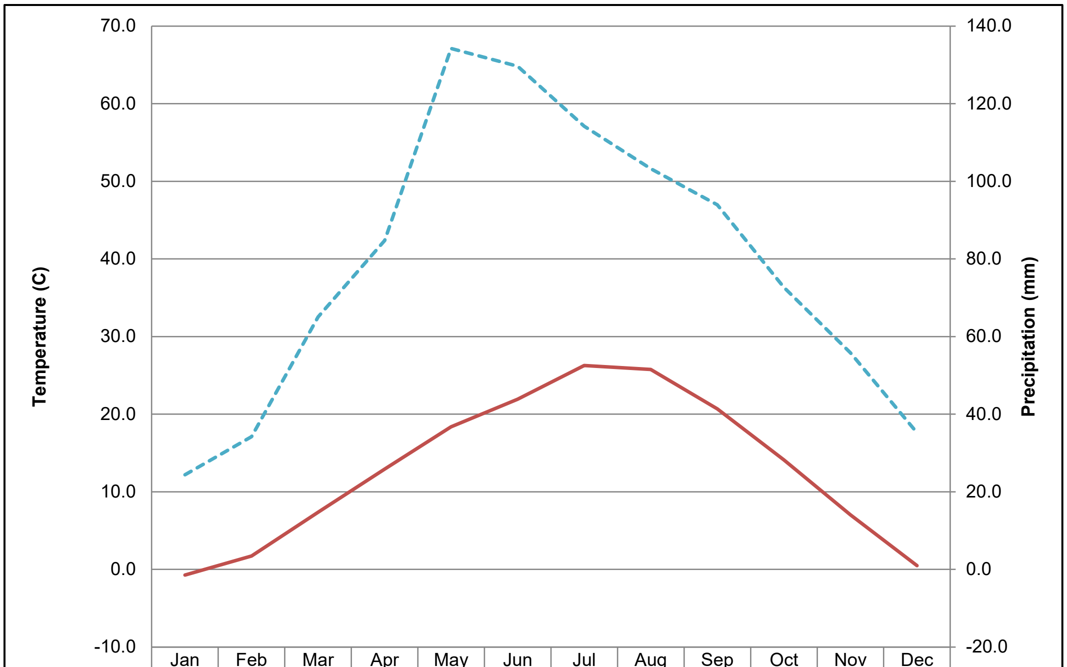
Figure 2.1-3. Mean monthly recreation visitation for TAPR for 2008–2012 (NPS 2013). Error bars represent 90% confidence intervals.

Visitors can explore TAPR via numerous nature and hiking trails and a preserve bus tour. No horseback riding, motorized or bicycle access are permitted. Bus tours, generally conducted from April through October, are scheduled up to several times per day (depending on demand) and go from the Visitor Center to the Scenic Overlook in Big Pasture via a 3.5-mile gravel road. The tour route passes through Windmill Pasture where the bison herd resides. The dirt roads on TAPR are only used for administrative/management purposes and by the tour bus for public tours. Over 40 miles of trails originating from the Visitor Center and four additional trailheads provide access to most areas of the preserve. Most visitors come to the Visitor Center and take self-guided tours of the historic Spring Hill Ranch complex. The Southwind Nature Trail is a popular 1.75-mile trail that leaves from the Ranch area and provides a scenic overlook to the northwest. Another popular trail is the Bottomland Nature Trail in the lower Fox Creek valley. Most visitors do not hike more than a mile or so from the trailheads. The trails offer exceptional solitude, exposure to prairie and riparian ecosystems and expansive prairie landscape views for hikers who venture further into the preserve.

2.1.6. Natural Resources Overview

<u>Climate</u>

The climate at TAPR is characterized by warm, moist summers and cold, dry winters (Figure 2.1-4). The average annual temperature at TAPR is 13.2° Celsius (C) (55.7° Fahrenheit (F)). The coldest month is typically January with an average of -1.3° C (30.7° F), a max of 5.3°C (41.5° F), and a min of -5.7° C (21.7° F). The warmest month is typically July with an average of 26.3° C (79.3° F), a max of 30.2° C (86.4° F), and a min of 23.2° C (73.8° F) (NCDC 2013). Growing season length is roughly 203 days with a last spring freeze around April 11–20 and a first fall freeze around October 11–20 (NOAA 2013). Additional information about climate, historic variability and climate change are presented in chapter 4.



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Temp	-0.7	1.7	7.4	12.9	18.4	21.9	26.3	25.8	20.7	14.1	7.0	0.5
Precip	24.4	34.2	65.0	84.7	134.2	129.7	114.2	103.2	94.0	72.7	55.8	35.2

Figure 2.1-4. Walter climate diagram of Tallgrass Prairie National Preserve 30-year temperature and precipitation averages (1982–2011) (data from NCDC 2013).

Geology and Soils

Tallgrass Prairie sits within the Flint Hills physiographic province, an elevated rolling landscape in eastern Kansas. The geology is comprised of erosion-resistant limestone, as well as softer shales and sandstone, and made up of over 40 separate geological formations (NPS 2000). The uneven erosion of this region has resulted in higher elevations. The Flint Hills are named for the nodules of chert (flint) laid down with the limestone and shales by the prehistoric seas that once covered the area. This chert, highly prized by Native Americans for its hardness and suitability for making tools, made the land unsuitable for cultivation, unlike many other regions of tallgrass prairie.

The soils of the preserve range from the thin coverings on the hilltops and hill flanks to the deeper areas located in stream valleys (NPS 2000). Soils are derived from the underlying limestone, sandstone, and shale, and are well-drained. A portion of the soils found in the stream bottom lands have been classified as “prime and unique farmlands,” which are defined as soils particularly suited for growing general or specialty crops. Three soil units within the preserve—Redding, Chase, and Ivan—are considered prime farmlands.

Hydrology

Tallgrass Prairie National Preserve contains a myriad of aquatic habitats, reflecting a complex hydrology. Two streams, Palmer Creek and Fox Creek, run through the preserve, with Palmer Creek running west-to-east in the northern part of the preserve and ultimately draining into Fox Creek. Fox Creek runs north-south and later connects with the Cottonwood River. Both Palmer Creek and Fox

Creek are monitored streams (CPCB 2003) and, as such, have been the subjects of previous and ongoing study to characterize and quantify the condition of these aquatic resources.

In addition to the two streams, TAPR is dotted with intermittent streams, seeps, wetlands, and even stock ponds, all of which contribute to the diverse hydrological character. Wetlands, for instance, are often found in the floodplains of Palmer and Fox creeks. These important hydrological features are complemented by seeps, springs, and 26 ponds constructed for stock use that dot the landscape (NPS 2000). Seeps and springs contribute to base flow of the larger streams, and the stock ponds serve as retention ponds during storms. The federally-endangered Topeka shiner (*Notropis topeka*) has been identified in TAPR, specifically in an unnamed tributary downstream from one of the retention dams used to create the stock ponds (NPS 2000).

Air Quality

Tallgrass Prairie National Preserve is designated as a Class II airshed and held to any and all applicable standards (NPS 2000). For the first few years after preserve establishment and during the development of the General Management Plan, air quality was not directly monitored in TAPR. At the time, however, air quality was generally presumed to be good (NPS 2000). Indicators of air quality, including ozone, visibility, particulate matter, and wet and dry deposition are now considered Vital Signs of park health and condition by the Heartland Inventory and Monitoring Network.

Land Use

The tallgrass prairie preserved and interpreted at TAPR once extended over hundreds of thousands of square miles and was maintained by local and regional processes. Many anthropogenic changes affecting the physical environment, prairie flora, fauna, and natural processes have occurred since settlement of the area by European emigrants. The majority of the region surrounding TAPR is managed for agricultural purposes. Deeper bottomlands soils tend to be cultivated or used for hay or pasture, while the "Flint Hill" uplands that have generally shallow soils are predominantly used for grazing livestock. Development is happening, albeit relatively slowly in this area, along major roads and in medium to larger cities, accompanied by increased traffic, noise and light pollution. The land around the preserve still has a rural character, with low human population densities and wide open spaces. As this region changes over time, the alterations to the larger landscape may further impact the ecological character and resources of the preserve.

Wildlife

The prairies of Kansas once supported a diverse wildlife fauna, but cultivation, livestock grazing and hunting have significantly altered the diversity and abundance of native fauna. Nonetheless, the preserve is an important refuge for wildlife species. A 1999 baseline survey for birds in the preserve found 132 species of birds and 15 grassland-associated species (NPS 2000). State-listed bird species include the short-eared owl (*Asio flammeus*), Henslow's sparrow (*Ammodramus henslowii*), and bobolink (*Dolichonyx oryzivorus*). The Heartland Network actively monitors breeding birds, considered a Vital Sign for parks in this network.

Large mammals like mule deer and white-tailed deer are known in the preserve and bison have been reintroduced; wild populations of other iconic species once found in this region, like grizzly and black bear, pronghorn antelope, mountain lion and elk, have long been extirpated (NPS 2000).

The diverse habitats in TAPR support both reptile and amphibian species. Initial surveys documented twenty-one species of amphibians and reptiles in the preserve (NPS 2000). These surveys were preliminary, though, and more rigorous inventories have not been conducted by the Inventory and Monitoring program.

The preserve contains the Topeka shiner (*Notropis topeka*), an endangered species protected by the Endangered Species Act (ESA), the state-listed Spotted sucker (*Minytrema melanops*), as well as the cardinal shiner (*Luxilis cardinalis*), a state Species in Need of Conservation (SINC, NPS 2000). The cardinal shiner population in the preserve is part of a relict population in the Cottonwood River drainage (KDWPT 2013).

<u>Vegetation</u>
The earliest botanical surveys of the region now protected as TAPR indicate that this region was nearly all prairie with only small areas of timber (NPS 2000). The tallgrass prairie is comprised of and dominated by the *Andropogon gerdardii* (big bluestem) – *Sorgashastrum nutans* (Indian grass) – *Schizachyrium scoparium* (little bluestem) Flint Hills herbaceous association. By 1999, over 400 species of vascular plants had been identified in the preserve (NPS 2000); recent inventories have documented over 500 plant species (NPS 2013b). Fire is a critical element in this ecosystem; the prairie habitat undergoes prescribed burning every spring (NPS 2000). Another important habitat is the lowland floodplain forests associated with Fox Creek. This habitat, considered the rarest in the state because of its historical conversion to agricultural and grazing lands, has been cultivated with smooth brome (*Bromus inermis*) and harvested for hay within the preserve. This area is targeted for restoration back to bottomland prairie and floodplain forest and prairie restoration has been initiated (NPS 2006a). In addition to maintaining and restoring tallgrass prairie, management efforts at the preserve target exotic invasive plant species. Caucasian bluestem (*Andropogon bladii*) and Sericea lespedeza (*Lespedeza cuneata*) have been found within the preserve.

2.2. Resource Stewardship

2.2.1. Management Directives and Planning Guidance

Each unit in the National Park System is required by the National Park Service Organic Act of 1916 to "conserve the scenery and natural and historic objects and the wildlife therein and to provide for the enjoyment of the same in such a manner and by such means as will leave them unimpaired for the enjoyment of future generations." The General Authorities Act in 1970 (as amended) reiterated the provisions of the Organic Act and emphasized that "these areas, though distinct in character, are united through their inter-related purposes and resources into one national park system as cumulative expressions of a single national heritage." It also re-emphasized the importance of "unimpaired" NPS resources for future generations. The enabling legislation establishes park purposes and legislatively authorized uses within a context of cultural and natural resources. The National Park Service Management Policies (NPS 2006a) provides Service-wide guidance for Park System planning, land protection, natural and cultural resources management, wilderness preservation and management, interpretation and education, use of the parks, park facilities and commercial visitor services. All management and planning documents developed for the preserve must adhere to these overarching documents and other laws, Executive Orders and Director's Orders.

In addition to these NPS-level documents, a number of important documents guide the management of natural resources in the preserve. The *General Management Plan* (GMP) (NPS 2000) articulates a management philosophy and provides broad direction and vision for future management decisions at the preserve, based on the preserve's enabling legislation. According to the preserve's GMP, the current implemented management alternative focuses on the integrated management of the natural and cultural resources of the preserve, which reflects the historic Flint Hills ranching context of the late 1800s. The management of the natural resources at the preserve focuses on the ecological, educational, and inspirational values of the tallgrass prairie, and understanding and facilitating important natural prairie processes that permit the prairie to fully express itself. Other important resource management guidance at the preserve includes the *Resource Management Plan* (NPS 1999), *Fire Management Plan* (Mancuso 2009), *Cultural Landscape Report* (Bahr Vermeer & Haecker, Architects 2004), *Bison Management Plan* (NPS 2009), and the *Tallgrass Prairie Bottomland Restoration Plan* (NPS 2006b).

Management Zones

Management zones were developed to facilitate planning and management of different areas and resources within the preserve. The following management zones are described in the *General Management Plan* (NPS 2000).

Visitor Information and Orientation Area

Primary visitor information and orientation is provided by the Visitor Center on KS-177, which serves as a primary staging area for bus tours and for basic education and interpretation efforts. The area includes visitor and administrative facilities such as offices, museum collections and archives storage, a maintenance area, the book store and parking areas. This area receives the greatest concentration of visitor use, and is adjacent to the Spring Hill Ranch complex and the bison pasture.

Flint Hills Ranching Legacy Area

The extent of the area is framed by the landscape as it is viewed from primary points such as the ranch house, the barn, and the area between the historic ranch headquarters area and the Lower Fox Creek School. Within this management area, existing stone and wire fences and topography are used as the physical boundaries for implementation of management actions. This management area is the primary focal point for interpreting the story of ranching in the Flint Hills region. The cultural resources are the primary resource of concern here; their protection is emphasized and sustainable range management practices are employed. Visitation to this area is particularly heavy in the ranch headquarters complex and the schoolhouse.

Day-Use Area

This area includes the lands east of the Fox Creek bottomland and the agricultural areas adjacent to the east/west county road. This area offers day-use opportunities for visitors to experience and learn about the tallgrass prairie, ranching history, and American Indian cultures through a variety of visitor activities. The focus of the area would be on providing opportunities for visitors to experience the preserve and explore its resources. Visitation in this area is relatively low.

Prairie Landscape Area

This area emphasizes the management of tallgrass prairie using prescribed fire and grazing by cattle and bison, while providing a variety of opportunities for the visitor to experience the prairie and prairie landscape. Opportunities for the visitor to experience quiet and solitude, extensive views, the relationship of earth and sky, wildlife, the multitude of flowering and other native plants, and the effects of various regimes of fire and grazing animals is the focus. Bison are an important element not only for their historic role within the tallgrass prairie ecosystem but also in meeting visitor expectations and thoughts about the prairie. Access and opportunities in this area require a greater commitment of time and energy, either by foot or on a preserve bus tour.

2.2.2. Overview of Resource Management Concerns

Regional Great Plains ecosystem stressors that can impact preserve resources and their management include altered disturbance regimes such as fire and flooding, conversion and fragmentation of natural habitats, spread of invasive exotic plants and animal species that threaten regional biological diversity, loss of native pollinators, altered hydrology and channel degradation of streams, sedimentation and pollution of streams (Schneider et al. 2011). Preserve management concerns highlighted in the *General Management Plan* (NPS 2000) and by preserve staff during the scoping process consist of natural resource issues as well as stressors from outside the preserve. Primary resource management concerns are briefly described below.

<u>Invasive Nonnative Plants</u>

Nonnative invasive plants have been introduced and have spread throughout the region via agriculture and other human disturbances and practices. Invasive exotic plants are of concern at TAPR because of their potentially detrimental effects on the native and restored tallgrass prairie communities. Fortunately, upland prairies have very little invasion by invasive nonnatives, but encroachment by woody species such as honeylocust (*Gleditsia triacanthos*), Osage orange (*Maclura pomifera*), buckbrush (*Symphoricarpos orbiculatus*), dogwoods (*Cornus* spp.) false indigo (*Amorpha fruticosa*) is an ongoing process that is managed using prescribed fire. Some of the primary target species include Sericea lespedeza (*Lespedeza cuneata*), Johnsongrass (*Sorghum halapense*), smooth brome (*Bromus inermis*), and musk thistle (*Carduus nutans*). An aggressive program to monitor and control invasive exotic plants is in place at TAPR.

<u>Threatened and Endangered Species</u>

The federally endangered Topeka shiner (*Notropis topeka*) is the only federally threatened or endangered species at TAPR. Topeka shiner conservation is challenging due to the notable alterations within the watersheds where it occurs. Alterations include spring development, streambank instability and turbidity from grazing and historic stock ponds that alter stream hydrology and favor predatory warm water fish species.

Prairie Quality and Natural Processes

The primary tools used to manage the prairie are active restoration (especially in the Fox Creek bottoms), weed management, prescribed fire and managed grazing. Fire is especially effective in controlling woody plant encroachment within the prairie. At community, pasture and preserve scales, managers are very interested in maximizing structural heterogeneity of vegetation to favor a diversity of plants and animals. Activities and plans strike a balance between activities that favor ecological conservation, satisfy administrative or compliance issues (e.g., smoke and smog problems from Flint Hills in distant urban centers), help maintain relationships and partnerships with nearby landowners (e.g., managing objections from ranchers regarding non-traditional burn practices), and directly support the preserve's historic mission.

Other Impacts of Land Uses on Visitor/Cultural Experience

The sights, sounds and landscape associated with the preserve environs have changed over time as human population has increased and uses of the area have become more intensive. Land-use changes and development outside the preserve impact the experience of visitors with regard to altered scenery, undesirable noise, light pollution and solitude. Moreover, important elements of the landscape including some native fauna are missing.

Water Quality and Altered Hydrologic Regime

Some streams are highly degraded due to upstream alterations including little buffering of riparian corridors, farming, nonpoint agricultural pollution, and pollution from livestock grazing. Both Palmer and Fox creeks are considered "impaired" streams by the EPA. Historic ponds within the preserve have also altered stream flows and watershed hydrology. Water quality and stream environments present significant management challenges with regard to aquatic biota and the endangered Topeka shiner.

2.2.3. Status of Supporting Science

Available data and reports varied significantly depending upon the resource topic. Much of the supporting baseline survey and monitoring data was collected through the ongoing Heartland Network of the Inventory and Monitoring (I&M) Program initiated in the early 2000s. The heartland Network also supported requests for geospatial data. Landscape context information and aspects of human dimensions were greatly supported by national program staff such as the Natural Sounds and Night Skies Division (NSNSD), the national NPS Air Quality program, and the NPScape Project within the Inventory and Monitoring Program. Additional information and data were provided by the preserve, published and unpublished reports and articles, and other outside experts noted in the individual resource sections.

2.3. Literature Cited

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Chapter 3. Study Scoping and Design

3.1. Preliminary Scoping

The initial phase of the study consisted of a series of meetings, conversations and collaborations between Colorado State University and NPS staff, including the Midwest Regional NPS Office, the Heartland I&M Network, preserve staff, Water Resources Division (NRCA proponent), and National I&M programs. Initial scoping consisted of reviewing the Heartland Inventory and Monitoring Network and Prairie Cluster Prototype Monitoring Program Vital Signs Monitoring Plan (DeBacker et al. 2005) in order to begin to understand the management and resource context for the preserve. Vital signs previously identified and prioritized for the preserve were the basis for a preliminary list of focal resources to support initial NRCA discussions with preserve and other NPS staff. A site visit and initial meetings took place September 17–19, 2012 at TAPR Headquarters. The purpose of the preliminary scoping meetings was to:

- Establish contact and begin dialogue with key staff members;
- Identify points of contact;
- Provide an overview of NRCA purpose and process (for preserve staff);
- Provide an overview of preserve context, administrative history and management concerns (for cooperators);
- Discuss analysis framework, reporting scales/units, and rating system;
- Identify and discuss priority/focal resources in support of framework development –
- Traditional natural resources (e.g., bison, water quality, rare plant),
- Ecological processes or patterns (e.g., fire regime),
- Specific natural or cultural/ethnographic features inextricably linked to natural resources, or
- Values linked to biophysical resources and landscape context (e.g., dark night skies, soundscape, viewscape);
- Discuss key NRCA concepts including indicators and measures, threats and stressors, and reference conditions;
- Identify and gather available data and information;
- Identify sources of expertise inside and outside the NPS;
- Define project expectations, constraints, and the need to balance depth vs. breadth; and
- Review the assessment timeline.

Key constraints placed on the scope of NRCA development included the following:

- The assessment will provide a snapshot of a subset of preserve resources, as determined through the scoping process;
- Some lower priority resources or those having little supporting data may not be fully examined to allow a more comprehensive analysis of higher-priority resources;

- The assessment will use existing information/data and not modeled or projected data, although limited analysis and data development may be undertaken where feasible (e.g., data to support views/scenery analysis) —future modeled data is only used in the climate change section; and
- Assignment of condition ratings may be constrained by insufficient information or inadequately defined reference conditions.

3.2. Study Design

3.2.1. Indicator Framework, Focal Resources and Indicators

The NRCA uses a framework adapted from The Heinz Center (2008) to examine condition and trends in key natural resources at the preserve (Table 3.2-1). The Heinz structure was identified in the NRCA guidance documents as a relevant framework that organizes indicators under each focal resource within broad groupings of ecosystem attributes related to: landscape context including system and human dimensions; chemical and physical components; biological components; and agents of change. Although threats and stressors are described for each focal resource, the Land Cover and Land Use, Fire Regime and Climate Change sections were added to address broad ecosystem-level processes and stressors affecting multiple resources. A small subset of the resources identified as important to the preserve and desirable to include in the NRCA during the scoping phase were either not included as focal resources or were addressed in a brief fashion due to lack of information or data, poor understanding of their ecological role and significance in the landscape, their absence at the preserve, or lack of justification to include them as a focal resource. The latter case for eliminating resources considered to have a lower priority for inclusion also reflected realities related to balancing cooperator budget, breadth of the assessment across many resources and depth of analysis. A total of 19 resources were examined and included here: six addressing system and human dimensions, three addressing chemical and physical attributes, and ten addressing biological attributes.

Table 3.2-1. Tallgrass Prairie National Preserve natural resource condition assessment framework.

Ecosystem Attributes	Focal Resources	Indicators and Measures of Condition
Landscape Context – System and Human Dimensions	Land Cover and Land Use	Land cover/land use Population and housing Conservation/protection status
	Night Sky	Anthropogenic light Anthropogenic light ratio (ALR)
	Soundscape	Ambient noise levels Anthropogenic sources of noise Traffic volumes on nearby and preserve roads
	Views and Scenery	Integrity of landscape views from key view points Housing densities surrounding the preserve Air quality-visibility
	Climate Change	Modeled temperature and precipitation vs. historic baseline Aridity – Palmer index (historic) and moisture deficit (modeled) Plant phenology
	Fire Disturbance Regime	Fire frequency (return interval) Seasonality Severity
Chemical and Physical	Air Quality	Level of ozone Atmospheric wet deposition of total N and total S Visibility haze index
	Stream Hydrology and Geomorphology	Proper functioning condition (PFC) rating Channel evolution model (CEM) stage
	Water Quality	Total dissolved solids Chloride Sulfate Dissolved oxygen Coliform bacteria Temperature
Biological – Plants	Prairie vegetation	Extent of vegetation community types Plant richness and diversity Vegetation structure and woody encroachment Invasive plant abundance/index
	Invasive exotic plants	Frequency Abundance and distribution Presence and abundance of state noxious plants
Biological – Animals	Aquatic macroinvertebrates	Richness and diversity metrics Hilsenhoff Biotic Index
	Birds	Native species richness (S) Bird index of biotic integrity (IBI) Occurrence and status of bird species of conservation concern

Table 3.2-1 (continued). Tallgrass Prairie National Preserve natural resource condition assessment framework.

Ecosystem Attributes	Focal Resources	Indicators and Measures of Condition
Biological – Animals (continued)	Bison	Ecosystem stewardship and process indicators Herd health and genetics Population size and demographics Visitor access to bison
	Butterflies	Native species richness Native species diversity Native species evenness Occurrence and status of butterfly species of conservation concern
	Fish Community	Native species richness Fish index of biotic integrity (IBI)
	Greater prairie chicken	Abundance and lek measures Breeding success Population estimates Climate Change Vulnerability
	Herptiles (limited)	Proportion of the expected species present
	Topeka shiner – at-risk biota	Topeka shiner abundance Relative abundance of predators Vulnerability to climate change

3.2.2. Reporting Areas

The reporting area for all resources is generally the entire area within the preserve boundary. In some cases indicators were analyzed using subsets based on geographic or ecological strata within the preserve, e.g., grassland birds and woodland birds. The results for those subsets were then combined into single preserve-wide condition and trend ratings for the resource. For several resources such as those capturing landscape context (e.g., land cover and land use, dark night skies, soundscape and viewscape), the extent of the analysis varies by resource, often extends outside preserve boundaries in a fixed or variable way and is in some cases influenced by the locations selected for analysis (e.g., location of key view points for scenery analysis).

3.2.3. General Approach and Methods

General Approach

This study employed a scoping process involving Colorado State University, preserve and NPS staff to discuss the NRCA framework, identify important preserve resources, and gather existing literature and data for each of the focal resources. Indicators and measures to be used for each resource were then identified and evaluated indicators. All available data and information was analyzed and synthesized to provide summaries and address condition, trend and confidence. Condition ratings compared the current condition(s) at the preserve to the reference condition(s) when possible. In some cases, due to interrelationships, a focal resource was used to help determine condition and/or trend for another focal resource. For example, changes in landcover/landuse and impervious surfaces within the watershed are used to support trend determination for stream hydrology.

Sources of Information and Data

Non-spatial data, published literature, unpublished reports and other grey literature related to conditions both inside and outside the preserve were obtained from myriad sources. The primary sources for preserve-specific resource data were preserve staff, Heartland I&M Network staff, and the public access side of the IRMA (Integrated Resource Management Applications) web portal, which is intended as a "one-stop shop" for data and information on preserve-related resources. Preserve and HTLN staff were also invaluable source of knowledge regarding resources, stressors and management history and activities. State and federal agency reports and data were downloaded using the web or obtained from the preserve or other agency staff. Spatial data were provided by the preserve, the Heartland Network, the NPS Midwest Region Office and other sources. GIS data developed to support analyses or maps were documented using NPS metadata standards. The NPS Inventory and Monitoring (I&M) program and Night Skies and Natural Sounds Division (NSNSD) provided valuable data to support the assessment. Primary data sources are described in each focal resource section. In some cases existing data were reworked in order to make them more useful for analysis. In the case of stream geomorphology and views/scenery, we collected data in the field to support those resources due to a lack of existing information and data.

Subject Matter Experts

A number of subject matter experts were consulted while developing this assessment. Expert involvement included in-person and telephone meetings, correspondence, and reviews of preliminary drafts. The experts consulted for each focal resource are listed in the resource sections in Chapter 4.

Data Analyses and NRCA Development

Data analysis and development of technical sections followed NRCA guidance and recommendations provided by the NPS. Data analyses were tailored to individual resources, and methods for individual analyses are described within each section of chapter four. As one of the tenets of the NRCA framework, geospatial analysis and presentation of results is used where possible throughout the assessment. Periodic contact between the authors, preserve and other NPS staff and subject matter experts took place as needed to obtain additional data and information or collaborate on an analysis framework or approach or on the interpretation of results.

Final Assessments

Final drafts followed a process of preliminary draft review and comment by preserve staff and other reviewers. Reviewer comments were incorporate and addressed to improve the analysis within the limits of the NRCA scope, schedule and budget.

Rating Condition, Trend and Confidence

For each focal resource, a reference condition for each indicator is established and a condition rating framework presented. The condition rating framework forms the basis for assigning a current condition to each indicator. In some cases current condition and trend may be based on data or information that is several or more years old. Condition may be based on qualitative, semi-quantitative or quantitative data. Trend is assigned where data exists for at least two time periods separated by an ecologically significant span or may be based on qualitative assessments using historical information, photographs, anecdotal evidence or professional opinion. It is not uncommon for there to be some correlation among indicators for a particular focal resource. In a few cases, the trend assigned to an indicator may be influenced by the data for a correlated indicator. For example, traffic trend data may influence the trend rating for anthropogenic noise levels.

The level of confidence assigned to each indicator assessed integrates the comfort level associated with the condition and/or trend rating assigned. A lower confidence (i.e., higher uncertainty) may be assigned where modeled data has considerable uncertainty or numerous assumptions, where changes may be small and no quantitative data is available, where statistical inference is poor (e.g., as is often the case where sample sizes are inadequate), where interannual or seasonal variability is very high or unknown, where detectability is difficult when monitoring (e.g., some plants and birds), where only several closely spaced data points are available for trend determination (e.g., invasive exotic plant sampling only several years apart and only 2 periods available), or where a very small proportion of the reference frame or population of interest is sampled (in time or space), which influences the representativeness of the sample (e.g., the timing and length of attended listening data for natural sounds analysis). Lack of information/data may result in an unknown condition rating, which is often associated with unknown trend and low confidence. Where vulnerability to climate was examined for the Topeka shiner and greater prairie chicken, climate change condition was not factored into the condition rating.

The climate change indicators were assigned an *insufficient data* status and low level of confidence. However, the estimated vulnerability for a particular resource was used as a trend indicator along with other indicators. We included climate change vulnerability only as an indicator of trend for focal species and communities of interest. Climate change exposure information is crucial contextual information, but is not included in the condition rating for each resource. Including climate change vulnerability in the trend rating raises a flag where vulnerability may be high and leading to deteriorating conditions for the resource.

Symbology and Scoring

This NRCA uses a standardized set of symbols to represent condition status, trend and confidence in the status and trend assessment (Table 3.2-2, Table 3.2-3). This standardized symbology provides some consistency with other NPS initiatives such as State of the Parks and Resource Stewardship Strategies. The overall assessment of the condition for a focal resource may be based on a combination of the status and trend of multiple indicators and specific measures of condition. A set of rules was developed for summarizing the overall status and trend of a particular resource when ratings are assigned for two or more indicators or measures of condition. To determine the combined condition, each red symbol is assigned zero points, each yellow symbol is assigned 50 points, and each green symbol is assigned 100 points. Open (uncolored) circles are omitted from the calculation. Average scores of 0 to 33 warrant significant concern, average scores of 34 to 66 warrant moderate concern and average scores of 67 to 100 indicate the resource is in good condition. In some cases certain indicators may be assigned larger weights than others when combining multiple metrics into a condition score. In those cases the authors provide an explanation for the weights applied.

Table 3.2-2. Standardized condition status, trend and confidence symbology used in this NRCA.

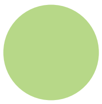
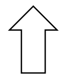
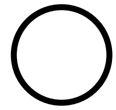
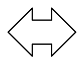
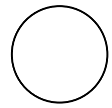
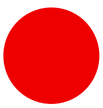
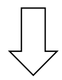
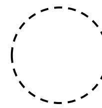
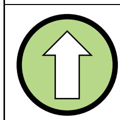
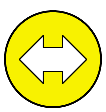
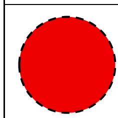
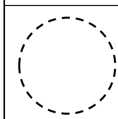
Condition Status		Trend in Condition		Confidence in Assessment	
Condition Icon	**Condition Icon Definition**	**Trend Icon**	**Trend Icon Definition**	**Confidence Icon**	**Confidence Icon Definition**
	Resource is in Good Condition		Condition is Improving		High
	Resource warrants Moderate Concern		Condition is Unchanging		Medium
	Resource warrants Significant Concern		Condition is Deteriorating		Low

Table 3.2-3. Examples of how condition symbols should be interpreted.

Symbol Example	Description of Symbol
	Resource is in good condition; its condition is improving; high confidence in the assessment.
	Condition of resource warrants moderate concern; condition is unchanging; medium confidence in the assessment.
	Condition of resource warrants significant concern; trend in condition is unknown or not applicable; low confidence in the assessment.
	Current condition is unknown or indeterminate due to inadequate data, lack of reference value(s) for comparative purposes, and/or insufficient expert knowledge to reach a more specific condition determination; trend in condition is unknown or not applicable; low confidence in the assessment.

To determine the overall trend, the total number of down arrows is subtracted from the total number of up arrows. If the result is 3 or greater, the overall trend is improving. If the result is -3 or lower, the overall trend is deteriorating. If the result is between 2 and -2, the overall trend is unchanged. Sideways trend arrows and cases where trend is unknown are omitted from this calculation.

Organization of Focal Resource Assessments

Background and Importance

This section provides information regarding the relevance of the resource to the preserve and the broader ecological or geographic context. This section explains the characteristics of the resource to help the reader understand subsequent sections of the document. Relevant stressors of the resource and the indicators/measures selected are listed or discussed.

Data and Methods

This section describes the source and type of data used for evaluating the indicators/measures, data management and analysis (including qualitative) methods used for processing or evaluating the data, and outputs supporting the assessment

Reference Conditions

This section describes the reference conditions applied to each indicator and how the reference conditions are cross walked to a condition status rating for each indicator. NRCAs must use logical and clearly documented forms of reference conditions and values. Reference condition concepts and guidance is briefly described in Chapter 1. A reference condition is "a quantifiable or otherwise objective value or range of values for an indicator or specific measure of condition that is intended to provide context for comparison with the current condition values. The reference condition is intended to represent an acceptable resource condition, with appropriate information and scientific or scholarly consensus" (NPS 2014). An important characteristic of a reference condition is that it may be revisited and refined over time. The nature of the reference condition prescribed for a particular resource can vary with the status of the resource relative to historic conditions and anticipated future conditions (Figure 3.2-1).

For example, substantial overlap may exist for prairie vegetation, moderate overlap may exist for birds and little or no overlap may exist for nonnative invasive plants. Reference conditions can be particularly difficult to define where presettlement conditions or range of variability are unknown, and/or where little inventory and monitoring data exist.

Condition and Trend

This section provides a summary of the condition for each indicator/measure based on available literature, data, and expert opinions. A condition status, trend and confidence designation for each indicator/measure is assigned and accompanying rationale is provided. Where multiple indicators or metrics are used, a single rating is consolidated for each resource using the condition rating scoring framework described earlier in this chapter.

Uncertainty and Data Gaps

This section briefly highlights information and data gaps and uncertainties related to assessment of the resource. Low confidence can be associated with a combination of data that is not current, insufficient data, unrepresentative data, poorly documented data, or data having poor precision and/or accuracy.

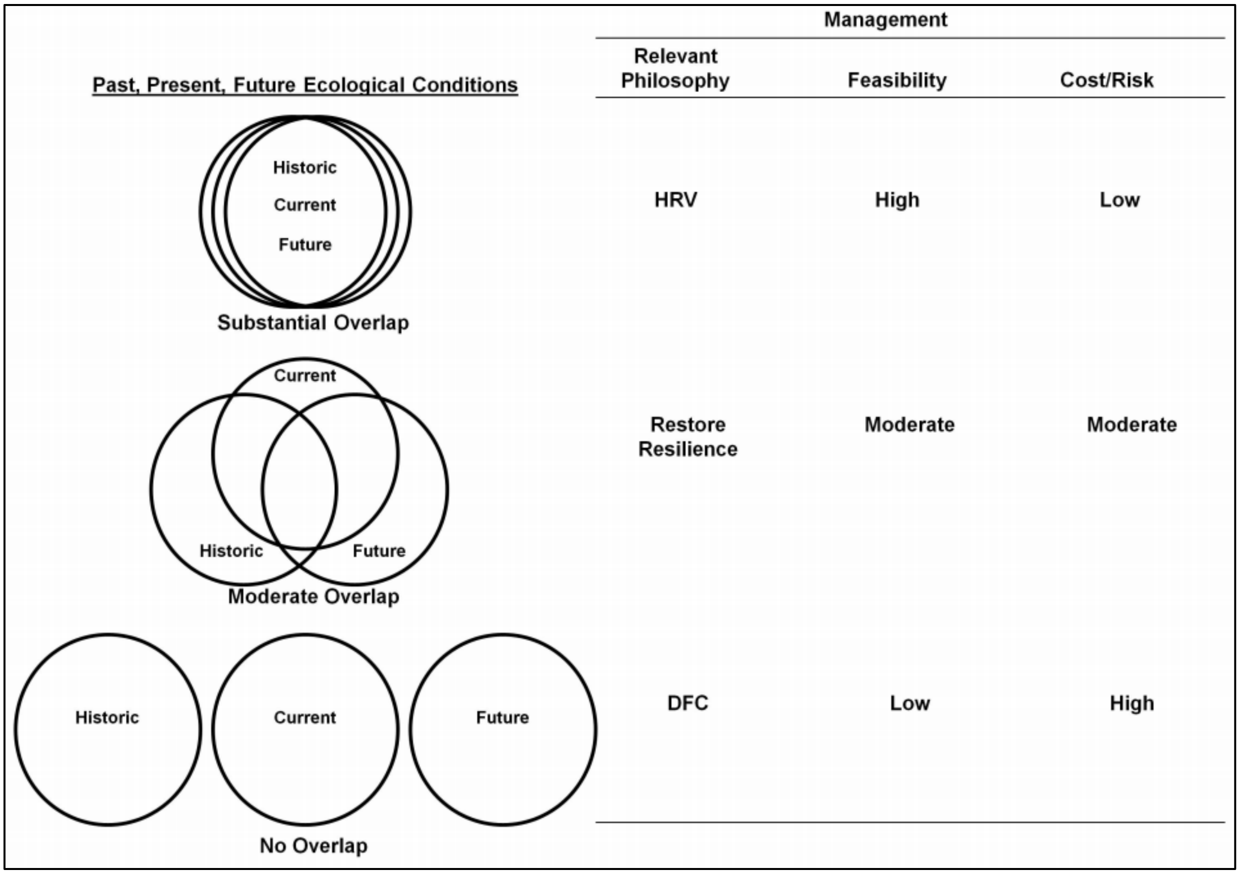


Figure 3.2-1. Illustration of three possible cases of the extent to which current ecosystem conditions in a place differ from historic conditions and from projected future conditions. Circles denote the range of variability for each time period. Also shown are the expected management criteria for each case. Abbreviations are HRV, historic range of variability and DFC, desired future conditions (Hansen et al. 2014).

Sources of Expertise

Individuals who were consulted or provided preliminary reviews for the focal resource are listed in this section.

Literature Cited

This section lists all of the referenced sources in this section.

3.3. Literature Cited

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Chapter 4. Natural Resource Conditions

4.1. Land Cover and Land Use

This section places preserve resources and management concerns within a local and regional context of land cover and land use and examines implications related to population and resource conservation. Using several metrics, it characterizes conditions and dynamics of the surrounding areas, highlights the potential effects of related landscape-scale stressors on preserve resources, and underscores the conservation value of the preserve to the surrounding region. The synthesis of national data uses a series of straightforward spatial analyses for areas within and surrounding the preserve. Condition and trend ratings are not assigned to these landscape context metrics. In some cases long-term data are not available and for the most part the preserve has little influence over activities occurring outside preserve boundaries. Longer-term data is available for some population and housing metrics.

Indicators of landscape context applied here include a variety of metrics for land cover and land use, population and housing, and land conservation status. Due to the relatively small size of the preserve, the overwhelmingly non-natural status of surrounding lands, and the lack of significant regional migration by terrestrial fauna of concern, road densities and habitat fragmentation and connectivity both within the preserve and outside the preserve are not examined.

4.1.1. Threats and Stressors

Land use is intensifying around many protected areas including national park units (Wittemyer et al. 2008, Wade and Theobald 2010, Davis and Hansen 2011, Hansen et al. 2014). Many parks in the region are concerned with the ecological consequences of habitat loss associated with urbanization outside park boundaries, conversion of surrounding areas to non-natural uses, as well as the effects of runoff from impermeable surfaces on hydrologic flows through the parks (Hansen and Gryskiewicz 2003). The growth of housing adjacent to protected areas can create a patchwork of land use that degrades the conservation impact of high-value protected areas on adjacent parcels and within the region (Radeloff et al. 2010). Protected areas are most effective when they conserve habitat within their boundaries and are connected with other protected areas via intact corridors (Radeloff et al. 2010). According to the Radeloff et al. study, the main threat to protected areas in the U.S. is housing density, which is highly correlated with population density. The adverse effects of development also impact the quality of the natural environment and visitor experience related to dark night skies, natural soundscapes and viewscapes/scenery.

TAPR is located in a unique geological area known as the Osage Plains/Flint Hills ecoregion. This region encompasses nearly 31,000 square miles in western Missouri, northeastern Oklahoma, and eastern Kansas. The more eastern Osage Plains part of the ecoregion has been heavily impacted by conversions from grassland to agriculture; more than 90% of its original acreage has been converted to row crops or hay production (Hamilton et al. 2000). In the western Flint Hills part of this region (where TAPR is located), shallow soils and bedrock outcrops have discouraged plowing in the area, leaving this part of the region largely intact (Hamilton et al. 2000). This western Flint Hills area contains approximately 80% of the world's remaining tallgrass prairie landscape (Hamilton et al. 2000).

Region-wide conservation planning for the Flint Hills region was formally initiated by TNC in 2000. A community-based conservation program called the Flint Hills Initiative was started to deal with threats and stressors to the region including but not limited to invasive species and "incompatible development" (Hamilton et al. 2000). TNC's goal for this region is to "maintain the unfragmented nature of this last expanse of tallgrass prairie and to improve the quality of site-specific habitats for target species and natural communities." (Hamilton et al. 2000). TNC relies heavily on voluntary cooperative efforts to bring together ranchers, landowners, and other stakeholders in the preservation of the biological integrity of the Flint Hills ecoregion.

4.1.2. Indicators and Measures

- Land cover and Use
- Extent of Anderson Level I classes
- Extent of natural vs. converted land cover
- Extent of impervious surface area
- Human population and housing
- Housing density
- Historic population: total and density
- Population: current and projected total and density
- Conservation status
- Protected area (ownership) extent
- Biodiversity conservation status (level of protection)

4.1.3. Data and Methods

Spatial data for land cover, population, and housing used for condition and trend analysis were provided by the NPS NPScape Program and follow protocols described in Monahan et al. (2012). Sources of other data are noted below.

Defining Areas of Interest

Landscape context elements within and adjacent to the preserve were compared to resource conditions in the broader region surrounding the preserve. Landscape attributes important to preserve resources often vary with scale or spatial extent. Relevant scales or areas of analysis (AOAs) include the landscape within the preserve itself (i.e., the reporting unit used for many focal resources in this report), the "boundary" area immediately adjacent to the preserve (e.g., 3 km buffer), the local area surrounding the preserve (e.g., within 30 km of the park boundary), the watershed area(s) upstream from the preserve influencing preserve streams, nearby counties, and the broader ecoregion. Areas of analysis used for the different landscape context indicators and metrics are based on recommendations from Monahan et al. (2012) (Table 4.1-1), and serve to capture a variety of scales to facilitate examination of the integrated effects of human activities. Contributing upstream watershed is included because it significantly influences water quality and watershed/hydrologic characteristics (Monahan and Gross 2012). The preserve is relatively small, regional topography is very gentle, and climate is fairly uniform throughout the areas of interest.

Table 4.1-1. Areas of analysis used for land cover and land use measures. "X" indicates area used.

Landscape Metric Category	Indicators and Measures	Areas of Analysis					
		3 km Buffer Around Park	Park + 30 km Buffer	Contributing Upstream Watershed	Counties Overlapping with Park + 30 km Buffer	Tallgrass Prairie Region	Flint Hills Region
Land Cover and Use	Anderson Level I	X	X	X	–	–	–
	natural vs. converted land cover	X	X	X	–	X	X
	impervious surfaces	–	–	X	–	–	–
Human Population and Housing	population total and density by census block group (historic and projected)	–	X	–	–	–	–
	historic population totals by county	–	–	–	X	–	–
	housing density 1970–2010	–	X	X	–	–	–
Conservation Status	Protected areas (ownership) and biodiversity conservation status	X	X	–	–	X	X

Land Cover

United States Geological Survey (USGS) National Land Cover Dataset (NLCD) data for 2006 was used to characterize current/recent conditions. NLCD data products are derived from Landsat Thematic Mapper (TM) imagery with a 30 m pixel resolution. NLCD summaries employ a well-documented, consistent procedure that is highly repeatable over time. Although NLCD data date back to 1992, differences in classification and analysis methods do not favor comparison of the 1992 data with 2006 data (Monahan et al. 2012). Procedures for the summarization of data for the following indicators are from NPS (2014a).

Anderson land cover/land use classes

NLCD data were interpreted and classified using Anderson Level I land cover classes (Table 4.1-2) for the areas of analysis listed in Table 4.1-1.

Table 4.1-2. Anderson land cover/land use classes (Anderson et al. 1976) and rules for reclassifying Anderson land cover as natural vs. converted land cover.

Anderson Level I Class	Anderson Level II Class	Natural/Converted
Open Water	–	Natural
Developed	–	Converted
Barren/Quarries/Transitional	–	Natural
Forest	–	Natural
Shrub/Scrub	–	Natural
Grassland/Herbaceous	–	Natural
Agriculture	Pasture/hay vs. cultivated agriculture	Converted
Wetlands	–	Natural

Acreage of natural vs. converted land cover

The NLCD Anderson Level I "developed" and "agriculture" classes were reclassified as "converted" (Table 4.1-2) and analyzed using the areas of analysis listed in 4.1-1. Other classes were classified as "natural".

Impervious surface area

The NLCD Anderson Level I "developed" classes are reclassified as "impervious" and all other land cover classes were classified as "pervious" and analyzed using the areas of analysis listed in 4.1-1. Areas that are more impervious reduce the amount of water infiltration into the soil and local water tables, and contribute to altered hydrographs and flashier runoff characteristics.

<u>Human Population and Housing</u>

Housing Density

Change from 1970 to 2010 and projected changes to 2050 were examined. The NPScape housing density metrics used here are based on the Spatially Explicit Regional Growth Model (SERGoM v3) (Theobald 2005). Housing density data are categorized into 11 non-uniform development classes described by Theobald (2005): rural (0–0.0618 units/ha), exurban (0.0618–1.47 units/ha), suburban (1.47–10.0 unit/ha), and urban (> 10.0 units/ha). The non-uniform ranges permit a much finer delineation of areas of low-density housing than is common for non-ecological studies (Monahan et al. 2012).

Total Population and Population Density

Historical data was derived from county-level population totals for all counties overlapping with the 30 km preserve buffer, and U.S Census Bureau block data from 1990, 2000 and 2010 for population density. Population density (number of people per square km) classes follow NPScape guidance (NPS 2014b).

<u>Conservation Status</u>

For our region of interest, the two primary sources of protected areas data were the Protected Areas Database-US (PAD-US) Version 2 (Conservation Biology Institute 2013) and the National Conservation Easement Database (NCED). The two databases are designed to be used together to show comprehensive protection status for areas of interest while using compatible database attributes such as ownership type and agency.

Ownership

Land ownership greatly influences the level of conservation protection. The PAD-US (CBI Edition) Version 2 is a national database of protected fee lands in the United States. It portrays the United States protected fee lands with a standardized spatial geometry with valuable attribution on land ownership, management designations, and conservation status (using national GAP coding systems). The National Conservation Easement Database (NCED) Version III (July 2013) is a voluntary national geospatial database of conservation easement information that compiles records from land trusts and public agencies throughout the United States. It is a collaborative partnership by the Conservation Biology Institute, Defenders of Wildlife, Ducks Unlimited, NatureServe, and the Trust for Public Land (National Conservation Easement Database 2013). As of May 2013, the acreage of publicly-held easements is considered to be 90% complete for Kansas; the accounting of the acreage of NGO-held easements in Kansas is currently estimated at approximately 21% complete. The low percentage of completeness for NGO-held easements is because: 1) they have not been digitized, 2) they were withheld from NCED, or 3) the NCED team is still working with the easement holders to collect the information (http://www.conservationeasement.us/about/completeness).

Level of Protection

The USGS Gap Analysis Program (GAP) uses a scale of 1 to 4 to categorize the degree of biodiversity protection for each distinct land unit (Scott et al. 1993). A status of "I" denotes the highest, most permanent level of maintenance, and "IV" represents no biodiversity protection or areas of unknown status. The PAD-US (CBI Version 2) database includes the coded GAP biodiversity protection status of each parcel. The NCED database is designed to accommodate the GAP protection status field but most parcels have not been assigned a GAP conservation value. The four status categories are described below.

Status I

These areas have permanent protection from conversion of natural land cover and a mandated management plan in operation to maintain a natural state within which disturbance events (of natural type, frequency, and intensity) are allowed to proceed without interference or are mimicked through management. Most national parks, TNC preserves, some wilderness areas, Audubon Society preserves, some USFWS National Wildlife Refuges and Research Natural Areas are included in this class.

Status II

These areas have permanent protection from conversion of natural land cover and a mandated management plan in operation to maintain a primarily natural state, but which may receive use or management practices that degrade the quality of existing natural communities. Some national parks, most wilderness areas, USFWS Refuges managed for recreational uses, and BLM Areas of Critical Environmental Concern are included in this class.

Status III

These areas have permanent protection from conversion of natural land cover for the majority of the area, but may be subject to extractive uses of either a broad, low-intensity type or localized intense type. This class also confers protection to federally-listed endangered and threatened species throughout the area. Most non-designated public lands, including USFS, BLM and state park land are included in this class.

Status IV

These areas lack irrevocable easement or mandate to prevent conversion of natural habitat types to anthropogenic habitat types. This class allows for intensive use throughout the tract, and includes those tracts for which the existence of such restrictions or sufficient information to establish a higher status is unknown. Most private lands fall into this category by default.

Protected areas data from the two databases was examined by owner type and by easement protection status within a 30 km buffer of the preserve boundary. GAP biodiversity protection values were summarized for NCED and PAD-US parcels by ownership type within the 30 km buffer areas of interest. Protected areas data was also examined within the entire range of the tallgrass prairie ecoregion. There is some spatial overlap between the PAD-US and NCED databases due to the existence of easements on some lands owned by federal, state and local agencies. Where easements existed on these public (i.e., protected) lands, the acreages were reported by owner only to avoid double counting in the number of protected acres.

4.1.4. Condition and Trend

Land Cover and Use

Extent of Anderson Level I Classes 2006

In the immediate vicinity of TAPR (3 km buffer) over 75% of land acreage is grassland/herbaceous cover, and nearly 16% is agriculture (i.e., hayed or row-cropped) (Table 4.1-3, Figure 4.1-1). Only 4% of the land area within 3 km of TAPR is developed. Within the 30 km buffer, over 72% of the acreage is grassland/herbaceous and 18% is used for agriculture. Land cover of the contributing upstream watershed of the preserve is over 88% grassland/herbaceous and 5% agriculture. The proportion of agricultural and developed acreage surrounding the preserve is very small compared to other parks in the Tallgrass Prairie ecoregion. Although the grasslands surrounding TAPR are fairly patchy and lack a high degree of connectivity, the patches are much larger than those surrounding other parks in the region (Figure 4.1-2).

Table 4.1-3. Anderson Level 1 land cover classes within 3 km and 30 km of the preserve boundary, and within the contributing upstream watershed of the preserve.

	3 km Buffer		Park + 30 km Buffer		Contributing Upstream Watershed	
Anderson Level I Classes	**Acres**	**% of Area**	**Acres**	**% of Area**	**Acres**	**% of Area**
Open Water	390	0.88%	9,947	1.04%	213	0.74%
Developed	1,872	4.22%	39,765	4.15%	901	3.12%
Barren/Quarries/Transitional	0	0.00%	190	0.02%	0	0.00%
Forest	1,025	2.31%	30,066	3.14%	503	1.74%
Scrub/Shrub	0	0.00%	179	0.02%	6	0.02%
Grassland/Herbaceous	33,675	75.84%	693,931	72.47%	25,589	88.65%
Agriculture	7,077	15.94%	173,251	18.09%	1,559	5.40%
Wetlands	365	0.82%	10,173	1.06%	92	0.32%
Total	**44,404**	**–**	**957,502**	**–**	**28,863**	**–**

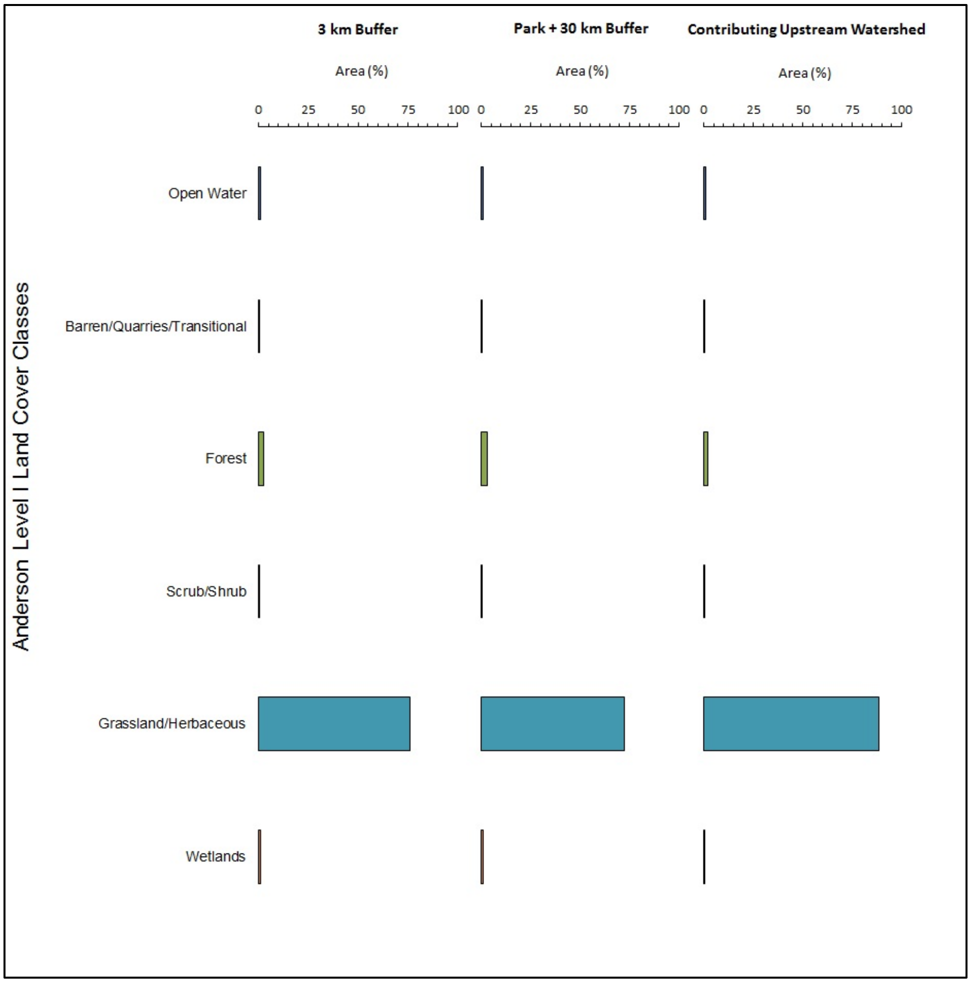

Figure 4.1-1. Anderson Level 1 land cover class proportions within 3 km and 30 km of the preserve boundary, and within the contributing upstream watershed of the preserve. Developed and agriculture land cover classes are omitted here to improve the scale of the graphic.

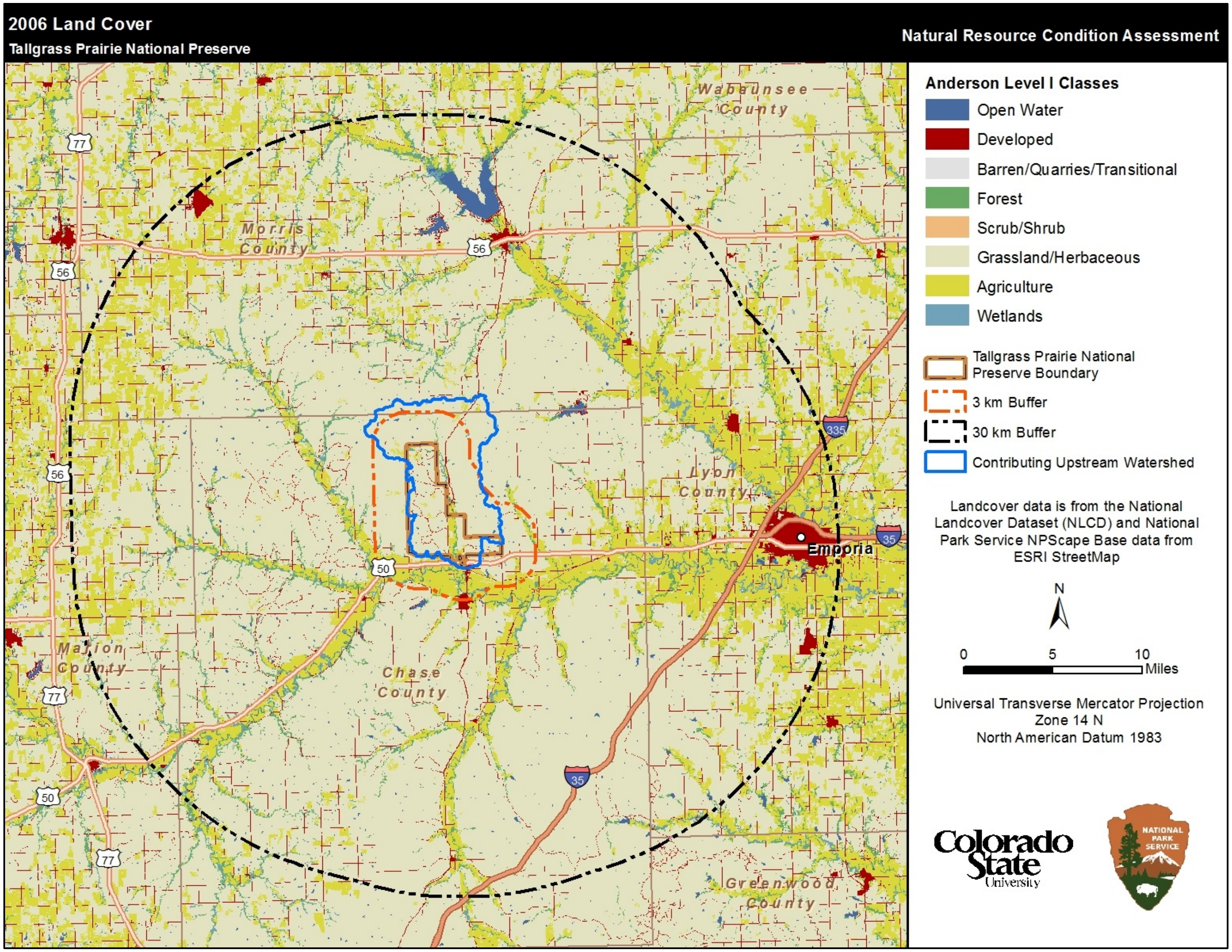

Figure 4.1-2. Anderson Level 1 land cover classes within 3 km and 30 km of the preserve boundary, and within the contributing upstream watershed of the preserve. National Land Cover Dataset data provided by NPS NPScape Program.

Natural vs. Converted Land Cover

Change in natural land cover is possibly the most basic indication of habitat condition (O'Neill et al. 1997). Knowing the proportion of natural land cover area to converted land area provides a general indication of overall landscape condition, offering insight into potential threats and opportunities for future conservation.

The proportion of converted acreage surrounding TAPR is low in relation to the Tallgrass Prairie ecoregion as a whole (Table 4.1-4, Figure 4.1-3). Within 30 km of the preserve boundary, only 22% of the area is classified as converted, and only 8.5% of the contributing upstream watershed is classified as converted (Figure 4.1-3).

Table 4.1-4. Natural vs. converted acreage within 3 km and 30 km of the preserve boundary, within the contributing upstream watershed of the preserve, and within the Tallgrass Prairie and Flint Hills Ecoregions.

	Natural		Converted	
AOA	**Acres**	**% of Area**	**Acres**	**% of Area**
3 km	35,461	79.86%	8,943	20.14%
Park + 30 km Buffer	744,485	77.75%	213,017	22.25%
Contributing Upstream Watershed	26,402	91.47%	2,461	8.53%
Tallgrass Prairie Ecoregion	63,104,955	32.73%	129,810,610	67.27%
Flint Hills Ecoregion	5,045,123	73.87%	1,784,223	26.13%

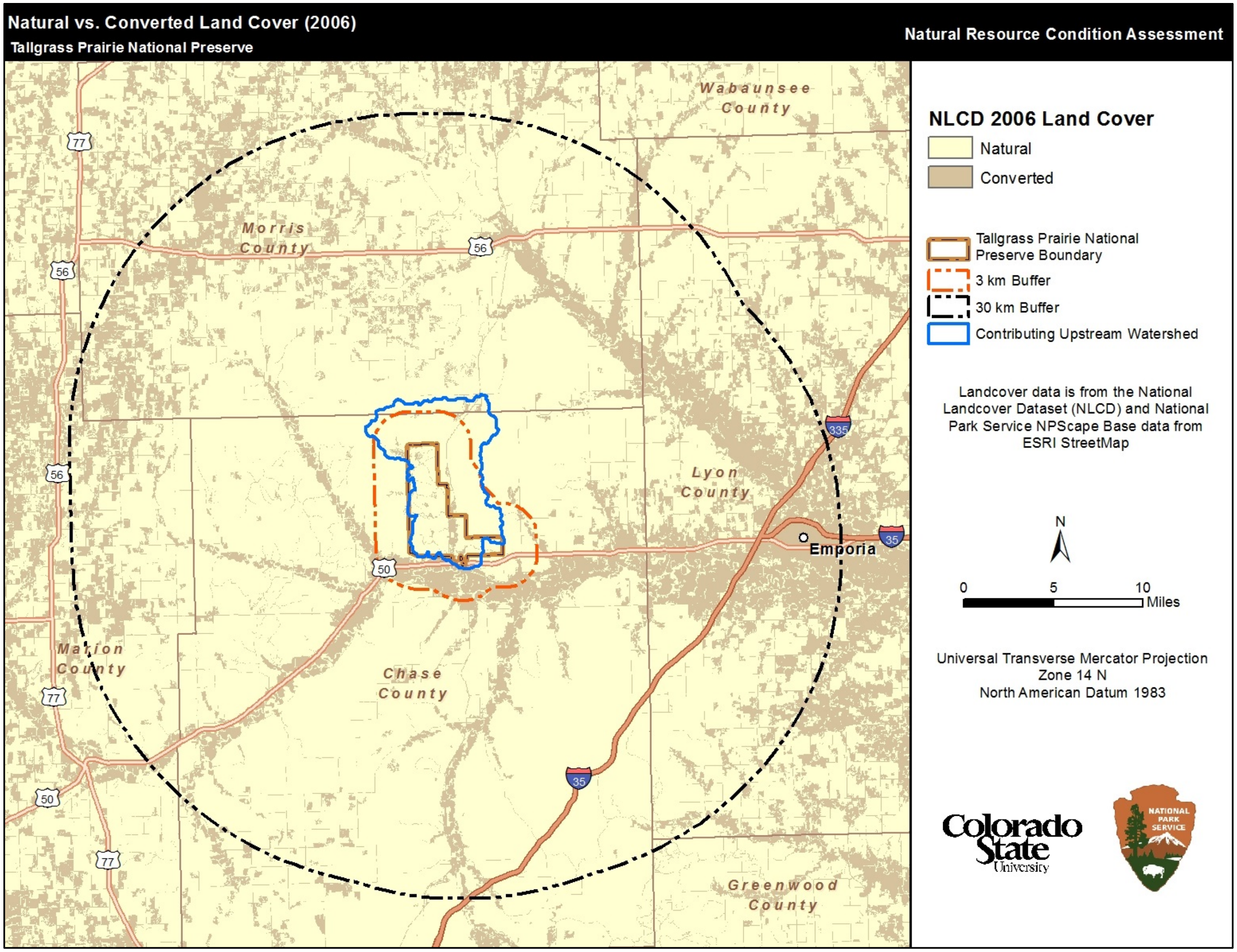

Figure 4.1-3. Natural vs. converted land cover classes within 3 km and 30 km of the preserve boundary, and within the contributing upstream watershed of the preserve. 2006 National Land Cover Dataset data provided by NPS NPScape Program.

Impervious Surface Area

Impervious surfaces include bare rock, paved roads, and areas covered with concrete/cement. These surfaces prevent infiltration of precipitation into the ground. This reduced infiltration can cause significant hydrological effects including quicker runoff into streams and rivers resulting in flooding, more rapid rising and dropping of streamflow after precipitation events, reduced local evapotranspiration, and reduced recharge of local aquifers. Imperviousness can also increase aquatic pollution as contaminant transport is increased by water flowing directly to a stream or other water body without the opportunity for uptake or decomposition by plants and soil organisms.

Most of TAPR's contributing upstream watershed (approximately 38% of which is within TAPR) is in the lowest imperviousness class (0–2% impervious surfaces) (Table 4.1-5, Figure 4.1-4). There is a very low degree of imperviousness in relation to other parks in the region. This is attributable to the fact that most of the surrounding acreage is grassland, and a low amount of development in the area. As a benchmark for future analysis, approximately 0.68% of the contributing upstream watershed of the preserve was classified as having >25% impervious surfaces (Table 4.1-5), the vast majority of which is concentrated near the town of Strong City, KS and along the State Highway 50 (Figure 4.1-4).

Table 4.1-5. Percent impervious surfaces acreage based on Anderson land cover classes within the contributing upstream watershed of the preserve.

Percent Impervious Surface	Acres	% of Area
0%–2%	28,059	97.22%
2%–4%	126	0.44%
4%–6%	68	0.24%
6%–8%	73	0.25%
8%–10%	67	0.23%
10%–15%	123	0.42%
15%–25%	151	0.52%
25%–50%	146	0.51%
50%–100%	50	0.17%
Total	**28,863**	**–**

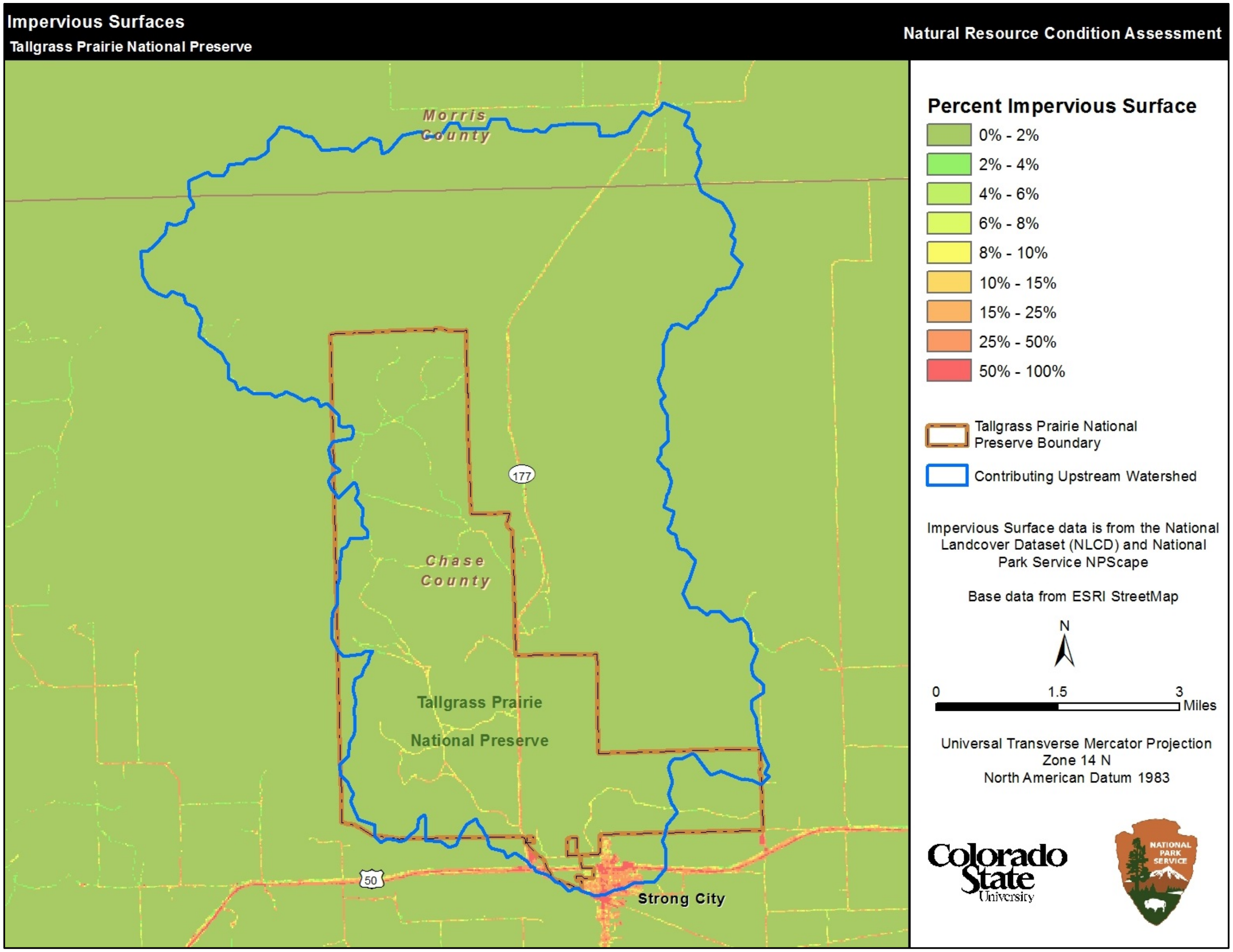

Figure 4.1-4. Percent impervious surfaces based on Anderson land cover classes within 3 km and 30 km of the preserve boundary, and within the contributing upstream watershed of the preserve. National Land Cover Dataset data provided by NPS NPScape Program.

Population and Housing

Historic and Projected Population

High human population density has been shown to adversely affect the persistence of habitats and species (Kerr and Currie 1995, Woodroffe 2000, Parks and Harcourt 2002, Luck 2007). Conversion of natural landscapes to agriculture, suburban, and urban landscapes is generally permanent, and this loss of habitat is a primary cause of biodiversity declines (Wilcove et al. 1998). Human conversion of landscapes can alter ecosystems and reduce biodiversity by replacing habitat with non-habitable cover types and structures, fragmenting habitat, reducing availability of food and water, increase disturbance by people and their animals, alter vegetation communities, and increase light, noise, and pollution.

Population density within 30 km of the preserve's boundary is low, with most of the area within this 30 km radius having a density of 1–20 people/km^2 (Table 4.1-6, Figure 4.1-5). Historically, population has declined slightly with the exception of Lyon County (Figure 4.1-6), which contains the City of Emporia, KS.

Table 4.1-6. Population density classes and acreage for 1990, 2000, and 2010 by census block group for the preserve and surrounding 30 km buffer.

	1990		2000		2010	
Population Density (#/km^2)	**Acres**	**% of Area**	**Acres**	**% of Area**	**Acres**	**% of Area**
1–20	928,761	97.00%	924,766	96.58%	924,731	96.58%
21–75	12,896	1.35%	16,288	1.70%	16,303	1.70%
76–150	3,907	0.41%	3,563	0.37%	4,919	0.51%
151–300	7,419	0.77%	6,885	0.72%	5,557	0.58%
301–750	2,387	0.25%	3,575	0.37%	3,834	0.40%
751–1200	457	0.05%	755	0.08%	476	0.05%
1201–1500	348	0.04%	0	0.00%	319	0.03%
1501–2000	473	0.05%	622	0.06%	1039	0.11%
2001–3000	788	0.08%	870	0.09%	320	0.03%
>3000	62	0.01%	174	0.02%	0	0.00%

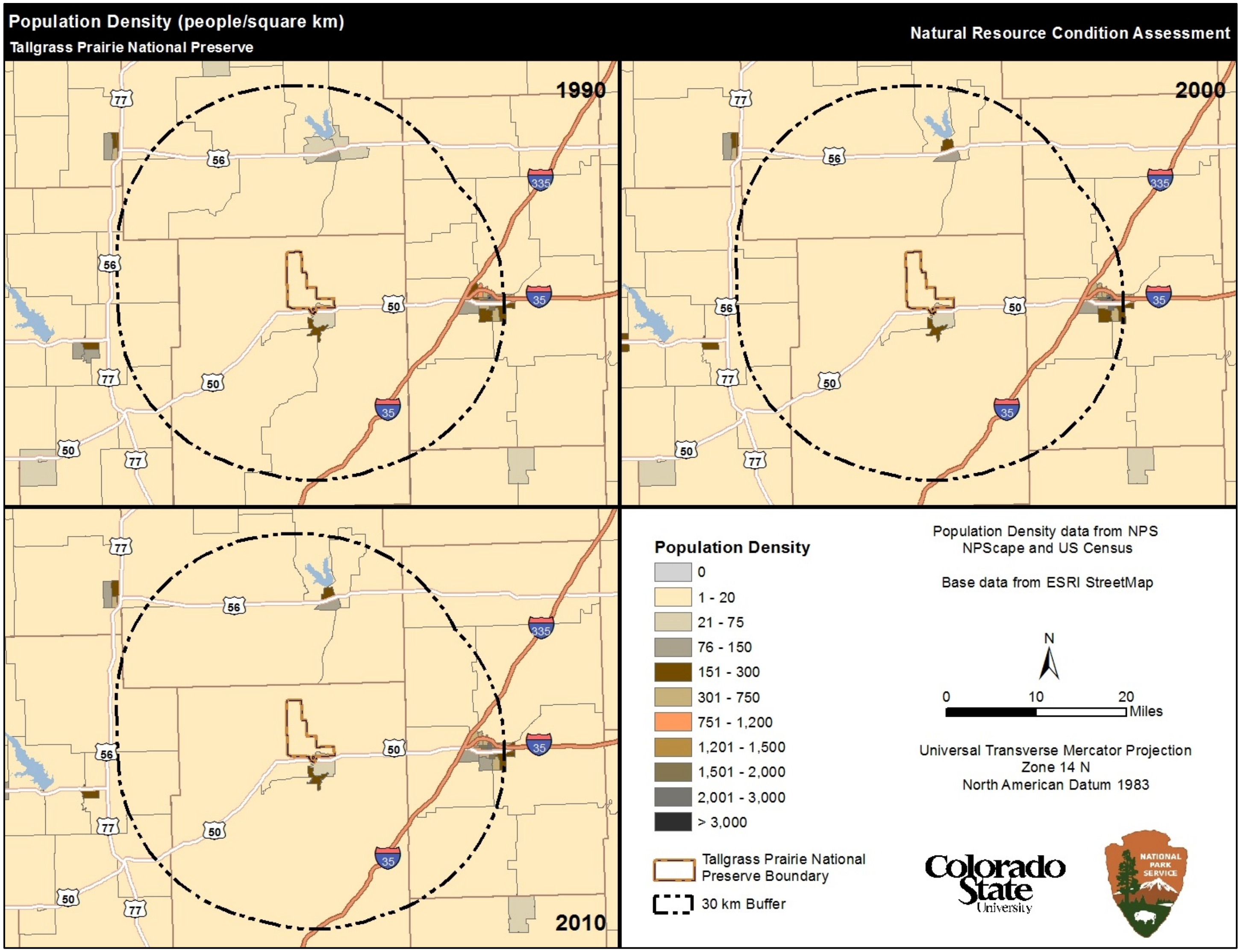

Figure 4.1-5. Population density for 1990, 2000, and 2010 by census block group for the preserve and surrounding 30 km buffer. U.S. Census data provided by NPS NPScape Program.

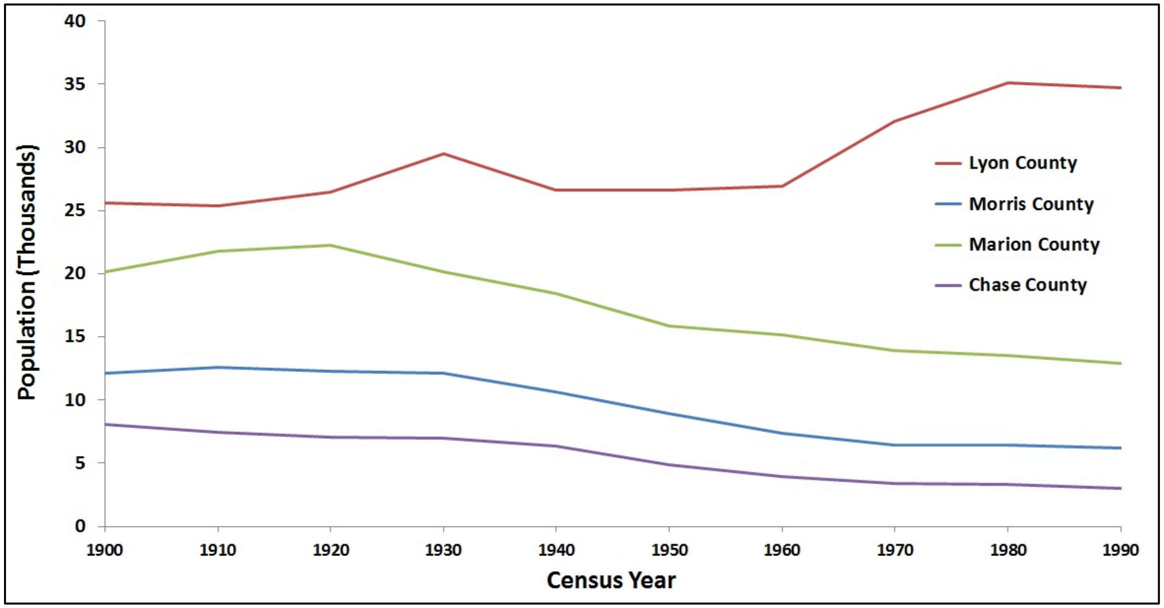

Figure 4.1-6. Historic population by decade for counties within 30 km of TAPR.

There is a slight increasing trend in population density, however, this increase is taking place in population classes that are still low in density (21-150 people/km^2). Overall population density is low in relation to other area parks.

Housing Density

Housing density in the region surrounding the preserve does not show marked patterns of change between 1970 and 2010 (Table 4.1-7, Figure 4.1-7). Areas shown in white in Figure 4.1-7 are primarily State Wildlife Management Areas and open water.

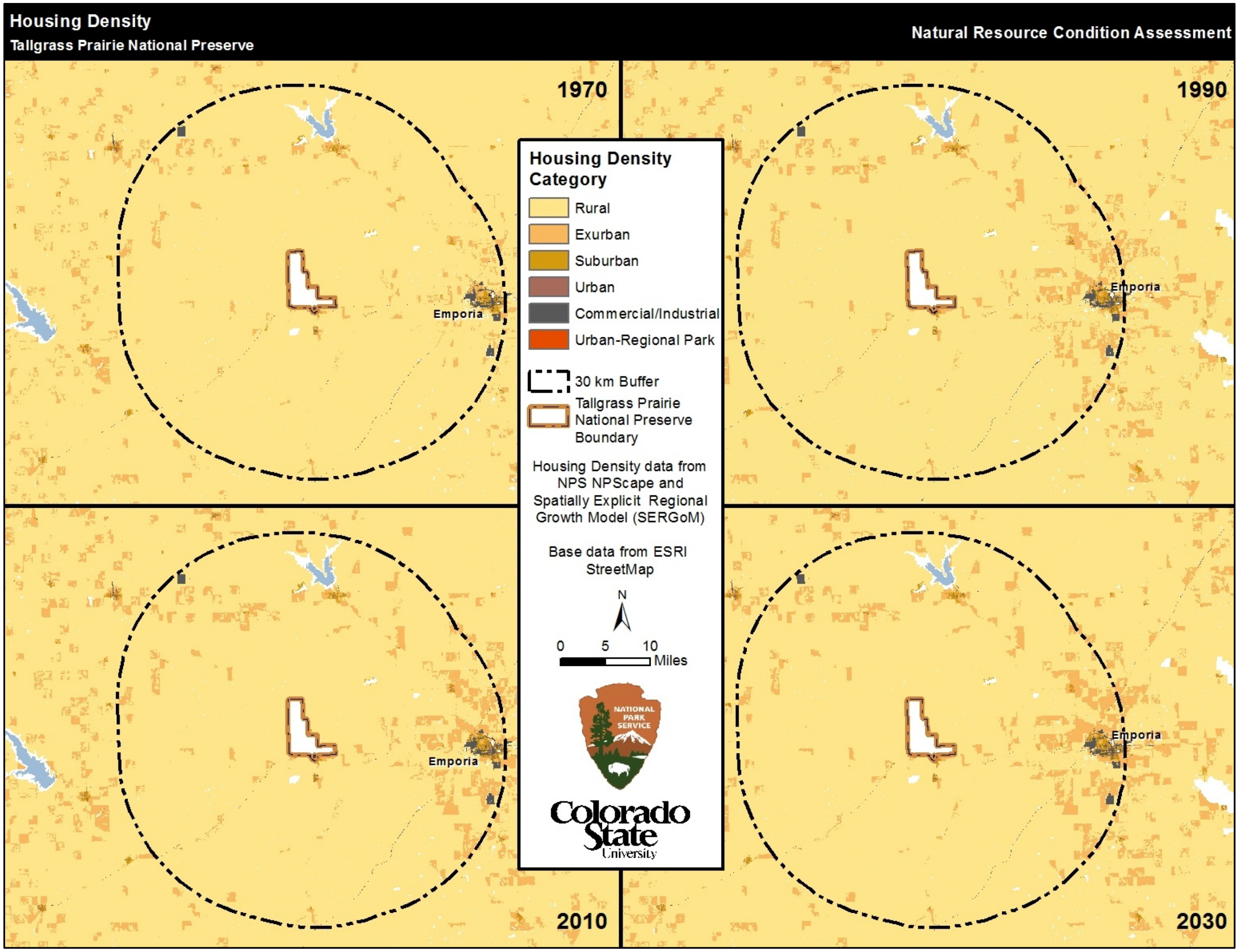

Figure 4.1-7. Historic and projected housing density for 1970, 1990, 2010 and 2030 for the preserve and surrounding 30 km buffer. SERGOM data provided by NPS NPScape Program.

Table 4.1-7. Historic and projected housing density classes by decade for 1970–2050 for the preserve and surrounding 30 km buffer.

	Rural (0–0.0618 units/ha)		Exurban (0.0618–1.47 units/ha)		Suburban (1.47–10.0 units/ha)	
Census Year	**Acres**	**% of Area**	**Acres**	**% of Area**	**Acres**	**% of Area**
1970	922,266	96.32%	27,480	2.87%	2,873	0.30%
1980	900,722	94.07%	48,354	5.05%	3,351	0.35%
1990	893,158	93.28%	55,631	5.81%	3,639	0.38%
2000	888,179	92.76%	60,897	6.36%	3,734	0.39%
2010	886,455	92.58%	62,238	6.50%	3,830	0.40%
2020	882,625	92.18%	65,972	6.89%	3,830	0.40%
2030	880,998	92.01%	67,600	7.06%	3,926	0.41%
2040	880,710	91.98%	67,791	7.08%	3,926	0.41%
2050	880,615	91.97%	67,983	7.10%	3,926	0.41%

Level of Protection

There are differences in the GAP status makeup within each of the AOA's. Within 30 km of the preserve, most protected land is in Status I or IV (Table 4.1-8 and 4.1-9; Figure 4.1-8). All of the protected acreage in the contributing upstream watershed is Status 1. For comparison, more than half of the protected acreage in the Tallgrass Prairie and Flint Hills ecoregions is Status IV, a low level of protection. More than 90% of land area in each of the AOA's with the exception of the contributing upstream watershed is not protected, which highlights the importance of TAPR and other occasional parcels that do provide biodiversity protection in the region. Moreover, in protected areas such as TAPR natural processes and disturbance regimes are more likely to occur and support a greater degree of biodiversity, as well as provide critical linkages to the surrounding natural landscape.

Land Cover and Land Use Summary

Land cover and land use indicators are summarized in Table 4.1-10. Overall, the preserve is within a semi-natural landscape with a high proportion of pasture land and prairie. Most of the stressors to the landscape surrounding TAPR are related to the conversion of rural agricultural land to housing developments, most of which is classed as exurban. This trend in land development, coupled with the lack of well-connected protected areas, should be of concern to the conservation of natural resources of Tallgrass Prairie National Preserve. However, overall, the status and degree of these threats and stressors on the preserve are low in comparison to other parks in the region.

Table 4.1-8. Acreage of lands within 30 km of the boundary of TAPR, within the contributing upstream watershed of the preserve, and within the Tallgrass Prairie and Flint Hills ecoregions having some level of conservation protection. Percentages are the proportion of total AOA area.

	Park + 30 km Buffer		Contributing Upstream Watershed		Tallgrass Prairie Ecoregion		Flint Hills Ecoregion	
Ownership	**Acres**	**% of Area**	**Acres**	**% of Area**	**Acres**	**% of Area**	**Acres**	**% of Area**
Federal	6,265	0.65%	0	0.00%	2,697,850	1.40%	220,773	3.23%
Native American	0	0.00%	0	0.00%	1,342,495	0.70%	0	0.00%
State	707	0.07%	0	0.00%	2,642,484	1.37%	38,529	0.56%
City and County	0	0.00%	0	0.00%	253,233	0.13%	0	0.00%
Private Conservation	10,811	1.13%	9,843	34.10%	202,828	0.11%	53,315	0.78%
Joint Ownership/Unknown	0	0%	0	0.00%	148,056	0.08%	0	0.00%
Other Conservation Easement	12,276	1.28%	0	0.00%	874,316	0.45%	37,443	0.55%
Total	**30,059**	**3.13%**	**9,843**	**34.10%**	**8,161,263**	**4.24%**	**350,059**	**5.12%**

Table 4.1-9. Biodiversity protection status of lands within 30 km of the preserve boundary, within the contributing upstream watershed of the preserve, and within the Tallgrass Prairie and Flint Hills ecoregions (PAD-US and NCED data). Percentages are the proportion of total AOA area.

	Park + 30 km Buffer		Contributing Upstream Watershed		Tallgrass Prairie Ecoregion		Flint Hills Ecoregion	
Protection Level	**Acres**	**% of Area**	**Acres**	**% of Area**	**Acres**	**% of Area**	**Acres**	**% of Area**
I (highest)	11,031	1.15%	9,843	34.10%	241,925	0.13%	43,717	0.64%
II	0	0.00%	0	0.00%	1,069,131	0.55%	8,134	0.12%
III	3,040	0.32%	0	0.00%	2,359,903	1.22%	64,778	0.95%
IV (lowest/status unknown)	15,988	1.67%	0	0.00%	4,490,304	2.33%	233,430	3.42%
Total	**30,059**	**–**	**9,843**	**–**	**8,161,263**	**–**	**350,059**	**–**

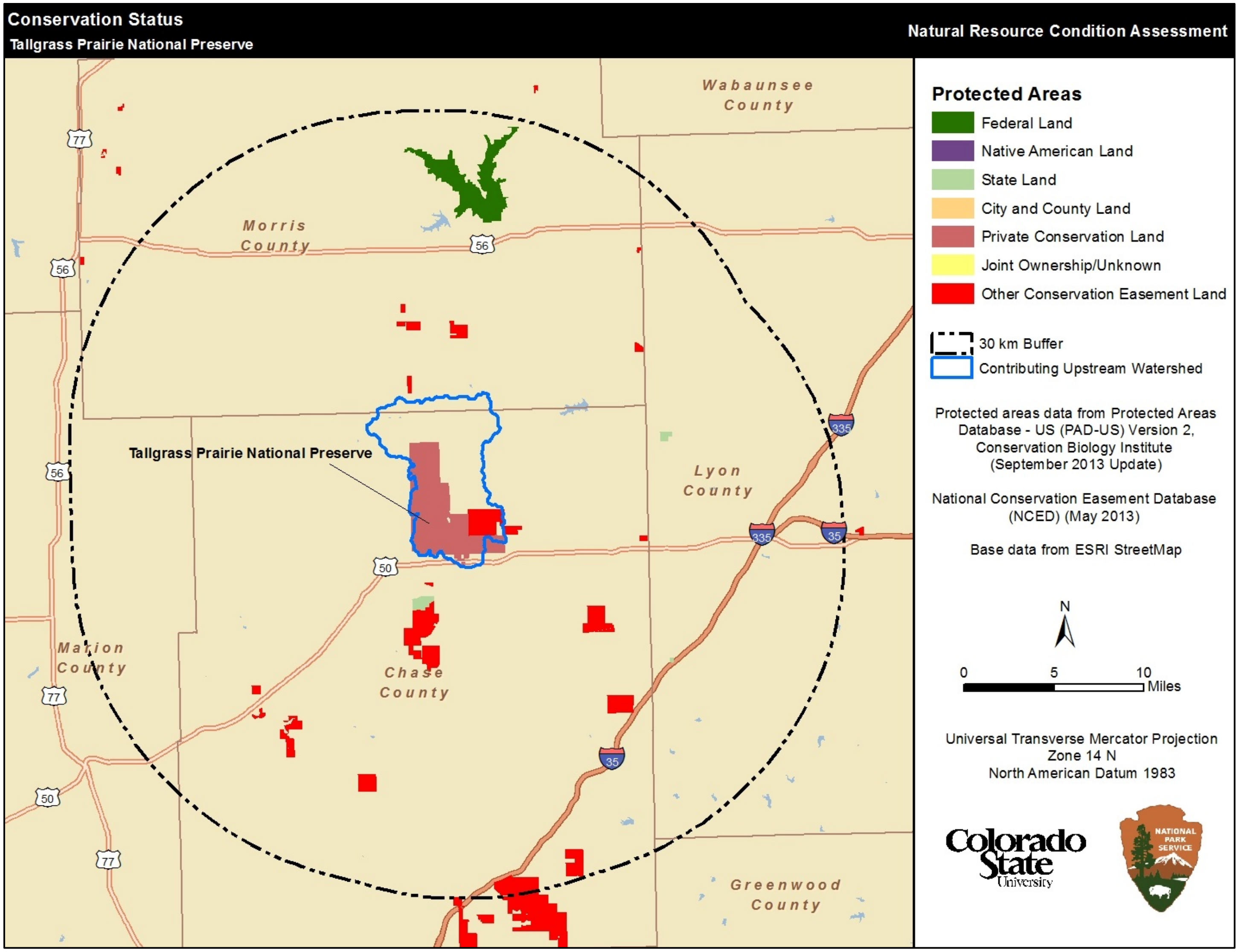

Figure 4.1-8. Conservation status of lands within 30 km of the TAPR boundary.

Table 4.1-10. Summary for land cover and land use indicators, Tallgrass Prairie National Preserve.

Landscape Metric Category	Indicator	Summary notes integrating results for 3 km, contributing upstream watershed and 30 km areas of interest
Land Cover	Extent of Anderson Level I and II classes	Most of the acreage surrounding TAPR is tallgrass prairie, regardless of AOA. The next most prevalent land use is agriculture, followed by developed.
	Extent of impervious surface area	There is a low degree of imperviousness in relation to other parks in the region. This is due to the fact that most of the surrounding acreage is grassland.
	Extent of natural vs. converted land cover	The proportion of converted acreage surrounding TAPR is low in relation to the Tallgrass Prairie Ecoregion as a whole.
Population and Housing	Historic and projected population total and density	Population density within 30 km of the preserve's boundary is low, with most of the area within this 30 km radius having a density of 1–20 people/km^2. The low population density of the area is attributable to the prevalence of unconverted grasslands surrounding TAPR. Historically, county populations in the surrounding area have been relatively constant with the exception of Lyon County, KS.
	Housing density	Within a 30 km radius of the preserve, the most notable trend is an increase in exurban areas and a corresponding decrease in rural acreage. There is an increase in the acreage of suburban areas but the major change in housing density is associated with the existing urban center of Emporia, KS. However, there is also a pattern of increasing exurban housing density in unincorporated areas, including areas close to major roads.
Conservation Status	Protected area extent and biodiversity protection status	With the exception of the contributing upstream watershed, only a small portion of the acreage in the region surrounding the preserve is protected through ownership or conservation easements. The rarity of protected lands within the region underscores the value of the preserve as a conservation island within a heavily agricultural region.

4.1.5. Uncertainty and Data Gaps

There are several sources of uncertainty associated with our analysis. The inclusion of 2011 and other data in the future will provide a more robust assessment of trends and rates of change in land cover and land use. Another source of uncertainty is associated with assumptions regarding the relationships between land ownership and conservation status. Although information about ownership and protection status can be useful, the degree to which biodiversity is represented within the existing network of protected areas is largely unknown (Pressey at al. 2002). Protection status and extent must be combined with assessments of conservation effectiveness (e.g., location, design, and progress toward conservation objectives) to achieve more meaningful results (Chape et al. 2005).

4.1.6. Sources of Expertise

- Bill Monahan, Ph.D., NPS Inventory and Monitoring Division, Fort Collins, Colorado. Dr. Monahan provided NPScape data summaries, consulted on the selection and use of various metrics, and provided helpful manuscript reviews.

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4.2. Night Sky

4.2.1. Background and Importance

National parks serve as refuges for the endangered resource of natural darkness and starry night skies. Existing studies from the NPS Midwest Region since 2000 found that dark night skies are rated as "extremely" or "very" important by 57% of visitor groups (Kulesza 2013). The National Park Service recognizes the significance of naturally dark night skies to humans and many wildlife species and aims to protect the night skies of parks just like other important natural resources. With nearly half of all species being nocturnal and requiring naturally dark habitat, the presence of excessive artificial light can cause significant impacts to these species (Rich and Longcore 2006). For humans, there is cultural, scientific, economic, and recreational value associated with high-quality night skies. NPS Management Policies state that the NPS "will preserve, to the greatest extent possible, the natural lightscapes of parks, which are natural resources and values that exist in the absence of human-caused light" (NPS 2006). The Management Policies also provide specific actions that the NPS will take to prevent the loss of dark conditions and natural night skies: restricting the use of artificial lighting where safety and resource requirements allow, utilizing minimal-impact lighting techniques, and providing shielding for artificial lighting (NPS 2006).

The National Park Service defines a natural lightscape as the resources and values that exist in the absence of human-caused light at night time. Natural lightscapes are critical for night time scenery and nocturnal habitat. There are many species that depend on natural patterns of light and dark for navigation, predation and other natural processes. Light pollution can have a negative effect on the organisms within a park and can also reduce the enjoyment of park visitors. Light pollution is the introduction of artificial light either directly or indirectly into the natural environment. Light pollution degrades the view of the night sky by reducing the contrast between faint extraterrestrial objects and the background of the luminous atmosphere. An example of light pollution is sky glow, sometimes referred to as artificial sky glow, light domes or fugitive light, which is the brightening of the night sky from human-caused light scattered into the atmosphere. Another form of light pollution is glare, which is the direct shining of light. Both of these forms of light pollution impact the human perception of nighttime, natural landscapes and features of the night sky (NPS 2014).

Excessive artificial light pollution in NPS units threatens to adversely impact natural and cultural resources and the quality of visitor experiences. It is important to document with reliable data existing baseline conditions of the lightscapes in national park units so that monitoring of long-term changes can be implemented and management actions taken to restore natural conditions, where necessary (NPS undated). Poor air quality in combination with light pollution can dim the stars and other celestial objects and lead to reduced ability to see starry skies. Poor air quality also "scatters" artificial light, resulting in parks near cities and other significant light sources having a greater "sky glow" than if pollution was not present (Kulesza 2013). The NPS has clearly declared its commitment to protecting dark night skies for the benefit of natural ecosystems and the enjoyment of current and future generations of park visitors.

The preserve's *General Management Plan and Environmental Impact Statement* (FGMP/EIS) identifies several visitor experience goals that "describe what experiences (cognitive, emotional, active, and sensory) should be available for visitors to the preserve" (NPS 2000, p. 13). Included among these goals are opportunities to experience the resources of the preserve in solitude and the ability to experience a greater personal "sense of place". The final goal states that visitors to the preserve will have the opportunity to "appreciate the special experiences of prairie sights, sounds, skyscapes, views, and feelings during all seasons and times—and during both day and night" (NPS, 2000 p. 14). These management goals clearly prioritize the protection of the preserve's night sky in a natural condition. The FGMP/EIS states that the provision of opportunities for visitors to experience quiet and solitude is a central emphasis of the Prairie Landscape Area management zone (NPS 2000, p. 39). According to the plan, "Repeatedly, the public has identified the vistas and views as some of the preserve's most important resources. The relationship of earth and sky, the feeling of vastness, and the openness of the landscape all contribute to a "sense of place." There are very few intrusions on the land" (NPS 2000, p. 75).

<u>Threats and Stressors</u>
The primary threats to dark night skies at Tallgrass Prairie National Preserve include light originating from modern transportation within and beyond the preserve's boundaries, artificial lighting in the preserve, and commercial, industrial, urban, and exurban development both nearby and in the region. Specific threats include light from vehicles on State Highway 177 and US-50 and artificial lighting from residential development in the nearby towns of Strong City and Cottonwood Falls, as well as Emporia and more distant urban centers. These artificial light sources are a distinct threat to the natural and historic lightscape of the preserve, as well as the quality of visitor experiences that can be offered to the public.

A comprehensive examination of landscape context related to landcover/landuse, population and housing, all of which are correlated with light pollution, was performed for the area surrounding the preserve and is presented in the *Land Cover and Land Use* section within this chapter. These parameters can be highly correlated with ambient light levels. Therefore changes in these factors can have significant impacts on the night sky of the preserve.

<u>Indicators and Measures</u>
- Anthropogenic light ratio (ALR)

4.2.2. Data and Methods
The NPS Natural Sounds and Night Skies Division (NSNSD) conducted night sky monitoring during a site visit to the preserve in 2010. Sky brightness was assessed at TAPR using a CCD camera system developed by NPS NSNSD. A CCD system takes pictures of the night sky using a mosaic of approximately 45 images. Sensors assign a brightness value to each pixel. The full resolution mosaic is then summarized according to the brightness values. Some clouds were present and affected the quality of the digital data collected (pers. comm. Chad Moore, NSNSD). The NSNSD also developed a nation-wide model of ambient light levels using data from Cinzano et al. (2001) and Duriscoe et al. (2013). Modeling was applied to all NPS units, including the entire area of Tallgrass Prairie National Preserve and the surrounding region. Modeling results allow estimation of the impact of anthropogenic light pollution on the darkness of night skies in the preserve.

Anthropogenic light is expressed as a ratio of anthropogenic to natural light referred to as the Anthropogenic Light Ratio (ALR). Using CCD data, average anthropogenic light is calculated by taking the total observed sky brightness and then removing the natural night sky component from the observed conditions. A natural night sky has an average brightness across the entire sky of 78 nL (nanolamberts, a measure of luminance). An ALR value of 0 is equivalent to the natural light level, while a value of 1 means that there is as much anthropogenic light as natural light present. The full resolution mosaic pixel data is used for these calculations. There is a medium level of confidence associated with the modeled anthropogenic and natural light levels (Moore et al. 2013). Because sky brightness is highly correlated with ALR, it is not used as an indicator, but can be included as complimentary data.

Other indicators sometimes used to assess the quality of the night sky include the Bortle dark sky scale and the limiting magnitude scale of sky brightness (Bortle 2001). No data is available for those indicators at this time.

4.2.3. Reference Conditions

The reference condition for the night sky in Tallgrass Prairie National Preserve is one in which the intrusion of artificial light into the night scene is minimized. To support this assessment, we have adopted a condition rating framework developed by the NPS State of the Parks Program. TAPR is considered a Level 1 park due to the presence of significant natural resources. For example, these areas include parks in which the nighttime photic environment has a greater potential influence on natural resources and ecological systems, night sky quality is higher, and anthropogenic light levels are lower compared to some other parks. As a result, these parks tend to be more sensitive to the effects of light pollution. The ALR values are applied spatially to the park, and the condition rating corresponds to the ALR level that exists in at least half of the park. (Table 4.2-1)

Natural sources of light (such as moonlight, starlight, and the Milky Way) will be more visible from the preserve than anthropogenic sources. As little outdoor lighting as is necessary to maintain a safe environment for visitors and employees will be utilized. To help the preserve achieve its cultural mission, it is important that the night sky retains its historic character.

Table 4.2-1. Condition rating framework for dark night skies, Tallgrass Prairie National Preserve (Moore et al. 2013).

Condition Rating	ALR Value
Resource is in Good Condition	ALR < 0.33 (<26 nL average anthropogenic light in the sky) At least half of the park area should meet this criteria
Resource Warrants Moderate Concern	ALR 0.33–2.00 (<26 nL average anthropogenic light in the sky) At least half of the park area should meet this criteria
Resource Warrants Significant Concern	ALR > 2.00 (<26 nL average anthropogenic light in the sky) At least half of the park area should meet this criteria

4.2.4. Condition and Trend

There are many sources of light influencing sky brightness at TAPR, with near and far anthropogenic sources of varying sizes along the horizon in all directions (Figure 4.2-1). Starting from the north (left side of image in Figure 4.2-1) and moving clockwise, light domes apparently visible in the CCD panorama composite image include the towns of Council Grove, Emporia, Strong City/Cottonwood Falls, El Dorado, Wichita, Herrington and Junction City.

Anthropogenic Light Ratio

The modeled ALR value (Figure 4.2-2) of 0.61 for the entire preserve falls within the "warrants moderate concern" condition rating. Modeled values indicate a night sky at TAPR 61% brighter than a natural or pristine sky. At these light levels, the Milky Way has lost most of its detail and is not visible along the horizon. Zodiacal light (or "false dawn"—a faint glow at the horizon just before dawn or just after dusk) is rarely seen. Anthropogenic light likely dominates light from natural celestial features and shadows from distant lights may be seen. Dark adaptation is possible in at least some directions, though visible shadows are likely present (NPS 2014).

The preserve is located close to a pocket of moderately dark night skies within the region. Sources of significant light pollution within the region include the cities of Kansas City, Missouri, Topeka, Kansas and Wichita, Kansas (Figure 4.2-2). Artificial lighting from regional and nearby sources appears to impact the level of darkness necessary for the enjoyment of naturally dark night skies and celestial viewing. Land use information for the region and area surrounding the preserve indicates increased development and urbanization over time, especially in the corridor along US Highway 50, which can further degrade dark night skies.

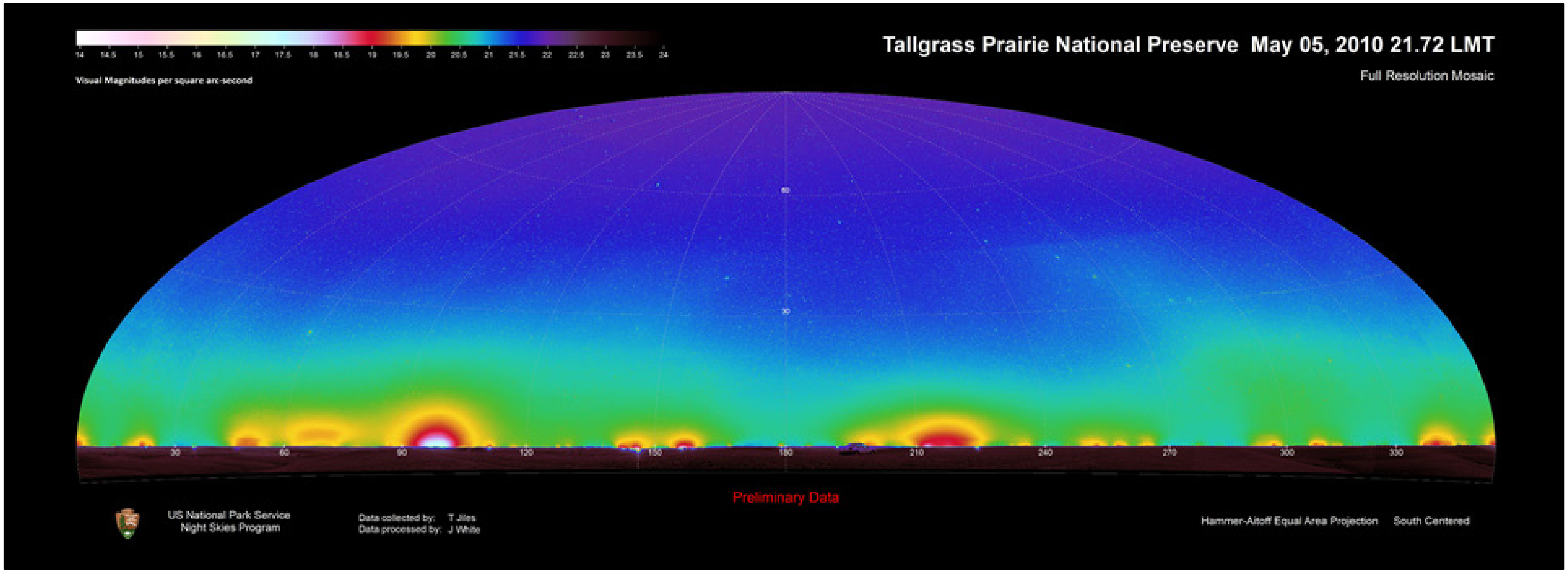


Figure 4.2-1. 360-degree panoramic image of all-sky brightness depicted in false colors, showing nearby light domes and other sources of anthropogenic light. (US National Park Service Night Skies Program image).

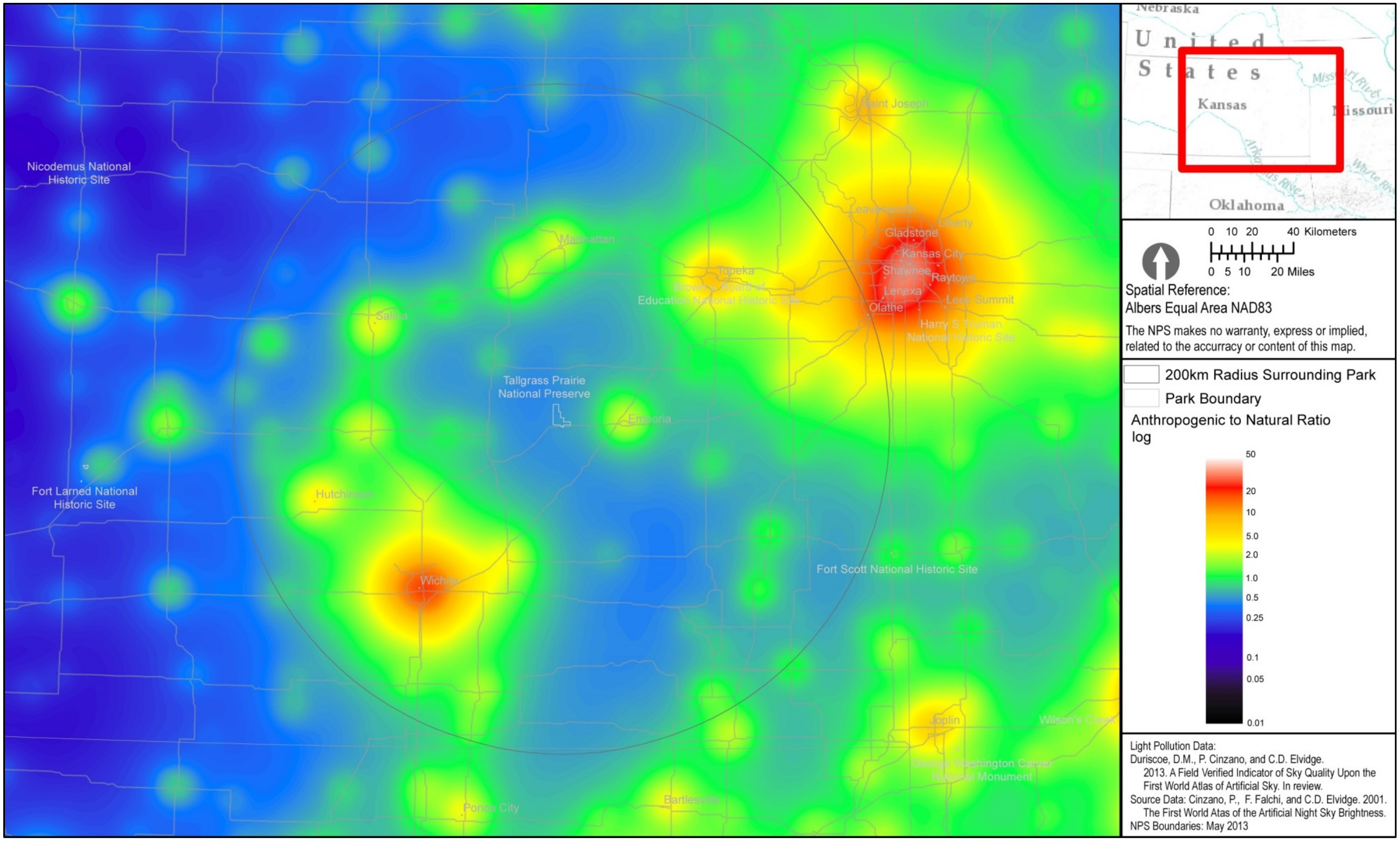
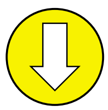
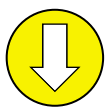


Figure 4.2-2. Anthropogenic to natural light ratio (ALR) for the night sky in the region surrounding Tallgrass Prairie National Preserve, Kansas. Modeled data from Duriscoe et al. (2013) and Cinzano et al. (2001). Visualization provided by NPS Natural Sounds and Night Skies Division and NPS Inventory and Monitoring Program MAS Group, August 2013.

Although the preserve night sky quality is degraded due to the proximity of the multiple population centers and corresponding light domes, locally the night sky condition may be better than surrounding areas (Table 4.2-2). The area provides habitat for nocturnal animals and offers occasional recreation opportunities after dark. Further, national parks are tasked with preserving night sky quality and can serve as an example to surrounding communities and agencies by taking steps to mitigate anthropogenic light within the park and providing opportunities for visitors to enjoy the night sky (NPS 2014). Land-use and population trends for the 30 km area surrounding the preserve (see section 4.1) as well as larger more distant cities will likely further degrade dark night skies in the preserve.

Table 4.2-2. Condition and trend summary for dark night skies at Tallgrass Prairie National Preserve.

Indicator	Condition Status/Trend	Rationale
Anthropogenic Sources of Light (ALR)		Median anthropogenic light ratio value of 0.61 warrants moderate concern. Land-use and population trends for the 30 km area surrounding the preserve as well as larger more distant cities will likely further degrade dark night skies in the preserve.
Dark Night Skies Overall		**Condition warrants moderate concern with a deteriorating trend. Confidence in the assessment is medium.**

4.2.5. Uncertainty and Data Gaps
The ALR provides a robust and quantitative measure of artificial night sky brightness. There is no doubt that the night skies are being influenced by anthropogenic light sources. Repeated measurements and modeling will help gauge changes in the night skies over time.

4.2.6. Sources of Expertise
- Chad Moore, Night Skies Program Manager, NPS Natural Sounds and Night Skies Division.

4.2.7. Literature Cited
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Duriscoe, D.M., P. Cinzano and C.D. Elvidge. 2013 A field-verified indicator of sky quality upon the first world atlas of artificial sky. In review.

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4.3. Soundscape

4.3.1. Background and Importance

Park natural soundscape resources encompass all the natural sounds that occur in parks, including the physical capacity for transmitting those natural sounds and the interrelationships among park natural sounds of different frequencies and volumes (NPS 2006). Visitors to national parks are often highly motivated to experience natural quiet and the sounds of nature (McDonald et al. 1995). Most visitors prefer to hear sounds that are intrinsic to the natural and cultural settings of the parks they are visiting. A growing body of research also documents the biological and behavioral impacts of unnatural and unusual noise on a variety of wildlife (Barber et al. 2010). Many species depend on natural soundscape conditions—free from anthropogenic noise intrusions—to successfully reproduce and survive (Habib et al. 2007, Rabin et al. 2006). In 2000 the NPS issued *Director's Order #47: Soundscape Preservation and Noise Management* "to articulate National Park Service operational policies that will require, to the fullest extent practicable, the protection, maintenance, or restoration of the natural soundscape resource in a condition unimpaired by inappropriate or excessive noise sources" (NPS 2000a). The order established guidelines for monitoring and planning to preserve park soundscapes.

New NPS management policies introduced in 2006 included several directives related to soundscapes, including the affirmation that "The Service will preserve, to the greatest extent possible, the natural soundscapes of parks. The Service will restore to the natural condition wherever possible those park soundscapes that have become degraded by unnatural sounds (noise), and will protect natural soundscapes from unacceptable impacts" (NPS 2006). Excessive anthropogenic noise in NPS units threatens to adversely impact natural and cultural resources and the quality of visitor experiences. The NPS has clearly declared its commitment to protecting intrinsic soundscapes for the enjoyment of current and future generations of park visitors.

TAPR's *General Management Plan/Environmental Impact Statement* (GMP/EIS) identifies several visitor experience goals that "describe what experiences (cognitive, emotional, active, and sensory) should be available for visitors to the preserve" (NPS 2000b, p. 13). Included among these goals are opportunities to experience the resources of the preserve in solitude and the ability to experience a greater personal "sense of place". The final goal states that visitors to TAPR will have the opportunity to "appreciate the special experiences of prairie sights, sounds, skyscapes, views, and feelings during all seasons and times—and during both day and night" (NPS 2000b, p. 14). These management goals clearly prioritize the protection of the preserve's soundscape in a natural condition. The GMP/EIS states that the provision of opportunities for visitors to experience quiet and solitude is a central emphasis of the Prairie Landscape Area management zone (NPS 2000b, p. 39). According to the Plan, "Repeatedly, the public has identified the vistas and views as some of the preserve's most important resources. The relationship of earth and sky, the feeling of vastness, and the openness of the landscape all contribute to a "sense of place." There are very few intrusions on the land" (NPS 2000b, p. 75).

Threats and Stressors

The dirt roads on TAPR are only used for administrative purposes and by the tour bus for public tours from the preserve Headquarters to the Scenic Overlook in Big Pasture. Most visitation on the preserve centers on areas of interest along the K-177 corridor, including the Visitor Center and Spring Hill Ranch Complex, the Lower Fox Creek Schoolhouse, and trails originating from the Spring Hill Ranch area and in the Fox Creek Valley. Most visitors do not hike more than a mile or so from the trailheads. The trails offer solitude, expansive prairie landscape views, and a soundscape dominated by natural sounds for hikers, especially in the central core of the preserve.

Primary threats to the natural soundscape include noise originating from modern transportation within and beyond the preserve's boundaries; from motorized preserve management activities; and from commercial, industrial, urban and exurban development. Aircraft noise is typically one of the most pervasive threats to natural sounds in NPS units. However, at present aircraft noise at TAPR does not appear to be a significant contributor. Major nearby airports include Wichita, Kansas; Kansas City, Missouri; Omaha, Nebraska; and Oklahoma City and Tulsa, Oklahoma. Some of the high elevation air traffic is from trans-continental east-west and north-south routes (FlightAware 2014). There is little regional propeller airplane traffic feeding larger airport hubs (University of Nebraska Omaha 2014). Air and vehicle traffic are projected to significantly increase at regional and national scales (U.S. Department of Transportation 2010, U.S. Department of Transportation 2013). While noise associated with preserve management activities may be minimized over time through the use of best management practices, the transportation and development noise sources are a distinct threat to the natural and historic soundscape of TAPR and the quality of visitor experiences.

A comprehensive examination of landscape context related to landcover/landuse, population and housing, all of which can degrade natural and historic soundscapes, was performed for the area surrounding the preserve and is presented in the *Landscape Context* section within this chapter. These parameters can be highly correlated with ambient sound levels. Therefore changes in these factors can have significant impacts on the soundscape of the preserve.

Indicators and Measures

- Anthropogenic sources of noise – presence/absence and relative noise level
- Traffic volume on US-50 and K-177 and NPS bus tours – vehicle counts
- Anthropogenic sound level impacts (modeled) – minimum, 1st quartile, median, 3rd quartile, maximum

4.3.2. Data and Methods

The condition of the soundscape at TAPR was evaluated based on data provided by the NPS Natural Sounds and Night Skies Division (NSNSD) and other sources. The NSNSD provided results from nation-wide modeling of ambient sound levels to support the condition assessment (Mennitt et al. 2013). Modeling was applied to all NPS units including TAPR and the surrounding region. This analysis permitted estimation of the impact of anthropogenic noise on natural sound levels in the preserve. Staff members were asked to identify natural and human-caused (extrinsic or intrinsic to the preserve's values) sounds present at TAPR. Staff members were also asked to describe the desired soundscape conditions for TAPR, including anthropogenic cultural sounds that could potentially be considered appropriate for the preserve's mission and purpose. Traffic volume data for US-50 and K-177 were obtained from the Kansas Department of Transportation traffic survey studies from 2009 and 2011. Traffic volume data for adjacent roads and highways are summarized in order to provide some context for the analysis of external sources of noise affecting the preserve, as well as the frequency of bus tours operating within the preserve. Qualitative information from TAPR staff is also used in this assessment.

Decibel Scale

Sound pressure levels are often represented in the logarithmic decibel (dB) scale. In this scale, 0 dB is equivalent to the lower threshold of human hearing at a frequency of 1 kHz. This scale can be adjusted to account for human sensitivity to different frequencies of sound, a correction known as A-weighting. A-weighted sound pressure levels are represented in the dBA scale. Examples of common sound sources (both within and outside of park environments) and their approximate dBA values are presented in Table 4.3-1 (Lynch 2009).

Table 4.3-1. Sound pressure level examples from NPS and other settings (Lynch 2009).

Park Sound Sources	Common Sound Sources	dBA
Volcano crater (Haleakala National Park)	Human breathing at 3 m	10
Leaves rustling (Canyonlands National Park)	Whispering	20
Crickets at 5 m (Zion National Park)	Residential area at night	40
Conversation at 5 m (Whitman Mission National Historic Site)	Busy restaurant	60
Snowcoach at 30 m (Yellowstone National Park)	Curbside of busy street	80
Thunder (Arches National Park)	Jackhammer at 2 m	100
Military jet at 100 m AGL (Yukon-Charley Rivers National Preserve)	Train horn at 1 m	120

4.3.3. Reference Conditions

The reference condition for the soundscape in TAPR is one dominated by natural and cultural sounds that are intrinsic to the preserve, such as the sounds of wind, rustling prairie vegetation, running water, birds, insects, amphibians, cattle, and non-motorized sounds associated with ranching and farming. Sounds from the railroad may also be considered culturally relevant to the preserve's "period of significance", but it is likely that the sound, intensity, and frequency of modern railroad activity is different than it was in the early 1900s (K. Hase, personal communication, July 23, 2013). Modern train horns are both louder and more frequent than train horns from the early 1900s. Preserve managers have identified the following natural sound sources that are no longer present in TAPR: bears, elk, pronghorn antelope, wolves, and Rocky Mountain locusts (*Melanoplus spretus*) (K. Hase, personal communication, September 9, 2013). A reference condition rating system for the three soundscape indicators is presented in Table 4.3-2.

Table 4.3-2. Reference condition rating framework for soundscape indicators at TAPR.

Indicator	Good Condition	Warrants Moderate Concern	Warrants Significant Concern
Anthropogenic Sources of Noise	Infrequent, low, or inaudible levels of anthropogenic noise. Annoyance level of visitors low. Recognizes historic train sounds.	Moderately frequent and audible anthropogenic noise. Annoyance level of visitors moderate.	Frequent and highly audible anthropogenic noise. Annoyance level of visitors high.
Road Traffic Volume	Not exceeding current traffic volumes of approximately 700 (K-177) and 3,900 (US-50) vehicles per day; no increase in the proportion of heavy commercial trucks. Based on 2005–2012 data.	5–10% increase in total traffic volume from current baseline; higher proportion of heavy commercial trucks.	>10% increase in total traffic volume from current baseline; higher proportion of heavy commercial trucks.
Anthropogenic Sound Level Impacts	Median impact ≤ 3 dBA (current level) Maximum impact ≤ 7.5 dBA (current level)	Median impact 3–5 dBA Maximum impact 7.5–10 dBA	Median impact ≥ 5 dBA Maximum impact ≥ 10 dBA

4.3.4. Condition and Trend

Anthropogenic Sources of Noise

The following common sources of anthropogenic noise were identified by staff members at TAPR (K. Hase, personal communication, June 21, 2013): train in Strong City; vehicles on surrounding highways; preserve administrative vehicles (including NPS staff, TNC staff, lessee, and researchers); preserve management equipment (including mowers, weed eaters, chainsaws, utility vehicles, and tractors); aircraft; and noise from Strong City. Airplane noise is very minor. Although most areas of the preserve experience infrequent or low levels of anthropogenic noise, the vast majority of visitation activities occur in the K-177 corridor either on trails or in the vicinity of historic resources within 0.25 miles of the paved road. Most residential areas and commercial activities are also associated with US-50 corridor and along K-177. In general, the noise from anthropogenic sources is low and infrequent, although occasional loud and annoying noise, especially from cars, trucks, and trains does occur.

Traffic Volume: US-50, K-177, and TAPR Bus Tours

US-50 follows an east-west development corridor and bisects the southern portion of the preserve. K-177 runs north-south, bisecting the southern half of the preserve. Traffic counts were compiled for the period between 1990 and 2012 (Figure 4.3 -1) to examine current volumes and historic trends (KDOT 2013).

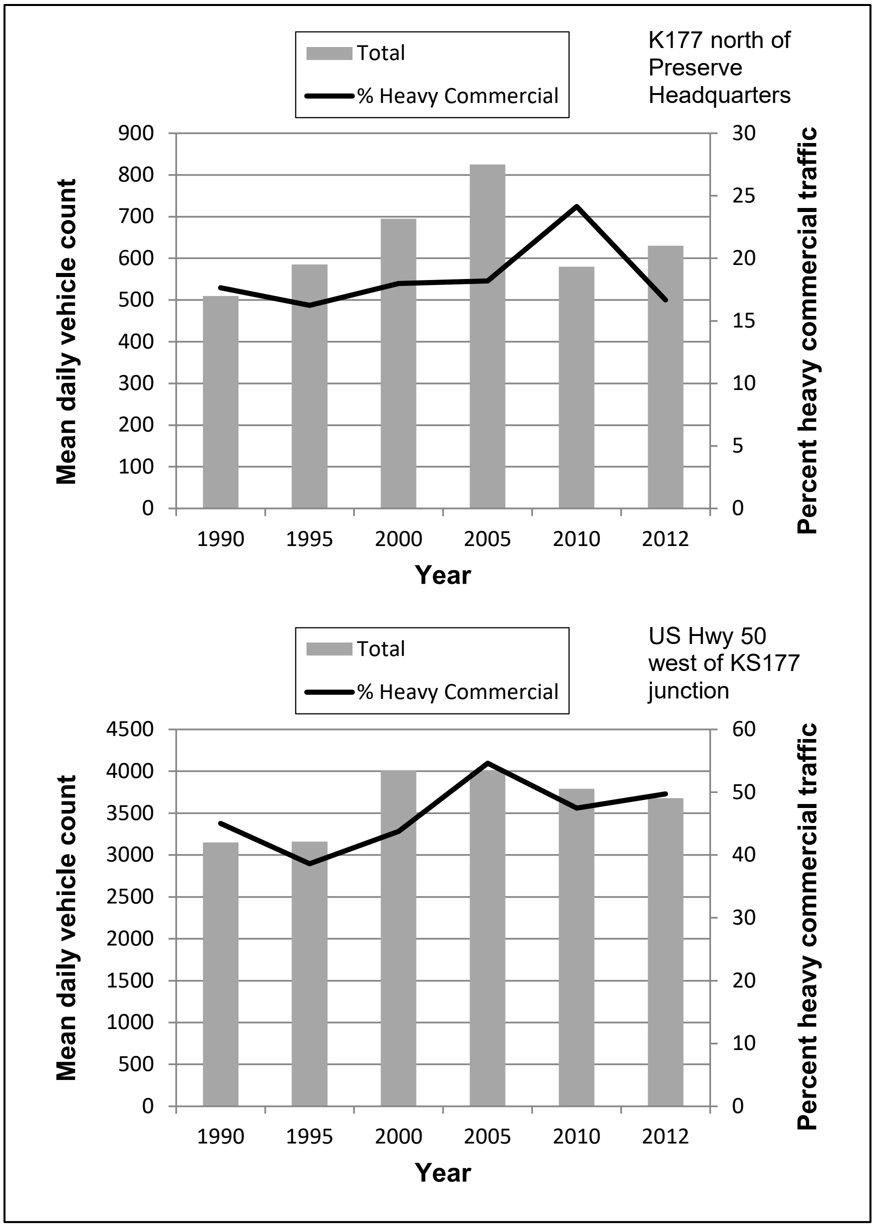


Figure 4.3-1. Mean total daily vehicle counts and percent heavy commercial traffic for K-177 north of the preserve headquarters (top) and US-50 west of the K-177 junction (data source: KDOT 2013).

For the years 2005, 2010 and 2012, K-177 traffic averaged 678 vehicles per day, 20% of which was heavy commercial vehicles. For the same period, US-50 traffic averaged 3827 vehicles per day, 51% of which was heavy commercial vehicles. For the 1990–2012 period, total traffic volume and percent heavy commercial traffic were significantly positively correlated with year (α=0.05) for US-50 but not for K-177.

The Kansas DOT also provided data from a traffic study related to holiday and weekend traffic on the K-177 corridor (S. Shields, personal communication, September 10, 2013). One of the study sites was located on K-177 just north of US-50 near Strong City. Traffic counts were collected during three periods in 2011: 5/12–5/17, 6/2–6/6 (motorcycle rally weekend), and 6/29–7/5 (motorcycle rally and holiday weekend). Average weekday daily traffic volume was 879 vehicles (including 14 motorcycles and 92 trucks). Average weekend daily traffic volume was 925 vehicles (including 33 motorcycles and 24 trucks). The weekend traffic count during the motorcycle rally was 1510 vehicles (including 597 motorcycles and 69 trucks), while the holiday weekend traffic count during the rally was 980 vehicles (including 149 motorcycles and 52 trucks). Traffic counts are summarized in Table 4.3-3.

Table 4.3-3. Traffic study results from K-177 corridor near Strong City (Kansas DOT 2013).

	Average Daily Traffic Volume (Number of Vehicles)		
Time Period	**All Traffic**	**Motorcycles**	**Trucks**
Weekday	879	14	92
Weekend	925	33	24
Weekend (motorcycle rally)	1510	597	69
Holiday Weekend (motorcycle rally)	980	149	52

TAPR managers provided data for the number of bus tours operated in the preserve. The number of bus tours from the last two years is shown in Table 4.3-4.

Table 4.3-4. Number of bus tours operated within TAPR by month, 2012–2013.

Year	April	May	June	July	August	September	October	TOTAL
2013	2	19	24	22	4*	No data	No data	71
2012	4	53	65	58	48	51	45	324

* Tours conducted outside preserve due to washed out roads

Anthropogenic Impacts on Ambient Sound Level

The NSNSD has used acoustic modeling to estimate the anthropogenic impact to the ambient sound level in TAPR, which is the existing sound level minus the estimated natural sound level (Mennitt et al. 2013). Mean impact thus provides a measure of how much anthropogenic noise is increasing the existing sound level above the natural sound level, on average, in the preserve. In TAPR, the mean impact was 2.7 dBA. Additional metrics describing a range of impacts across the landscape of the preserve were also obtained. Minimum impact (minimum sound level impact in the preserve) was 0.6 dBA, 1st quartile impact (25% of points in the preserve have this level or impact or less) was 2.2 dBA, median impact (50% of the preserve has this impact or less) was 2.6 dBA, 3rd quartile impact was 3.3 dBA (75% of the preserve has this impact or less), and maximum impact (maximum impact value inside preserve boundaries) was 7.3 dBA (Table 4.3-5). Modeled mean impacts in the area immediately surrounding TAPR as well as the larger region are shown in Figure 4.3-2. Estimated sound level impacts in the southern and northern ends of the preserve are slightly higher compared to modeled impacts in the central core of the preserve. Therefore, the rating for this indicator is considered good with medium confidence. No trend data is available.

Table 4.3-5. Anthropogenic sound level impacts.

Minimum	1st quartile	Median	3rd quartile	Maximum
0.6 dBA	2.2 dBA	2.6 dBA	3.3 dBA	7.3 dBA

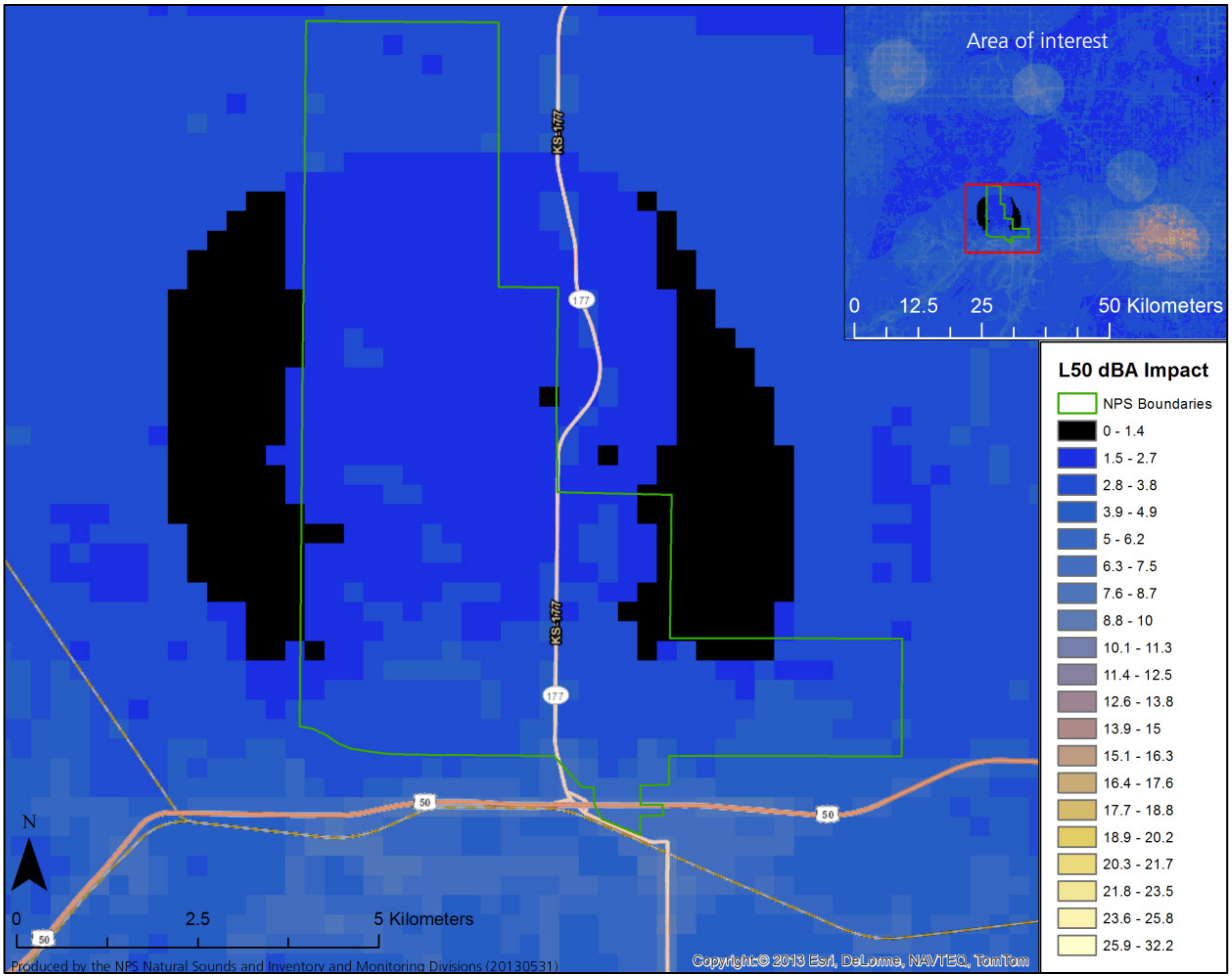


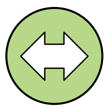
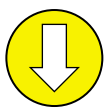
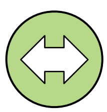
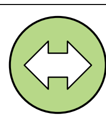
Figure 4.3-2. Modeled mean sound level impacts in the area immediately surrounding TAPR and in the larger region (inset). Graphic provided by NSNSD (May 2013).

For reference in translating sound level impacts into functional effects (for human visitors and resident wildlife), an increase in background sound level of 3 dB produces an approximate decrease in listening area of 50%. In other words, by raising the sound level in TAPR by just 3 dB, the ability of listeners to hear the sounds around them is effectively cut in half. Furthermore, an increase of 5 dB leads to an approximate decrease in listening area of 68%, and an increase of 10 dB decreases listening area approximately 90%.

Overall Condition

Although there are limited quantitative data available to assess the condition of the soundscape in TAPR, the nationwide modeling of anthropogenic sound level impacts indicates that anthropogenic noise is only moderately increasing the existing ambient sound level above the natural ambient sound level of the preserve (mean impact = 2.7 dBA). Based on these modeling estimates, as well as traffic volumes on roads adjacent to the preserve and the number and type of anthropogenic noise sources that are audible within the preserve, the soundscape in TAPR is in good overall condition with an unchanging trend. There are both external and internal threats to the quality of the soundscape in TAPR, but qualitative evidence suggests that the trend in the condition of the soundscape is unchanging. Table 4.3-6 summarizes the status and trend for each of the soundscape and natural sounds indicators. The confidence associated with these ratings is medium due to the limited data available.

Table 4.3-6. Condition and trend summary for soundscape at Tallgrass Prairie National Preserve.

Indicator	Condition Status/Trend	Rationale
Anthropogenic Sources of Noise		Noise from anthropogenic sources is low and infrequent. Occasional louder noise from cars, trucks, and trains does occur.
US-50 and K-177 Traffic Volume		Average daily traffic volume from the K-177 corridor north of Strong City approximates the 2005–2012 average, but US-50 traffic volumes south of the preserve appear to be increasing over the past 20 years with high proportions of heavy commercial traffic. This will impact ambient noise levels in the southern part of the preserve. Bus tours operated within TAPR contribute a negligible amount of traffic noise.
Ambient Sound Level		Anthropogenic noise is only moderately increasing the existing ambient sound level above the natural ambient sound level of the preserve (median impact < 3.0 dBA and maximum impact < 7.5 dBA). The central core of the preserve is only slightly affected by anthropogenic noise.
Soundscape and Natural Sounds Overall		**Soundscape is in good condition, with an unchanging trend. Confidence in the assessment is medium.**

4.3.5. Uncertainty and Data Gaps

No descriptive acoustical monitoring studies have been conducted in TAPR to measure ambient sound levels or the audibility of different intrinsic and extrinsic sound sources in different areas of the preserve. Although limited acoustical monitoring data have been collected in TAPR, studies in similar parks improve the accuracy of the nationwide modeling data that have been applied to TAPR in this report. No evaluative research has been collected to determine the social impacts of existing soundscape conditions on visitor experiences in TAPR.

4.3.6. Sources of Expertise

- Emma Lynch, Acoustical Resource Specialist, NPS Night Skies and Natural Sounds Division
- Kristen Hase, Chief of Natural Resources, Tallgrass Prairie National Preserve
- Heather Brown, Chief of Interpretation, Tallgrass Prairie National Preserve
- Scott Shields, Environmental Scientist, Kansas Department of Transportation

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4.4. Scenery

4.4.1. Background and Importance

Scenery (i.e., visual resources) has important value in terms of historic and cultural context, aesthetics, tourism and human health. Scenery encompasses the visible physical features on a landscape including the land, water, vegetation, structures, animals and other features, and is linked to air quality-related values and dark night skies. The National Park Service Organic Act of 1916 specifies that the NPS shall "conserve the scenery and the natural and historic objects and the wildlife therein and provide for the enjoyment of the same in such manner and by such means as will leave them unimpaired for the enjoyment of future generations." Protection and conservation of scenic resources is also required under other legislation and policies such as the National Environmental Policy Act, Federal Land Policy and Management Act, National Historic Preservation Act, the Clean Air Act and NPS guidance. The current *NPS Management Policies* (NPS 2006) do not provide specific guidance regarding service-wide policies or practices for scenery conservation.

Lower Fox Creek schoolhouse in late summer, Tallgrass Prairie National Preserve (NPS photo).

Within the NPS Midwest Region, scenic views were ranked as the 1st or 2nd most important criteria for visit quality 33% of the time, and rated *extremely* or *very important* by 89% of respondents (Kulesza et al. 2013). Park units generally address visual resource management on a case-by-case basis (Mark Meyer, personal comment August 2013), and effort is increasingly applied to conservation of visual resources as forces and development external to parks impact visual landscapes supporting natural and historic views.

The prairie ecosystem that once covered the tallgrass prairie region is one of horizontal character. Fields of grass extend outward towards the horizon, with only a few trees or other vertical features extending above prairie grasslands and the horizon. Even as settlers converted the prairie to agricultural fields, the horizontal nature of the landscape remained intact. Horizontal manmade elements constitute the greatest inconsistencies in the landscape views from the preserve.

Legislation and planning documents support the importance of conserving scenery at the preserve. The primary legislative intents of the preserve are "to preserve, protect, and interpret for the public an example of a tallgrass prairie ecosystem on the Spring Hill Ranch, located in the Flint Hills of Kansas"; and "to preserve and interpret for the public the historic and cultural values represented on the Spring Hill Ranch." The preserve's *General Management Plan* articulates the desired future for scenic resources on TAPR, which represents the conditions that would be desirable to have in place in order to achieve the purpose of the preserve (NPS 2000). Specific desires include maintaining "open and unobstructed views, an integral part of the prairie experience". The desired future emphasizes that the vistas and views have been repeatedly identified by the public as some of the preserve's most important resources. At TAPR, the relationship of earth and sky, the feeling of vastness (during both day and night), and the openness of the landscape all contribute to a "sense of place." Existing developments should be managed to enhance views (e.g., power lines buried), and future developments should enhance and not detract from this important resource (NPS 2000).

Tallgrass Prairie National Preserve combines quintessential cultural and natural landscape elements, offering opportunities for extraordinary and inspirational scenic views of the Flint Hills prairie landscape. The scenery and context of the preserve are described succinctly by BVHA (2004): "The preserve occupies a splendid and scenic Flint Hills location, representing one of the last areas of native tallgrass prairie remaining on the continent. Its scenic beauty is a byproduct of its geomorphology, geology, and vegetation. Visitors are drawn to its expansive landscape, romantic pioneer associations, and historic ranching traditions, as well as to its value as a managed prairie ecosystem. The preserve's compelling combination—wide blue skies, golden grasses, rock outcrops, historic 19th-century architecture, and rolling hills—holds a unique place in American natural and cultural history."

The preserve was recognized as a National Historic Landscape (NHL) in 1997 for its representation of the transition from the open range to the enclosed holdings of large companies in the 1880s. The NHL period of significance for the preserve is 1878–1904. Landscape features associated with the preserve include several collections of domestic and agricultural buildings, structures, and small-scale features associated with historic ranching operations; a school house; prehistoric and historic archeological resources; stock ponds; former crop fields; cultivated grass pastures; and areas of native tallgrass prairie (BVHA 2004). Although there have been changes to the landscape since that period, the existing ranch continues to represent the NHL period of significance and retains a good deal of integrity. The *Tallgrass Prairie National Preserve Cultural Landscapes Report* (BVHA 2004) assesses preserve significance and integrity, and examines needs and goals associated with providing interpretive opportunities to visitors.

There are NPS initiatives that collectively support park scenery and viewshed conservation, including support for NPS renewable energy and visual resources staff, and development of a Scenery Conservation Program within the NPS Air Resources Division. Other federal agencies such as the Bureau of Land Management, Forest Service and Fish and Wildlife Service also have established or are developing programs to promote scenery conservation. Important components of these initiatives include scenery inventory, evaluation and conservation, with consideration to renewable energy visual impacts and viewshed impacts extending beyond park boundaries.

Threats and Stressors

The vast majority of threats and stressors to the preserve viewscape are related to development and incompatible land uses outside the preserve boundary:

- Air pollution/haze affects visitors' ability to see features, color and detail in distant views.
- Suburban/exurban development.
- Industrial and commercial development along the Highway 50 corridor—large/tall structures are more important than acreage occupied. Industrial development is also related to other incompatible elements such as visible smoke/steam/dust, roads, and commercial signage.
- Other man-made structures, including farms and public buildings that have larger structures (e.g., outbuildings, silos, and storage facilities) and more mechanized equipment relative to the historic reference periods.
- Roads and traffic and associated movement and noise.
- Energy development and infrastructure (e.g., power transmission structures and lines, and wind turbines.
- Communications structures.

Indicators and Measures

- Scenic quality of landscape views
- Housing densities in the surrounding 30 km area
- Potential visibility of new wind turbines
- Air quality – visibility

4.4.2. Data and Methods

Scenery has not been previously evaluated at TAPR. Landscape views are discussed and important views are briefly described in the *Cultural Landscape Report* for the preserve (BVHA 2004), but specific view points and the quality of existing views have not previously been examined. Measures supporting this assessment include both quantitative and qualitative assessments. The assessment framework integrates ground-based measures of scenic quality from key viewpoints, a geospatial analysis of housing density, and air quality visibility information. In this assessment we use the terms scenery, views, and scenic resources interchangeably. The viewshed is the total landscape that can be seen from a particular location, which could be a point, such as a scenic overlook; a line, such a travel route; or an area, such as a lake. Several factors limit the spatial extent of the viewshed from a given viewpoint either in the real world or when using geospatial modeling. These factors include topography, vegetation, manmade structures, target height, viewer height, the curvature of the earth, and atmospheric refraction. The actual visibility of an object is influenced by the viewer's eyesight; the object's size, shape, color, reflectivity, and orientation to the viewer; the lighting that falls on the object; the presence of haze and other factors (DOI 2013).

The preserve previously established 19 photo points to monitor changes in vegetation and other landscape elements. Five of those pre-existing photo points are in the same approximate locations as the views examined in this NRCA: viewpoint 1 corresponds to historic point M, viewpoint 2 corresponds to historic point M, viewpoint 3 corresponds to historic point G, viewpoint 13 corresponds to historic point I, and viewpoint 14 corresponds to historic point L. A comparison of current views with historic photos was not made.

<u>Scenic Quality</u>

Key Viewpoints and Views

A viewpoint is the designated location from which a viewed landscape is evaluated. The viewed landscape or view is the scene the observer is looking at from the viewpoint. Some viewpoints may have several different and distinct views. In some cases a single view may encompass all directions from a viewpoint.

Important viewpoints and associated views were discussed with preserve staff as part of the NRCA scoping process. Significant views noted in the schematics presented in the park's *Cultural Landscapes Report* (BVHA 2004, Figure 78) were discussed and specific viewpoints and views were identified on an aerial photo of the preserve. Several views identified by preserve staff were not visited due to time constraints. Views identified but not visited/evaluated include the northern part of Big Pasture and the central ridge in Crusher Hill pasture (i.e., Crusher Hill). Nine key or primary viewpoints and associated views considered important relative to the preserve's mission and/or having high levels of visitation, and five secondary points/views were evaluated (Figure 4.4-1). Secondary views are located at vantage points at least several hundred meters from a road or trail, along an unmaintained road or trail, or in other locations that would be infrequently visited.

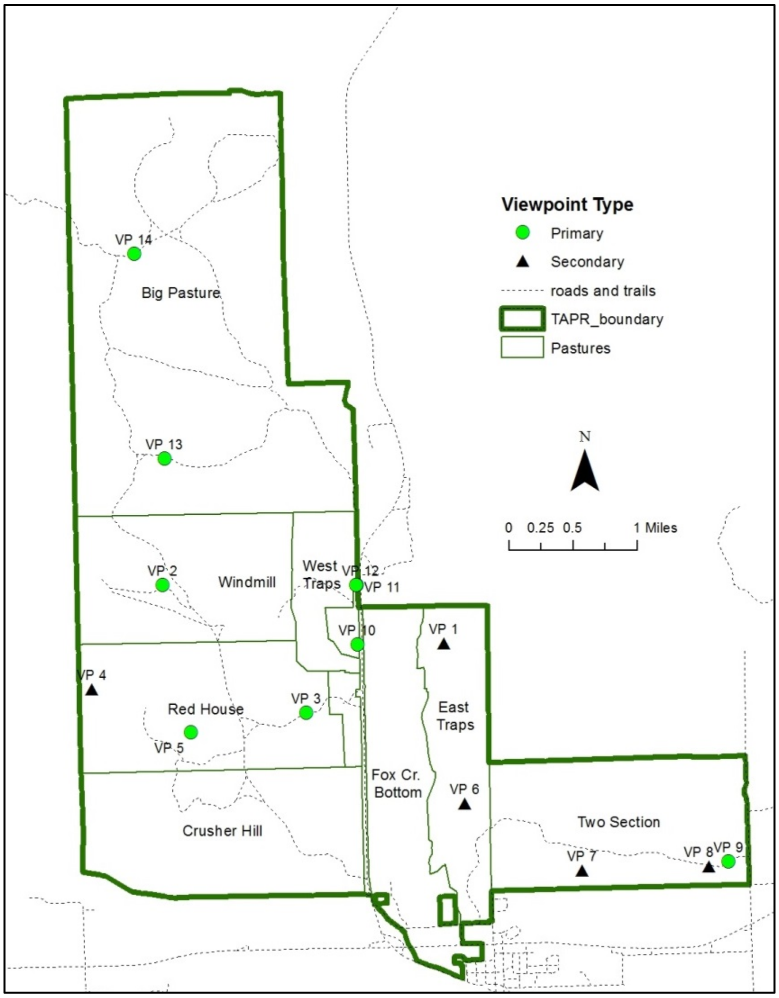


Figure 4.4-1. Location of primary and secondary viewpoints at Tallgrass Prairie National Preserve.

Panoramic photos for the primary and secondary views were taken by CSU staff in July 2013 with a Canon G10 camera using a 50 mm focal length and an image resolution of 14.6 megapixels. Each high-resolution panorama consisted of five to six overlapping photos in a single row that were combined using Gigapan Stitch™ software. Resulting photos had a field of view approximately 80–140 degrees wide and 20–25 degrees tall. Panorama photos with a size of approximately 16,000 x 35,000 pixels were exported as .tiff graphics ranging from 60–100 megabytes in size. Original and stitched panoramic photographs and associated location data will be delivered to the preserve with the NRCA. Several panorama stitches do show minor stitching issues as a result of inadequate reference features in adjacent overlapping photos. This is caused by the relatively homogeneous texture of some expansive prairie views.

Each view was evaluated by CSU staff in July 2013 using methodology developed by the NPS Scenery Conservation Program (SCP), Air Resources Division. Using the SCP methodology, a landscape character type was assigned to each view (NPS Scenery Conservation Program 2014a). Possible types include natural/natural appearing, pastoral, agricultural, rural, suburban, urban and industrial. Primary landscape types present at TAPR are natural/natural-appearing, rural and agricultural landscapes. For each view, landscape character elements were characterized and evaluated within the foreground, middle-ground and background using a streamlined version of the SCP methods.

The distance zones are based on visibility of features rather than specific, fixed distances from the observer (Figure 4.4-2). For the foreground, human scale is most important and the viewer may feel that they are "part of the landscape". Surface features are often visible, colors are distinct and details of human and wildlife activities are most easily observed. For the middle-ground, viewers may feel more like they are looking "at the landscape" rather than "being in it". Patterns and landforms define the view, rather than individual elements. Objects such as trees, shrubs, rock outcrops and houses form a texture or pattern. Details are lost and the outlines of objects are less distinct. Colors become more muted and less distinct at the farther reaches of the middle-ground. The background is characterized by elements being very far away. Texture and patterns have largely disappeared. The horizon and landforms such as mountains dominate the backdrop. In some areas of rolling or mountainous terrain, in heavily vegetated landscapes, or urban settings the background may not be seen at all or it may not have a discernable limit (NPS Scenery Conservation Program 2014a).

Figure 4.4-2. Example of approximate distance zones used in characterizing and evaluating landscape views in the Great Plains (CSU photo).

The scenic quality of each viewed landscape was evaluated based on the assigned landscape character and the assessment of the viewed landscape, and incorporates both natural and cultural considerations. Scenic quality scores were assigned to landscape character integrity, which is based on an evaluation of landscape elements present (landform, land cover, land use and human structures), the quality and condition of those elements, and the presence and type of inconsistent elements in the view. Dominant and secondary elements visible in each distance zone are the main drivers of the scenic quality rating. The conspicuousness of manmade features affects their impact as inconsistent elements within a view (Table 4.4-1).

Table 4.4-1. Characteristics affecting the conspicuousness of human-made features (Struthers et al. 2014).

Characteristic	Less Conspicuous	More Conspicuous
Distance	Distant from the vantage point	Close to the vantage point
Size (height, length, volume)	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

Housing Densities in the Surrounding Area

Houses and their associated utilities and roads commonly degrade the quality of landscape views comprised of natural and/or cultural elements. Housing density data derived from U.S. Census Bureau Data and summarized by the NPS NPScape program were used to examine the distribution and extent of housing density classes within a 30 km area surrounding the preserve. A comprehensive examination of land cover, land use, population and housing density is presented in Section 4.1 of this assessment. The extent and percentage of housing density classes between 1970 and 2050 were examined using development classes described by Theobald (2005): rural (0–0.0618 units/ha), exurban (0.0618– 1.47 units/ha), suburban (1.47–10.0 unit/ha), and urban (> 10.0 units/ha).

Potential Visibility of New Wind Turbines

Background and Impact Considerations

Harnessing the power of the wind has a long history across America's landscape. Factory-made windmills have been used for pumping water on farms since the 1850s (Oklahoma Historical Society 2012). Settlers in the westward expansion used windmills to pump water for use on farms and ranches, and windmills were later an integral part of electrifying rural America (DOE 2014). This continues today, with small to industrial scale wind farms dotting the landscape in areas of favorable wind characteristics. The American Wind Energy Association, a national trade group, reports that as of the end of 2015, there were approximately 1,000 utility-scale wind projects generating over 74,000 megawatts (MW) and over 48,800 wind turbines installed across 40 U.S. states plus Puerto Rico and Guam (AWEA 2016).

The prairie ecosystem that once covered the region is one of horizontal character: fields of grass extend outward towards the horizon, with only a few trees or other vertical features jutting above grass level. Even as settlers converted the prairie to agricultural fields, the horizontal nature of the landscape remained intact. When TAPR was created, the surrounding agricultural lands did not interfere with the distant views and the sense of open, endless prairie. This viewshed is an important resource value for the preserve, as it is for many parks, monuments, and historic sites. Protecting these views from modern intrusion is an important management goal of the preserve (NPS 2000). Furthermore, the development of wind farms and wind turbines within the viewsheds of the preserve is a significant management concern and would be inconsistent with the scenic values of these landscapes (personal comment, Kristen Hase).

Wind turbines (and other associated tall structures, including transmission and meteorological towers) introduce strong vertical elements to the landscape. These structures produce visual contrasts due to the form, color, lines, and movement of turbines and associated infrastructure, including impacts from blinking or static lights (DOI 2013). Moreover, the turbines are so large that the scale is often unbalanced relative to other landscape elements. Distance can attenuate some of the scenic impacts. However, nearby viewers might be unable to ignore the disruption to the viewshed, from the sweep of the rotors, the reflectivity of the surface, or even the shadows cast by the structures as the sun moves across the sky (DOI 2013). The visibility of a wind energy facility or individual turbines is influenced by the distance and orientation of affected location with respect to turbines; rotor size and height of turbines; blade orientation, pitch, and speed (dependent on wind speed and direction); geographic location and sun angle; local topography; presence of screening vegetation; weather/cloud cover; presence of airborne particles/haze and other factors (DOE 2013, DOI 2013). The magnitude of the visual impacts associated with a given wind energy facility would depend on site- and project-specific factors (DOE 2013), including:

- Distance of the proposed wind energy facility from viewers;
- Weather and lighting conditions;
- Size of the facility (i.e., number of turbines) and turbine spacing;
- Size (including height and rotor span) of the wind turbines;
- Surface treatment of wind turbines, the control building, and other structures (primarily color);
- The presence and arrangements of lights on the turbines and other structures;
- Viewer characteristics, such as the number and type of viewers (e.g., hosting landowners, residents, tourists, motorists, and workers) and their attitudes toward renewable energy and wind power;
- The visual quality and sensitivity of the landscape, including the presence of sensitive visual and cultural resources including historic properties;
- The existing level of development and activities in the wind energy facility area and nearby areas, and the landscape's capacity to withstand human alteration without loss of landscape character; and
- The presence of workers and vehicles for maintenance activities.

Because the visual impact can be highly variable with structure characteristics, site and environmental conditions as well as viewer dependent factors, the assessment of some impacts on visual resources is complex and somewhat uncertain. Nonetheless, for nearby viewers, the very large sizes and strong geometric lines of both the individual turbines and a collective array of turbines could dominate views, and the large sweep of moving rotors would tend to focus attention (DOE 2013).

Analysis Approach

A spatial analysis of visibility of wind turbines was completed to examine the impact of potential wind energy farms on scenic views from the preserve. Viewshed analysis support was provided by the NPS Midwest Region Geospatial Support Center. Viewshed analysis produced several spatial data layers: areas where an 80 m tall windmill hub would be visible, areas where a 130 m tall windmill blade would be visible, the percent vertical visibility of the 80 m structure visible from each viewpoint, and a layer showing how many viewpoints would "see" a specific pixel if a wind turbine were located within it. The turbine hub height of 80 m and 100 m rotor diameter height of 130 m represent a "typical" windmill that would produce 2.2–3.0 megawatts. The analysis used a 3 m digital elevation model (some areas used a 10 m model where the 3 m model was unavailable), considered earth curvature, and was performed on bare earth (i.e., did not consider the effects of vegetation or other non-terrain obstructions on observer views). Following guidance in Sullivan et al. (2013), a conservative interpretation suggests that an appropriate radius for visual impact analyses with respect to wind turbines would be 48 km (30 mi), the facilities would be unlikely to be missed by casual observers at up to 32 km (20 mi) and could be major sources of visual contrast at up to 16 km (10 mi). The spatial analysis performed by the NPS Midwest Region did not constrain the hub or rotor visibility distances based on visibility considerations described above, and therefore may overstate visibility beyond the 48 km suggested by Sullivan et al. (2013) for this type of analysis.

This turbine visibility analysis used seven viewpoints regarded by preserve staff to be of significance to the visitor experience (input provided by Kristen Hase). Each 10 meter pixel within the 80 meter height viewshed was analyzed to determine how many viewpoints would be able to see a turbine hub at that particular pixel, with the result being between zero and seven (the minimum and maximum number of viewpoints able to "see" each pixel). This number was then converted to a "Pixel Visibility Category" with a green, yellow, or red rating based on the NRCA framework. If a pixel were visible to between zero and two viewpoints, a green, or "Low Visibility" rating was given. For pixels with between three and five viewpoints affected, a yellow, or "Moderate Visibility" rating was given. Any pixel visible by six or seven viewpoints was given a "High Visibility" rating and colored in red.

Air Quality – Visibility

Visibility can affect view condition by limiting the distance and clarity of the observed views. Poor visibility due to air quality degradation can reduce the quality and integrity of landscape views over time. Condition and trends in air quality attributes are examined in more detail in Section 4.7 of this report.

Visibility is measured using the Haze Index in deciviews (dv). Visibility conditions are the difference between average current visibility and estimated average natural visibility, where the average natural visibility is the mean between the 40th and 60th percentiles (NPS ARD 2013a). Five-year interpolated averages are used in the contiguous US.

4.4.3. Reference Conditions

Considerations for both scenic and historic integrity at the preserve are integrated within the scenic quality evaluation. The reference state is based on a range of natural conditions and historic/cultural elements that would have existed in the period referenced by the preserve's mission. Generally, the historic landscape representing the late 1800s would have been characterized by open vistas dominated by grazed tallgrass prairie; farm fields, pastures and hay fields near the Spring Hill Ranch complex and in the Fox Creek bottoms; occasional patches of shrubs; woodland corridors along perennial streams; and occasional small towns. There would have been infrequent farmsteads nearby having one or more small buildings, livestock, and gardens. Occasional stock ponds and watering tanks, fences and gates, fencerows, corrals, and occasional dirt roads would have been present.

Many of the inconsistent elements consist of strong vertical features that make them highly conspicuous. Inconsistent landscape elements within views can be inside or outside the preserve. Examples of inconsistent landscape elements common to the region include:

- Paved roads and high density of dirt roads and/or high traffic volumes;
- Urban, suburban and exurban development;
- Rural homes that are not farms;
- Industrial-era farm structures and equipment (e.g., large silos, tractors, other mechanized machinery);
- Energy and communication infrastructure, including wind turbines, electrical and phone transmission lines, and communication towers such as cell phone towers;
- Fencing that uses modern designs and higher densities that are inconsistent with the historic period of interest;
- Commercial and industrial structures;
- Car and truck traffic;
- Commercial advertisement elements such as billboards and excessive signage;
- Vegetation that is inconsistent with the reference condition and landscape character type (e.g., trees within upland prairie); and
- Some preserve structures and infrastructure.

A summary of reference conditions and condition class rating for scenic quality, housing density, and visibility indicators is shown in Table 4.4-2, Table 4.4-3, and Table 4.4-4, respectively.

Table 4.4-2. Condition rating framework for scenic quality at Tallgrass Prairie National Preserve (modified from NPS Scenery Conservation Program 2014b).

Component	Significant concern	Moderate Concern	Good Condition
Landscape Character Elements	Few important character elements are plainly visible and/or many important elements are missing.	Some important landscape features are present, but some important elements are missing.	Most or all important elements of the designated landscape character are plainly visible (e.g., natural features, land use types, structures, etc.).
Quality and Condition of Elements	Most elements are of poor quality and/or in poor condition. Many or most natural-appearing elements are poor examples of the idealized features. Built elements appear to be of poor quality, or are not well cared for.	Most elements are of fair quality and/or in fair condition. Some natural-appearing elements such as vegetation may not all appear to be healthy or vigorous or may be outside of the natural range of variability expected; lakes and rivers may appear polluted or littered with debris. Some built elements may be of lower quality, are of unfinished construction, or not well cared for.	Most elements are of high quality and in good condition, such as a diverse native prairie, a robust healthy forest, or a lake with clean water and a natural-looking shoreline, but natural cycles and stress agents within the natural range of variability are acceptable. Built elements use appropriate materials, designs, and finishes and appear to be well cared for.
Inconsistent Elements	Many or major inconsistent elements are plainly visible and may be dominant features in the view.	Some inconsistent landscape character elements are plainly visible.	Only a few minor inconsistent landscape character elements such as industrial facilities in a natural landscape or suburban housing developments in an agricultural landscape are plainly visible.

Table 4.4-3. Condition class descriptions for housing densities (modified from Struthers et al. 2014).

Condition Class	Description
Good	Undeveloped or rural, agricultural (farm and ranch) housing dominates. Housing densities are primarily < 0.07 units /ha. Small concentrated areas of higher densities may exist, but usually not in proximity to the observation point and are relatively inconspicuous.
Moderate Concern	Housing densities are more prominent in the landscape and are generally exurban in character with densities between 0.07 and 1.5 units/ha, but the scenic and historic values are largely maintained.
Significant Concern	Higher density housing generally falls within the suburban class (>1.5 to 10 units/ha) or more dense classes, such that the scenic and historic value is either lost or close to being lost.

Table 4.4-4. Condition rating framework for visibility (NPS ARD 2013b).

Condition Class	Visibility
Good	<2 dv
Moderate Concern	2–8 dv
Significant Concern	>8 dv

4.4.4. Condition and Trend

Scenic Quality from Primary and Secondary Viewpoints

Scenic quality was evaluated for nine primary and five secondary views. Some views were classified as having more than one viewed landscape character type. Most prairie views had natural/natural appearing landscapes in all portions of the view, with occasional historic, rural, agricultural, and urban/exurban character elements in the middle ground and background. A description of each view is presented below.

Primary Views

Viewpoint 2: Windmill Pasture to east, south and west

This viewpoint is located on a high point several hundred meters west of the Overlook Road in west-central Windmill Pasture in the vicinity of TAPR photo point H. The point requires foot travel and provides more expansive views than those obtained from the road nearby. This point takes in much of the scenery viewed from the road by visitors engaging in bison tours in Windmill Pasture. Main views are to the east, south (Figure 4.4-3) and west (Figure 4.4-4). Views to the north are flatter and less expansive. The landscape character type is natural/natural appearing. The view directions examined are dominated by prairie vegetation in the foreground, middle ground and background. Some woodland patches are visible in the middle ground and background. Portions of Fox Creek woodlands can be seen to the east and southeast. Visible anthropogenic elements include the Fox Creek Schoolhouse to the east and distant structures to the south outside the boundary near Strong City. Looking south, there is some evidence of old erosion in the drainage. Photographs looking east did not stitch properly but individual photos are available. Bison are often part of the view in this area.

Figure 4.4-13. Panoramic view from Gas House Pasture (now Big Pasture) Overlook looking northeast (viewpoint 13, view "Gas House Overlook to northeast and south"). CSU Photo July 2013.

Figure 4.4-14. Panoramic view from Gas House Pasture (now Big Pasture) Overlook looking south (viewpoint 13, view "Gas House Overlook to northeast and south"). CSU Photo July 2013.

Viewpoint 14: West Branch to northwest, northeast and southeast

This viewpoint is on a high point along a maintained gravel trail in West Branch Pasture (now Big Pasture). The point is in the vicinity of TAPR photo point L. The point provides expansive prairie views within the heart of the preserve. Main views are to the northwest (Figure 4.4-15), northeast (Figure 4.4-16) and southeast (Figure 4.4-17). The landscape character type is natural/natural appearing. The view is dominated by prairie vegetation in the foreground, middle ground and background. Scattered trees and occasional woodland patches are visible in the middle ground, especially in the Palmer Creek drainage. No stock ponds are visible. Woodlands in the Fox Creek bottom are

Center. The background is dominated by rolling prairie. Some woodland patches are visible in the prairie and forested patches are visible in the Fox Creek bottom. A few inconsistent modern elements including a communications tower to the southeast are visible in the background but are inconspicuous. There is some evidence of old erosion in drainages.

Figure 4.4-5. Panoramic view from eastern Red House Pasture looking northeast (viewpoint 3, view "Red House to northeast and southeast"). CSU Photo July 2013.

Figure 4.4-6. Panoramic view from eastern Red House Pasture looking southeast (viewpoint 3, view "Red House to northeast and southeast"). CSU Photo July 2013.

Viewpoint 5: Red House spring to southwest

This viewpoint is located on a high point northeast of Red House Spring and accessed by a maintained two-track trail that continues to the spring area. Main views are to the south and west overlooking Red House Spring and the surrounding area (Figure 4.4-7). The landscape character type is natural/natural appearing with some agricultural elements (i.e., fences). Prairie vegetation dominates in the foreground. The middle ground includes scattered individuals and groves of cottonwoods and other mesic deciduous trees in the spring area and in the drainage bottom. The background is dominated by rolling prairie on the horizon and distant woodlands along the Cottonwood River and its tributaries to the south. There is some evidence of old erosion along drainages and old ranch roads. The cottonwood grove and scattered trees appear to be inconsistent elements that may not have been present during the historic period.

Figure 4.4-7. Panoramic view from Red House Pasture looking southwest across Red House Spring area (viewpoint 5, view "Red House Spring to southwest"). CSU Photo July 2013.

Viewpoint 9: Two Section Pasture (east) to east

This viewpoint is located on a high point along a main gravel road in the southeast corner of Two Section Pasture. The main view is to the east (Figure 4.4-8). The landscape character type is rural. Prairie vegetation dominates on the preserve in the foreground. The middle ground includes an old farm, a newer ranchette, a private pond, a dirt road, a commercial trucking/storage facility, a preserve parking lot and wooded areas along Stout Run. The background is dominated by rolling prairie, scattered woodlands, rural development and modern agricultural structures such as a feedlot complex along Old Highway 50. Inconsistent background elements are less conspicuous than those in the foreground and middle ground.

Figure 4.4-8. Panoramic view from Two Section Pasture looking east off the preserve (viewpoint 9, view “Two Section (east) to east”). CSU Photo July 2013.

Viewpoint 10: Ranch House front yard to east

This viewpoint is located in the front yard of the Spring Hill Ranch House. The main view overlooks Fox Creek bottoms and prairie-covered hills to the east (Figure 4.4-9). The landscape character type is a mixture of natural/natural appearing, rural and agricultural types. The foreground is dominated by the house yard and fence, mowed area, road shoulders and State Highway 177. The middle ground includes hay pastures and Fox Creek woodlands. The background is dominated by prairie-covered hills on the horizon. Inconsistent elements include the paved state highway, large mowed area between the house and road, phone/electric poles and lines in the middle ground, scattered trees in upland prairie including on the skyline, and several communications towers on the ridge to the southeast. Inconsistent elements in the background are relatively inconspicuous due to their distance from the viewpoint.

Figure 4.4-9. Panoramic view from the front of the Spring Hill Ranch House looking east (viewpoint 10, view “Ranch House front yard to east”). CSU Photo July 2013.

Viewpoint 11: Lower Fox Creek School to northeast and southeast

This viewpoint is located on the east side of the Lower Fox Creek School. Main views overlook the Fox Creek bottoms and prairie-covered hills to the northeast (Figure 4.4-10), east and southeast (Figure 4.4-11). Lands to the east and northeast are outside the preserve boundary and privately owned. The landscape character type is a mixture of natural/natural appearing, rural and agricultural types. The foreground is dominated by prairie vegetation including a high diversity of native forbs, a stone fence, gravel access road and State Highway 177. The middle ground includes hay pastures and Fox Creek woodlands. The background is dominated by prairie-covered hills and woodlands on the horizon. Inconsistent elements include the paved state highway, phone/electric poles and lines, a Port-a-John in the parking area, scattered trees in upland prairie including on the skyline, and several communications towers on the distant ridge to the southeast. Inconsistent elements in the background are relatively inconspicuous due to their distance from the viewpoint.

Figure 4.4-10. Panoramic view from the front of the Lower Fox Creek School looking northeast (viewpoint 11, view “Fox Creek School to northeast and southeast”). CSU Photo July 2013.

Figure 4.4-11. Panoramic view from the front of the Lower Fox Creek School looking southeast (viewpoint 11, view “Fox Creek School to northeast and southeast”). CSU Photo July 2013.

Viewpoint 12: Lower Fox Creek School to west

This viewpoint is located at the rear of the Lower Fox Creek School. The main view is to the west (Figure 4.4-12). The landscape character type is natural/natural appearing with a few agricultural elements. The foreground is dominated by prairie vegetation including a high diversity of native forbs, a stone pile, a T-post fence, ranch road gate and scattered shrubs. The middle ground includes rolling prairie and scattered clumps of trees in the drainage. The background is dominated by prairie-covered hills to the horizon. Inconsistent elements include scattered groves of trees and a rock pile.

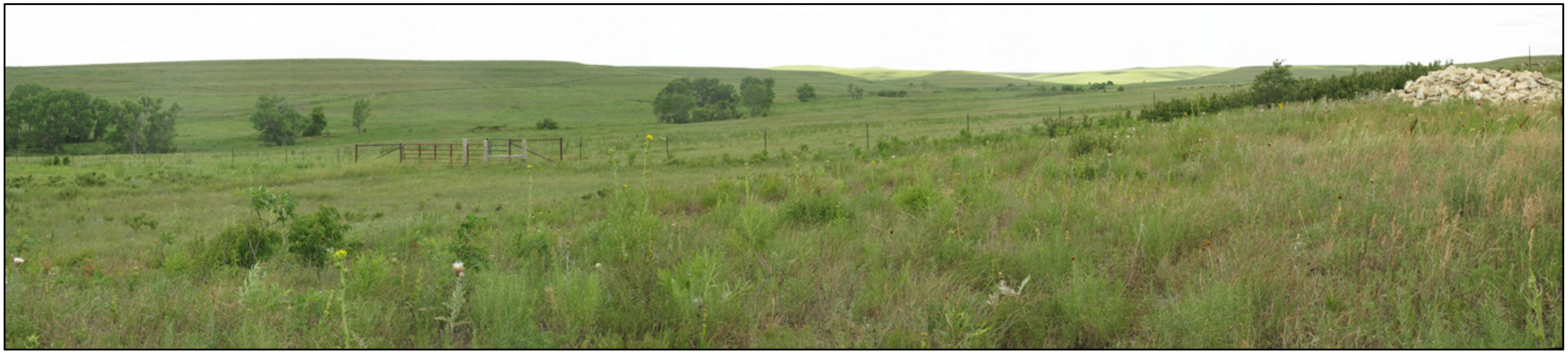


Figure 4.4-12. Panoramic view from the rear of the Lower Fox Creek School looking west (viewpoint 12, view “Fox Creek School to northeast and southeast”). CSU Photo July 2013.

Viewpoint 13: Gas House Scenic Overlook to northeast and south

This viewpoint is on a high vantage point at the loop at the terminus of the Overlook Trail preserve bus tour in Gas House Pasture (now Big Pasture). The point is in the vicinity of TAPR photo point I. The point provides expansive prairie views within the heart of the preserve and is accessed via the bus tour or on foot from the Headquarters/ranch area. Main views are to northeast (Figure 4.4-13) and south (Figure 4.4-14). The landscape character type is natural/natural appearing. The view is dominated by prairie vegetation in the foreground, middle ground and background. Scattered trees and occasional woodland patches are visible in the middle ground and background in the Palmer Creek and Gas House Creek drainages. One stock pond is visible to the east. Woodlands in the Fox Creek bottom are visible in parts of the background. The Lower Fox Creek School is visible by the discerning viewer near the horizon to the southeast. A few inconspicuous small farm and rural structures are visible on private lands in the distance to the east and northeast. More structures and several communications towers are visible to the south in and around Strong City and along the Highway 50 corridor.

Figure 4.4-13. Panoramic view from Gas House Pasture (now Big Pasture) Overlook looking northeast (viewpoint 13, view "Gas House Overlook to northeast and south"). CSU Photo July 2013.

Figure 4.4-14. Panoramic view from Gas House Pasture (now Big Pasture) Overlook looking south (viewpoint 13, view "Gas House Overlook to northeast and south"). CSU Photo July 2013.

Viewpoint 14: West Branch to northwest, northeast and southeast

This viewpoint is on a high point along a maintained gravel trail in West Branch Pasture (now Big Pasture). The point is in the vicinity of TAPR photo point L. The point provides expansive prairie views within the heart of the preserve. Main views are to the northwest (Figure 4.4-15), northeast (Figure 4.4-16) and southeast (Figure 4.4-17). The landscape character type is natural/natural appearing. The view is dominated by prairie vegetation in the foreground, middle ground and background. Scattered trees and occasional woodland patches are visible in the middle ground, especially in the Palmer Creek drainage. No stock ponds are visible. Woodlands in the Fox Creek bottom are visible in parts of the background, as are several inconspicuous sections of State Highway 177. A few inconspicuous structures and several communications towers are barely visible to the south in and around Strong City and along the Highway 50 corridor.

visible in parts of the background, as are several inconspicuous sections of State Highway 177. A few inconspicuous structures and several communications towers are barely visible to the south in and around Strong City and along the Highway 50 corridor.

Figure 4.4-15. Panoramic view from West Branch Pasture (now Big Pasture) looking northwest (viewpoint 14, view "West Branch to northwest, northeast and southeast"). CSU Photo July 2013.

Figure 4.4-16. Panoramic view from West Branch Pasture (now Big Pasture) looking northeast (viewpoint 14, view "West Branch to northwest, northeast and southeast"). CSU Photo July 2013.

Figure 4.4-17. Panoramic view from West Branch Pasture (now Big Pasture) looking southeast (viewpoint 14, view "West Branch to northwest, northeast and southeast"). CSU Photo July 2013.

Secondary Views

Viewpoint 1: East Traps (north) to north, west and south

This viewpoint is located on a ridge on the east side of Fox Creek valley in the vicinity of TAPR photo point M. Access to the vantage point is approximately 500 m by foot from an old ranch road that climbs out of Fox Creek towards the east. The view overlooks the Fox Creek valley and prairie covered hills to the north (Figure 4.4-18), west (Figure 4.4-19) and south (Figure 4.4-20). The landscape character type is a mixture of natural/natural appearing and agricultural types. The foreground and middle ground are dominated by prairie vegetation and Fox Creek woodlands and pastures. The background is dominated by prairie-covered hills and woodlands on the horizon, and also contains the Visitor's Center and the historic ranch complex. The Lower Fox Creek School is barely visible across the valley to the northwest. Inconsistent elements include small sections of the paved State Highway 177, scattered trees in upland prairie including on the skyline, several communications towers on the distant ridge to the south, and several structures visible south of the preserve west of highway 177. Inconsistent elements in the background are relatively inconspicuous due to their distance from the viewpoint.

Figure 4.4-18. Panoramic view from East Traps Pasture (north) looking north (viewpoint 1, view “East Traps (north) to north, south and west”). CSU Photo July 2013.

Figure 4.4-19. Panoramic view from East Traps Pasture (north) looking west (viewpoint 1, view "East Traps (north) to north, south and west"). CSU Photo July 2013.

Figure 4.4-20. Panoramic view from East Traps Pasture (north) looking south (viewpoint 1, view "East Traps (north) to north, south and west"). CSU Photo July 2013.

Viewpoint 4: Red House west boundary north and west

This viewpoint is located on a ridge accessed via an unmaintained ranch road that follows the ridge beyond Red House Spring. Main views are off the preserve to the north and west (Figure 4.4-21). The landscape character type is natural/natural appearing. The view directions examined are dominated by prairie vegetation in the foreground, middle ground and background. Visible anthropogenic elements include one small farm to the west and a communications tower to the southwest. Both structures are inconspicuous. A stock pond is in the middle ground. Photographs looking north did not stitch properly but individual photos are available.

Figure 4.4-21. Panoramic view from the west side of Red House Pasture looking west (viewpoint 4, view “Red House west boundary north and west”). CSU Photo July 2013.

Viewpoint 6: East Traps (south) to south

This viewpoint is located on a ridge on the east side of Fox Creek valley northwest of the Two Section Corrals along the Fox Creek Tributary. Access to the vantage point is approximately 500 m by foot from the corrals gate. The view overlooks the Fox Creek tributary coming into Fox Creek from the east and the Lower Fox Creek valley (Figure 4.4-22). The landscape character type is a mixture of natural/natural appearing and agricultural types. The foreground and middle ground are dominated by prairie vegetation and Fox Creek woodlands, pastures and prairie restoration areas. The background is dominated by prairie-covered hills. Inconsistent elements include small sections of the paved State Highway 177, water treatment/settling ponds, scattered trees in upland prairie, two communications towers on both the ridge to the south and to the southeast, and several structures visible south of the preserve west of highway 177. Inconsistent elements in the background are relatively inconspicuous due to their distance from the viewpoint.

Figure 4.4-22. Panoramic view from East Traps Pasture looking south (viewpoint 6, view "East Traps (south) to south"). CSU Photo July 2013.

Viewpoint 7: Two Section (south) to southwest

This viewpoint is located in the head of a drainage in south-central Two Section Pasture. Access to the point is approximately 500 m by foot from main east-west Two Sections Pasture road. The view extends outside the preserve towards the developed Strong City (Figure 4.4-23). The landscape character type is a mixture of natural/natural and rural types. The foreground and middle ground are dominated by prairie vegetation and with scattered clumps of trees and shrubs in the drainage bottom. The background contains prairie-covered hills, Fox Creek and Cottonwood River woodlands, several inconspicuous communications towers, and structures including residences, a church and electric power poles/lines. Two large communications towers visible to the south are highly conspicuous and inconsistent elements.

Figure 4.4-23. Panoramic view from Two Section Pasture looking southwest (viewpoint 7, view "Two Section (south) to southwest). CSU Photo July 2013.

Viewpoint 8: Two Section (southeast) to south

This viewpoint is located along a narrow ridgeline in eastern Two Section Pasture just west of viewpoint 9 along the maintained road. The view extends outside the preserve to the south (Figure 4.4-24). The landscape character type is a mixture of natural/natural and pastoral. The foreground is prairie vegetation. Grazing cattle were present when the view was evaluated. The middle ground also contains prairie vegetation, scattered trees, trees along a fencerow, and a small farm. The background is relatively hazy, dominated by woodlands, prairie vegetation and scattered developed areas/structures. One inconspicuous communications tower is visible to the southwest. The prevalence of trees in the view is considered inconsistent with the landscape character type.

Figure 4.4-24. Panoramic view from Two Section Pasture looking southwest (viewpoint 8, view “Two Section (south) to south). CSU Photo July 2013.

All views were evaluated and assigned a scenic quality rating (Table 4.4-5) using the criteria in Table 4.4-2. Most views are expansive and emphasize a large-scale tallgrass prairie landscape with few modern intrusions. All but one primary view received a good scenic quality rating. Views are tightly linked to the preserve mission and purpose. The scenic quality of secondary views varied from good to moderate concern. Views extending outside the preserve to the south, especially those including the Highway 50 developed corridor near Strong City, had the lowest ratings due to the conspicuousness of inconsistent elements such as rural and exurban housing, commercial development and communications towers. The overall rating for scenic quality is good with an unchanging trend. Confidence in the assessment is high due to the consistent high quality of the views and buffered landscapes that are not anticipated to be appreciably developed in the near future.

Table 4.4-5. Summary of primary and secondary view scenic quality condition ratings at Tallgrass Prairie National Preserve.

View Type	Viewpoint/View	Landscape Character Elements	Quality and Condition of Elements	Inconsistent Elements	Scenic Quality Rating
Primary or Key Views	Viewpoint 2: Windmill to E, S and W	good	good	good	good
	Viewpoint 3: Red House to NE and SE	good	good	good	good
	Viewpoint 5: Red House spring to SW	–	good	good	good
	Viewpoint 9: Two Section Pasture (east) to E	moderate concern	moderate concern	moderate concern	moderate concern
	Viewpoint 10: Ranch House front yard to east	good	good	moderate concern	good
	Viewpoint 11: Fox Creek School to NE and SE	good	good	moderate concern	good
	Viewpoint 12: Fox Creek School to W	good	good	good	good
	Viewpoint 13: Gas House Overlook to NE and S	good	good	good	good
	Viewpoint 14: West Branch to NE, NW and SE	good	good	good	good
Secondary Views	Viewpoint 1: East Traps (north) to N, S and W	good	good	good	good
	Viewpoint 4: Red House W boundary N and W	good	good	good	good
	Viewpoint 6: East Traps (south) to S	good	good	good	good
	Viewpoint 7: Two Section Pasture (south) to SW	good	good	significant concern	moderate concern
	Viewpoint 8: Two Section (southeast) to S	moderate concern	moderate concern	moderate concern	moderate concern

<u>Housing Densities</u>

Housing density in the region surrounding the preserve does not show marked patterns of change between 1970 and 2010 (Table 4.4-6). Within a 30 km radius of the preserve, the most notable trend is an increase in exurban areas and a corresponding decrease in rural acreage. There is an increase in the acreage of suburban areas but the major change in housing density is associated with the existing urban center of Emporia. However, there is also a pattern of increasing exurban housing density in unincorporated areas close to major roads. These general patterns of change are projected to continue through 2050. The degree of change from rural to exurban and suburban acreage appears to be small compared to other parks in the region. The extent of commercial acreage within the 30 km area has remained steady at approximately 395 acres (0.47% of the area) and is not forecast to change between now and 2050.

Table 4.4-6. Housing density classes within 30 km of Tallgrass Prairie National Preserve (1970–2050) (data provided by NPS NPScape Program).

Census Year	Rural (0–0.0618 units/ha)		Exurban (0.062–1.47 units/ha)		Suburban (1.47–10.0 units/ha)		Urban (>10.0 units/ha)	
	Acres	% of Area	Acres	% of Area	Acres	% of Area	Acres	% of Area
1970	81,155	96.32%	2,414	2.87%	255	0.30%	33	0.04%
1980	79,260	94.07%	4,253	5.05%	298	0.35%	48	0.06%
1990	78,589	93.28%	4,893	5.81%	318	0.38%	58	0.07%
2000	78,153	92.76%	5,355	6.36%	332	0.39%	64	0.08%
2010	78,003	92.58%	5,477	6.50%	335	0.40%	65	0.08%
2020	77,665	92.18%	5,808	6.89%	341	0.40%	66	0.08%
2030	77,523	92.01%	5,948	7.06%	343	0.41%	66	0.08%
2040	77,501	91.98%	5,969	7.08%	344	0.41%	66	0.08%
2050	77,485	91.97%	5,984	7.10%	344	0.41%	66	0.08%

Locally, there is little acreage protected from development by virtue of ownership but some conservation easements do exist. Although the housing density is predominantly rural, small concentrated areas of higher densities exist close to the preserve, are visible from some primary and secondary view points, and are relatively conspicuous. Based on the current extent of these housing density categories and forecast change, this indicator is currently in good condition with regard to impacts on views, with a slightly deteriorating trend and a moderate level of confidence. Additional details are presented in the *Land Cover and Land Use* chapter of this assessment.

<u>Potential Visibility of New Wind Turbines</u>
Wind power generating facilities in the counties surrounding TAPR range from single turbines generating less than one megawatt to farms of 100 turbines generating over 100 megawatts of power (e.g., Elk River Wind Farm) (Figure 4.4-25). Fortunately, despite the proximity to the preserve, the 80 meter hubs and the 130 meter blades of these turbines are not visible from the preserve due to regional topography.

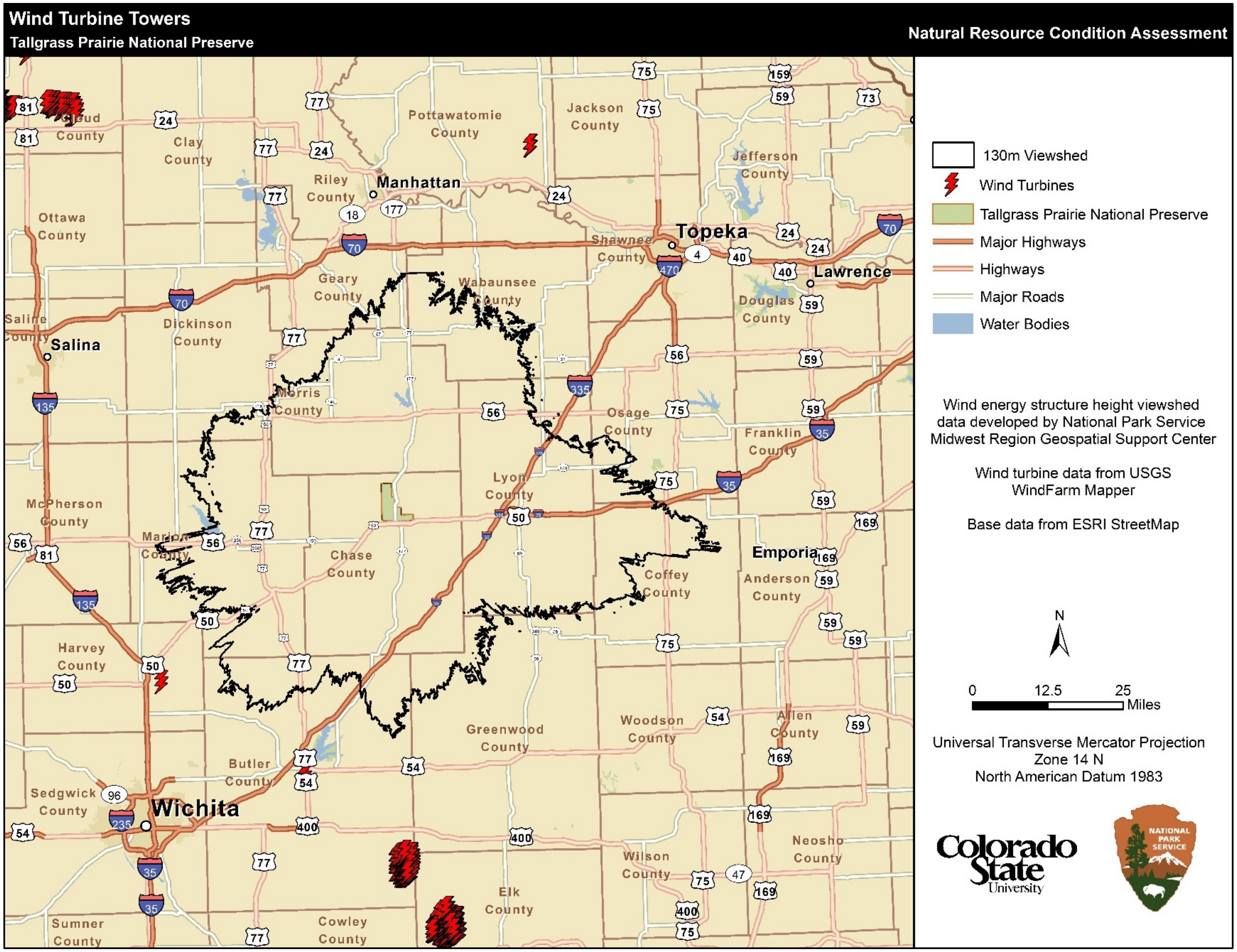


Figure 4.4-25. Existing wind turbine projects in the vicinity of TAPR and distance in which 130 structures would be seen from TAPR. Data from USGS WindFarm Mapper and NPS Midwest Region Geospatial Support Center.

With average annual wind speeds between 6.5 and 8.0 m/s, the area surrounding the park has suitable and attractive wind resources for electricity production (DOE 2014). With assistance from the NPS Midwest Region Geospatial Support Center, the potential visibility of 80 m tall and 130 m tall wind turbine structures from viewpoints within the park were examined relative to the National Renewable Energy Laboratory (NREL) wind suitability data layer (Figure 4.4-26). The analysis addresses the following questions: 1) where would construction of wind turbines potentially affect views from the park?, 2) How much of the area falls within suitable wind energy production areas in the context of future wind farm development, and 3) are there projects proposed or in development that may impact views from important park view points?

Results show that 80 m turbine hubs could potentially be seen on a total of about 1,585,724 acres; 130 m tall rotor blades could potentially be seen on a total of about 2,293,087 acres. Eighty-meter tall turbines would be visible approximately 45 miles to the east, 30 miles to the south, 22 miles to the west, and almost 30 miles to the north, while rotor blades (130 miles) would be visible for approximately 1–10 additional miles in any direction (Figure 4.4-26).

The viewshed area in the south end of the park is generally classified by NREL as having good wind power potential. Most of the visible area to the west, north, and east is generally classified by NREL as having fair wind power potential (Figure 4.4-26). The spatial data in Figure 4.4-26 is summarized in Table 4.4-7. Over 75% of the area where 80 m and 130 m blade rotors turbines would be visible falls in the fair to excellent wind suitability classes. This indicates that there is significant potential for future wind farm development to affect key park views, especially to the south.

As of 2016, there are three proposed wind projects within the viewshed of TAPR. The Doyle North 1 and 2 Wind Projects, in Marion County west and southwest of the town of Florence near the intersection of Highways 50 and 77, were issued Conditional Use Permits from Marion County in 2010 and 2011. These projects could have up to 99 turbines and 260 MW capacity combined. A Conditional Use Permit for Doyle A north and west of Florence, an expansion of the Doyle North Project, was applied for by Windborne Energy, Inc. from Marion County in January 2015. Although site preparations have begun at several turbine locations, the future of the Doyle wind farm complex is uncertain. The other project is the Reading Wind Project in eastern Lyon County and western Osage County south of the town of Reading, proposed by Renewable Energy Systems Americas, Inc. (RES Americas), could encompass 25,000 acres and produce as much as 250 MW. RES Americas has erected two meteorological towers and will be completing a year-long study of wind conditions in spring 2017 (KEIN 2016). A commercial wind farm was proposed by FPL Energy in the early 2000s for west-central Chase County, but the project was not granted required county approvals and is not anticipated to move forward (KEIN 2016).

The exact locations and proposed footprints of these large commercial-scale wind developments are unknown. The Doyle Project area is approximately 45 km west of the center of the preserve, while the Reading Project area appears to be over 50 km east of the center of the preserve

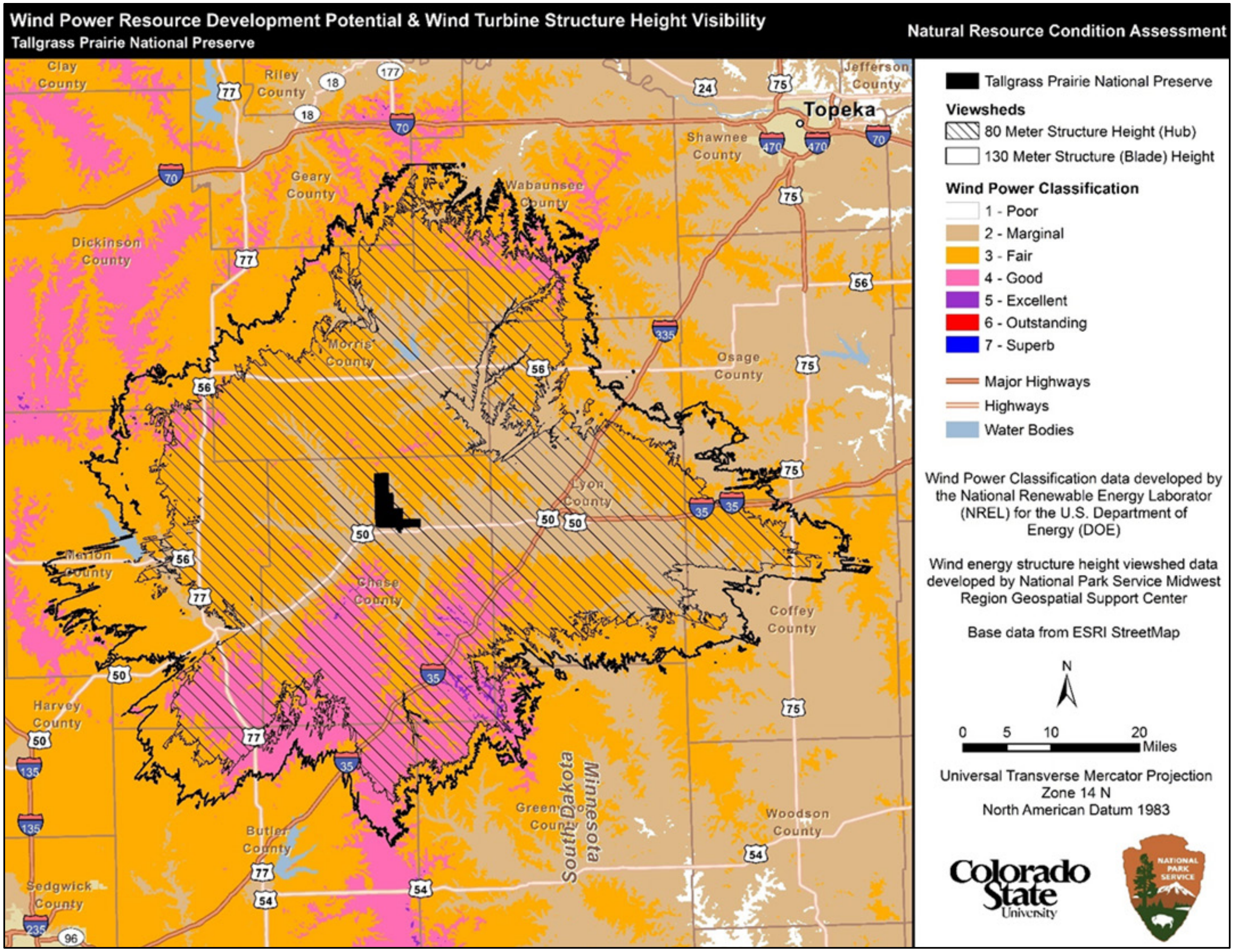


Figure 4.4-26. Combined area potentially visible within the viewshed of key viewpoints within Tallgrass Prairie National Preserve for 80 m (turbine hub) and 130 m (rotor blade) wind energy structure heights. Data from NREL and NPS Midwest Region Geospatial Support Center.

Table 4.4-7. Area in acres and percentage of viewshed within each National Renewable Energy Lab wind power suitability class for 80 m and 130 m structure heights for Tallgrass Prairie National Preserve.

Wind Energy Structure Height	Poor Wind Power Class	Marginal Wind Power Class	Fair Wind Power Class	Good Wind Power Class	Excellent or Better Wind Power Class	Total acres all Classes within Viewshed
80 m turbine hub	69 (<.01%)	375,049 (23.7%)	910,334 (57.4%)	294,921 (18.6%)	5,351 (0.3%)	1,585,724
130 m structure	69 (<.01%)	517,433 (22.6%)	1,386,538 (60.5%)	383,650 (16.7%)	5,397 (0.2%)	2,293,087

These distances are at or beyond distances believed to produce noticeable visual impacts (Sullivan et al. 2013). The proposed project areas appear to be located near the outer margin of the 80 m height turbine visibility (Figure 4.4-26). If visible at these distances, some or all of the proposed project turbine hubs might be visible in addition to the rotor blades.

Although known proposed projects appear to pose little threat to views from TAPR, the analysis shows that commercial-scale wind farms are being developed in areas with only "fair" wind energy potential. Therefore, as commercial wind farms become more feasible economically, even areas classified below "good" wind energy potential may be developed to produce electricity.

Scenic viewpoints used in this analysis with view to the south that may be vulnerable include Viewpoint 5 (Red House Spring), 11 (Fox Creek School), 13 (Gas House Overlook), and 14 (West Branch). These four views were analyzed further to evaluate how much of a wind turbine tower located within any given pixel outside the park would be visible from that viewpoint. Figures 4.4-27 through 4.4-30 show that a significant portion of the viewshed to the south of each of these four points would have a tower visibility from 50% to 100%, meaning at least half of the tower would be visible from the key viewpoints. As a whole, the 80 meter viewshed has a fairly low vulnerability to view degradation due wind development, with 66.7% of the viewshed being in the "Low Visibility" category (Figure 4.4-31). As previously stated, the area south of the preserve appears particularly susceptible to view degradation.

This indicator is in good condition with a declining trend. There are currently no wind towers within the 80 meter or 130 meter viewsheds of TAPR. Although there are three projects in various stages of development, with additional future projects possible, none of these are located within the radius likely to be seen by casual observers (32 km) discussed by Sullivan et al. (2013). Contributing to the declining trend is the realization that wind projects are being developed in areas of only "fair" wind energy potential due to socioeconomic constraints beyond the scope of this analysis. The potential for future wind development is very high and efforts should be made now to preserve these viewsheds into the future. Confidence is low due to the assumptions associated with viewshed modeling applied here and uncertainties regarding actual future development of wind farms in the region.

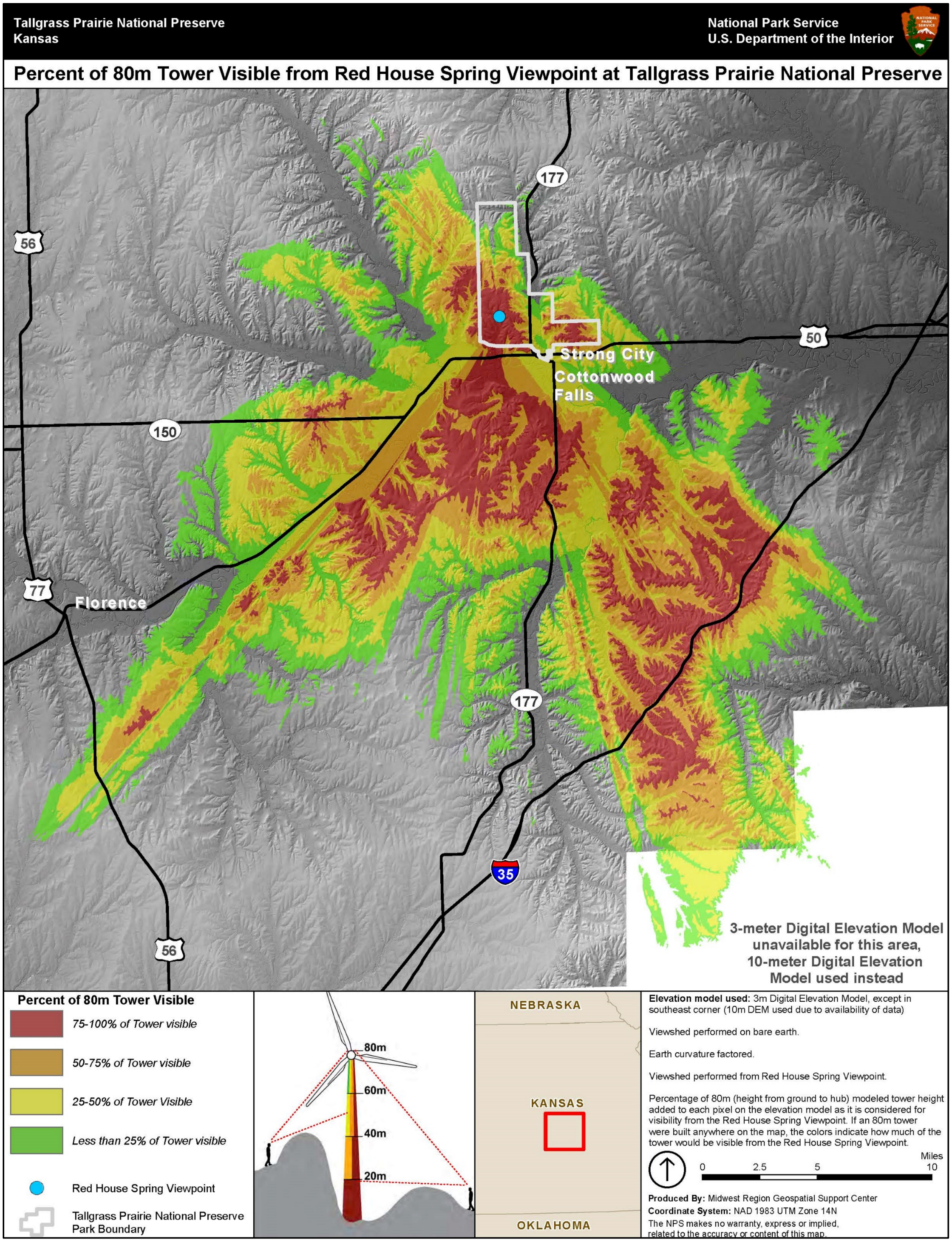


Figure 4.4-27. Degree of visibility from Red House Spring, based on 80 m turbine height (data and graphic provided by NPS Midwest Region Geospatial Support Center September 2016).

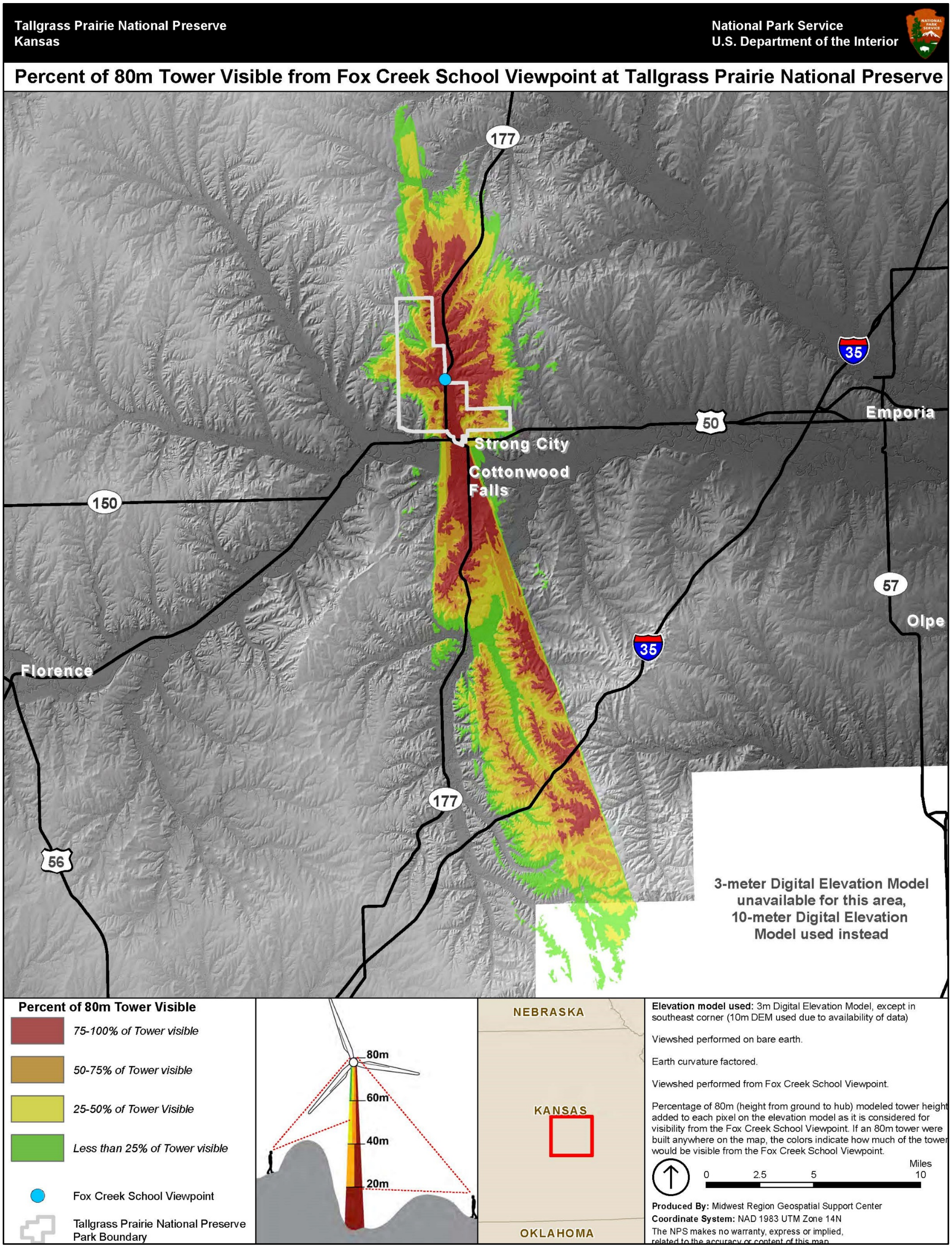


Figure 4.4-28. Degree of visibility from Fox Creek School, based on 80 m turbine height (data and graphic provided by NPS Midwest Region Geospatial Support Center September 2016).

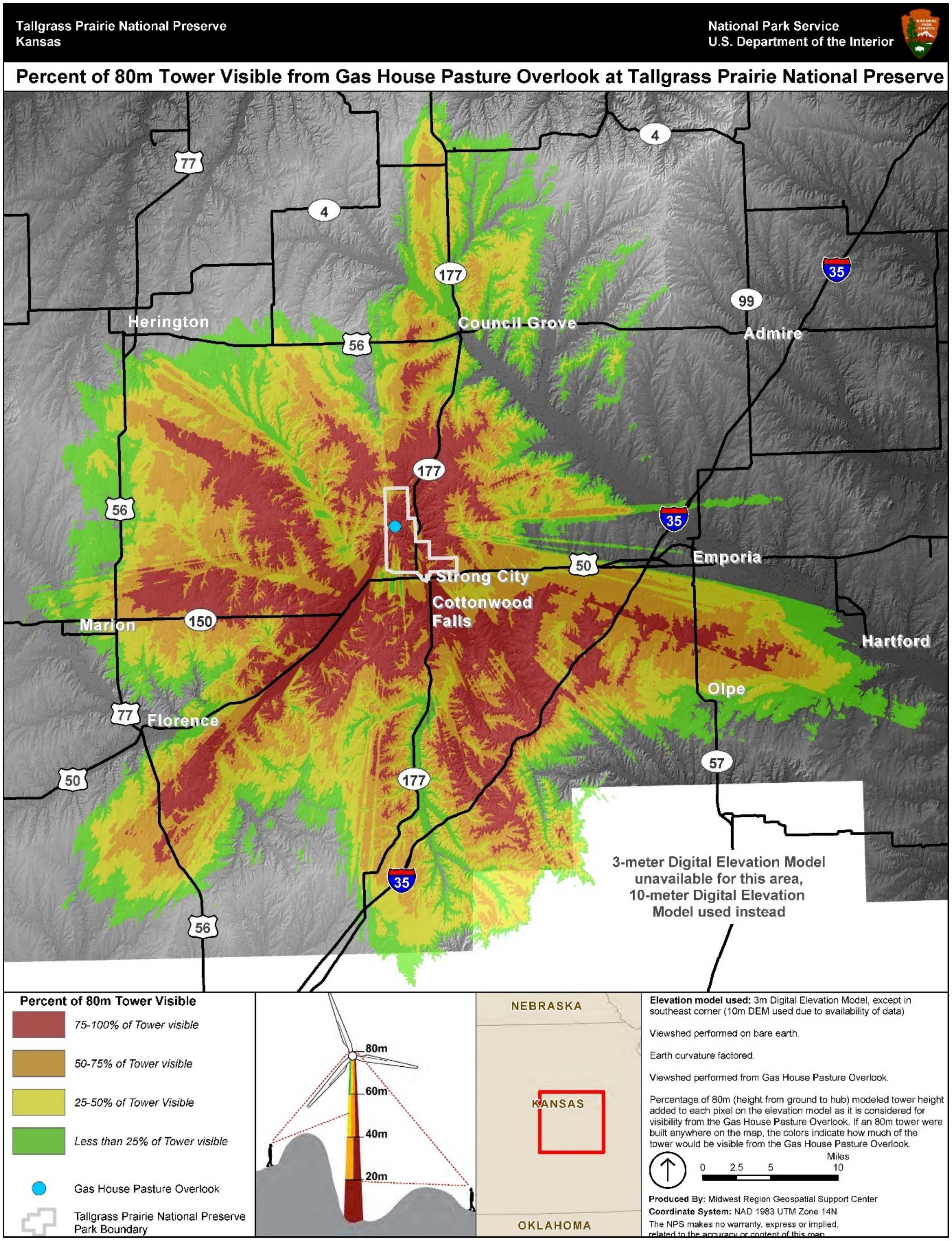


Figure 4.4-29. Degree of visibility from Gas House Pasture Overlook, based on 80 m turbine height (data and graphic provided by NPS Midwest Region Geospatial Support Center September 2016).

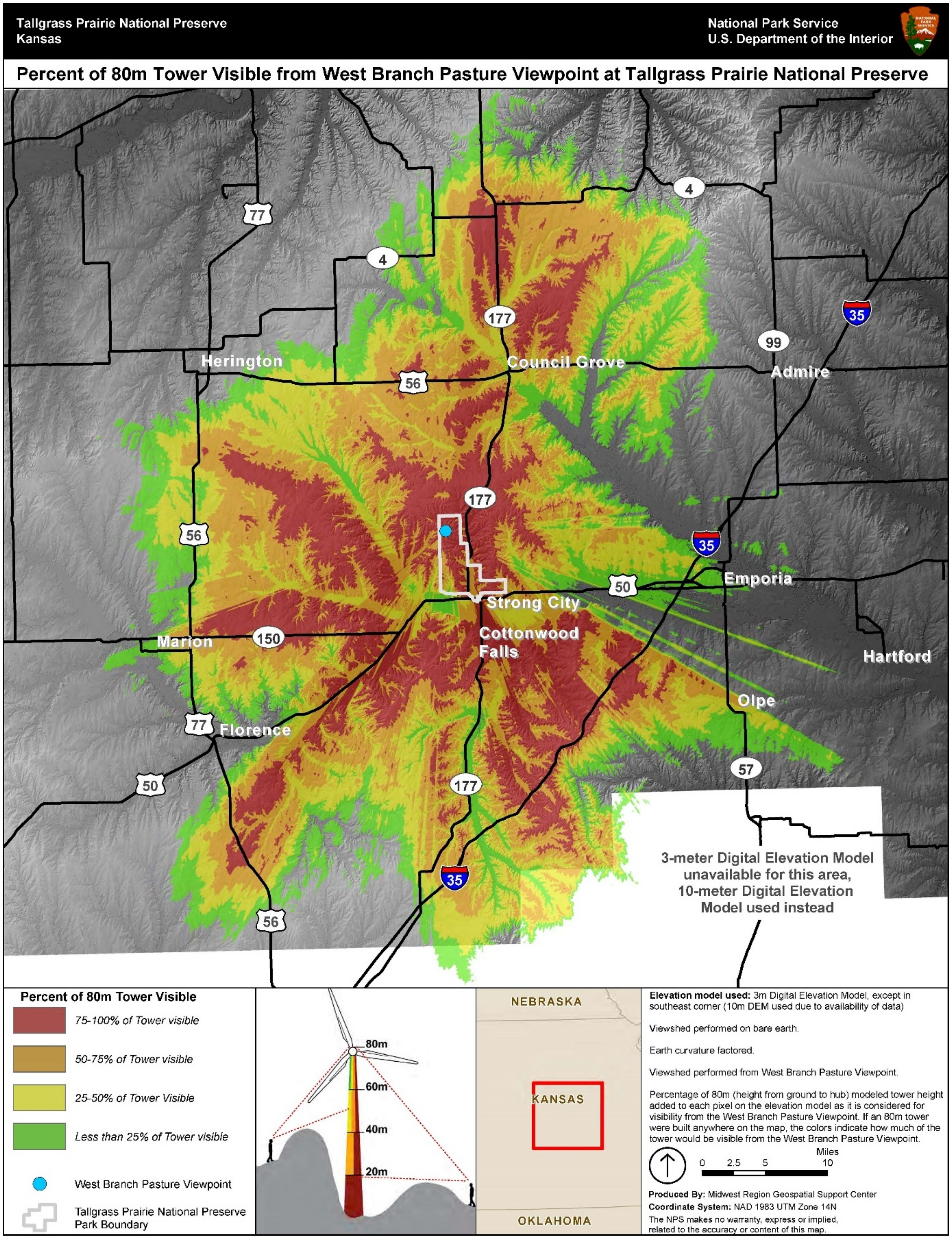


Figure 4.4-30. Degree of visibility from West Branch Pasture, based on 80 m turbine height (data and graphic provided by NPS Midwest Region Geospatial Support Center September 2016).

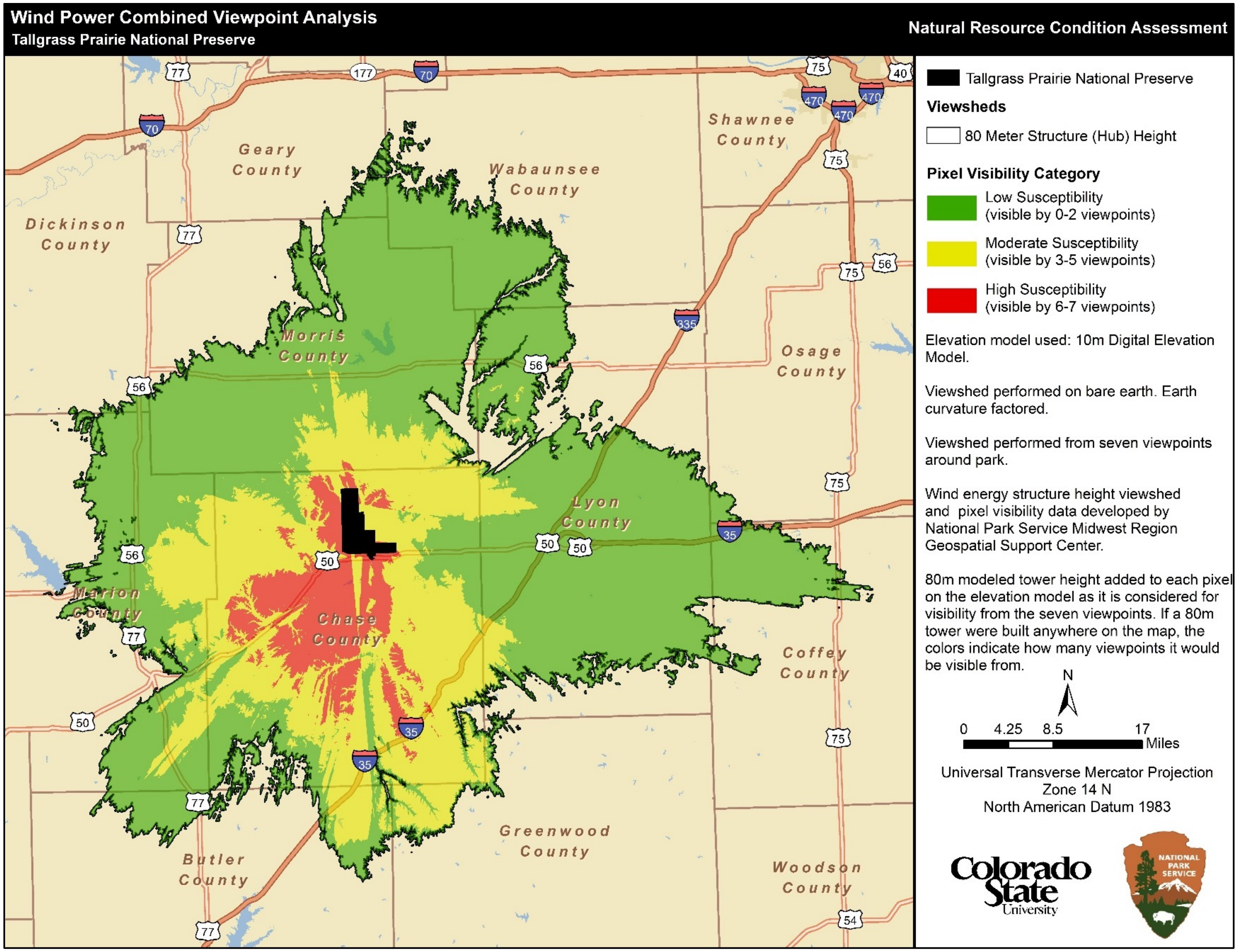


Figure 4.4-31. Combined pixel visibility from seven important viewpoints at TAPR, based on 80 m turbine height (data provided by NPS Midwest Region Geospatial Support Center September 2016).

Air Quality – Visibility

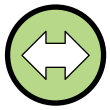
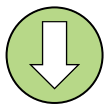
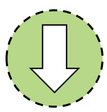
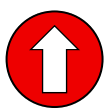
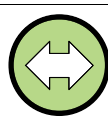
The five-year averages for visibility consistently fall in the "Poor Condition" category. Visibility levels have ranged between 9.9 dv and 11.4 dv from 2001 to 2010. The data show a statistically significant decreasing trend indicating that the condition of this indicator is improving (NPS ARD 2013b). The condition of this indicator warrants significant concern, with an improving trend and medium confidence due to the regional and modeled nature of the data.

Overall Condition and Trend

Park views have changed little since the park's creation in 1996. The views are expansive and of generally high quality, consisting of natural or natural-appearing settings with some historic elements/features and agricultural character. Rural and suburban elements, energy and communication lines and structures, and roads and highways and other non-period elements are rare within the park but are occasionally evident outside the park, especially to the south. Some views from near the southern preserve border looking south toward Strong City and the Highway 50 corridor are impacted by residential and commercial development, communications towers and other inconsistent elements. The conspicuousness of these elements is linked strongly to the distance from the viewpoint. Although development surrounding the park is inconsistent with the landscape character associated with the park mission and purpose, many park views are buffered by their remoteness and the predominance of ranching and grasslands in most areas to the east, north and west of the preserve. There is considerable overlap in the views seen from many of the primary and secondary viewpoints discussed here. Housing densities in the surrounding 30 km area are not projected to change significantly through the year 2050. However, a small number of conspicuous structures could significantly impact landscape views. The evaluation of potential visibility of new wind turbine developments highlights an issue that is of great concern to the preserve and illustrates graphically the park views that may be impacted. Visibility is generally poor based on recent data, but appears to be improving.

Overall condition of views is good with an unchanging trend (Table 4.4-8). Confidence in the assessment is high. Condition of scenery is weighted most heavily toward the scenic quality ratings, which are based on actual views and human observations from the primary viewpoints. Less weight is given to the examination of housing densities and landcover, which illuminates larger landscape issues that may affect the park into the future and also impact secondary views in and around the park. Primary views within the park are relatively well-buffered from development in the surrounding area, but some views are vulnerable to degradation as the rural ranching and agricultural landscape changes over time.

Table 4.4-8. Condition and trend summary for scenery at Tallgrass Prairie National Preserve.

Indicator	Condition Status/Trend	Rationale
Scenic Quality		Nearly all primary views received a good scenic quality rating. The views are expansive and of generally high quality, consisting of natural or natural-appearing settings with some historic elements/features and agricultural character. Rural and suburban elements, energy and communication lines and structures, and roads and highways and other non-period elements are rare within the park but are occasionally evident outside the park, especially to the south.
Housing Densities in the Surrounding 30 km Area		Within a 30 km radius of the park, the most notable trend is an increase in exurban areas and a corresponding decrease in rural acreage. There is an increase in the acreage of suburban areas but the major change in housing density is associated with the existing urban center of Emporia. However, there is also a pattern of increasing exurban housing density in unincorporated areas, including areas close to major roads such as Highway 50 near the preserve. Additional details are presented in the Land Cover and Land Use chapter of this assessment.
Potential Visibility of Wind Turbines		There are currently no wind towers within the 80 meter or 130 meter viewsheds of TAPR. Although there are three projects in various stages of development, with additional future projects possible, none of these are located within the radius likely to be seen by casual observers (32 km) discussed by Sullivan et al. (2013). Contributing to the declining trend is the realization that wind projects are being developed in areas having only "fair" wind energy potential due to socioeconomic constraints beyond the scope of this analysis.
Air Quality – Visibility		The five-year averages for visibility consistently fall in the NPS Air Resources Division "poor condition" category. However, there is a statistically significant indication of improving visibility (NPS ARD 2013b). See the *Air Quality* section of the NRCA for more details.
Scenery and Views Overall		**Condition is good with an unchanging trend. Confidence in the assessment is high.**

4.4.5. Uncertainty and Data Gaps

Further examination of key park views by preserve staff is recommended incorporating the scenic quality protocols being developed by the NPS Scenery Conservation Program. Some key viewpoints identified by park staff were not visited due to project constraints.

4.4.6. Sources of Expertise

- Rob Bennetts, Network Coordinator, Southern Plains I&M Network, NPS Inventory and Monitoring Division
- Mark Meyer, Renewable Energy Visual Resource Specialist, NPS Natural Resources Stewardship/Science, Air Resources Division
- Matthew Colwin, National Park Service Midwest Region Geospatial Support Center

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4.5. Climate Change

4.5.1. Background and Importance

Climate change is increasingly recognized as a major stressor of biological taxa, communities and ecological systems. Understanding the magnitude and effects of changing climate is essential within the NPS to “manage for change while confronting uncertainty” while developing new management and adaptation strategies (National Park System Advisory Board Science Committee 2012) and a significant scientific component of the NPS *Climate Change Response Strategy* (NPS 2010). Resources vulnerable to climate change at Tallgrass Prairie National Preserve (TAPR) include the federally endangered Topeka shiner (*Notropis topeka*).

The climate suitable for Great Plains grasslands is expected to remain relatively stable with some expansion to the north in Canada, but the range of tallgrass prairie along the eastern boundary is expected to contract (Rehfeldt et al. 2012). This contraction would potentially affect tallgrass prairie primarily in Illinois, southwestern Minnesota, Iowa, northern Missouri, and the eastern portions of South Dakota, Nebraska, Kansas, Oklahoma and Texas. Increasing CO_2 tends to increase plant growth and water use efficiency, but may be limited by water and nutrient availability. Transpiration rates usually decline as CO_2 increases, while, in many plants, photosynthesis and growth increase. Growth response to CO_2 is usually highest in rapidly-growing plants and in plants with the C3 photosynthetic pathway (most woody plants and 'cool-season' grasses) versus the C4 pathway (most 'warm-season' grasses) (Polley 1997).

Changes in grassland composition due to the interaction of temperature, moisture, nutrient availability and CO_2 are very difficult to predict (Polley 1997, Morgan et al. 2008), but evidence increasingly suggests that rising CO_2 and temperature plus increased winter precipitation can favor herbaceous forbs, legumes, and woody plants in many Great Plains rangelands, with uncertain changes in the balance between cool-season and warm-season perennial grasses (Morgan et al. 2008). Changes in species composition will likely vary by region and by year and will depend on depth and timing of available soil water as well as disturbance factors such as grazing, fire, and disease, which can have strong influence on plant communities (Bagne et al. 2013). Long-term research at the Konza Prairie found that net primary productivity in tallgrass prairie is a product of spatial and temporal variability in light, water, and nutrients, driven by a combination of topography, fire history, and climate, and is not driven strongly by precipitation alone (Briggs and Knapp 1995). Dynamics shaping plant community composition will also be influenced by increasingly severe and frequent droughts, floods and fires (Bagne et al. 2013).

Overall climate change vulnerability for a particular resource is estimated using a combination of exposure, sensitivity and adaptive capacity (Glick et al. 2011). The synopsis of potential changes to the preserve climate presented here characterizes the “exposure” component of resource vulnerability. Climate change is examined here using modeled future climate scenarios, but potential resource vulnerability and management implications are based on the relative amounts and directions of changes rather than specific magnitudes or thresholds of change. Although the preserve can do its part to mitigate greenhouse gas emissions and optimize the efficiency of preserve operations vis a vis greenhouse gases, climate change and its associated effects on preserve resources are largely out of the control of preserve managers. It is happening and will require an evaluation of the vulnerability of preserve resources. Moreover, specific and diverse adaptation measures for some preserve resources may be necessary to mitigate effects of climate change and transition to future climatic conditions.

Threats and Stressors

Increases in atmospheric greenhouse gases are resulting in changes in global, regional and local climates. Changes in the amounts and patterns of temperature and precipitation have numerous direct and indirect effects on environmental conditions and biota. An increase in the frequency of extreme weather is also anticipated under climate change.

Indicators and Measures

- Temperature changes from baseline – minimum, mean, and maximum temperatures (monthly)
- Precipitation changes from baseline – annual and seasonal; very heavy events
- Indices of aridity/drought – historic period of record and future vs. baseline period
- Plant phenology (baseline only) and growing season – enhanced vegetation index values for onset of spring greenup, maximum greenness (peak vegetation) and onset of minimum greenness; projected changes in frost-free period.

4.5.2. Data and Methods

A variety of data and analysis approaches are used to characterize the climate during the historic period of record and examine possible changes in climate for the preserve. A combination of site-specific and regional results is presented. Historic climate and modeled future climate change were examined for the area extending approximately 30 km from the preserve boundary. Because the preserve is relatively small and topographically uniform, geographic variation within the preserve is minimal; monthly values were therefore averaged across the area of interest.

Consolidation of future modeled climates and comparisons with historic baseline and graphic representation of results was supported by the USGS North Central Climate Science Center (NCCSC) hosted by Colorado State University (http://revampclimate.colostate.edu/). Future climate projections for the NCCSC products are presented for several scenarios of future greenhouse gas concentrations (i.e., emission scenarios); representative concentration pathway (RCP) 8.5 represents the high emissions scenario and RCP 4.5 represents a moderate emissions scenario. Comparing carbon dioxide concentrations and global temperature change between the 2000 Special Report on Emission Scenarios (SRES) and the 2010 Representative Concentration Pathways (RCP) scenarios, SRES A1 is similar to RCP 8.5, SRES A1B is similar to RCP 6.0 and SRES B1 is similar to RCP 4.5 (Walsh et al. 2014b). Examination of historic climate data used PRISM (4 km) data downloaded from http://cida.usgs.gov (Prism Climate Group 2014). Climate projections for non-spatial graphics use CMIP5 downscaled data downloaded from the Green Data Oasis website (http://gdo-dcp.ucllnl.org/downscaled_cmip_projections/dcpInterface.html) (CMIP5 Modeling Groups 2014). CMIP5 downscaling procedures are described in Maurer et al. (2002). Approximately 35 general circulation models (GCMs) that use quantitative methods to simulate the interactions of the atmosphere, oceans, land surface, and ice were used for the NCCSC summaries. Because the variability in results among models makes interpreting results problematic, ensemble summaries were used to combine the simulations of multiple GCMs and quantify the range of possibilities for future climates under the different emission scenarios. Using ensemble median values based on the results from many GCMs provides a more robust climate simulation versus using results of individual models (Girvetz et al. 2009). Seasonal summaries use the following groupings: winter = December, January, and February; spring = March, April, and May; summer = June, July, and August; and autumn = September, October, and November.

The Palmer Drought Severity Index (PDSI) uses temperature and precipitation data to calculate water supply and demand, incorporates soil moisture, and is considered most effective for unirrigated cropland (Palmer 1965, USDA 2014). Long-term drought is cumulative, so the intensity of drought during a point in time is dependent on the current weather patterns plus the cumulative patterns of the previous period. The Index is used widely by the U.S. Department of Agriculture and other agencies. PSDI values range between -4.00 or less (extreme drought) and +4.00 or greater (extreme moisture). The index uses a value of 0 as "normal". The Palmer Index is most effective in determining long term drought (i.e., lasting at least several months). Monthly PSDI values were obtained from the National Climatic Data Center (NCDC 2013). Assumptions of the PSDI regarding the relationship between temperature and evaporation may give biased (i.e., overestimated evaporation) results in the context of climate change (Sheffield et al. 2012). However, examination of historic PSDI does appear to corroborate known drought periods and the PSDI approach is not used to model future drought.

Moisture deficit was modeled using the web-based Climate Wizard Custom tools applying 12 km downscaled climate projections for more than 15 different GCMs (The Nature Conservancy, University of Washington and University of Southern Mississippi 2014; Maurer et al. 2007). High (A2) and Medium (A1B) emissions scenarios were used for the Climate Wizard results. The balance between precipitation and the amount of water that an ecosystem could potentially use though evaporation and transpiration (i.e., potential evapotranspiration or PET) is the basis for the climatic moisture deficit. PET is higher with warmer temperatures and more daylight hours. PET was calculated based on monthly temperature and monthly average number of daylight hours using a modified version of the Thornethwaite equation and procedures described by Wolock and McCabe (1999). Climatic moisture deficit quantitatively estimates moisture stress in a system; a higher moisture deficit reflects higher moisture stress. A deficit (in mm) occurs only when precipitation (i.e., supply) is less than PET (i.e., demand) in a given month. Moisture deficit increases if precipitation decreases or temperature increases (PET increases). Deficit is calculated as monthly PET minus precipitation (in mm), and is set to zero if precipitation is greater than PET. Monthly results are summed to provide seasonal or annual values (The Nature Conservancy, University of Washington and University of Southern Mississippi 2014).

Plant phenology was examined using existing and freely available remote sensing data, specifically the NASA-funded 250 meter spatial resolution land-surface phenology product for North America. This product is calculated from an annual record of vegetation health observed by NASA's Moderate Resolution Imaging Spectroradiometer (MODIS) instrument. The land surface phenology product summarizes all the observations throughout a year into a few, key, ecologically relevant biophysical parameters or metrics (ORNL DAAC 2012). MODIS land products include two Vegetation Indexes (VIs) derived from the remotely sensed fraction of photosynthetically active radiation detected every one to two days by the MODIS sensors. Normalized difference vegetation index (NDVI) and enhanced vegetation index (EVI) datasets represent 8 day composites of MODIS data at the 250 meter spatial resolution scale. The revisit interval for any geographic point is approximately 1–2 days. The resulting land surface phenology metrics are produced from these composites using an enhanced algorithm within the TIMESAT software program (Tan et al. 2011). Phenology data for pixels within the preserve boundary were gathered and summarized by Kevin James of the Heartland I&M Network using procedures and tools described in James et al. (2013). It was important to keep the pixels examined within the preserve, since most areas outside the preserve differ from the prairie within the preserve.

Plant phenology serves as an excellent global warming indicator because it is one of the most readily observable ecosystem reactions to climate change (McEwan et al. 2011). Increases in temperature are responsible for plants flowering earlier in the spring and the delayed onset of dormancy in autumn. This affects not only synchrony among plants, pollinators and complex evolutionary adaptation, but can shorten (or lengthen) a plant's growing season. Phenology also plays an important role in the amount of water released to the atmosphere via evapotranspiration, sequestration of carbon in new growth, and the amount of nitrogen utilized from the soil (Ibanez et al. 2010).

Plant phenology in the preserve and surrounding area is primarily governed by a combination of plant genetics and the effects of weather and day length. If plant communities change due to management, disturbance, changing climate, or other drivers, then plant phenology may also change due to those compositional changes. For example, cool-season grasses such as smooth brome (*Bromus inermis*) tend to start growing earlier in the spring, reach maximum production and flower earlier compared to warm season grasses such as little bluestem (*Schizachyrium scoparium*) and indiangrass (*Sorghastrum nutans*). In a study of temperature changes and plant phenology in the northern Great Plains, Dunnell and Travers (2011) found that 5% to 17% of the species observed have significantly shifted their first flowering time either earlier or later relative to the previous century. Overall, they found that as spring temperatures in the northern Great Plains have increased and the growing season has lengthened, some spring flowering species have advanced their first flowering time, some fall species have delayed their first flowering, and some species have not changed (Dunnell and Travers 2011).

Although there is a plethora of collaborative scientific endeavors including the USA National Phenology Network, high resolution spatial and temporal phenology data is generally unavailable for most locations. Approaches used to investigate the influence of global change on terrestrial plant and ecosystem phenology include species-level observation networks such as the USA National Phenology Network, remote sensing such as MODIS analysis used here, Eddy-covariance monitoring of carbon fluxes using recording stations, phenology modeling and plot-scale global change experiments. A review of the utility, limitations and temporal and spatial resolution of various methods is presented by Cleland et al. (2007). Here we use a greenness index derived from MODIS imagery to characterize plant phenology.

4.5.3. Reference Conditions

For most indices, the reference condition for this assessment is an 85-year period from about 1895, when meteorological data was first collected, to 1980, when a significant change in many climate indices roughly began. Although there may be some changes occurring during this period, the long reference period avoids bias associated with wet, dry, warm and cold periods or extreme events such as prolonged or severe drought. Some analyses of historic data use a 1950–1980 baseline because of limited dates associated with downscaled CMIP5 data. For the climatic moisture deficit projections, future values were compared to a baseline period of 1961–1980. For frost-free season length, the baseline period was 1901–1960.

4.5.4. Historic Conditions, Range of Variability and Modeled Changes

<u>Temperature</u>

Historic Trends

A linear model was fit to average minimum and average maximum monthly temperature for 1895–1980 and 1980–2012 in the vicinity of TAPR (Figure 4.5-1). The earlier period corresponds to a timeframe that is generally associated with no change in climate or a slower rate of change compared to 1980 or later. At TAPR, mean minimum monthly temperatures did not increase significantly over time during 1895–1980 (p=0.082) or from 1980–2012 (p=0.511). The model results for mean monthly maximum temperature over time were not statistically significant for either period (p values of 0.321 and 0.822, respectively).

Trends in monthly minimum temperatures over time are further illustrated in a graphical representation of the data for the period of record (Figure 4.5-2, top), which normalizes differences between a baseline period of 1895 to 1980 with individual monthly values. For example, relative to the baseline period, cooler temperatures across most months are evident in the period before 1980 compared to more recent years. High temperatures associated with severe droughts that occurred in the 1930s, 1950s, and 2010s are clearly shown in Figure 4.5-2 (bottom). An anomaly plot showing annual mean temperatures over time further illustrates significant changes in this variable during the recent past, with minimum temperatures for most years since 1930 being 0.5–1.5 deg. C above the long term average. Monthly data was also grouped by season into model quartiles for minimum temperature (Figure 4.5-3). Seasonal data shows a distinct increase in minimum temperatures in spring and summer over the past several decades and cooler autumns during the same period (Figure 4.5-4).

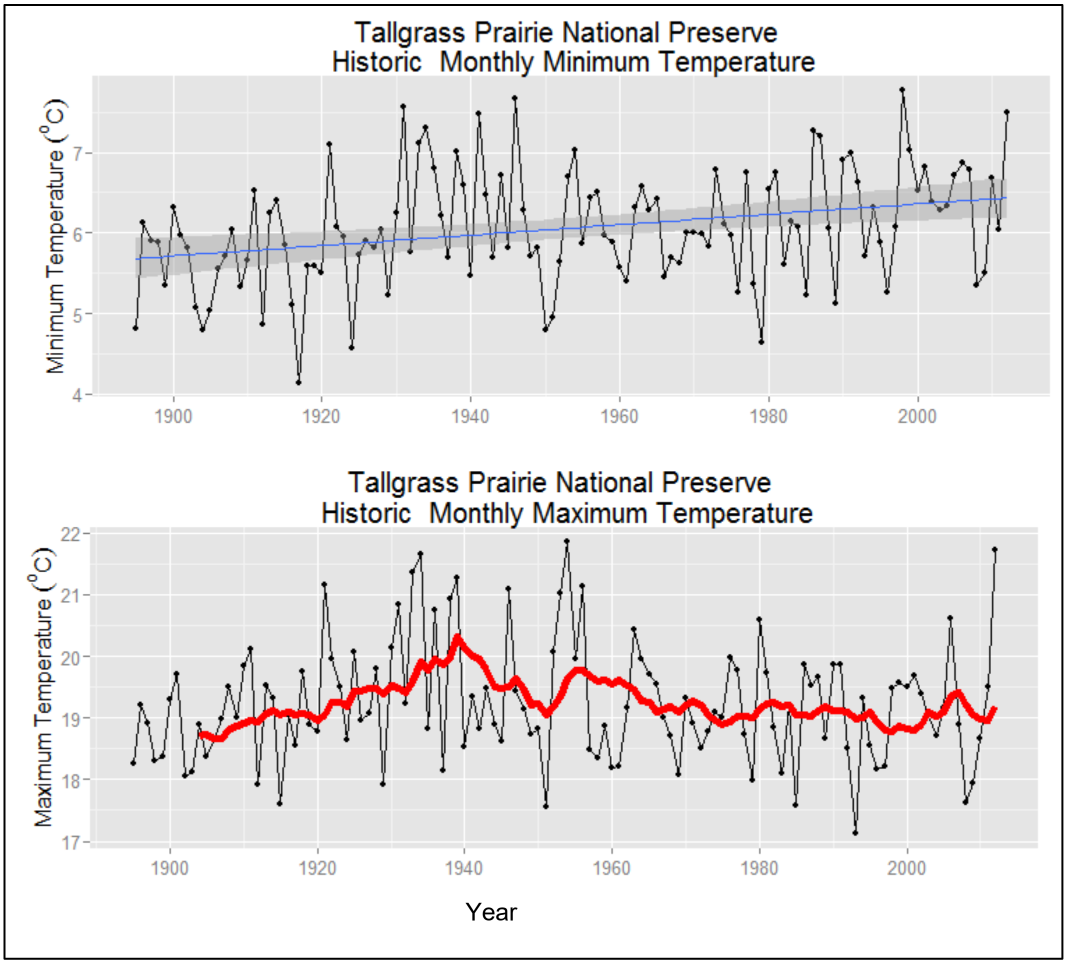

Figure 4.5-1. Historic PRISM data for minimum temperature showing significant linear model fit (top) and maximum temperature with a five year lag running mean (bottom) (Data and graphic prepared by NCCSC).

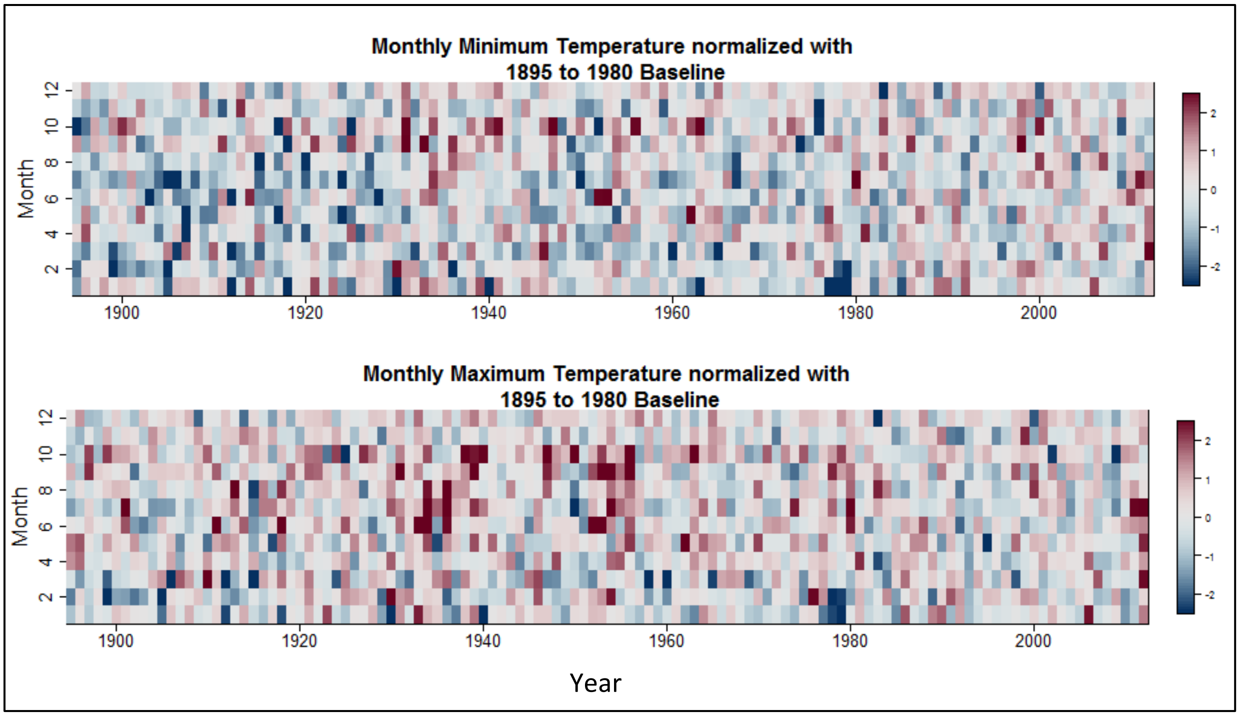

Figure 4.5-2. Mean monthly minimum temperature (top) and monthly maximum temperature (bottom) showing the normalized difference from a baseline (1895–1980) period for each month and year for Tallgrass Prairie National Preserve. The baseline is calculated monthly within the specified year range. The pixels are normalized by month and colors range from +/- 2.5 standard deviations from the mean of the baseline period. Red cells are warmer than baseline, while blue cells are cooler than baseline. (Data and graphic prepared by NCCSC).

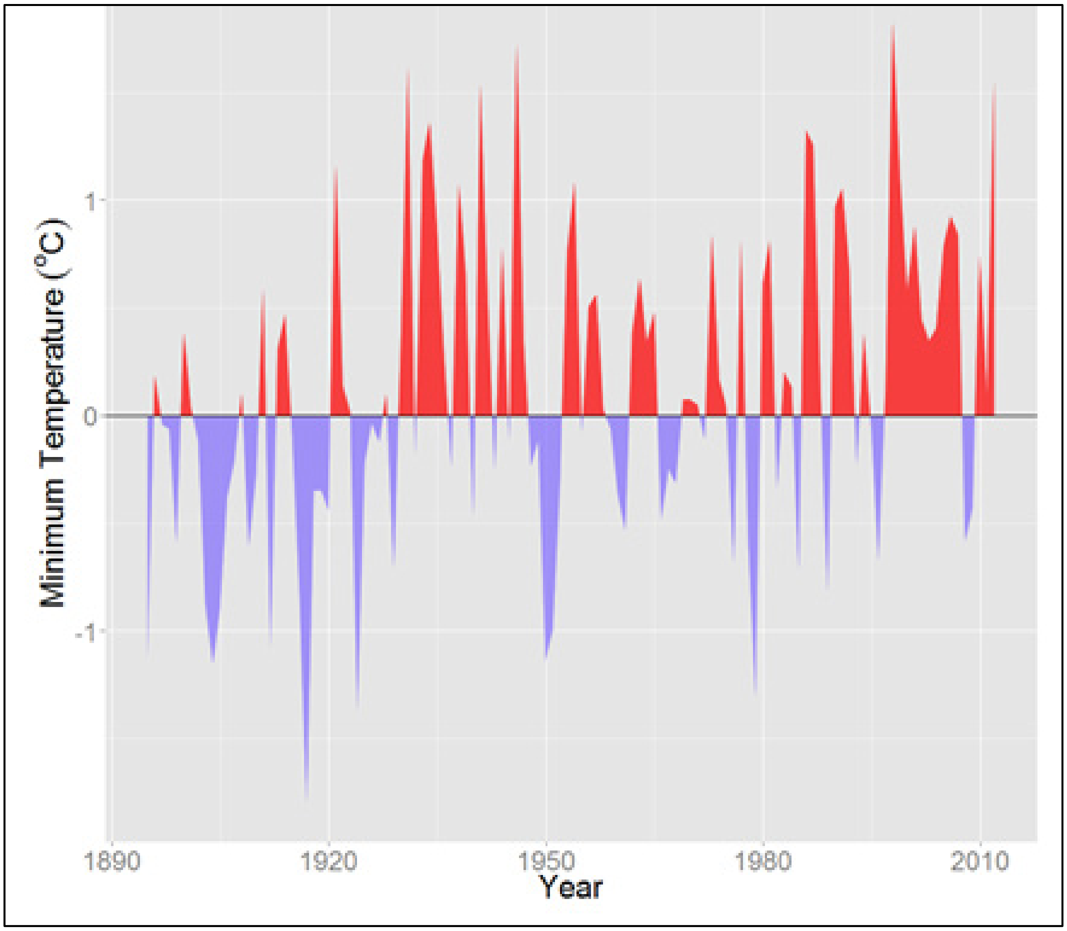

Figure 4.5-3. Anomaly plot for mean minimum temperature showing the difference between individual years from 1895 to 2012 and a baseline (1895 to 1980 average) for Tallgrass Prairie National Preserve (Data and graphic prepared by NCCSC).

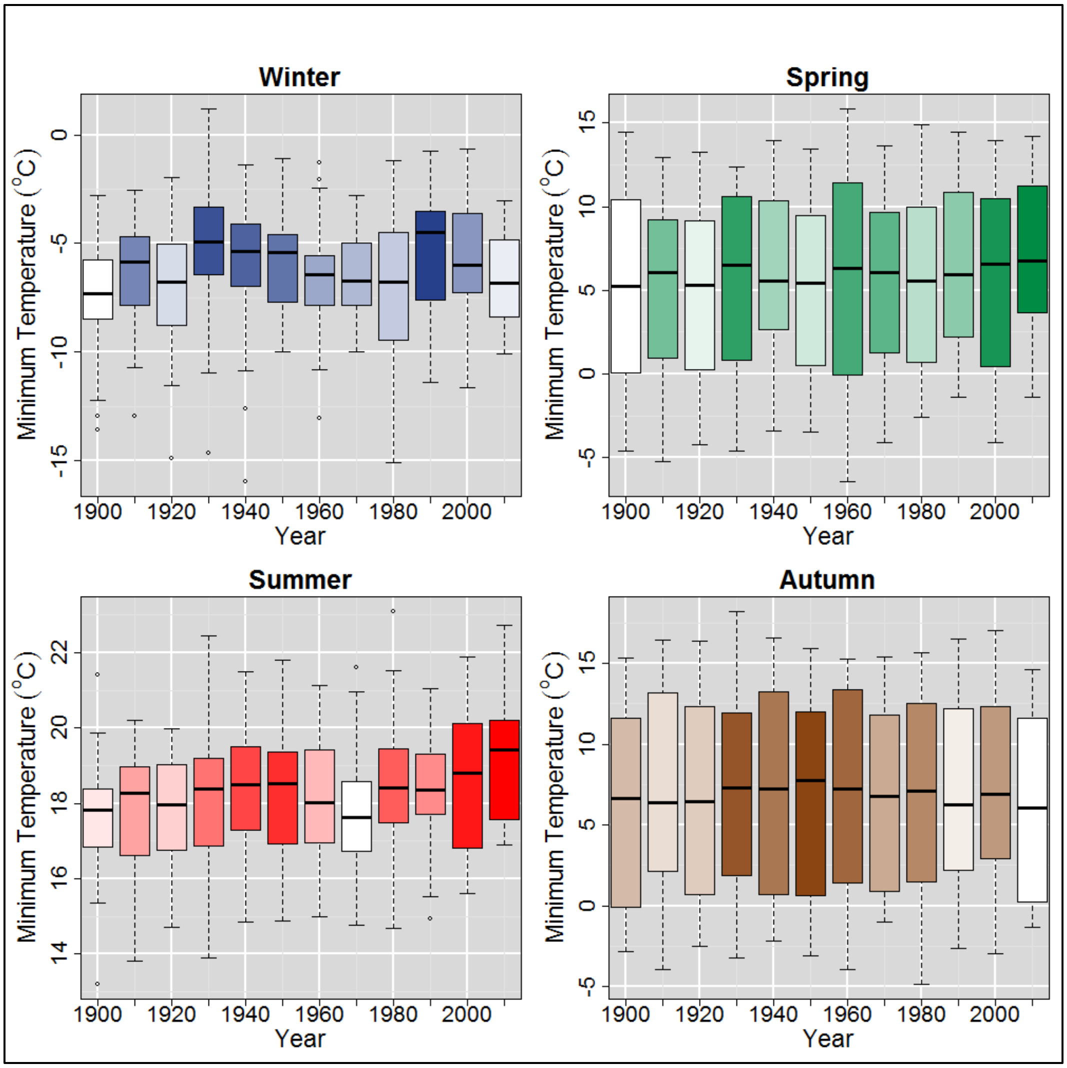

Figure 4.5-4. Seasonal historic mean minimum temperature quartiles using PRISM data at Tallgrass Prairie National Preserve. Within a season, darker colors represent higher temperatures (Data and graphic prepared by NCCSC).

Modeled Future Changes

Models indicate that temperatures at the preserve will rise significantly under climate change (Figure 4.5-5). According to median ensemble estimates, both minimum and maximum temperature are expected to increase by approximately 2–3 °C by 2050, and by approximately 3.0–6.5 °C by 2100, depending on the scenario (Figure 4.5-5).

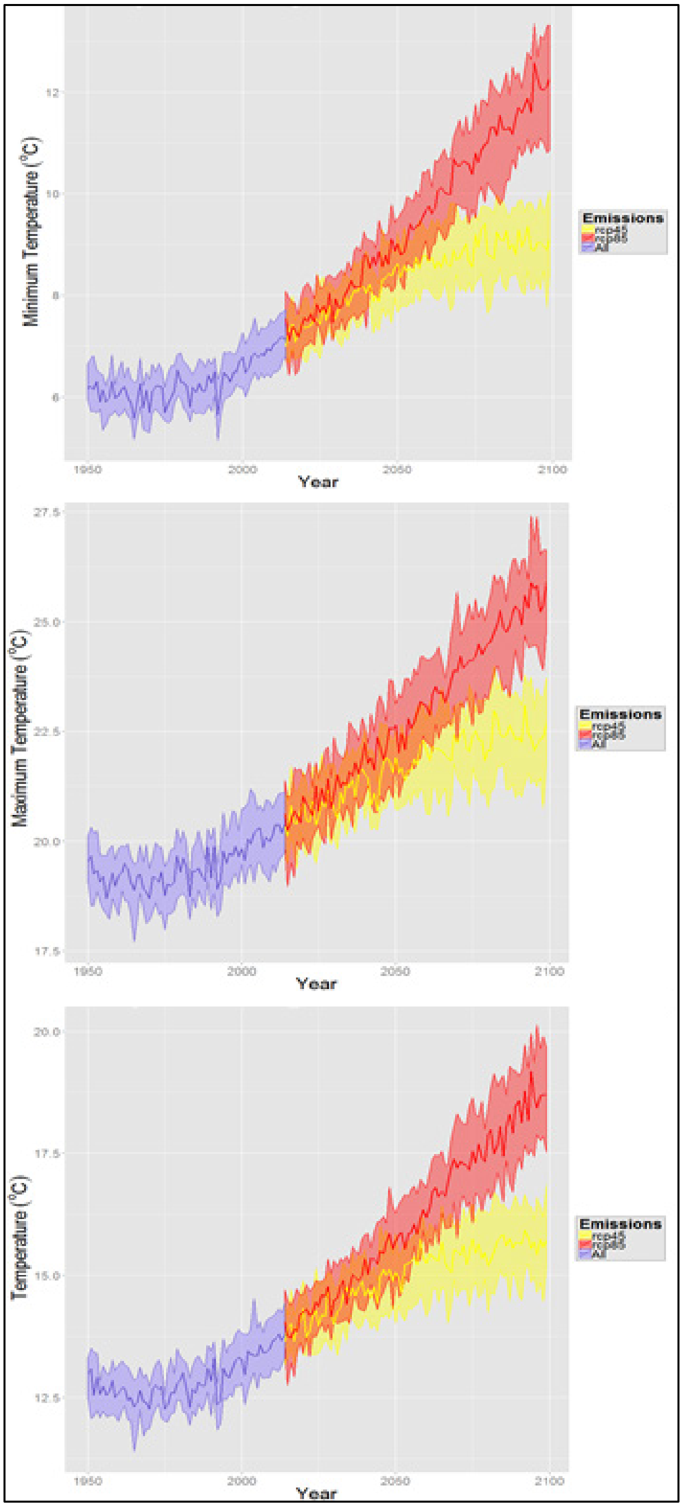

Figure 4.5-5. Projections for annual minimum, maximum and mean temperature with median, 25 and 75% quantiles grouped by emissions scenario for Tallgrass Prairie National Preserve. (Data and graphic prepared by NCCSC).

Precipitation

Historic Trends

Historic trends in monthly and annual precipitation for 1895–2010 were examined to understand patterns and variability. Mean monthly precipitation appears to be increasing for some months in the latter half of the period of record, but patterns of seasonality are not clear (Figure 4.5-6). Linear regression of mean monthly precipitation with time were not significant for the 1895–1970 period (p>0.20) or the 1970–2012 period (p>0.15) (Figure 4.5-7). Variability in seasonal and annual precipitation is relatively high.

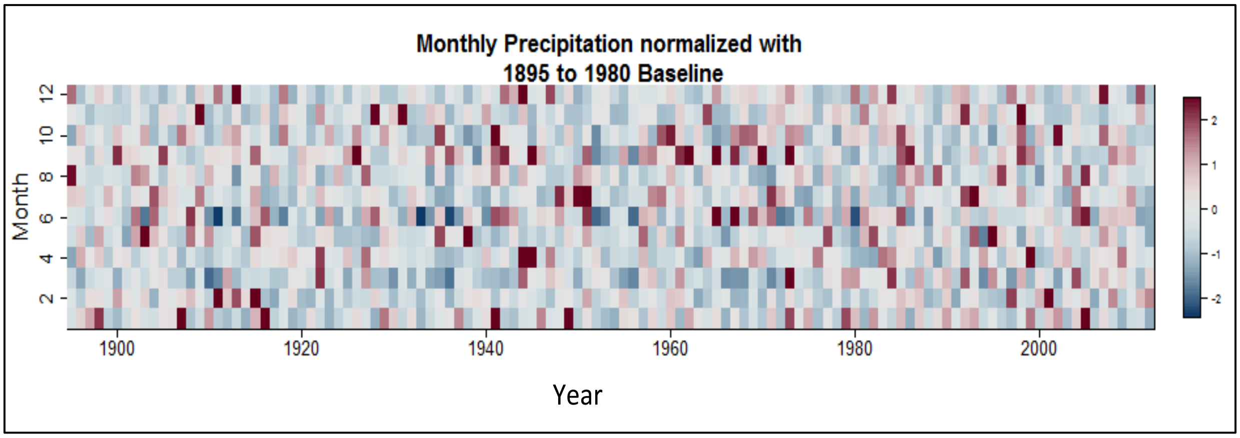

Figure 4.5-6. Mean monthly precipitation showing the normalized difference from a baseline (1895–1980) period for each month and year for Tallgrass Prairie National Preserve. The baseline is calculated monthly within the specified year range. They pixels are normalized by month and colors range from +/- 2.5 standard deviations from the mean of the baseline period. (Data and graphic prepared by NCCSC).

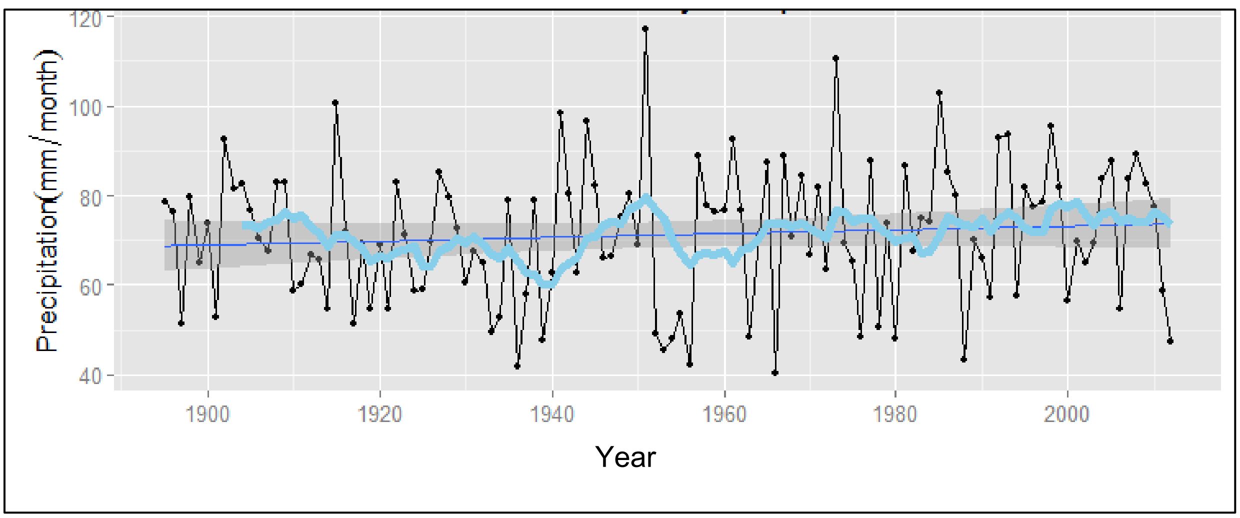

Figure 4.5-7. Historic PRISM data for precipitation at Tallgrass Prairie National Preserve showing linear model fit and a five year lag running mean. (Data and graphic prepared by NCCSC).

In recent decades there have been increases nationally in the annual amount of precipitation falling in very heavy events, defined as the heaviest 1% of all daily events from 1901 to 2012. The largest regional increases have been in the Northeast, Great Plains, Midwest and Southeast regions when compared to the 1901–1960 average (Walsh et al. 2014a). Regional results for the Midwest region including TAPR indicate an increase of 20 to 30% or more in the annual amount of precipitation falling in very heavy events over the past few decades (Figure 4.5-8).

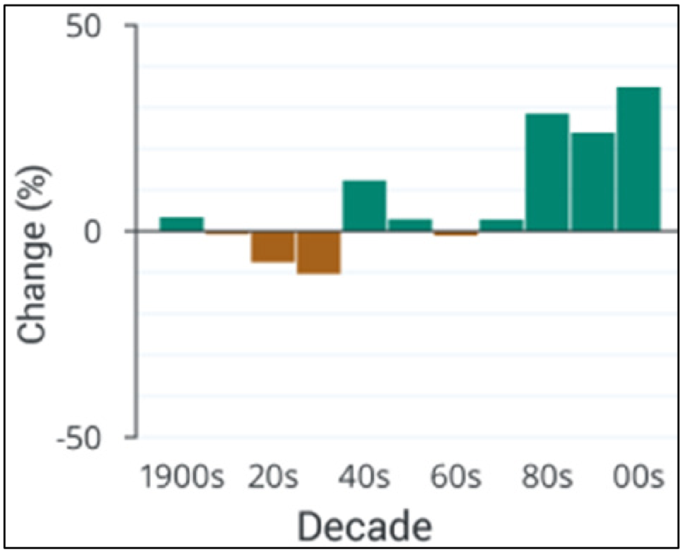

Figure 4.5-8. Percent changes in the annual amount of precipitation falling in very heavy events compared to the 1901–1960 average for the Midwest region including Iowa and Minnesota. A very heavy event is defined as the heaviest 1% of all daily events from 1901 to 2012. The far right bar is for 2001–2012 (Kunkel et al. (2013) as presented in Walsh et al. (2014a).

Modeled Future Changes

Modeled climate through the year 2100 shows an increase in mean monthly precipitation under both moderate (RCP4.5) and high (RCP8.5) emission scenarios (Figure 4.5-9). Both the medium and high emission scenarios produce higher mean monthly precipitation compared to the baseline period, with increases of approximately 3.2–4.1 mm (0.13–0.16 inches) per month or approximately 38.4–49.2 mm (1.51–1.94 inches) per year by the 2040s and 3.6–5.2 mm (0.14–0.20 inches) per month or 43.2–62.4 mm (1.69–2.46 inches) per year by the 2080s.

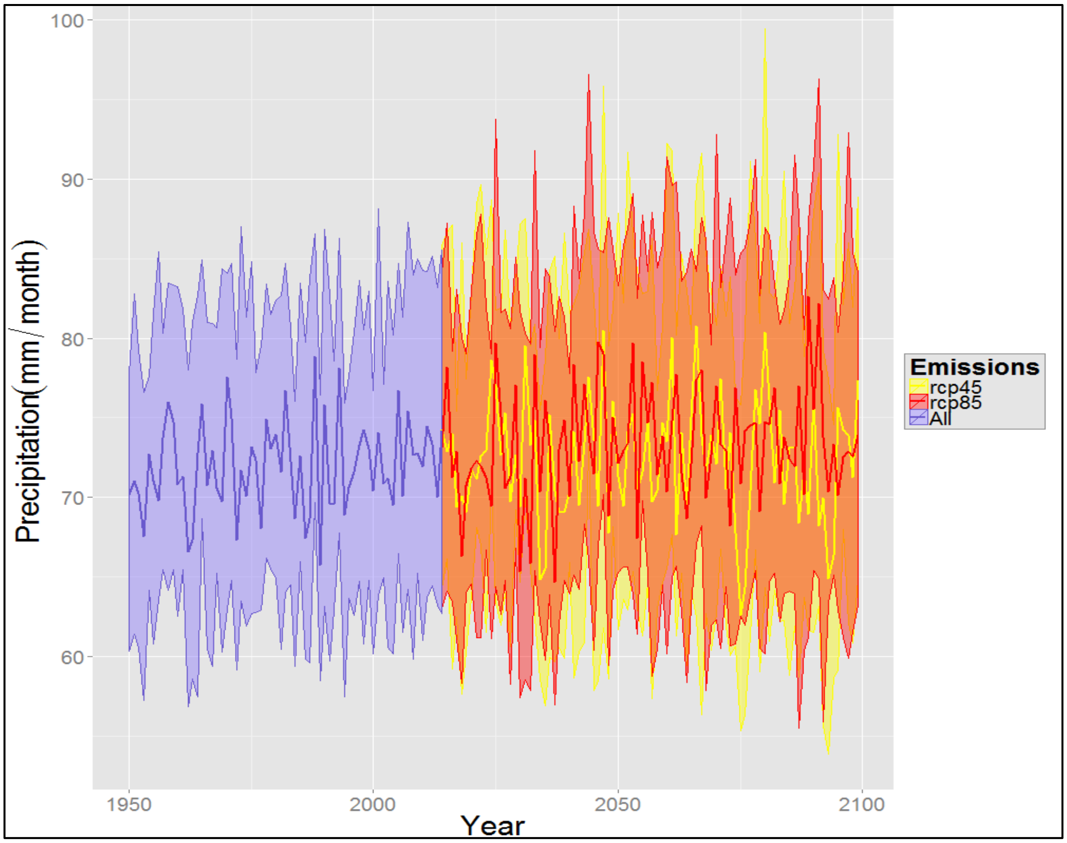

Figure 4.5-9. Projections for precipitation/month with mean, 25% and 75% quantiles grouped by emissions scenario for Tallgrass Prairie National Preserve. (Data and graphic prepared by NCCSC).

Aridity

Aridity and moisture availability is examined using the Palmer Drought Severity Index (Palmer 1965) for the historic 1940–2012 period. A climatic deficit index (The Nature Conservancy, University of Washington and University of Southern Mississippi 2014) is used to compare the 1961–1980 baseline with mid-century (2050) and end-century (2095) modeled values for medium (A1B) and high (A2) emission scenarios.

Historic Trends

Palmer Drought Severity Index (PDSI) values were calculated for the period from 1940 to 2012 (Figure 4.5-10). The Palmer Index is most effective in determining long term drought (i.e., at least several months). Long-term drought is cumulative, so the intensity of drought during a point in time is dependent on the current weather patterns plus the cumulative patterns of the previous period. PSDI values range between -4.00 or less (extreme drought) and +4.00 or greater (extreme moisture). The index uses a value of 0 as “normal”, and value of -1.5 is considered drought. While drought is sometimes described as cyclic, the frequency and duration of cycles is highly unpredictable. For the period of record, TAPR PDSI data shows periodic moderate to severe drought lasting 2–5 years occurring every 5 to 15+ years since about 1915.

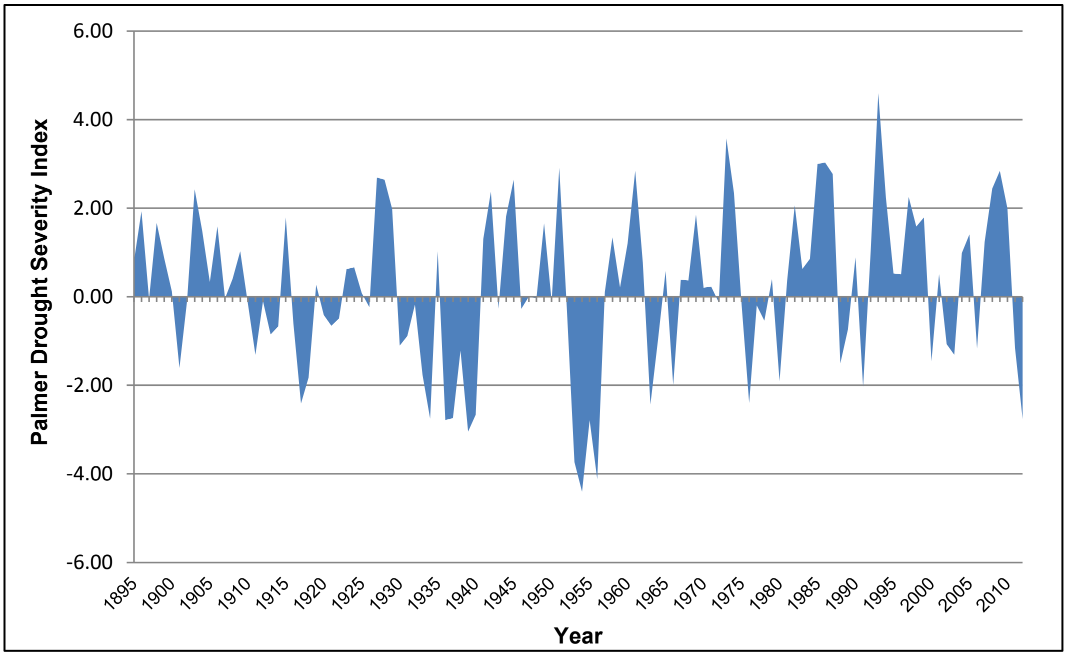

Figure 4.5-10. Palmer Drought Severity Index from 1895 –2012 for Tallgrass Prairie National Preserve. Negative values represent dry conditions and positive values represent moist conditions (NCDC 2013a).

Modeled Future Changes

Modeled results varied by emissions scenario and season and were highly variable across global circulation models. By 2050, annual moisture deficit is projected to be between 115 mm (4.5 in) per year (moderate emissions scenario 50th percentile value) and 88 mm (3.5 in) per year (high emissions scenario 50th percentile value). By 2095, annual moisture deficit is projected to be between 211 mm (8.3 in) per year (moderate emissions scenario 50th percentile value) and 252 mm (9.9 in) per year (high emissions scenario 50th percentile value) (Figure 4.5-11). Seasonal changes under both scenarios show relatively unchanged moisture deficits in the winter, moderate deficits in spring, and significant deficits in summer, and moderately moist autumn conditions.

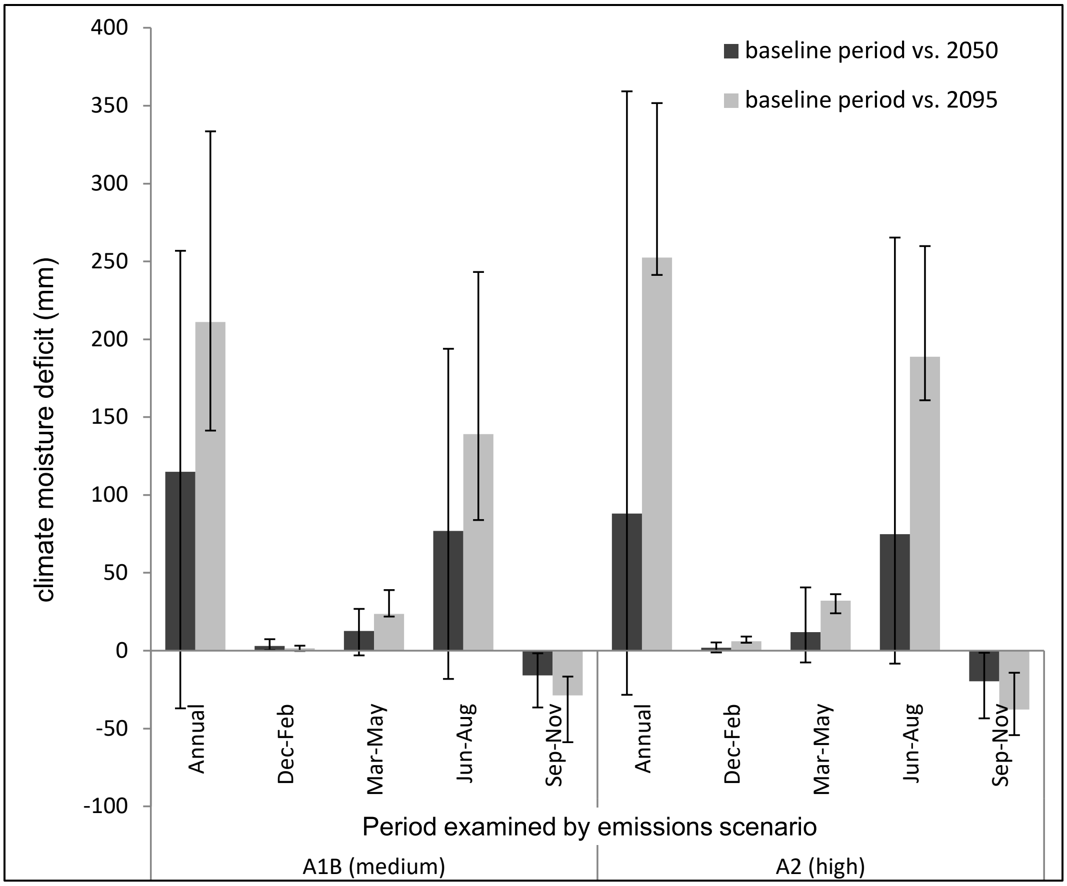

Figure 4.5-11. Annual and seasonal climatic moisture deficit for 2040–2060 and 2090–2099 compared to the baseline 1961–1980 period under two emission scenarios for a 30 X 30 km area surrounding Tallgrass Prairie National Preserve. Higher positive values indicate increasing aridity. Median values with 25% and 75% quartile limits.

Plant Phenology and Frost-Free Period

Plant Phenology

For the 11-year baseline period of record (2000–2010), the mean greenup date was April 18 (90% confidence interval of +/- 5.0 days), mean vegetation greenness peaked on July 20 (90% confidence interval of +/- 2.6 days) and mean onset of minimum greenness was November 15 (90% confidence interval of +/- 11.8 days) (Figure 4.5-12). Dates for maximum greenness were most consistent from year to year, followed by greenup dates and onset of minimum greenness. The distribution of annual values for the three metrics over the baseline period is shown in Figure 4.5-13.

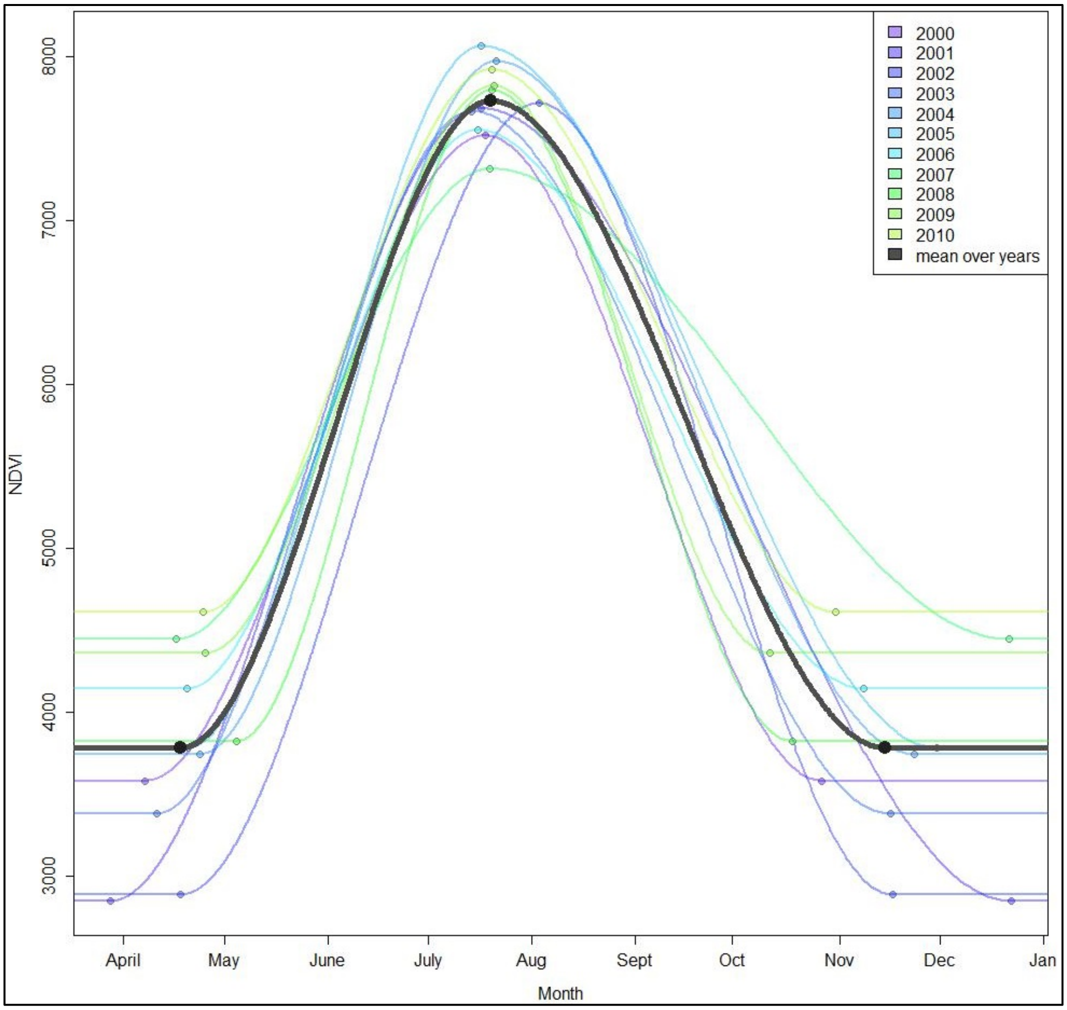

Figure 4.5-12. Phenology curves for Tallgrass Prairie National Preserve based on MODIS imagery vegetation indices. The graph shows dates for greenup initiation (left), maximum greenness (center), and the end of vegetation senescence or onset of minimum greenness (browndown end) (right) for the period of record. Data visualization provided by Kevin James, Heartland I&M Network.

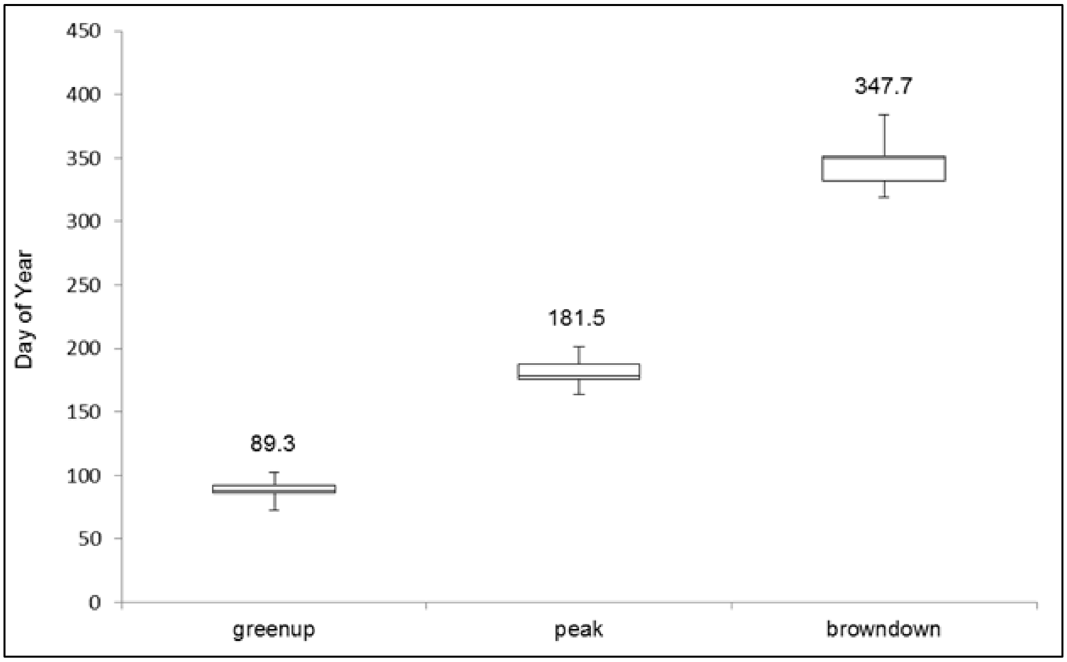

Figure 4.5-13. Box plots for the base period for dates associated with onset of vegetation greenup, maximum greenness and onset of minimum greenness at Tallgrass Prairie National Preserve, based on MODIS EVI data. Lines represent median values, boxes represent the limits of 25th and 75th percentile values and whiskers represent remaining values. Numbers above box plots are means for each phenological period.

Frost-Free Period

The length of the frost-free season is a major determinant of the types of plants and crops that do well in a particular region. These observed climate changes are correlated with increases in satellite-derived estimates of the length of the growing season (Jeong et al. 2011). The frost-free season length, defined as the period between the last occurrence of 32°F in the spring and the first occurrence of 32°F in the fall, has been gradually increasing since the 1980s (USEPA 2012). The last frost in the spring has been occurring earlier in the year, and the first frost in the fall has been happening later. In the eastern Great Plains region, the average frost-free season for 1991–2011 was about 9–10 days longer than during 1901–1960 (Walsh et al. 2014a). A longer growing season can increase carbon sequestration in plants (Peñuelas et al. 2009) and increase the growth of both desirable and undesirable plants. In some cases where moisture is limited, greater evaporation and plant transpiration associated with the longer growing season can mean less productivity due to increased drying (Melillo et al. 2014).

By the 2070–2099 period, the frost-free season for the eastern Great Plains is projected to rise significantly as heat-trapping gas emissions continue to grow, increasing by 10–20 days under the lower emissions (B1) scenario and 30–40 days under the higher (A2) emissions scenario compared to the 1901–1976 baseline period (Melillo et al. 2014).

Overall Assessment

Indications are that the climate in this park region is already becoming drier (despite increasing precipitation), hotter, and is potentially more prone to more frequent and extreme weather events. Trends in the indicators are projected to continue or accelerate by the end of the century. Because these changes in the environment are beyond the control of preserve managers and climate is not a conventional resource to be managed, climate change is not evaluated using the condition status and trend framework applied in this condition assessment. Research and monitoring related to climate change, the anticipated vulnerability of specific resources vis-a-vis climate change, and its associated effects on resources and interaction with other ecological processes can be informed by this broad overview of the magnitude of climate change in the park region.

4.5.5. Management and Ecological Implications

Changing climate is anticipated to impact Great Plains grasslands in a number of ways, and is likely to compound the effects of existing stressors and increase the vulnerability of grasslands to pests, invasive species and loss of native species (NFWPCAP 2012). Species ranges and ecological dynamics are already responding to recent climate shifts, and current reserves including NPS units will be unable to support all species, communities and ecosystems (Heller and Zavaleta 2009), some of which form the core of their park mission. Some of the key anticipated ecological impacts and potential management implications of climate change in the tallgrass prairie region and at TAPR include:

- Contraction of tallgrass prairie extent along its eastern boundary (Rehfeldt et al. 2012);
- Increased plant production in northern latitude and high altitude Great Plains rangelands and decreased plant productivity in the southern Great Plains (Morgan et al. 2008);
- Increases in invasive exotic plants (Morgan et al. 2008);
- Reduced water availability – projected annual and seasonal moisture deficits indicate that any increase in precipitation in the region is unlikely to be sufficient to offset overall decreases in soil moisture and water availability due to increase temperatures, increase water utilization and aquifer depletion (Karl et al. 2009). Water dependent habitats are especially at risk due to increased evaporation resulting in altered aquifer and surface water dynamics (Bagne et al. 2013).
- More frequent extreme events such as heat waves, droughts and heavy rains (Karl et al. 2009), with heavier rainfall events likely in the northern and central areas (Kunkel et al. 2013) and increasing likelihood of flooding in the wetter, northern portions of the Great Plains (USEPA 2013);
- Limited ability for species and communities to adapt; the relatively flat terrain characterizing these grasslands increases vulnerability to climate change because species and habitats may be obliged to migrate long distances to compensate for temperature shifts. This challenge is exacerbated by the highly fragmented and altered agricultural landscape in the region (Bagne et al. 2013).

- A decrease in rainfall may lead to a net carbon loss in the system (IPCC 2007). Trees and shrubs show higher CO_2 responsiveness than do herbaceous plants, which may lead to increases in woody plants as atmospheric CO_2 rises (IPCC 2007).
- Climate change is likely to exacerbate existing stressors related to anthropogenic disturbances at landscape scales including energy development and agriculture that fragment the landscape and hinder species adaptation (Bagne et al. 2013, Shafer et al. 2014).
- Livestock grazing is an enormous management driver at TAPR and a key part of the preserve's mission. Livestock will be negatively affected by the projected increase in high temperature extremes and heat waves. Forage quality will likely decline due to higher C:N ratios and lower crude protein content (Milchunas et al. 2005). Managers should consider opportunities to improve genetic stock (Shafer et al. 2014) and regularly evaluate rangeland carrying capacities. In a synthesis assessing mitigation and adaptation strategies for climate change in North American Rangelands, Joyce et al. (2013) identify some specific climate change adaptation options for grazing management that may be relevant for cattle and bison at TAPR (Table 4.5-1). Many of the adaptation options are described as "no regrets" strategies that promote ecosystem resilience and can be justified without emphasis on pending climate change. Anticipatory strategies occur when climate-change impacts are acknowledged as likely. Adaptive responses are planned but not implemented until climate change occurs (Joyce et al. 2013). TAPR is already implementing some of these strategies.

Table 4.5-1. Some specific grazing management adaptation options identified by Joyce et al. (2013). Options that significantly conflict with the preserve mission are not included here.

Factor	Degree of Adaptation		
	"No regrets"	**Anticipatory**	**Adaptive/Planned**
Grazing Management Options	• Enhance invasive species monitoring and control • Enhance drought management • Evaluate short-term weather forecasting to support forage inventory and stocking decisions • Evaluate alternate income sources • Conservation stocking, extend forage supply, ecological restoration • Grazing season: match forage quality and supply with animal requirements • Evaluate cow size: smaller animals require less intake and have higher feed efficiency • Evaluate fire management: fuel management and prescribed burning • Cultivate social networks to enhance adaptive capacity to current extreme events (e.g., drought)	• Evaluate environmental and economic risk in grazing resources associated with current management plan • Evaluate the use of drought-resistant species in forage planting • Enhance drought planning to include herd size, composition, reserve forage, and destocking strategies • Address forage quality shifts by evaluating supplemental feeding options [for cattle]	• Change cattle breed such as from *Bos taurus* to *Bos indicus* • Change class of animal : stocker vs. cow-calf for greater flexibility • Shift livestock breed to address increased pests • Facilitate engagement among scientists and managers to enhance the usability of climate change scientific information for rangeland management

It is increasingly clear that given significant shifts in climatic variables, adaptation efforts will need to emphasize managing for inevitable ecological changes and concurrently adjusting some management objectives or targets (Stein et al. 2013). In a review of articles examining biodiversity conservation recommendations in response to climate change, Heller and Zavaleta (2009) synthesized conservation recommendations with regard to regional planning, site-scale management, and modification of existing conservation plans. They found that most recommendations offer general principles for climate change adaptation but lack specificity needed for implementation. Specific adaptation tools and approaches will undoubtedly help park managers with these challenges. Adaptation approaches need to be intentional, context-specific and based on a deliberative process, rather than selected from a generic menu of options (Stein et al. 2014).

While climate change cannot be controlled by the preserve, managers can take steps to minimize the severity of exposure to these changes and help conserve sensitive resources as the transition continues. Although an in-depth analysis of the effects of climate change on preserve natural resources goes beyond the scope of this NRCA, a preliminary evaluation of the vulnerability of targeted preserve resources is being prepared to help understand how climate change vulnerability might be integrated in future assessments. Existing condition analyses and data sets developed by this NRCA will be useful for subsequent preserve -level climate change studies and planning efforts.

4.5.6. Uncertainty and Data Gaps

Climate change projections have inherently high uncertainty. Confidence is higher in modeled temperature dynamics and lower for modeled precipitation totals and seasonal patterns. The largest uncertainty in projecting climate change beyond the next few decades is the level of heat-trapping gas emissions (Walsh et al. 2014b). Information gaps to help manage resources and understand the repercussions of climate change to the preserve include the need for: 1) more specific, applied examples of adaptation principles that are consistent with uncertainty about the future; 2) a practical adaptation planning process to guide selection and integration of recommendations into existing policies and programs; and 3) greater integration of social science and extension of adaptation approaches beyond preserve boundaries (Heller and Zavaleta 2009).

4.5.7. Sources of Expertise

- Jeffrey Morisette, Director, DOI North Central Climate Science Center. Provided data and expertise regarding modeled climate and metrics.
- Marian Talbert, Biostatistician, DOI North Central Climate Science Center. Provided data and expertise regarding modeled climate and metrics and reviews of preliminary draft.
- John Gross, Climate Change Ecologist, NPS Inventory and Monitoring Program National Office. Provided expertise regarding modeled climate and metrics and reviews of preliminary draft.
- Kevin James, Plant Ecologist, Heartland I&M Program. Provided phenology data.

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4.6. Fire Disturbance Regime

4.6.1. Background and Importance

According to *NPS Management Policies* (NPS 2006), natural resources in NPS units will be managed to preserve fundamental physical and biological processes, as well as individual species, features, and plant and animal communities. The *Policies* specifically mention the importance of restoring natural processes such as fire to areas that have been disturbed by fire suppression, as well as the importance of maintaining open areas in situations where they were formerly maintained by natural processes. Further principles and strategic guidelines governing the management of wildland fire on NPS parks are presented in *Director's Order #18: Wildland Fire Management* (NPS 2010). At Tallgrass Prairie National Preserve (TAPR), fire is a critical natural process that is being used in conjunction with other tools and techniques to restore the natural landscape and ethnographic character of the area, restore the tallgrass prairie ecosystem and manage introduced exotic plants and woody species.

Fire is one of the principal disturbances on the landscape at TAPR, both historically and currently. Settlement by European emigrants in the 19th century led to fire suppression in the region (NPS 2010). Fire played an integral role in the ecological functioning of the tallgrass prairie system. Fire once helped maintain this tallgrass prairie in eastern Kansas, where ample precipitation exists for woody plants such as sumac (*Rhus* sp.), wild plum (*Prunus* sp.) and dogwood (*Cornus* sp.). From a fire and fuels perspective, grazing by livestock and bison influenced the fire regime by reducing fuel accumulation and standing fuels. Currently there is grazing at TAPR by bison and cattle; grazing by native ungulates, other mammals and insects also occurs. The role of fire and its importance to a healthy prairie ecosystem is well documented throughout the ecological literature (Anderson et al. 1970, Bragg and Hulbert 1976, Buell and Facey 1960, Hartnett et al. 1996, Wright and Bailey 1982). The tallgrass prairie system contains plant and animal communities that are fire-adapted or fire-dependent, requiring periodic episodes of fire to retain their ecological integrity. Under unnatural fire suppression, these communities can experience undesirable impacts such as unnatural successional trends, loss of habitat for fire-adapted species, or vulnerability to unnaturally severe wildland fire (NPS 2006).

In recent years, scientists and land managers have recognized the importance of creating heterogeneity on the landscape to promote diversity, sustain species adapted to natural disturbance regimes, and foster a variety of faunal habitat structures (Wiens 1997, Fuhlendorf and Engle 2001, Reinking 2005). In tallgrass prairie, the primary disturbance agents of fire and grazing interact with other biotic and abiotic factors to maximize heterogeneity and species diversity on the landscape (Fuhlendorf et al. 2006, Hamilton 2007, Knapp et al. 1999). A system incorporating grazing and regular prescribed fire referred to as patch-burn grazing has been used substantially in the Flint Hills region since the 1990s. Under patch-burn grazing, burned areas promote focal grazing, where the majority of grazing time is spent within the portion of the area that has been burned within the past year (Figure 4.6-1). By burning patches within a pasture, fire and grazing cause local changes in the plant community and increase heterogeneity within pastures, among pastures within the preserve, and within the larger regional landscape (personal comment Mike DeBacker, September 2012). As the focal disturbance is shifted to other patches over time, changes in local plant communities result in what has been described as a shifting mosaic (Fuhlendorfer and Engle 2001, 2004; Hamilton 2007).

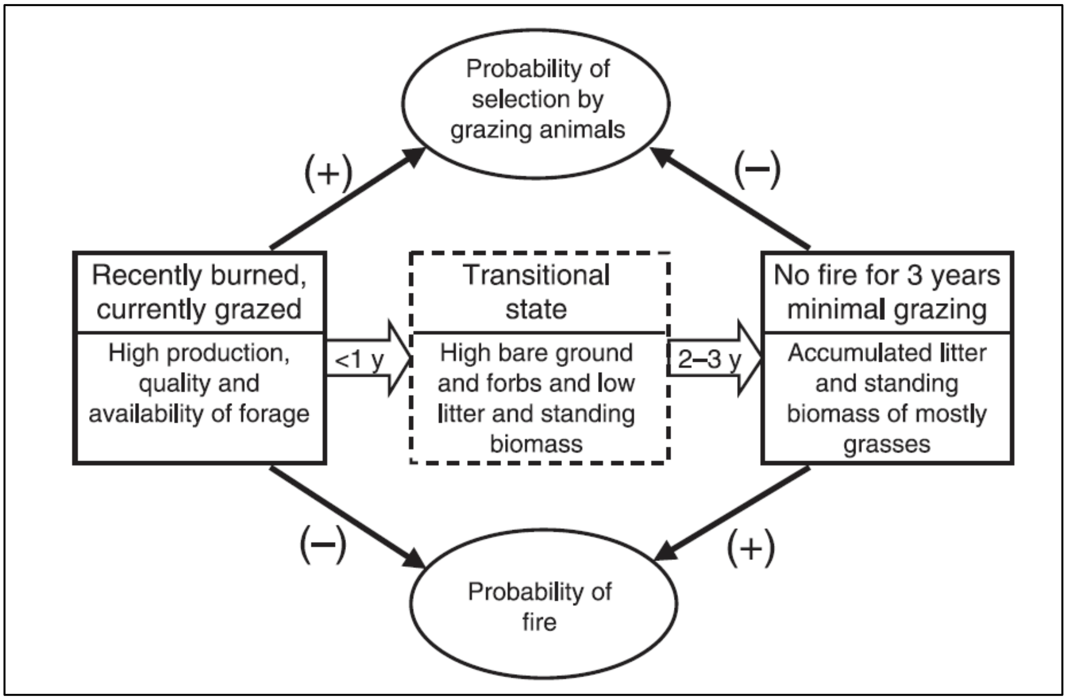


Figure 4.6-1. A conceptual model demonstrating the dynamics of a patch within a shifting mosaic landscape. Ovals represent the primary drivers (fire and grazing) while squares represent the ecosystem states within a single patch as a function of time since focal disturbance. Solid arrows indicate positive (+) and negative (–) feedbacks in which plant community structure influences the probability of fire and grazing (from Fuhlendorf and Engle 2004).

While ecosystem traits such as increased heterogeneity and mean species richness may benefit from synergistic effects of fire and grazing (by cattle or bison), even without grazing the ecosystem benefits from fire, and especially frequent fire, are clear (Hartnett et al. 1996, Bowles and Jones 2013). The strategy of creating a diverse and shifting mosaic of seral stages is healthy for the ecosystem and tends to benefit native flora and fauna (Gaetani et al. 2010). For example, the greater prairie-chicken, a State of Kansas Tier I species of concern (Wasson et al. 2005), requires a mosaic of habitats to complete its life cycle.

Under the current *Fire Management Plan* (NPS 2010) the preserve uses prescribed fires to favor native prairie vegetation and help to control the abundance of woody and invasive plants, in conjunction with mechanical and chemical exotic vegetation control. TAPR is currently divided into 15 burn units. Prescribed fires are completed in spring only. The burn units are typically burned on a 1–3 year rotation. Managed fire frequency aims to be shorter than the historical average to help manage undesirable species and woody plants. Individual burn plans are prepared and approved for the implementation of each prescribed fire, and wildland fires are immediately suppressed.

Fire ecology monitoring has occurred at TAPR since 2010. Monitoring involves collecting a suite of data that are used to evaluate the effectiveness of fire use on the landscape. Monitoring includes documenting the fire environment (weather, fuels, topography), fire behavior (manner and rate of spread, flame length, etc.), and fire effects (percent of fuels consumed, changes in plant and animal community composition and structure, etc.). Data collected include fuel load, fuel moisture (1-hr and 10-hr), soil moisture, burn day weather, fire behavior, smoke observations, and fire severity. Sampling methods for fire ecology monitoring are described in detail in *Fire Ecology Monitoring Protocol for the Heartland Inventory and Monitoring Network* (Leis et al. 2011). The evaluation of objectives concerning the improvement of nesting bird habitat, control of woody and undesirable vegetation, and increasing native plant diversity is being examined by the Heartland Inventory and Monitoring Network.

According to species lists maintained by the Kansas Department of Wildlife and Parks, there are four federally listed endangered species that may occur on the preserve: the Topeka shiner (*Notropis topeka*), Eskimo Curlew (*Numenius borealis*), Whooping Crane (*Grus americana*), and American burying beetle (*Nicrophorus americanus*) (KDWPT 2014). Of these four species, only the Topeka shiner has been documented at TAPR. An Environmental Assessment has been completed for fire management activities at TAPR and a *Finding of No Significant Impact* was issued. The *Fire Management Plan* complies with Section 7 of the Endangered Species Act, and consideration of endangered species habitat is included in the planning section of the pre-season fire planning checklist (NPS 2010).

Fire Regime Components

As a natural process and disturbance agent, fire directly or indirectly influences a number of the focal resources addressed in this assessment, including prairie vegetation, invasive exotic plants, faunal resources, views and scenery, and cultural use and resources. As such fire is perhaps the most influential ecological driver currently shaping the preserve. The fire regime is characterized by fire frequency, seasonality, extent and severity. For the Flint Hills region, Earls (2006) proposed four historical periods on the basis of differing fire regimes since the beginning of the Holocene period (circa 12,000 B.P.): The fire is entirely lightning-caused fires during the early Holocene, aboriginal-dominated fire through approximately 1850, Anglo-American-settlement fire during the third and early fourth quarters of the nineteenth century, and cattle-pasture burning in the late 1800s to the present (Earls 2006). Reference conditions likely attempt to approximate the aboriginal-dominated fire regime, which share some characteristics with the cattle-pasture burning period.

Fire Frequency

Before the arrival of European agriculture, fires on the Great Plains often covered vast areas with much of the burned area far from the ignition source due to the long distances that a fire could burn uninterrupted through ample and uninterrupted fuels. The frequency of lightning-caused fires in the region is relatively low and most presettlement and post-settlement fires are thought to be of anthropogenic origin (Schroeder and Buck 1970). Modern agricultural practices have virtually eliminated fire spread and thus vastly reduced the fire frequency on remaining prairie remnants, a fact that is often mitigated by land managers through the use of prescribed fire. Historic fire frequency was high, with average return intervals estimated to be less than 10 years (Guyette et al. 2010, Wright and Bailey 1982).

Lack of frequent fire in tallgrass prairie usually results in increased woody encroachment (Bragg and Hulbert 1976, Briggs et al. 2002, Bowles and Jones 2013). Conversely, high frequency fire with return intervals of two years or less over the course of a decade or more may decrease species richness (Davison and Kindscher 1999, Collins et al. 1995, Collins et al. 2002), though it should be noted that some species richness arises from undesirable species. High frequency fire may also help control some invasive species (Smith and Knapp 1999). The relationship between fire and undesirable species has led many land managers to use a fire frequency of less than 5 years in the Great Plains to control woody vegetation and minimize their encroachment into the prairie.

Fire Seasonality

The timing of burns plays a role in determining vegetation responses (Towne and Owensby 1984, Engle and Bidwell 2001, Towne and Kemp 2003). The timing of the burn in relation to plant growth stage may influence the abundance or expression of plant guilds. In general, species that are actively growing, flowering, or setting seed at the time of fire tend to decline over repeated applications during this point in their phenology. Species that benefit most from fire are usually those that are just beginning to grow (Davison and Kindscher 1999). The response of woody plants to season of burning is unclear. Burning during drought or during seed set may result in slow post-fire recovery (Pyne et al. 1996). Some literature suggests that late summer burns promote subdominant species such as some forbs without compromising the vigor of dominant warm-season grasses (Copeland et al. 2002) and may favor early flowering species that would otherwise be eliminated by competition from large, late flowering C4 grasses (Howe 1994, 1995, 2000).

Prior to European settlement, fire generally escalated during drought years (Anderson et al. 1970). The pre-settlement fire season covered many months (Anderson et al. 1970, Knapp and Seastedt 1998) and fires on the Great Plains were possible for much of the year due to both anthropogenic and natural causes (Bragg and Hulbert 1976, TPNPERC 2005). Large fires, which accounted for most of the acreage burned, were restricted to those periods when fuels were dry across vast acreages allowing fires to spread unimpeded (Wright and Bailey 1982). The introduction of widespread cattle grazing in the mid to late 19th century spurred extensive annual anthropogenic burning, usually during mid to late April, to favor the warm-season perennials favored by livestock (McMurphy and Anderson 1965, Owensby and Anderson 1967, Anderson et al. 1970). Burning had been practiced prior to this time by Native Americans, but the regularity and seasonality of burning were both altered by European settlers.

Seasonality of prescribed burn programs is often determined by containment considerations and often differs from presettlement seasonality of burns. Spring fires are often easier to conduct successfully than other seasons due to high soil moisture and frequent rains. However, the traditional burn season of February to April has some of the fewest hours per day available to conduct prescribed burns (Weir undated). Managers consider a host of factors when determining burn timing such as target plant phenology, prescription weather, local events, acceptance of fire, and availability of operational crews.

Fire Severity

Fire severity during prescribed grassland fires is usually low due to moderate weather conditions, limited fuel and the relatively short residence time of the fire as it passes over any given point on the landscape. However, energy output from a fire at the high end of this range may be as much as four times that of a fire at the low end (Engle et al. 1993, Ewing and Engle 1988). In prairie ecosystems, fire severity will increase as fuel loads increase with time since burn and where shrubs encroach.

Fire Extent

The extent of historic fires on the prairie landscape varied widely. Almost all fire regimes exhibit a power law probability distribution of fire size versus number of fires, meaning the vast majority of fires are very small and only a handful are very large (Cui and Perera 2008). However, the acreage accounted for by the few large fires accounts for the vast majority of all acres burned and therefore these few large fires are of outsized important to the overall fire regime.

Burn size is important in part because of its effect on encroachment, particularly of woody species. Prairie remnants with stands of woody species close by will experience higher rates of seeding from undesirable species. The preserve's large size aids in applying large prescribed burns, reducing unburned pockets available to woody species. This will help to prevent seeding and subsequent encroachment, easing the burden of woody species control.

In terms of present day fire management, bigger fires are not always better, and fires of the extent of those that burned 200 years ago no longer occur. The preserve is an island of intact tallgrass prairie surrounded for miles by a patchwork of agricultural lands, remnant prairie patches and grazed rangelands of varying condition. Therefore, the needs of prairie species must be met to the greatest extent possible using habitat within the preserve boundaries, necessitating management of a mosaic of communities and seral/structural stages on a much smaller geographic scale than would have occurred in pre-settlement times. For these reasons, fire extent is not considered further in this assessment as an indicator.

Implications of Climate Change on Fire Regime

The effects of changing climate on the fire regime and fire-related ecological effects at the preserve have not been modeled or examined in detail. A comprehensive summary of historic climate variation and climate change projections for the preserve and surrounding area is presented in the *Climate Change* section in this chapter. Results for precipitation, temperature, aridity, and growing season vary by emissions scenario, future time period and sometimes by season. In general, the climate at TAPR is forecast to become hotter and wetter compared to the current climate, but increased temperatures are anticipated to more than offset the increase in precipitation resulting in drier environmental conditions. Both minimum and maximum temperatures are expected to increase by approximately 2–3 ^{o}C by 2050, and by approximately 3.0–6.5 ^{o}C by 2100, depending on the emissions scenario. Precipitation is projected to increase by approximately 3.2–4.1 mm (0.13–0.16 inches) per month or 38.4–49.2 mm (1.51–1.94 inches) per year by the 2040s. Very heavy rainfall events are projected to become more frequent. As an index of drought, annual summer season moisture deficits ranging from 211–252 mm (8.3–9.9 inches) compared to historic baseline conditions are forecast for medium and high-emission scenarios by 2095. It is getting significantly warmer earlier in the spring and the growing season is projected to lengthen by 10–40 days per year by 2100, depending on the emissions scenario.

Specific implications of climate change on the preserve's fire regime and fire management cannot be predicted with a high level of confidence, but some generalizations and likely scenarios merit discussion. Wildland fire in the region surrounding the preserve is virtually non-existent. Prescribed burning outside the preserve occurs on some private and public lands. The fire regime at the preserve is highly managed and driven by prescribed fire events planned for specific dates within burn units of a defined size and location. Therefore, it seems unlikely that the fire return interval would be affected by climate change. Prescribed burns in the preserve are currently conducted only during fuels and weather conditions meeting a burn prescription window (i.e., acceptable range of temperature, humidity, wind and fuel conditions) to minimize the chance of fires getting out of control or producing unwanted smoke. Similar prescription windows would be applied in the future. Therefore, future fire intensity and severity would likely be similar to current fire intensity and severity. Severity of later summer burns may increase since severity is affected by soil moisture. The most significant management implication of climate change may be that prescribed burning prescription windows may become smaller and/or fewer in number as minimum and maximum temperatures rise and relative humidity declines. These changing factors would make it more difficult for the preserve to reach prescribed burn acreage/frequency objectives, especially when the preserve is scheduling burns supported by non-resident crews well ahead of the scheduled burn. Summer and late summer/fall burns may also be more difficult to schedule with smaller prescription windows, or periods meeting prescription may occur earlier or later in the year.

Threats and Stressors

- Highly managed nature of fire outside of the preserve, which reduces the possibility of fire spread into the preserve.
- Continued alteration of the natural fire regime within the preserve with respect to seasonality of fire.
- Encroachment by commercial and residential development outside the preserve boundary that may place additional constraints on burning due to fire risk and smoke (safety) and air quality considerations.

Indicators and Measures

- Fire frequency
- Fire seasonality
- Fire severity

4.6.2. Data and Methods

Fire history from preserve records is used to examine fire regime indicators and determine the overall fire regime within the period of record. No empirical data is available prior to the start of preserve records, however there are voluminous anecdotal descriptions of the pre-settlement fire regime of the

Great Plains and other grassland ecosystems from historic journals, newspaper articles, and other sources that have since been compiled and corroborated by current research.

Data were obtained from the preserve and the Heartland I&M Network. Current fire data are generally limited to the year, size, and generalized season of the fire (winter, spring, summer, or fall). Fire data were summarized to support evaluation of fire return interval (i.e., fire frequency), seasonality, and fire severity. Because burn units changed over, time, data were consolidated into larger areas for analysis (Figure 4.6-2, Figure 4.6-3).

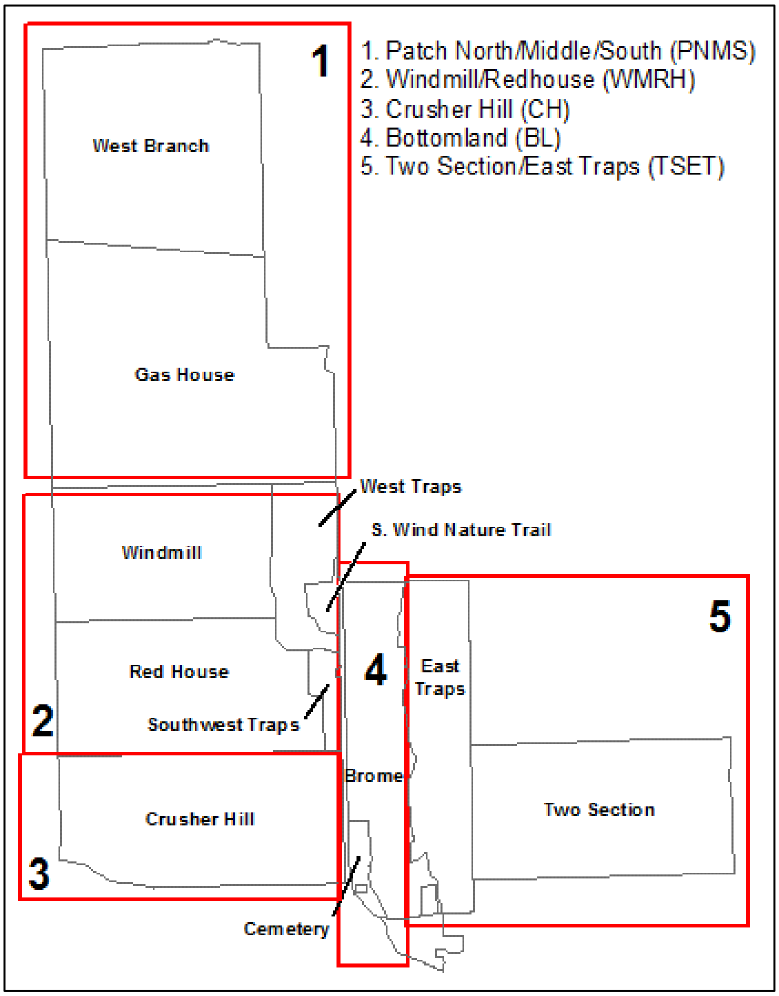


Figure 4.6-2. Burn units used at TAPR from 1998–2005 and consolidated units (in red) used for analysis.

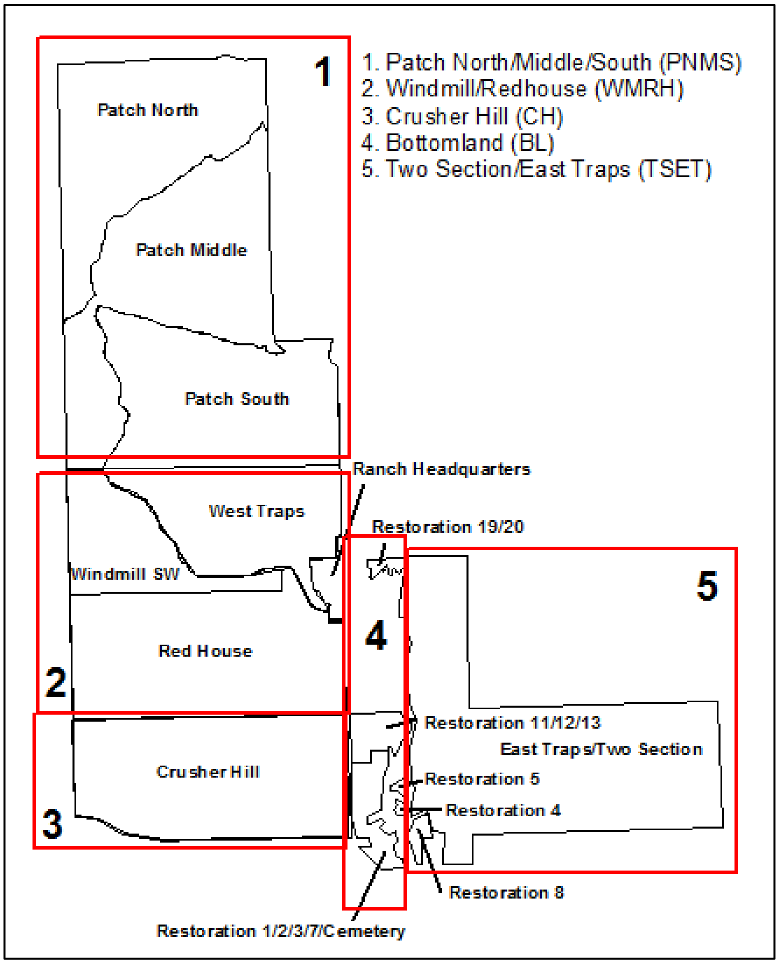


Figure 4.6-3. Burn units used at TAPR from 2006–2010 and consolidated burn units (in red) used for analysis.

4.6.3. Reference Conditions

The pre-settlement fire regime, based on published literature, is used as the reference condition for assessing condition status and trend of the fire regime. Achieving a "good condition" rating under present day land management pressures may not be feasible for a variety of reasons. These include challenges related to sensitive resources; preserve stakeholder needs, concerns and expectations; smoke management and fire containment needs; budgetary issues; and invasive species considerations. Nonetheless, the pre-settlement fire regime is documented to have been well-suited to maintaining the biotic and abiotic elements of a healthy and functional prairie ecosystem and no alternative regime has been demonstrated to achieve the same benefits. A review of fire regime characteristics in the Flint Hills region prepared by Earls (2006) confirms the findings of other published literature and provides additional details for the region.

The condition rating framework for fire indicators at Tallgrass Prairie National Preserve is shown in Table 4.6-1.

Table 4.6-1. Condition rating framework for fire indicators at Tallgrass Prairie National Preserve.

Indicator	Good Condition	Warrants Moderate Concern	Warrants Significant Concern
Fire Frequency	• mean fire return interval for all burn units ≤5 years • fire return interval regularly varies within and among burn units	• mean fire return interval for all burn units 6–10 years • fire return interval occasionally varies within and among burn units	• mean fire return interval for all burn units >10 years • little or no variation in fire frequency within and among burn units
Fire Seasonality	• season of most burns executed within historic range (March–October) • season of burns regularly varies within and among burn units	• more than ¼ of burns executed outside of historic range • seasonality of burns occasionally varies within and among burn units	• more than ½ of burns executed outside of historic range • little or no variation in seasonality of burns within and among burn units
Fire Severity	• burns occasionally result in moderate to high burn severity	• burns very rarely result in moderate to high burn severity	• no burns result in moderate to high burn severity

4.6.4. Condition and Trend

Fire Frequency

Current management at Tallgrass Prairie includes an active prescribed burn program that burns a portion of the preserve nearly every year. Within the period for which data is available, starting in 1998, the fire return interval was four years or less, with frequencies for most units being one or two years, which compares well with the reference condition (Figures 4.6-4 and 4.6-5). Fire frequency increased substantially in the last three years of the analysis period (2008–2010).

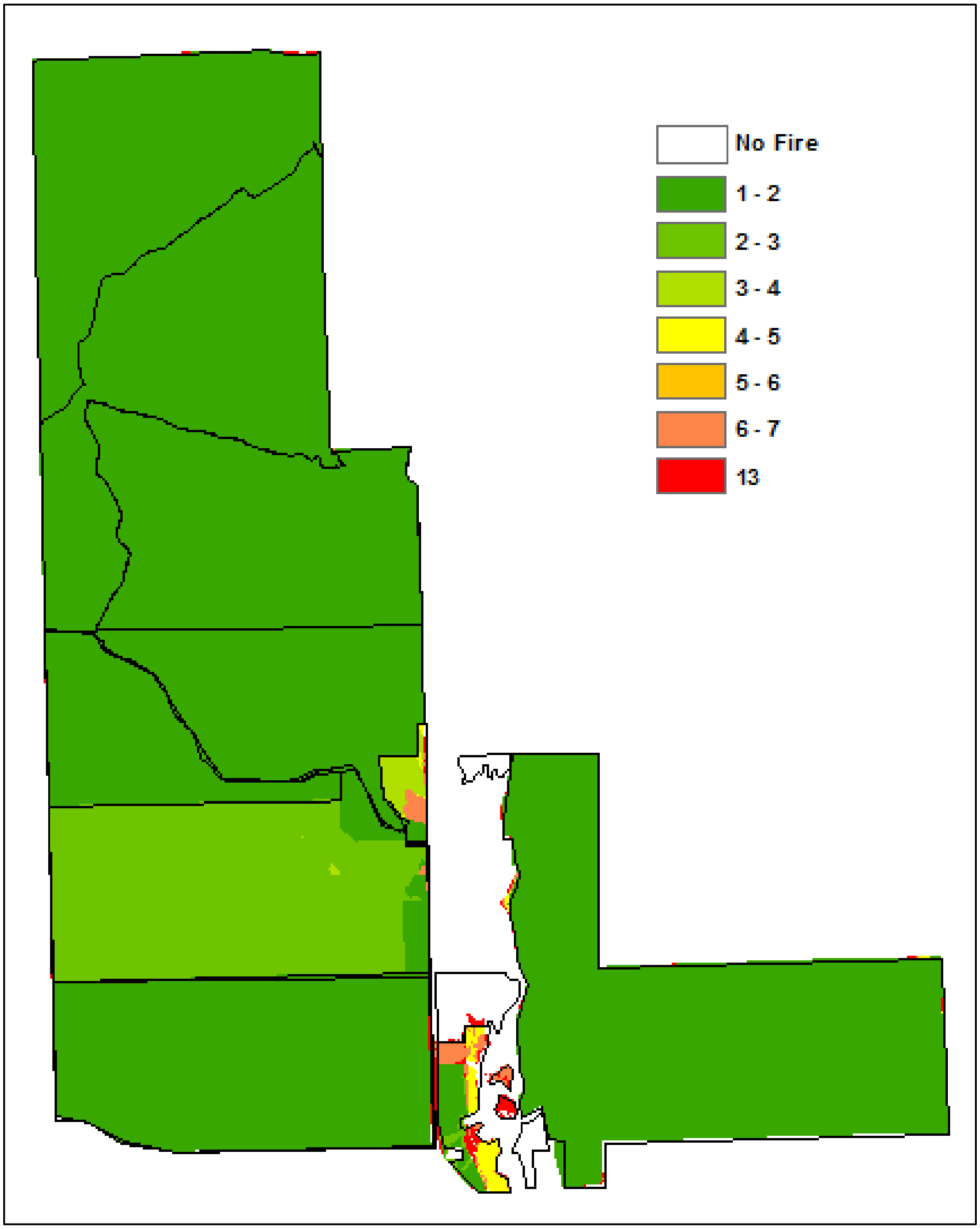


Figure 4.6-4. Average fire return interval, in years, from 1998 to 2010.

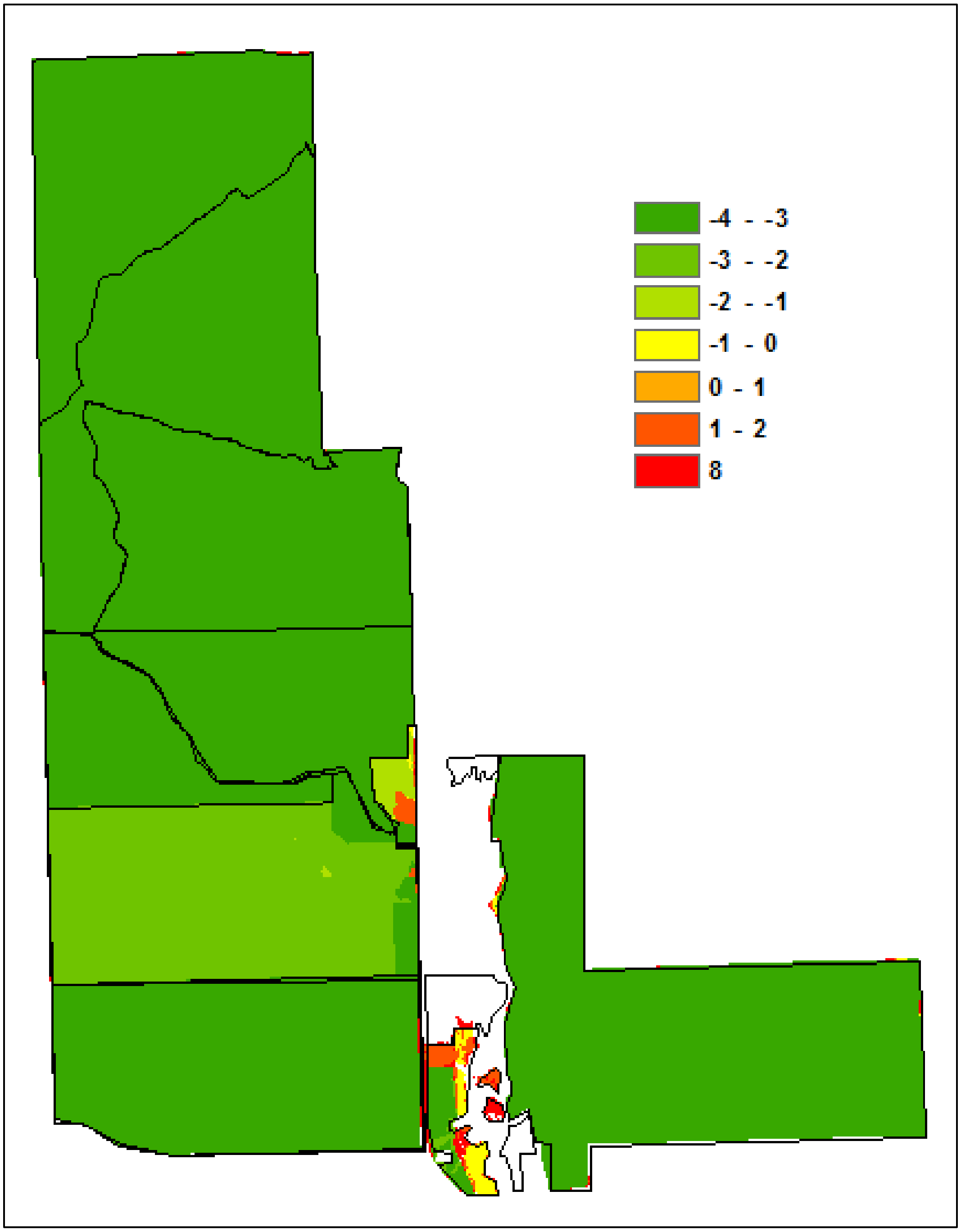


Figure 4.6-5. The historic return interval (5 years) subtracted from the average return interval.

The fire return interval is currently quite homogenous both within and between burn units (Figure 4.6-4). The PNMS consolidated unit had the lowest variability while other consolidated units showed moderate to high variability. Overall, spatial variability in fire return interval is lacking, with different burn units receiving only slightly differing fire return intervals. That may suffice for the short term, but in the longer term, increased temporal (within a burn unit) and spatial (between burn units) variability are likely desirable. In regard to temporal variability, there appears to be a tendency to burn at 1 or 2 year intervals; these two intervals account for more than 88% of all fire return intervals (Figure 4.6-6). Most of the longest intervals occurred near the visitor's center and in the lower Fox Creek drainage near Strong City. There is no apparent spatial pattern in burn frequency. Although fire return intervals are consistently less than 5 years, the condition of this indicator warrants moderate concern because there is little variability in the fire frequency within and among burn units.

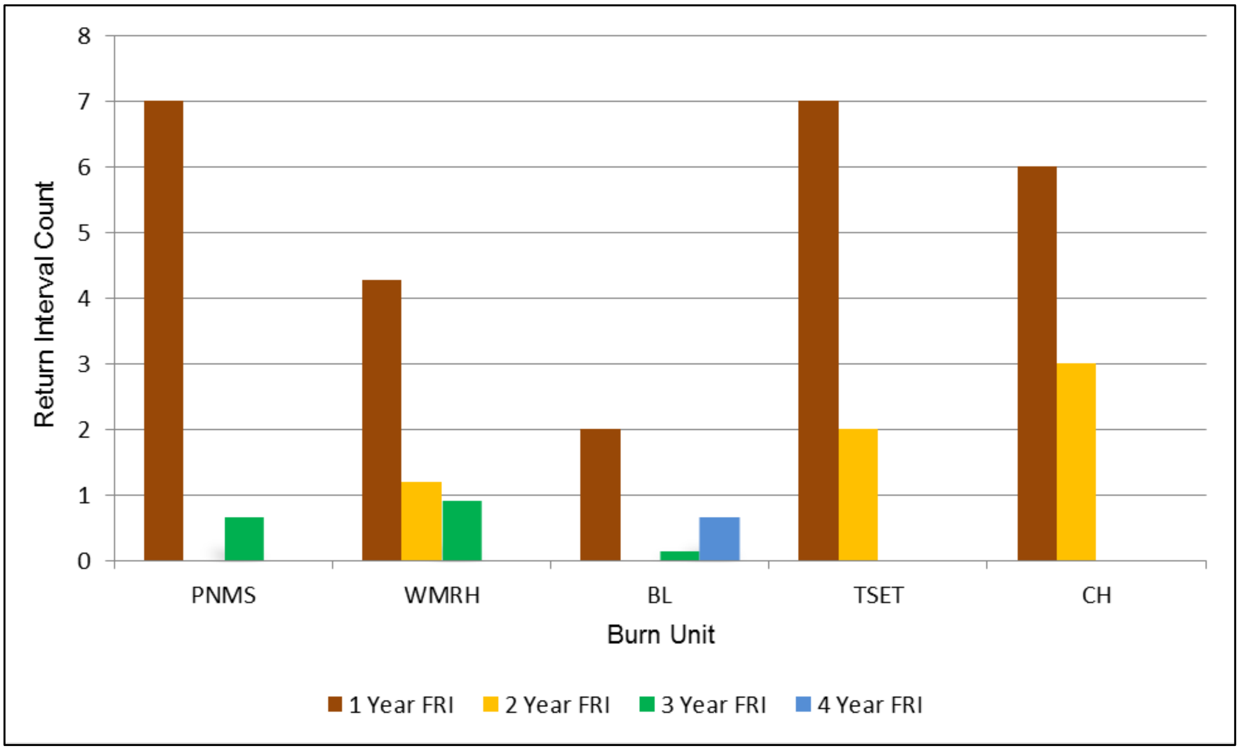


Figure 4.6-6. The count of return interval frequency in each burn unit of TAPR from 1998 to 2010. FRI = Fire Return Interval.

Fire Seasonality

At TAPR, virtually all burns occur during the spring, though there are infrequent late-May burns in the recent fire history. Consistent spring burns and lack of variability in burn seasonality may tend to benefit warm season grasses at the expense of cool season grasses and some forbs (Towne and Kemp 2003, Towne and Owensby 1984). This likely differs from the variability in seasonality of burn that was experienced under reference conditions. Because there is little or no variation in seasonality of burns within and among burn units, the condition of this indicator warrants significant concern.

Fire Severity

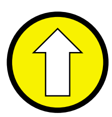
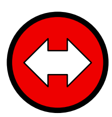
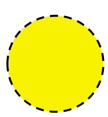
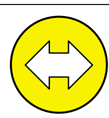
There is no information with which to directly assess fire severity although it can be assumed that fire severity will increase with time since fire. Given that burn frequency is generally higher than the reference condition, it can be extrapolated that burn severity is probably consistent with or lower than the reference condition of mostly low to moderate burn severity.

However, this also means that if fires were in prescription that they were planned to be of low intensity if the prescription was for low winds, moderate humidity and moderate temperature. The inferred lack of significant variability in fire severity warrants moderate concern for this indicator with an unknown trend due to lack of data. Very short fire return intervals produce consistently low to moderate-severity burns, resulting in moderate concern for this indicator.

Overall Rating

The condition of the fire regime warrants moderate concern with an unchanging trend (Table 4.6-2). The trend is weighted more heavily toward fire frequency than the other indicators. Fire regime components vary in their ability to meet reference conditions for the preserve. Although fire frequencies generally fall within the desired range, variability in the seasonality of fire may limit the restoration benefits and reduce heterogeneity within the prairie. Administrative uncertainties and inconsistent funding of prescribed burn management may adversely affect the condition of this resource over time.

Table 4.6-2. Condition and trend summary for fire regime at Tallgrass Prairie National Preserve.

Indicator	Condition Status/Trend	Rationale
Fire Frequency		Results indicate the fire return interval from 1998 to 2010 has overall been within the range of the reference condition or even more frequent. The last three years indicate a downward trend in fire frequency toward the reference condition. However, there is little variability in the fire frequency within and among burn units.
Fire Seasonality		Data is complete but coarse. The timing within a season is important to post-fire responses. The current spring-only burning program probably conflicts with more variable burn timing in the reference condition. There is generally a lack of variability in the seasonality of burning.
Fire Severity		Data related to fire severity does not exist. Extrapolated data suggests that fire severity falls within the range of the reference conditions. However, conservative fire prescription windows to minimize the risk of fires escaping or endangering property and health are characterized by conditions that produce low to moderate severity. Therefore, high-severity fires are likely occurring less often than under presettlement conditions. Data is not available to assess the current trend.
Fire Regime Overall		**The condition of the fire regime warrants moderate concern with an unchanging trend. Confidence in the assessment is medium due to conflicting trends and lack of information regarding fire severity.**

4.6.5. Uncertainty and Data Gaps

No burn data after 2010 were available. It is unknown whether burning has continued in the interim. There is no way to assess burn severity from the existing data.

4.6.6. Sources of Expertise

- Sherry Leis, Fire Science Program Leader and Heartland Inventory and Monitoring Network Cooperator, Missouri State University Biology Department, Springfield, Missouri. Ms. Leis provided helpful reviews on the draft manuscript.

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4.7. Air Quality

4.7.1. Background and Importance

The NPS Organic Act, Air Quality Management Policy 4.7.1, and the Clean Air Act of 1977 and its subsequent amendments protect and regulate the air quality of the National Parks within the United States. The NPS is responsible for protecting air quality and related issues which may be impacted by air pollution. Many resources in parks can be affected by air pollution. For example, scenic vistas require good visibility and low haze. Human-made pollution can harm ecological resources, including water quality, plants and animals. Air pollution can also cause or intensify respiratory symptoms for visitors and employees at NPS areas. Because of these many links, poor and/or declining air quality can impact park visitation. A synthesis of seven visitor studies conducted in the NPS Midwest Region found that clean air was ranked as *extremely important* or *very important* by 88% of visitor groups (Kulesza et al. 2013).

National Park Service units fall under two different classifications for air quality protection. Class I airsheds are defined as national parks over 6,000 acres (2,428 ha), national wilderness areas, national memorial parks over 5,000 acres (2,023 ha), or international parks in existence as of August 7, 1977 (NPS ARD 2013a). Class II airsheds are areas of the country protected under the Clean Air Act, but identified for somewhat less stringent protection from air pollution damage than a Class I area, except in specified cases (NPS ARD 2013a). Based on these classifications of airsheds, TAPR falls under the Class II area of protection.

Air quality can have a significant impact on the vegetation and ecology of an area. The NPS Air Resources Division describes ground-level ozone as having a larger effect on plants than all other air pollutants combined (NPS ARD 2012a). Nitrogen (ammonia - NH_4) and sulfur (sulfate - SO_3) deposition can cause acidification of water bodies, while excess nitrate (NO_3) can lead to nutrient effects on biodiversity. Decreased visibility from haze does not affect the ecology of an area so much as it affects the human element through decreased viewing opportunities of the protected lands and surrounding areas.

As of December 2012, the TAPR area was not listed by the EPA as an area of nonattainment for any air quality indicators (EPA 2013). TAPR experiences “high” exposure to atmospheric nitrogen (N) enrichment and has been described as being highly at risk from N enrichment (Sullivan et al. 2011a). TAPR also has “high” exposure to acidic deposition from sulfur (S) and N emissions and has been described as being highly at risk from acidic deposition (Sullivan et al. 2011b).

Threats and Stressors

The Kansas Department of Health and Environment (KDHE) cites hot, dry summers leading to increased ground-level ozone and prescribed burning of tallgrass prairie in the Flint Hills region as the primary air quality concerns in rural areas of Kansas, especially in the spring when much of the burning occurs (Figure 4.7.1) (KDHE 2010). Public agencies and private landowners conduct prescribed burns in the Flint Hills area to promote prairie production and control weedy and woody species from encroaching on the tallgrass prairie (KDHE 2010). Prescribed burning under sub-optimal conditions can lead to ozone, PM_{10}, and $PM_{2.5}$ levels that exceed federal standards outlined in the National Ambient Air Quality Standards (NAAQS) section of the Clean Air Act. Reduced visibility from smoke is also a concern for vehicular or airport safety and for aesthetic value of the landscape. Cautions taken since the implementation of the Flint Hills Smoke Management Plan in 2010 include timing of prescribed burns, non-essential burning restrictions in affected counties, and monitoring of meteorological conditions that could affect air quality during burns (KDHE 2010). Other sources of nitrogen and sulfur pollution include regional metropolitan centers and industry.

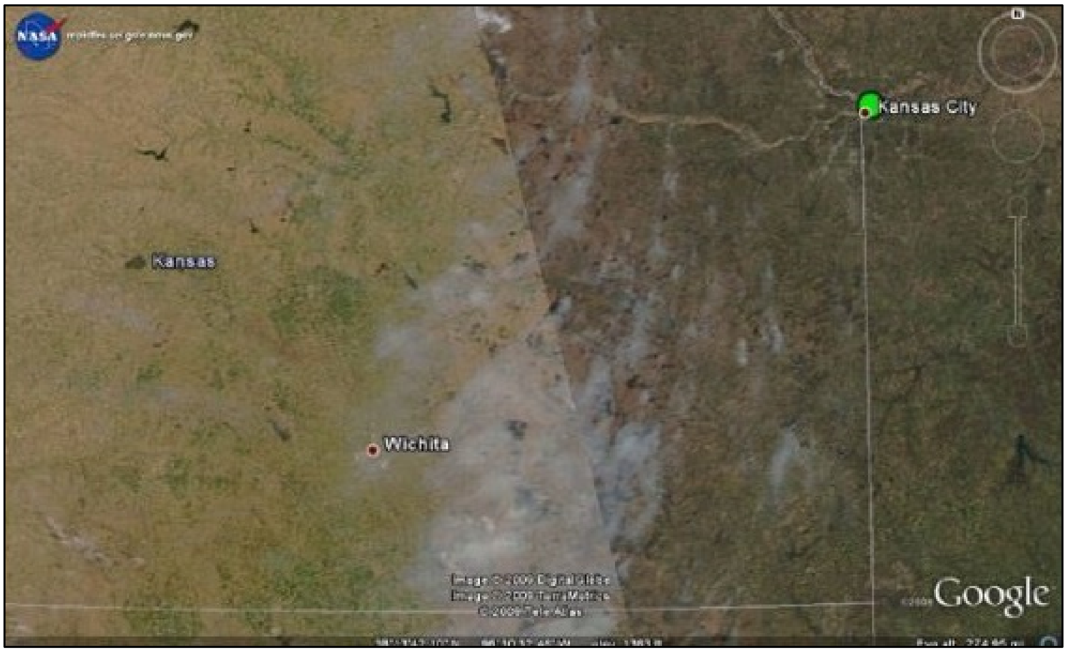


Figure 4.7-1. April, 2009 satellite image showing heavy smoke plumes in Eastern Kansas near TAPR (KDHE 2010).

<u>Indicators and Measures</u>
- Level of ozone
- Atmospheric wet deposition in total N and total S
- Visibility haze index

4.7.2. Data and Methods
The NPS Air Resources Division (ARD) has produced an interactive Air Atlas that shows the 5-year interpolated values for ozone, atmospheric deposition, and visibility at each NPS property across the contiguous US. Interpolated values for ozone, wet deposition, and visibility were used to assess the air quality condition at TAPR. The NPS ARD Air Atlas provides the best air quality information for TAPR.

The NPS ARD (2013b) published the trends and conditions of air quality at all NPS properties using data from 2000–2009 and 2005–2009, respectively. This publication used a non-parametric regression technique known as the Theil Method to determine ozone, deposition, and visibility trends using yearly data. Although the five-year averages may appear to have some trends, these are not always supported by statistical analysis. Currently, there are no monitoring stations for ozone or wet deposition located within TAPR. Monitoring data originates from regional monitoring stations and interpolated values. The nearest ozone monitoring station is located in Wichita, Kansas, about 50 miles southwest of TAPR. Wet deposition is monitored at two stations in the region; one is located at Konza Prairie (50 miles north of the preserve) and the other at Farlington, Kansas (approximately 100 miles southeast of TAPR) (NPS ARD 2001).

4.7.3. Reference Conditions

Reference conditions are based on USEPA standards or have been recommended by NPS ARD (2012b, 2013c). A summary of reference conditions and condition class rating for air quality indicators is shown in Table 4.7-1.

Table 4.7-1. Reference condition framework for air quality indicators.

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

<u>Ozone</u>

Ozone is known to impact vegetation and human health and is a concern at many NPS units. Ozone is able to enter leaves through stomata and causes chlorosis and necrosis of leaves (Figure 4.7-2), among other problems. Soil moisture plays a big role in the uptake of ambient ozone. Moist soils allow plants to transpire and increase stomatal conductance which, in turn, increases ozone uptake (Panek and Ustin 2004). Ozone causes problems for humans as well, including difficulty breathing, chest pain, coughing, inflamed airways, and making lungs more susceptible to infection (EPA 2012).

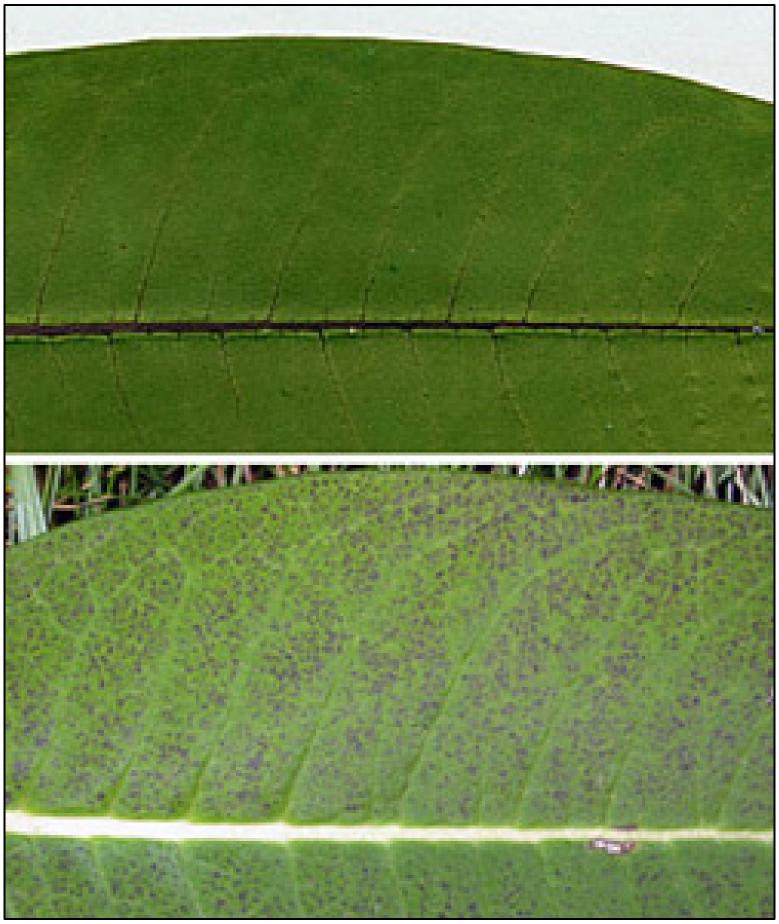


Figure 4.7-2. *Asclepias syriaca* normal leaf (top) and ozone-injured leaf (bottom). Photo: NPS ARD.

The EPA's standard benchmark for protecting human health is 75 parts per billion (ppb) of ozone, averaged over an 8-hour period. The 3-year average of the annual 4th-highest daily maximum 8-hour average ozone concentration must not exceed the 75 ppb mark to meet the EPA standard. The NPS ARD utilizes the five-year averages of 4th highest daily maximum 8–hour ozone concentrations for parks within the contiguous United States (NPS ARD 2013c). The NPS ARD ranks ozone conditions as "good" for levels less than or equal to 60 ppb, "moderate" for values between 61–75 ppb, and "poor" for levels greater than or equal to 76 ppb (Table 4.7-1) (NPS ARD 2013c).

Wet Deposition

The NPS ARD (2013c) considers parks that receive less than 1 kg/ha/yr each of nitrogen and sulfur as being in "good" condition", parks receiving between 1–3 kg/ha/yr are ranked as "moderate" condition, and parks that receive more than 3 kg/ha/yr are ranked as "poor" condition" (Table 4.7-1) (NPS ARD 2013c).

Visibility

Visibility is measured using the Haze Index in deciviews (dv). Visibility conditions are the difference between average current visibility and estimated average natural visibility, where the average natural visibility is the mean between the 40th and 60th percentiles (NPS ARD 2013c). Five-year interpolated averages are used in the contiguous U.S. Visibility is considered to be in "good" condition if visibility is less than 2 dv, "moderate" condition for values between 2–8 dv, and "poor" condition for values greater than 8 dv (Table 4.7-1) (NPS ARD 2013c).

4.7.4. Condition and Trend

Condition status ratings for air quality indicators are summarized in Table 4.7-2.

Table 4.7-2. Results for air quality indicators at Tallgrass Prairie National Preserve (NPS ARD 2012a, 2012b, 2012c).

Averaged 5-year Period	Ozone (ppb)	Total N (kg/ha/yr)	Total S (kg/ha/yr)	Visibility (dv)
2006–2010	69.1 (moderate)	4.9 (poor)	2.8 (moderate)	10.0 (poor)
2005–2009	70.3 (moderate)	5.2 (poor)	3.0 (moderate)	10.6 (poor)
2004–2008	70.1 (moderate)	5.1 (poor)	3.0 (moderate)	10.9 (poor)
2003–2007	72.9 (moderate)	5.5 (poor)	3.3 (poor)	11.4 (poor)
2001–2005	74.6 (moderate)	5.7 (poor)	3.4 (poor)	9.9 (poor)

<u>Ozone</u>

There are 7 plant species identified within TAPR that are sensitive to ozone (Table 4.7-3).

Table 4.7-3. TAPR plant species sensitive to Ozone (NPS ARD 2003, 2004).

Scientific Name	Common Name
Asclepias syriaca	Common milkweed
Fraxinus pennsylvanica	Green ash
Parthenocissus quinquefolia	Virginia creeper
Cercis canadensis	Redbud
Sambucus canadensis	American elder
Platanus occidentalis	American sycamore
Robinia pseudoacacia	Black locust

From 2006–2010 TAPR experienced a 4^{th} highest 8-hr ozone average concentration of 69.1 parts per billion (ppb) (Table 4.7-2) (NPS 2012a). The ozone levels at TAPR improved slightly from the 2001–2005 period to the 2006–2010 period, but the trend is not statistically significant (NPS ARD 2013b). This indicator warrants moderate concern, with an unchanging trend and medium confidence due to the regional and modeled nature of the data.

<u>Wet Deposition</u>

The five-year averages for total N consistently fall in the "poor" category and total S deposition consistently falls in the "moderate" category (Table 4.7-2). The deposition rates improved slightly from the 2001–2005 period to the 2006–2010 period, but the trend is not statistically significant (NPS ARD 2013b). The condition of this indicator warrants significant concern, with an unchanging trend and medium confidence due to the regional and modeled nature of the data.

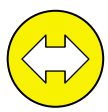
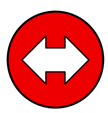
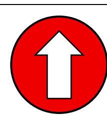
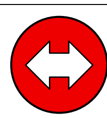
Visibility

The five-year averages for visibility consistently fall in the "poor" category. Visibility levels have been between 9.9 dv and 11.4 dv between 2001 and 2010. The data show a statistically significant decreasing trend indicating that the condition of this indicator is improving. The condition of this indicator warrants significant concern, with an improving trend and medium confidence due to the regional and modeled nature of the data.

Overall Condition

Based on the evaluation of ozone, N and S wet deposition and visibility, air quality condition warrants significant concern, with an unchanging trend (Table 4.7-4). Confidence in the assessment is medium. Impacts to air quality appear to be largely from distant sources that are affecting regional air quality, or local sources including prescribed burns used by farmers, ranchers and natural resource managers.

Table 4.7-4. Condition and trend summary for air quality at Tallgrass Prairie National Preserve.

Indicator	Condition Status/Trend	Rationale
Ozone		Ozone levels have been improving since 2001, but the trend is not statistically significant.
Wet Deposition (total N and total S)		Wet deposition measurements are consistently high for TAPR.
Visibility		Visibility measurements are consistently poor for TAPR. However, there is a statistically significant indication of improving visibility.
Air Quality Overall		**The condition of air quality indicators warrants significant concern with an unchanging trend. Confidence in the assessment is medium.**

4.7.5. Uncertainty and Data Gaps

Monitoring stations are needed at TAPR to better understand the specific air quality conditions at the preserve used in this analysis. The only air quality monitoring station within the preserve monitors the parameters needed to measure visibility, but does not measure wet deposition or ozone. The Air Atlas interpolations are adequate, but can misrepresent park conditions due to modeling errors. Monitoring of air quality conditions within TAPR or nearby would eliminate uncertainty from the interpolations.

4.7.6. Sources of Expertise

- The NPS ARD manages the national air resource management program for the NPS. They, along with NPS regional offices and park staff, provide air quality analysis and expertise relevant to air quality topics.

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Sullivan, T. J., G. T. McPherson, T. C. McDonnell, S. D. Mackey, and D. Moore. 2011b. Evaluation of the sensitivity of inventory and monitoring national parks to acidification effects from atmospheric sulfur and nitrogen deposition: Heartland Network (HTLN). Natural Resource Report NPS/NRPC/ARD/NRR—2011/359. National Park Service, Denver, Colorado.

4.8. Stream Hydrology and Geomorphology

4.8.1. Background and Importance

NPS Management Policies (NPS 2006) specify that the Service will manage watersheds as complete hydrologic systems and minimize human-caused disturbance to the natural upland processes that deliver water, sediment, and woody debris to streams. Processes include runoff, erosion, and disturbance to vegetation and soil caused by fire, insects, weather events and other stressors. The Service will manage streams to protect stream processes such as flooding, stream migration, and associated erosion and deposition that create habitat features. The Service will protect watershed and stream features primarily by avoiding impacts on watershed and riparian vegetation and by allowing natural fluvial processes to proceed unimpeded (NPS 2006). Preserve and national NPS goals require an integrated perspective that includes upland vegetation and grazing management, wildlife management, management of springs and impoundments, and riparian zone management, all of which affect aquatic resources and surface water quality. Planning and management documents for TAPR do not contain specific management objectives or targets for preserve streams.

The desired future for hydrologic resources on the preserve, which represent the conditions that would be desirable to have in place in order to achieve the purpose of the preserve, is articulated in the preserve's *General Management Plan* (GMP) (NPS 2000)—"The preserve's seeps, springs, and streams are in good ecological condition and support a healthy and diverse aquatic community." The desired future goes on to emphasize that healthy aquatic resources are vital to a fully functioning prairie ecosystem, and should be assessed and either maintained or restored to function as integral parts of the ecosystem (NPS 2000).

Stream hydrology at TAPR is affected by an extensive network of seeps and springs and by numerous stock ponds (Figure 4.8-1). In addition to riparian areas, these are important water sources for livestock. Springs were the original source of water on the ranch. Many springs produce substantial amounts of water even in the dry weather of summer; because of their reliability, they are especially important water sources for livestock and flora and fauna on the preserve. A comprehensive inventory of springs documented 237 springs across the landscape (Kansas Geological Survey 2001). According to the 2001 inventory the flow rate for 135 of these springs (57%) was estimated at 1 gallon per minute (gpm) or less. Almost all of these springs are intermittent, or "wet weather," springs. Thirty-nine springs (16%) had flow rates estimated at 5 gpm or more. Nearly all the springs on the preserve are classified as contact springs, whereby water flows from permeable limestone lying on top of less permeable shale. Springs form where water moving through permeable layers is intersected by a stream valley or hillside. Although springs and ponds are linked to stream hydrology and may affect aquatic resources, their condition is not examined here. The condition of water quality and aquatic macroinvertebrates is addressed in separate sections within this chapter.

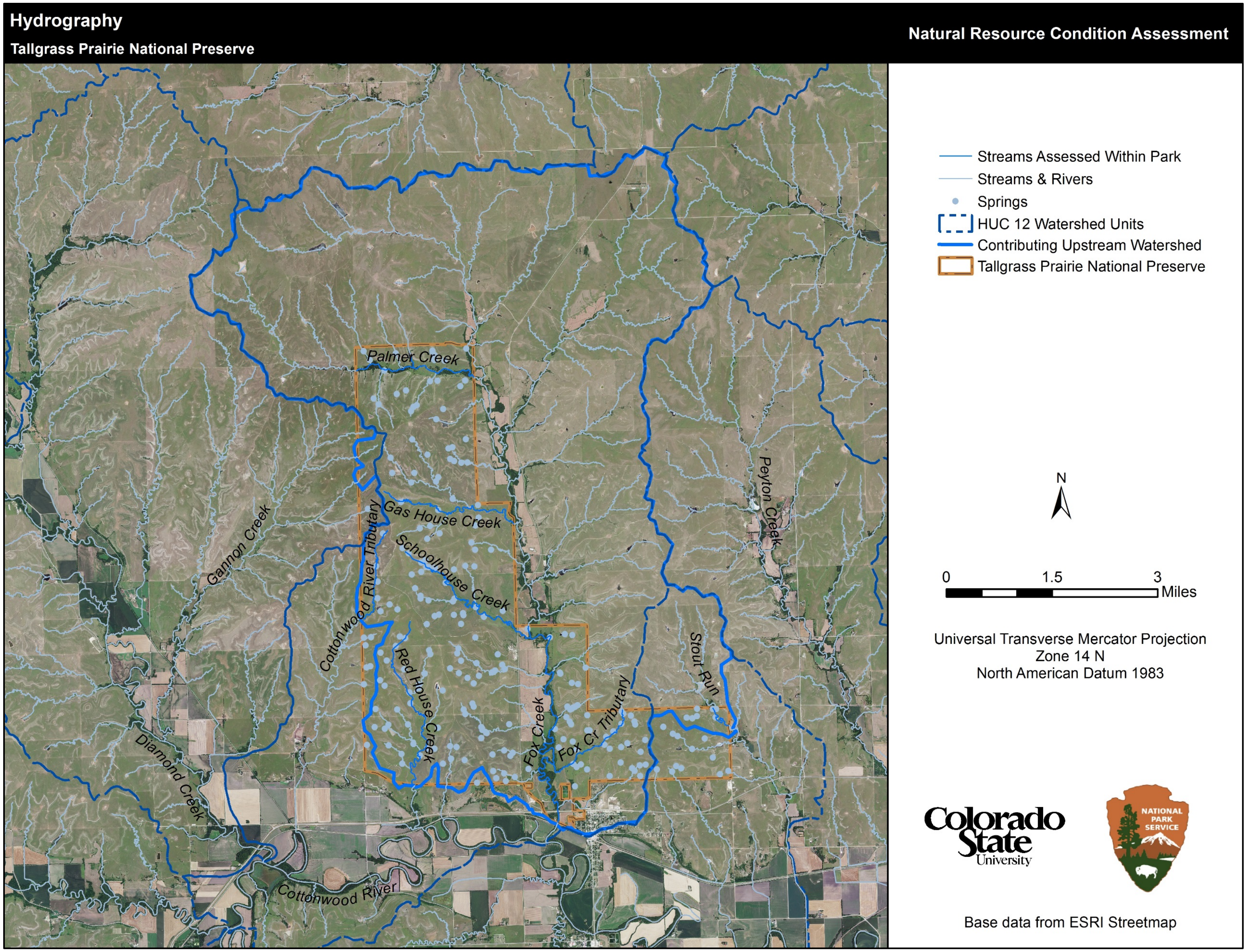


Figure 4.8-1. Surface hydrography of Tallgrass Prairie National Preserve, Kansas.

Twenty six stock ponds serve primarily as water sources for cattle and bison and secondarily as retention ponds for surface water runoff during storm events. Ponds are unnatural to the native ecosystem and have impacted secondary streams throughout the preserve (NPS 2000). Under the current Preferred Alternative of the GMP, many spring boxes, dams, and stock ponds are maintained and continue their original use (as watering points for livestock) as determined by an evaluation of their operational value and historical significance. Criteria for this evaluation may include National Register of Historic Places criteria, flood control and sediment management value, plant and animal species present, potential use in managing grazing patterns, and whether or not there is a connection to perennial springs. Some stock ponds or stream boxes found to be of low value may be removed in the future (NPS 2000).

Stream condition depends on interactions between inflowing supplies of water and sediment, valley setting, and external controls such as riparian vegetation. A stream is generally considered stable and in equilibrium when its sediment-transport capacity balances the sediment supply delivered from the watershed and upstream reaches such that the stream dynamically maintains its pattern, dimension, and profile over engineering time scales of about 50 years. If watershed changes alter the flow regime, sediment supply, vegetative reinforcement, or the channel directly, the stream may undergo a period of instability involving incision and/or widening in response. During this transition period, streams commonly exhibit increased erosion, bank failures, and aggradation which can negatively influence aquatic and riparian habitats which are major determinants of biotic composition.

Tallgrass Prairie once spread over 170 million acres across North America. Agriculture and urban sprawl have replaced the prairie and today less than 4% remains. The Tallgrass Prairie National Preserve encompasses 10,894 acres of which the local streams play a vital role in the ecosystem. The hydrology of prairie stream systems tend to be more extreme due to the variable nature of the summer convective thunderstorms that can leave streams dry in times of drought or flooding during wet times (Dodds et al. 2004). These intermittent flashy flow patterns directly affect the stream channel characteristics and surrounding riparian area.

Approximately 97% of TAPR's contributing upstream watershed is classified as having 0–2% impervious surfaces. Approximately 0.7% of the contributing upstream catchment of the preserve was classified as having >25% impervious surfaces (Table 4.1-5), the vast majority of which is concentrated near the town of Strong City. Landcover and landuse characteristics of TAPR's contributing upstream watershed are examined in detail in the *Land Cover and Land Use* section of this chapter. The objective of this study is to assess the hydrology and geomorphology within Tallgrass Prairie National Preserve to determine current condition of School House Creek, Red House Creek, Gas House Creek, Tributary to Cottonwood River, Stout Run, Palmer Creek, Tributary to Fox Creek, and Fox Creek relative to a defined reference condition.

<u>Threats and Stressors</u>

- Livestock impacts to streambanks and water quality. Stocking rates were reduced substantially when grazing rights were purchased by TNC in 2006, but some stream reaches continue to show evidence of ongoing trampling by livestock.

- Historic degradation of stream stability resulting in channel incision, headcutting and slumping resulting in continued instability and accelerated erosion
- Climate change may increase the incidence of extreme runoff events, which may impact recovery of streams from historic overgrazing periods.

Indicators and Measures

- Proper functioning condition (PFC) rating
- Channel evolution model (CEM) stage

4.8.2. Data and Methods

Several surveys related to hydrology and geomorphology have been completed since the creation of the preserve (The Watershed Institute (TWI) 2010a, 2010b). The TWI surveys evaluated stream reaches on a southern tributary to Fox Creek and Gas House Creek to document and monitor geomorphic changes in tributary channels after land management changes including reduced cattle stocking rates were instituted in 2006. Both surveys concluded that streambed instability was minimal and there was some bank instability. Even though several banks rated high for streambank erosion potential, the amount of predicted erosion was considered small. However, these studies do not provide a consistent and comprehensive snapshot of stream hydrology condition and function within the preserve.

Eight streams were visually assessed for Proper Functioning Condition (PFC) (BLM 1998) and Channel Evolution Model (CEM) stage (Schumm et al. 1984) along their course within the preserve (Figure 4.8-1). Field assessments by Colorado State University were conducted in June, 2013. PFC assessment consisted of evaluating seventeen hydrologic, vegetative, soil and geomorphological parameters ultimately leading to a PFC and CEM ratings for the stream reach. PFC condition characteristics are described below. The CEM rating was used to support the PFC determination as well as indicate the trend in condition, especially where Functional at Risk conditions exist.

Proper Functioning Condition

Streams and associated riparian areas are functioning properly when adequate vegetation, landform, or large woody debris is present to:

- Dissipate stream energy associated with high waterflows, thereby reducing erosion and improving water quality;
- Filter sediment, capture bedload, and aid floodplain development;
- Improve floodwater retention and groundwater recharge;
- Develop root masses that stabilize stream banks against cutting action;
- Develop diverse ponding and channel characteristics to provide habitat and the water depths, durations, temperature regimes, and substrates necessary for fish production, waterfowl breeding, and other uses; and
- Support greater biodiversity.

Functional – At Risk
These riparian areas are in functional condition, but an existing soil, water, vegetation, or related attribute makes them susceptible to degradation. For example, a stream reach may exhibit attributes of a properly-functioning riparian system, but it may be poised to suffer severe erosion during a large storm in the future due to likely migration of a headcut or increased runoff associated with recent urbanization in the watershed. When this rating is assigned to a stream reach, then its "trend" toward or away from PFC is assessed.

Nonfunctional
These are riparian areas clearly are not providing adequate vegetation, landform, or large woody debris to dissipate stream energy associated with high flows, and thus are not reducing erosion, improving water quality, sustaining desirable channel and riparian habitat characteristics, and so on as described in the PFC definition. The absence of certain physical attributes such as a floodplain where one should exist is an indicator of nonfunctioning conditions.

Channel Evolution Model (CEM)
Developed by Schumm et al. (1984), the CEM is designed to determine the stage of stream evolution in incising channels. CEM scores of I, III, and V may not indicate trends but a CEM Type II channel usually indicates a deteriorating trend. CEM Type IV channel indicates an improving trend.

Determining the CEM stage is a useful tool for managers to not only help identify the current condition of the stream but also to indicate the possible future trend allowing for informed management decisions about stream protection and rehabilitation. There are many reasons why incision may occur within a stream, but it is generally due to a disparity between sediment-transport capacity and sediment supply (Watson et al. 2002). Incision sometimes manifests as a headcut that will progress upstream as long as the sediment-transport capacity is higher than the supply and no resistive strata are encountered. Eventually the channel will incise deep enough to where bank failures occur due to geotechnical instability. Failures are generally caused by bank heights greater than the critical bank height, which results in mass failures and widening in the channel. With the addition of new sediment to the channel from the failed banks, the ratio of sediment-transport capacity to supply may switch, resulting in aggradation and a decrease in bed slope. The decreased bed slope reduces the sediment-transport capacity of the stream eventually resulting in a new dynamic quasi-equilibrium slope and a newly-stable channel. This evolution takes place in five stages and can generally be seen in order from upstream to downstream (Figure 4.8-2).

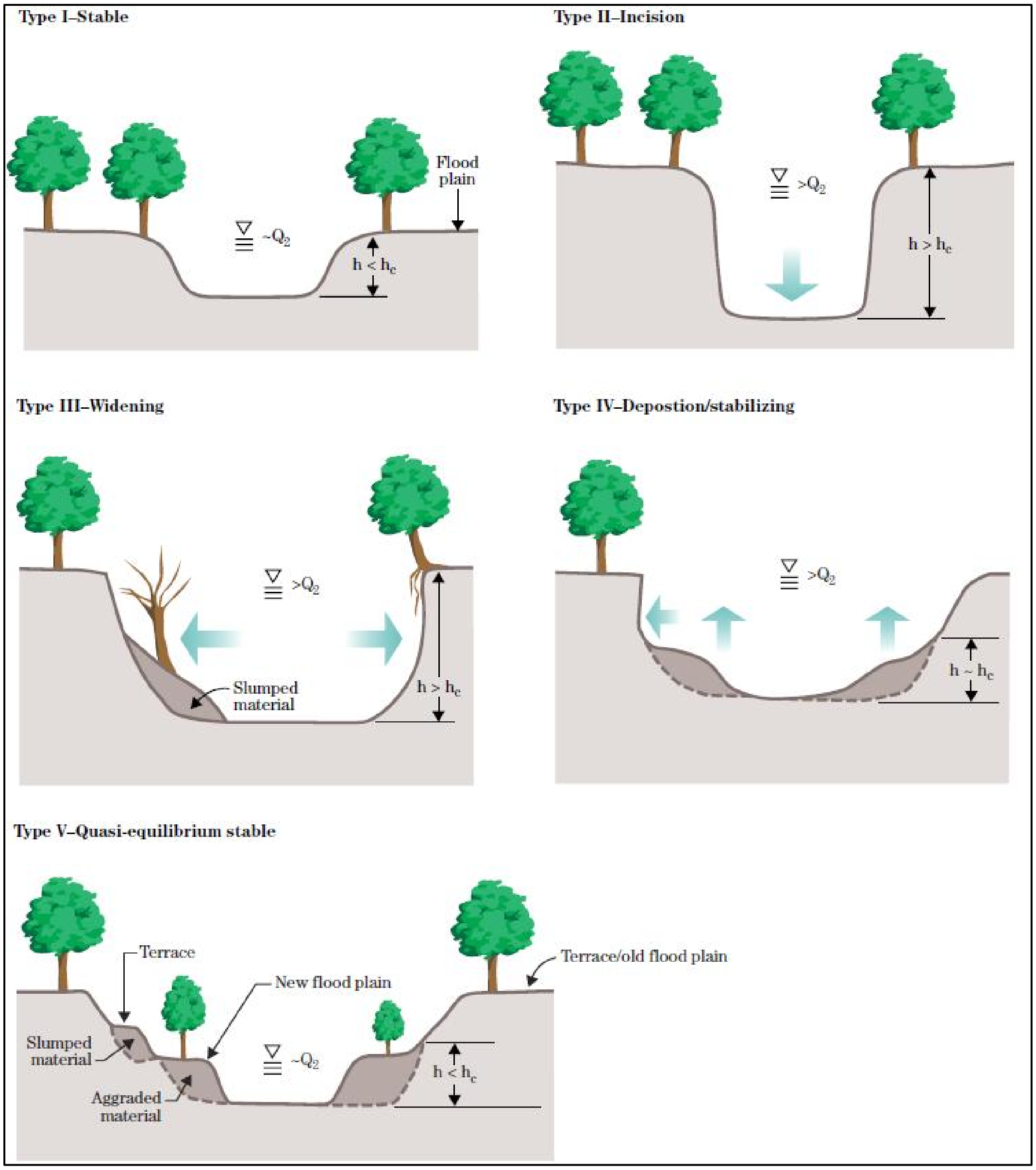


Figure 4.8-2. Cross-section view of the five types of channels in the CEM (NRCS 2007).

A CEM Type I reach is located upstream of a headcut and is considered stable. A CEM Type II reach is defined as actively incising, however, bank heights are still below critical bank height so bank failures are not present. In CEM Type III, bank heights are now above critical bank height, which results in mass bank failures and channel widening. In CEM Type IV, the channel begins to tend toward a stable state due to aggradation from an influx of sediment from the eroded banks. Bank failures may still be present in this stage of evolution. Finally, CEM Type V is when the channel has recovered because a new balance between sediment-transport capacity and supply has been reached. CEM stage was determined by walking the stream lengths in an upstream to downstream direction. The channel was visually assessed for signs of incision, bank failures, aggradation, and terracing to help determine stage. If definitive breaks in CEM score were seen along the stream, different reach scores were assigned. CEM stage scores ranged from Stage 1 to Stage 5 in half-stage increments.

4.8.3. Reference Conditions

The current condition of a stream is evaluated relative to a defined reference condition. Inherent within the PFC scoring of functioning condition is the idea of potential, which is defined as the "highest ecological status an area can attain given no political, social, or economic constraints" (Schumm et al. 1984). Likewise, for CEM stage the reference condition would be a Stage 1 channel type where the sediment supply is in balance with sediment transport, creating a stable channel. It was assumed for these historically prairie ecosystems that the reference condition for the streams would be based upon a stable channel whose flow and sediment regime had not been altered in any way.

The PFC and CEM framework is translated into a NRCA condition status rating as follows:

- Resource is in good condition – Proper Functioning Condition rating with CEM Type I (historic) or Type V (restored/rehabilitated) channel.
- Resource warrants moderate concern – Functional At-Risk rating often with a downward or no apparent trend CEM Type II, or with an upward or no apparent trend CEM Type IV channel.
- Resource warrants significant concern – Nonfunctional PFC rating often with CEM Type III channel.

4.8.4. Condition and Trend

The confidence level associated with condition and trend ratings on all streams was medium.

School House Creek

Eight PFC criteria were rated positively, seven negatively, and two criteria were scored N/A for beaver presence and large woody material, resulting in a PFC rating of Functional–At Risk with an upward trend. Adequate sources of large woody material were present; historically, prairie streams, especially low-order streams, usually had open canopy due to fire, grazing, and hydrology (Dodds et al. 2004). The flow regime has been affected by two dammed ponds in place on tributaries to School House. The riparian area has not achieved its potential extent but seems to be recovering from a grazing legacy as evidenced by rushes (*Juncus* spp.) and willows (*Salix* spp.) revegetating point bars and failed banks (Figure 4.8-3). Composition of wetland plant species is diverse (cottonwood (*Populus* spp.), willow (*Salix* spp.), rush (*Juncus* spp.), and false indigo (*Amorpha* spp.)) but most plants present are upland species which do not have the root masses capable of withstanding high-flow events. Multiple age-classes of the wetland species are not well-represented. Bedrock was found in most places <1 ft. below the channel bed surface and incision could still occur down to this layer. Bedrock is also present along some banks but fluvial erosion was occurring in most other areas. Mass wasting is occurring in most bends but point bars seemed to be revegetating at the same rate as the failure, indicating a possible natural rate of lateral movement. The creek was scored CEM Stage 4 as at some point the creek had incised beyond the bank's critical heights, creating failures. However, these failures are more rotational and revegetating as the stream is benefitting from not being grazed since at least 1996. Based on the assessment, School House Creek condition warrants moderate concern with an improving trend.

Figure 4.8-3. New lower banks are becoming revegetated on School House Creek, indicating a trend towards a stable channel. (CSU photo).

Red House Creek

Two criteria were scored positively, thirteen negatively, and two were not applicable for beaver presence and large woody material, resulting in a PFC rating of Functional-At Risk with no apparent trend. The flow regime has been affected by three dammed ponds in place along tributaries of Red House Creek. Trampling by cattle has created an over-widened channel with bare banks in areas and has negatively impacted bank revegetation (Figure 4.8-4).

Aggradation is present, especially along the downstream end where rills and gullies are forming along bare banks and cattle trails which act as a conduit for sediment to enter directly into the stream. A fine veneer up to 1 ft. in depth was present in many areas and point bars mostly consist of fine sediment with no vegetation, indicating a greater supply of sediment to the stream than which it can transport. Wetland plant species are sparse with only false indigo (*Amorpha* spp.) present. Upland plant species are dominant along banks and they do not have root masses capable of preventing bank erosion. Banks are undercut in bends and some runs with mass wasting occurring in most bends. Trampling by cattle is accelerating bank failures in areas. The creek was scored CEM Stage 3.5 as the channel is still adjusting but appeared to be moving towards a Stage 4. However, this progression is being affected by cattle trampling. Based on the assessment, Red House Creek condition warrants moderate concern with an unchanging trend.

Figure 4.8-4. Trampling in areas along Red House Creek is slowing revegetation of failed banks. (CSU photo).

Gas House Creek

Three criteria were scored positively, twelve negatively, and two N/A for beaver presence and large woody material, resulting in a Nonfunctional PFC rating. The flow regime has been affected by a man-made pond in place on a tributary of Gas House Creek. The channel is deeply incised and has downcut to bedrock in areas. Banks are undercut in most areas and mass wasting is occurring mostly in bends. Cattle trampling is accelerating bank failures and has created an over-widened channel (Figures 4.8-5 and 4.8-6). Plants trying to revegetate bare banks are also being trampled by cattle, keeping some banks bare. A few rush (*Juncus* spp.), sedge (*Carex* spp.), and willow (*Salix* spp.) are present but upland plant species were dominant along the banks. False indigo (*Amorpha* spp.) is more prevalent upstream. Occasional gullies are forming along cattle trails and are delivering fine sediment directly into the channel. Aggradation is present throughout the reach, but especially directly downstream of failing banks.

There is little to no vegetation on point bars and what plants are present are being trampled by cattle. The creek was scored CEM Stage 3.5 as the channel is still adjusting but appeared to be moving towards a Stage 4; however, trampling by cattle is negatively affecting this progression. Based on the assessment, Gas House Creek condition warrants significant concern with an unchanging trend.

Figure 4.8-5. Trampling in areas along Gas House Creek is accelerating bank failures and slowing revegetation of failed banks. (CSU photo).

Figure 4.8-6. Upper section of Tributary to Diamond Creek. (CSU photo).

Tributary to Cottonwood River

Five criteria were rated positively, ten negatively, and two N/A for beaver presence and large woody material, resulting in a PFC rating of Functional-At Risk with no apparent trend (Figure 4.8-7). The channel was slightly incised and banks were undercut in most areas. Mass wasting is occurring in some bends where bank height has surpassed its critical height and angle. Bedrock is present in banks where the channel runs along the steep hillsides and also in most areas 0 to 1 ft. below the bed surface. Some bank failures are revegetating, while others remain bare. Upland grasses are dominant along banks with false indigo (*Amorpha* spp.) also prominent. Rush (*Juncus* spp.), sedge (*Carex* spp.), and cottonwood (*Populus* spp.) were sparse. Slight trampling from bison is occurring in the uppermost part of the creek. It appeared that the stream may be recovering from historic grazing but still adjusting to the flashy hydrology associated with prairie systems. A large reservoir halfway down the reach may be influencing the hydrology downstream and causing the channel to adjust its sinuosity, gradient, and width/depth ratio. The creek was scored CEM Stage 2 as the channel has incised but bank failures were limited. Based on the assessment, the Tributary to Cottonwood River condition warrants moderate concern with an unchanging trend.

Figure 4.8-7. Gas House Creek is deeply incised with bare banks. (CSU photo).

Stout Run

Four criteria were rated positively, twelve negatively, and one N/A for beaver presence, resulting in a PFC rating of Functional-At Risk with a downward trend. The stream begins below a dammed pond which has altered the flow regime. The channel has downcut slightly and banks are undercut with mass wasting occurring in some bends. Cattle trampling was the main concern for the channel's condition as banks are severely trampled and bare (Figure 4.8-8). Upland gullies and rills are delivering sediment directly to the stream. Bank failures along runs are directly caused by trampling and are creating an over-widened channel. Vegetation trying to establish on point bars is also being trampled by cattle.

Some bank failures caused by trampling have created mid-channel vegetated islands that without the influence from cattle may not have occurred. These islands could also reinforce channel widening. Willows (*Salix* spp.) and false indigo (*Amorpha* spp.) are present in the reach but upland grasses are dominant along banks. The creek was scored CEM Stage 2 as the channel has incised but most bank failures were directly caused or accelerated by cattle trampling. Based on the assessment, the Tributary to Cottonwood River condition warrants moderate concern with a deteriorating trend.

Figure 4.8-8. Trampling along Stout Run is accelerating bank failures and slowing revegetation. (CSU photo).

<u>Palmer Creek</u>

Twelve criteria were rated positively, four negatively, and one N/A for beaver presence, resulting in a PFC rating of Functional-At Risk with an improving trend. The flow regime has been affected by six dammed ponds along tributaries that run into Palmer Creek. The channel has historically downcut to bedrock in most areas and has become over-widened. Vegetation is reestablishing and seems to encroach on the stream which could possibly begin to help narrow the channel (Figure 4.8-9). Due to the presence of bedrock and larger cobbles along the channel bottom, impact from cattle trampling is minimal. Some cattle trails are creating gullies that directly deposit sediment to the stream. Fluvial erosion is occurring in bends and some runs, and mass wasting is occurring in some bends. Overall the stream seems to be heading towards a new equilibrium as point bars and old bank failures are becoming revegetated with wetland plant species forming new lower banks. Willow (*Salix* spp.), rush (*Juncus* spp.), sedge (*Carex* spp.), and various hardwood are dominant along the stream banks and should help prevent erosion on newly-formed lower banks. The creek was scored CEM Stage 4 as the channel seemed to be heading towards a new equilibrium. Based on the assessment, the Palmer Creek condition warrants moderate concern with an improving trend.

Figure 4.8-9. Revegetation of lower banks along Palmer Creek is a possible sign of the stream moving towards a new stable channel. (CSU photo).

Tributary to Fox Creek (southeast corner of preserve)
Four criteria were rated positively, twelve negatively, and one N/A for beaver presence, resulting in a PFC rating of Functional-At Risk with no apparent trend. The flow regime has been affected by two dammed ponds along tributaries that run into Fox Creek. The upstream section of the creek is bedrock controlled in both the banks and along the channel bottom (Figure 4.8-10). Areas with bedrock are wider than areas without, but the entire channel appears over-widened. Along the downstream end, before joining with Fox Creek, the channel is deeply incised with mass wasting occurring in bends (Figure 4.8-11). Aggradation is occurring, especially downstream where point bars consist of fine sediment with little to no vegetation. A possible backwater effect from Fox Creek during high-flow events, combined with the lack of bedrock controlling vertical stability, may be why the stream appears more degraded at the downstream end. Elsewhere, a mix of upland grasses and wetland plant species are revegetating bars and failed banks but most vegetation appears young, possibly indicating a recovering trend.

The creek was scored CEM Stage 2.5 in the downstream end and in areas without bedrock as the channel was wider with more bank failures present. Areas controlled by bedrock were more representative of Stage 4 due to the revegetation of failed banks that may eventually form a new lower bank. Based on the assessment, the Tributary to Fox Creek condition warrants moderate concern with an unchanging trend.

Figure 4.8-10. Bedrock presence in the bed and banks of Tributary to Fox Creek is helping maintain a more stable channel in areas. (CSU photo).

Figure 4.8-11. The downstream section of Tributary to Fox Creek is deeply incised with bare banks. (CSU photo).

<u>Fox Creek</u>

Three criteria were rated positively, thirteen negatively, and one was N/A for beaver presence, resulting in a PFC rating of Functional-At Risk with no apparent trend. Fox Creek is a deeply-incised stream with failing banks in bends without bedrock present (Figure 4.8-12). Upstream, there is more bedrock present but the channel is over-widened. Point bars and failed banks are revegetating with mostly upland plant species with occasional wetland plants as well. Farther downstream, the creek is more incised with severe aggradation. A fine veneer at least 2-ft deep covers most of the channel bed. Many failed banks and point bars are revegetating with upland plant species including some that were invasive. Trees have fallen into the river from failing banks and are acting as sediment traps. It is uncertain whether the woody debris is helping protect the banks or exacerbating the mass wasting. Backwater effect from the Cottonwood River during high-flow events, mixed with episodes of drought, may be keeping the stream from finding a new equilibrium. The creek was scored CEM Stage 4 as it appears to be trying to establish a new revegetated lower bank but some banks were still continuing to fail. Based on the assessment, the Fox Creek condition warrants moderate concern with an unchanging trend.

Figure 4.8-12. Fox Creek is deeply incised with bare banks in areas (CSU photo).

<u>Overall Condition</u>

There are no streamflow gaging stations present on any of the streams that run through the preserve. Therefore, we present a general discussion of prairie stream hydrology. In Tallgrass Prairie National Preserve, shallow soils above limestone and shale bedrock means that water from high-intensity rainstorms can be delivered quickly to the channel through overland flow from the surrounding hillslopes. During field reconnaissance on the preserve, a ~2-inch rainstorm turned the gravel two-track roads that run through the preserve into small creeks themselves (Figure 4.8-13). In dry years many of the streams dry up completely except for some spring-fed pools (Kristen Hase, pers. comm.). It is this variable and extreme flow regime that can influence erosion rates along the banks and channel bed. The presence of dammed spring-fed ponds on many of the stream tributaries has also affected the flow regime but additional research would be required to define how the hydrology has been changed.

Results were summarized for all streams examined (Table 4.8-1). Trampling from cattle grazing appears to have a significant negative impact on the streams within the preserve. Due to the lack of trees along many of the upper reaches of the streams, the cattle tend to escape the summer heat by congregating in areas along the creeks with trees. Most of the streams have been grazed annually since 1996 for roughly 90 days each spring and summer. Many of the streams that were recently grazed by cattle were severely trampled. However, School House Creek has not been grazed since before 1996 and was in much better condition that the other streams. The lack of grazing has allowed vegetation to grow along previously-failed banks and the channel appears to be heading towards a new equilibrium. This would not have been possible with the annual grazing regime on other creeks. Overall, the flashy flow regime that is intrinsic in the prairie system may create more erosion potential than in other less flashy systems but grazing practices appear to be creating and accelerating degradation along many of the streams. Therefore, the overall condition of the streams within Tallgrass Prairie National Preserve warrants moderate concern with an unchanging trend.

Figure 4.8-13. Overland flow occurring on a gravel road within the preserve after a 2 inch storm event, July 2013 (CSU photo).

Table 4.8-1. Condition and trend summary for stream hydrology and geomorphology at Tallgrass Prairie National Preserve.

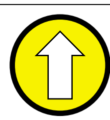
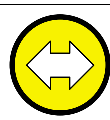
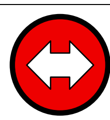
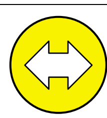
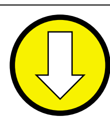
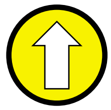
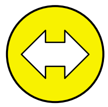
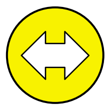
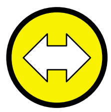
Indicator	Condition Status/Trend	Rationale
School House Creek		With cattle not present for at least the past 17 years the creek has begun to stabilize and become revegetated along previously trampled banks. This should continue unless cattle are allowed back.
Red House Creek		Trampling from cattle is removing vegetation from the banks and accelerating failures. The creek seemed to be recovering but the cattle appear to be preventing recovery and causing more degradation.
Gas House Creek		Trampling from cattle has created an over-widened channel with bare banks. Accelerated bank failures also due to cattle are creating a degraded channel.
Tributary to Cottonwood River		The creek appears to be recovering from historic cattle grazing. Impacts from buffalo are minimal. A reservoir downstream is affecting the hydrology and may be causing the channel to adjust.
Stout Run		Trampling from cattle along the channel is severe in areas leading to bare banks and accelerated bank failures. The creek is becoming over-widened and degraded due to trampling.

Table 4.8-1 (continued). Condition and trend summary for stream hydrology and geomorphology at Tallgrass Prairie National Preserve.

Indicator	Condition Status/Trend	Rationale
Palmer Creek		Palmer Creek has downcut to bedrock in many areas. The channel is over-widened but vegetation is establishing along channel banks indicating that the creek may be heading towards a new equilibrium.
Tributary to Fox Creek		The whole channel appears over-widened but the upstream is in better condition with bedrock controls present. Downstream the channel is deeper incised with more bank failures occurring.
Fox Creek		The channel is deeply incised and over-widened. Severe aggradation is occurring downstream that may be a result from backwater condition from the Cottonwood River downstream. Vegetation is establishing on the lower banks possibly creating a new lower bank in areas.
Stream Hydrology and Geomorphology Overall		**Stream condition warrants moderate concern with an unchanging trend. Confidence in the assessment is high.**

4.8.5. Uncertainty and Data Gaps

Recording discharge data for Fox Creek and other low-order creeks in the preserve would help determine how the flashy (and sometimes intermittent) flow regime, along with possible backwater effects, are affecting the streams. Additional data would also provide insight on how the dammed ponds are affecting the flow regime of the creeks.

4.8.6. Literature Cited

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4.9. Water Quality

4.9.1. Background and Importance

Surface waters at TAPR include a variety of perennial and intermittent streams, springs and ponds. Fox Creek and Palmer Creek are the primary perennial surface waters (Figure 4.9-1). Palmer Creek runs west to east near the northern boundary of TAPR and is a tributary to Fox Creek. Fox Creek bisects TAPR and flows from north to south. Fox Creek and Palmer Creek contained very high levels of fecal coliforms in the years shortly after TAPR's establishment as a NPS property in 1996 (NPS 2000). It was assumed that the high levels of fecal coliforms were due to runoff from heavily grazed pastures and concentration of livestock in riparian areas. Livestock stocking rates have since been significantly reduced.

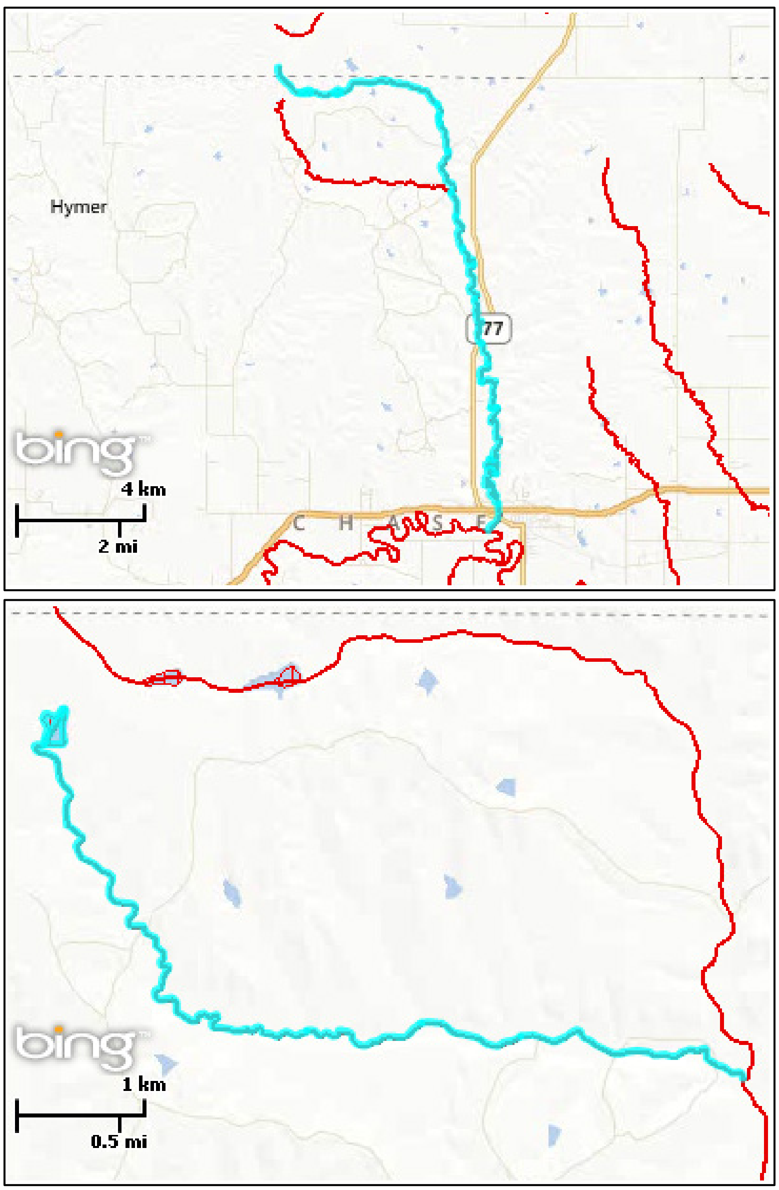


Figure 4.9-1. Fox Creek (top) and Palmer Creek (bottom) in blue (EPA 2013a).

The federal Clean Water Act (as amended in 1972) requires states to adopt water quality standards to protect lakes, streams, and wetlands from pollution. The standards define how much of a pollutant can be in the water and still meet designated uses, such as drinking, fishing, and swimming. A water body is "impaired" if it fails to meet one or more water quality standards. To identify and restore impaired waters, Section 303(d) of the Clean Water Act requires states to assess all waters to determine if they meet water quality standards, list waters that do not meet standards (also known as the 303d list) and update the list every even-numbered year, and conduct total maximum daily load (TMDL) studies to establish pollutant-reduction goals needed to restore waters. Federal and state regulations and programs also require implementation of restoration measures to meet TMDLs. Delisting of impaired waters only occurs when new and reliable data indicates that the water body is no longer impaired.

Currently, Fox Creek and Palmer Creek are considered impaired stream reaches under section 303(d). A TMDL for Fox Creek has been developed to reduce total load allocation of nitrogen and phosphorous by 25% (EPA 2013a, EPA 2013b). Fox Creek is also listed as impaired for turbidity, but there is currently no TMDL available (EPA 2013a, EPA 2013c). Palmer Creek is listed as impaired for dissolved oxygen, but there is currently no TMDL available (EPA 2013a, EPA 2013d).

Threats and Stressors

Water quality through TAPR is most affected by agricultural practices on the upper reaches of Fox Creek and its tributaries. These include livestock (primarily cattle) grazing throughout these watersheds, including disturbance and fecal waste deposited in riparian zones, and some fertilizer use for crop and hay cultivation in the Fox Creek valley. Grazing is the only land-use practice within the Palmer Creek watershed. Climate change may be another stressor to water quality at TAPR. Drought years and high temperatures may reduce the volume of water, lower dissolved oxygen concentrations, and help concentrate pollutants.

Indicators and Measures

Total Dissolved Solids

Total dissolved solids (TDS) measures the total concentration of dissolved substances in water (SDWF 2013). TDS may consist of inorganic minerals, or salts, in ionic and organic material. TDS for a sample of water is measured by passing the sample through a 0.45 micron filter to remove suspended solids, the remaining water is evaporated and the remaining residue represents the TDS concentration in milligrams per liter (mg/L) (USBR 2013). Common sources of TDS include natural sources such as mineral springs, but dissolved solids may also come from industrial sources, sewage, fertilizers, road runoff, and soil erosion. TDS concentrations can impact the water balance of cells within aquatic organisms by causing the cells to swell when TDS is too low and to shrink when TDS is too high (EPA 2013e).

Chloride

Chloride forms inorganic salts that may be deposited into surface waters from a variety of sources such as road salting, oil and gas wells, and agricultural runoff (McDaniel 2013). High levels of chloride can be toxic to freshwater fish and macroinvertebrates. The toxicity of chloride is increased when mixed with potassium or magnesium, as it is with certain road salts (NHDES 2013). When these metals are released from chloride, dissolved oxygen levels are reduced which causes additional stress to aquatic life (NHDES 2013). Additionally, high chloride levels can facilitate some fast growing invasive plants, such as Eurasian water milfoil, which can out-compete native fauna (Evans and Frick 2001).

Sulfate

Sulfate is a constituent of TDS and may form salts with sodium, potassium, calcium, magnesium, and other cations. Sulfate can be found naturally in surface waters but anthropogenic sources such as waste from pyrite oxidation, and coal preparation waste water may lead to elevated levels of sulfate. Elevated levels of sulfate may be toxic to some macroinvertebrates while fish are more tolerant of excess sulfate (IDNR 2013).

Dissolved Oxygen

Dissolved oxygen (DO) in water bodies is critical for aquatic fauna. Oxygen enters water bodies from the atmosphere as well as ground water discharge. Photosynthesis also plays a key role in DO availability because of the effect of water clarity and duration of sunlight on water temperature (USGS 2013a). The amount of DO in a water body is related to the temperature of the water body; cold water can hold more oxygen than warm water (USGS 2013a). All forms of aquatic life use DO and therefore, DO is used to measure the "health" of lakes and streams.

Coliform Bacteria

Coliform bacteria are measured by total coliform through a laboratory test examining the number of bacteria colonies that grow on a prepared medium (USGS 2013b). Fecal coliforms and E. coli are coliform bacteria found in the intestinal tract of warm-blooded animals. Coliform bacteria can cause a variety of illnesses and have been used to establish microbial water quality criteria (USGS 2013b).

Nitrate and Nitrite as Nitrogen

Nitrate and nitrite as N is a measure of the inorganic forms of nitrogen. Excessive nitrogen in a water body can lead to increased plant production and toxic conditions for aquatic life as well as humans (EPA 2013j).

Total Phosphorus

Total phosphorus is a measure of all forms of phosphorus found in a water sample. Like nitrogen, phosphorus can be found in a variety of forms. Excessive phosphorus in a water body can also lead to greatly increased plant production which can, in turn, lead to eutrophication of water bodies. Large growths of plants or algae along waterways can lead to illness in fish and the death of large numbers of fish (EPA 2013f).

Turbidity

Turbidity is a measure of the clarity of a liquid. Turbidity of water is influenced by the amount of clay, silt, organic and inorganic matter, algae, plankton, and microscopic organisms (USGS 2013c). High concentrations of particulate matter can impact water temperature by blocking sunlight from the lower strata of the water column. Large particulate loads can also result in sedimentation which can have negative impacts on aquatic life. Turbidity is also able to provide food and shelter for pathogens that may impact aquatic life as well as human health (USGS 2013c).

Aquatic Macroinvertebrates

Macroinvertebrates are organisms that are visible by the naked eye. Aquatic macroinvertebrates live in the water for all or part of their lives and are dependent on good water quality (NYNRM 2013). Aquatic macroinvertebrates are part of the food chain in aquatic environments and therefore an integral part of a water body. They are sensitive to chemical, physical, and biological water conditions, and are a good indicator of water quality (EPA 2013g). Some aquatic macroinvertebrates such as stonefly nymphs are more sensitive to water quality than other taxa. Stonefly nymphs cannot survive low DO levels and their absence may indicate the impaired "health" of a water body (EPA 2013g). Aquatic macroinvertebrates are assessed independently in a separate section of this chapter.

Flow Rates

The amount or volume of water that flows through a water body over a certain length of time is the flow rate. Flow rates are important to aquatic and terrestrial fauna as well as to water quality (EPA 2013h). Larger flow rates can ameliorate pollutants in a water body faster than smaller flow rates. Organisms are influenced by water body flow rates as well; some aquatic fauna require fast flowing waters while others require calm pools or springs (EPA 2013h). Flow rate data is not available for examined streams so this indicator is not assessed.

4.9.2. Data and Methods

The NPS (1998) had previously compiled surface-water quality data for TAPR using six of the EPA's national databases: Storage and Retrieval (STORET) water quality database management system, River Reach File (RF3), Industrial Facilities Discharge (IFD), Drink Water Supplies (DRINKS), Flow Gages (GAGES), and Water Impoundments (DAMS). In addition to retrieving data from within TAPR's boundary, stations from 3 miles upstream and 1 mile downstream were included—it should be noted that the NPS (1998) report includes many stations that are far outside of these indicated limits. The retrieval resulted in 7,422 observations at 41 different monitoring stations. There were 4 NPS monitoring locations (TAPR 0034, TAPR 0035, TAPR 0036, and TAPR 0040) located within the preserve boundary. None of the 4 stations located within the preserve contained longer-term records, but their data is used here as a snapshot of water quality. There were five stations (TAPR 0012, TAPR 0015, TAPR 0025, TAPR 0029, and TAPR 0027) in the study area that included longer-term data. However, each of these stations was too far outside of TAPR's watershed to warrant using their data here. A new search of the STORET site was completed to look for any new monitoring data since the NPS (1998) study. The four NPS stations did not contain any new data but there were two Kansas Department of Health and Environment (KDHE) stations listed with data through 2011.

The KDHE maintains two water quality monitoring stations at discrete locations; one along Fox Creek (SC718) and the other on Palmer Creek (SC719) (KDHE 2013). These stations are both located within the TAPR boundary. They contain fourteen years of data (1999–2013) that are used here for examining the condition and trend of water quality over time. Current data from these stations was obtained from the Chief of Watershed Planning, Monitoring, and Assessment Section of the Bureau of Water, Kansas Department of Health and Environment.

4.9.3. Reference Conditions

The reference conditions for TAPR's water quality are the Kansas Department of Health and Environment (KDHE) water quality standards for surface waters, which provide limits for health of freshwater organisms as well as drinking water standards. The Environmental Protection Agency (EPA) standards are also listed for reference purposes (Table 4.9-1).

Table 4.9-1. KDHE and EPA standards for surface-water quality (KDHE 2005, EPA 2013i, EPA 2013j).

Parameter	Kansas Standard	EPA Standard
Total Dissolved Solids	n/a	≤250 mg/L
Chloride	≤ 860 mg/L	≤ 860 mg/L[B]
Sulfate	n/a	≤ 250 mg/L[B]
Dissolved Oxygen	≥5.0 mg/L	≥ 4.0 mg/L
Coliform Bacteria	262/2358 CFU/100 ml[A]	≤ 200 CFU/100 mL
Nitrogen	≤10 mg/L[B]	0.88 mg/L[D]
Phosphorous	0.067 mg/L[C]	0.067 mg/L[D]
Turbidity	n/a	7.83 NTU[D]

[A] Separate standards for summer and winter seasons (KDHE 2005)

[B] standard for drinking water

[C] An adaptive approach is described, using interpretive numbers that are neither adopted numeric criteria or final values that will be adopted by Kansas (T. Stiles, personal communication, 17 December 2013)

[D] Based on aggregate eco-region V nutrient criteria (EPA 2013j)

Indicators with values within the published standards are considered to be in good condition. Those with slight compliance problems or where a TMDL plan has been established warrant moderate concern. Those that significantly exceed compliance limits or that exceed limits but do not have a developed TMDL warrant significant concern.

4.9.4. Condition and Trend

Total Dissolved Solids

The EPA standard for dissolved solids is less than or equal to 250 mg/L; KDHE does not have an established standard for TDS. The mean values of TDS at each monitoring station exceed the EPA standard. Palmer Creek (SC719), a tributary of Fox Creek, has a larger minimum, maximum, and mean value of TDS than Fox Creek (SC718). The condition of TDS in Fox Creek (Table 4.9-2; Figure 4.9-2) and Palmer Creek (Figure 4.9-3) warrant moderate concern and exhibit an unchanging trend.

Table 4.9-2. TDS measurements from two monitoring stations including minimum, maximum, and mean values (mg/L).

Station	Period of Record	# Observations	Minimum	Maximum	Mean
SC718	7/98–9/13	80	152.63	390.2	292.2
SC719	7/98–9/13	81	184.89	428.61	330.18

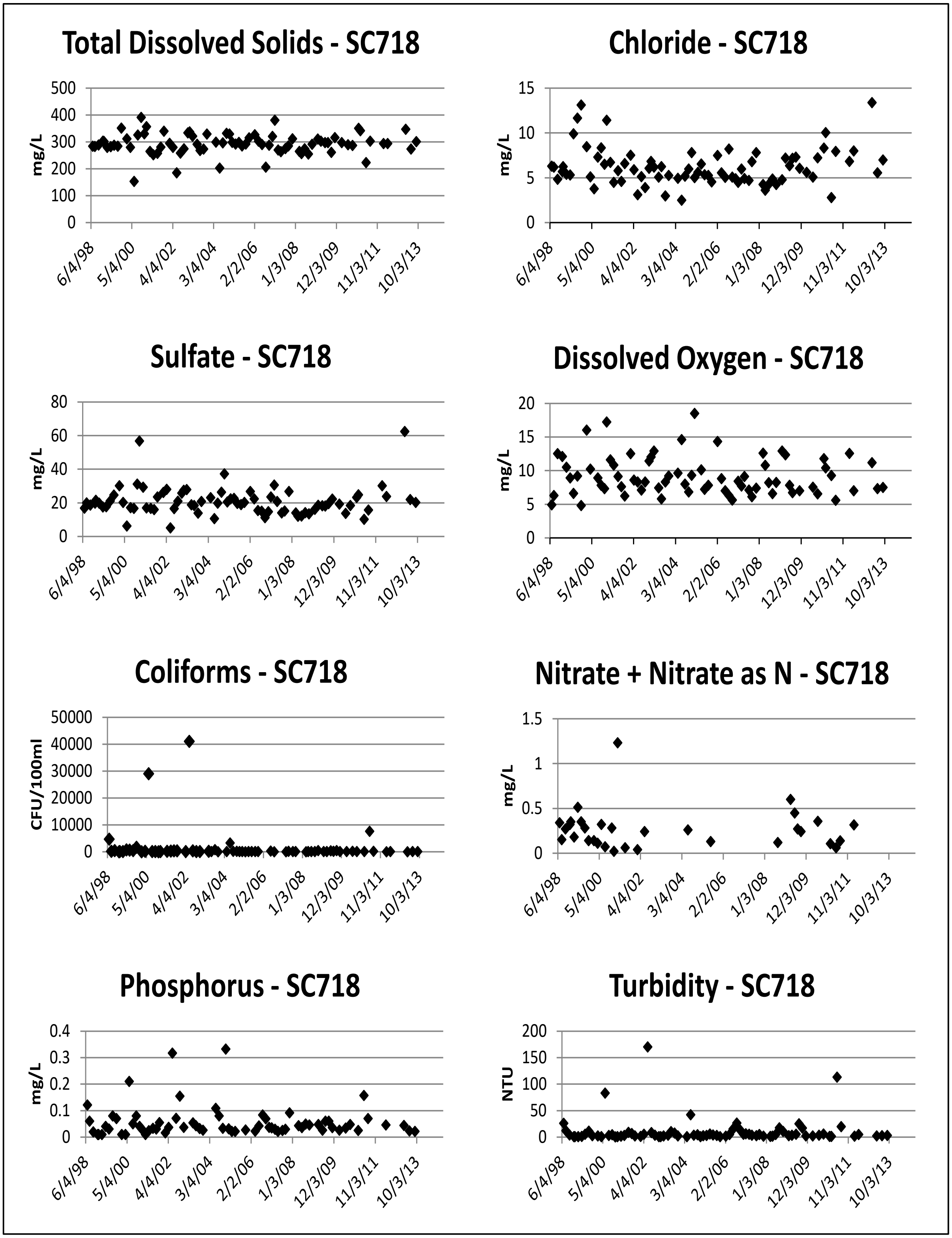


Figure 4.9-2. Fox Creek (SC718) scatterplots of water quality measures over time.

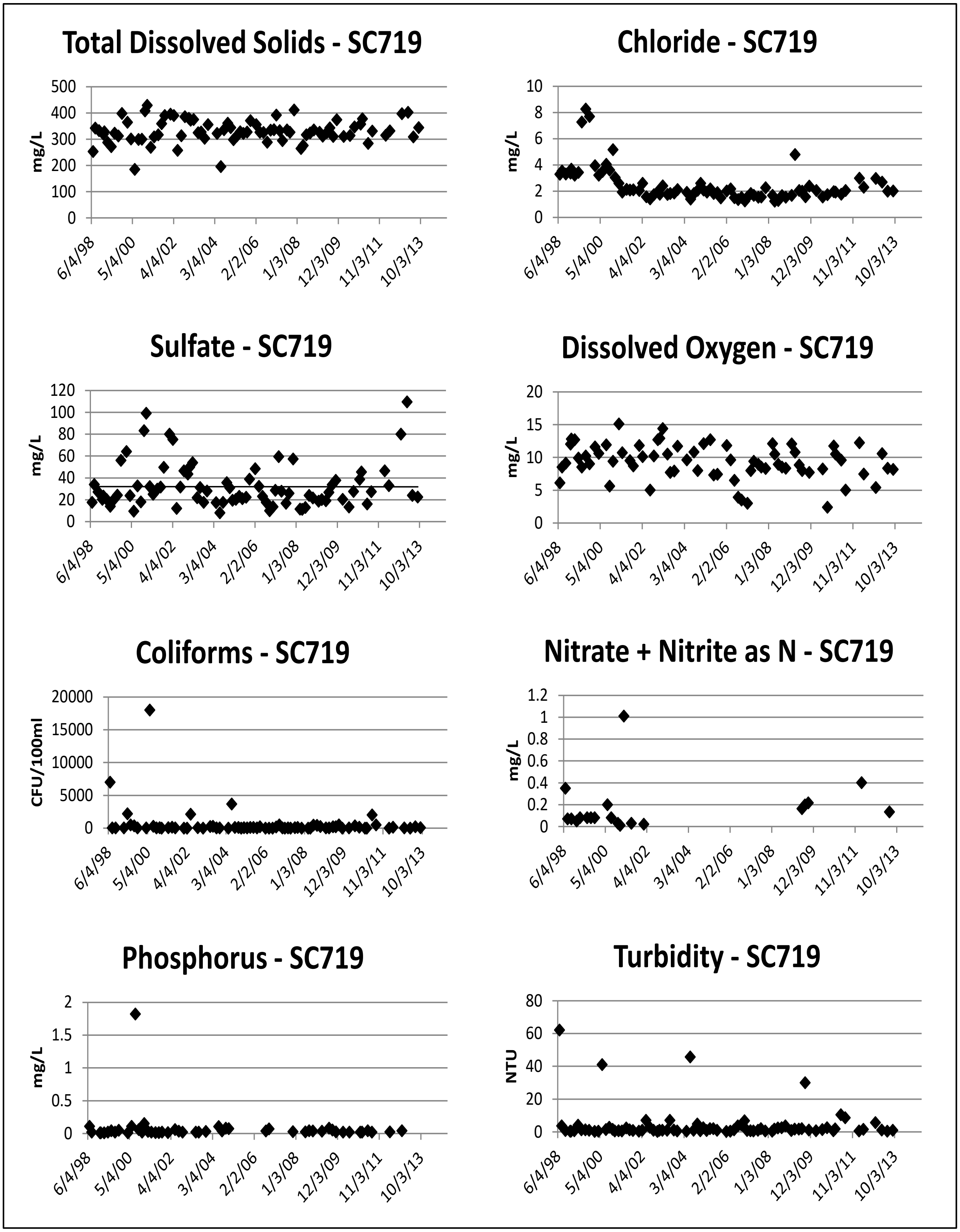


Figure 4.9-3. Palmer Creek (SC719) scatterplots of water quality measures over time.

Chloride

The KDHE and EPA standard for chloride in surface waters is less than or equal to 860 mg/L. Both stations have measured chloride in significantly lower concentrations than the standard (Table 4.9-3). The trend of chloride in Fox Creek (SC718) (Figure 4.9-2) and Palmer Creek (Figure 4.9-3) is unchanging.

Table 4.9-3. Chloride measurements from three monitoring stations including minimum, maximum, and mean values (mg/L).

Station	Period of Record	# Observations	Minimum	Maximum	Mean
SC718	7/98–9/13	80	2.48	13.37	6.18
SC719	7/98–9/13	81	1.24	8.26	2.45
TAPR0040	7/18/77	1	5.0	5.0	5.0

Sulfate

The EPA standard for sulfate is less than or equal to 250 mg/L, while KDHE does not have a published standard. The measured concentrations of sulfate at the Fox Creek (SC718) and Palmer Creek (SC719) stations are much lower than the EPA standard (Table 4.9-4). Sulfate levels for Fox Creek (Figure 4.9-2) and Palmer Creek (Figure 4.9-3) are in good condition and the overall trend continues to be unchanging and within the EPA standard.

Table 4.9-4. Sulfate measurements from three monitoring stations including minimum, maximum, and mean values (mg/L).

Station	Period of Record	# Observations	Minimum	Maximum	Mean
SC718	7/98–9/13	80	5.07	62.34	20.80
SC719	7/98–9/13	81	8.03	109.39	32.08
TAPR0040	7/18/77	1	14.0	14.0	14.0

Dissolved oxygen

The EPA standard for DO is greater than or equal to 4 mg/L while the KDHE standard is stricter at greater than or equal to 5 mg/L (Table 4.9-5). The mean DO concentration for each station over the period of record is greater than the strict KDHE standard. However, each station had a minimum DO concentration that was lower than the standard and in the case of Palmer Creek (SC719) a concentration that was lower than the EPA standard. DO values for Fox Creek (SC718) (Figure 4.9-2) and Palmer Creek (Figure 4.9-3) warrant moderate concern while the trend is unchanging and, with the exception of a few readings, is consistently above the EPA and KDHE standards.

Table 4.9-5. Dissolved oxygen measurements from six monitoring stations including minimum, maximum, and mean values (mg/L).

Station	Period of Record	# Observations	Minimum	Maximum	Mean
SC718	7/98–9/13	80[A]	4.8	18.5	9.17
SC719	7/98–9/13	80[B]	2.38	15.1	9.31
TAPR0034	7/29/96	1	4.3	4.3	4.3
TAPR0035	6/27/95	1	6.7	6.7	6.7
TAPR0036	6/27/95	1	7.5	7.5	7.5
TAPR0040	7/18/77	1	12.0	12.0	12.0

[A] 7 observations had a measure of DO that was below the detectable limit

[B] 10 observations had a measure of DO that was below the detectable limit

Coliform bacteria

The EPA standard for coliform bacteria in surface waters is less than or equal to 200 CFU/100 ml. The KDHE uses a different approach based on the recreational water use type and a geometric mean from at least 5 samples from separate 24 hour periods within a 30-day window. Palmer Creek (SC719) is classified as a secondary contact recreation, class A water with a geometric mean standard of 2,358 CFU/100 ml. Fox Creek (SC718) is classified as a primary contact recreation, class B water with a geometric mean standard of 262 CFU/100 ml from April 1–October 31 and a geometric mean standard of 2,358 CFU/100 ml from November 1–March 31. Bacteria sampling from these two stations does not meet the established guidelines for a geometric mean calculation as stated above therefore, binomial sampling is used by KDHE to determine the probability of a reading being above the coliform standard. Neither Fox Creek nor Palmer Creek are listed as being impaired by coliform bacteria so binomial sampling has not been conducted for this NRCA; the descriptive statistics are provided instead.

Coliform bacteria sampling methodologies were changed by KDHE during 2003 from sampling all fecal coliforms to sampling only E. coli bacteria. This change was spurred by findings of the EPA that found poor correlation between fecal coliform counts and certain forms of illness. The resulting differences between the two CFU concentration results are noticeable; fecal coliform concentrations tend to be higher than just those looking at E. coli. Both sets of measures are examined here.

The Palmer Creek station (SC719) has recorded maximum CFU concentrations that are well above the standard established by KDHE but the mean values indicate that most concentrations are well below the KDHE standard. The Fox Creek station (SC718) also has maximum concentrations that are well above the standard established by KDHE. The mean value for summer sampling of fecal coliforms during the 1998–2003 period exceeded the standard of 2358 CFU/100 ml. During the 2003–2013 sampling period the summer mean was also higher than the standard. The winter samples during each of the sampling periods did not exceed the established standard. Coliform values for Fox Creek (Figure 4.9-2) and Palmer Creek (Figure 4.9-3) show several spikes but the majority of coliform readings are very low which warrants moderate concern and indicates an unchanging trend (Table 4.9-6).

Table 4.9-6. Total coliform measurements from three monitoring stations including minimum, maximum, and mean values (CFU/100 ml).

Station	Period of Record	# Observations	Minimum	Maximum	Mean
SC718[A]	7/98–5/03	27	10	41000	2995.2
	Winter	–	–	–	255.56
	Summer	–	–	–	4365.0
SC718[B]	7/03–9/13	42	10	7541	360.36
	Winter	–	–	–	31.64
	Summer	–	–	–	524.71
SC719[A]	7/98–5/03	31	10	18000	1009.7
SC719[B]	7/03–9/13	43	10	3654	258.0

[A] Fecal coliform sampling

[B] *E. coli* sampling

Nitrogen

Mean concentrations of nitrogen in Palmer Creek (SC719) and Fox Creek (SC718) are below the EPA and KDHE standards. The maximum concentration recorded at each station exceeds the EPA standard of 0.88 mg/L. There were many nitrogen values that were below the detectable limit of the analysis. The data for Fox Creek (Figure 4.9-2) and Palmer Creek (Figure 4.9-3) show an unchanging trend where nearly all of the values are at or below 0.5 mg/L. Because Fox Creek is impaired by nutrients the current condition warrants moderate concern (Table 4.9-7).

Table 4.9-7. Nitrate + nitrite as nitrogen measurements from two monitoring stations including minimum, maximum, and mean values (mg/L).

Station	Period of Record	# Observations	Minimum	Maximum	Mean
SC718	7/98–9/13	80[A]	0.02	1.23	0.26
SC719	7/98–9/13	80[B]	0.01	1.01	0.17

[A] 48 observations had quantities of N below the detectable limit

[B] 60 observations had quantities of N below the detectable limit

Phosphorus

The EPA and KDHE standard for phosphorus is 0.067 mg/l. The maximum concentration recorded at each station exceeded this standard. The mean concentration at the Fox Creek station (SC718) is just below the standard. The mean concentration at the Palmer Creek station (SC719) exceeds the standard by 0.013 mg/l. Fox Creek (Figure 4.9-2) and Palmer Creek (Figure 4.9-3) show an unchanging trend of phosphorus levels. Because Fox Creek is impaired by nutrients the current condition warrants moderate concern (Table 4.9-8).

Table 4.9-8. Total phosphorus measurements from two monitoring stations including minimum, maximum, and mean values (mg/L).

Station	Period of Record	# Observations	Minimum	Maximum	Mean
SC718	7/98–9/13	80[A]	0.01	0.332	0.06
SC719	7/98–9/13	80[B]	0.01	1.82	0.08

[A] 10 observations had quantities of P below the detectable limit

[B] 31 observations had quantities of P below the detectable limit

Turbidity

Fox Creek is impaired by turbidity, but a TMDL has not been developed. The EPA standard for turbidity is 7.83 NTU. There is no KDHE established standard for turbidity. The Fox Creek station (SC718) has a mean value exceeding the EPA standard. The mean value for Palmer Creek station (SC719) does not exceed the EPA standard. Fox Creek (Figure 4.9-2) and Palmer Creek (Figure 4.9-3) show an unchanging trend for turbidity with an occasional spike. Because Fox Creek is impaired by turbidity and a TMDL has not been developed, the current condition warrants significant concern (Table 4.9-9).

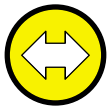
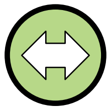
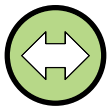
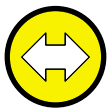
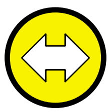
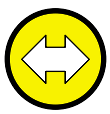
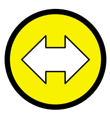
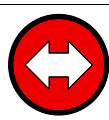
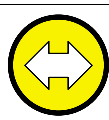
Table 4.9-9. Turbidity measurements from five monitoring stations including minimum, maximum, and mean values (mg/L).

Station	Period of Record	# Observations	Minimum	Maximum	Mean
SC718	7/98–9/13	80	0.48	170	10.16
SC719	7/98–9/13	80	0.27	62	4.0
TAPR0034	7/29/96	1	23.7	23.7	23.7
TAPR0035	6/27/95	1	9.6	9.6	9.6
TAPR0036	6/27/95	1	8.5	8.5	8.5

Condition and Trend Summary

Chloride and sulfate levels are considered good for the two creeks examined (Table 4.9-10). Total dissolved solids, dissolved oxygen, total coliform, nitrogen and phosphorus warrant moderate concern, and turbidity warrants significant concern. The indicators rated moderate and significant concern are often impacted by agricultural practices including grazing, the latter of which is the only land-use practice occurring in the Palmer Creek watershed. The “impaired” status of several indicators for both creeks downgraded the condition for those indicators. The water quality for TAPR is assessed with a high level confidence because of the KDHE stations (SC718, SC719) have been in operation since 1998. The available data has enough continuity to determine a trend since 1998.

Table 4.9-10. Condition and trend summary for water quality at Tallgrass Prairie National Preserve.

Indicator	Condition Status/Trend	Rationale
Total Dissolved Solids		TDS mean values are outside of the established EPA standard.
Chloride		Chloride values are significantly lower than the established standards.
Sulfate		Sulfate values are below the established standards.
Dissolved Oxygen		DO mean values are generally within the established standards, although some low values were recorded. However, Palmer Creek is listed as impaired by DO, increasing the condition status from good to moderate.
Total Coliform		Coliform mean values are outside of the EPA standard and exceed the KDHE recreational water standards on occasion, though many readings are well below the standards. Occasional extremely high values are a concern.
Nitrogen		Nitrogen values are consistently within the established standards but Fox Creek has an established TMDL for nutrient loading, increasing the condition status from good to moderate.
Phosphorus		Phosphorus values for Fox Creek are within the standard, while values for Palmer Creek are outside of the established standards. There is an established TMDL for Fox Creek for excessive nutrient loading.
Turbidity		Turbidity readings in Fox Creek are outside of the established standard. Fox Creek is listed as impaired by turbidity.
Water Quality Overall		**Overall water quality condition warrants moderate concern with unchanging trend and a high level of confidence.**

4.9.5. Uncertainty and Data Gaps

Due to the diligent monitoring of Fox Creek and Palmer Creek by KDHE, with the exception of flow data there is adequate data for TAPR water quality. The NPS had monitoring locations within TAPR for short-term monitoring projects that have since been discontinued. The preserve may consider monitoring the streams within other portions/areas of the preserve. This data will specifically answer water quality questions within TAPR. Native prairie does an excellent job of filtering water and yields excellent water quality.

4.9.6. Sources of Expertise

- The Kansas Department of Health and Environment (KDHE) is the primary source of expertise for water quality running through TAPR in Palmer and Fox Creeks. The NPS Water Resources Division is the secondary source of expertise for water quality within TAPR.
- Thomas Stiles, Chief, Watershed Planning, Monitoring, and Assessment Section; Bureau of Water, Kansas Department of Health and Environment
- Anthony Stahl, Stream Chemistry Monitoring Program Manager, Watershed Planning, Monitoring, and Assessment Section; Bureau of Water, Kansas Department of Health and Environment

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4.10. Prairie Vegetation

4.10.1. Background and Importance

Tallgrass prairie once covered some 570,000 km^2 of central North America, extending eastward from Nebraska and Kansas through the "Prairie Peninsula" of Iowa, Illinois, parts of Minnesota, Missouri, Wisconsin, and western Indiana, and north to eastern portions of the Dakotas and southern Canada (Transeau 1935, Risser et al. 1981, Anderson 2006). Although the tallgrass prairie developed in areas where precipitation levels are favorable for the growth of trees and shrubs, in pre-settlement times, fire, drought, and ungulate grazing acted to prevent invasion by shrubs and trees, and favored warm-season grass species (Stubbendieck and Wilson 1986, Sims and Risser 2000, Anderson 2006). Areas formerly dominated by tallgrass prairie are now largely converted to cultivated agriculture, and examples of this vegetation are reduced to scattered remnant unplowed tracts or smaller restored tracts. TAPR lies within the region of greatest concentration of remnant tracts (Figure 4.10-1).

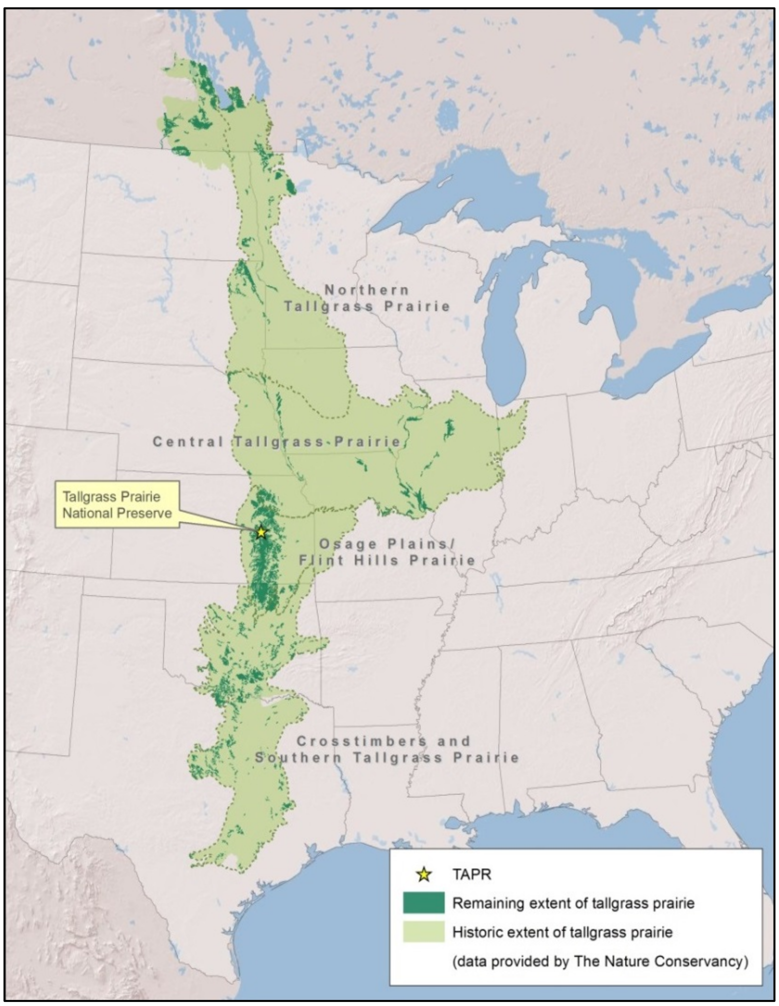


Figure 4.10-1. Location of TAPR in the context of historic and remnant extent of tallgrass prairie.

TAPR lies within the Ozark Plains/Flint Hill Prairie ecoregion, which encompasses nearly 31,000 square miles, in portions of west-central Missouri, northeastern Oklahoma and much of eastern

Kansas. The Flint Hills are characterized by gently sloping, prairie-dominated hills of limestone and shale, with a local elevational relief of 300–500 ft. The area contains the headwaters of many of the ecoregion's streams and rivers (TNC 2000).

Tallgrass prairie is the dominant vegetation community at TAPR, representing a nationally significant tract of unplowed native grassland. Uplands on TAPR are dominated by two USNVC vegetation associations (USNVC 2013). *Andropogon gerardii-Sorghastrum nutans-Schizachyrium scoparium* Flint Hills Herbaceous Vegetation (Flint Hills tallgrass prairie) occupies 8,675 acres or 79.8% of the preserve. The second most dominant plant community is the rocky breaks community on steeper ravine slopes dominated by a mixed-grass prairie of *Schizachyrium scoparium - Bouteloua curtipendula - Bouteloua gracilis* Central Plains Herbaceous Vegetation occupies 965 acres or 9% of the preserve. Approximately 217 acres have been restored to a planted mix of tallgrass prairie species (Kindscher et al. 2011). Restoration of some former croplands and pastures in the Fox Creek bottomlands began in 2003 using seeding, burning, haying and weed treatments (Robb 2011). The bottomland restoration includes portions of approximately 244 acres mapped by Kindscher et al. (2011) as smooth brome. USNVC and other map units are described by Kindscher et al. (2011) (Figure 4.10-2).

In recent years, scientists and land managers have recognized the importance of creating heterogeneity on the landscape to promote diversity, sustain species adapted to natural disturbance regimes, and foster a variety of faunal habitat structures (Wiens 1997, Fuhlendorf and Engle 2001, Reinking 2005). In tallgrass prairie, the primary disturbance agents of fire and grazing interact with other biotic and abiotic factors to maximize heterogeneity and species diversity on the landscape (Fuhlendorf et al. 2006, Hamilton 2007, Knapp et al. 1999). A system incorporating grazing and regular prescribed fire referred to as patch-burn grazing has been used in the Flint Hill region. Under patch-burn grazing, burned areas promote focal grazing, where the majority of grazing time is spent within the portion of the area that has been burned within the past year. By burning patches within a pasture, fire and grazing cause local changes in the plant community and increase heterogeneity within pastures, among pastures within the preserve, and within the larger regional landscape (personal comment Mike DeBacker, September 2012). As the focal disturbance is shifted to other patches over time, changes in local plant communities result in what has been described as a shifting mosaic (Fuhlendorfer and Engle 2001, 2004; Hamilton 2007). Most of the acreage on the preserve is burned every one to three years.

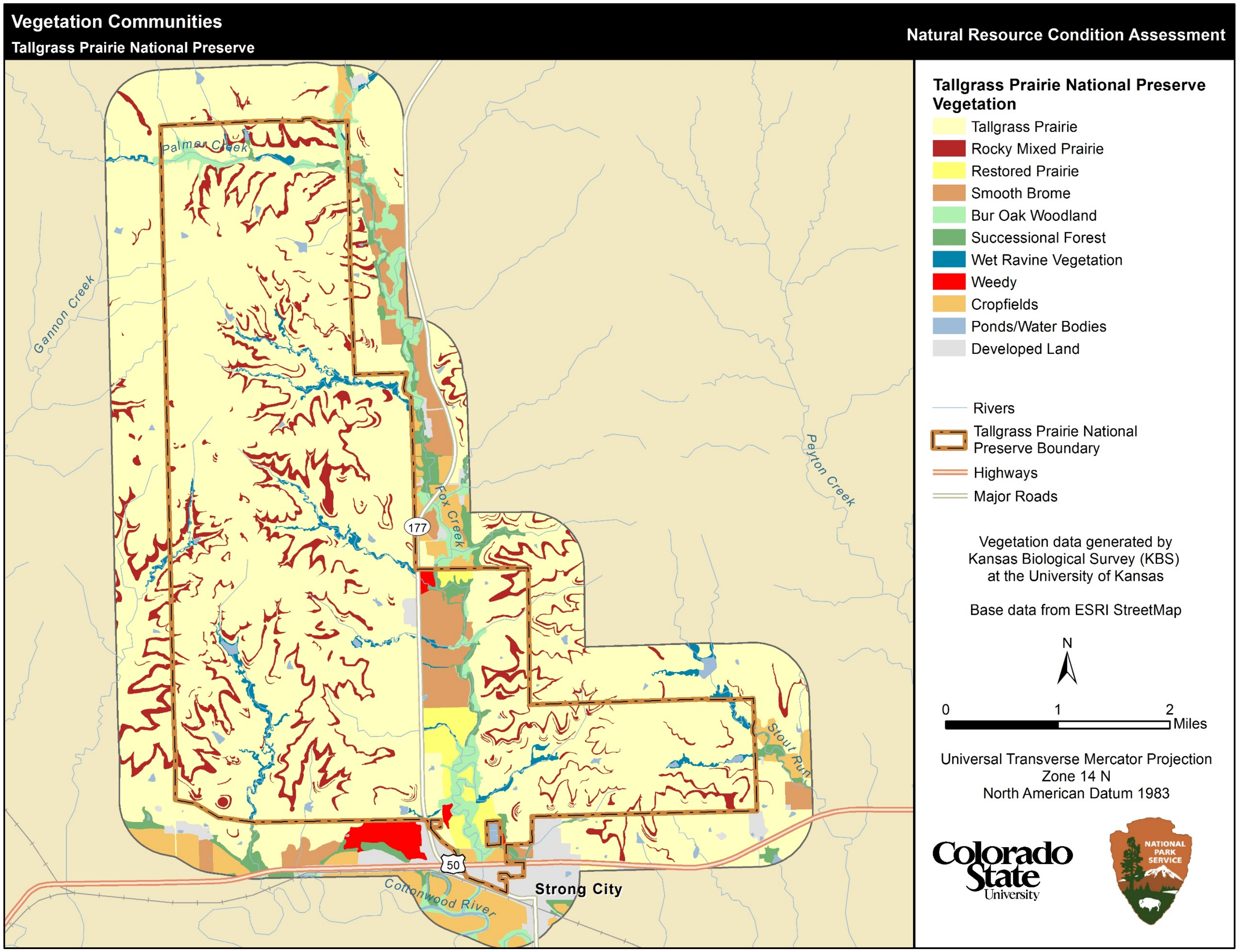


Figure 4.10-2. Distribution of mapped vegetation communities, Tallgrass Prairie National Preserve (data from Kindscher et al. 2011).

For all ecological sites at TAPR, published Natural Resource Conservation Service (NRCA) state-and-transition models and ecological site descriptions emphasize grazing as the main driver of vegetation community composition and condition. The general pattern is one where the most desirable condition is dominated by the tallest grasses (and corresponding production) that the site can support, mostly tallgrass and midgrass species. Continuous grazing and especially heavy continuous grazing typically leads to a less desirable state dominated by shorter grasses, less vigorous midgrasses and tallgrasses, and an increase in bare ground and cover of forbs. Long-term drought and weed invasion can also be a stressor influencing community changes. Recovery of communities towards the reference condition is largely driven by implementation of long-term prescribed grazing (initially) and subsequent prescribed grazing and rest during the growing season, assisted by the use of seeding in the initial stages (as necessary) and prescribed fire in the latter stages (NRCS 2014).

Threats

Primary threats to the condition of the prairie vegetation at TAPR are 1) invasion by exotic plant species, 2) loss of native species diversity and/or shifts in grassland species dominance that convert the tallgrass prairie to other grassland community types, 3) invasion of the grassland by woody species, and 4) alteration of historic evolutionary pressures from grazing and fire.

Indicators and Measures

We evaluated the condition of the prairie community at TAPR using metrics for species composition, diversity, and vegetation structure:

- Species composition measured as proportion of native species cover by site.
- Native species richness by site (S)
- Native species diversity by site (Modified Shannon, Hill's N1)
- Native species evenness by site (Hill's E5)
- Structure as measured as native forb + graminoid cover and woody cover by site
- Invasive exotic species

4.10.2. Data and Methods

The NPS Heartland Inventory and Monitoring Network (HTLN) has been monitoring vegetation at TAPR since 1997. A total of 61 sites in the western pastures have been monitored. Thirty of these are core monitoring sites that were read annually from 2002 to 2008 and in 2010 (James 2011) (Figure 4.10-3). The monitoring sites are distributed across a variety of soil types and ecological sites, with the vast majority having a reference plant community dominated by tallgrass prairie. The Rocky Mixed Prairie map class is found predominantly within the Shallow Limy 31–38" PZ ecological site and the Tallgrass Prairie map class dominates on most other ecological sites (Table 4.10-1).

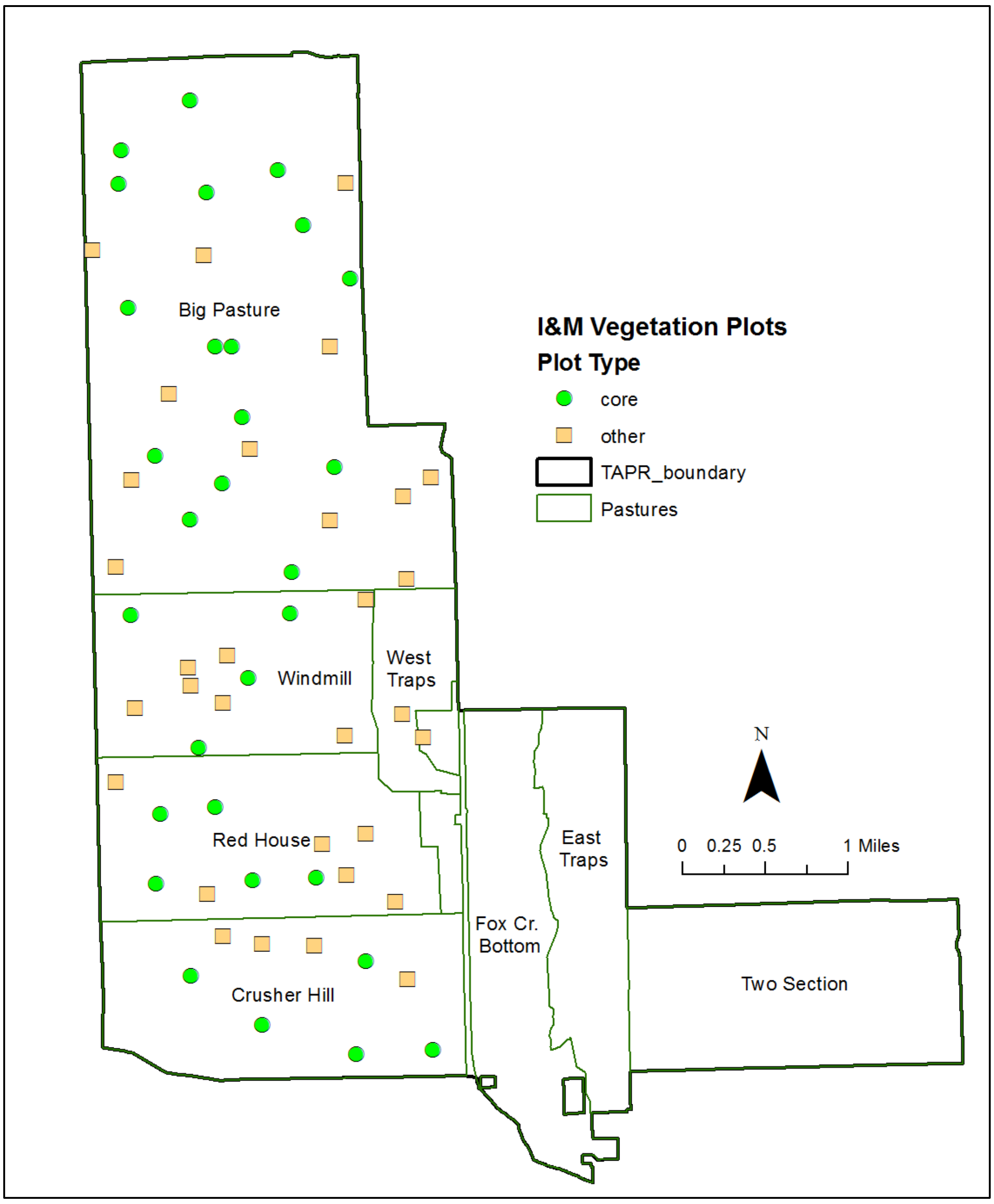


Figure 4.10-3. Distribution of vegetation monitoring plots on TAPR.

Table 4.10-1. Distribution of vegetation monitoring sites by soil type and NRCA ecological site.

Mapped Soil Type	NRCS Ecological Site	Plant Community Reference Condition	Core Monitoring Sites	Other Monitoring Sites	Totals
Clime-Sogn complex 3-20% slopes	Limy Upland 31–38" PZ (R076XY012KS)	tallgrass	11	11	22
Dwight silt loam 1–3% slopes	Sodic claypan 30–36" PZ (R076XY005KS)	midgrass	–	2	2
Florence-Matfield cherty silt loams	Flint Ridge 30–36" PZ (R076XY009KS)	tallgrass/ midgrass	1	2	3
Labette-Dwight complex 1–3% slopes	Loamy Upland 31–38" PZ (R076XY015KS) and Sodic claypan 30–36" PZ (R076XY005KS)	tallgrass, midgrass	1	4	5
Labette-Sogn complex 0–8% slopes	Loamy Upland 31–38" PZ (R076XY015KS) and Shallow Limy 31–38" PZ (R076XY028KS)	tallgrass, midgrass (Rocky prairie)	14	9	23
Tully cherty silty clay loam 5–15% slope	Upland Hills 32–40" PZ (R076XY100KS)	tallgrass	2	2	4
Tully silty clay loam 3–7% slopes	Upland Hills 32–40" PZ (R076XY100KS)	tallgrass	1	–	1
Zaar silty clay 3–7% slopes	Clay Upland 35–42" PZ (RO74XY007KS)	tallgrass/ midgrass	–	1	1
Totals	**–**	**–**	**30**	**31**	**61**

At each site data are collected on two permanent parallel transects (50 m in length and 20 m apart), each with five 10 m^2 circular plots placed at 10 m intervals. Foliar cover is estimated in the 10 m^2 plot using a modified Daubenmire cover scale. Three nested frequency plots (1.0, 0.1, and 0.01 m^2) are read within the large plot. The 0.1 ha area between the two transects is used to collect data on woody species greater than 5.0 cm dbh in the understory and overstory canopy layers. Summary data reported for each site (transect pair) consist of: 1) plant species richness and diversity, 2) the ratio of exotic to native species, 3) species abundance and frequency, (4) woody species density and basal area, (5) overstory canopy cover and (6) ground cover characteristics (James et al. 2009).

Invasive exotic plants data explored in a separate section within this chapter are used here as an indicator of the condition of prairie vegetation.

4.10.3. Reference Conditions

Because we can only indirectly address the condition of prairie vegetation within TAPR, we used metrics that could be derived from the HTLN vegetation monitoring data to assess condition. A resource condition rating framework integrating the reference condition concepts discussed below is shown in Table 4.10-2.

Table 4.10-2. Resource condition indicator rating framework for prairie vegetation indicators at TAPR.

Indicator	Good Condition	Warrants Moderate Concern	Warrants Significant Concern
Composition	≥ 80% relative cover of native species	60 to <80% relative cover of native species	< 60% relative cover of native species
Native Species Richness	>85% of 1998 mean	70–85% of 1998 mean	<70% of 1998 mean
Native Species Diversity	>85% of 1998 mean	70–85% of 1998 mean	<70% of 1998 mean
Native Species Evenness	>85% of 1998 mean	70–85% of 1998 mean	<70% of 1998 mean

Table 4.10-2 (continued). Resource condition indicator rating framework for prairie vegetation indicators at TAPR.

Indicator	Good Condition	Warrants Moderate Concern	Warrants Significant Concern
Structure Native graminoid + forb	Relative cover of native graminoids or forbs 20–80% of combined cover for those two groups	Relative cover of native graminoids or forbs 10–20% of combined cover for those two groups	Relative cover of native graminoids or forbs <10% of combined cover for those two groups
Woody Plants	Woody plant cover < 4%	Woody plant cover 4–6%	Woody plant cover >6%

The ideal condition for TAPR would be the complete absence of non-native species, representing conditions during pre-settlement times. Although non-native species are present at TAPR, the prairie vegetation at this unit is largely intact and contains a high relative percent cover of native species. We consider a baseline reference condition as a "best attainable condition" (*sensu* Stoddard et al. 2006) under which the composition, diversity, and structure of prairie vegetation at TAPR is sufficient to maintain the plant community in a stable or improving condition.

Threshold levels of non-native species cover have not been rigorously defined. Spyreas et al. (2004) found an average of 36% relative percent cover of non-native species in Illinois prairie grasslands. Miles and Knops (2009) reported that sites dominated (>60% relative cover) by native prairie grass (*A. gerardii* and *S. scoparium*) were more likely to follow successional patterns typical of prairie communities. We used a level of 60% relative cover of native plant species as a threshold below which the prairie vegetation community is likely to face significant challenges in recovery to a functioning condition. An upper threshold of 80% relative native plant species cover indicating good condition is based on levels specified by NatureServe and Natural Heritage Program ecologists for good to excellent condition ranking in other types of remnant prairie communities (e.g., Decker 2007, WNHP 2011, NatureServe 2013), and on values observed at remnant tallgrass prairie sites in the Midwest (Taft et al. 2006, Sivicek and Taft 2011).

Indices of richness and diversity are intended to estimate biological variability and quality in a way that allows comparison of different sites within a community type or of different periods at a single site (Heip et al. 1998). Such indices are relatively easy to generate, but can be difficult to interpret in relation to the expected condition and trajectory of real-world species assemblages. Moreover, diversity indices summarize the structure of a community, not its functioning (Heip et al. 1998). Expected values of these indices for particular community types have not been, and probably cannot be defined (Hurlbert 1971, Ludwig and Reynolds 1988), and variation in both historical and microsite characteristics can produce significant differences in the composition and structure of two nominally identical plant communities (Sluis 2002, Hanson et al. 2008). There is, however, some evidence that plant species richness, diversity, and evenness is generally greater in remnant prairies than in restored prairies (Kindscher and Tieszen 1998, Sluis 2002, Polley et al. 2005, Taft et al. 2006), so that higher index values are broadly indicative of higher quality. In the absence of well-defined standards for such metrics, we have adopted an approach for this assessment where values in the first year of vegetation monitoring with the current protocol (1998) represent a reference point or baseline for comparison with subsequent years.

We assessed three indices of diversity and evenness for native species in TAPR prairie vegetation. The first, most straightforward measure of community richness is the number of all native species (S) in the sample, regardless of their abundances. Our second measure of diversity is Hill's N1 (a modified Shannon's index), which estimates the number of *abundant* species in the sample. Hill's N1 downplays the contribution of rare species and gives additional insight into the relative importance of each community member. Lastly, we calculated the modified Hill's ratio evenness index (E5), which approaches zero as a single species becomes more dominant.

Comparison of functional group structure between years involves a combination of quantitative and qualitative evaluation. Because no expected values for relative cover of native forbs vs. native grasses have been established, we compare the relative proportion of the two groups as a baseline, with the expectation that both groups should be well represented. In some prairie restorations, the abundance of native forbs has been relatively low compared to remnant prairies, often because few native forb seeds were used in the seeding mix or native forbs were sometimes historically impacted in the course of controlling broad-leaved weeds using non-selective herbicides. Woody species cover indicator levels are based on long term average values for woody guild cover in prairie vegetation. These levels are in broad agreement with the LANDFIRE Biophysical Setting Model for Osage Plains/Flint Hills Tallgrass Prairie (LANDFIRE 2008), where about 4% of the area is expected to be in a woody succession class. Finally, because woody species are being actively controlled or killed, we expect that values should remain at or below 1997 levels.

4.10.4. Condition and Trend

Species Composition

The proportion of native plant species present at monitoring sites has been consistently high (Figure 4.10-4) with a mean of 94% or greater in all monitoring years. The species composition metric indicates good condition with an unchanging trend and high confidence.

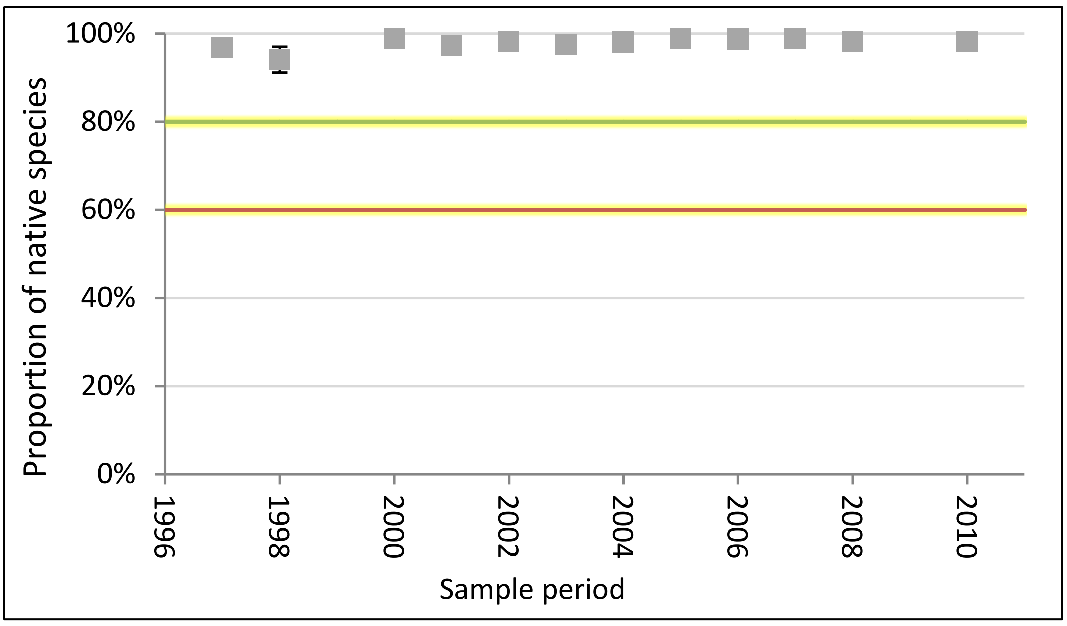


Figure 4.10-4. Mean proportion of native plant species across monitoring sites during monitoring years 1997–2010. Error bars represent 90% confidence intervals of the mean. Upper (green) line represents good condition threshold, lower (red) line represents significant concern threshold.

Native Species Diversity

Native species richness for prairie communities at TAPR has fluctuated, but was reasonably stable during the core site monitoring period from 2000 to 2008. The overall monitoring period average is between 22 and 70 species per site (Figure 4.10-5a). The lowest richness scores were in 1997–1998; subsequent sample values are significantly higher. Prairie communities at TAPR have maintained a mean of well over 85% that of the 1997 reference point, indicating good condition and an unchanging trend.

Native species diversity as measured by Hill's N1 is variable among years (Figure 4.10-5b). Although there is a slight suggestion of values having declined from peak levels of monitoring years 2003–2006, overall trends appear unchanging. In all years, means were well above 85% of the 1997 mean, indicating good condition. Means for native species evenness as measured by Hill's E5 have never reached the level measured in 1997, but appear generally stable from 2003 on (Figure 4.10-5c). Because this metric is difficult to interpret in relation to prairie vegetation quality, our confidence in this indicator is low. Overall, native species diversity at TAPR appears to be in good condition with an unchanging trend.

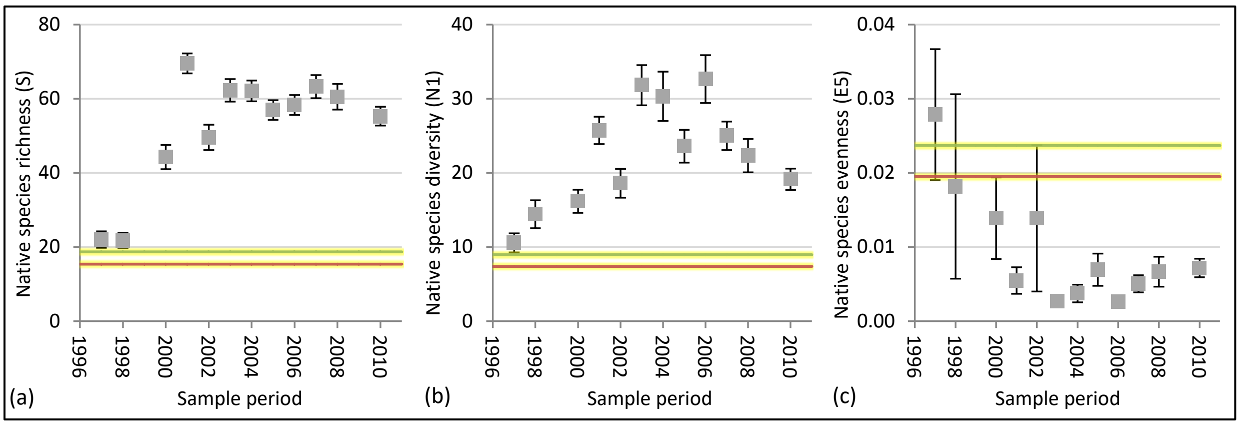


Figure 4.10-5. Estimates of (a) native species richness (b) native species diversity, and (c) evenness for TAPR during monitoring years 1997–2010. Error bars represent 90% confidence intervals around the mean. Upper (green) line represents 85% of the 1997 mean, lower (red) line represents 70% of the 1997 mean.

Structure

Non-native forbs and graminoids are a relatively minor component of prairie community structure in most areas on TAPR. Native graminoids typically account for about 55% of the cover of all native non-woody plant species combined. Relative proportions of native graminoids are variable between years, ranging from 42–73% (Figure 4.10-6). In all years, the native graminoid / native forb split included at least 20% of each functional group, indicating good condition with an unchanging trend.

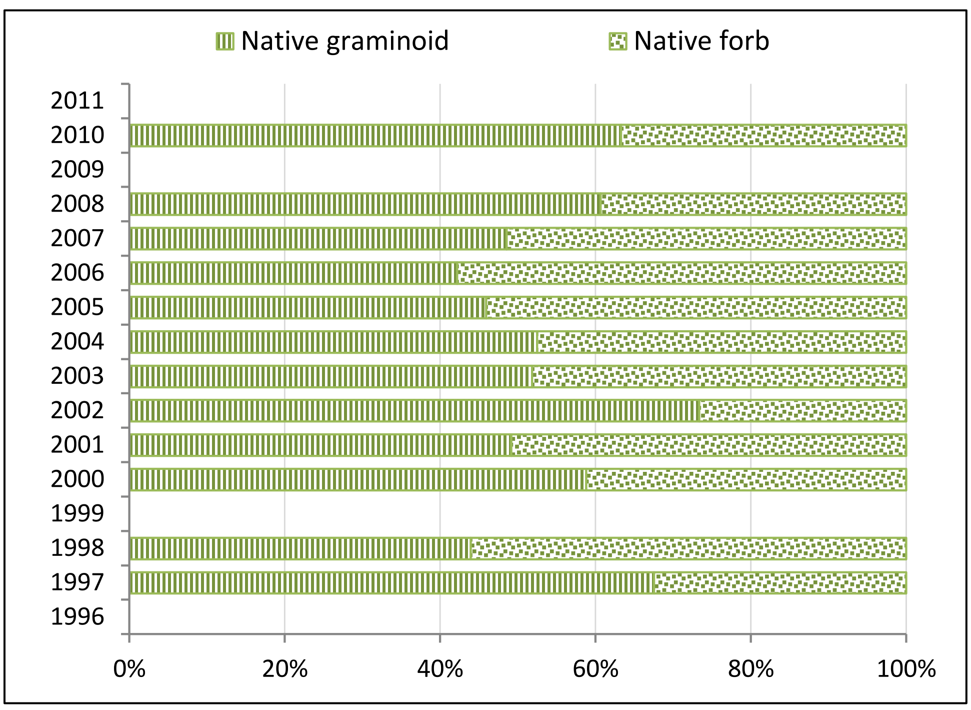


Figure 4.10-6. Percent cover of native forbs and graminoids at TAPR as a proportion of the combined total cover of the two functional groups.

Overall, woody species in prairie vegetation at TAPR averaged 4.6% cover for all monitoring years (Figure 4.10-6). Values in 1997–1998 were higher, averaging over 18% across sampling sites. However, with the exception of 2007, all subsequent monitoring years have been below 3% woody cover, indicating good condition with an unchanging trend (Figure 4.10-7).

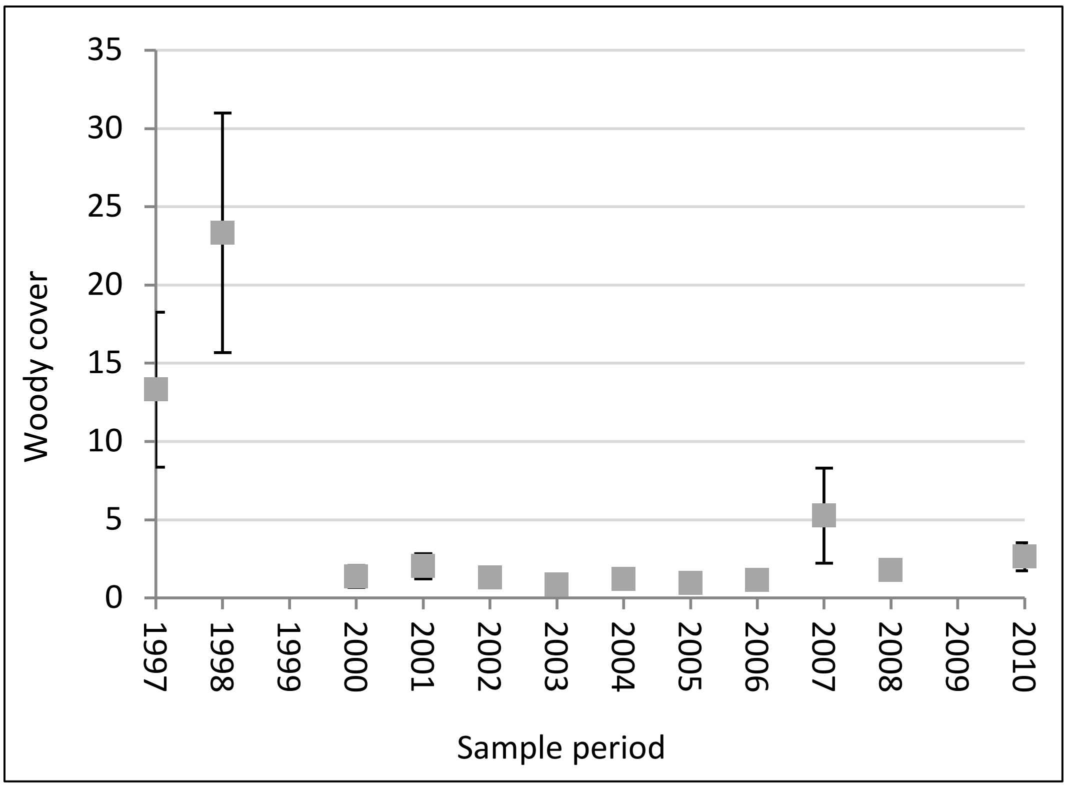


Figure 4.10-7. Mean percent woody cover at TAPR during monitoring years 1997–2010. Error bars represent 90% confidence intervals around the mean.

Invasive Exotic Plants

Invasive exotic plants at TAPR are evaluated in section 4.11. Metrics for number, frequency, and abundance of IEP species at TAPR, including state-listed noxious weeds, indicate that this resource is in good condition with an unchanging trend.

Overall Condition

Community composition of prairie vegetation at TAPR is in good condition, with high cover of native plant species and an unchanging trend. Native species evenness values are difficult to interpret, but overall values for the submetrics of native species diversity are good and appear to be unchanging. Vegetation structure at TAPR is in good condition with an unchanging trend. Woody species cover is consistently low after initial higher values in the early monitoring years. Invasive exotic plant species are rarely present in the uplands, and show an unchanging trend. The overall condition of prairie vegetation at TAPR is good and our quantitative metrics show relatively unchanging conditions for the time period of approximately 1996–2011 (Table 4.10-3). In some areas, enhanced management of prescribed fire and cattle grazing (especially since grazing rights were acquired), bison introduction, and prairie restoration projects in the Fox Creek bottomlands are believed to be increasing the heterogeneity and quality of vegetation and overall habitat quality for plants and animals. Confidence in the assessment is medium.

Table 4.10-3. Condition and trend summary for Tallgrass Prairie National Preserve.

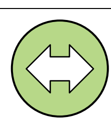
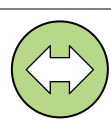
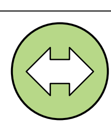
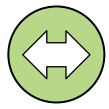
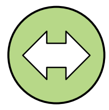
Indicator	Condition Status/Trend	Rationale
Community Composition		Native plant species dominate prairie vegetation at TAPR, and have maintained a mean relative cover of at least 94%.
Native Species Diversity		Native species richness for prairie communities at TAPR has remained reasonably stable, averaging 52 species per site with 22 abundant species. Species evenness is highly variable.
Vegetation Structure		Native forbs and graminoids are well represented in prairie vegetation, and levels of woody vegetation cover are generally less than 3%.

Table 4.10-3 (continued). Condition and trend summary for Tallgrass Prairie National Preserve.

Indicator	Condition Status/Trend	Rationale
Invasive Exotic Plants		No IEP species have high frequency or cover. Most search units have few to no IEP species present. Two state-listed noxious weed species are present with very low cover.
Prairie Overall		**Prairie vegetation is in good condition with an unchanging trend. Recent management initiatives are anticipated to result in improving trends in some areas. Confidence in the assessment is medium.**

4.10.5. Uncertainty and Data Gaps

Preservation of intact prairie communities at TAPR is challenging given the potential effects of nonnative invasives and altered disturbance regimes. There have been no vegetation surveys east of Highway 177 or in woodland and riparian areas. There is also a lack of data regarding sensitive and/or missing species and species of conservation importance.

High variability in sample data due to interannual weather differences, phenology and small sample sizes can make it difficult to interpret data and detect statistically significant changes or lack thereof over time. Confidence intervals from early sampling years indicates that precision has improved in subsequent years, however, additional improvements in sample design may assist managers to better characterize conditions and evaluate the effectiveness of management activities.

4.10.6. Sources of Expertise

- Heartland I&M Network staff provided input to reference condition thresholds for woody plants.

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4.11. Invasive Exotic Plants

4.11.1. Background and Importance

The terms non-native, alien, and exotic are all used to describe species that have been introduced to an area. Introduced species vary widely in their potential to cause harmful changes to ecosystems; most non-native species are not invasive, although they are usually indicative of some type of disturbance. Executive Order (EO) 13112 defines an invasive species as "…an alien (or non-native) species whose introduction does, or is likely to cause economic or environmental harm or harm to human health". Under the EO, federal agencies are directed to prevent introductions, provide control and minimize the economic, ecologic and human health impacts of invasive species. Invasive species include all taxa of organisms, not just plants. These species can degrade habitat quality by displacing native species that provide important food, nesting material, or cover (e.g., Jakle and Gatz 1985, Trammel and Butler 1995). Wilcove et al. (1998) identified the spread of alien species as the second most important threat to biodiversity in the U.S. Heavy infestation of non-native species can also alter fire, soil water, and nutrient dynamics (Sheley and Petroff 1999). Finally, such infestations may hamper recreational activities, detract from visitor experiences, and present a significant challenge to the NPS directive to maintain natural resources unimpaired for future generations (NPS 2009, 2013).

Management and monitoring of invasive exotic plants is a priority for parks within the Heartland Inventory and Monitoring Network (HTLN). During the vital signs selection process in 2003, invasive exotic plants were identified as the second most important management issue for TAPR (Young et al. 2007a). Invasive exotic plants are spread into NPS units by various pathways, including roads, trails, and riparian corridors (Young et al. 2007a). The number of non-native plant species is often correlated with visitation levels and extent of backcountry trails and riparian areas (Allen et al. 2009).

TAPR's native and restored tallgrass prairies are core natural resources for the preserve, and are ecologically significant within the Flint Hills region. The intact native upland prairie areas are generally free of invasive plants or have sporadic and relatively low abundance of invasive species. Areas with higher infestations tend to occur in the Fox Creek valley in the southern part of the preserve. Most invasive plants in the preserve are associated with areas that were farmed and/or improved as pasture and later restored to prairie (Young et al. 2009). Management efforts are focused on preventing further invasion and managing invasives on restored prairies using fire, herbicides and mechanical methods such as cutting and haying.

In 2011, the Heartland Exotic Plant Management Team works with preserve staff to monitor and control invasive plants. Crews often concentrate efforts on Johnsongrass (*Sorghum halepense*) and honey locust trees (*Gleditsia triacanthos*) to reduce seed sources contributing to woody plant encroachment in the prairie (Beard and App 2012). Invasive plant control will continue across the preserve with special attention to woody plant management, restored prairie areas and state-listed noxious weed infestations.

<u>Threats and Stressors</u>

Threats to the condition of TAPR from the presence of invasive exotic plant species include 1) the alteration of native species dominance and loss of rare species, 2) changes in nutrient cycles, soil chemistry, and water availability, and 3) overall shifts in community productivity.

<u>Indicators and Measures</u>

We assessed the condition of invasive exotic plants at TAPR by evaluating:

- Introduced exotic plant frequency
- Introduced exotic plant abundance
- Introduced exotic plant distribution
- State noxious weed presence/status

4.11.2. Data and Methods

The HTLN has developed an invasive exotic plant monitoring protocol (Young et al. 2007b) that uses a prioritization database for species to be monitored in network parks. High priority exotic plants are designated based on a consensus of state and regional exotic plants lists, and the designation is intended to identify those exotic plant species that are likely to be highly invasive in natural areas. TAPR has three watch lists: 1) the early detection watch list, identifying high priority species known to occur in the state but not known to occur in the preserve based on the NPSpecies database; 2) the preserve-established watch list, containing high priority species known to occur in the unit based on the NPSpecies database; and 3) the preserve-based watch list, which includes plants selected by preserve managers or network staff and that may not have been included on the other lists due to incomplete information in NPSpecies or USDA Plants (e.g., state distribution information was inaccurate) databases or due to differing opinions regarding network designation of a plant as a high priority (Table 4.11-1). The preserve-based watch list for Tallgrass Prairie National Preserve includes two native species, buffalobur nightshade (*Solanum rostratum*) and Eastern redcedar (*Juniperus virginiana*), which can rapidly colonize disturbed sites. Six of the preserve-listed species are considered noxious weeds by the state of Kansas: Nodding plumeless thistle (*Carduus nutans*), Canada thistle (*Cirsium arvense*), Leafy spurge (*Euphorbia esula*), Sericea lespedeza (*Lespedeza cuneata*), Kudzu (*Pueraria montana* var. *lobata*) and Johnsongrass (*Sorghum halepense*). Of those six listed, only Johnsongrass (*Sorghum halepense*) has been documented at TAPR. Although aquatic species are included on the watch lists, surveys have focused on terrestrial communities, only occasionally documenting aquatics.

Table 4.11-1. Watch lists for invasive exotic plants at TAPR (Bell et al. 2011).

Watch List	Scientific Name	Common Name
NPS Early Detection Watch List	*Ailanthus altissima*	Tree of heaven
	Alnus glutinosa	European alder
	Arundo donax	Giant reed
	Azolla spp	Mosquitofern
	Berberis thunbergii	Japanese barberry
	Bothriochloa bladhii	Caucasian bluestem
	Centaurea solstitialis	Yellow star-thistle
	Centaurea stoebe ssp micranthos	Spotted knapweed
	Cirsium vulgare	Bull thistle
	Cynanchum louiseae	Louise's swallow-wort
	Dactylis glomerata	Orchardgrass
	Dioscorea oppositifolia	Chinese yam
	Dipsacus fullonum	Fuller's teasel
	Dipsacus laciniatus	Cutleaf teasel
	Egeria densa	Brazilian waterweed
	Elaeagnus angustifolia	Russian olive
	Elaeagnus umbellata	Autumn olive
	Euonymus fortunei	Winter creeper
	Euphorbia esula*	**Leafy spurge**
	Glechoma hederacea	Ground ivy
	Hesperis matronalis	Dames rocket
	Humulus japonicus	Japanese hop
	Lespedeza bicolor	Shrub lespedeza
	Lespedeza cuneate*	**Sericea lespedeza**
	Lonicera japonica	Japanese honeysuckle
	Lonicera maackii	Amur honeysuckle
	Lonicera tatarica	Tatarian honeysuckle
	Lotus corniculatus	Bird's-foot trefoil
	Lotus glaber	Narrow-leaf bird's- foot trefoil
	Lysimachia nummularia	Creeping jenny
	Lythrum salicaria	Purple loosestrife
	Myriophyllum aquaticum	Parrot feather watermilfoil

* Kansas listed noxious weeds in bold text.

Table 4.11-1 (continued). Watch lists for invasive exotic plants at TAPR (Bell et al. 2011).

Watch List	Scientific Name	Common Name
NPS Early Detection Watch List (continued)	*Pastinaca sativa*	Wild parsnip
	Phalaris arundinacea	Reed canarygrass
	Phragmites australis	Common reed
	Plantago lanceolata	Narrowleaf plantain
	Poa compressa	Canada bluegrass
	Polygonum cuspidatum	Japanese knotweed
	Populus alba	White poplar
	Potamogeton crispus	Curly pondweed
	Potentilla recta	Sulphur cinquefoil
	Pueraria montana* var. *lobate***	**Kudzu**
	Pyrus calleryana	Callery pear
	Rhamnus cathartica	Common buckthorn
	Schedonorus pratensis	Meadow fescue
	Securigera varia	Crownvetch
	Solanum dulcamara	Climbing nightshade
	Tamarix ramosissima	Saltcedar
	Torilis arvensis	Spreading hedgeparsley
	Torilis japonica	Erect hedgeparsley
	Typha angustifolia	Narrowleaf cattail
	Vinca minor	Common periwinkle
Preserve-Established Watch List	*Alliaria petiolata*	Garlic mustard
	Arctium minus	Lesser burdock
	Bromus inermis	Smooth brome
	Bromus tectorum	Cheatgrass
	Carduus nutans*	**Nodding plumeless thistle**
	Holcus lanatus	Common velvetgrass
	Melilotus officinalis	Yellow sweetclover
	Morus alba	White mulberry
	Poa pratensis	Kentucky bluegrass
	Robinia pseudoacacia	Black locust
	Rosa multiflora	Multiflora rose
	Schedonorus pheonix	Tall fescue
	Sorghum halepense*	**Johnsongrass**
	Ulmus pumila	Siberian elm
	Verbascum thapsus	Common mullein
Preserve-Based Watch List	*Bassia scoparia*	Burningbush (Kochia)
	Bromus racemosus	Bald brome
	Cirsium arvense*	**Canada thistle**
	Juniperus virginiana*	Eastern red cedar
	Solanum rostratum	Buffalobur nightshade
	Bromus japonicus	Japanese brome

* Kansas listed noxious weeds in bold text.

Exotic plant monitoring at TAPR was conducted at TAPR in 2006 and 2010 using systematically-located line transects with a random start point, resulting in 301 contiguous line transects across the preserve (Figure 4.11-1). Except where truncated by the preserve boundary, the length of line transects as well as the distance between the lines of contiguous transects is 400 m, resulting in a grid that is used for displaying and analyzing results. Along each transect line, a belt of 3 to 12 m width is surveyed, and foliar cover classes are estimated for species of interest (Young et al. 2007b). Cover classes consisted of the following: 0= not present, 1=0.1–0.9 m^2, 2=1–9.9 m^2, 3=10–49.9 m^2, 4= 50–99.9 m^2, 5=100–499.9 m^2, 6=499.9–999.9 m^2, 7=1000–4999.9 m^2, 8=5000–9999.9 m^2, and 9=10,000–14999.9 m^2). In some cases the search area was wider for selected species.

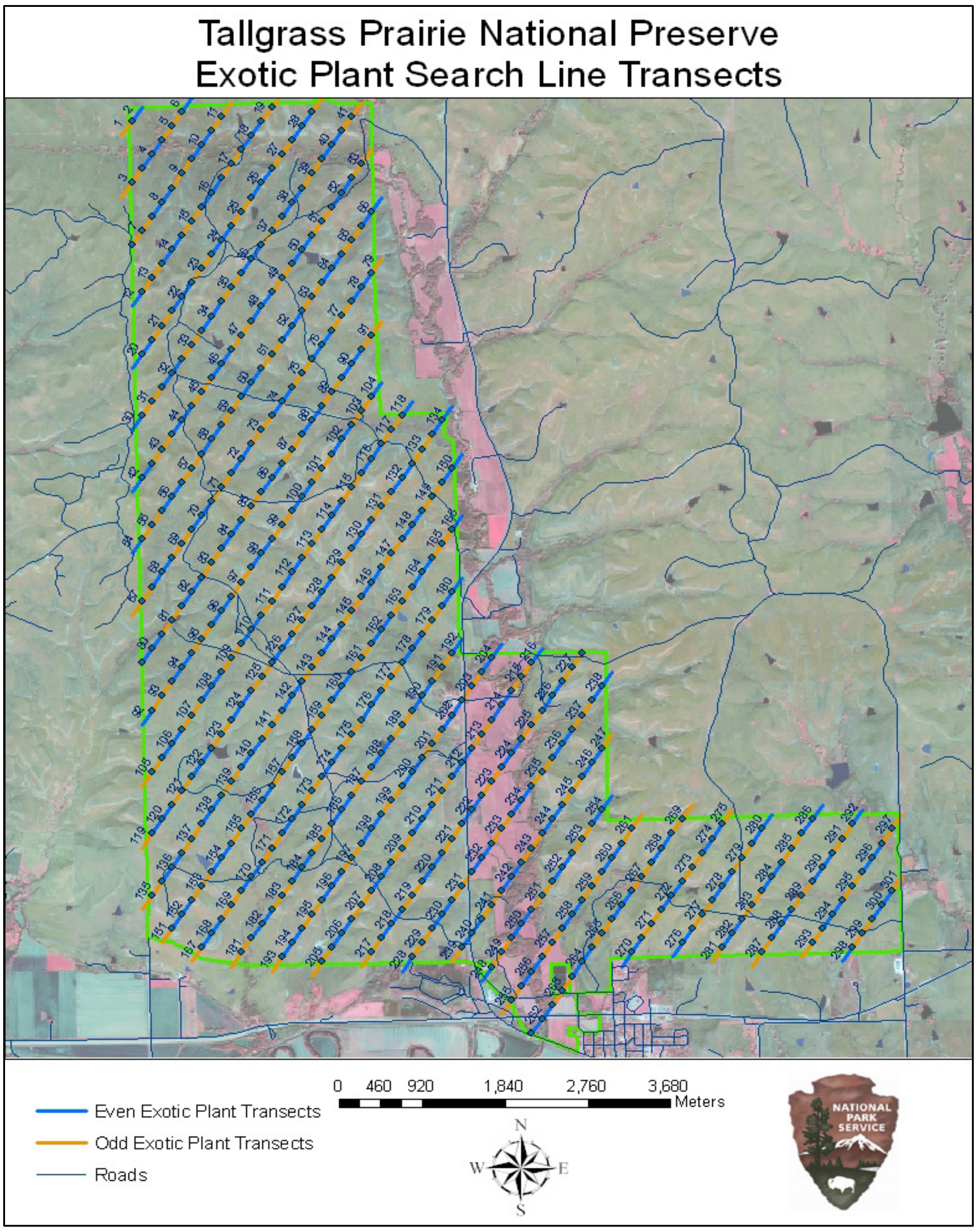


Figure 4.11-1. Exotic plant search units at TAPR (Young et al. 2007).

Entire polygons were not searched. A preserve -wide cover range was estimated using the high and low values of the cover classes for each invasive exotic plant encountered. A minimum cover estimate was calculated as the sum of lower endpoints of cover classes divided by the calculated maximum area searched (2.98% of the preserve), i.e., an estimate of the lowest possible cover within the greatest possible area searched. Likewise, a maximum cover estimate was calculated as the sum of cover class upper endpoints divided by the calculated minimum area searched (0.75% of the preserve), representing an estimate of the highest possible cover within the smallest area searched. These minimum and maximum cover estimates provide an estimated range of cover that accounts for the uncertainty arising from the sampling method (Bell et al. 2011). Monitoring began in 2006, was repeated in 2010 and will be repeated every five years.

Frequency and cover data were abstracted from Bell et al. (2011). Changes in cover by search unit were evaluated using data from INP_Accessv2.0.mdb, provided by network staff. Cover classes were converted to midpoints and summed across species for each search unit.

Acreage values and vegetation plot data derived from the 2011 vegetation mapping effort (Kindscher et al. 2011) were examined to provide a baseline for the spatial extent of weedy polygons located largely within the Fox Creek bottoms (Table 4.11-2).

Table 4.11-2. Extent of plant communities dominated by species on preserve watch lists (data from Kindscher et al. 2011).

Map Class (2011)	Description	Dominant Species	Number of Polygons	Acres (hectares)	Percent of TAPR
Restored Prairie	Planted Semi-natural Restored Tallgrass Prairie, areas that were restored to a tallgrass prairie mix of species	*Sorghastrum nutans* *Bromus japonicus* *Panicum virgatum* *Conyza canadensis* *Andropogon gerardii* *Tripsacum dactyloides* *Ambrosia artemisiifolia*	9	216.8 (87.7)	2.0%
Smooth Brome	*Bromus inermis - (Pascopyrum smithii)* Semi-natural Herbaceous Vegitation CEGL005264	*Bromus inermis*	4	244.1 (98.8)	2.2%
Weedy	Areas of disturbed vegetation, former feedlots	*Bromus inermis* *Bromus japonicus* *Panicum virgatum* *Conyza canadensis* *Andropogon gerardii* *Tripsacum dactyloides* *Ambrosia artemisiifolia*	3	27.6 (11.2)	0.3%

4.11.3. Reference Conditions

The ideal condition for TAPR would be the complete absence of non-native species, representing conditions during pre-settlement times. Because this type of reference condition is not feasible for a unit with the history and extent of TAPR, we instead consider a baseline reference condition as conditions under which the integrity of prairie plant communities remains essentially unimpaired, and under which natural processes that are affected by species composition are able to operate within the natural range of variation. We used a three-class condition scale to evaluate the condition and trend for the preserve with reference to invasive plant species and state-listed noxious weed species (Table 4.11-3 and 4.11-4). A good condition ranking would be achieved under conditions where IEP species are present but at generally low frequency and cover levels, and in only isolated patches. Conditions where many IEP species are present with substantial cover for some species, and the problem is widespread, indicate a condition warranting significant concern. Because species numbers and distribution are naturally variable from year to year even in the absence of control efforts, we focused our trend evaluation on the largest change classes, instead of on those of a few percentage points. A combined change in cover of more than 500 percentage points for all species sampled in the polygon is used to indicate "substantial" increase or decrease.

Table 4.11-3. Reference condition rating framework for invasive exotic plants at TAPR.

Condition	Frequency	Abundance	Distribution	State Noxious Weeds
Good	In the most recent monitoring period, no IEP species are present with >50% frequency	In the most recent monitoring period, no IEP species are present with estimated cover range that exceeds 15% of total park acres	In the most recent monitoring period, <10% of search units have >5 IEP species present	No state noxious weed species are present
Moderate Concern	In the most recent monitoring period, a few IEP species (1–3) are present with >50% frequency	In the most recent monitoring period, a few IEP species (1–3) are present with cover range that exceeds 15% of total park acres	In the most recent monitoring period, >10% of search units have >5 IEP species present, AND <25% have 10 or more IEP species present	1–3 state noxious weed species are present, AND state noxious weed species acreage is <1% of preserve area

Table 4.11-3 (continued). Reference condition rating framework for invasive exotic plants at TAPR.

Condition	Frequency	Abundance	Distribution	State Noxious Weeds
Significant Concern	In the most recent monitoring period, many IEP species (>3) are present with >50% frequency	In the most recent monitoring period, many IEP species (>3) are present with cover range that exceeds15%of total park acres	In the most recent monitoring period, >25% of search units have 10 or more IEP species present	More than 3 state noxious weed species are present OR state noxious weed species acreage is >1% of preserve area

Table 4.11-4. Reference trend rating framework for invasive exotic plants at TAPR.

Trend	Symbol	Change in IEP cover from 2006 to 2010
Improving	⇧	25% or more of search units have a substantial(decrease in IEP cover AND fewer than 15% have a substantial increase in IEP cover
Unchanging	⇔	>75% of search units have no substantial increase or decrease in IEP cover AND <25% of search units have a substantial decrease in IEP cover
Deteriorating	⇩	>25% of search units have a substantial increase in IEP cover

4.11.4. Condition and Trend

<u>Frequency</u>

A cumulative total of 19 IEP species have been detected at TAPR during the two monitoring periods. In the most recent (2010) monitoring, several species not previously detected (*Schedonorus pheonix*, *Poa pratensis*, *Ailanthus altissima*, and *Bothriochloa bladhii*) were found. No species was present with frequency above 50% (Figure 4.11-2). Frequency for many species increased from 2006 to 2010. These results indicate good condition, with a declining trend and medium confidence level.

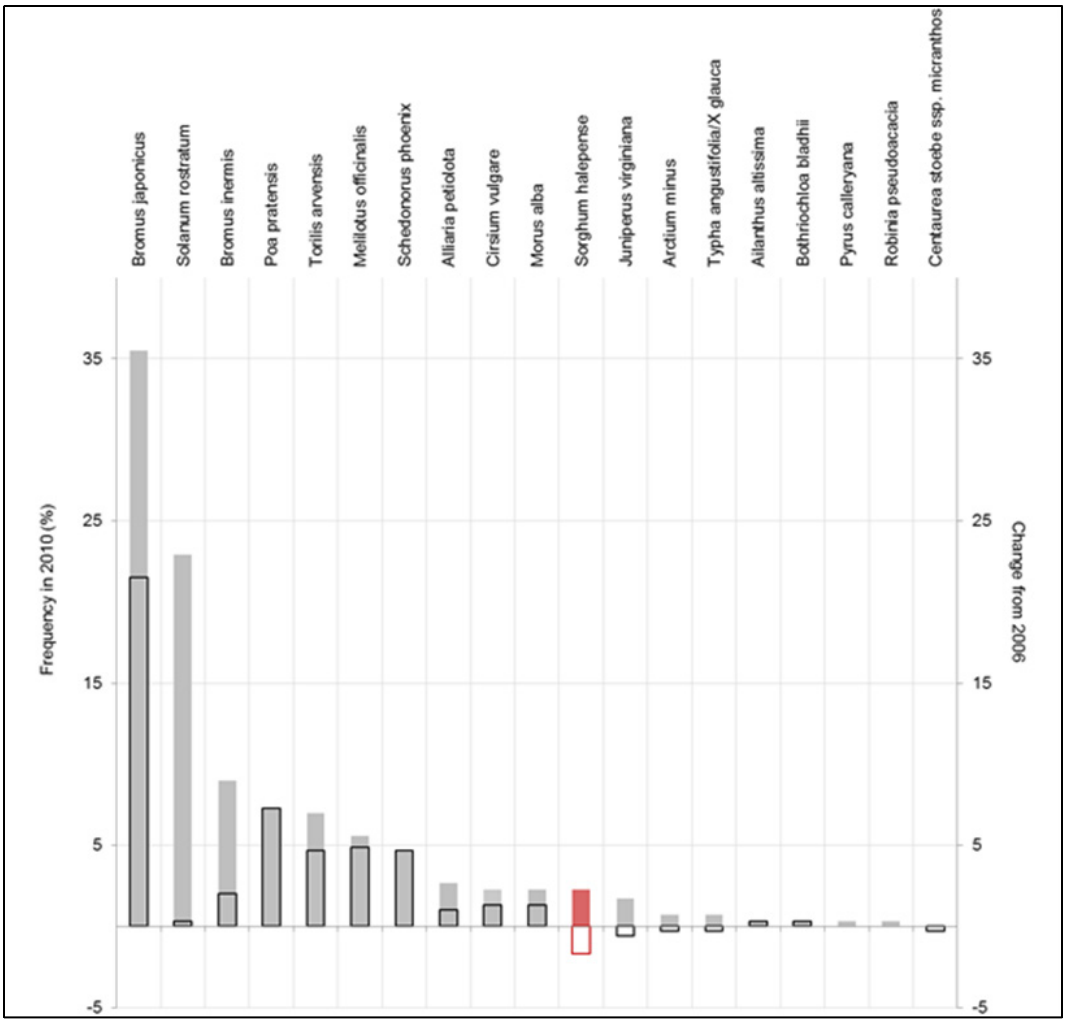


Figure 4.11-2. Frequency of IEP species at TAPR in 2010 (solid bars), and change in frequency from 2006 (open bars). Species sorted by decreasing percent frequency. Values for Kansas state-listed noxious species are shown in red.

<u>Abundance</u>

Estimated cover ranges as reported by Bell et al. (2011) indicate that *Bromus inermis* is the most abundant IEP species at TAPR, although its cover in 2010 does not exceed 15% of the total acreage of the preserve (Figure 4.11-3). Increases in cover were generally small. Results for this indicator show good condition, with an unchanging trend and medium confidence level.

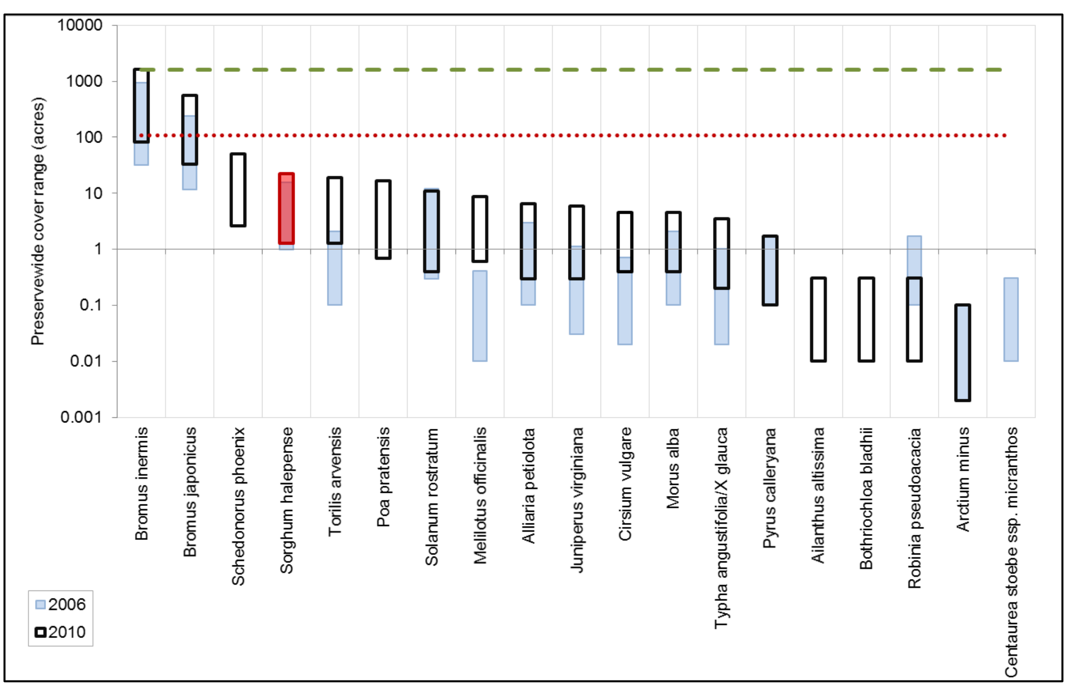


Figure 4.11-3. Cover ranges of IEP species at TAPR in 2006 and 2010. Species are sorted by decreasing 2010 cover acreage (note log scale). The 15% cover threshold for all IEP species (see text) is indicated by a dashed line. Values for Kansas state-listed noxious species are shown in red, and the 1% state-noxious cover threshold is shown as a dotted line.

Distribution

Thirty-six percent of search units at TAPR had no IEP species present in 2010 (Figure 4.11-4a). The majority of the remaining units (61%) have 1–5 IEP species. Eight search units had between 6 and 10 IEP species, and a single search unit had 11 IEP species. Units with high presence of IEP species are concentrated in the Fox Creek bottom and a handful of historic corrals and feedlot areas. Nineteen search units (6%) primarily in the cultivated bottoms adjacent to Fox Creek had a substantial increase in IEP cover (Figure 4.11-4b). Three search units (1%) had a substantial decrease in IEP cover. Ninety-three percent of search units were unchanged or had no IEP species present. Considered separately, the unrestored Fox Creek Bottoms and restored prairie areas merit moderate management concern. Over the entire preserve, however, results for this indicator show good condition, with an unchanging trend and medium confidence level

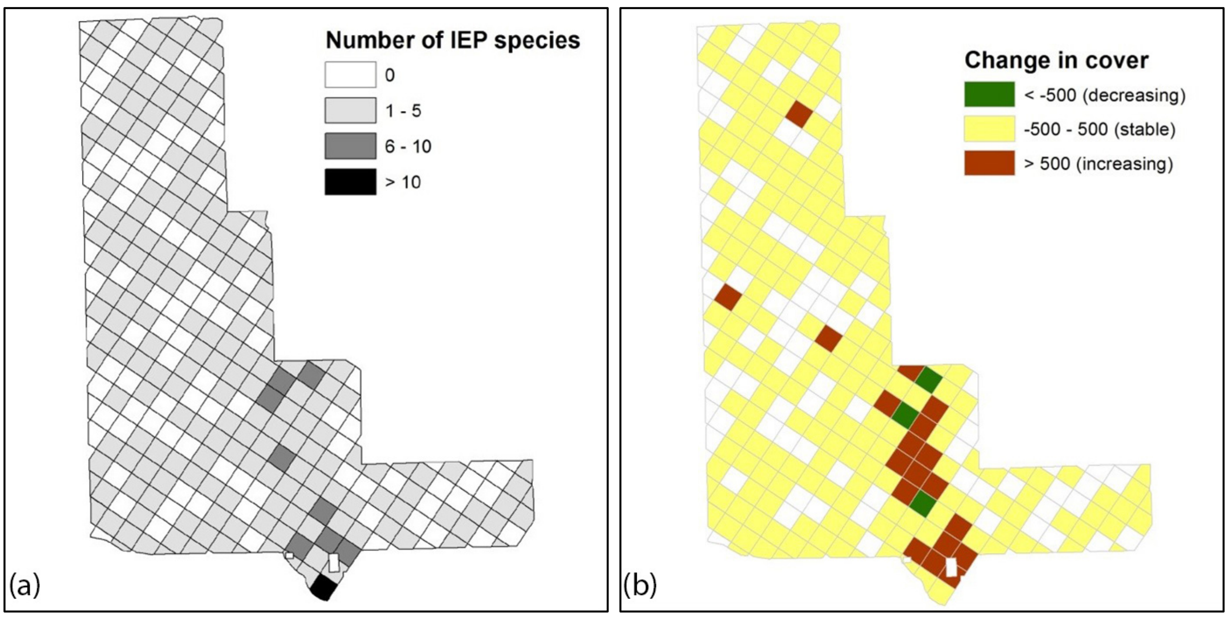


Figure 4.11-4. Number of IEP species by search unit in 2010 (a) and net change in cover class of each species (combined) between 2006 and 2010 (b).

State Noxious Weeds

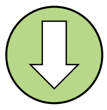
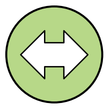
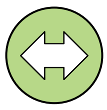
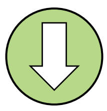
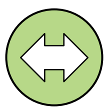
One Kansas state-listed noxious weed species (*Sorghum halepense*) was present in 2010 (Figure 4.11-2). Its total cover was 25.2 acres, or 0.2% of preserve acreage. These results indicate good condition, with a slight declining trend and medium confidence level.

Overall Condition and Trend

The IEP monitoring data is rich in spatial and non-spatial information, and presents challenges in determining an overall rating for the preserve. Trends in individual species are more straightforward to assess and interpret than composition changes due to multiple species and abundances. Based on the four indicators evaluated, preserve is in good condition with an unchanging trend. The lack of more than two years of monitoring data, the necessity of estimating cover ranges from transects, and confidence associated with defining reference conditions result in a medium level of confidence for the assessment.

Indicators of condition for IEP species at TAPR are summarized in Table 4.11-5. As noted above, the primary areas of concern for IEP species and state-listed noxious weeds are the unrestored Fox Creek Bottoms and restored prairie areas. If considered separately, the condition of the Fox Creek bottoms warrants significant concern with a deteriorating trend.

Table 4.11-5. Condition and trend summary for invasive exotic plant species at Tallgrass Prairie National Preserve.

Indicator	Condition Status/Trend	Rationale
Frequency		No IEP species is present with high frequency, although two species (Japanese brome and buffalobur nightshade) have frequency of >10%.
Abundance		No IEP species has an estimated cover range exceeding 25% of the total acreage of the preserve. A couple of invasive grass species (smooth brome and Japanese brome) are the primary contributors to IEP abundance. Outside of historic corrals and feedlot areas, the Fox Creek bottoms had the most abundant weeds.
Distribution		Most search units have few to no IEP species present, indicating that the contiguous grassland is more likely to function according to natural processes.
State Noxious Weeds		One Kansas state-listed noxious weed species (*Sorghum halepense*) having low cover were present in 2010.
Invasive Exotic Plant Species Overall		**The overall condition for invasive exotic plants is good with an unchanging trend Confidence in the assessment is medium.**

4.11.5. Uncertainty and Data Gaps

The available data reflects intensive surveys covering all areas of the preserve and addressing preserve -based watch lists. Spatial and temporal resolution of the data is high.

4.11.6. Sources of Expertise

- Craig Young, Biologist and Invasive Plant Program Leader for the NPS Heartland I&M Network, provided reviews for this chapter.

4.11.7. Literature Cited

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4.12. Aquatic Macroinvertebrates

Stonefly nymph. Stonefly nymphs are especially sensitive to changes in water quality (NPS 2010).

4.12.1. Background and Importance

Macroinvertebrates are organisms that are visible to the naked eye. Aquatic macroinvertebrates complete all or part of their life cycle in water, and because of this are dependent on water quality (NYNRM 2013). Aquatic macroinvertebrates are an important component in the ecology of a water body because they are an essential part of the food chain in aquatic environments. Aquatic macroinvertebrates are often used as indicators of water quality and overall watershed health (EPA 2013). Some species are tolerant of pollution or poor water quality, while others are highly sensitive to it. The presence or absence of tolerant and intolerant taxa can therefore be an indication of a water body's condition and water quality (EPA 2013). Species diversity can also be an indicator of habitat health, as a diverse habitat with more ecological "niches" can generally support more species. For these reasons, aquatic macroinvertebrate indices are included in this condition assessment to indicate aquatic habitat diversity and suitability, condition of natural processes, and also as a proxy for water quality. Physical and chemical water quality attributes are examined in the *Water Quality* section of this report.

Prairie once covered approximately 160 million acres of North America, but more than 95% of this resource has been altered by human disturbance (Samson and Knopf 1994). Prairie streams were a critical part of these plains ecosystems, but as the prairie was altered, many of these prairie streams were also lost. Many of the remaining prairie fragments are not sufficiently large to support proper ecological functioning of their resident streams (Hall et al. 2003, Dodds et al. 2004). Today, prairie streams continue to face anthropogenic threats—understanding their ecology has become critically important (Dodds et al. 2004). Although some of the prairie streams and their watersheds at TAPR are largely protected, they remain vulnerable to human disturbance.

The Heartland Inventory and Monitoring Network (HTLN) began monitoring water quality and invertebrate community structure in Palmer and Fox creeks at TAPR in September 2009. As of 2009, monitoring objectives were to: 1) determine the status and trends of invertebrate species diversity, abundance, and community metrics; and 2) relate the invertebrate community to overall water quality through quantification of metrics related to taxa richness, abundance, diversity, and region-specific multi-metric indices as indicators of water quality and habitat conditions (Bowles et al. 2008). This assessment examines aquatic invertebrate monitoring data collected in September 2009 and attempts to assess condition and trends using a suite of aquatic invertebrate indicators for Palmer and Fox Creek.

<u>Threats and Stressors</u>

The majority of the Palmer Creek watershed within TAPR is characterized as prairie. It is subject to minimal anthropogenic disturbance outside of livestock grazing activities. Numerous anthropogenic stressors occur in the Fox Creek watershed. These include animal waste from cattle operations, runoff from agricultural lands, and sedimentation (EPA 2005, 2008). The intermittent nature of prairie streams, including those in this study, may also serve as seasonal stressors, which could cause them to appear impaired (Lytle 2002).

Indicators and Measures

Richness and Diversity

- Family richness
- Genus richness
- Genus evenness
- EPT richness
- EPT ratio
- Shannon index

Pollution Tolerance

- Hilsenhoff Biotic Index (HBI)

4.12.2. Data and Methods

Methods and procedures used in this report follow Bowles et al. (2008), *Monitoring Protocol for Aquatic Invertebrates of Small Streams in the Heartland Inventory & Monitoring Network*. Samples were collected at one reach of Palmer Creek and one reach of Fox Creek in September 2009. Three successive riffles were sampled and three benthic invertebrate samples were collected at each riffle, resulting in nine total samples for each creek. A Surber stream bottom sampler (500 µm mesh, 0.09 m^2) was used to collect the samples. Samples were sorted in the laboratory following a subsampling routine described in Bowles et al. (2008). Taxa were identified to the lowest practical taxonomic level (usually genus) and counted (Cribbs and Bowles 2012).

Metrics calculated for each sample included genus richness, Shannon diversity index, EPT (Ephemeroptera, Plecoptera, Trichoptera) richness, EPT ratio (EPT density/(EPT density + Chironomidae density)), genus evenness (where 0 = minimum evenness, 1 = maximum evenness), percentage EPT abundance (i.e., the percentage of the total invertebrate abundance comprised of EPT), and Hilsenhoff biotic index (HBI). Shannon's index accounts for both abundance and evenness of the species present and index values are greater when all taxa in a sample are equally abundant. For biological data, values of Shannon's index typically range from 1.5 (low species richness and evenness) to 3.5 (high species evenness and richness). The HBI is calculated using tolerance values (TVs) assigned to individual taxa. A TV between 0 and 3 would be classified as intolerant and values from 7 to 10 would be classified as tolerant (Barbour et al. 1999). By definition, HBI scores range from 0 to 10, with 10 indicating the most disturbed community. For most metrics used here, higher values are associated with better stream conditions, except for HBI where smaller values indicate better conditions.

4.13.3. Reference Conditions

Due to the lack of data prior to 2009 for Fox and Palmer Creeks, comparisons are drawn from aquatic macroinvertebrate assemblages and biological condition of other small, Midwestern plains streams such as those studied in Bass (1994), Harris et al. (1999), and aquatic invertebrate monitoring reports for other parks in the Heartland Network. The framework for determining resource condition ratings is shown in Table 4.12-1. These ratings are based on reference values obtained from best available data.

Table 4.12-1. Resource condition indicator rating framework for aquatic macroinvertebrate communities at Fox and Palmer Creeks at TAPR.

Indicator	Good Condition	Warrants Moderate Concern	Warrants Significant Concern
Family Richness[A]	>10	5–10	<5
Genus Richness[A]	>15	7–15	<7
EPT Richness[B]	>14	8–14	<8
EPT Ratio[C]	>0.75	0.25–0.75	<0.25
Shannon Index[C]	>2.5	1–2.5	<1
Genus Evenness	Unknown	Unknown	Unknown
Hilsenhoff Biotic Index[D]	0.00–4.25	4.26–6.50	6.51–10.00

[A] Bowles (2009): values for these metrics were obtained by combining the author's valuation of Pipestone Creek at Pipestone National Monument (used as a proxy for Fox and Palmer Creeks) as "mildly impaired" with values of these metrics from Bukantis (1998).

[B] VWQD (2008): values from this report are from a small, high gradient stream and are used here as an estimate for TAPR aquatic communities. Confidence in these reference values is low.

[C] Wilhm (1970)

[D] Hilsenhoff (1988)

4.13.4. Condition and Trend

Data for the initial data collection year of 2009 are shown in Table 4.12-2.

Table 4.12-2. Means and 90% confidence intervals for invertebrate metrics collected from Fox and Palmer Creeks, Tallgrass Prairie National Preserve in 2009 (data from Cribbs and Bowles 2012).

	Fox Creek (n=9)		Palmer Creek (n=9)	
Metric	Site Mean	CI_{90}	Site Mean	CI_{90}
Family Richness	15.44	13.96–16.92	14.56	12.79–16.33
Genus Richness	16.89	15.41–18.37	15.22	13.43–17.01
EPT Richness	8.00	7.92–8.08	6.10	5.41–6.79
EPT Ratio	0.77	0.62–0.92	0.73	0.62–0.84
Shannon Index	2.00	1.87–2.13	2.04	1.96–2.12
Genus Evenness	0.69	0.64–0.74	0.74	0.71–0.77
Hilsenhoff Biotic Index	5.26	5.00–5.52	5.20	4.92–5.48

Fox Creek

A total of 41 taxa were collected in Fox Creek in 2009. Mean genus richness in riffles was 16.89. Roughly one-fourth of all taxa collected were sensitive, having TVs of 3 or less. Sensitive taxa present in samples included the caddisfly (Trichoptera) genus *Chimarra* (TV= 2.8, 18.8% of the total benthic sample) and the riffle beetle genus *Microcylloepus* (Coleoptera) (TV= 2.1). The HBI values were moderate among riffles with scores ranging from 4.7–6.0 (mean= 5.3). Mean EPT richness for Fox Creek was 8, indicating this stream partially supports biological life under the Kansas Department of Health and Environment criteria (KDHE 2004). EPT taxa were dominant among samples, comprising 72.6% of total individuals, and the most prevalent taxon was the tolerant caddisfly (Trichoptera) genus *Cheumatopsyche* (TV= 6.6), making up 26% of the benthic density. The relatively high EPT ratio for Fox Creek (0.77) indicates that the dipteran family Chironomidae did not dominate a substantial portion of the benthic community among samples. The percentage composition of Chironomidae in the total benthic community varied greatly from 1.5% to 57.8% (mean= 14.8%). Shannon's index among samples ranged from 1.69 to 2.39 (mean= 2.0). Genus evenness ranged from 0.57 to 0.81 (mean= 0.69).

Palmer Creek

A total of 36 taxa were collected during the 2009 sampling of Palmer Creek. Mean genus richness across riffles was 15.2 (range= 9–19). Mean EPT richness was relatively low (6.1), which is classified as non-supporting under KDHE (2004) criteria. The EPT ratio was 73% and the percentage composition of Chironomidae in the total benthic community ranged from 0%–49% (mean= 20%). In most samples, the three dominant taxa included Baetidae (TV= 4.0), Chironomidae (TV= 6.0), and the mayfly genus *Baetis* (TV= 6.0). Shannon's index among samples ranged from 1.76 to 2.23 (mean= 2.04). Genus evenness ranged from 0.67 to 0.86 (mean= 0.74). Sensitive taxa that were found include *Helicopsyche* (Trichoptera: Helicopsychidae), *Chimarra* (Trichoptera: Philopotamidae) and *Prosimulium* (Diptera: Simuliidae); all had TVs less than 3. The top three dominant taxa comprised the majority of benthic densities for all samples (range 8.8 to 21.3%, mean= 14.7%). HBI was moderate for all samples ranging from 4.36 to 5.84 (mean= 5.20).

Overall Condition

A previous survey of Fox Creek conducted by the United States Environmental Protection Agency (EPA 2008) indicated this stream did not meet aquatic life criteria because it only partially supported biological communities. This judgment was based on assessments of aquatic invertebrate, fecal coliform bacteria, suspended solids and sulfates that did not compare favorably with those of regional reference streams. Similarly, Palmer Creek was listed as partially supporting biological communities based upon invertebrate samples (EPA 2005). Water quality collected in this study met the Kansas aquatic life criteria (KDHE 2004) for prairie streams.

Interpretation of aquatic invertebrate results is somewhat mixed. EPT richness was low for each stream suggesting severe impairment, but EPT ratio, and moderate tolerance indices (HBI) for both streams do not indicate severe impairment, which suggests that the streams are functioning normally. Fox Creek and Palmer Creek both had similar scores for invertebrate community indices. Several intolerant taxa were represented in samples from Fox Creek (21% of the total individuals) and Palmer Creek (8.3%). The invertebrate metrics presented in this report are generally comparable to those observed for other regional streams, and suggest the data for Fox and Palmer creeks fall within a normal range for the region (MacFarlane 1983; Harris et al. 1991, 1999; Bass 1994; Whiles et al. 2000; Hall et al. 2003; Sarver et al. 2002; Zelt and Frankforter 2003; Kosnicki and Sites 2007; Poulton et al. 2007; Hutchens et al. 2009).

Results were similar for the two streams examined. Based on the evaluation of aquatic macroinvertebrate metrics and comparisons with similar streams, condition of the resource warrants moderate concern (Table 4.12-3). Due to the lack of data, trends cannot be determined. Confidence in the assessment is low due to lack of monitoring data over time and uncertainty associated with reference conditions.

Collectively, the available data suggest that Fox Creek and Palmer Creek may be mildly impaired, although such a designation is not decisive. Both Fox Creek and Palmer Creek have occasionally been reported to have elevated nitrogen and phosphorus levels that potentially can cause biological degradation (EPA 2005, 2008). The majority of the Palmer Creek watershed within TAPR is characterized as prairie, and it is subject to minimal anthropogenic disturbance outside of grazing impacts including some riparian area impacts. Numerous anthropogenic stressors occur in Fox Creek's watershed upstream of TAPR (EPA 2005, 2008). The intermittent nature of prairie streams, including those in this study, may also serve as seasonal stressors, which could cause them to appear impaired (Lytle 2002). Continued monitoring of invertebrate communities will provide important water quality and aquatic life information to TAPR resource managers regarding the health of Fox Creek and Palmer Creek's respective watersheds.

Table 4.12-3. Condition and trend summary for the aquatic macroinvertebrate communities in Fox and Palmer Creeks, TAPR.

Indicator	Condition Status/Trend	Rationale
Family Richness		Family richness values show that both Fox and Palmer Creeks are in good condition.
Taxa/Genus Richness		Genus richness values show that both Fox and Palmer Creeks are in good condition for this metric.
EPT Richness		EPT richness warrants significant concern in Palmer Creek and moderate concern in Fox Creek. The overall metric is considered to warrant significant concern as Fox Creek was on the very low end of the moderate range.
EPT Ratio		EPT ratio values show that both Fox and Palmer Creeks warrant moderate concern.
Shannon Index		Shannon index values show that both Fox and Palmer Creeks warrant moderate concern for this metric.
Genus Evenness		Current condition is unknown due to lack of availability of reference values for genus evenness.
Hilsenhoff Biotic Index (HBI)		HBI values show that both Fox and Palmer Creeks warrant moderate concern for this metric.
Aquatic Macroinvertebrate Community Overall		**Condition of the resource warrants moderate concern with an unknown trend. Confidence in the assessment is low.**

4.13.5. Uncertainty and Data Gaps
Because only one year of data was available, trends could not be determined for Fox and Palmer Creeks. Considerable uncertainty regarding reference conditions exists.

4.13.6. Sources of expertise
- No outside sources of expertise were used.

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4.13. Bird Community

4.13.1. Background and Importance

The National Park Service protects and manages natural resources within the National Park boundaries. Grassland and woodland birds are conspicuous components of those parks residing within prairie ecotones and compose an important natural resource within grassland parks of the Heartland Inventory and Monitoring Network (HTLN). In addition, grassland birds have been in consistent decline since the 1970s (Sauer et al. 2000). This decline has been caused by multiple factors including the conversion of grassland to other land cover types, habitat fragmentation, and mowing regimes (Lookingbill 2012). In 2005, NPS formally recognized this decline and began taking actions to combat the loss of grassland birds (Peterjohn 2006). The NPS recommends a species-specific approach to park management that focuses on obligate grassland species. An obligate grassland bird is defined as "any species that has become adapted to and reliant on some variety of grassland habitats for part or all of its life" (Vickery et al. 1999).

Grassland bird populations are excellent indicators of environmental condition because individual species assemblages associate with specific grassland types, they occur across a continuum of anthropogenic disturbances, species assemblages are predictive of these disturbance levels, birds are easily detected and through the use of numerous standardized methods they are well researched (Bibby et al. 2000, Canterbury et al. 2000, Browder et al. 2002, Bryce et al. 2002, NABCI 2009). In addition, birds are well liked by the public, the public can relate to concerns about bird communities, birding is a popular activity at most parks, and bird songs contribute to the natural soundscape.

The upland grassland habitat present at TAPR supports wintering, feeding, and breeding populations of both resident and migrating birds. Because of the rarity of non-agricultural lands in the region, TAPR is especially valuable by providing relatively unfragmented patches of native prairie that serve as a refuge within a highly altered agricultural landscape. Monitoring the change in avian community composition and abundance in these habitats is important for detecting ecosystem change. The habitat fragmentation and conversion of native vegetation to agricultural and urban landscapes occurring outside the preserve will negatively impact populations of some bird species that are preserve residents, particularly specialist species that have evolved within stable environments (Devictor et al. 2008, La Sorte 2006). Avian community composition and diversity should improve with the restoration of native prairie and woodland plant communities both within TAPR and the surrounding landscape over time (Johnson 2006, Boren et al. 1999).

Threats

Threats to the TAPR bird community include the conversion of habitats to agricultural and urban uses including cultivation and livestock grazing and residential, commercial, and industrial development locally, regionally and within the extent of migratory patterns (Hansen and Gryskiewicz 2003). These uses result in habitat loss, habitat fragmentation, water pollution and the disruption of hydrologic flow regimes. In turn, these modifications disrupt ecological functions important to ecosystem integrity and important to maintaining the community and composition of species at TAPR comparable to that of the natural habitat of the region (Jorgensen and Müller 2000). Consequently, the ecological functioning of TAPR depends upon maintaining the natural systems outside preserve boundaries. These changes in land use are linked to ecological function by five mechanisms (Hansen and Gryskiewicz 2003):

- Land use activities reduces the functional size of a reserve, eliminating important ecosystem components lying outside the park boundary;
- Land use activities alter the flow of energy or materials across the landscape irrespective of the park's political boundary, disrupting the ecological processes dependent upon those flows both outside and inside the park and across its boundaries;
- Habitat conversion outside the reserve may eliminate unique habitats, such as seasonal habitats and migration corridors;
- The negative influences of land use activities may extend into the reserve and create edge effects; and
- Increased population density may directly impact parks through increased recreation and human disturbance.

Indicators and Measures

- Native species richness (S)
- Bird index of biotic integrity (IBI)
- Occurrence and status of bird species of conservation concern

4.13.2. Data and Methods

The Heartland Inventory and Monitoring Network (HTLN) has implemented long-term monitoring of birds at network parks including TAPR. The purpose of this monitoring is to track changes in bird community composition and abundance, and to monitor bird response to changes in habitat structure and other habitat variables related to management activities (Peitz et al. 2008). HTLN began systematic surveys of breeding birds and their habitat at TAPR in 2001. Monitoring was conducted every year at a subsample of 242 permanent sites arranged in a systematic grid of 400 x 400 meter cells (originating from a random start point) (Peitz 2011). This grid was rotated 34 degrees from north to avoid station survey points from being impacted by roads, fences and other structures (Figure 4.13-1). Peitz (2011) classified 18 of the permanent plots (sites 159 through 176) as riparian. For this analysis, these 18 sites were classified as woodland, while the remaining 242 sites were analyzed as grassland. Data from the 242 grassland sample sites were used to determine the condition of the grassland bird community; the 18 riparian sites were used to determine condition of the woodland bird community. The number of sites sampled per year varied, ranging from 241 to 40 for the grassland sites and 18 to 16 for the woodland sites. Variable circular plot methodology was used, wherein all birds seen or heard at plots during 3 to 5-minute sampling periods were recorded along with their corresponding distance from the observer (Peitz et al. 2008). The number of sites sampled varied among years, so the mean values of the indicators per sample site were used to assess condition and trend in the bird community at TAPR.

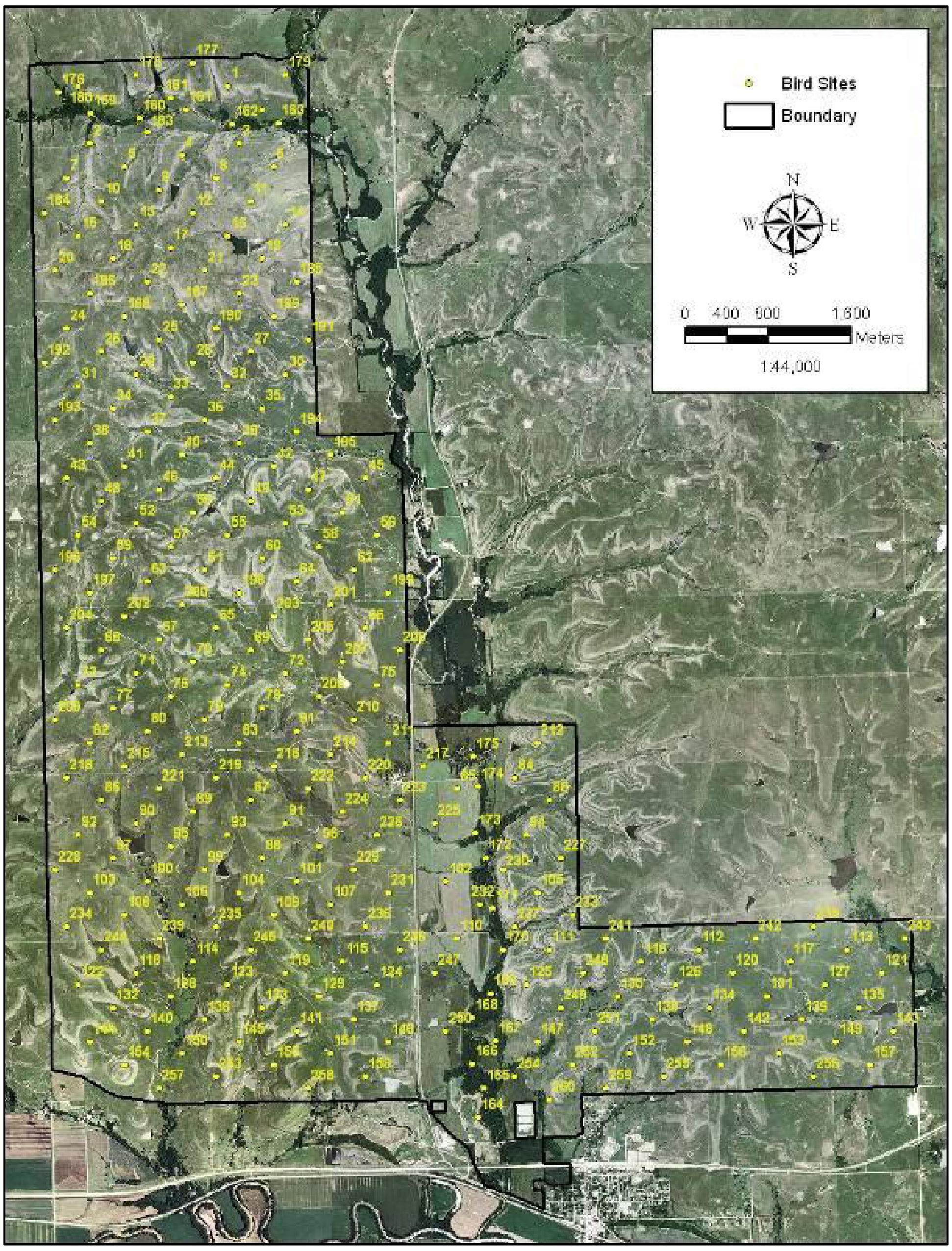


Figure 4.13-1. Bird plot locations on Tallgrass Prairie National Preserve, Kansas (Peitz 2011).

Additional bird datasets that include survey sites within TAPR exist, but were not used in this assessment. Kansas State University, surveyed bird populations from 2011 to 2013 at 5 locations on TAPR (Sandercock et al. 2014) and the University of Nebraska monitored 40 sites at TAPR in 2008 and 2009 (Rehme 2010).

Information on the abundance of wintering birds and migratory birds during spring and fall migration for TAPR is limited. There is a current effort by the Nature Conservancy of Kansas, in partnership with the U. S. Fish and Wildlife Service, to gather data supporting recognition of the Flint Hills region as a landscape of hemispheric importance for migrating songbirds, raptors and shorebirds (TNC 2015). Two priority bird species for which the Flint Hills act as a major migration linkage include the American golden-plover (*Pluvialis dominica*) and Sprague's pipit (*Anthus spragueii*) (Jones 2010; USFWS 2010). The Flint Hills region, within which TAPR resides, is an unfragmented expanse of native prairie supporting essential forage for these two species during migration, allowing them to replenish body reverses to complete their migration and enhancing their reproductive success once their breeding grounds are reached (USFWS 2010; Fellows et al. 2001). The American golden-plover is listed on the National Audubon Society/American Bird Conservancy's Watchlist (2007) and the Sprague's pipit is a Candidate for listing as "Endangered" or "Threatened" under the Endangered Species Act of 1973 (Jones 2010). Short-eared owls are known to winter within the Flint Hills, including within areas that overlap with TAPR (Wiggins 2004). Short-eared owls are tracked by the Kansas Natural Heritage Inventory (S2B, S3N) and are listed as a species in need of conservation by Kansas Wildlife, Parks and Tourism.

To evaluate trends over time, we compared the occurrence of species detected during the initial survey conducted at TAPR in 2001 to species detected during the 2012 survey. We compared species richness between the two years, 2001 and 2012, separately for the grassland and woodland sample sites. Only native species were included in calculations of species richness, as the inclusion of exotic/non-native species would make interpretation of richness results problematic from a biotic integrity standpoint.

Bird Index of Biotic Integrity (IBI) values were calculated separately for the grassland and woodland samples, and included a guild for exotic/non-natives and compared this index between the years 2001 and 2012. The bird IBI is based on the methodology developed for bird communities of the mid-Atlantic Highlands (O'Connell et al. 1998a). It is important to note that the bird IBI was modified from O'Connell et al. (1998a) to reflect the land-use and land-cover types of the HTLN (e.g., grassland for the grassland IBI and riparian woodland for the woodland IBI and pasture and row crop, urban and suburban area for both IBIs). Specialist guilds included in the IBI tend to be associated with either extensive grassland cover or extensive woodland cover. Therefore, higher IBI scores reflect bird communities associated with aspects of mature grassland structure, function, and composition for the grassland IBI and mature woodland structure, function, and composition for the woodland IBI. For example, sites with higher grassland bird IBI scores consist of a bird community with more grassland-dependent species, ground cleaners, and single-brooded or open ground nesters (i.e., specialists) but with fewer omnivores, exotic/non-natives, nest predators/brood parasites and residents (i.e., generalists). An extensive discussion for why these guilds are chosen over others is found in Standard Operating Procedure #9 – Bird Community Index (Marshall et al. Undated).

To calculate the IBI score, species are first assigned to guilds (some species may be assigned to more than one guild, depending on their life history traits). The proportional species richness of each guild is then calculated by dividing the number of species detected within a specific guild by the total number of species detected. The next step in the bird IBI is to rank each category of proportional species richness for each guild on a scale of 5 (high integrity) to 0 (low integrity) (O'Connell et al. 1998a, 1998b, 2000). For specialist guilds, the highest-occurrence category is ranked a "5," the next highest a "4," etc. For generalist guilds, the ranking is reversed; a "5" is assigned to the lowest-occurrence category. Therefore, a site can receive a rank of "5" for a guild if the site supports the highest category of proportional species richness for a specialist guild or the lowest category of proportional species richness for a generalist guild. The final bird IBI score is then calculated by summing the rank for each guild's proportional species richness, across all guilds.

A community at the theoretical maximum high IBI score, or highest integrity, consists of a bird community with only specialist guilds and without any generalist guilds. The integrity represented by a particular IBI score is based upon a theoretical maximum community at TAPR receiving a grassland bird IBI score of 44 and the theoretical minimum community, a score of 10, which corresponds to either only species from "specialist guilds" being detected or only species from "generalist guilds" being detected, respectively. Similarly calculated, the theoretical maximum and minimum woodland bird IBI scores at TAPR are 86 and 23.5, respectively. As with the grassland bird community, a woodland bird community with a high IBI score will contain more specialist guild members and fewer generalist guild members.

The biotic or ecological "condition" described by the bird IBI, then moves along a disturbance gradient from relatively intact, extensive, mature grassland or woodland with high IBI scores to more disturbed, developed or urban grassland or woodland with low IBI scores. Some riparian forest birds were recorded at the grassland sample sites, however, forest guilds (i.e., bark prober, upper-canopy forager, lower-canopy forager, aerial screener, aerial sallier, canopy nester, forest-ground nester, forest generalist, interior forest obligate, and riparian dependent) were not used to calculate the grassland bird IBI score. The reverse was true of the woodland sites and grassland guilds (i.e., grassland ground cleaner, grassland ground nester, and grassland dependent) were not used to calculate the woodland bird IBI. The response guilds incorporated into the grassland and woodland bird IBIs are listed in Table 4.13-1.

Table 4.13-1. Bird species guilds used to calculate the IBI score at Tallgrass Prairie National Preserve.

Bird Index of Biotic Integrity (IBI)	Biotic Integrity Element	Guild Category	Response Guild	Number of Species in Guild	Guild Classification
Grassland IBI	Functional	Trophic	omnivore	26	generalist
	Functional	Insectivore Foraging Behavior	grassland ground gleaner	10	specialist
	Compositional	Origin	exotic/non-native	4	generalist
	Compositional	Migration Status	Resident	20	generalist
	Compositional	Migration Status	temperate migrant	21	generalist
	Compositional	Number Of Broods	single-brooded	34	specialist
	Compositional	Population Limiting	nest predator/brood parasite	6	generalist
	Structural	Nest Placement	grassland ground nester	20	specialist
	Structural	Nest Placement	shrub nester	11	generalist
	Structural	Primary Habitat	grassland dependent	6	specialist
Woodland IBI	Functional	Trophic	omnivore	12	generalist
	Functional	Insectivore Foraging Behavior	bark prober	0	specialist
	Functional	Insectivore Foraging Behavior	upper canopy forager	0	specialist
	Functional	Insectivore Foraging Behavior	lower canopy forager	5	specialist
	Functional	Insectivore Foraging Behavior	aerial sallier	0	specialist
	Functional	Insectivore Foraging Behavior	aerial screener	3	specialist
	Compositional	Origin	exotic/non-native	1	generalist
	Compositional	Migration Status	resident	11	generalist
	Compositional	Migration Status	temperate migrant	10	generalist
	Compositional	Number Of Broods	single-brooded	14	specialist
	Compositional	Population Limiting	nest predator/brood parasite	6	generalist
	Structural	Nest Placement	canopy nester	8	specialist
	Structural	Nest Placement	forest ground nester	0	specialist
	Structural	Nest Placement	shrub nester	8	generalist
	Structural	Primary Habitat	forest generalist	4	generalist
	Structural	Primary Habitat	interior forest obligate	0	specialist
	Structural	Primary Habitat	riparian dependent	3	specialist

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

Our intent for this context was to determine which species that occur at TAPR are considered species of concern at either a national or local scale, and to assess the current status (occurrence) of those species at the preserve. This analysis was restricted to those species that were either breeding at the preserve or that were residents. Those species occurring at the preserve during migration only and incidental occurrences of species outside of their normal range were excluded.

To identify priority conservation species we used lists developed by Partners in Flight (PIF), a cooperative effort among federal, state and local government agencies that identifies and assesses species of conservation concern based on biological criteria including population size, breeding distribution, non-breeding distribution, threats to breeding, threats to non-breeding, and population trend (Panjabi et al. 2005). PIF assessments are conducted at both the national and regional scale. At the national scale, the PIF North American Landbird Conservation Plan identifies what are considered “Continental Watch List Species” and “Continental Stewardship Species” (Rich et al.

2004). Conservation Watch List Species are considered by PIF as those with the greatest need for conservation 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 significant percentage of their world breeding and/or nonbreeding population (i.e., breeding population for migratory birds) confined to a specific avifaunal biome. Avifaunal biomes are adjoining areas in North America that share similar avifaunas as identified through cluster analysis (Rich at al. 2004). We consulted the PIF Conservation Watch List and Stewardship species list to identify birds at TAPR that are of national conservation priority.

PIF has also adopted Bird Conservation Regions (BCRs), after the North American Bird Conservation Initiative. BCRs are ecologically distinct regions in North America with similar bird communities, habitats and resource management issues. Regional bird conservation plans are developed by PIF using the BCRs as the unit of planning and the same principles of concern (Watch List and Continental Stewardship species) are applied at the scale of the BCR. This approach recognizes that some species may be declining dramatically at the local scale even though they are not of high concern nationally. TAPR is within the Osage Plains physiographic area and the conservation plan for this area was also reviewed to identify those bird species that are of conservation priority within the local area (Fitzgerald et al 2000).

4.13.3. Reference Conditions

Little historic survey data exists for Tallgrass Prairie National Preserve. Comprehensive bird surveys using a statistically rigorous sample design were implemented in 2001 (Peitz et al. 2011). Bird reference condition for both the grassland and woodland sample sites is based on the initial HTLN 2001 bird survey results. Maintaining or exceeding the level of biodiversity as defined by initial calculation of native species richness (as an index of diversity) and the initial quality of bird community composition as defined by the initial IBI score are considered good condition. A condition rating framework for birds is shown in Table 4.13-2.

The grassland bird IBI score reflects a disturbance gradient from relatively intact and extensive grassland with high IBI scores to more disturbed, developed or urban grassland with low IBI scores. Threshold levels for bird IBI scores have not been rigorously defined, but O'Connell et al. (2000) established thresholds that include four categories of condition corresponding to the proportional species richness of each specialist guild and generalist guild. For the grassland bird IBI score at TAPR these thresholds include the following categories: 1) excellent (highest integrity) – score of 34.1–44.0; 2) good (high integrity) – score of 29.1–34.0; 3) fair (medium integrity) – score of 22.1–29.0; and 4) poor (low-integrity rural and low-integrity urban) – score of 10.0–22.0. For the woodland bird IBI the values and ranges for these corresponding four categories were: 1) 67.1–86.0, 2) 58.1–67.0, 3) 45.1–58.0, and 4) 23.5–45.0. The condition classes were modified to determine the resource condition indicator scoring for the TAPR bird IBI (Table 4.13-2) using a three-tiered rating system.

Table 4.13-2. Resource condition rating framework for birds at Tallgrass Prairie National Preserve, Kansas.

Community	Indicator	Resource is in Good Condition	Warrants Moderate Concern	Warrants Significant Concern
Grassland Birds	Native Species Richness (S)	>85–100+ % of 2001 value	70–85% of 2001 value	<70% of 2001 value
	Index of Biotic Integrity	29.1–44.0	22.1–29.0	10.0–22.0
	Bird Species of Conservation Concern	85–100+ % of 2001 value	70–85% of 2001 value	<70% of 2001 value
Woodland Birds	Native Species Richness (S)	>85–100+ % of 2001 value	70–85% of 2001 value	<70% of 2001 value
	Index of Biotic Integrity	58.1–86	45.1–58.0	23.5–45.0
	Bird Species of Conservation Concern	85–100+ % of 2001 value	70–85% of 2001 value	<70% of 2001 value

We also compared the candidate list of species of concern to the actually list of species observed at TAPR during the 2012 survey. We used the number of species of concern recorded in the initial survey year of 2001 as the reference condition for comparison. The condition of the resource is considered higher if more species of concern are observed. This implies that the populations of those species are increasing and/or they are using the preserve more.

4.13.4. Condition and Trend

Grassland Birds

Species Richness

A total of 33 native species were recorded at grassland sampling stations in 2012. The most common species was the dickcissel (*Spiza americana*). The eastern meadowlark (*Sturnella magna*), upland sandpiper (*Bartramia longicauda*), brown-headed cowbird (*Molothrus ater*) and red-winged blackbird (*Agelaius phoeniceus*) were all moderately common (Table 4.13-3). The number of native species observed in 2012 (33) is similar to the 34 species recorded in 2001.

Table 4.13-3. Bird species recorded in 2012 and 2001 at prairie survey stations on Tallgrass Prairie National Preserve.

Common Name	Species Name	AOU Code	Number Observed 2012	Number Observed 2001
American crow	*Corvus brachyrhynchos*	AMCR	10	0
Bank swallow	*Carpodacus mexicanus*	BANS	5	2
Barn swallow	*Hirundo rustica*	BARS	33	22
Bell's vireo[A]	***Vireo bellii***	**BEVI**	**2**	**0**
Blue-gray gnatcatcher	*Polioptila caerulea*	BGGN	0	6
Blue jay	*Cyanocitta cristata*	BLJA	0	1
Blue-winged teal	*Anas discors*	BWTE	1	0
Brown thrasher[B]	*Toxostoma rufum*	BRTH	13	15
Brown-headed cowbird	*Molothrus ater*	BHCO	105	224
Canada goose	*Branta canadensis*	CAGO	4	0
Cattle egret	*Bubulcus ibis*	CAEG	0	7
Cliff Swallow	*Petrochelidon* pyrrhonota	CLSW	0	35
Common grackle	*Picoides pubescens*	COGR	22	5
Common nighthawk	*Buteo jamaicensis*	CONI	39	54
Dickcissel[A]	***Spiza americana***	**DICK**	**428**	**283**
Eastern bluebird	*Sialia sialis*	EABL	7	6
Eastern kingbird	*Archilochus colubris*	EAKI	6	6
Eastern meadowlark[B]	*Sturnella magna*	EAME	291	130
Grasshopper sparrow[A]	***Ammodramus savannarum***	**GRSP**	**49**	**406**
Great blue heron	*Ardea herodias*	GBHE	8	4
Greater prairie-chicken[A]	***Tympanuchus cupido***	**GPCH**	**20**	**4**
Great-tailed grackle	*Quiscalus mexicanus*	GTGR	0	4
Green (Green-backed) heron	*Butorides virescens*	GRHE	8	0
Hairy woodpecker	*Picoides villosus*	HAWO	0	5
Henslow's sparrow[A]	***Ammodramus henslowii***	**HESP**	**11**	**0**
Horned lark	*Eremophila alpestris*	HOLA	0	10
Killdeer	*Charadrius vociferus*	KILL	16	34
Lark sparrow[B]	*Chondestes grammacus*	LASP	**0**	**5**
Mourning dove	*Zenaida macroura*	MODO	41	46
Northern (Yellow-shafted) flicker	*Colaptes auratus*	YSFL	13	0
Northern bobwhite[B]	*Colinus virginianus*	NOBO	82	0
Northern cardinal	*Parus bicolor*	NOCA	11	0

[A] Species that Partners in Flight considered of continental importance (also in bold).

[B] Partners in Flight Priority Species for Physiographic Area 33: The Osage Plains (also highlighted in gray).

Table 4.13-3 (continued). Bird species recorded in 2012 and 2001 at prairie survey stations on Tallgrass Prairie National Preserve.

Common Name	Species Name	AOU Code	Number Observed 2012	Number Observed 2001
Northern rough-winged swallow	*Stelgidopteryx serripennis*	NRWS	0	5
Orchard oriole[B]	*Icterus spurius*	OROR	9	7
Red-bellied woodpecker[A]	***Melanerpes carolinus***	**RBWO**	**3**	**4**
Red-tailed hawk	*Chordeiles minor*	RTHA	36	0
Red-winged blackbird	*Agelaius phoeniceus*	RWBL	108	117
(Eastern) Rufous-sided towhee	*Pipilo erythrophthalmus*	EATO	2	0
Sedge wren	*Cistothorus platensis*	SEWR	0	3
(Eastern) Tufted titmouse	*Parus bicolor*	ETTI	3	0
Turkey vulture	*Thryothorus ludovicianus*	TUVU	26	5
Upland sandpiper[B]	*Bartramia longicauda*	UPSA	119	161
Warbling vireo	*Vireo gilvus*	WAVI	9	0
Western kingbird	*Tyrannus verticalis*	WEKI	0	14
Western meadowlark	*Sturnella neglecta*	WEME	124	0
Yellow warbler	*Setophaga petechia*	YWAR	0	2
White-breasted nuthatch	*Sitta carolinensis*	WBNU	18	0

[A] Species that Partners in Flight considered of continental importance (also in bold).

[B] Partners in Flight Priority Species for Physiographic Area 33: The Osage Plains (also highlighted in gray).

The slope of the linear regression line for mean native grassland bird species richness per sample site was negative, but insignificant ($r^2 = 0.27$, $p = 0.10$), suggesting an unchanging trend in the richness of native grassland bird species richness at TAPR. The 90 percent confidence intervals for the years 2001 to 2012 also suggest stability in native species richness since 2001 (Figure 4.13-2). In 2012, an average of 5.0 native grassland bird species per sample site were recorded at TAPR, greater than the management target of 85 percent of 2.8, the mean number of native species recorded in 2001 when monitoring was initiated.

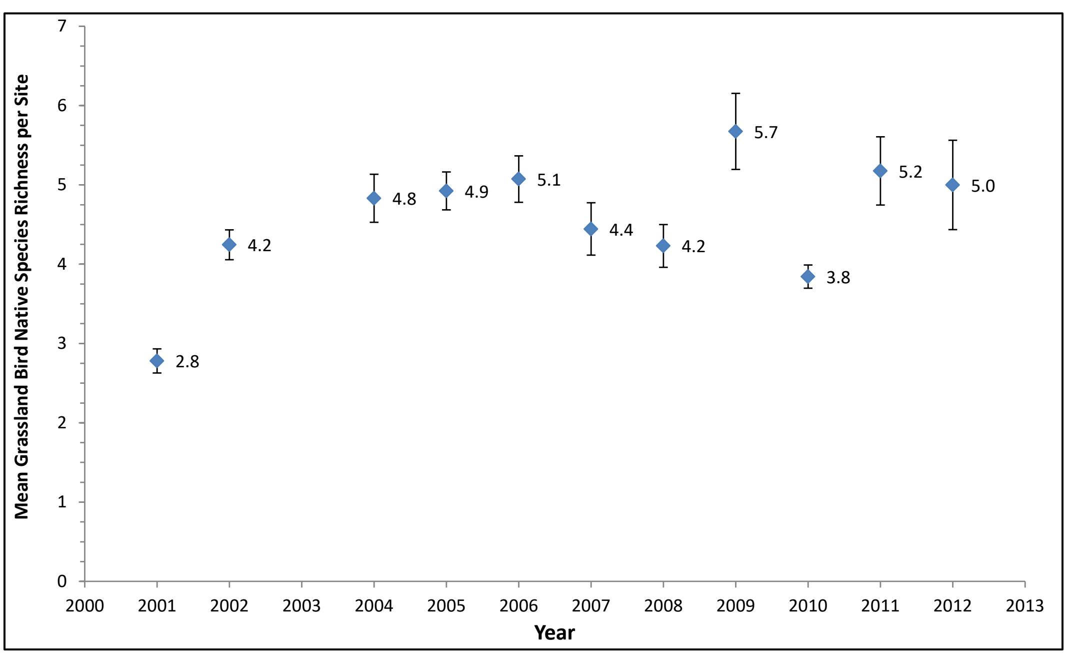


Figure 4.13-2. Means and 90 percent confidence intervals for native grassland bird species richness per sample site at Tallgrass Prairie National Preserve from 2001 to 2012.

Index of Biotic Integrity

The mean grassland bird IBI score per sample site in 2012 was 35.4, less than the 2001 score of 36.8 and a score indicating that composition of the bird community at TAPR is of high integrity (Table 4.13-2). The slope of the linear regression line for the grassland bird IBI scores was negative and insignificant ($r^2 = 0.49$, $p = 0.02$), indicating a decrease the biotic integrity of the bird community between 2001 and 2012. However, there is great overlap in the 90 percent confidence intervals for the scores, suggesting the biotic integrity of the bird community has remained stable since 2001 (Figure 4.13-3).). In 2012, the grassland IBI score of 35.4 indicates the grassland bird community is in good condition (Table 4.13-2).

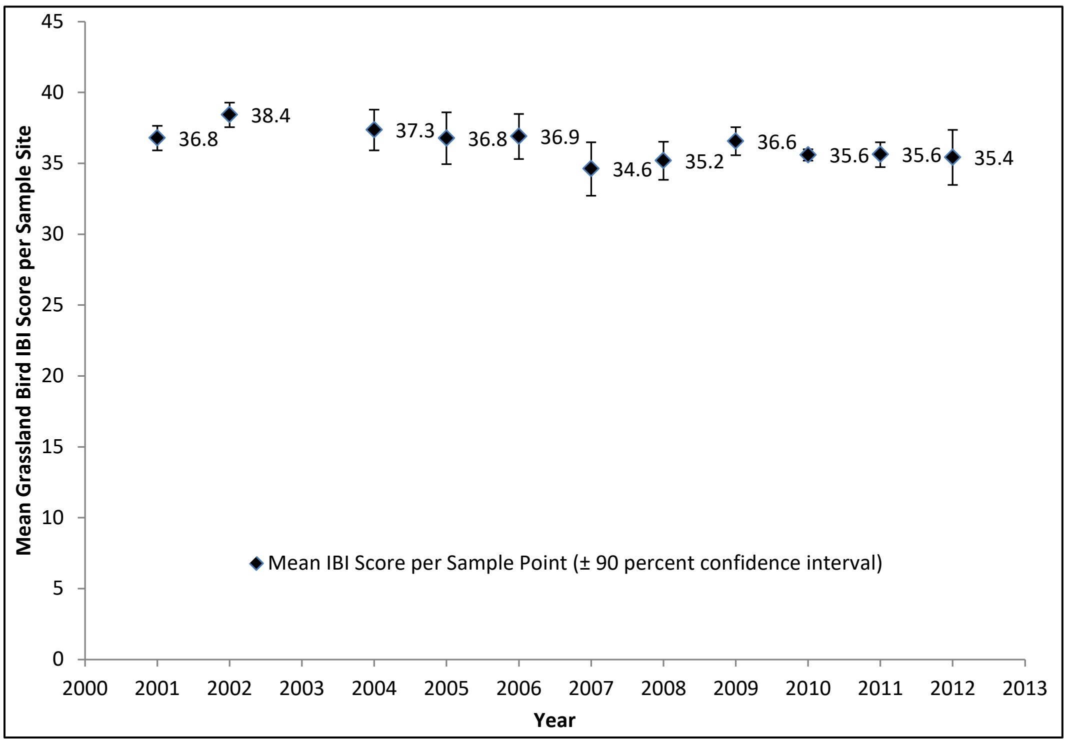


Figure 4.13-3. Means and 90 percent confidence intervals for grassland bird species IBI score per sample site at Tallgrass Prairie National Preserve from 2001 to 2012.

Species of Concern

Eleven species found at TAPR during the 2012 grassland bird survey are listed as Partners in Flight birds of concern (Rich et al. 2004, Fitzgerald et al. 2000), which is two more than the 9 species of concerned reported in 2001 (Table 4.13-3). In 2012, six grassland obligate species were recorded at TAPR including the dickcissel, eastern meadowlark, grasshopper sparrow, greater prairie-chicken, Henslow's sparrow and upland sandpiper. Five grassland obligate species recorded in 2001 with only the western meadowlark missing from the 2012 survey. The most common species of concern recorded and their habitat at TAPR in 2012 were the dickcissel (tallgrass prairie or weedy fields), eastern meadowlark (tallgrass prairie with a moderate forb component), northern bobwhite (grasslands with more moderate shrub cover) and upland sandpiper (short, uniform grass cover). Noticeably declining in number in 2012, compared to the 2001 survey, is the grasshopper sparrow (Table 4.13-3).

The slope of the linear regression line for the mean number of grassland bird species of concern per sample site was positive and insignificant ($r^2 = 0.71$, $p = 0.001$), suggesting an increasing trend in the number of bird species of concern present at TAPR. The 90 percent confidence intervals for the mean number of species of concern per sample site also suggests their numbers have increased since 2001 (Figure 4.13-4). In 2012, the mean number of bird species of concern per sample site at TAPR was 3.1, greater than the management target of 85 percent of 1.6, the number recorded in 2001.

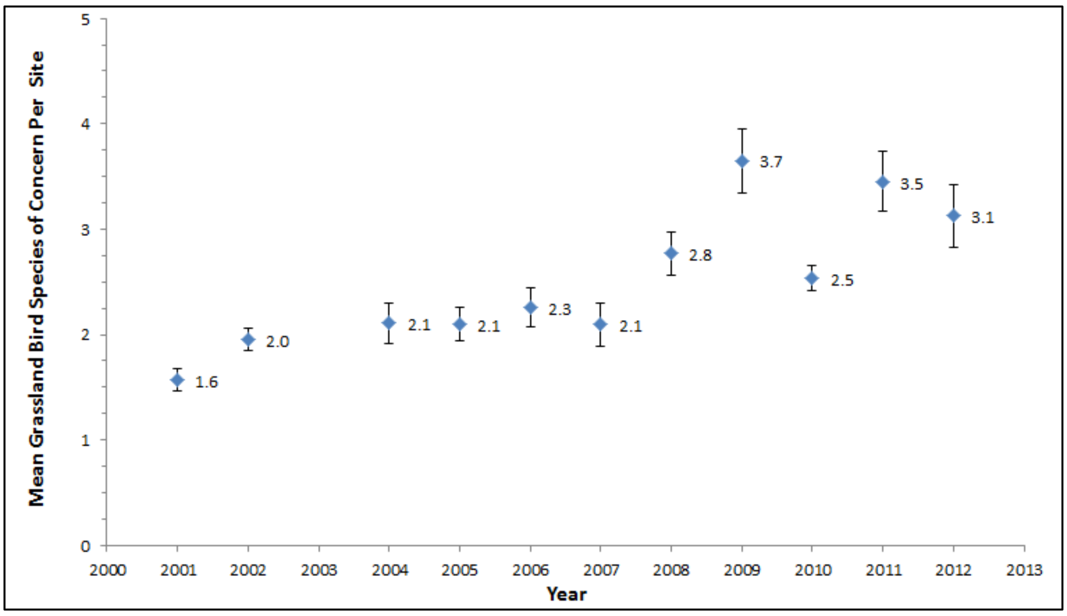


Figure 4.13-4. Means and 90 percent confidence intervals for the number of grassland bird species of concern per sample site at Tallgrass Prairie National Preserve from 2001 to 2012.

Woodland Birds

Species Richness

There were 39 native species and 40 species in total recorded at woodland sampling stations in 2012. The most common species was the red-bellied woodpecker (*Melanerpes carolinus*). The dickcissel (*Spiza americana*), tufted titmouse (*Parus bicolor*), eastern wood-pewee (*Contopus virens*), Carolina wren (*Thryothorus ludovicianus*) and white-breasted nuthatch (*Sitta carolinensis*) were all moderately common (Table 4.13-4). The 39 native species observed in 2012 was greater than the 26 recorded during the 2001 survey (Table 4.13-4).

Table 4.13-4. Bird species recorded in 2012 and 2001 at woodland survey stations on Tallgrass Prairie National Preserve.

Common Name	Species Name	AOU Code	Number Observed 2012	Number Observed 2001
(Eastern) Tufted titmouse	*Parus bicolor*	ETTI	45	3
Acadian flycatcher	*Empidonax virescens*	ACFL	12	0
American crow	*Corvus brachyrhynchos*	AMCR	16	2
American goldfinch	*Carduelis tristis*	AMGO	18	14
Barn swallow	*Hirundo rustica*	BARS	9	0
Barred owl	*Strix varia*	BDOW	2	3
Bell's vireo[A]	***Vireo bellii***	**BEVI**	**5**	**0**
Belted kingfisher	*Megaceryle alcyon*	BEKI	0	3
Bewick's wren	*Thryomanes bewickii*	BEWR	0	4
Black-billed cuckoo	*Coccyzus erythropthalmus*	BBCU	0	1
Black-capped chickadee	*Poecile atricapillus*	BCCH	24	2
Blue grosbeak	*Passerina caerulea*	BLGR	1	0
Blue jay	*Cyanocitta cristata*	BLJA	31	5
Blue-gray gnatcatcher	*Polioptila caerulea*	BGGN	30	2
Brown thrasher[A]	***Toxostoma rufum***	**BRTH**	**0**	**1**
Brown-headed cowbird	*Molothrus ater*	BHCO	10	1
Carolina wren	*Thryothorus ludovicianus*	CARW	41	10
Dickcissel[A]	***Spiza americana***	**DICK**	**50**	**0**
Downy woodpecker	*Picoides pubescens*	DOWO	22	5
Eastern bluebird	*Sialia sialis*	EABL	8	0
Eastern wood-pewee[B]	*Contopus virens*	EAWP	43	10

[A] Species that Partners in Flight considered of continental importance (also in bold).

[B] Partners in Flight Priority Species for Physiographic Area 33: The Osage Plains (also highlighted in gray).

Table 4.13-4 (continued). Bird species recorded in 2012 and 2001 at woodland survey stations on Tallgrass Prairie National Preserve.

Common Name	Species Name	AOU Code	Number Observed 2012	Number Observed 2001
Grasshopper sparrow[A]	***Ammodramus savannarum***	**GRSP**	**8**	**0**
Gray catbird	*Dumetella carolinensis*	GRCA	0	1
Great crested flycatcher	*Myiarchus crinitus*	GCFL	17	15
House finch	*Haemorhous mexicanus*	HOFI	5	0
House wren	*Troglodytes aedon*	HOWR	10	0
Indigo bunting[A]	***Passerina cyanea***	**INBU**	**18**	**1**
Kentucky warbler[A]	***Geothlypis formosa***	**KEWA**	**11**	**0**
Mourning dove	*Zenaida macroura*	MODO	32	0
Northern (Baltimore) oriole[B]	*Icterus galbula*	BAOR	5	0
Northern (Yellow-shafted) flicker	*Colaptes auratus*	YSFL	25	0
Northern cardinal	*Parus bicolor*	NOCA	37	8
Northern parula	*Setophaga americana*	NOPA	8	0
Orchard oriole[B]	*Icterus spurius*	OROR	0	3
Prothonotary warbler[A]	***Protonotaria citrea***	**PROW**	**0**	**9**
Red-bellied woodpecker[A]	***Melanerpes carolinus***	**RBWO**	**59**	**6**
Red-eyed vireo	*Vireo olivaceus*	REVI	17	0
Red-tailed hawk	*Chordeiles minor*	RTHA	3	0
Ruby-throated hummingbird	*Archilochus colubris*	RTHU	6	0
Summer tanager	*Piranga rubra*	SUTA	4	0
Turkey vulture	*Thryothorus ludovicianus*	TUVU	15	0
Warbling vireo	*Vireo gilvus*	WAVI	4	0
Western kingbird	*Tyrannus verticalis*	WEKI	5	0
White-breasted nuthatch	*Sitta carolinensis*	WBNU	40	0
White-eyed vireo[A]	***Vireo griseus***	**WEVI**	**0**	**9**
Wild turkey	*Meleagris gallopavo*	WITU	12	0
Yellow warbler	*Setophaga petechia*	YWAR	18	12
Yellow-billed cuckoo[B]	*Coccyzus americanus*	YBCU	6	5
Yellow-throated vireo[A]	***Vireo flavifrons***	**YTVI**	**0**	**2**

[A] Species that Partners in Flight considered of continental importance (also in bold).

[B] Partners in Flight Priority Species for Physiographic Area 33: The Osage Plains (also highlighted in gray).

The slope of the linear regression line for mean native woodland bird species richness per sample site was positive and moderately statistically significant ($r^2 = 0.33$, $p = 0.06$) suggesting an increasing trend in the richness of the woodland bird community at TAPR. The 90 percent confidence intervals for mean native species richness per sample site for the years 2001 to 2012, indicate an increasing trend in woodland bird native species richness towards the end of the sample period after 2008 (Figure 4.13-5). In 2012, there were 39 native woodland bird species recorded at TAPR, greater than 26, the number recorded in 2001 when monitoring was initiated at TAPR.

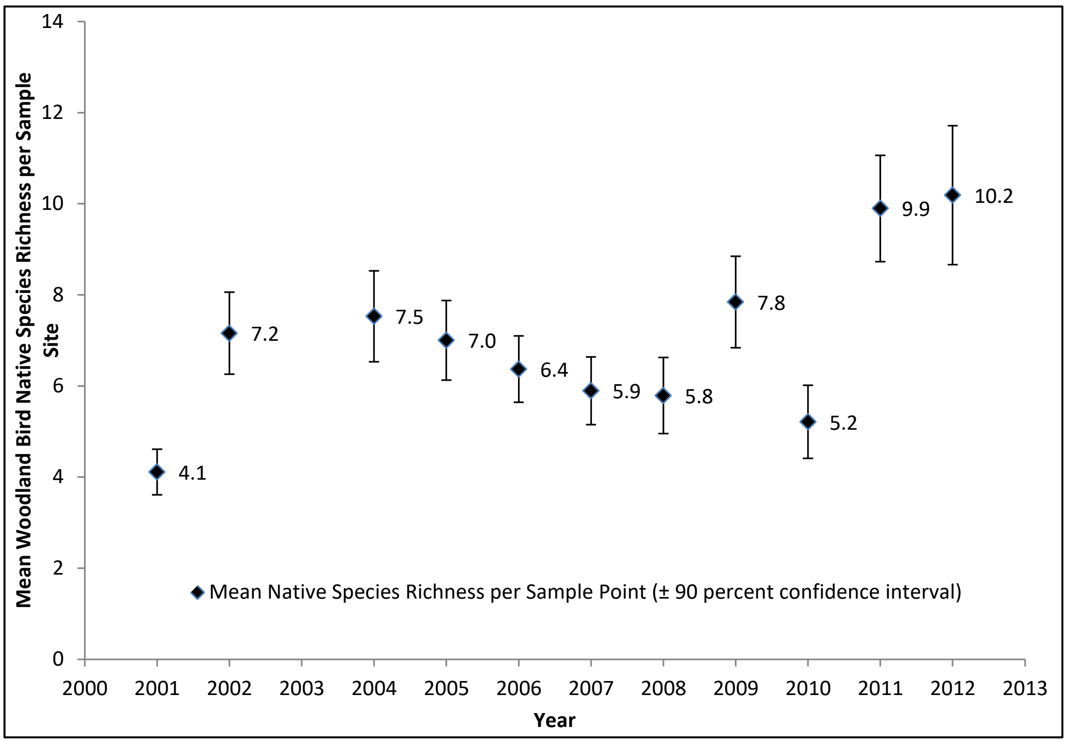


Figure 4.13-5. Mean native woodland bird species richness per sample site at Tallgrass Prairie National Preserve from 2001 to 2012 with 90 percent confidence intervals.

Index of Biotic Integrity

The mean woodland bird IBI score in 2012 of 52, although higher than the 2001 score of 48, indicates that composition of the riparian woodland bird community at TAPR is of moderate integrity (Table 4.13-2). The slope of the linear regression line for the grassland bird IBI scores is flat, suggesting an unchanging trend in the IBI scores at TAPR. Additionally, the 90 percent confidence intervals for the scores overlap, also suggesting the scores have remained stable since 2001 (Figure 4.13-6).

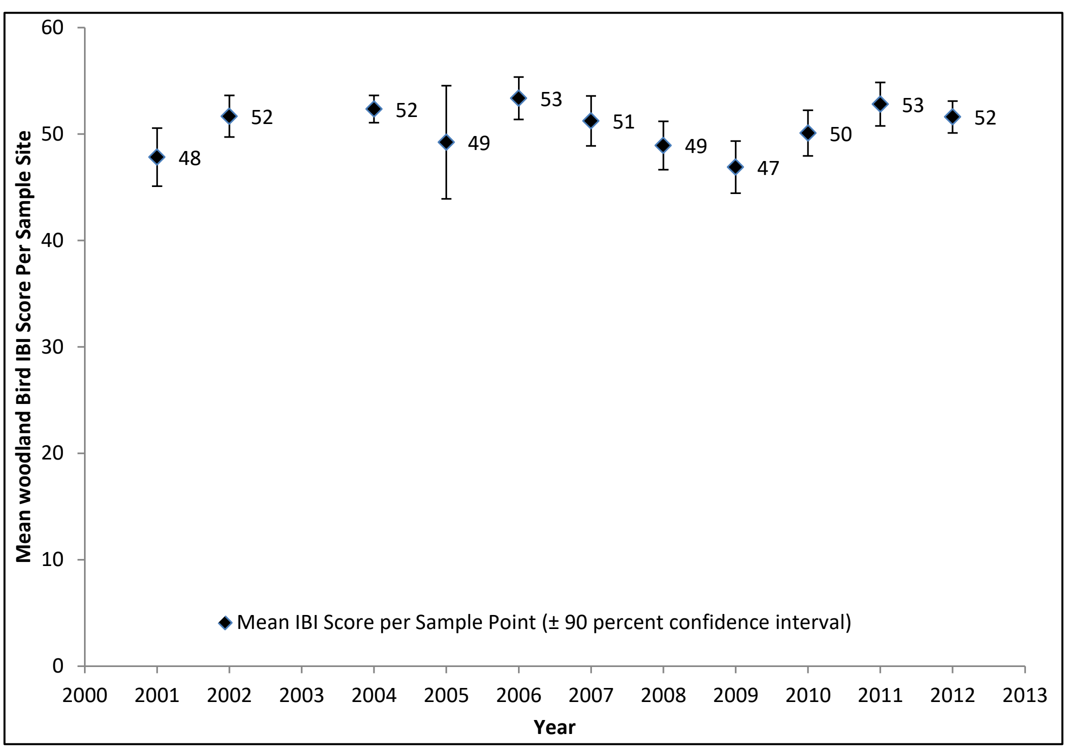


Figure 4.13-6. Means and 90 percent confidence intervals for woodland bird species IBI score per sample site at Tallgrass Prairie National Preserve from 2001 to 2012.

Species of Concern

Ten species found at TAPR during the 2012 riparian woodland bird survey are listed as Partners in Flight birds of concern (Rich et al. 2004, Fitzgerald et al. 1998). This is greater than the eight species of concern recorded in 2001 at TAPR, the initial year of monitoring (Table 4.13-4). No riparian obligate species were observed at TAPR in 2012, but the belted kingfisher (*Megaceryle alcyon*), mallard (*Anas platyrhynchos*) and red-winged blackbird (*Agelaius phoeniceus*) were recorded in

2009. The most common species of concern recorded in 2012 were the red-bellied woodpecker (*Melanerpes carolinus*) (bottomland and flood plain hardwood forests) and dickcissel (tallgrass prairie or weedy fields). Noticeably declining in number in 2012, compared to the 2001 survey, is the grasshopper sparrow (Table 4.13-4).

The slope of the linear regression line for woodland bird species of concern was positive, but insignificant ($r^2 = 0.23$, $p > 0.05$) suggesting an unchanging trend in the number of woodland bird species of concern. There also is considerable overlap in the 90 percent confidence intervals for the years 2001 to 2012, also indicating an unchanging trend in woodland bird species of concern (Figure 4.13-7). In 2012, there were nine woodland bird species of concern recorded at TAPR, greater than the management target of 85 percent of nine, the number recorded in 2001.

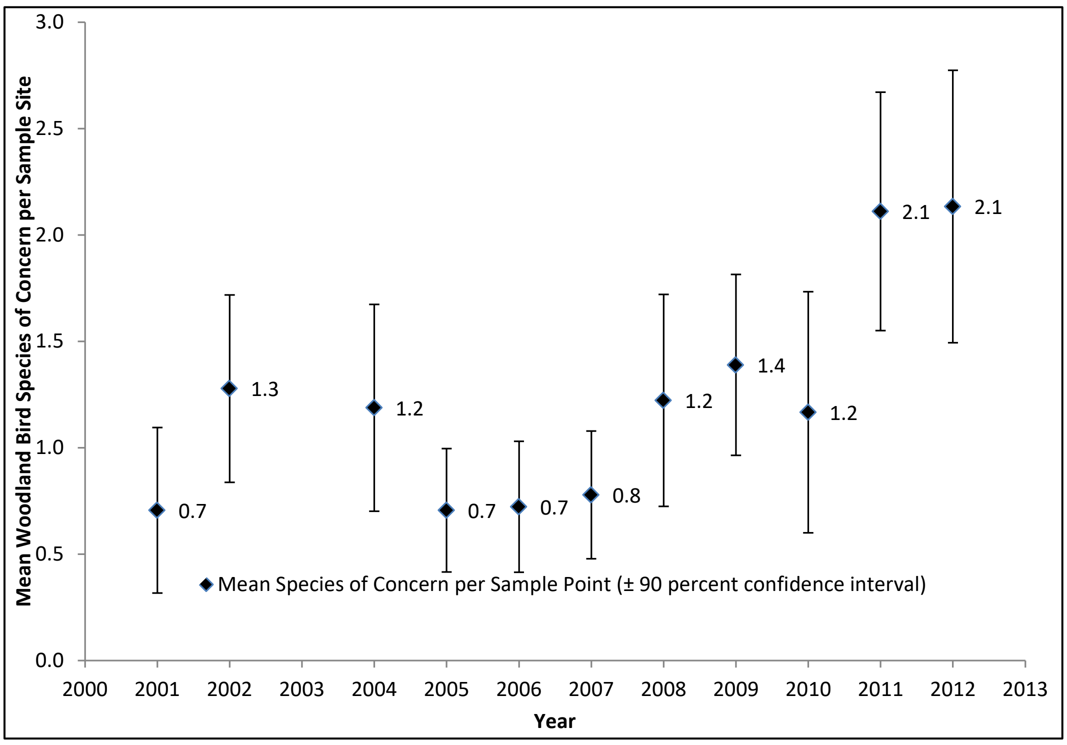
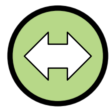
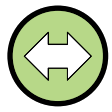
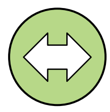
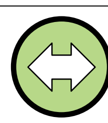
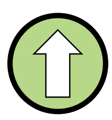
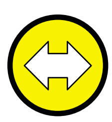
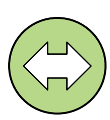
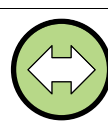
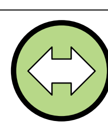


Figure 4.13-7. Mean grassland bird species of concern per sample site at Tallgrass Prairie National Preserve from 2001 to 2012 with 90 percent confidence intervals.

Overall Condition and Trend

The values for the metrics of native species richness, the bird IBI, and the number of species of concern present in 2012 indicate that the TAPR grassland and woodland bird communities are in good condition, with a number of obligate grassland birds and a community structure that is representative of a moderately disturbed landscape (Table 4.13-5). The woodland IBI value warranted moderate concern. The values for these metrics calculated for the years 2001 to 2012 suggest an unchanging trend in bird community diversity and structure at TAPR.

Table 4.13-5. Condition and trend summary for birds at Tallgrass Prairie National Preserve.

Community	**Indicator**	**Condition Status/Trend**	**Rationale**
Grassland Birds	Native Species Richness (S)		Native grassland bird species richness has fluctuated between 30 and 52 species from 2001 to 2012 with richness equaling 33 in 2012, greater than the management target of 85 percent of 33. Analysis of the grassland bird monitoring data indicates an unchanging trend in native species richness between 2001 and 2012.
	Bird Index of Biotic Integrity		In 2012, the grassland bird IBI score was 36.5 (good condition). Analysis of the grassland bird IBI scores between 2001 and 2012 indicates an unchanging trend in the biotic integrity of the bird community between 2001 and 2012.
	Species of Conservation Concern		The number of bird species of concern fluctuated between 8 and 15 species between 2001 and 2012 with 11 species of concern present in 2012, greater than the management target of 85 percent of 8. Analysis of the grassland bird monitoring data indicates an unchanging trend in the number of bird species of concern present between 2001 and 2012.
	Overall Condition		–
Woodland Birds	Native Species Richness (S)		Native woodland bird species richness has fluctuated between 26 and 46 species from 2001 to 2012 with richness equaling 40 in 2012, greater than the management target of 85 percent of 26. Analysis of the woodland bird monitoring data indicates an increasing trend in native species richness between 2001 and 2012.
	Bird Index of Biotic Integrity		In 2012, the woodland bird IBI score was 50 (warrants moderate concern). Analysis of the woodland bird IBI scores indicates an unchanging trend in the biotic integrity of the bird community between 2001 and 2012
	Species of Conservation Concern		The number of woodland bird species of concern fluctuated between 5 and 14 species from 2001 to 2012 with 9 species of concern present in 2012, greater than the management target of 85 percent of 9. Analysis of the woodland bird monitoring data indicates an unchanging trend in the number of bird species of concern present between 2001 and 2012.
	Overall Condition		–
Birds Overall			**Condition is good with an unchanging trend. Confidence in the assessment is high.**

4.13.5. Uncertainty and Data Gaps

Confidence in this assessment was high as is the confidence in the trend analyses. Eleven surveys provide ample data upon which to assess condition and recent trends. A factor potentially affecting the quality of the data is the probability that a bird that is present during the time the point count is occurring is detected. The protocols used for monitoring birds in the HTLN rely on a 5-minute count interval. Extending the interval to 10 minutes would improve the probability of detecting a species. Nonetheless, because points are surveyed only once per year, there is always the chance that rare or less vocal species will go undetected. This can be a problem when calculating the index of biotic integrity, which is calculated based on the number of species within different guilds.

Data on the abundance of migratory and wintering birds at TAPR was sparse or completely lacking and investigation of bird populations during these periods is an important need.

4.13.6. Sources of Expertise

- David Peitz, a wildlife biologist at the Heartland I&M Network is responsible for collecting the monitoring data at TAPR upon which this assessment is based and also for leading the design of the protocol used to monitor birds at parks of the HTLN (Peitz et al. 2008).

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4.14. Bison

"[The NPS] supports the collective vision of a future in which great herds of bison roam across vast expanses, without detecting agency boundaries. Accomplishing this will take better cooperation on public lands and strong partnerships with private land owners. The National Park Service will continue to support restoration of bison as a keystone species in North American ecosystems and also as an important part of the heritage of North American cultures. Our part is to ensure that bison have not just survived, but remain an authentic part of the American heritage."[2]

4.14.1. Background and Importance

Prior to the late 1700s, North American plains bison (Bison bison) populations in the Great Plains are estimated between 25 and 40 million animals (Flores 1991, Shaw 1995). Bison's original range spanned more than two billion acres and included over twenty distinct ecosystems. Commercial and subsistence hunting, competition with livestock, killing of bison as government policy to subjugate American Indian tribes, and other causes led to the precipitous decline of both plains and wood bison. By the late 1800s, only a few hundred bison survived in various small captive and wild herds across North America. It is estimated that bison currently occupy less than 1% of their original North American range (Sanderson et al. 2007). Bison were gone from the Flint Hills area by the early 1870s; the last reported sightings in the state were in 1898 (Choate 1987).

Restoration of the bison (Figue 4.14-1) is a National Park Service and Department of Interior priority, and an explicit action (#26) in the NPS Director's Call to Action (NPS 2011). NPS Management Policies (NPS 2006) directs bison conservation management to integrate evolved ecological scales and processes, internal and external partnerships, genetics, population dynamics, and restoration. Bison conservation, management and threats have been examined in an integrated manner by national and international scientists, managers and organizations in recent years (Dratch and Gogan 2010, Gates et al. 2010, Gross et al. 2006, Lammers et al. 2013, Redford and Fearn 2007, Sanderson et al. 2008). From an ecosystem management perspective, bison can contribute significantly to the ecological integrity and ecosystem functioning of grasslands at TAPR (Table 4.14-1). From a global conservation perspective, bison at TAPR can contribute directly to the goal of restoring wild bison. Redundancy of genetically unique populations is a key element of conservation in the traditional sense, and especially when disease and other potential catastrophes pose real dangers (pers. comm. John Gross, Nov 2013). For this reason the NPS creates and manages satellite or sub-populations (i.e., comprising larger metapopulations[3]) of bison to promote bison conservation goals and minimize risk to individual populations.

2 Remark by Michael Soukup, then Associate Director for Natural Resources Science and Stewardship, USDI National Park Service at an international bison management meeting (Redford and Fearn 2007).

3 A metapopulation is a population that consists of several discrete subpopulations linked together by immigration and emigration. Dispersal is a key component that acts as a bridge between subpopulations at the metapopulation scale to provide immigrants to otherwise isolated habitat patches (Merriam and Wegner 1992).

Figure 4.14-1. Grazing bison in Windmill Pasture. (CSU photo).

Table 4.14-1. Ecosystem processes that bison can strongly influence (from Gates et al. 2010—see Hobbs (1996), Knapp et al. (1999), Larter and Allaire (2007) and Truett et al. (2001)).

Ecological Process	Description
Create patches	Grazing can produce a dynamic mosaic of vegetation patches that differ in seral stage and that differ due to variations in grazing intensity.
Enhance nutrient cycling rates	Bison grazing can enhance nutrient turnover and change dominant system mode from detritus-decomposition to consumption-defecation.
Enhance habitat quality	Bison grazing can increase habitat suitability for prairie dogs, pronghorn and other species.
Modify fire regime	Bison consume fine fuels and create trails and trampled areas that reduce fire intensity and extent, and modify the effect of fire on vegetation heterogeneity.
Create disturbances	Trampling and wallows create seedbeds for some species; localized tree stands that are not tightly clumped are susceptible to major damage by rubbing, horning and thrashing by bison.
Stimulate primary production	Bison grazing removes senescent material from grasslands and increases light penetration, nutrient availability, and growth.
Disperse plant seeds	Bison transport seeds in fur and gut, and may enhance establishment of (native and exotic) plants via consumption, seed coat digestion, and defecation in nutrient rich media.
Maintain floral diversity	Bison grazing can result in greater grass and forb species diversity.
Support carnivores and scavengers	Bison are prey to some large carnivores, and bison carcasses can contribute to supporting scavengers.

The NatureServe global and U.S. national conservation status for bison is *Apparently Secure* (G4/N4), which is defined as a fairly low risk of extinction or elimination due to an extensive range and/or many populations or occurrences, but with possible cause for some concern as a result of local recent declines, threats, or other factors. The International Union for Conservation of Nature has red listed the American bison as *near threatened* (Gates and Aune 2008). The species is considered extirpated in Kansas, and occurs as wild, free-ranging populations in only small fragments of the once vast range in North America, namely in and around Yellowstone National Park and on five smaller Department of Interior properties (Department of Interior 2014). Despite the high numbers of bison in North America, commercial production does not provide for conservation of the bison as wildlife in the sense used for Red List designation (Gates and Aune 2008). The vast majority of the current population of over 400,000 bison is reintroduced and confined on both public and private lands, with approximately 95% of the animals managed as domestic livestock (Boyd 2003, Gates and Ellison 2010). The number of bison in conservation herds has totaled about 20,000 since 1930

(Freese et al. 2007). Approximately 10,000 bison are currently managed on Department of Interior lands (Department of the Interior 2014).

Establishment of the TAPR Herd

Between 1913 and 1916, a founding herd was established at the Wind Cave Game Reserve located on present-day Wind Cave National Park and adjacent U.S. Forest Service land. The Wind Cave herd included fourteen bison received as a gift from the New York Zoological Society (Bronx Zoo herd was established in 1899) through the American Bison Society in 1913 and six bison received from Yellowstone National Park in 1916 (Muenchau 2002, Dratch and Gogan 2010). The history of the Wind Cave herd is described in Dratch and Gogan (2010), and includes various events and cycles of sale, culling, baiting of bison into Custer State Park, changes in park size, changes in herd size, brucellosis and control measures. Due to positive brucellosis testing, 50% of the herd was shot in 1964 and the fully fenced park was placed under quarantine by South Dakota from 1982–1986. Testing in the park has revealed no positive brucellosis reactors since1985. Between 1987 and 2007, over 1,500 live bison from the Wind Cave herd were distributed to various Native American tribes, non-profit organizations and state and federal agencies (Dratch and Gogan 2010).

In 2000, TAPR completed a *General Management Plan and Environmental Impact Statement* (GMP) (NPS 2000) that called for reintroducing bison to the preserve, but did not include a detailed strategy for the reintroduction. A *Bison Management Plan and Environmental Assessment* (NPS 2009) developed in partnership with The Nature Conservancy (TNC) evaluated several alternatives for reintroducing and managing bison at the preserve. The no-action/preferred alternative selected and implemented at the preserve reintroduced bison to the 1,074-acre Windmill Pasture year round. Maximum carrying capacity was estimated at approximately 100 animals, with 73 animal unit equivalents (AUE)[4] as the average herd size. The initial herd consisted of 13 bison from Wind Cave National Park delivered to TAPR in 2009. The animals were disease-free and had no evidence of cattle gene introgression.

While there are local ecological restoration benefits of having a bison herd at TAPR, they are somewhat limited due to the small size and managed nature of the herd and the administrative limits placed on the acreage they may occupy on the preserve. Wide-scale bison conservation necessarily entails innovative partnerships with both traditional and non-traditional partners to allow bison to range across multiple jurisdictions at larger landscape scales (Dratch and Gogan 2010). Nonetheless, bison at TAPR can contribute to prairie and ecosystem restoration goals within the portion of the preserve that they occupy, are an important icon for the preserve and the NPS, and a major draw for preserve visitation. In the long term and as the TAPR bison herd grows, there may be opportunities to expand the role of bison in restoration and conservation of ecological resources within the preserve and through partnerships with others in the Flint Hills ecoregion. Additional objectives of TAPR satellite herd management are to support the population and genetic objectives of Wind Cave National Park bison herd management and DOI bison objectives.

Goals for species conservation and recovery are tightly linked to objectives for: 1) herd health and genetics, and 2) population size and demographics (Gates et al. 2010, Department of the Interior 2014). If the objectives for herd health/genetics and population size/demographics at TAPR are met, then a contribution is being made toward conserving the species rangewide. At TAPR, a sub-objective of bison conservation is to establish a model TNC-NPS partnership herd, which may include the potential to generate revenue.

Threats and Stressors

Existing rangewide threats include habitat loss, genetic manipulation of commercial bison for market traits, small population effects in most conservation herds, limited ranges and population sizes, cattle gene introgression, loss of genetic non-exchangeability through hybridization between bison subspecies, and the threat of depopulation as a management response to infection of some wild populations hosting reportable cattle diseases (Boyd and Gates 2006, Gates and Aune 2008). An additional threat to populations of this species is culling to prevent the spread of bovine tuberculosis

4 A 1,000 lb. cow is the standard measurement of an animal unit.

and brucellosis (Gates and Aune 2008). While short-term effects of climate variability are likely to depend on the magnitude and timing of precipitation during the year. A recent study found the possibility that bison could be negatively affected by sustained hotter, drier conditions affecting forage quality. The effects of future climate change on grazers will be a mix of short-term and long-term responses of grasslands, with longer-term consequences depending on the rates of climate change and rates at which climate change feeds back to factors such as forage quality (Craine 2013).

At TAPR, the primary threats to the resource include risks associated with a relatively small herd size, lack of some natural selection pressures and predators, loss of genetic diversity over time, and the potential for exposure to domestic cattle diseases.

Indicators and Measures

Indicators and measures were selected based on published information with special attention to Sanderson et al. (2008), Lammers et al. (2013), and input from Kristen Hase (TAPR) and John Gross (NPS).

- Ecosystem Stewardship and Processes
- Bison are within their historic geographic range
- Freedom of movement
- Range carrying capacity and condition
- Interaction with ecosystem processes
- Interaction with native vertebrates
- Herd Health and Genetics
- Presence of "reportable" diseases
- Disease and health management actions
- Cattle gene introgression
- Genetic diversity
- Population Size and Demographics
- Bison herd size
- Bison sex ratio, age distribution, and social units
- Visitor access to bison

4.14.2. Data and Methods

Data to support this assessment includes genetic testing results from samples analyzed by the DNA Technologies Core Laboratory at Texas A&M University. Mitochondrial DNA introgression status, nuclear microsatellite introgression status, parentage microsatellite markers, and a set of additional polymorphic markers were accessed from the 10 bison samples received on October 22, 2009 from the Tallgrass Prairie National Preserve. Data and information related to bison herd dynamics and demographics were provided by Kristen Hase. Information and professional opinion regarding other aspects of bison management and interaction with other ecosystem components and visitors were provided by TAPR TNC and NPS staffs.

4.14.3. Reference Conditions

Reference conditions for bison indicators are based on TAPR management objectives or conservation targets articulated in the TAPR *General Management Plan/EIS* (NPS 2000), the TAPR *Bison Management Plan and Environmental Assessment* (NPS 2009), published literature and the professional opinions of preserve and other NPS staffs (Table 4.14-2).

Table 4.14-2. Resource condition rating framework for bison at Tallgrass Prairie National Preserve.

Category	Indicator	Resource is in Good Condition	Condition Warrants Moderate Concern	Condition Warrants Significant Concern
Ecosystem Stewardship and Processes	geographic representation	herd location is within top 3 representations of tallgrass prairie conservation/ restoration within historic species range	herd location is within top 10 representations of tallgrass prairie conservation/ restoration within historic species range	herd location is outside historic species range
	freedom of movement	animals move freely within fenced pasture	movements are limited by some internal barriers	movements are tightly controlled within small, fenced areas
	range carrying capacity	bison grazing within prairie carrying capacity and accommodating dry periods/years; no supplemental feeding	grazing needs exceed prairie carrying capacity some years with overuse of some localities	in most areas grazing consistently exceeds carrying capacity lowering the resilience of the vegetation; some supplemental feeding
	interaction with ecosystem processes	the herd interacts year-round with all acreage available to bison (currently 1,100 ac.)	herd interacts year-round with 50–90% of the available acreage	herd interacts significantly with <50% of the available acreage
	interaction with native vertebrates	most native vertebrates are present (all native herbivores, some [bison] predators, and most bison-dependent species are present); high level of intra-specific interactions	some native vertebrates present (some native herbivores, few or no [bison] predators, and some bison-dependent species are present), some intra-specific interactions, and/or restoration efforts are underway	few or no native vertebrates; species restoration is not happening or is in planning phase
Herd Health and Genetics	presence of “reportable” diseases	no reportable diseases present	no reportable diseases that cannot be treated, including some “test and slaughter” options	presence of one or more reportable diseases that cannot be treated or that require depopulation
	disease and health management	no mineral supplements, antibiotics or vaccines used	minimal use of mineral supplements, treatment, antibiotics or vaccines	moderate to heavy use of supplements, treatment, antibiotics or vaccines
	cattle gene introgression	none or <1%	1–3%	>3%
	genetic diversity	>85% of Wind Cave herd genetic diversity ; genetic (allelic) diversity > 4.40, the average for other federal herds	75–85% of Wind Cave herd genetic diversity; genetic (allelic) diversity 4.00–4.40	<75% of Wind Cave herd genetic diversity; genetic (allelic) diversity <4.00
Herd Size and Demographics	herd size	50–100 animals and stable or increasing	consistent progress toward goal of 50–100 animals	population stagnant above or below target population range or declining
	herd demographics	all aspects of herd demographics are unmanaged or managed to match natural reference conditions	two or more aspects of herd demographics are managed to match natural reference conditions	one or fewer aspects of herd demographics are managed toward reference conditions or management inconsistent with ecological recovery
Visitor Access	visitor access	Preserve visitors have full access to the bison herd for most of the year	visitors have limited access to the bison herd for most of the year or full access for part of the year	visitors have very limited access to the bison herd most of the year

4.14.4. Condition and Trend

Condition and trend of bison was assessed by examining numerous quantitative and qualitative indicators of condition. The indicators fall into four main categories:

- Ecosystem stewardship and processes
- Herd health and genetics
- Herd size and demographics
- Visitor access

Ecosystem Stewardship and Processes

NPS conservation goals include viable populations of wild bison (Figure 4.14-2). Viability includes the capacity of the population to maintain itself without significant demographic or genetic manipulation by people for the foreseeable future (Soule 1987). Maintaining wild populations of bison subject to the evolutionary pressures under which they evolved and to which they are adapted is a crucial challenge to bison conservation (Soukup 2007). In addition to viability, bison conservation principles considered relevant for evaluating the geographic and numerical status of bison include resiliency, representation, and redundancy (Shaffer and Stein 2000). Resiliency refers to the need to preserve individual populations large enough to have a high probability of persisting for extended periods in the presence of minimal management, and which preserve genetic diversity and the potential for adaptation to changing conditions. Representation reflects the need to preserve populations of a species across the fullest array of environments in which it occurred originally. Redundancy refers to the need to preserve a sufficient number of large populations to safeguard against local catastrophes (Gates et al. 2010). These considerations are incorporated into NPS management from park to national scales.

Figure 4.14-2. Bison herd at Tallgrass Prairie National Preserve (CSU photo).

The TAPR bison herd is part of the 4% of plains bison that are managed primarily for conservation purposes in North America. The ecological role of bison, simplified using the indicators below, is diminished when significant interference between bison and their habitat and other ecosystem components exists. The area where the ecological role of bison is significant is now limited to a small number of relatively small preserves, with the only non-captive herds existing in and around Yellowstone National Park and several other DOI properties. For this reason, the bison has been described as being “ecologically extinct” across its former range (Freese et al. 2007). Nonetheless, within the confines of managed preserves and within the constraints related to actual or perceived threats of disease transmission to livestock, bison can be an integral part of the local ecosystem, influencing patterns of vegetation structure and composition, fire dynamics, predator/prey and trophic relationships and other processes important to ecosystem function and restoration.

Geographic Representation

The TAPR bison herd is located within the documented historic range of the plains bison. It is part of the Wind Cave metapopulation, which also exists within the historic geographic range. This indicates the resource is in good condition with a high level of certainty. Trend is not applicable to this indicator.

Freedom of Movement

The TAPR bison herd moves freely year-round within 1,100 ac Windmill Pasture. There are no internal barriers and the movement of animals is not limited or directed within the pasture. Therefore the spatial and temporal (daily and seasonal) patterns of use are driven by bison needs and preferences. This indicates the resource is in good condition with an unchanging trend and a high level of confidence.

Range Carrying Capacity

In 2006, staff from the Natural Resources Conservation Service (NRCS) conducted a range site assessment at the preserve to estimate annual forage production. NRCS considered grazeable acres, soil type and range condition in making the determinations. Windmill Pasture is estimated to have an annual forage production of 690,223 pounds, or 873.7 animal unit months (AUMs). On a scale ranging from poor to excellent, range condition for the 1,074 acres included in the NRCS inventory of Windmill Pasture assigned a rating of "fair" to 42 acres (4%), "good/fair" to 93 acres (9%) and "good" to 938 acres (87%) (NRCS undated). An increase in the condition of the range could increase the amount of forage and corresponding carrying capacity for bison. To translate available forage from cattle to bison units, the preserve used an AU equivalent estimate of 1.25 for a bison cow with a six month or younger calf, 1.0 for a dry cow, 1.5 for a mature bison bull, and smaller AU values for younger animals (Bragg et al. 2002). A more precise forage allocation model would also incorporate deer, antelope, and other large herbivores, but unfortunately this is difficult to quantify (NPS 2009).

The bison stocking rate at the preserve is based on approximately 25 percent of the annual herbage production. Over a twelve-month grazing period, each animal unit (AU) requires approximately 9,500 pounds of forage. According to forage production for Windmill Pasture, year-round stocking of bison could average up to 73 animal units (874 AUMs / 12 months). This translates to 14.7 acres per animal unit. Taking into consideration the culling strategy, conservative modeling figures, and herd demographics, the maximum number of bison for Windmill Pasture is estimated at approximately 100 animals (NPS 2009). The reference condition for rangeland carrying capacity consists of the bison herd grazing within prairie carrying capacity and accommodating dry periods. The herd numbered 58 animals at the end of 2014, including some calves, which is well below the average estimated carrying capacity for the pasture. The range condition is anticipated to be unchanged or could improve as the herd grows. The range carrying capacity indicates the resource is in good condition, with an unchanging trend and high level of confidence.

Interaction with Ecosystem Processes

Some of the ecosystem processes affected by bison include vegetation heterogeneity driven by differential grazing, impacts to trees, wallow disturbance, modification of fire regime due to variable and patterned fuel loading, and nutrient redistribution via excretion. The TAPR bison herd interacts year-round with all acreage administratively available to bison at TAPR, which comprises approximately 10% of the preserve. There are significant benefits within Windmill Pasture specifically related to bison disturbance. Many of these interactions are distinct to bison and do not occur in other parts of the preserve grazed by cattle. This indicates the resource is in good condition with a high level of certainty and an unchanging trend.

Interaction with Native Vertebrates

Bison grazing affects other plains animals by altering vegetation structure, species composition and nutritional quality. Year-round grazing by bison is generally better for wildlife than uniform short-duration high-intensity grazing in the spring, especially when such grazing follows a burn that removes litter and structure. Year-round grazing can be detrimental to many wildlife species if it occurs at high levels and creates a uniform habitat, but that is not anticipated with the conservative bison stocking rates estimated for bison management areas at TAPR (NPS 2009). In addition to grazing impacts, bison can influence wildlife in other ways. For example, bison wallows provide important breeding habitat for native amphibians (Gerlanc and Kaufman 2003). Used in combination with patchy prescribed fire, bison grazing should have significant positive effects on habitat heterogeneity, which should increase wildlife diversity, distribution, and abundance (Fuhlendorf et al. 2006, Hamilton 2007).

Large mammal species such as *Odocoileus hemionus* (mule deer), *Odocoileus virginianus* (white-tailed deer), bobcat (*Felix rufus*), coyote (*Canis latrans*), red fox (*Vulpes vulpes*) and badger

(*Taxidea taxus*) are present in the preserve. Some large mammal species that were historically present but are no longer found at TAPR include *Ursus americanus* (black bear), *Ursus horribilis* (grizzly bear), *Felis concolor* (mountain lion), *Cervus canadensis* (elk), *Antilocapra americana* (pronghorn), and *Canis lupus nubilis* (Great Plains wolf), a subspecies of gray wolf (NPS 2000). Bison and prairie dogs both interact as keystone species where they occur together, but the historic range of the black-tailed prairie dog (*Cynomys ludovicianus*) was west of the tall grass prairie of the Flint Hills (Van Pelt 1999). A number of ground-nesting birds including the greater prairie chicken (*Tympanuchus cupido*) are known to occur at TAPR and benefit from the patchiness and diversity resulting from bison grazing and disturbance. No information is available regarding specific bison-dependent species at TAPR.

Because many native vertebrates are present, no bison predators are present, bison are actively creating diverse habitats, and prairie restoration efforts are underway, the condition of this indicator warrants moderate concern with an unchanging trend and a medium level of confidence.

<u>Herd Health and Genetics</u>

"Reportable" or "Notifiable" Diseases

Although diseases may limit bison population growth and productivity they are unlikely to cause extirpation. However, the presence of diseases "reportable" under federal or state/provincial statutes may lead to management interventions that impact conservation (Gates and Ellison 2010). Livestock diseases that restrict trade or pose a risk to human health may be "reportable" or "notifiable" under federal and provincial/state legislation. Of most concern are infectious organisms that may negatively affect bison populations or their conservation, either through direct pathogenic effects or indirectly as a consequence of management interventions (Aune et al. 2010). Detection of a reportable disease can trigger a variety of management responses. For captive herds, interventions may include quarantine, treatment, or eradication of infected captive animals or herds; or limiting inter-population or inter-jurisdictional transport of bison. Aune et al. (2010) describe nine federally-listed diseases of concern recognized by the American Bison Specialist Group (ABSG) in North America, seven of which were listed in 2008 listed as "notifiable" under World Organization for Animal Health (OIE) standards. These diseases of concern include anaplasmosis, anthrax, bluetongue, bovine spongiform encephalopathy, bovine brucellosis, bovine tuberculosis, bovine viral diarrhea, Johne's disease, and malignant catarrhal fever (sheep associated).

The Wind Cave parent herd has not had any recent significant chronic disease issues (Aune et al. 2010). South Dakota is currently brucellosis-free in cattle and an accredited bovine tuberculosis-free State (South Dakota Animal Industry Board 2014). Vaccination of Wind Cave National Park bison for brucellosis was discontinued in 1997 (NPS 2009). Observation for diseases and periodic testing are used to ensure that management could respond swiftly if an infectious disease were documented. Testing of all TAPR bison was completed in October of 2013 for anaplasmosis, bovine brucellosis, and Johne's disease and one animal destined to be culled and sent to the Sedgwick County Zoo (Wichita, Kansas) was tested for bovine tuberculosis. Anaplasmosis tested positive in 14 out of the 25 animals tested. Results for all other diseases were negative in all animals. Following these results, all bison were treated with medicated feed for anaplasmosis during the fall of 2013 and the winter of 2014. Based on these results, the resource is in good condition with an unchanging trend and a high level of confidence.

Disease and Health Management Actions

National Park Service policies generally discourage the use wildlife disease and health management actions. The minimization of actions such as de-worming and providing supplemental minerals, antibiotics and vaccines allows wildlife be exposed to natural selection pressures and to adapt accordingly.

None of the park units in the Northern Great Plains with bison provides supplemental forage or minerals. TNC policies are more considerate of such supplements, especially when they can reduce the likelihood of problems such as animal breakouts or nutritional stress. It is TNC's policy to manage bison herds under a "minimum supplement strategy" during both growing and non-growing seasons. The need for supplements may be greater on smaller tracts that may have few salt deposits available for bison, which is the case at TAPR. For these reasons, TAPR bison are managed using a “minimum supplemental strategy”. Salt and mineral sites are currently located throughout preserve pastures for supplementing cattle. These same sites may be utilized for bison mineral supplements as necessary (NPS 2009).

The NPS convened a workshop in 2003 to evaluate bison management issues and approaches relevant to TAPR, including disease issues (National Park Service 2004). In accordance with recommendations from the workshop and the bison reintroduction Environmental Assessment, the initial founding herd of 13 bison from Wind Cave National Park was tested for brucellosis, tuberculosis, and Johne’s disease and de-wormed prior to entry in Kansas. Vaccination for brucellosis is optional in Kansas (NPS 2009). Initially, the preserve had elected not to vaccinate bison for any other diseases in an attempt to allow the population to be as free from human intervention as possible. As a part of herd monitoring, management and culling operations, preserve bison were tested for anaplasmosis, bovine brucellosis, and Johne’s disease in October 2013. Anaplasmosis tested positive in 14 out of the 25 animals tested. Results for all other diseases were negative in all animals. Following these results, all bison were treated with medicated feed for anaplasmosis during the fall of 2013 and the winter of 2014. Bison were also vaccinated in October 2013 for blackleg, a bacterial infection found occasionally in the Flint Hills. Bison are dewormed once a year using Safe-Guard® dewormer (NPS 2009). Antibiotics may be administered to the bison (e.g., for anaplasmosis). Preserve bison will be tested for brucellosis and possibly other diseases and animals may be vaccinated during roundups until managers decide that vaccinations are no longer necessary.

Although use of mineral supplements, treatment, antibiotics or vaccines is minimal at TAPR, it is considered a necessary component of bison management. As time passes the need for brucellosis and other disease testing and vaccination may be eliminated. Because some mineral supplement and vaccinations are used, this indicator warrants moderate concern for the resource, with an unchanging trend and a moderate level of confidence.

Cattle Gene Introgression

Introgressive hybridization is one of the major threats to bison species conservation, and documenting its presence and severity is critical to understanding its influence on evolution and effective conservation of bison (Halbert et al. 2005). Hybridization between North American bison (*Bison bison*) and domestic cattle began in the late 1800s as some ranchers experimented with cattle-bison crosses or purchased crossed animals from others in the course of establishing commercial or conservation herds (Garretson 1938, Coder 1975). To date, evidence of mitochondrial or nuclear domestic cattle gene introgression has been identified in all but six of 14 U.S. and Canadian public bison populations (Halbert et al. 2005, Halbert and Derr 2007). Freese et al. (2007) estimated that less than 1.5% of bison are genetically pure *Bison*. Most of the 12 Department of Interior herds show low levels of cattle introgression, averaging less than 1% (Hedrick 2009). The benefits to bison fitness from reducing cattle ancestry from 1% to 0% are unknown. However, since cattle have been selected for agricultural traits for millennia, their ancestry is potentially very detrimental in a wild species such as bison (Hedrick 2009).

Herds showing no evidence of cattle ancestry by current molecular methods are the highest priority for protection (Dratch and Gogan 2010). Only one of the more than 50 private bison herds examined to date showed no evidence of cattle gene introgression (J. N. Derr, pers. comm.). There are no nearby bison herds that could introduce cattle genes to the TAPR bison herd through ingress or egress of bison across the preserve boundary. Bison introduced to the herd only originate from herds showing no evidence of cattle gene introgression.

Cattle gene introgression at TAPR was examined by the DNA Technologies Core Laboratory at Texas A&M University using October 2009 samples from 10 of the 13 original animals from Wind Cave National Park and again in 2013 using samples from all 26 TAPR animals. Laboratory results from both periods indicate all of the samples contained bison mitochondrial DNA; no domestic cattle alleles were identified among the14 nuclear markers used to evaluate introgression in bison. Therefore, at the level of current analytical detection limits, no evidence of bison-cattle hybridization was detected. These results indicate the resource is in good condition with an unchanging trend and high level of confidence.

Genetic Diversity

Potentially low genetic variation is a conservation management concern. This is largely due to low initial founder herd sizes, subsequent bottlenecks and genetic isolation The total number of independent animals that the five founding herds contributed to the present conservation herds in the United States may be less than 50 (Hedrick 2009). Several aspects of genetic diversity were examined: 1) the amount of genetic diversity present in the herd compared to the parent Wind Cave herd; 2) the level of genetic diversity compared to Federal bison herds; and 3) parental assays (2013 testing only).

Levels of genetic diversity compared to the parent Wind Cave herd:

Genetic diversity of the TAPR bison herd was examined by the DNA Technologies Core Laboratory at Texas A&M University using 2009 samples from 10 of the 13 original animals and 2013 samples from 26 animals. Samples were genotyped for standard parentage markers (11 microsatellites) and an additional 29 polymorphic (containing more than one allele) nuclear markers. This information was used to evaluate levels of polymorphism compared with a baseline set of 145 Wind Cave National Park bison samples. Based on these 40 markers, the average number of alleles for the Tallgrass National Prairie Preserve animals tested was estimated at 3.13 alleles per locus in 2009 and 3.26 alleles per locus in 2013, while the 145 Wind Cave National Park samples had an average of 3.65 and 3.73 alleles per locus in 2009 and 2013, respectively. Therefore, we see a slight increase in the genetic diversity at TAPR between 2009 and 2013. Prior to introducing any other animals at TAPR, the 10 bison from Wind Cave National Park that represent the foundation herd for the Tallgrass Prairie National Preserve herd captured approximately 85.4% of the known genetic diversity from the parent Wind Cave National Park herd.

Levels of genetic diversity compared to Federal Bison Herds:

A total of 40 polymorphic (containing more than one allele) nuclear markers were scored in 10 samples submitted from the Tallgrass Prairie National Preserve in 2009. The average number of alleles for 11 of the 40 polymorphic nuclear markers was compared among the samples from the TAPR and 9 historically significant bison populations (Table 4.14-3). Preserve samples were found to contain relatively low levels of genetic (allelic) diversity, 4.09, when compared with the 9 historic bison populations. The average number of alleles is a reflection of genetic diversity and is influenced by past population size. Populations which remain small for long periods of time tend to lose alleles at a rapid rate, and low numbers of alleles are generally believed to have negative effects on the long-term evolutionary potential of a population/species. High levels of genetic diversity are desirable for long-term herd survival, and low levels of genetic diversity are often due to small population size over long periods of time. However, the small sample size used in this calculation may also have contributed to this finding, and a more definitive answer is not possible without evaluating additional samples from this population (J. Derr note). All of the alleles identified from the 10 Tallgrass Prairie National Preserve samples were consistent with alleles found in these 8 U.S. federal bison herds. The 2009 value of 4.09 is lower than the mean value of 4.40 alleles for 9 Federal herds (not including TAPR) and significantly lower than the Wind Cave value of 5.18.

Table 4.14-3. Comparison of the average number of alleles found in samples from ten animals in the Tallgrass Prairie NP bison herd (2009 samples) with those found in other historically significant bison populations. Values for historically significant bison populations derived from previously published data (Halbert and Derr, 2008; Halbert et al. 2004).

Population	Sample Size	Loci Typed	Number of Alleles
Badlands National Park	328	11	4.64
Fort Niobrara National Wildlife Refuge	178	11	4.45
National Bison Range	179	11	5.27
Texas State Bison Herd	40	11	2.73
Theodore Roosevelt National Park – North Unit	309	11	3.64
Theodore Roosevelt National Park – South Unit	368	11	4.73
Wichita Mountains National Wildlife Refuge	37	11	4.09
Wind Cave National Park	345	11	5.18
Yellowstone National Park	505	11	4.91
Tallgrass Prairie National Preserve	10	11	4.09

Parentage Analysis:

Parentage analysis was performed in 2013 against previously sampled bison from the TAPR herd. Each of the 13 calf samples, as well as a 4 year old cow, was matched to a likely dam and sire. Results indicate that one bull aged 5 ½ as of the fall of 2013 has done all of the breeding during the three years leading up to testing. To maximize genetic diversity, this dominant bull was culled from the herd and sent to TNC's Smoky Valley Ranch (Kansas) in February 2014.

Results for genetic diversity indicate that the resource has at least 85% of the genetic diversity found in the Wind Cave herd, but relatively low levels of allelic diversity compared to the average value for other Federal herds and the Wind Cave herd. Therefore, the condition warrants moderate concern with a moderate level of confidence due to relatively small sample sizes and incomplete sampling of the TAPR herd in 2009. Also, additional genetic material has been introduced to the TAPR herd from other sources since 2009. Genetic diversity is expected to increase over time as animals are introduced from the Wind Cave herd and other sources.

Herd Size and Demographics

Herd Size

Almost all herds must be increased in size to avoid negative genetic effects on a decades-to-century time scale (Gross et al. 2006). To preserve genetic variation in bison over a two-hundred year period, it is recommended that herds should be managed at a population level of 1,000 animals or more, with a sex ratio that enables competition between breeding bulls (Dratch and Gogan 2010, Gross and Wang 2005, Gross et al. 2006). Because refuges and national parks (with the exception of Yellowstone) that currently have bison cannot support a herd of this size, the NPS has implemented a metapopulation strategy using satellite herds to help reach population goals for each NPS herd. Based on the range carrying capacity for Windmill Pasture estimated in 2006, the TAPR herd size is capped at a maximum of 100 animals and an average herd size of 73 animals (NPS 2009). As the bison herd grows, vegetation monitoring of range conditions will be considered when determining culling numbers and targeted maximum and average annual herd size. The sub-population goal of 50–100 animals within TAPR will help to achieve the 1000 animal goal for the Wind Cave herd. A strategy of periodic introduction of animals from the Wind Cave herd or other sources and removal of a portion of the population will be used over time to reach population goals while preserving genetic diversity over time.

The original herd from Wind Cave National Park consisted of thirteen animals; seven bulls and six 1–3 year old heifers (a female that has never calved). The age of the animals helped ensure that they had different mothers to maximize genetic diversity. Growth of the herd has been steady since its creation in 2009 (Figure 4.14-3). In 2012, two original WICA bulls died and two 3–4 year old bulls were transferred from TNC Dunn Ranch (Missouri) to TAPR. In 2013, two original WICA cows (mature females that have given birth to at least one or two calves) died, one unidentified original WICA bull (presumably from the 5 year old age class) died, and a 1–2 year old heifer was transferred to the Sedgwick County Zoo in Wichita, Kansas (pers. comm. Kristen Hase December 2013). Several additional changes occurred by June 2014, including the culling of a dominant 5 year old bull that was found to have fathered all calves during the three previous years. In October 2014 an additional 30 head of bison, made up of 13 males and 17 females ranging in age from 1.5 to 2.5 years, arrived to join the TAPR herd, bringing total herd size to 58 animals. The herd size indicator warrants moderate concern due to risks associated with relatively small herd size, with an improving trend. Confidence in the assessment is high.

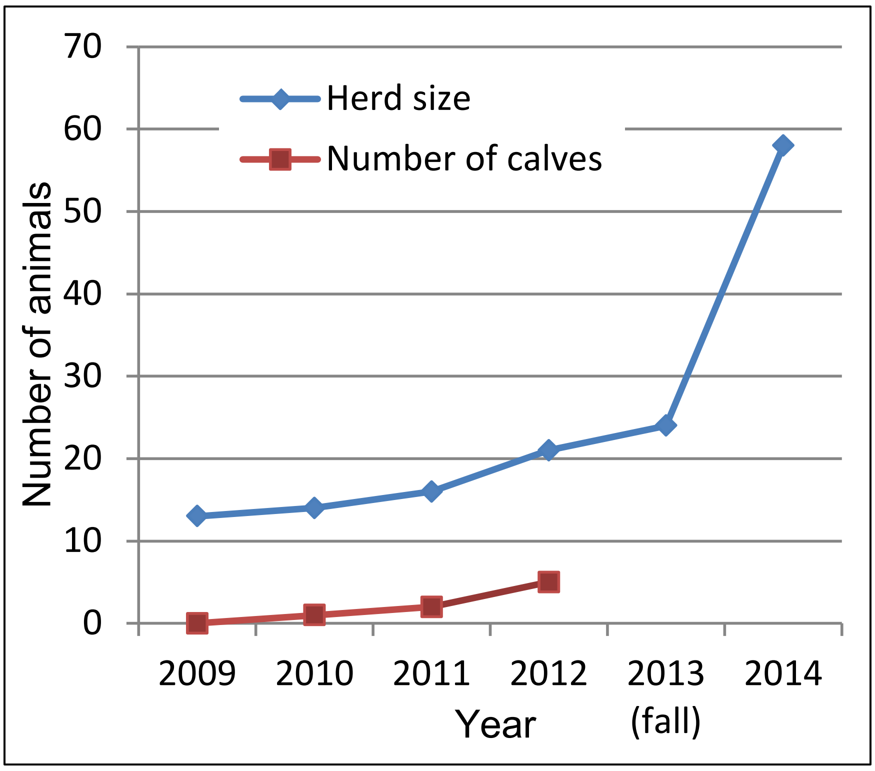


Figure 4.14-3. Bison herd size and number of calves over time at Tallgrass Prairie National Preserve.

Management of Herd Demographics

Herd demographics include aspects such as population size/density, sex ratio, age structure, and social units. Preserve managers target an approximate equal sex ration of males to females within the herd, although this may deviate up to a 4:6 ratio and stay within the desired range (Figure 4.14-4). The strategy for periodic culling to remove some animals to minimize inbreeding depression and periodic introduction of new animals is in development, and will likely incorporate both intentional and random elements. As the herd grows, managers will aim to minimize hands-on management in order to maximize natural selection pressures while maximizing genetic diversity. In the meantime, managers are actively altering population size and social structure (removing overly dominant bulls). Based on this assessment, management of herd demographics warrants moderate concern due to the active management of two or more aspects of herd demography. However, less management of demographics may be necessary as the herd approaches the range carrying capacity. The trend is unchanging and confidence in the assessment is high.

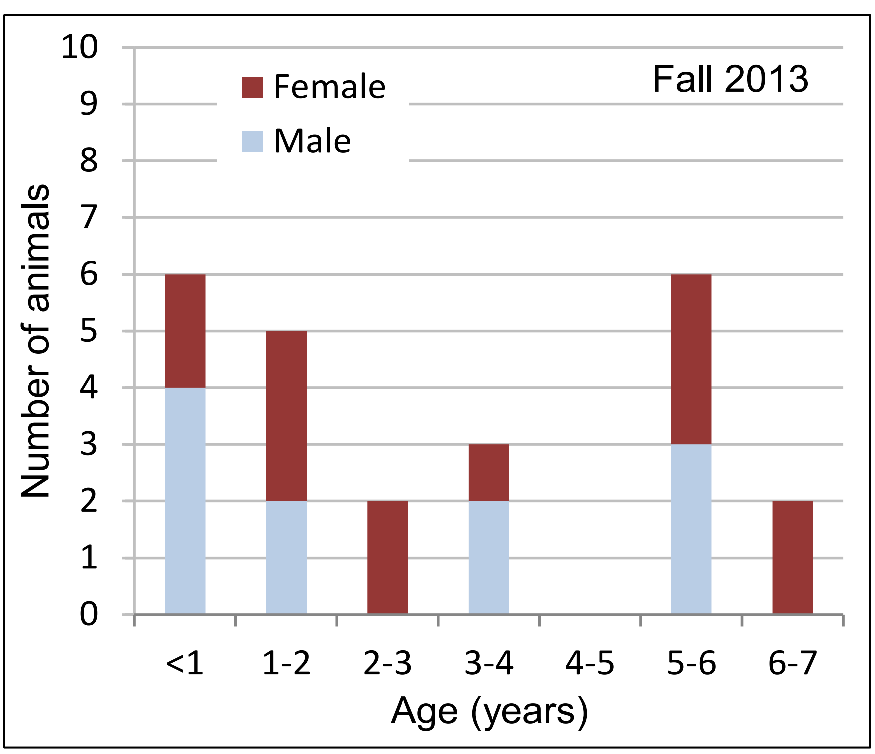


Figure 4.14-4. Fall 2013 TAPR bison population demographics by age and sex (demographics prior to introductions in fall 2014).

Visitor Access

Bison are an important element not only for their historic role within the tallgrass prairie ecosystem, but also in meeting the visitor's expectations about the prairie. Visitor access to the prairie is offered daily by ranger-guided bus tours and designated hiking trails. Both the bus tour route and two hiking trails directly pass through Windmill Pasture. This pasture is the closest pasture to the historic ranch headquarters, which is the primary access and visitation point for most visitors (Figure 4.14-5). Because of the rolling terrain and drainages dissecting the prairie, bison are not always seen by visitors traveling on established trails within Windmill Pasture. However, visibility of bison by visitors is expected to increase as the herd grows over time. Visitors have full access to the bison herd year round. The indicator is in good condition with an improving trend and a high level of confidence.

Figure 4.14-5. The bison herd roams freely within Windmill Pasture. (CSU photo).

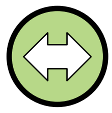
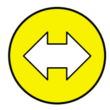
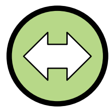
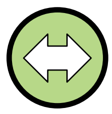
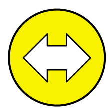
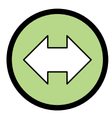
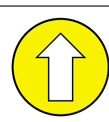
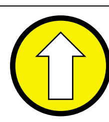
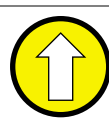
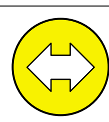
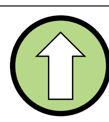
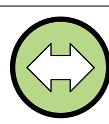
Overall Condition

Based on condition status and trend ratings for indicators and sub-indicators related to ecosystem stewardship and processes, herd health and genetics, herd size and demographics, and visitor access, the bison resource at TAPR is in good condition with an unchanging trend (Table 4.14-4). Confidence in the overall assessment is high. Several of the sub-indicators that warrant moderate concern have an improving trend.

Table 4.14-4. Condition and trend summary for bison at Tallgrass Prairie National Preserve.

Indicator	Sub-indicator	Condition Status/Trend	Rationale
Ecosystem Stewardship and Processes	Overall Condition		–
	geographic representation		The herd is located within an excellent example of native habitat within the historic range of bison. Local trend is not applicable.
	freedom of movement		Bison are allowed to move freely and year-round within the areas available to them.
	range carrying capacity		The bison herd is well-below the range carrying capacity. Carrying capacity will be re-evaluated periodically as the herd approaches estimated carrying capacity.

Table 4.14-4 (continued). Condition and trend summary for bison at Tallgrass Prairie National Preserve.

Indicator	Sub-indicator	Condition Status/Trend	Rationale
Ecosystem Stewardship and Processes (continued)	interaction with ecosystem processes		The TAPR bison herd interacts year-round with all acreage available to the herd; interaction involves grazing, wallowing, effects on fire behavior and other effects.
	interaction with native vertebrates		Some native vertebrates including some native herbivores are present; no bison predators are present; bison are actively creating diverse habitats; and restoration efforts are underway.
Herd Health and Genetics	Overall Condition		–
	presence of “reportable” diseases		No reportable or notifiable diseases are known to exist in the TAPR herd. Screening, testing, treatment and vaccinations help maintain a disease-free status.
	disease and health management actions		Although use of mineral supplements, treatment or vaccines is minimal at TAPR, they are considered a necessary part of bison management. As time passes the need for testing and vaccination may be eliminated.
	cattle gene introgression		At the level of current analytical detection limits, samples from 26 bison in 2013 detected no evidence of bison-cattle hybridization.
	genetic diversity		Measures of genetic diversity were relatively low compared to other federal bison herds. Genetic diversity may increase over time as animals are introduced.
Herd Size and Demographics	Overall Condition		–
	herd size		The herd is growing steadily.
	herd demographics management		Two or more aspects of herd demography – population density and social units (overly dominant bulls) are or will be actively managed.
Visitor Experience	Overall Condition		Visitors have full access to the bison herd year round and visibility of bison by visitors is expected to increase as the herd grows.
Bison Overall			**The resource is in good condition with an unchanging trend. Confidence in the assessment is high.**

The benefits of bison at TAPR are manifold, including ecological, cultural and visitation aspects. Results indicate a robust and healthy herd within a framework that supports both national and local NPS goals and mutual goals of the NPS and TNC. Perhaps the most obvious challenge to bison management at TAPR is the administrative limit placed on the acreage available to bison.

Periodic parentage testing is recommended for the TAPR herd for at least the next few generations to ensure that multiple bulls contribute offspring and to help limit inbreeding as this herd expands to the carrying capacity of the preserve. Parentage testing in 2013 identified a dominant bull that was subsequently culled to increase genetic diversity in calves. In addition, future testing may well indicate that future introductions of additional bison from the Wind Cave National Park parent herd into the TAPR breeding program may help offset [any] loss of diversity as the TAPR population expands (James Derr letter to Kristen Hase, October 2010).

Limiting bison to 10% of the preserve significantly limits the ability of bison to act as an important ecological restoration agent in its native habitat and also limits the contribution that TAPR can make toward Wind Cave herd size objectives. For example, access to the Palmer Creek floodplain, especially in winter, would likely mirror pre-European patterns of use and enable bison to interact with ecosystems and communities that are not present in the upland pasture. Access to Fox Creek bottoms is more complicated logistically due to the highway (personal comment K. Hase September 2014). While administrative constraints present during the creation of the preserve shaped the preserve's mission in favor of preserving a snapshot of a historic cattle ranching setting, the purchase of cattle grazing rights on preserve lands by the TNC opens up new possibilities for the future. Can the preserve mission be modified or reinterpreted to reflect a newer administrative reality and desired vision for the preserve? A more balanced vision for historic landscape integrity and ecological restoration could be possible. Such a vision would allow for the expansion of the bison herd onto more acreage within the preserve with concomitant benefits for ecosystem restoration. Some of the indicators that warranted moderate concern might be ameliorated by having a larger herd occupying a larger area.

4.14.5. Uncertainty and Data Gaps

The certainty associated with the assessment is very high in general. Because the TAPR herd is cattle-gene and disease free it is especially important to maintain those characteristics. There is an opportunity to examine the effects of the bison herd on ecosystem properties and processes in Windmill Pasture. The current vegetation sampling design could be modified to improve the power of statistical inferences from that pasture relative to other pastures.

4.14.6. Sources of Expertise

- Dr. James Derr, Professor, Department of Veterinary Pathobiology, Texas A&M University. Provided information about genetic testing results and interpretation.
- John Gross, NPS Climate Change Response Program; information sources and indicators and measures.
- Kristen Hase, Land Manager, Tallgrass Prairie National Preserve; information sources and indicators and measures, review of preliminary draft.

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4.15. Butterflies

4.15.1. Background and Importance

The National Park Service is responsible for preserving and restoring the natural abundances and diversity of animal populations within the NPS system and with minimizing human impacts to those animal populations. Grassland butterflies are conspicuous components of the parks residing within prairie ecotones and compose an important natural resource within grassland parks, which represent one of the most endangered ecosystems in the United States.

NPS lands provide some of the most intact and high-quality prairie habitat remaining in the Midwest. Grasslands at Tallgrass Prairie National Preserve (TAPR) offer quality habitat for native butterflies. Large parcels of high-quality prairie are rare in the region. Therefore, TAPR is especially valuable by providing relatively undisturbed patches of prairie habitat critical for sustaining native butterflies within a highly altered agricultural landscape. The habitat fragmentation and conversion of native vegetation to agricultural and urban landscapes occurring outside the preserve will negatively impact populations of some butterflies resident to TAPR, particularly intolerant species that have evolved within stable environments (Knopf and Samson 1994). Butterfly community composition and diversity should improve with restoration and the appropriate management of prescribed burns both within TAPR and in the surrounding landscape (Pywell et al. 2004, Swengel and Swengel 1998, Vogel et al. 2007).

Nominal data exist on the long-term population dynamics of grassland butterflies in North America, but there is no doubt that they have declined across the prairie province since the early 1900s (Swengel and Swengel 1998). The regal fritillary butterfly has declined throughout North American prairies, occurring today only as relatively small, localized populations (Swengel 1993). The Dakota skipper and the Poweshiek skipperling have also become more localized and restricted to prairie fragments (Opler and Krizek 1984, Johnson 1986). The monarch butterfly has also been in decline in North America, particularly at wintering sites in Mexico (CBE et al. 2014).Within its breeding range, which includes Kansas, the monarch decline is attributed to the drastic reduction of milkweed that has occurred due to increased herbicide spraying (CBE et al. 2014). This decline has led the U.S. Fish and Wildlife Service to conduct a status review of the monarch under the Endangered Species Act (ESA).

Butterflies are an excellent indicator of environmental condition because habitat preferences and host plant associations are relatively well-known; the metapopulation dynamics, dispersal, and effects of different habitats on butterfly movement behavior are well known; and grassland obligate butterflies respond quickly to changes in native vegetation (Debinski et al. 2000). Invertebrates including butterflies perform vital ecological roles including pollination, seed dispersal, nutrient cycling, and they are prey for other wildlife species (Black et al. 2001, Losey and Vaughan 2006). Nonetheless, butterflies are often overlooked in management planning and priorities, especially with regard to endangered species (Black et al. 2001). Butterflies are not specifically mentioned in the General Management Plan for the preserve (NPS 2000) but are now being monitored to some degree. Since 2009, the Marvin Schwilling Memorial Butterfly Count has been conducted annually at TAPR. Additionally, Sievert and Prendergast (2011) surveyed butterflies from 2009 through 2010 at TAPR.

<u>Threats and stressors</u>

The major threats to butterflies within the HTLN prairie parks are habitat loss, fragmentation, and fire management. Prairie habitat throughout the Great Plains has been lost or fragmented by agricultural and urban development. The remaining prairies continue to be threatened by agricultural conversion and grazing. Management of prairies is also an issue because grassland butterflies appear to be more sensitive to fire than some other prairie-dependent species (Swengel 1998). Fire has impacted butterfly populations, and in some places it is known to have caused local extirpation (Shepard 2005a). There is evidence that fire return intervals of two years or less can severely impact butterflies, with units left unburned for 6 to 8 years offering the best habitat for grassland butterflies (Swengel and Swengel 1998, Vogel et al. 2007). At TAPR there is some evidence that the butterfly community is actually more diverse on areas one year post-burn (Sievert and Prendergast 2011). The seasonal timing of fires, high fire frequencies, or high frequency of management activities such as mowing can lead to loss of host plants, removal of nectar sources during critical periods, and destruction of larvae (Shepard 2005b).

Indicators and Measures

- Native Species Richness (S)
- Native species diversity (Modified Shannon, Hill's N1)
- Native species evenness (Hill's E5)
- Occurrence and status of butterfly species of conservation concern

4.15.2. Data and Methods

TAPR has been conducting a butterfly count at the preserve since 2009. This citizen science research initiative is an annual butterfly survey that takes place on and near TAPR. Data from the butterfly counts conducted from 2009 to 2013 were used to assess the condition of the butterfly community at TAPR. Sampling occurred in 2014 but was cut short because of inclement weather, which appeared to result in fewer species and individuals per species being observed compared to earlier data. For this reason, data from 2014 are not included in this summary.

The butterfly counts at TAPR follow the North American Butterfly Associations annual 4th of July butterfly count protocol. Counts are performed on one day in either June or July over a period not to exceed 24 hours. Counts are conducted within a 15-mile diameter circle (i.e., site) and are performed by four individuals per site. The purpose of these counts is to provide long-term data on trends in butterfly numbers. Since 2009, six independent sites have been surveyed at TAPR. Two to four sites have been surveyed in any given year.

To evaluate trends over time, we compared the occurrence of species detected during the initial survey conducted at TAPR in 2009 to species detected during the 2013 survey. We compared native species richness, diversity, evenness, and the number of species of conservation concern present between 2009 and 2013. Only native species were included in calculations of the condition indicators, as the inclusion of exotic/non-native species would make interpretation of results problematic from a biodiversity standpoint.

To identify butterfly species that are of conservation concern we used species listed as either endangered or threatened by the U. S. Fish and Wildlife Service (USFWS) under the Endangered Species Act; U. S. Forest Service (USFS) and Bureau of Land Management (BLM) sensitive species lists; NatureServe G1 to G3 and S1 ranked species; and state lists of endangered, threatened and special concern species.

Kansas-listed species are protected by regulations enforced by the state that prohibit activities that negatively impact listed species populations and their critical habitat. Including butterflies on the condition assessment for TAPR that are listed under the Kansas State Endangered Species Act recognizes that some species may be declining dramatically at the local scale, even though they are not nationally endangered.

4.15.3. Reference Condition

Little historic survey data exists for TAPR. Butterfly reference condition is based on results of the initial 2009 butterfly count. Maintaining or exceeding the level of biodiversity as defined by initial calculation of native species richness and diversity (as indices of diversity) and the initial quality of butterfly community composition as defined by the initial value of species evenness are considered good condition. A condition rating framework for butterflies is shown in Table 4.15-1.

Table 4.15-1. Resource condition rating framework for butterflies at Tallgrass Prairie National Preserve, Kansas.

Indicator	Resource is in Good Condition	Warrants Moderate Concern	Warrants Significant Concern
Native Species Richness (S)	>85–100+ % of 2009 value	70–85% of 2009 value	<70% of 2009 value
Native Species Diversity (Hill's N1)	>85–100+ % of 2009 value	70–85% of 2009 value	<70% of 2009 value
Native Species Evenness (Hill's E5)	>85–100+ % of 2009 value	70–85% of 2009 value	<70% of 2009 value
Butterfly Species of Conservation Concern	>85–100+ % of 2009 value	70–85% of 2009 value	<70% of 2009 value

We also compared the candidate list of species of conservation concern to the actual list of species observed at TAPR during the 2013 survey. We used the number of species of conservation concern recorded in the initial survey year of 2009 as the reference condition for comparison. The condition of the resource is considered better if more species of conservation concern are observed. This implies that the populations of those species are increasing and/or they are using the preserve more.

4.15.4. Condition and Trend

Species Richness

A total of 49 species were recorded in 2013. The most common species were the pearl crescent (*Phyciodes tharos*) and variegated fritillary (*Euptoieta claudia*). The number of species observed exceeds the 39 species recorded during the 2009 butterfly count at TAPR. The American lady (*Vanessa virginiensis*), gray copper (*Lycaena dione*), orange sulphur (*Colias eurytheme*), and regal fritillary (*Speyeria idalia*) were moderately common (Table 4.15-2).

Table 4.15-2. Butterfly species recorded in 2013 and 2009 at Tallgrass Prairie National Preserve.

Common Name	Species Name	Number Observed 2013	Number Observed 2009	Nature Serve Rank
American lady	*Vanessa virginiensis*	143	6	G5S5
Arogos skipper[A]	***Atrytone arogos***	**10**	**61**	**G3S3S4**
Black swallowtail	*Papilio polyxenes*	74	8	G5S5
Bronze copper	*Lycaena hyllus*	2	0	G5S4S5
Cabbage white	*Pieris rapae*	9	5	G5SNA
Checkered White	*Pontia protodice*	38	2	G4S5
Clouded skipper	*Lerema accius*	0	0	G5SNR
Clouded sulphur	*Colias philodice*	22	3	G5S5
Cloudless sulphur	*Phoebis sennae*	3	2	G5S5B
Common buckeye	*Junonia coenia*	63	2	G5S5
Common checkered-skipper	*Pyrgus communis*	9	33	G5S5
Common roadside-skipper	*Amblyscirtes vialis*	1	0	G4S5
Common sootywing	*Pholisora catullus*	2	2	G5S5
Common wood nymph	*Cercyonis pegala*	2	1	G5S5
Coral hairstreak	*Satyrium titus*	1	4	G5S4S5
Crossline skipper	*Polites origenes*	0	1	G4G5S4S5
Dainty Sulphur	*Nathalis iole*	1	3	G5SNA
Delaware skipper	*Anatrytone logan*	11	6	G5S5
Dotted skipper[A]	***Hesperia attalus***	**1**	**0**	**G3G4S2S3**
Dun skipper	*Euphyes vestris*	23	3	G5S5
Eastern comma	*Polygonia comma*	3	0	G5S5
Eastern tailed-blue	*Cupido comyntas*	31	46	G5S5
Eastern tiger swallowtail	*Papilio glaucus*	2	2	G5S5
Eufala skipper	*Lerodea eufala*	1	3	G5S5B

[A] Considered a species of conservation concern (also in bold).

Table 4.15-2 (continued). Butterfly species recorded in 2013 and 2009 at Tallgrass Prairie National Preserve.

Common Name	Species Name	Number Observed 2013	Number Observed 2009	Nature Serve Rank
Fiery skipper	*Hylephila phyleus*	0	0	G5S5B
Giant swallowtail	*Papilio cresphontes*	1	0	G5S4S5
Gorgone Checkerspot	*Chlosyne gorgone*	0	0	–
Gray copper	*Lycaena dione*	100	25	G5S4S5
Gray hairstreak	*Strymon melinus*	19	4	G5S5
Great spangled fritillary	*Speyeria cybele*	54	2	G5S5
Hackberry Emperor	*Asterocampa celtis*	4	0	G5S5
Horace's duskywing	*Erynnis horatius*	3	0	G5S4S5
Juniper hairstreak	*Callophrys gryneus*	0	4	G5S4S5
Juvenal's duskywing	*Erynnis juvenalis*	0	0	G5S5
Least skipper	*Ancyloxypha numitor*	3	4	G5S5
Little yellow	*Eurema lisa*	2	0	G5S5B
Little wood-satyr	*Megisto cymela*	3	0	G5S5
Marine blue	*Leptotes marina*	0	0	G5S4B
Monarch	*Danaus plexippus*	53	90	G5S5B
Mourning cloak	*Nymphalis antiopa*	2	0	G5S5
Northern Cloudywing	*Thorybes pylades*	0	2	G5S4
Nysa roadside-skipper	*Amblyscirtes nysa*	2	0	G5S5
Orange Sulphur	*Colias eurytheme*	187	63	G5S5
Ottoe skipper[A]	***Hesperia ottoe***	**0**	**2**	**G3G4S2S3**
Painted lady	*Vanessa cardui*	92	2	G5SNA
Phaon crescent	*Phyciodes phaon*	5	0	G5S4B
Pearl crescent	*Phyciodes tharos*	883	186	G5S5
Pipevine swallowtail	*Battus philenor*	1	0	G5S2B S5N
Reakirt's blue	*Echinargus isola*	0	14	G5S4B
Red admiral	*Vanessa atalanta*	6	1	G5S5B
Regal fritillary[A]	***Speyeria idalia***	**317**	**160**	**G3S4**
Sachem	*Atalopedes campestris*	6	6	G5S5B
Silver-spotted skipper	*Epargyreus clarus*	0	2	G5S5
Silvery checkerspot	*Chlosyne nycteis*	11	2	G5S5
Sleepy orange	*Eurema nicippe*	1	0	G5S4B
Southern Cloudywing	*Thorybes bathyllus*	0	0	G5S4
Southern dogface	*Zerene cesonia*	1	0	G5S4B
Summer azure	*Celastrina neglecta*	4	0	G5S5
Tawny emperor	*Asterocampa clyton*	2	0	G5S5
Tawny-edged Skipper	*Polites themistocles*	0	19	G5S4
Variegated fritillary	*Euptoieta claudia*	851	169	G5S5B
Viceroy	*Limenitis archippus*	0	0	G5S5
Wild indigo duskywing	*Erynnis baptisiae*	4	0	G5S5
Zabulon skipper	*Poanes zabulon*	0	1	G5S5

[A] Considered a species of conservation concern (also in bold).

The recorded number of butterflies per species was quite variable between 2009 and 2013; 33 species exhibited an increase in abundance and 17 exhibited a decrease (Table 4.15-2). Two of the four species of conservation concern exhibited increases in abundance; the dotted skipper (*Hesperia attalus*) increased from 0 to 1, and the regal fritillary increased from 160 to 317. The other species of conservation concern, the Arogos skipper (*Atrytone arogos*) declined from 61 in 2009 to 10 in 2013 and the Ottoe skipper (*Hesperia ottoe*) declined from 3 in 2009 to 0 in 2013.These totals combine data from all sample sites and do not have an associated measure of precision.

The mean native butterfly species richness per site at TAPR has fluctuated, but appears to be reasonably stable between 2009 and 2013 (Figure 4.15-1). The slope of the linear regression for native butterfly species richness was positive but not statistically significant ($r^2 = 0.04$, $p = 0.74$), suggesting an unchanging trend in the richness of the butterfly community at TAPR. In 2013, there were 28.3 mean native butterfly species per site recorded at TAPR, which is greater than the management target of 85% of 8.3, the value recorded in 2009 when monitoring was initiated at TAPR. Results indicate species richness is in good condition (Table 4.15-2). The confidence intervals suggest low precision in estimated native species richness in most years. Confidence in the results is low due to the low precision of the estimates and the limited years of data upon which this evaluation is based.

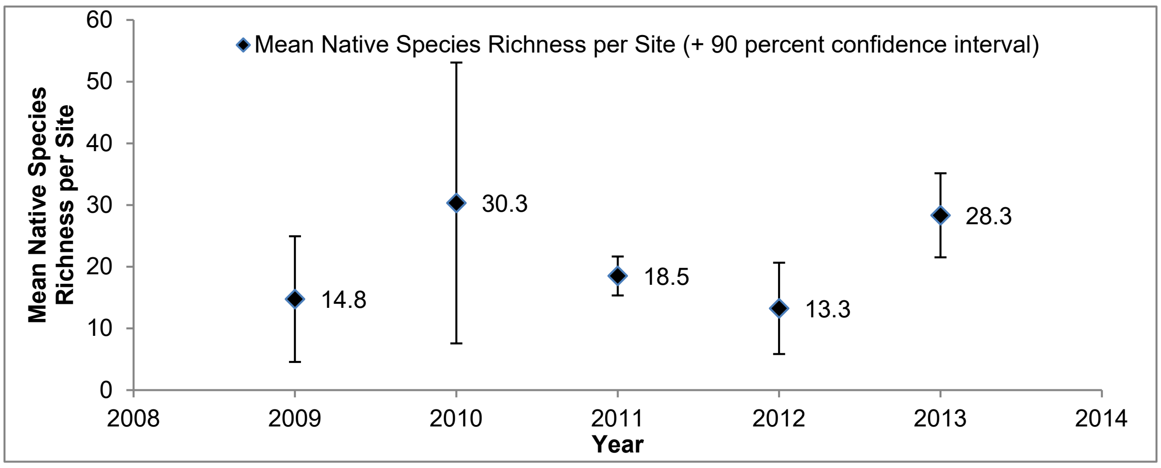


Figure 4.15-1. Native butterfly species richness at Tallgrass Prairie National Preserve from 2009 to 2013.

Species Diversity

The mean native butterfly species diversity per site at TAPR has fluctuated, but has been reasonably stable between 2009 and 2013 (Figure 4.15-2). The slope of the linear regression line for native species diversity was positive, but not statistically significant ($r^2 = 0.06$, $p = 0.7$), suggesting an unchanging trend in native species diversity at TAPR. In 2013, mean native species diversity per site at TAPR was 9.6, greater than the management target of 85 percent of 7.4, the value in 2009 when butterfly counts were initiated at TAPR. Native butterfly species diversity recorded in 2013, when compared to the 2009 value indicates the current value of species diversity warrants moderate concern (Table 4.15-1).

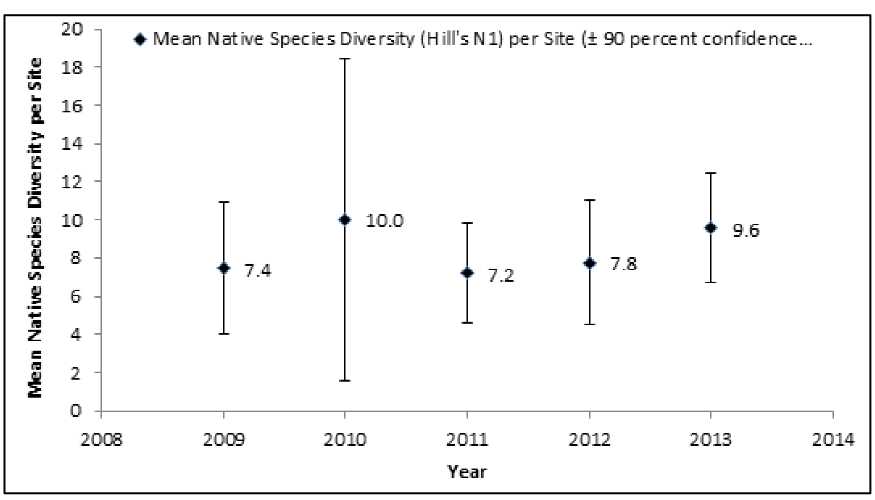


Figure 4.15-2. Native species diversity at Tallgrass Prairie National Preserve from 2009 to 2013.

The confidence intervals suggest low precision in the calculated values for mean native species diversity per site for the years 2009 through 2013. Low precision of the calculated values of species diversity and the limited years of data upon which this evaluation is based result in medium confidence in the assessment.

Species Evenness
The mean native butterfly species evenness per site at TAPR has fluctuated, but has been reasonably stable during the monitoring period 2009 to 2013 (Figure 4.15-3). The slope of the linear regression line for native species evenness was negative, but not statistically significant ($r^2 = 0.002$, $p = 0.94$), suggesting an unchanging trend in native species evenness at TAPR. In 2013, native species evenness was 5.9, greater than the management target of 85 percent of 5.5, the value in 2009 when butterfly counts were initiated at TAPR. Comparison of evenness recorded in 2013 and 2009 indicates the current value of species evenness is in good condition (Table 4.15-1).

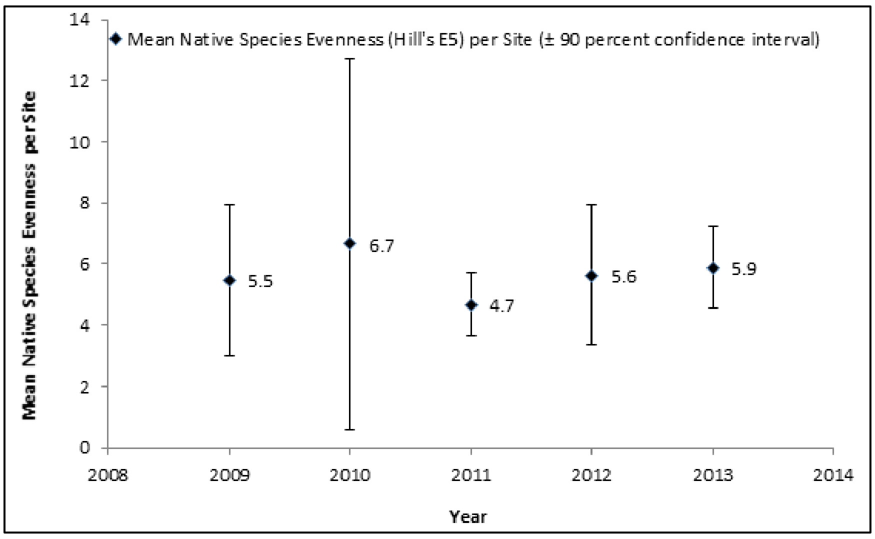


Figure 4.15-3. Native species evenness at Tallgrass Prairie National Preserve from 2009 to 2013.

The confidence intervals suggest low precision in the calculated values for mean native species evenness per site for the years 2009 through 2013. Low precision of the calculated values of species diversity and the limited years of data upon which this evaluation is based result in low confidence in the assessment.

Species of Conservation Concern
The number of butterfly species of conservation concern remained stable from 2009 to 2013 at TAPR (Figure 4.15-4). An average of 1–2 species of conservation concern per site were recorded at TAPR in all years monitored. The Arogos skipper, dotted skipper, Ottoe skipper, and regal fritillary were the four species of conservation concern recorded at TAPR (Table 4.15-1). The regal fritillary is currently under review by the USFWS for listing. These species are considered vulnerable by NatureServe and two of them, the Ottoe skipper and regal fritillary, have been redlisted by the Xerces Society, an international nonprofit organization that protects wildlife through the conservation of invertebrates and their habitat. The slope of the linear regression line for the number of species of conservation concern was positive but not statistically significant ($r^2 = 0.53$, $p = 0.16$), suggesting an unchanging trend in the number of species of conservation concern at TAPR. In 2013, there were 1.67 mean species of conservation concern per site present at TAPR, greater than the management target of 85 percent of 1.25, the value in 2009 when butterfly counts were initiated. These results indicate good condition (Table 4.15-1).

The confidence intervals suggest low precision in the calculated values for the mean species of conservation concern for the years 2009 through 2013. Low precision of the calculated values of species diversity and the limited years of data upon which this evaluation is based result in medium confidence in the assessment.

Although not meeting the criteria of a species of concern and not analyzed as such in this assessment, the monarch butterfly is also currently being review by the USFWS for listing. The abundance of the monarch butterfly fluctuated dramatically, ranging from 6 to 185, during the four year period analyzed and did not exhibit a consistent trend in the numbers counted among years.

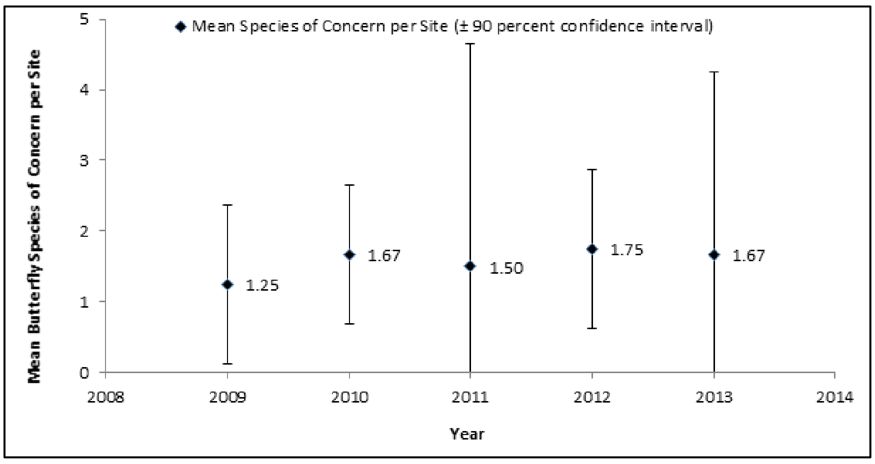
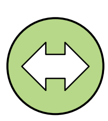
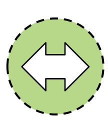
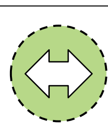
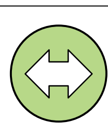
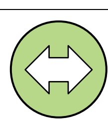


Figure 4.15-4. The mean number of species of conservation concern at Tallgrass Prairie National Preserve from 2009 to 2013, with 90% confidence intervals.

Condition Summary

The values for the metrics of native species richness, diversity, evenness and the number of species of conservation concern present in 2013 indicate that TAPR is in good condition. There are four vulnerable butterfly species present and a community structure that is representative of a moderately disturbed landscape (Table 4.15-3). Of particular interest is the large population of the regal fritillary, a butterfly that is considered vulnerable by NatureServe and redlisted by the Xerces Society. The species is considered at moderate risk of extinction due to a restricted range, relatively few populations, and recent and widespread declines. With the large population of regal fritillary at TAPR, the preserve appears to provide high-quality habitat and may play an important role in species recovery. The values for the metrics calculated for the years 2009 to 2013 suggest an unchanging trend in butterfly community diversity and structure at TAPR. Overall confidence in the assessment is medium, but year to year variability is high and the biological relevance of the reference condition is unknown.

Table 4.15-3. Condition and trend summary for butterflies at Tallgrass Prairie National Preserve.

Indicator	Condition Status/Trend	Rationale
Native Species Richness		Mean native butterfly species richness per site has fluctuated between 13.3 and 30.3 species from 2009 to 2013 with richness equaling 28.3 in 2013 (good condition). The 2013 estimate is greater than the management target of 85 percent of 14.8.
Native Species Diversity		Mean native butterfly species diversity per site has fluctuated between 7.2 and 10.0 from 2009 to 2013 with evenness equaling 9.6 in 2013 (good condition). The 2013 estimate is greater than the management target of 85 percent of 7.4.
Native Species Evenness		Mean native butterfly species evenness per site has fluctuated between 4.7 and 6.7 from 2009 to 2013 with evenness equaling 5.9 in 2013 (good condition). The 2013 estimate is greater than the management target of 85 percent of 5.5.
Species of Conservation Concern		The mean number of butterfly species of conservation concern per site fluctuated between 1.25 and 1.75 species from 2009 to 2013 with 1.67 species of conservation concern present in 2013 (good condition). The 2013 estimate is greater than the management target of 1.06.
Butterflies Overall		**Condition is good with an unchanging trend. Confidence in the assessment is medium.**

4.15.5. Uncertainty and Data Gaps

Confidence in this assessment was medium. The key uncertainty related to the assessment of the butterfly community at TAPR is in the limited years of data upon which the assessment is based. Also, this assessment is based upon monitoring data collected over multiple years by multiple observers with varying skills in surveying butterfly populations. The short sampling window applied each year is vulnerable to annual changes in weather or other factors affecting seasonal butterfly abundance. This variation could introduce non-sampling error into the data, leading to bias in the type or number of butterflies recorded by different observers. Non-sampling errors associated with data collection could be reduced by establishing a training program for all data collectors and by retaining collectors over multiple years. Another factor affecting the quality of the data is the probability that a butterfly that is present during the time that surveys are conducted. The protocol used for monitoring butterflies in the HTLN relies on visual encounter surveys and at TAPR these are performed only once per year, leaving the chance that rare species will go undetected. This can be a problem when assessing native species richness and the number of species of concern, and when calculating the indices of diversity, which are based on the number and proportion of rare and common species observed.

In addition, there were differences in sampling effort with variation in which sites were sampled every year and the number of sites sampled per year. If more sites are added to the butterfly sampling protocol at TAPR, then sampling all of these sites, or at least a subset utilizing all of the same sites every year, would minimize any difference in sampling effort among the years analyzed.

4.15.6. Sources of Expertise

- Kristen Hase, Chief of Natural Resources, Tallgrass Prairie National Preserve, Strong City, Kansas. Kristen supplied the data and supporting resources upon which this assessment is based.

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4.16. Fish Community

4.16.1. Background and Importance

The National Park Service protects, preserves, and manages biological resources and related ecosystem processes in the national park system including aquatic resources. Prairie stream fish are components of these aquatic systems and are important components of grassland parks of the Heartland Inventory and Monitoring Network (HTLN). North American freshwater fish, including prairie stream fish, have been in declined since the early 20th century (Hoagstrom et al. 2006, Jelks et al. 2008, Barrineau et al. 2010). This decline has been caused by multiple factors including conversion of uplands to cropland and livestock pasture (beginning in the 1880s) (Knopf and Samson 1996), habitat fragmentation caused by reservoir construction (beginning in the 1950s), reduced discharge caused by groundwater withdrawal (beginning in the 1960s), and invasion by non-native fishes (Gido et al. 2010). In 2001, the NPS formally recognized the decline of the Topeka shiner at HTLN Parks. In 2008 this concern was extended to all native fish and actions were initiated to combat the loss of prairie stream fish (Potter Thomas et al. 2001, Dodd et al. 2008). The NPS recommends an approach to managing this critical resource that focuses on monitoring the prairie stream fish community to understand community condition and trend and how they correlate with management actions.

Prairie stream fish populations hold an intrinsic value as environmental indicators because they are important components of prairie aquatic ecosystems. Specific species are intolerant of chemical pollutants or habitat changes, making their assemblages indicative of water and habitat quality (Pflieger 1997, Barbour et al. 1999, Schrank et al. 2001). Therefore, fish community composition offers an indication of stream environmental health. The native fish populations of prairie streams have undergone profound changes with many species either declining in number or being extirpated. Alterations to the landscape caused by changes in land use, land cover and hydrology have contributed to habitat degradation (Knopf and Samson 1996). Long-term monitoring of abundance and diversity of native fish species at parks of the Heartland I&M Network supports evaluations of stream biotic integrity and the quality of fish habitat, providing park managers with the science-based understanding needed to make informed decisions regarding the management of aquatic ecosystems.

NPS lands provide some of the least impacted stream habitat remaining in the Midwest. Because of the rarity of non-agricultural lands in the region, TAPR is especially valuable by providing some protected patches of stream habitat critical for sustaining native prairie fishes within a highly altered agricultural landscape (Dodd et al. 2008). Habitat fragmentation and conversion of native vegetation to agricultural and urban landscapes occurring outside the preserve will negatively impact populations of some fish species resident to TAPR, particularly intolerant species that have evolved within stable environments (Knopf and Samson 1996, Gido et al. 2010). Fish community composition and diversity should improve with native prairie restoration, water treatment, flow management, dam removal, or cessation of groundwater pumping both within TAPR and in the surrounding landscape (Gido et al. 2010).

<u>Threats and Stressors</u>

The fish community at TAPR has been affected by habitat destruction, degradation, modification, fragmentation, and introduced predaceous fish (NPS 2008). Agriculture and development in the surrounding landscape have resulted in siltation, reduced water quality, tributary impoundment, stream channelization, instream gravel mining, and changes in stream hydrology (NPS 2008). Dams and other barriers on rivers and streams restrict fish and wildlife movements, leaving large expanses of potential habitat uninhabited and/or suppressing gene flow among populations (Schneider et al. 2011).The combined and interacting effects of these influences have resulted in population declines and range reduction of freshwater fish not only at TAPR, but also in the region surrounding the preserve.

Protection of freshwater biodiversity is difficult because it is influenced by the upstream drainage network, the surrounding land, and activity in the riparian zone (Dudgeon et al. 2006). Modifications to the surrounding landscape disrupt ecological functions important to ecosystem integrity and to maintaining the community and composition of species at TAPR comparable to that of the natural habitat of the region (Jorgensen and Müller 2000). Consequently, the ecological functioning of TAPR depends upon maintaining the natural systems outside preserve boundaries. These changes in land use are linked to ecological function at TAPR by five mechanisms (Hansen and Gryskiewicz 2003):

1. Land use activities reduces the functional size of a reserve, eliminating important ecosystem components lying outside the park boundary;
2. Land use activities alter the flow of energy or materials across the landscape irrespective of the park's political boundary, disrupting the ecological processes dependent upon those flows both outside and inside the park and across its boundaries;
3. Habitat conversion outside the reserve may eliminate unique habitats, such as seasonal habitats and migration corridors;
4. The negative influences of land use activities may extend into the reserve and create edge effects; and
5. Increased population density may directly impact parks through increased recreation and human disturbance.

Indicators and Measures

- Native species richness (S)
- Fish index of biotic integrity (IBI)
- Occurrence and status of fish species of conservation concern

4.16.2. Data and Methods

The HTLN has implemented long-term monitoring of fish at parks within the HTLN network including TAPR (Dodd et al. 2008). The purpose of this monitoring is to determine the status and long-term trends in fish community composition and abundance, and to correlate this community data to water quality and habitat conditions. Results will help managers understand how fish respond to changes in habitat structure and other habitat variables related to land use changes and management activities (Dodd et al. 2008). HTLN fish monitoring began in 2001. The number of sites sampled per year varied, ranging from 18 reaches from 11 streams (2001 to 2006) to 13 reaches from 12 streams (2007 to 2010) (Figures 4.16-1 and 4.16-2). Data from a total of 19 sample reaches were used to determine the condition of the fish community. Fish sampling was conducted in September and October using a common sense seine. All fish were counted and identified to species. Starting in 2006, 30 individuals per species at each reach were also measured and weighed, and any diseases or anomalies were recorded.

Additional fish datasets that include survey sites within TAPR exist, but were not used in this assessment. The Kansas Department of Wildlife, Parks and Tourism (KDWPT 2016) has surveyed fish populations since 1994 at over 750 sites from throughout Kansas including 3 locations on TAPR (KDWPT 2006). A subset of the 750 sites is monitored annually by KDWPT. The Fish Ecology Lab (2016) at Kansas State University has monitored three sites within TAPR on Fox Creek annually since 2008. Data from these sampling efforts have been published in the scientific literature (Martin et al 2013; Troica and Gido 2014).

To evaluate trends over time, we compared the occurrence of species detected during the initial survey conducted at TAPR in 2001 to species detected during the 2010 survey. Only native species were included in calculations of species richness, as the inclusion of exotic/non-native species would make interpretation of richness results problematic from a biotic integrity standpoint.

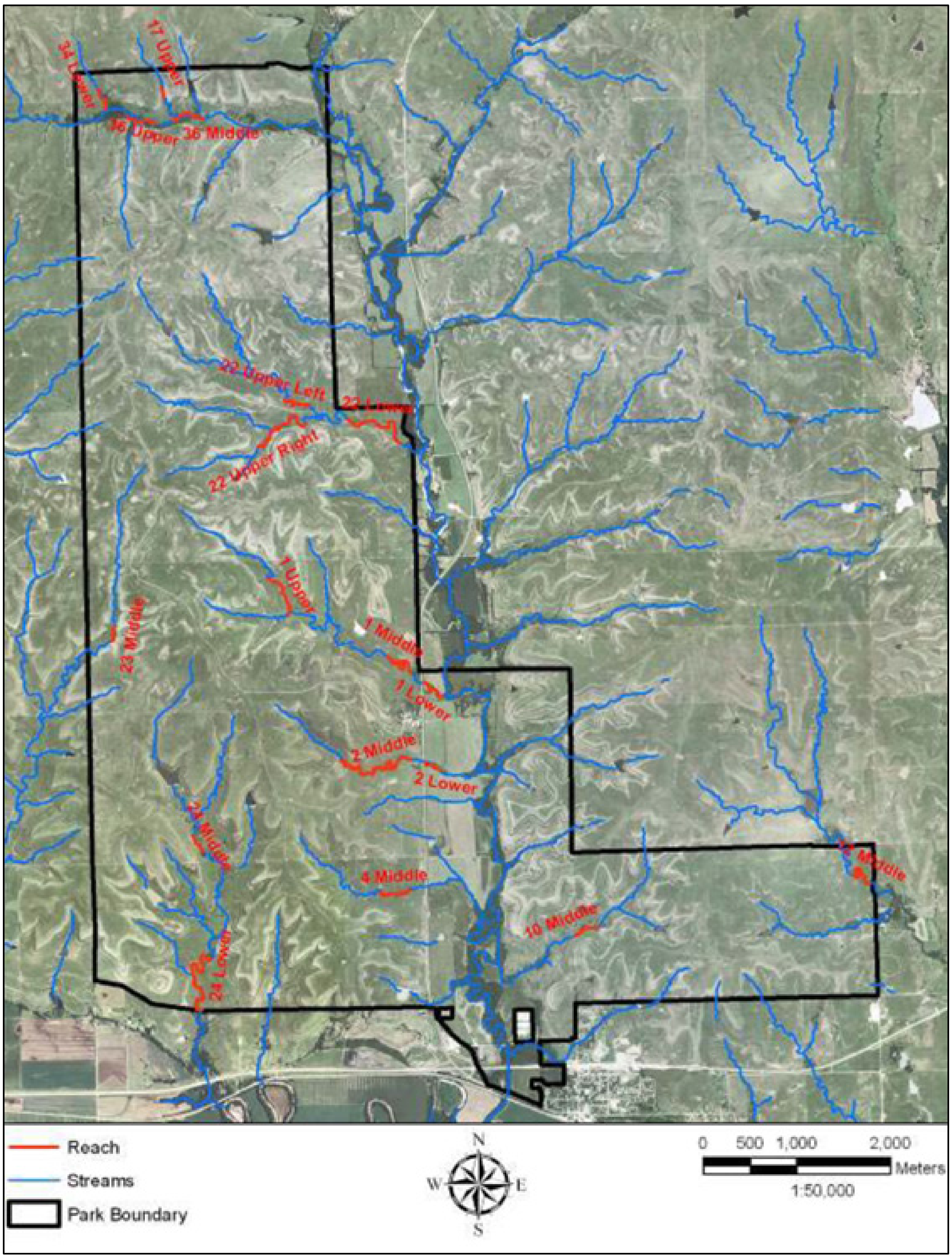


Figure 4.16-1. Locations of reaches sampled annually from 2001–2006 at Tallgrass Prairie National Preserve (graphic from Dodd et al. 2010).

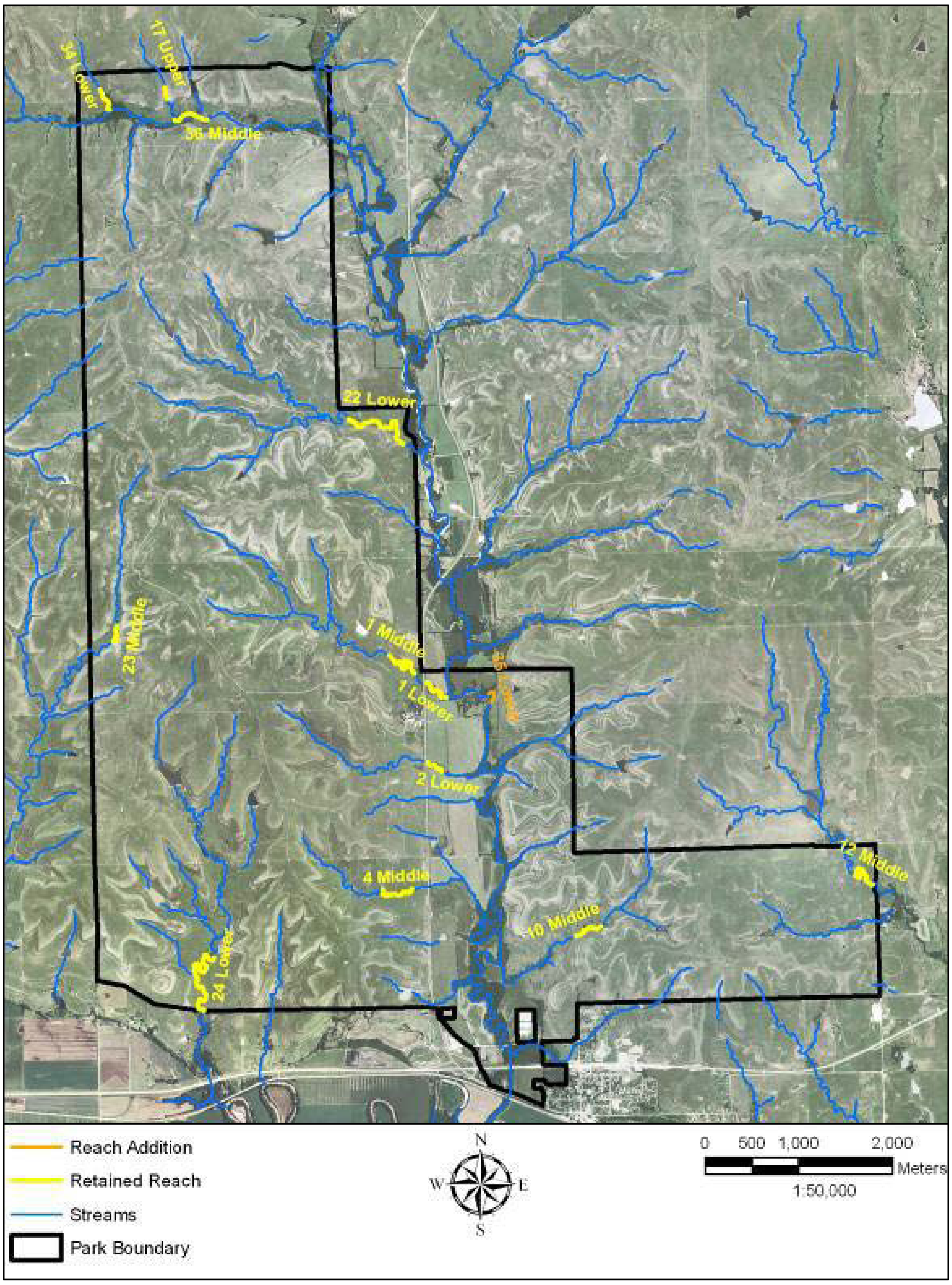


Figure 4.16-2. Locations of reaches retained and sampled annually from 2007–2010 (yellow), plus one additional reach added in 2007 (orange) and subsequently sampled annually from 2007 to 2010 (graphic from Dodd et al. 2010).

Fish Index of Biotic Integrity (IBI) values were calculated and compared between the years 2001 and 2010. The fish IBI is based on methodology developed for fish communities of the Ozark Highland streams (Dauwalter et al. 2003). It is important to note that the fish IBI was modified from Dauwalter et al. (2003) to reflect the prairie stream fish species that are present at TAPR. Specialist guilds included in the IBI tend to be associated with more pristine and less degraded freshwater habitats. Therefore, higher IBI scores reflect fish communities associated with habitats where water quality is high and with fewer land-use changes in the upland affecting instream conditions. For example, sites with higher fish IBI scores consist of a fish community with more insectivores, carnivores, darters, sculpins, madtom species, and lithophilic spawners (i.e., specialist guilds), but with fewer algivorous/herbivorous, invertivorous and piscivorous species, green sunfish, bluegill, yellow bullhead and channel catfish (i.e., generalist guilds). Communities with higher IBI scores tend to have lower occurrences of black spot or other anomalies compared to more degraded communities. An extensive discussion for why these guilds are chosen over others is found in Dauwalter et al. (2003).

The biotic or ecological "condition" described by the fish IBI, then moves along a disturbance gradient from a relatively intact, pristine, high water quality stream with high IBI scores to a more disturbed, developed or urban landscape with lower water quality and with low IBI scores. Classification of the fish species observed at TAPR into trophic and reproductive behavior guilds followed the classifications of Smogor and Angermeier (1999) as reported in Dauwalter et al (2003). The response guilds incorporated into the fish IBIs are listed in Table 4.16-1.

Table 4.16-1. Fish species guilds used to calculate the IBI score.

Biotic Integrity Element	Guild Category	Response Guild	Number of Species in Guild	Relationship to IBI Score
Functional	Trophic composition	percent algivorous/herbivorous, invertivorous and piscivorous	5	Negative
	Trophic composition	percent invertivorous	10	Positive
	Trophic composition	percent carnivorous	2	Positive
Tolerance – Intolerance	Tolerant species	percent green sunfish, bluegill, yellow bullhead and channel catfish	4	Negative
	Intolerant species	number of darter, sculpin, and madtom species	4	Positive
Physical Condition	Fish health	percent with black spot or an anomaly	14	Negative
Structural	Reproductive behavior	Number of lithophilic spawning species	19	Positive

A broader fish conservation context was evaluated by examining the native fish community to determine which species that occur at TAPR are considered species of conservation concern either nationally or in Kansas, and to assess the current status (occurrence) of those species at the preserve. To identify fish species that are of conservation priority we used species listed as either endangered or threatened by the U. S. Fish and Wildlife Service (USFWS) under the Endangered Species Act; U. S. Forest Service (USFS) and Bureau of Land Management (BLM) sensitive species lists; NatureServe G1 to G3 and S1 ranked species; and State lists of endangered, threatened and special concern species.

Most state governments have endangered species statutes or acts, which consider the species risk of extinction within the state and list at risk species as either endangered, threatened, or special concern. Listed species are then protected by regulations enforced by state governments preventing activities that negatively impact listed species populations and their critical habitat. Including fish on the condition assessment for TAPR that are listed on the Kansas State Endangered Species Act recognizes that some species may be declining dramatically at the local scale, even though they are not of high concern nationally.

4.16.3. Reference Conditions

Little historic fish survey data exist for Tallgrass Prairie National Preserve. HTLN data collected between 2001 and 2010 is the primary data source. The number of sites sampled per year varied, ranging from 18 reaches from 11 streams (2001 to 2006) to 13 reaches from 12 streams (2007 to 2010) (Figures 4.16-1 and 4.16-2). Fish reference condition for all sampled reaches is based on the initial HTLN 2001 fish survey results. Maintaining or exceeding the level of biodiversity as defined by initial calculation of native species richness (as an index of diversity) and the initial quality of fish community composition as defined by the initial IBI score are considered good condition. A rating system for departure from good condition is shown in Table 4.16-2.

Table 4.16-2. Resource condition rating framework for fish at Tallgrass Prairie National Preserve, Kansas.

Indicator	Resource is in Good Condition	Warrants Moderate Concern	Warrants Significant Concern
Native Species Richness (S)	>85–100+ % of 2001 value	70–85% of 2001 value	<70% of 2001 value
Index of Biotic Integrity	60.1–100	40.1–60.0	0–40.0
Fish Species of Conservation Concern	85–100+ % of 2001 value	70–85% of 2001 value	<70% of 2001 value

The fish IBI score reflects a disturbance gradient from relatively intact and high quality stream ecosystem with high IBI scores to more disturbed, developed or urban stream ecosystem with low IBI scores. To calculate the IBI score, species are first assigned to guilds based on taxonomic composition, trophic composition, reproductive composition and fish condition (some species may be assigned to more than one guild, depending on their life history traits). The proportional richness of each guild is then calculated by dividing the number of individuals or species detected within a specific guild by the total number of individuals or species detected.

The next step in the fish IBI is to standardized metrics to score from 0 to 10 by developing threshold limits and linear equations after Dauwalter (2003). Threshold limits were minimum, 50th, and 95th percentile values for individual sample reaches of parks within the HTLN. After determining threshold limits, we adjusted each metric to score from 0 (very poor condition) to 10 (good condition) by using the equation:

$$MS = A + (B \times MR)$$

where MS = metric score, MR = raw metric value calculated from the sample reach data, A = the y-intercept in the regression of MS versus MR, and B = the slope in the regression of MS versus MR. Regressions were computed from the points for the upper and lower thresholds, which were assigned scores of 0 or 10 depending on a metric's relationship with stream site quality. Finally, IBI scores were standardized to score from 0 to 100. The final fish IBI score was calculated as follows:

$$IBI = \frac{(\sum_{i=1}^{N} MS_i) \times 10}{N}$$

where IBI = IBI score, MS = metric score of the i^{th} metric, and N = the number of metrics.

A community at the theoretical maximum high IBI score, or highest integrity, consists of a fish community with only specialist guilds and without any generalist guilds.

Threshold levels for fish IBI scores have not been rigorously defined, but Dauwalter et al. (2003) established thresholds that include four categories of condition corresponding to the standardized fish IBI score. For the fish IBI score at TAPR these thresholds include the following categories: 1) excellent (highest-integrity) – score of 80.1–100.0; 2) good (high-integrity) – score of 60.1–80.0; 3) fair (medium integrity) – score of 40.1–60.0; 4) poor (low-integrity rural and low-integrity urban) – score of 20.1–40.0; and 5) poorest (lowest integrity) – score of 0–20.0. To accommodate the three tiered nature of the assessment framework the two highest condition categories were combined into a single “high integrity” category, the middle class was considered a “fair integrity” category, and the two lowest condition categories were combined into a single “low integrity” category for the fish community at TAPR (Table 4.16-2).

We also compared the candidate list of species of concern to the actual list of species observed at TAPR during the 2011 survey. We used the number of species of concern recorded in the initial survey year of 2001 as the reference condition for comparison. The condition of the resource is considered higher if more species of concern are observed. This implies that the populations of those species are increasing and/or they are using the preserve more. A rating condition framework integrating reference condition concepts for native fish is shown in Table 4.16-2.

4.16.4. Condition and Trend

Species Richness

A total of 12 species were recorded at stream sampling stations in 2010; the most common species was the redfin shiner (*Lythrurus umbratilis*). Mean native species richness per sample reach in 2010 of 8.3 was similar to the 8.1 species recorded in 2001 (Figure 4.16-3). The creek chub (*Semotilus atromaculatus*), central stoneroller (*Campostoma anomalum*) and green sunfish (*Lepomis cyanellus*) were moderately common (Table 4.16-3). This total is only one half of the 24 species recorded during the 2001 fish survey at TAPR.

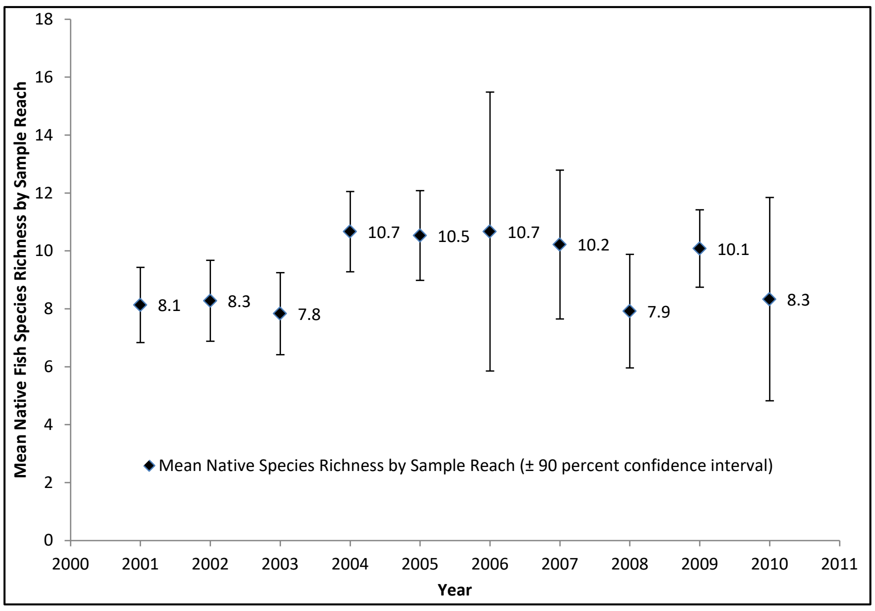


Figure 4.16-3. Means and 90 percent confidence intervals for native fish species richness per sample reach at Tallgrass Prairie National Preserve from 2001 to 2010.

Table 4.16-3. Fish species recorded in 2010 and 2001 at fish survey stations on Tallgrass Prairie National Preserve.

Common Name	Species Name	Number Observed 2010	Number Observed 2001	USFS and Federal ESA List Status[A]	Nature Serve Global Rank	State List Status[B]
Black bullhead	*Ameiurus melas*	6	0	–	G5	–
Blackstripe topminnow	*Fundulus notatus*	0	49	–	G5	–
Bluegill	*Lepomis macrochirus*	12	5	–	G5	–
Bluntnose minnow	*Pimephales notatus*	42	188	–	G5	–
Brook silverside	*Labidesthes sicculus*	0	3	–	G5	–
Cardinal shiner	*Luxilus cardinalis*	10	787	–	G4	SINC
Carmine shiner	*Notropis percobromus*	0	1	–	G5	–
Central stoneroller	*Campostoma anomalum*	140	1615	–	G5	–
Common carp	*Cyprinus carpio*	0	490	–	G5	–
Creek chub	*Semotilus atromaculatus*	234	198	–	G5	–
Fathead minnow	*Pimephales promelas*	0	108	–	G5	–
Green sunfish	*Lepomis cyanellus*	130	355	–	G5	–
Johnny darter	*Etheostoma nigrum*	0	1	–	G5	–
Largemouth bass	*Micropterus salmoides*	0	3	–	G5	–
Longear sunfish	*Lepomis megalotis*	8	8	–	G5	–
Mimic shiner	*Notropis volucellus*	0	1	–	G5	–
Mosquitofish	*Gambusia affinis*	0	129	–	G5	–
Orangespotted sunfish	*Lepomis humilis*	8	17	–	G5	–
Orangethroat darter	*Etheostoma spectabile*	61	367	–	G5	–
Redfin shiner	*Lythrurus umbratilis*	338	280	–	G5	–

[A] U. S. Fish and Wildlife Service Federal Status: LE = listed endangered, LT = listed threatened, P = proposed, C = candidate.

[B] State Status: SE = state endangered, ST = state threatened, SINC = state Species in Need of Conservation.

Table 4.16-3 (continued). Fish species recorded in 2010 and 2001 at fish survey stations on Tallgrass Prairie National Preserve.

Common Name	Species Name	Number Observed 2010	Number Observed 2001	USFS and Federal ESA List Status[A]	Nature Serve Global Rank	State List Status[B]
Sand shiner	*Notropis ludibundus*	0	105	–	G5	–
Slim minnow	*Pimephales tenellus*	0	23	–	G5	–
Spotted sucker	*Minytrema melanops*	0	1	–	G5	SINC
Topeka shiner	*Notropis topeka*	2	7	LE	G3	ST
Yellow bullhead	*Ameiurus natalis*	0	6	–	G5	–

[A] U. S. Fish and Wildlife Service Federal Status: LE = listed endangered, LT = listed threatened, P = proposed, C = candidate.

[B] State Status: SE = state endangered, ST = state threatened, SINC = state Species in Need of Conservation.

The slope of the linear regression line for mean native fish species richness per sample reach was positive, but not statistically significant ($r^2 = 0.04$, $p = 0.58$), suggesting an unchanging trend in the richness of the fish community at TAPR. The 90 percent confidence intervals for native species richness for the years 2001 to 2010 overlap, also suggesting stability in native species richness since 2001 (Figure 4.16-3). The confidence intervals also suggest low precision in the calculated values of mean species richness for the years 2006, 2007 and 2010. In 2010, there were 8.3 mean native fish species per sample reach recorded at TAPR, which is greater than the management target of 85% of 8.3, the value recorded in 2001 when monitoring was initiated at TAPR. The mean native fish species richness per sample reach recorded in 2010, when compared to the 2001 value, indicates species richness is in good condition (Table 4.16-3).

Index of Biotic Integrity

The mean fish IBI score per sample reach in 2010 was 71.0 compared to the 2001 score of 58.4. This IBI score indicates that composition of the fish community at TAPR in 2010 was in good condition (Table 4.16-2). The slope of the linear regression line for the fish IBI scores was positive, but not statistically significant ($r^2 = 0.28$, $p = 0.12$), indicating stability in the biotic integrity of the fish community between 2001 and 2011. The 90 percent confidence intervals for the scores overlap, also suggesting the biotic integrity of the fish community has not changed since 2001, when monitoring was first initiated at TAPR (Figure 4.16-4). The confidence intervals also suggest low precision in the calculated value of mean species richness for the year 2010.

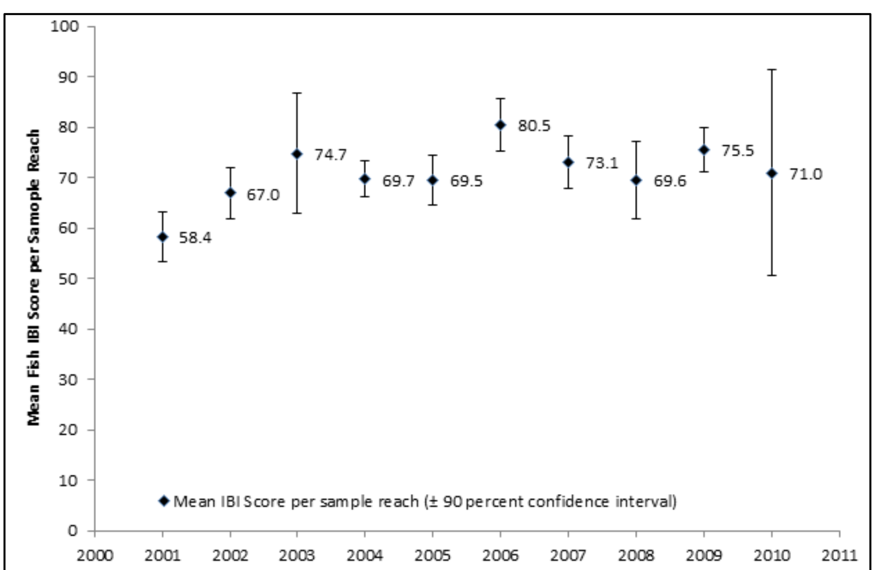


Figure 4.16-4. Means and 90 percent confidence intervals for fish species IBI scores at Tallgrass Prairie National Preserve from 2001 to 2010.

Species of Concern

The Topeka shiner is listed as endangered by the USFWS under the Endangered Species Act and is also ranked G3 by NatureServe. This fish was recorded during both the 2001 and 2010 surveys with the number recorded decreasing in 2010 (Table 4.16-3). Survey effort declined by 28%, from 18 reaches surveyed in 2001 to 13 in 2010, making it possible that the decrease noted in 2010 is an artifact of the difference in sampling effort between the two years. This decrease, although in absolute terms included only 5 few individuals, was a decrease in the Topeka shiner population of over 71 percent at TAPR.

The slope of the linear regression line for the mean number of fish species of concern per sample site was negative, but not statistically significant ($r^2 = 0.19$, $p = 0.21$), suggesting an unchanging trend in the number of fish species of concern present at TAPR. The 90 percent confidence intervals for the mean number of species of concern per sample site also suggest an unchanging trend since 2001 (Figure 4.16-5). The confidence intervals also suggest low precision in the calculated values of mean species of concern for most years analyzed. In 2010, the mean number of fish species of concern per sample site at TAPR numbered 0.33, less than the management target of 85 percent of 1.07, the number recorded in 2001 when fish monitoring was initiated at TAPR. The mean number of fish species of concern recorded per sample reach in 2010, when compared to the 2001 value, warrants significant concern (Table 4.16-2).

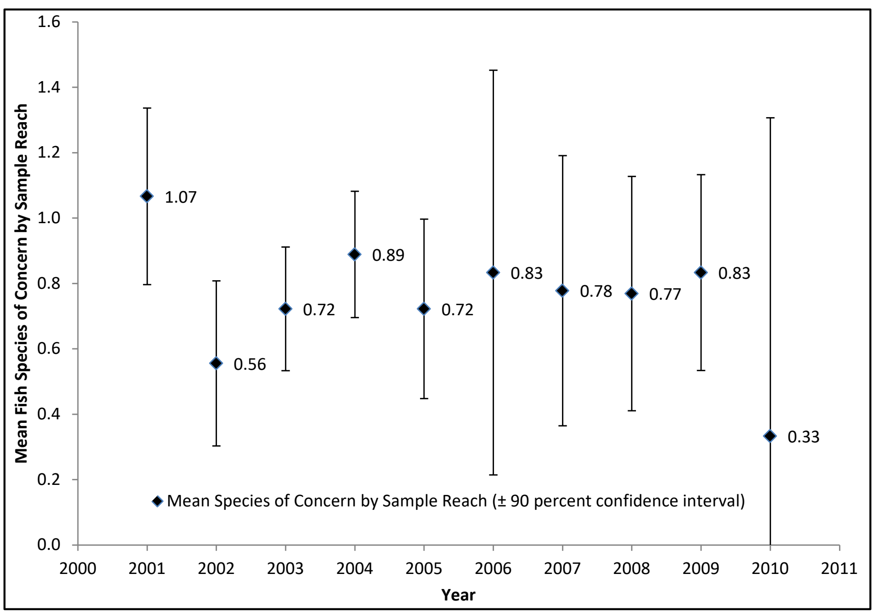
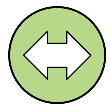
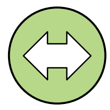
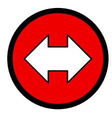
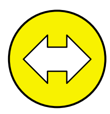


Figure 4.16-5. Means and 90 percent confidence intervals for number of fish species of concern at Tallgrass Prairie National Preserve from 2001 to 2010.

<u>Overall Condition and Trend</u>

The values for the metrics of native species richness, the fish IBI, and the number of species of concern present in 2010 indicate that fish community condition warrants moderate concern. The federally-listed endangered Topeka shiner is present and a community structure is generally representative of a moderately disturbed landscape (Table 4.16-4). Data from 2001 to 2010 suggest an unchanging trend in fish community diversity and structure at TAPR.

Table 4.16-4. Condition and trend summary for fish at Tallgrass Prairie National Preserve.

Indicator	Condition Status/Trend	Rationale
Native Species Richness (S)		Mean native fish species richness per sample reach has fluctuated between 7.8 and 10.7 species from 2001 to 2010 with mean richness equaling 8.3 in 2011 (good condition), greater than the management target of 85 percent of 8.1. Analysis of the fish monitoring data indicates an unchanging trend in native species richness from 2001 to 2010.
Fish Index of Biotic Integrity		In 2010, the mean fish IBI score per sample reach was 71.0 (good condition). Analysis of the mean fish IBI scores indicates an unchanging trend in the biotic integrity of the fish community between 2001 and 2010.
Species of Conservation Concern		The mean number of fish species of concern per sample site fluctuated between 0.33 and 1.07 species from 2001 to 2010 with 0.33 species of concern present in 2010 (warrants significant concern), less than the management target of 85 percent of 1.07. Monitoring data indicates an unchanging trend in the mean number of species of concern and their abundance between 2001 and 2010.
Fish Overall		**Condition warrants moderate concern with an unchanging trend. Confidence in the assessment is medium.**

4.16.5. Uncertainty and Data Gaps

Assessments of ecological change should preferably use long-term data spanning decades (Holmes 2010 and Magurran et al. 2010). The 10 years of monitoring data available for this assessment is a good foundation and continued monitoring will enable the assessment of variability over time and space and assure the accuracy of the assessment (Dornelas et al. 2012).

Another factor affecting the quality of the data is the probability that a fish that is present during the seine sampling is occurring is detected. Electrofishing would likely improve the probability of detecting a species, but because each stream reach is surveyed only once per year, there is always the chance that rare species will go undetected. This can be a problem when assessing native species richness and the number of species of conservation concern, and when calculating the index of biotic integrity, which is calculated based on the number of species within different guilds.

In addition, there were differences in sampling effort with more stream reaches being sampled in some years of monitoring. This confounding influence makes it difficult to identify whether differences in the indicator values, by year, result from true changes in their values or are an artifact of the variation in sample effort. Sampling the same stream reaches and the same number of reaches in every year of monitoring would control for this bias. However, by comparing the mean value of the indicators for each stream reach sampled, we can, to some extent, control for unequal sample sizes and can examine differences in the values of the indicators by year.

4.16.6. Sources of Expertise

- Hope Dodd, a Fisheries Biologist, Heartland I&M Network and Prairie Cluster Prototype Programs. Hope is responsible for collecting the monitoring data at TAPR upon which this assessment is based and also for leading the design of the protocol used to monitor fishes at parks of the HTLN (Dodd et al. 2008). Her research interests focus on anthropogenic disturbances in lotic systems and assessment of these long-term effects on water quality, habitat, and biota.

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4.17. Greater Prairie-Chicken

4.17.1. Background and Importance

The greater prairie-chicken (*Tympanuchus cupido*), a member of Family Phasianidae (grouse and turkeys), was historically found throughout the prairielands of central United States, with a discontinuous population along the northeastern coast (Robb and Schroeder 2005)(Figure 4.17-1). It is considered a Tier I species of greatest conservation need by the State of Kansas (Wasson et al. 2005) in both prairie and deciduous floodplain habitats. The species is iconic within the Great Plains grasslands and at Tallgrass Prairie National Preserve (TAPR), and is popular both with birders and as a game species. The species extended its range into grassland habitats to the northwest as far as Alberta and westward into Colorado in the 1800s (Figure 4.17-2). Range extension was facilitated by grassland regeneration once bison populations were severely decimated and via scattered grain farms that provided supplemental food and cover (Svedarsky et al. 2000). However, populations began to decline as grassland habitats became more isolated and were replaced by intensive agricultural development across the Great Plains. Though the combined subspecies once occupied a vast range across the central United States, from Canada through Texas and east to the Atlantic, the greater prairie-chicken now exists in restricted areas across a fragmented landscape. The population at TAPR exists within the pre-European settlement geographic range of the species.

Figure 4.17-1. Greater prairie chicken at Tallgrass Prairie National Preserve (NPS photo).

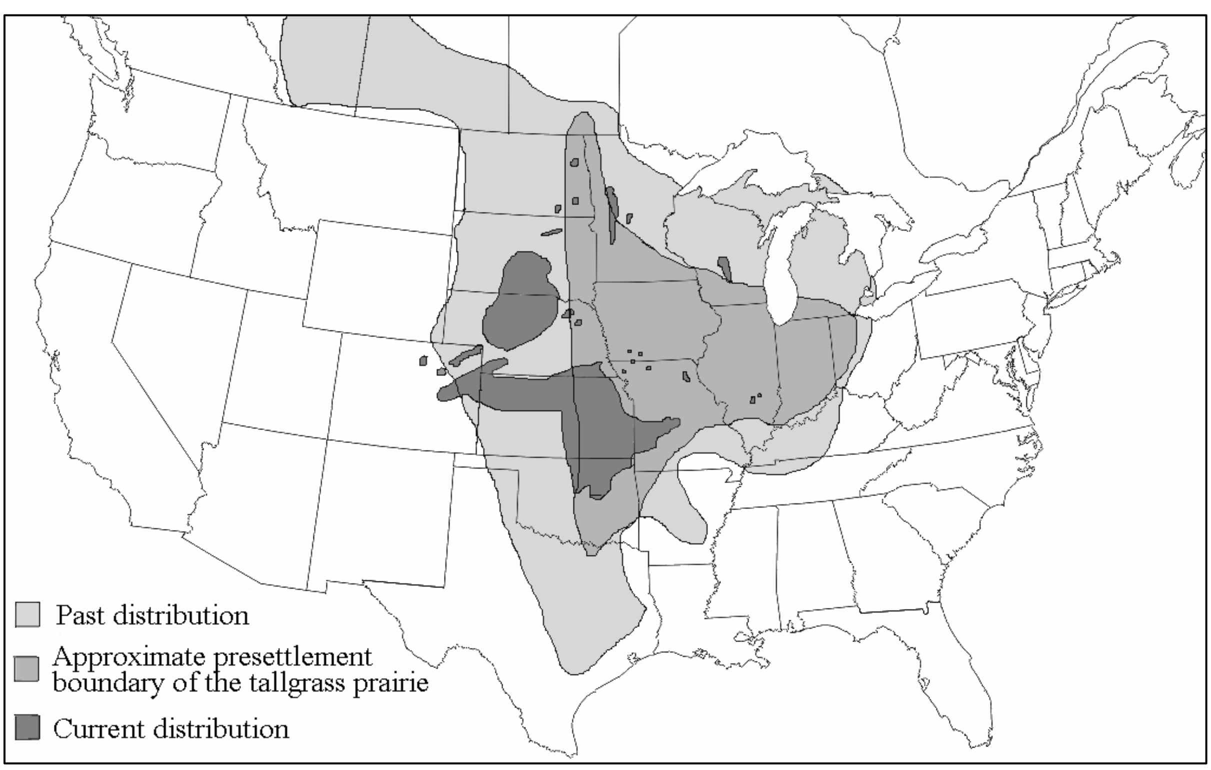


Figure 4.17-2. Breeding distribution of greater prairie-chicken in the United States and southern Canada. Past (adapted from Schroeder and Robb 1993) and current (adapted from Westemeier and Gough 1999), distribution of the greater prairie-chicken in North America. Solid line delineates the approximate presettlement boundary of the tallgrass portion of the prairie biome (adapted from various sources) (graphic from Svedarsky et al. 2003).

The species includes two extant subspecies—Attwater's prairie-chicken (*T. c. attwateri*) in coastal prairies of Texas and the more-broadly distributed greater prairie-chicken (*T. c. pinnatus*) (herein, "prairie-chicken"), as well as the extinct heath hen (*T. c. cupido*), which was extirpated from the northeastern United States. The Attwater's prairie-chicken is an endangered species under the Endangered Species Act (USFWS 1967).

The greater prairie-chicken is very similar in appearance to the federally-threatened lesser prairie-chicken, although slightly larger and with somewhat darker plumage. The prairie-chicken is a medium-sized (2–3 lbs., 18 in. long, 28 in. wingspan) bird approximating the size of a chicken. It is a ground-dwelling bird with heavily-barred plumage of white and shades of brown. Its short tail is usually darker, rounded, and can be pitched vertically when the bird is displaying. When males are in courtship, feathers on either side of the neck are erect, unfeathered yellow/orange patches above the eyes are displayed, and unfeathered orange/red sacs along the lateral sides of the neck are inflated.

Prairie-chicken distribution has greatly contracted since the early 1900s to remnant tallgrass and midgrass prairies of Wisconsin, Minnesota, Nebraska, Kansas, South Dakota, with isolated populations in North Dakota, Illinois, and Iowa (Robb and Schroeder 2005) (Figure 4.17-2). General habitat descriptions for prairie-chicken identify open, contiguous mid-to-tallgrass prairies with rolling hills and sparse or interspersed scrub or shrubs. Depending on where you are in the prairie-chicken range, the habitat can vary from tallgrass prairie, to rolling sandhill prairie, to grassland scrub.

Prairie-chickens are most easily observed during breeding season when males are actively attracting and competing for mates at leks. Leks are areas that are sparsely vegetated and slightly elevated compared to the surrounding area. For example, lek sites in the Flint Hills of Kansas typically consist of vegetation less than 50 cm in height (Horak 1985), and lek sites in eastern Colorado consist of vegetation less than 10 cm in height (Schroeder and Braun 1992). In contrast, nesting habitat is characterized by more consistent, dense grass cover. Nests are bowls of grass, leaves, and feathers in areas with higher vertical vegetation cover and greater ground cover for nest concealment.

After fledging, the hen and chicks alter habitat use to areas that have less cover and are recently disturbed (Svedarsky 1988). Disturbance can be fire, grazing, haying, mowing, or other disturbances that reduce cover near the ground, but that can provide food resources, easy travel for chicks, and have regenerated enough to provide concealment. Winter habitat use for prairie-chickens switches to consistently dense vegetation or snow for roosting (mid-day, night).

As with many wildlife species, the diet for prairie-chickens is dependent on season, age, sex and availability. Common food items include grains, leaves, buds, and insects, with grains being dominant for adults and insects being dominant for juveniles (Robb and Schroeder 2005). Primary predators for adult prairie-chickens are avian raptors, including hawks and owls, and coyotes, while nest predators are a more diverse mammalian assemblage, including skunks, badgers, raccoons, ground squirrels, and opossums (Robb and Schroeder 2005).

At TAPR, the success of prairie-chicken populations is dependent upon the continuity of quality habitat for necessary roosting, nesting, and fledging habitat, but also as a refuge from severe stochastic weather events. Timing and severity of spring precipitation can cause nest destruction, nest abandonment, or direct mortality, while severe winter cold and precipitation can increase mortality rates. Insect populations, which are vital for juvenile survival, are sensitive to periodic drought and can limit growth of population growth of grouse and their relatives (Flanders-Wanner et al. 2004).

<u>Threats and Stressors</u>

The biggest threat for prairie-chickens at TAPR, as in other parts of the species' range, is the availability of landscape-level habitat matrices that allow for seasonal, sex-specific, and age-specific habitat needs (Robb and Schroeder 2005). Optimizing available habitat for prairie-chickens may require expanding the amount of area dedicated to less intensive grazing and burning regimes. The Kansas Coordinator for Partners in Flight Program has voiced concerns regarding regional declines in species such as the greater prairie-chicken (NPS 2000). Regional declines in populations of some avian species such as the greater prairie-chicken may be in part due to the practice of annual spring burning and early intensive stocking, which reduces vegetative cover during the nesting season

(Kansas Biological Survey personal communication 1998 cited in NPS 2000). Evidence from Kansas suggests these impacts have likely contributed to the 75–80% decline in the greater prairie-chicken population over the past 20 years (Johnson et al. 2011). Encroachment on grasslands by trees and other woody vegetation can have a negative impact on prairie-chicken habitat (Hagen et al. 2005, Johnson et al. 2011).

Breeding success was greatest in areas that avoided annual burning and early-season grazing. Expanding the amount of acreage with year-long grazing and longer timespans between burns may increase prairie-chicken breeding and population size (Robbins et al. 2002). At TAPR, approximately 3,800 acres per year are managed using a patch-burn grazing strategy that optimizes habitat conditions for a variety of native grassland wildlife.

There are a host of avian and mammalian predators on prairie-chickens, but the intensity of this predation pressure varies with the availability of alternate prey items and predator foraging strategies (Schroeder and Baydack 2001). Scarcity of primary prey items can increase predator search effort and increase the likelihood of encountering prairie-chicken nests, juveniles, and adults. However, habitat quality and availability can play a role in predation pressure. As habitat fragmentation increases prairie-chickens may increase movement to access ideal habitat patches, thus exposing themselves to predator detection more frequently. Also, predation pressure can increase as predator density and diversity are higher in these areas (Schroeder and Baydack 2001).

Indicators and Measures

- Population estimates: traditional lek surveys, other lek-based indices and mark-resight population estimates
- Breeding success
- Vulnerability to climate change

4.17.2. Data and Methods

CSU worked with TAPR to gather existing lek survey data and scoured the published literature for relevant prairie-chicken population data. Long-term lek data were available for the Flint Hills region (McNew 2010), and short-term lek data at TAPR was sporadic from 2001 to present (Clifton 2003, Foote 2009, unpublished field notes from G. J. Horak 2008–2011).

The vulnerability of the prairie-chicken to climate change effects was evaluated using the Climate Change Vulnerability Index (CCVI) (Young et al. 2011). The CCVI is a Microsoft Excel-based spreadsheet tool developed by NatureServe. It is designed as a rapid-assessment tool intended to be used primarily for practical planning purposes by natural resources managers and USFWS staff. It is designed to be complementary to the NatureServe Conservation Status ranks and other information, but it does not duplicate information in those ranks such as the size of a specific population. The intended application scale of the tool is up to the state or province level. The primary purpose of the CCVI is to produce a relative ranking or priority list for species of concern with respect to climate change vulnerability. The CCVI divides vulnerability into two components: 1) exposure to climate change within the assessment area (e.g., a highly sensitive species will not suffer if the climate where it occurs remains stable), and 2) sensitivity of the species to climate change (e.g., an adaptable species will not decline even in the face of significant changes in temperature and/or precipitation).

4.17.3. Reference Conditions

Understanding the extent and quality of prairie-chicken habitat on TAPR in a historical context is challenging. Prior to the establishment of TAPR in 1996, the nearly 11,000 ac of prairie was used for various degrees of grazing, with various levels of spring burning to regenerate grasses and improve forage production (Foote 2009). TAPR is co-managed by the NPS and TNC, with a majority of the pasture lands maintained in uncultivated grasslands.

Because the history of active land use and management in the region precedes accurate records of prairie-chicken abundance at TAPR, it is difficult to find a reference condition that adequately portrays the true potential of prairie-chicken production. Long-term lek count data suggest that densities reached some of their highest levels in the late 1970s and early 1980s, when mean prairie-chicken density was approximately 4 males per km^2 for multiple years (Clifton 2003). However, land management practices of that era and those still prevalent today, emphasizing annual spring burning followed by intense grazing, can be detrimental to prairie-chicken production (Applegate and Horak 1999, Robbins et al. 2002). Likely, the best management practices are ones that mimic the frequency, severity, and patchiness of historic lightning-caused prairie fires with less-concentrated grazing (Hartnett et al. 1996, Reinking 2005). Burning every 3–5 years with year-long, less-intensive grazing creates advantageous mosaics of leking, nesting, brood-rearing, roosting, and winter habitat (Robb and Schroeder 2005). Peaks in prairie-chicken abundance may have coincided with such diverse habitat matrices when croplands were limited to less than 25% of the overall landscape (Svedarsky et al. 2003). Reference conditions for breeding success are poorly defined for the area. Recent data collected in and near TAPR is used as a condition benchmark representing moderate management concern. The results for climate change vulnerability were not used in the condition rating, but did weight in for the trend rating.

4.17.4. Condition and Trend

<u>Population Estimates</u>

Lek Counts and Related Data

The most-consistent data on prairie-chicken abundance comes from traditional lek surveys. This method provides an index of prairie-chicken populations by driving prescribed routes and stopping periodically to listen for male booming (Horak and Applegate 1998). This technique is popular because it is easy to implement, is relatively inexpensive, and the data from it are easily analyzed (Clifton and Krementz 2006). Traditional lek surveys in the region are performed twice in the spring (20 March–20 April) each year. The survey consists of driving a 16-km route and stopping every 1.6 km to listen for 3 minutes for male booming. After the survey, individuals drive the route and flush birds at each lek to determine the number of males. Since it assumes that booming will be heard if it is within 1.6 km of either side of the driving route, the area relevant for the survey is 51.2 km^2 (3.2 km x 16 km), and numbers are expressed as number of males per area.

Based on historic data of male density at lek sites (Figure 4.17-3), there is some variability in annual prairie-chicken abundance. The historic data (1968–2009) suggest the regional population is declining but with comparably low numbers during the early 1970s and early 2000s. More severe declines may be underway from the 1980s when lek counts were at their highest to the early 2000s (Figure 4.17-3).

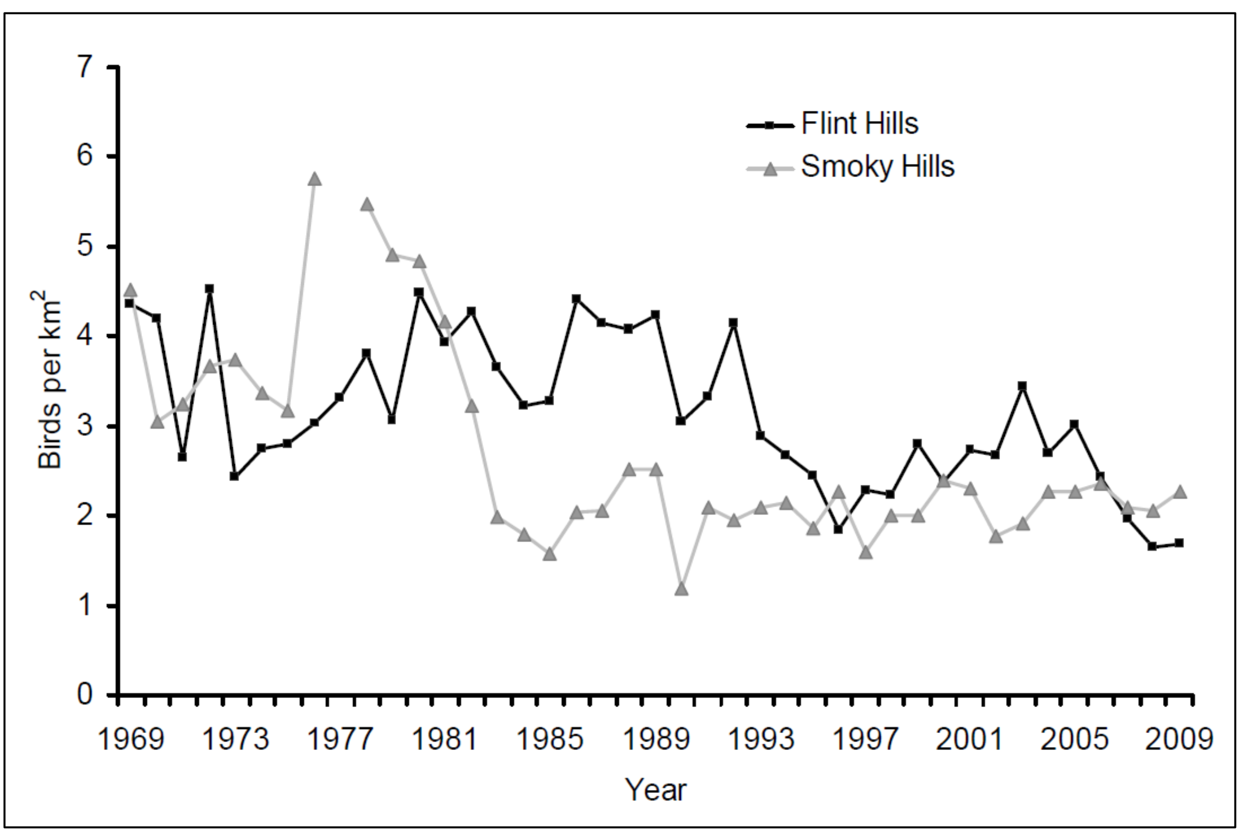


Figure 4.17-3. Density of male greater prairie-chickens on the Flint Hills and Smoky Hills regions of Kansas, 1968–2009 (unpublished data, Kansas Department of Wildlife and Parks from McNew (2010)).

The abundance of prairie-chickens at TAPR is less well understood. In 2002, density of males ranged from 0.1/km^2 to 0.7/km^2 using 13 survey routes over a 529 km^2 area of TAPR (Clifton 2003). There is a gap in data from 2002 until 2006. Foote (2009) collected data at lek sites from 2006–2008 but the traditional lek count methodology was not followed. The number of males observed while conducting 10–11 lek counts (5x more than typically done) at 11 leks more than doubled between 2006 and 2007, and increased only slightly from 2007 to 2008 (Figure 4.17-4). Interestingly, the proportion of known lek sites occupied (naïve estimate based on presence at a lek) by prairie-chickens increased steadily from 2006 to 2008 (Figure 4.17-4), suggesting that growth in the male population may have led to increased use of available habitat at TAPR. The number of females documented each year decreased from 14 to 3 over the 3 years. Because Foote was unable to identify the sex of 36, 19, and 33 individuals in 2006, 2007, and 2008, respectively, the trend in female abundance may not be accurate. It is possible that the number of females has been stable, but was undetected because the sex of many individuals was undetermined.

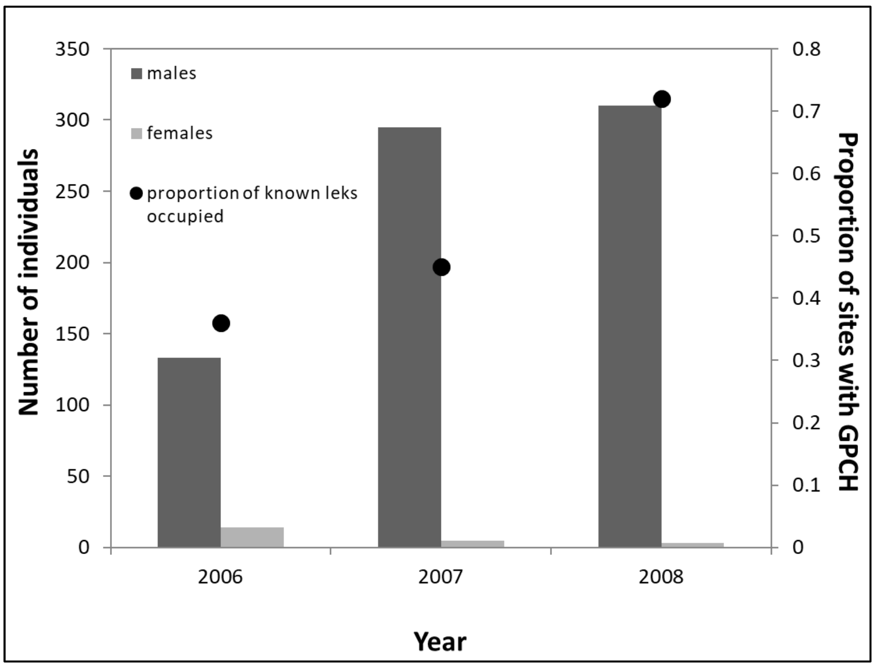


Figure 4.17-4. Proportion of 11 known prairie-chicken leks occupied, number of males observed, and number of females observed at Tallgrass Prairie National Preserve, 2006–2008 (Foote 2009).

Lek data collected by Jerry Horak (Figure 4.17-5) suggest the population increased between 2008 and 2010. These data were collected using a traditional lek count methodology and equate to densities of 0.6, 1.2, and 1.8 males/km^2 in 2008, 2009, and 2010, respectively. These densities are greater than those recorded by Clifton (2003) during her surveys in 2002, but are well below those estimated for the region (Figure 4.17-3).

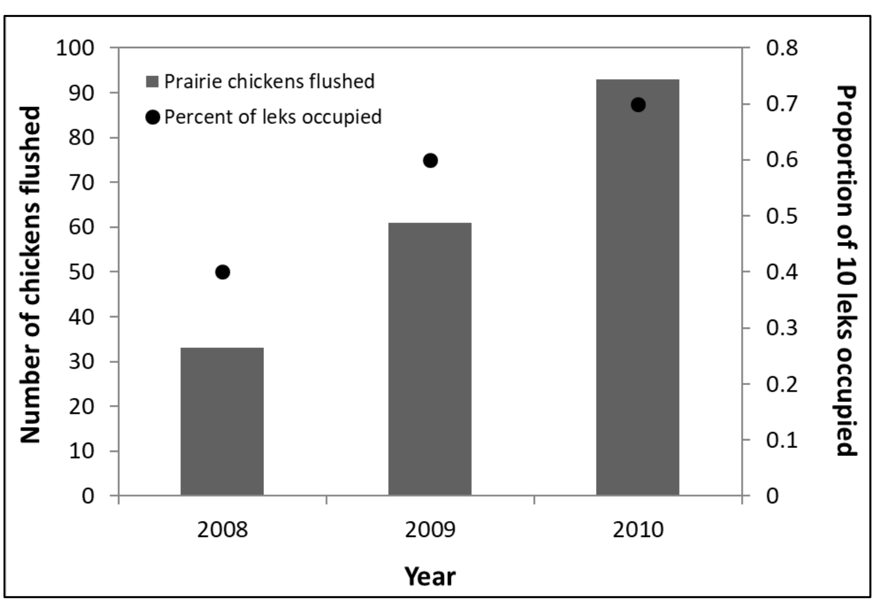


Figure 4.17-5. Number of greater prairie-chickens flushed and proportion of leks occupied at Tallgrass Prairie National Preserve, Kansas 2008–2011 (Horak undated).

Both Foote (2009) and Horak surveyed in 2008 but observed different levels of occupancy (0.7 vs. 0.4, respectively; Figs. 4.17-4, 4.17-5). This suggests that timing of survey, observer, or other factors play a role in prairie-chicken detectability and can lead to different conclusion regarding population status (Clifton and Krementz 2006).

Data collection methodology changed again in 2011, as prairie-chicken population data collection transitioned to Kansas State University (McNew et al. 2011, Sanderson et al. 2012). Based on numbers of males and females captured at leks, the population appears to have decreased, especially in respect to the number of males (if capture probability was 100%) (Figure 4.17-6). Interestingly, breeding habitat may have increased as males dispersed to greater number of leks in 2012 (26 compared to 17 in 2011). It is unclear, however, if effort to capture prairie-chickens for the on-going telemetry study was 100% successful at capturing all available individuals at a lek. Also, it is unclear if all available leks were surveyed during these years.

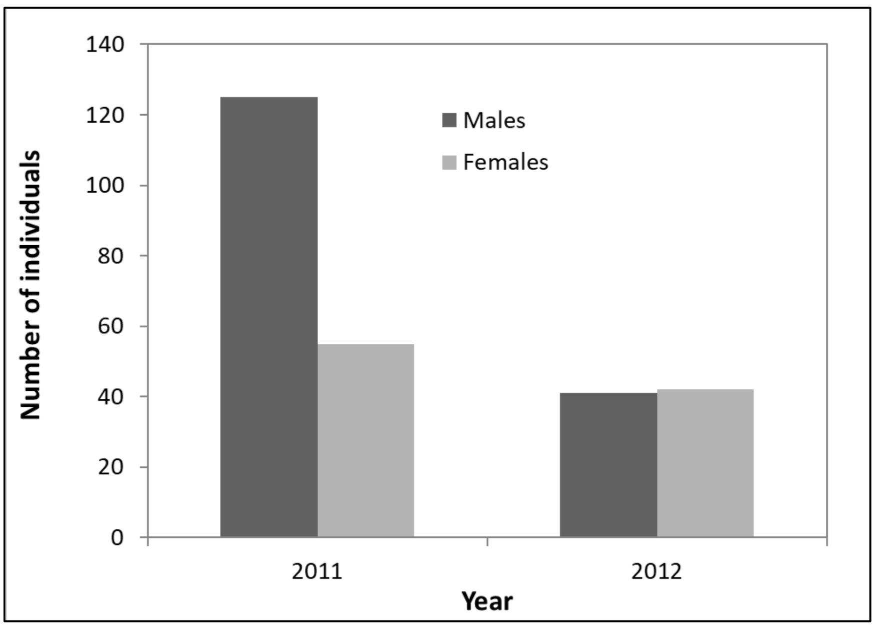


Figure 4.17-6. Number of male and female greater prairie-chickens at Tallgrass Prairie Preserve, Kansas, in 2011 and 2012 (McNew et al 2012, Sanderson et al. 2012).

Unfortunately, site-specific prairie-chicken population data collection has not been standardized on TAPR making it is challenging to determine trends in abundance. Probably the best indicator of prairie-chicken population condition can be extracted from regional data collection by Kansas Department of Wildlife and Parks (KDWP) (Figure 4.17-3), which suggests populations have been steadily declining since the 1980s. Horak's data from 2008–2010 appears to be collected using traditional lek count methodology and may be comparable with the KDWP data for the region. If so, then TAPR prairie-chicken populations are similar to the historic estimates from throughout the Flint Hills region and may be stable.

Extrapolation of traditional lek count data to population trend is further complicated by the lack of estimation of detectability of individuals (Clifton and Krementz 2006). Although the traditional lek count protocol is widely recognized as the most popular sampling process it fails to address the probability of detecting birds (Applegate 2000). For example, the probability of detecting males and females at a lek is different because of the displaying behavior of males. Additionally, detectability can be affected by landscape, weather, animal age, survey methodology, and observer abilities (Clifton and Krementz 2006). Techniques that account for detectability will provide reliable information for population status and trend (Applegate 2000). These results for lek counts and related measures indicate that the prairie-chicken population warrants moderate concern with an unchanging trend.

Mark-Resight Population Estimates

The best (i.e., least biased) data on prairie-chicken populations at TAPR come from efforts to estimate population size using mark-resight techniques (Clifton 2003, Clifton and Krementz 2006). Mark-resight techniques estimate population size based on the observations of unmarked and marked individuals during sampling periods (Williams et al. 2002). On the northern section of TAPR in

Chase County, Clifton and Krementz (2006) captured and tagged birds with telemeters, and then returned to observe tagged and untagged birds, comparing results to traditional lek counts. In 2002, they estimated population size at 50–59 birds in this section of TAPR, compared to 7–34 birds using traditional lek counts (Clifton and Krementz 2006). Not only are the traditional lek counts less precise, but are biased low. Radio telemetry can be an expensive method of marking and resighting prairie-chickens, but it is possible to use leg color-banding, or a combination of telemetry and leg banding as the marking technique (Clifton and Krementz 2006).

Although the reference condition for this metric is not well established, and continuity in monitoring approaches has been poor, available data indicates that populations are moderate in size and may currently be stable. The indicators for population size warrant moderate concern with an unknown trend and low confidence.

Breeding Success

There are limited data on prairie-chicken breeding success at TAPR, but recent studies provide baseline metrics for comparison (McNew et al. 2011, Sanderson et al. 2012). Apparent nest success (percent of nest that produced chicks) in 2011 was 34% with the greatest proportion of nests (27%) found in patch-burned, grazed landscapes that comprised a minority (7%) of the landscape but had some of the highest nest success (50% apparent nest success). In 2012, apparent nest success was approximately 28% with a majority (58%) of successful nests being found on grazed lands that were burned 2 years before. This recent data is used as a reference condition for future comparisons, and is believed to warrant moderate concern, with an unknown trend and low confidence.

Vulnerability to Climate Change

Each vulnerability factor was scored and results were compiled into an overall CCVI rating for the species (Table 4.17-1). By 2050, within its current range in Kansas the species was considered Not Vulnerable/Presumed Stable. Within TAPR, the species was also considered Not Vulnerable /Presumed Stable. Confidence in the species information used in the assessment was very high. Several factors relating to indirect exposure to climate change were ranked as slightly less vulnerable at the TAPR scale compared to the state-level scale. These results are similar to those published by Zack et al. (2010), whose CCVI assessment for the greater prairie-chicken in Bird Conservation Region 19 within the Great Plains determined that the species would be Presumed Stable under climate change.

Table 4.17-1. Summary of CCVI factor ratings for the greater prairie-chicken at TAPR.

		Degree to which Factor Influences Vulnerability	
Indicator	**Factor influencing vulnerability**	**Range Statewide**	**Within TAPR**
Indirect Exposure to Climate Change	1) Exposure to sea level rise	Neutral	Neutral
	2a) Distribution relative to natural barriers	Neutral	Neutral
	2b) Distribution relative to anthropogenic barriers	Somewhat Increase	Somewhat Increase-Neutral
	3) Predicted impact of land use changes resulting from human responses to climate change	Somewhat Increase-Neutral	Neutral
Sensitivity to Climate Change	1) Dispersal and movements	Somewhat Decrease	Somewhat Decrease
	2ai) Predicted sensitivity to changes in temperature: historical thermal niche	Neutral	Neutral
	2aii) Predicted sensitivity to changes in temperature: physiological thermal niche	Neutral	Neutral
	2bi) Predicted sensitivity to changes in precipitation, hydrology, or moisture regime: historical hydrological niche	Somewhat Increase-Neutral	Somewhat Increase-Neutral
	2bii) Predicted sensitivity to changes in precipitation, hydrology, or moisture regime: physiological hydrological niche	Neutral	Neutral

Table 4.17-1 (continued). Summary of CCVI factor ratings for the greater prairie-chicken at TAPR.

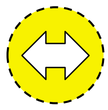
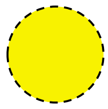
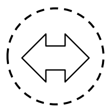
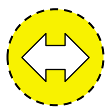
Indicator	Factor influencing vulnerability	Degree to which Factor Influences Vulnerability: Range Statewide	Degree to which Factor Influences Vulnerability: Within TAPR
Sensitivity to Climate Change (continued)	2c) Dependence on a specific disturbance regime likely to be impacted by climate change	Neutral	Neutral
	2d) Dependence on ice, ice-edge, or snow-cover habitats	Neutral	Neutral
	3) Restriction to uncommon geological features or derivatives	Somewhat Decrease	Somewhat Decrease
	4a) Dependence on other species to generate habitat	Neutral	Neutral
	4b) Dietary versatility (animals only)	Neutral-Somewhat Decrease	Neutral-Somewhat Decrease
	4c) Pollinator versatility (plants only)	Not applicable	Not applicable
	4d) Dependence on other species for propagule dispersal	Neutral	Neutral
	4e) Forms part of an interspecific interaction not covered by 4a–d	Neutral	Neutral
	5a) Measured genetic variation	Somewhat Increase	Somewhat Increase
	5b) Occurrence of bottlenecks in recent evolutionary history	Unknown	Unknown
	6) Phenological response to changing seasonal temperature and precipitation dynamics	Unknown	Unknown

Although the prairie-chicken was not deemed especially vulnerable to climate change throughout its Kansas range, there are factors of its biology that can make it susceptible to climate alterations. In particular, bird's range is limited by human-based habitat modifications and does not allow the flexibility to expand northward if habitat in the south becomes less suitable. Additionally, as habitat becomes more constricted and reduces gene flow among populations, the bird loses capacity to adapt to rapidly-altered landscapes. Because the greater prairie-chicken has no specific thermal or physiological affinities to cold environments, has the capacity to disperse when habitat is available, is not linked to any particular geological features or other species for vital life history components, and has a relatively general diet it is not considered to be vulnerable to climate changes forecast for 2050. The climate change indicator was assigned an *insufficient data* status and low level of confidence. However, the estimated vulnerability for a particular resource was used as a trend indicator along with other indicators.

<u>Overall Condition and Trend</u>

Population and breeding success estimates indicate the condition of the greater prairie-chicken warrants moderate concern, with an unchanging trend (Table 4.17-2). Vulnerability of the species to climate change appears low. Continued and enhanced use of a fire and grazing regime that is favorable to habitat needs of the prairie-chicken should help to increase populations over time.

Table 4.17-2. Condition and trend summary for greater prairie-chicken at Tallgrass Prairie National Preserve, Kansas.

Indicator	Condition Status/Trend	Rationale
Population Size		Compared to historic abundance estimates, populations appear low but may be stable or increasing; mark-resight sampling is the most reliable metrics for population estimates but is incomplete for the preserve and does not include trend data.
Breeding Success		Recent data is the only reliable source for this indicator. There is no trend information for these data, but they are the most reliable source for breeding success on TAPR.
Climate Change Vulnerability *		The climate change vulnerability analysis estimated that the species is not vulnerable/presumed stable with regard to climate change through 2050. Only the trend in this indicator is applied to the overall rating of this resource.
Greater Prairie-Chicken Overall		**Condition warrants moderate concern with a slightly deteriorating or unchanging trend. Confidence in the assessment is low.**

*Anticipated, not known trend

4.17.5. Uncertainty and Data Gaps

The biggest data gap is consistent and unbiased population monitoring data. Although traditional lek counts are the easiest method of getting annual data on male density, they are tend to underestimate population size (Clifton and Krementz 2006). Nonetheless they are sensitive to changes in populations over time. Mark-resight methodology can estimate populations more accurately but do require greater investment of time and money. If annual mark-resight methods are impractical, then consistent sampling using traditional lek counts would be the minimal amount of information that should be collected, maintained, and used for assessing status and trend. Assessments of breeding success are valuable to understand how recruitment bolsters population stability, but, as with mark-resight sampling, requires greater investment of time and money (McNew 2010).

4.17.6. Sources of Expertise

- Jim Pitman of the Kansas Department of Wildlife and Parks was consulted for prairie-chicken population and habitat condition throughout the Flint Hills region.
- David Peitz of the National Park Service
- Gerald Horak of Kansas Department of Wildlife and Parks (retired)
- Lance McNew of USGS Alaska Science Center and Rebekah Foote of Missouri Department of Conservation provided valuable input.

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4.18. Herpetofauna

4.18.1. Background and Importance

The National Park Service protects, preserves, and manages biological resources and related ecosystem processes in the national park system including terrestrial and aquatic resources. Prairie herpetofauna or herptiles (amphibians and reptiles) are important components of terrestrial and aquatic systems within Heartland Inventory and Monitoring Network (HTLN) parks. Herpetofauna have experienced worldwide declines with multiple factors including habitat loss, habitat fragmentation, disease, pollution, and climatic shifts among others, combining to cause these declines (Becker et al. 2007, Cushman 2006, Fogell 2004). Herpetofauna species are considered to be effective indicators of the quality and condition of terrestrial and aquatic systems (Mifsud 2014, Welsh and Droege 2001). Herpetofauna populations, especially amphibians, are excellent indicators of environmental conditions and habitat quality because they are sensitive to habitat changes including wetland filling or draining, urbanization, and other activities within a watershed that can alter hydrologic regimes (Pechmann et al. 1991, Blaustein et al. 1994, Fontenot et al. 1996). In 2002 and 2003, NPS conducted herpetofauna surveys at TAPR. Prior to this survey effort the status of herpetofauna at TAPR was unknown (Fogell 2004).

NPS lands provide some of the least impacted habitat remaining in the Midwest serving as refugia for some species. Undeveloped portions of Fox and Palmer Creeks in particular, both on and off the preserve, may offer good habitat for native herpetofauna (Fogell 2004). Although reptiles and amphibians are only mentioned briefly in the *General Management Plan for Tallgrass Prairie National Preserve* (NPS 2000), because of the rarity of non-agricultural lands in the region TAPR is especially valuable by providing relatively large and undisturbed patches of native prairie within a highly altered landscape (Hansen and Gryskiewicz 2003). Habitat fragmentation and conversion of native vegetation to agricultural and urban landscapes occurring outside the preserve will negatively impact populations of some herpetofauna species resident to TAPR, particularly intolerant species that have evolved within stable environments (Knopf and Samson 1996, Gido et al. 2010).

Herpetofauna community composition and diversity should improve with management actions such as native prairie restoration, ecologically desirable flow modifications, dam removal, and cessation of groundwater pumping both within TAPR and in the surrounding landscape (Gido et al. 2010). Part of the restoration at TAPR includes managing prescribed burns. Since the mid to late 1980s, frequent spring burning has been used throughout the Flint Hills, including at TAPR, to increase livestock forage (Fogell 2004). This practice has altered the prairie vegetation and indirectly impacted the herpetofaunal population. Additionally, herpetofauna are particularly susceptible to fire in the spring and fall when they are more active; fire during these times can lead to direct mortality (Gaetani et al. 2010). Preserve managers currently manage fire at TAPR to better reflect the historic fire cycle of burning approximately every 3 years, although burns outside of spring are rare. The change in fire frequency and the timing of burns should increase habitat heterogeneity and positively impact herpetofauna community composition at TAPR (Gaetani et al 2010). Today TAPR supports a diverse community of reptiles with more than 40 species having the potential to occur in the preserve (Fogell 2004; Taggart et al. 2016).

<u>Threats</u>

The herpetofauna community at TAPR has been adversely affected by prescribed burning and habitat conversion, degradation, modification, and fragmentation (Hansen and Gryskiewicz 2003 and Gaetani et al. 2010). Agriculture and development in the surrounding landscape have resulted in the loss of both terrestrial and aquatic habitat (Hansen and Gryskiewicz 2003). Fire management has altered the structure and heterogeneity of the habitat at TAPR (Gaetani et al 2010). The combined and interacting effects of these influences may have resulted in population declines and range reduction of herpetofauna at TAPR and the surrounding region. The ecological functioning of TAPR depends upon maintaining the natural systems both inside and outside preserves boundaries. Changes in land use are linked to ecological function at TAPR by five mechanisms (Hansen and Gryskiewicz 2003):

1. Land use activities reduce the functional size of a park, eliminating important ecosystem components outside a park boundary;

2. Land use activities alter the flow of energy or materials across the landscape irrespective of the park's political boundary, disrupting the ecological processes dependent upon those flows both outside and inside the park and across its boundaries;
3. Habitat conversion outside the park may eliminate unique habitats, such as seasonal habitats and migration corridors;
4. The negative influences of land use activities may extend into the park and create edge effects; and
5. Increased population density may directly impact parks and preserves through increased recreation and human disturbance.

Indicators and Measures

- Percent of the expected species present

4.18.2. Data and Methods

Herpetofauna were surveyed at TAPR during the spring and summer of 2002 and 2003 (Fogell 2004). The information presented in this report is the summary of his findings. Based on distribution maps and historic records of species occurrence, 35 species of herpetofauna potentially occur within TAPR. These species include 1 species of salamander, 7 frogs and toads, 5 turtles, 6 lizards and skinks, and 15 snakes (Table 4.18-1). Multiple sampling techniques were employed at TAPR including visual encounter, overturning natural cover objects, and anuran-calling in order to sample the spatial variation and habitats available within the preserve (Fogell 2004). Of these five techniques, the primary method used to survey amphibians and reptiles was the visual encounter survey (Fogell 2004).

Table 4.18-1. Herpetofauna species observed in the 2002 and 2003 surveys at Tallgrass Prairie National Preserve (Fogell 2004).

Class	Common name	Species	Status on TAPR
Amphibians	American toad	*Anaxyrus americanus*	unconfirmed
	Barred tiger salamander	*Ambystoma mavortium*	confirmed
	Bullfrog	*Lithobates catesbeiana*	confirmed
	Common mudpuppy	*Necturus maculosus*	unconfirmed
	Cope's Gray treefrog	*Hyla chrysoscelis*	confirmed
	Cricket frog	*Acris blanchardi*	confirmed
	Great plains toad	*Anaxyrus cognatus*	unconfirmed
	Plains leopard frog	*Lithobates blairi*	confirmed
	Western chorus frog	*Pseudacris triseriata*	confirmed
	Western narrowmouth toad	*Gastrophryne olivacea*	confirmed
	Woodhouse's toad	*Bufo woodhousii*	confirmed
Reptiles	Common garter snake	*Thamnophis sirtalis*	confirmed
	Common kingsnake	*Lampropeltis getula*	confirmed
	Eastern collared lizard	*Crotaphytus collaris*	confirmed
	Dekay's brownsnake	*Storeria dekayi*	unconfirmed
	Eastern copperhead	*Agkistrodon contortrix*	unconfirmed
	False map turtle	*Graptemys pseudogeographica*	unconfirmed
	Five-lined skink	*Plestiodon fasciatus*	unconfirmed
	Flathead snake	*Tantilla gracilis*	confirmed
	Glossy snake	*Arizona elegans*	unconfirmed
	Gopher snake	*Pituophis catenifer*	confirmed
	Great Plains rat snake	*Pantherophis emoryi*	confirmed
	Great Plains skink	*Plestiodon obsoletus*	confirmed
	Lesser earless lizard	*Holbrookia maculate*	unconfirmed
	Lined snake	*Tropidoclonion lineatum*	confirmed
	Massasauga	*Sistrurus catenatus*	confirmed
	Northern water snake	*Nerodia sipedon*	confirmed

Table 4.18-1 (continued). Herpetofauna species observed in the 2002 and 2003 surveys at Tallgrass Prairie National Preserve (Fogell 2004).

Class	Common name	Species	Status on TAPR
Reptiles (continued)	Ornate box turtle	*Terrapene ornata*	confirmed
	Painted turtle	*Chrysemys picta*	confirmed
	Plainbelly water snake	*Nerodia erythrogaster*	confirmed
	Prairie kingsnake	*Lampropeltis calligaster*	confirmed
	Prairie skink	*Plestiodon septentrionalis*	unconfirmed
	Racer	*Coluber constrictor*	confirmed
	Red-eared slider	*Trachemys scripta*	confirmed
	Ringneck snake	*Diadophis punctatus*	confirmed
	River Cooter	*Pseudemys concinna*	unconfirmed
	Six-lined racer	*As[idoscelis sexlineata*	unconfirmed
	Slender glass lizard	*Ophisaurus attenuates*	unconfirmed
	Snapping turtle	*Chelydra serpentina*	confirmed
	Speckled kingsnak	*Lampropeltis holbrooki*	unconfirmed
	Spiny softshell	*Apalone spinifera*	confirmed
	Texas horned lizard	*Phrynosoma cornutum*	confirmed
	Western milksnake	*Lampropeltis gentilis*	confirmed
	Western rat snake	*Pantherophis obsoleta*	confirmed
	Western ribbon snake	*Thamnophis proximus*	confirmed
	Western worm snake	*Carphophis vermis*	unconfirmed

4.18.3. Reference Conditions

Reference condition was set to the number of species with the potential to occur within the preserve. These species were identified by Fogell (2004), are listed in the NPSpecies database, or are from the Kansas Herpetofaunal Atlas (Taggart 2016). Fogell (2004) also accounted for suitable habitat within the preserve that was available for each species and eliminated those species that are known to be extirpated from the region. Other quantitative metrics and thresholds describing the population dynamics of species or the herpetofauna group as a whole could not be determined due to limitations associated with the data. However, the Fogell (2004) study allows us to make some inference regarding the condition of herpetofauna within the preserve and can be used as the basis for future monitoring efforts. The resource is considered to be in good condition if at least 85 percent of expected species are confirmed present, to warrant moderate concern if 70–85 percent of expected species are confirmed present, and to warrant significant concern if less than 70 percent of expected species are confirmed present.

4.18.4. Condition and Trend

The 2002–2003 survey found 80% of expected amphibians and 61% of expected reptiles. Overall, 30 species were confirmed out of 46 expected species for a 65% confirmation rate, which warrants significant concern (Table 4.18-2). Ratios of observed to expected species were as follows: 7/9 frogs and toads (78%); 1/2 salamanders (50%); 5/7 turtles (71%); 3/8 lizards (37.5%); and 15/20 snakes (75%). No trend assessment is currently possible due to the single sample period dating to over a decade ago. Because presence-absence data alone is fairly insensitive to population changes and changes in the condition of the preserve's habitats in the intervening years could be influencing herpetofauna presence, abundance or diversity at TAPR, the confidence in the assessment is low.

Table 4.18-2. Condition and trend summary for herpetofauna at Tallgrass Prairie National Preserve.

Indicator	Condition Status/Trend	Rationale
Percent of Expected Species Confirmed		The percent of expected herpetofauna species confirmed in 2002 and 2003 was 65% of expected species. Analysis of the herpetofauna data for trend was not possible because only one period of sampling data was available for analysis.
Herpetofauna Overall		**Condition warrants significant concern with an unknown trend. Confidence in the assessment is low.**

4.18.5. Uncertainty and Data Gaps

Herpetofauna data were limited for TAPR. Survey data were only available for a single time period and no monitoring data were available. Inventory surveys were able to document species present on site, however, the lack of detection of a species does not equate to a local extirpation. The absence of a species may be an artifact of the sampling design or the seasonal timing of the survey. Trends were not identified for herpetofauna within the preserve because results were available for only a single survey effort. Comprehensive surveys from numerous sites within TAPR and over an extended time period are recommended to assess condition and trends in the herptile community.

4.18.6. Sources of Expertise

- Daniel Fogell, a herpetologist and science instructor, Southeast Community College, Lincoln, Nebraska.

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4.19. Topeka Shiner

4.19.1. Background and Importance

Topeka shiner (USFWS).

The Topeka shiner (*Notropis topeka*) is a member of Family Cyprinidae (carp, true minnows, and their relatives) and was historically found throughout the central prairie regions of the United States within portions of Iowa, Kansas, Minnesota, Nebraska, South Dakota, and Missouri (USFWS 2009). The species was listed as a federally endangered species by the U.S. Fish and Wildlife Service (USFWS) in 1998 under the authority of the Endangered Species Act of 1973 (USFWS 1998). This finding was based on the large number of historic records of occurrence and recent intensive surveys for the species, which indicate the species has undergone serious decline. Other reasons for the Topeka shiner's listing cited by the USFWS include habitat loss, predation by introduced fish, and the inadequacy of existing regulatory mechanisms.

Critical habitat for the species is designated in portions of Iowa, Minnesota and Nebraska (USFWS 2005). The designated critical habitat reflects the need for habitat complexes and individual stream reaches of sufficient size to provide habitat for Topeka shiner populations large enough to be self-sustaining over time, despite fluctuations in local conditions. In Kansas, the Topeka shiner exists in several Flint Hills watersheds, including Fox Creek. In and near the preserve, critical habitat was proposed for the following reaches: #1a consisting of Fox Creek from U.S. Highway 50 upstream through T18S, R8E, Sec. 29; #1b consisting of an unnamed tributary to Fox Creek, from their confluence (T18S, R8E, Sec. 32), upstream through T18S, R8E, Sec. 31; and #1c consisting of an unnamed tributary to Fox Creek, from their confluence (T18S, R8E, Sec. 29), upstream through T18S, R8E, Sec. 19 (USFWS 2005).

All reaches proposed as critical habitat in Kansas, including those at TAPR, were excluded from designation because Kansas has a management plan that is considered to provide adequate protection and recovery of the Topeka shiner in the state. The Kansas State management plan measures satisfy the following three criteria: (1) they provide a conservation benefit to the species (i.e., the plans must maintain or provide for an increase in the species population or enhancement or restoration of its habitat within the area covered by the plan); (2) they provide assurances that they will be or will continue to be implemented; and (3) they provide assurances that they will be effective (i.e., the plans must identify biological goals, have provisions for reporting progress, and are of a duration sufficient to implement the actions and achieve the goals and objectives) (USFWS 2005).

Populations of the Topeka shiner are excellent indicators of environmental condition because the species is intolerant of chemical pollutants, habitat changes, and predation by introduced piscivorous fish species making their assemblages indicative of water and habitat quality (Pflieger 1997, Barbour et al. 1999, Schrank et al. 2001, USFWS 2009). For this reason, Topeka shiner populations offer an indication of stream environmental health.

The Topeka shiner is a small minnow not exceeding 3 inches in total length (75 millimeters). The head is short, with a moderately slanted mouth and the eye diameter is equal to or slightly longer than the snout. The Topeka shiner's dorsal and pelvic fins each contain 8 bony rays supporting the membranes of the fin while the anal and pectoral fins contain 7 and 13 rays respectively. The fishes back, or dorsal surface, is olive-green in color, with a distinct dark stripe preceding the dorsal fin. Along the lateral sides there is a dusky stripe that runs the entire longitudinal length of the fish's body. The scales above this dusky stripe are darkly outlined and appear cross-hatched while below the line the scales lack coloring and appear silvery-white.

The species has declined throughout its historical distribution since the early 1900s (Cross and Moss 1987, Harlan and Speaker 1987), and has been extirpated from many localities. It currently exists in fragmented populations within a smaller portion of its range, but still occurs in all six states in its historical range (Figure 4.19-1) (Mammoliti 2004). Since the federal listing in 1998, the Topeka shiner has received much attention - recent studies have shown that the species status in the northern extent of the range is much better than previously believed. The extent of the species population decline is not as severe as originally presumed, and the vulnerability of many of the remaining populations is substantially lower than presumed at the time the species was listed by USFWS as an endangered species (NatureServe 2014). Most of the remaining occupied habitat is in South Dakota, Minnesota and Kansas (USFWS 2009), comprising less than 10% of its original geographic range (MDNR 2014).

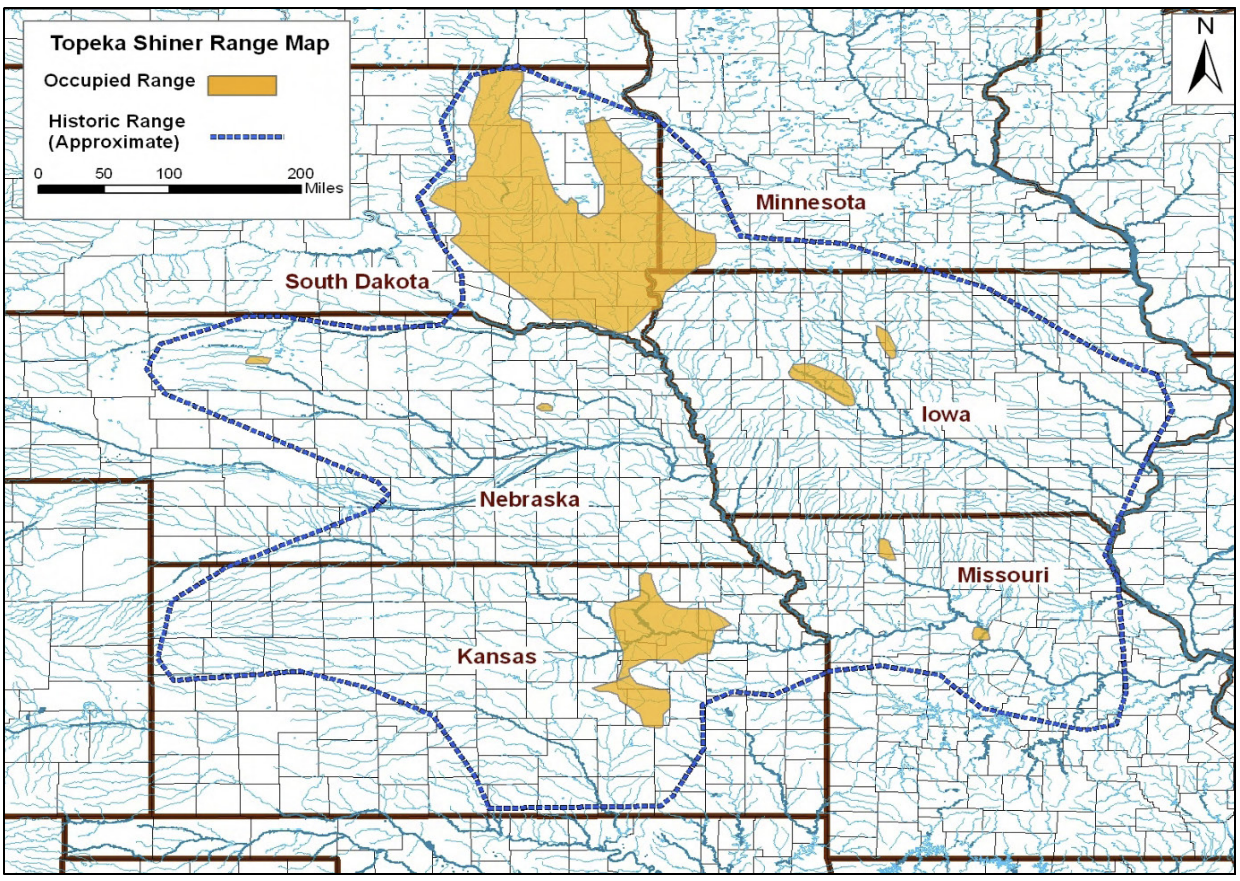


Figure 4.19-1. Current and historic geographic range of the Topeka shiner (USFWS 2009).

The Topeka shiner inhabits small to mid-sized, headwater, prairie streams of high water quality and with cool to moderate water temperatures (USFWS 1998). These streams generally are perennial, although some occupied streams may show periodic or intermittent flow during summer. During summer months when surface flow ceases, pool water levels and cool water temperatures are maintained by groundwater seepage.

Stream substrate suitable for the Topeka shiner is predominantly clean gravel, cobble and sand, but bedrock and clay hardpan overlain by silt are not uncommon (Minckley and Cross 1959). The Topeka shiner is a multiple clutch spawner that lays its eggs from May through July in pool habitats over Green sunfish (*Lepomis cyanellus*) and orangespotted sunfish (*Lepomis humilis*) nests (Pflieger 1997) as well as on other silt-free substrates (USFWS 1998). The Topeka shiner reaches sexual maturity in their second summer. It is an opportunistic omnivore whose diet consists of aquatic insects, microcrustaceans, larval fish, algae, and detritus (Hatch and Besaw 2001). The species has a three year lifespan; populations are typically dominated by the 0 and 1-year age classes (Dahle 2001).

Primary predators of the Topeka shiner are other fish species. Introduced piscivores are considered a serious threat to the Topeka shiner. The most common native predator is the green sunfish, which is found throughout the range of the Topeka shiner. The spotted bass (*Micropterus punctulatus*) and largemouth bass (*M. salmoides*) are also native predators of the Topeka shiner, but they naturally occurred only in the downstream reaches of streams while Topeka shiners typically occupied stream headwaters. The introduction of the piscivorous largemouth bass, crappie (*Pomoxis* spp.), and bluegill (*Lepomis macrochirus*) into stream headwaters have typically eliminated Topeka shiner and other stream cyprinids (USFWS 2009).

At TAPR, the success of the Topeka shiner population depends upon maintaining the stream hydrology of Fox Creek, its tributaries and the water quality of existing instream pools. In addition, managing constructed ponds in tributaries and preventing introduction of piscivores will be important to protecting the Topeka shiner at TAPR. This can be difficult because activities miles away from the preserve can affect water quality and fish community structure within the preserve.

<u>Threats</u>

Topeka shiner are intolerant of certain human-caused disturbances and habitat alterations including impoundment; channelization; increased sedimentation from cultivation, building projects, water diversion projects, and heavy and continuous grazing both onsite and upstream of TAPR; increased nutrient loading from cultivation including from cropland upstream of TAPR; and introduction of piscivores including introductions occurring upstream of TAPR.

Predation by introduced game fish, both native and nonnative, into areas not naturally occupied by these fish has resulted in the loss of Topeka shiner populations (Prophet et al. 1981). Game fish introduced into impoundments disperse into pools both up and downstream of the impoundment, where cyprinids can then no longer persist (Layher 1993).

Conversion of prairie to cropland and subsequent groundwater withdrawal has altered stream hydrology, resulting in both decreased surface and groundwater flows causing declines in stream water quality which coincide with declining Topeka shiner populations (Cross and Moss 1987). In addition, increased surface runoff attributed to excessive grazing has contributed to increased stream sedimentation again reducing stream water quality (USFWS 2009).

Impoundments have caused the loss of Topeka shiner populations across its entire range. During times of drought and diminished stream flows Topeka shiner attempt to survive in impoundments, where they are subject to predation by piscivorous fishes (Mammoliti 2002).

Climate change is expected to contribute to changes that further stress Topeka shiner populations. Increases in temperature and changes in rainfall patterns will further alter the timing and amount of water recharge and runoff. Increases in precipitation projected for the region are not expected to offset decreases in soil moisture and groundwater depletion (USFWS 2009).

<u>Indicators and Measures</u>

- Topeka shiner abundance
- Relative abundance of predators
- Vulnerability to climate change

4.19.2. Data and Methods

The Heartland Inventory and Monitoring Network (HTLN) has implemented long-term monitoring of fish at network parks including TAPR (Dodd et al. 2008) to determine the status and long-term trends in fish community composition and abundance and to correlate this community data to water quality and habitat conditions. This allows for monitoring of how fish respond to changes in habitat structure and other habitat variables related to land-use changes and management activities (Dodd et al. 2008). Systematic surveys of fish and their habitat at TAPR began in 2001. For the ten years when sampling occurred, the number of sites sampled per year varied, ranging from 18 reaches from 11 streams (2001 to 2006) to 13 reaches from 12 streams (2006 to 2010) (Figures 4.19-2 and 4.19-3). Data from a total of 19 sample reaches were used to determine the condition of the Topeka shiner population. In one of the 10 years sampled no Topeka shiners were recorded and in five of the remaining nine years sampled, Topeka shiners were only recorded at one of the sampled reaches. The relative abundance of predaceous fish relative to Topeka shiner abundance was also used to determine condition.

Relative abundance of predaceous fish was calculated as follows:

$$Relative\ Abundance = \frac{annual\ mean\ abundance\ of\ predaceous\ fish\ per\ sample\ reach}{annual\ mean\ abundance\ of\ Topeka\ shiner\ per\ sample\ reach}$$

For those sample reaches where no Topeka shiners were recorded but predaceous fish were recorded, the abundance of the Topeka shiner was set to "1" for calculating the relative abundance of predaceous fish. The mean abundance of the Topeka shiner per sample reach and the relative abundance of predaceous fish recorded per sample reach were used to assess condition and trend in the Topeka shiner population at TAPR. Fish sampling was conducted in August and September using a common sense seine. Topeka shiner were identified and counted. Starting in 2006, individuals at each reach were also measured and weighed, and any diseases or anomalies were recorded.

The vulnerability of the community to climate change effects was evaluated using the Climate Change Vulnerability Index (CCVI) (Young et al. 2011). The CCVI is a Microsoft Excel-based spreadsheet tool developed by NatureServe. It is designed as a rapid-assessment tool intended to be used primarily for practical planning purposes by natural resources managers and USFWS staff. It is designed to be complementary to the NatureServe Conservation Status ranks and other information, but it does not duplicate information in those ranks such as the size of a specific population. The intended application scale of the tool is up to the state or province level. The primary purpose of the CCVI is to produce a relative ranking or priority list for species of concern with respect to climate change vulnerability. The CCVI divides vulnerability into two components: 1) exposure to climate change within the assessment area (e.g., a highly sensitive species will not suffer if the climate where it occurs remains stable), and 2) sensitivity of the species to climate change (e.g., an adaptable species will not decline even in the face of significant changes in temperature and/or precipitation).

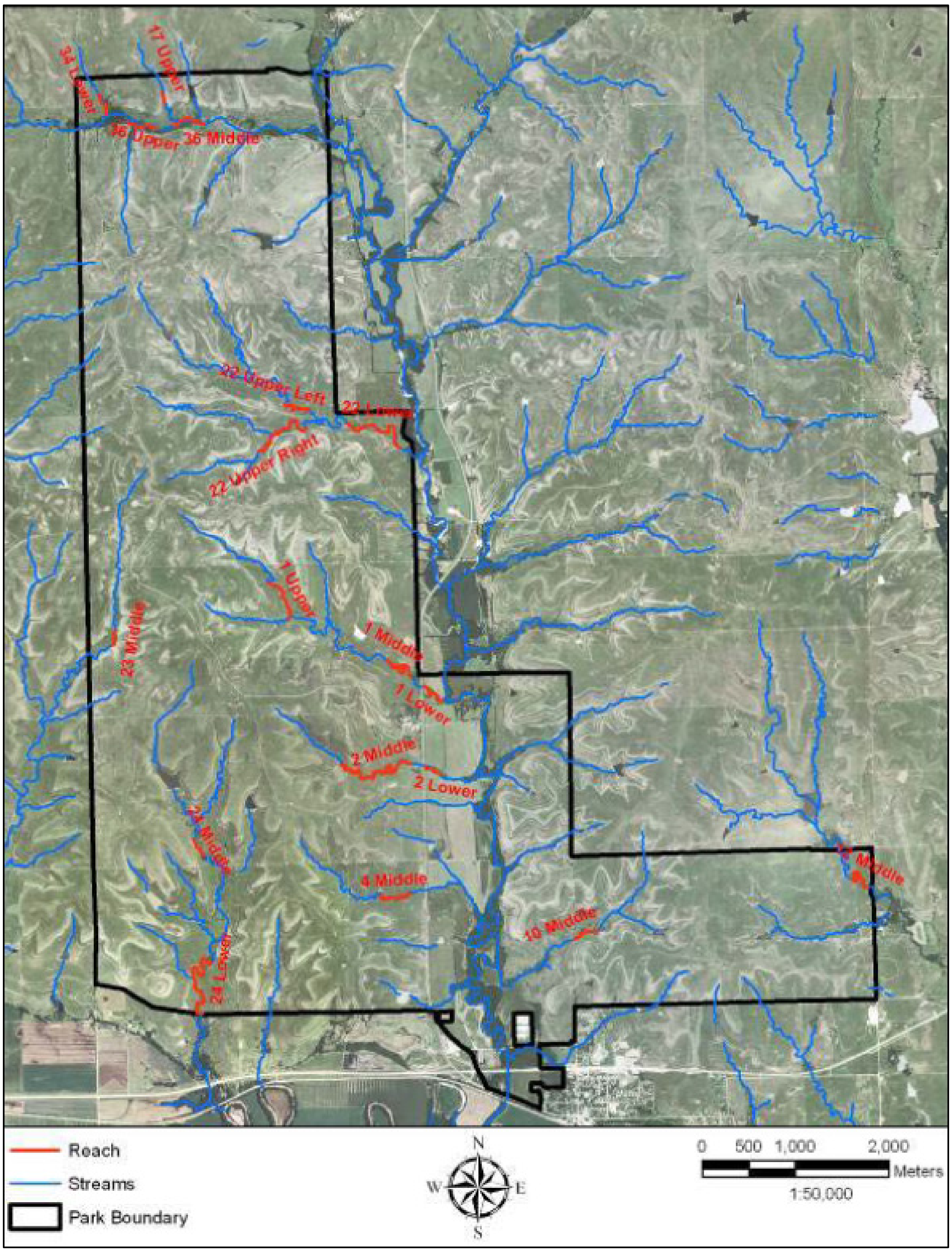


Figure 4.19-2. Locations of reaches sampled annually from 2001–2006 at Tallgrass Prairie National Reserve (Graphic from Dodd et al. 2010).

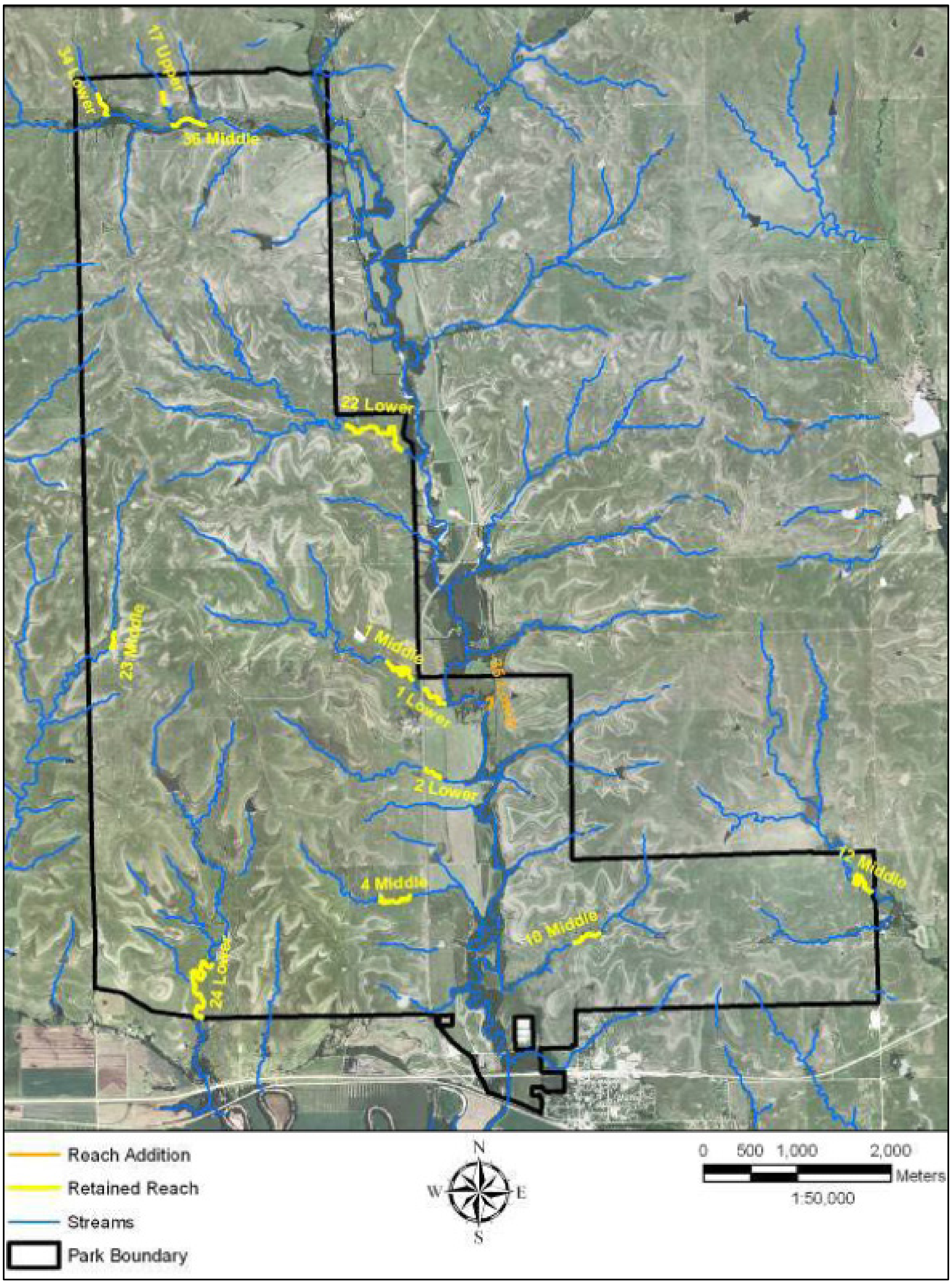


Figure 4.19-3. Locations of reaches retained and sampled annually from 2007–2010 (yellow), plus one additional reach added in 2007 (orange) and subsequently sampled annually from 2007 to 2010 (Graphic from Dodd et al. 2010).

4.19.3. Reference Condition

Little historic survey data exists for Tallgrass Prairie National Preserve or from watersheds close to the preserve. Fish surveys conducted on TAPR are described above. The sampling procedure was modified in 2006, when sampling effort at TAPR was reduced from 18 reaches to 13 with one new reach added to the sample (Dodd et al. 2008, 2010). There was a great deal of variation observed in the annual abundance of Topeka shiner recorded during the 10 years of sampling (Figure 4.19-3). No Topeka shiners were present in 2009 samples. In order to account for this variation, and to evaluate trends over time, we compared the mean abundance of Topeka shiner per sample reach detected during the 2010 survey conducted at TAPR to the mean abundance in 2001, considering the 2001 mean to represent the reference condition.

Maintaining or exceeding the level of mean Topeka shiner abundance per sample reach recorded in 2001 is considered good condition. As with Topeka shiner results, a wide range of relative abundance for predaceous fish was recorded across the 10 years sampled (Figure 4.19-4). To evaluate trends over time, we compared the mean relative abundance of predaceous fish per sample reach detected in 2010 to the mean abundance calculated in 2001, using the 2001 mean for relative abundance to represent the reference condition. Maintaining or reducing the level of mean relative abundance per sample reach of predaceous fish recorded in 2001 is considered good condition. A rating system for departure from good condition is shown in Table 4.19-1. The results for climate change vulnerability were not used in the condition rating, but did weigh in for the trend rating.

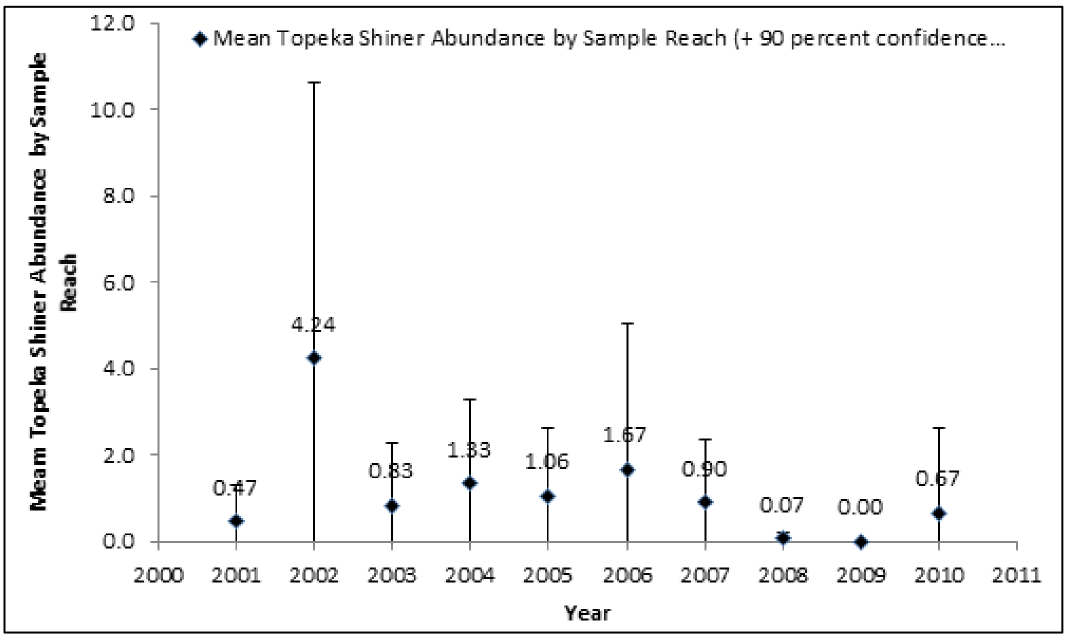


Figure 4.19-4. Means and 90 percent confidence intervals for Topeka shiner abundance across reaches sampled at Tallgrass Prairie National Preserve from 2001 to 2011.

Table 4.19-1. Resource condition rating framework for fish at Tallgrass Prairie National Preserve, Kansas.

Indicator	Resource is in Good Condition	Warrants Moderate Concern	Warrants Significant Concern
Topeka Shiner Abundance	>85–100+ % of 2001 value	70–85% of 2001 value	<70% of 2001 value
Relative Abundance of Predators	≤100% of 2001 value	101–115% of 2001 value	>115% of 2001 value

4.19.4. Condition and Trend

Topeka Shiner Abundance

The mean abundance per sample reach for the Topeka shiner recorded between 2001 and 2010 is highly variable, ranging from a low of 0 recorded in 2009 to a high 4.24 recorded in 2002 (Figure 4.19-4). In 2010, mean number of shiners per reach was 0.67, greater than the mean abundance per sample reach of 0.47 recorded in 2001, indicating the population is in good condition. The slope of the linear regression line for Topeka shiner mean abundance per sample reach was negative but statistically insignificant ($r^2 = 0.24$, $p = 0.15$) suggesting abundance of the Topeka shiner has not changed during the sampling period. The 90 percent confidence intervals for mean Topeka shiner abundance for the years 2001 through 2010 suggest no differences among years and also indicate relatively low precision in the calculated values for many of the years sampled (Figure 4.19-4).

Predaceous Fish Relative Abundance

The relative abundance of the predaceous fish species recorded between 2001 and 2010 was high, ranging from a low of 13.8 recorded in 2003 to a high of 93.0 in 2006 (Figure 4.19-5). In 2010, mean abundance was 23.8, 125 percent of the mean predaceous fish relative abundance per sample reach recorded in 2001. The slope of the linear regression line for predaceous fish relative mean abundance per sample reach was positive, but not statistically significant ($r^2 = 0.005$, $p = 0.85$) suggesting relative abundance of predaceous fish has not changed during the period of sampling. The 90 percent confidence intervals for mean predaceous fish relative abundance for the years 2001 through 2010 also suggest no difference in the values and indicate low precision in the calculated values for 2006 and 2010. Results for this indicator suggest the condition of the resource warrants moderate concern (Table 4.19-1). Precision of the estimates is low resulting in medium confidence.

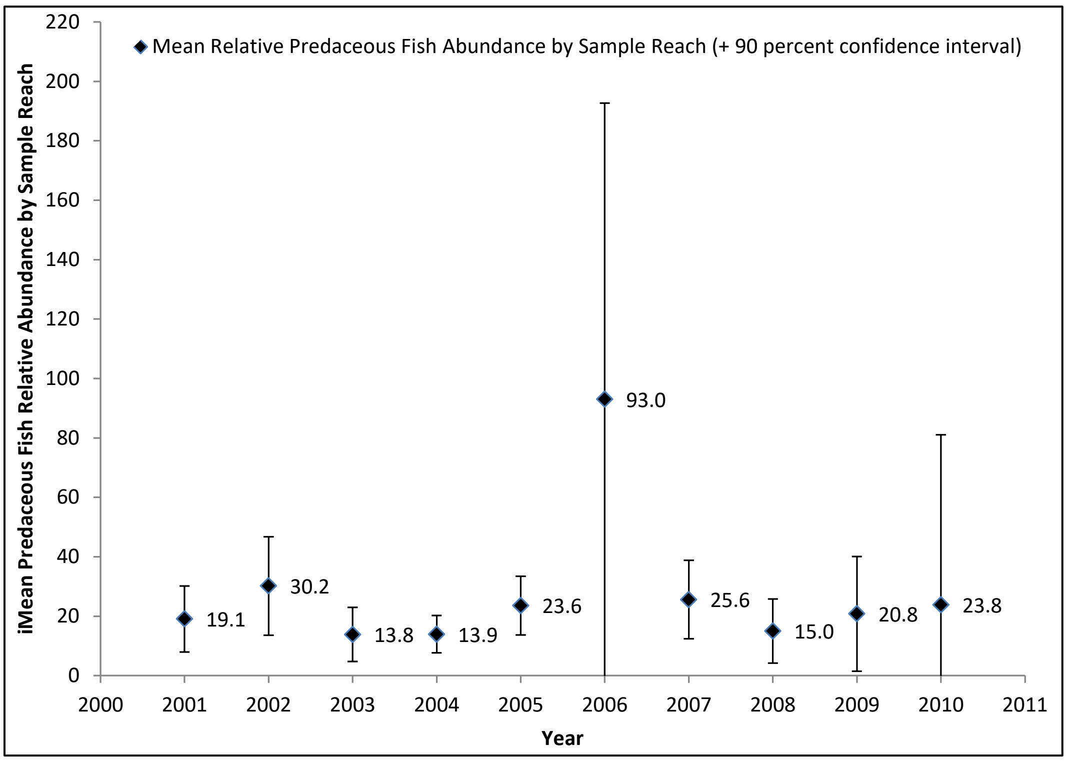


Figure 4.19-5. Means and 90 percent confidence intervals for predaceous fish relative abundance at Tallgrass Prairie National Preserve from 2001 to 2011.

<u>Climate Change Vulnerability Results</u>

Each CCVI factor was scored (Table 4.19-2) and results were compiled into an overall CCVI rating. By 2050, within its current range in Kansas the species is considered Highly Vulnerable. Within TAPR, the species is considered to be Moderately Vulnerable by 2050. There are factors of the Topeka shiner's biology that can make it susceptible to climate alterations. In particular, the Topeka shiner is dependent upon instream pools and off-channel wetlands that could be reduced in number and distribution within the streams that the fish inhabits at TAPR. This is particularly true during drought, which is predicted for the region under climate change. It is particularly important for Topeka shiner to access these wet refugia during times of drought. With water withdrawal and impoundment predicted to increase in the future their habitat may become more fragmented, making it difficult for current population to access these refugia and persist. The climate change indicator was assigned an *insufficient data* status and low level of confidence. However, the estimated vulnerability for a particular resource was used as a trend indicator along with other indicators.

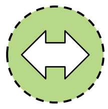
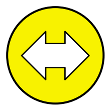
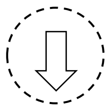
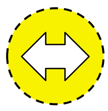
Table 4.19-2. Summary of CCVI factor ratings for the Topeka shiner, Tallgrass Prairie National Preserve.

Indicator	Factor Influencing Vulnerability	Degree to which Factor Influences Vulnerability	
		Rangewide/State	Within TAPR
Indirect Exposure to Climate Change	1) Exposure to sea level rise	Neutral	Neutral
	2a) Distribution relative to natural barriers	Somewhat Increase	Somewhat Increase
	2b) Distribution relative to anthropogenic barriers	Greatly Increase	Somewhat Increase
	3) Predicted impact of land use changes resulting from human responses to climate change	Increase	Neutral
Sensitivity to Climate Change	1) Dispersal and movements	Increase	Increase
	2ai) Predicted sensitivity to changes in temperature: historical thermal niche	Somewhat Increase	Somewhat Increase
	2aii) Predicted sensitivity to changes in temperature: physiological thermal niche	Increase	Increase
	2bi) Predicted sensitivity to changes in precipitation, hydrology, or moisture regime: historical hydrological niche	Increase	Greatly Increase
	2bii) Predicted sensitivity to changes in precipitation, hydrology, or moisture regime: physiological hydrological niche	Increase	Increase
	2c) Dependence on a specific disturbance regime likely to be impacted by climate change	Neutral	Neutral
	2d) Dependence on ice, ice-edge, or snow-cover habitats	Neutral	Neutral
	3) Restriction to uncommon geological features or derivatives	Neutral	Neutral
	4a) Dependence on other species to generate habitat	Neutral	Neutral
	4b) Dietary versatility (animals only)	Neutral	Neutral
	4c) Pollinator versatility (plants only)	Not applicable	Not applicable
	4d) Dependence on other species for propagule dispersal	Neutral	Neutral
	4e) Forms part of an interspecific interaction not covered by 4a–d	Neutral	Neutral
	5a) Measured genetic variation	Unknown	Unknown
	5b) Occurrence of bottlenecks in recent evolutionary history	Increase-Somewhat Increase	Increase-Somewhat Increase
	6) Phenological response to changing seasonal temperature and precipitation dynamics	Unknown	Unknown

<u>Overall Condition and Trend</u>

Topeka shiner abundance and the relative abundance of predaceous fish present in 2011 indicate that resource warrants moderate concern. The Topeka shiner is present at low abundances and precise sample estimates are problematic, resulting in a medium level of confidence. A community of predaceous fish that prey upon the Topeka shiner is moderate in abundance (Table 4.19-3). Additionally, the values for these metrics calculated for the years 2001 to 2010 suggest that the current trend in condition is unchanging. However, there are concerns that moderate vulnerability to climate change within the preserve could result in declining populations.

Table 4.19-3. Condition and trend summary for the Topeka shiner at Tallgrass Prairie National Preserve.

Indicator	Condition Status/Trend	Rationale
Topeka Shiner Abundance		Mean Topeka shiner abundance per sample reach has fluctuated between 0 and 4.24 from 2001 to 2010 with mean abundance equaling 0.67 in 2010 (good condition), more than the management target of 85 percent of 0.47. Analysis of the fish monitoring data indicates a stable trend in mean Topeka shiner abundance from 2001 to 2010. Precision of the estimates is relatively low.
Relative Abundance of Predaceous Fish		In 2010, the mean relative abundance of predaceous fish per sample reach was 23.8 (warrants significant concern). Analysis of the mean relative abundance indicates a stable trend in the number of predaceous fish at TAPR between 2001 and 2010.
Climate Change Vulnerability *		The Topeka shiner was found to be highly vulnerable to climate change throughout its current range in the United States and moderately vulnerable within TAPR. Only the trend in this indicator is applied to the overall rating of this resource.
Topeka Shiner Overall		**Condition warrants moderate concern with an unchanging to declining trend. Confidence in the assessment is low.**

*Anticipated, not known trend

4.19.5. Uncertainty and Data Gaps

Assessments of ecological change should preferably use long-term data spanning decades (Holmes 2010 and Magurran et al. 2010). The 11 years of monitoring data available for this assessment is a good foundation and continued monitoring will enable the assessment of variability over time and space and assure the accuracy of the assessment (Dornelas et al. 2012).

Another factor affecting the quality of the data is the probability that a Topeka shiner that is present during the time that seining is occurring is detected. The protocols used for monitoring fish in the HTLN rely on the use of a common sense seine. Electrofishing could improve the probability of detecting more individuals, but because each stream reach is surveyed only once per year, there is always the chance that rare species like the Topeka shiner will go undetected. This can be a problem when assessing rare species.

In addition, there were differences in sampling effort with more stream reaches being sampled in some years of monitoring. The issue that occurs when sampling for rare species is that the greater the number of individual samples taken, the greater is the number of individuals that will be found. This confounding influence makes it difficult to identify whether differences in the indicator values by year, result from true changes in their values or result because variable numbers of reaches were sampled across the years. This could be controlled for by sampling the same number of stream reaches in every year of monitoring.

4.19.6. Sources of Expertise

- Hope Dodd, Fisheries Biologist, Heartland I&M Network and Prairie Cluster Prototype Programs.
- William Stark, Fort Hays State University, Hays, Kansas.
- Vernon Tabor, fish and wildlife biologist in the U. S. Fish and Wildlife Service's Kansas Field Office, Manhattan, Kansas.

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Chapter 5. Summary and Discussion

This section summarizes condition and trend results by focal resource, highlights management implications and interrelationships among resources, reinforces relationships between resource condition and landscape context elements, and consolidates data gaps.

5.1. Condition Summary and Management Implications

A total of 19 focal resources were examined: six addressing landscape context - system and human dimensions, three addressing chemical and physical attributes, and ten addressing biological attributes. Status and trend assigned to each focal resource and a synopsis of supporting rationale are presented in Table 5.5-1.

Table 5.1-1. Summary of focal resource condition and trend for Tallgrass Prairie National Preserve.

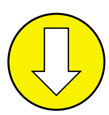
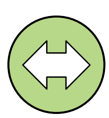
Category	Resource	Condition and Trend	Rationale for Overall Condition/Trend Rating
Landscape Context – System and Human Dimensions	Land Cover and Land Use	**condition and trend not assigned**	Most land cover and land use-related stressors at TAPR and in the larger region are related to the development of rural agricultural land and increases in population/housing over time. Conversion of hay and pasture lands to cropland is also a concern, as the former class has much higher conservation value. Although most bottomlands are farmed or hayed, much of the surrounding lands to the east, north and west consist of grazed prairie grasslands that provide significant buffering and connectivity for the preserve. A lack of significantly-sized and linked protected areas would help to conserve natural resources at the preserve to include dark night skies, natural sounds and scenery.
	Night Sky		Median anthropogenic light ratio value of 0.61 warrants moderate concern. Land-use and population trends for the 30 km area surrounding the preserve as well as larger more distant cities will likely further degrade dark night skies in the preserve.
	Soundscape		Nationwide modeling of anthropogenic sound level impacts indicates that anthropogenic noise is only moderately increasing the existing ambient sound level above the natural ambient sound level of the preserve. Based on these estimates, traffic volumes on roads adjacent to the preserve, and the number and type of anthropogenic noise sources that are audible within the preserve, the soundscape in TAPR is in good overall condition, with an unchanging trend. There are both external and internal threats to the quality of the soundscape in TAPR, but qualitative evidence suggests that the trend in the condition of the soundscape is unchanging.

Table 5.1-1 (continued). Summary of focal resource condition and trend for Tallgrass Prairie National Preserve.

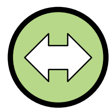
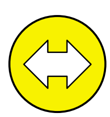
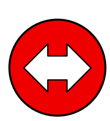
Category	Resource	Condition and Trend	Rationale for Overall Condition/Trend Rating
Landscape Context – System and Human Dimensions (continued)	Scenery and Views		The views are expansive and of generally high quality, consisting of natural or natural-appearing settings with some historic and agricultural elements. Rural and suburban elements, energy and communication lines and structures, and highways and other non-period elements are rare within the preserve but are occasionally evident outside the preserve. Some views from near the southern preserve border looking south toward Strong City and the Highway 50 corridor are impacted by residential and commercial development, communications towers and other inconsistent elements. Many preserve views are buffered by their remoteness and the predominance of ranching and grasslands in most areas to the east, north and west. Within the region, there is an increase in exurban areas and a corresponding decrease in rural acreage. Development of new wind turbine projects is a significant threat to preserving views at TAPR. Haze is poor in the area but appears to be improving.
	Climate Change	**condition and trend not assigned**	The preserve climate is already becoming drier (despite increasing precipitation), hotter, and is potentially more prone to more frequent and extreme weather events. Trends are projected to continue or accelerate by the end of the century. Research and monitoring related to climate change, the anticipated vulnerability of specific resources vis-a-vis climate change, and its associated effects on resources and interaction with other ecological processes such as grazing a fire can be informed by this broad overview of the magnitude of climate change. It also supports ongoing, anticipatory and adaptive management. More specific climate change adaptation tools and techniques appear to be needed at the preserve scale.
	Fire Disturbance Regime		Fire regime components vary in their ability to meet reference conditions for the preserve. Although fire frequencies generally fall within the desired range, variability in the seasonality of fire may limit the restoration benefits and reduce heterogeneity within the prairie. Fire severity is estimated to be below desired levels of severity and heterogeneity. Administrative uncertainties and inconsistent funding of prescribed burn management may adversely affect the condition of this resource over time.
Chemical and Physical Environment	Air Quality		Based on the evaluation of ozone, N and S wet deposition, and visibility, air quality condition warrants significant concern with an unknown trend. Visibility appears to be improving. Impacts to air quality are largely from distant sources that are affecting regional air quality, or from local sources including prescribed burns used by farmers, ranchers and resource managers.

Table 5.1-1 (continued). Summary of focal resource condition and trend for Tallgrass Prairie National Preserve.

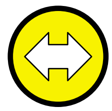
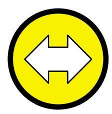
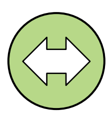
Category	Resource	Condition and Trend	Rationale for Overall Condition/Trend Rating
Chemical and Physical Environment (continued)	Stream Hydrology and Geomorphology		Applying the Proper Functioning Condition and Channel Evolution Model framework, seven out of eight streams warranted moderate concern and one stream (Gas House Creek) warranted significant concern. Incision, stream widening and bank failure were commonly observed, Trampling of riparian areas by cattle was common and the condition is largely attributed to excessive concentration of cattle in and around the streams. School House Creek, which has not been grazed for over 15 years and Palmer Creek showed signed of recovery/improvement. Stock ponds on many tributaries also are likely impacting stream processes.
	Water Quality		Palmer and Fox Creeks both had acceptable chloride and sulfate levels. Total dissolved solids, dissolved oxygen, total coliform, nitrogen and phosphorus warrant moderate concern, and turbidity warrants significant concern. The indicators rated moderate and significant concern are often impacted by agricultural practices including grazing, the latter of which is the only land-use practice occurring in the Palmer Creek watershed. The “impaired” status of several indicators for both creeks downgraded the condition for those indicators.
Biological – Plants	Prairie Vegetation		The overall condition of prairie vegetation at TAPR is good and conditions are relatively unchanged during 1996–2011. Prairie vegetation is dominated by native plant species. Native species richness has remained reasonably stable, although species evenness is highly variable. Native forbs and graminoids are well represented and levels of woody vegetation cover are generally less than 3%. No invasive exotic species have high frequency or cover, and most search units have few to no IEP species present. In some areas, enhanced management of prescribed fire and cattle grazing (especially since grazing rights were acquired), bison introduction, and prairie restoration projects in the Fox Creek bottomlands are likely increasing the heterogeneity of vegetation and overall habitat quality.

Table 5.1-1 (continued). Summary of focal resource condition and trend for Tallgrass Prairie National Preserve.

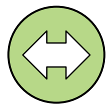
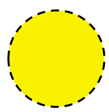
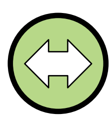
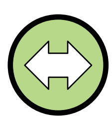
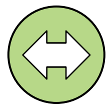
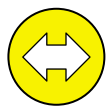
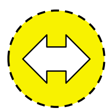
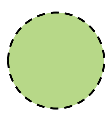
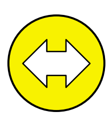
Category	Resource	Condition and Trend	Rationale for Overall Condition/Trend Rating
Biological – Plants (continued)	Invasive Exotic Plants		IEP species are fairly infrequent, although Japanese brome and buffalobur nightshade have frequencies of >10%. No IEP species has an estimated cover range exceeding 25% of the total acreage of the preserve. A couple of invasive grass species (smooth brome and Japanese brome) are the primary contributors to IEP abundance. Most search units have few to no IEP species present, indicating that the contiguous grassland is more likely to function according to natural processes. Two Kansas state-listed noxious weed species having low cover were present in 2010. Outside of historic corrals and feedlot areas, the Fox Creek bottoms have the most pervasive weed problems.
Biological – Animals	Aquatic Macroinvertebrates		Condition ratings were similar for Palmer and Fox Creeks. Previous survey results indicated the streams were partially supporting biological communities. Results from more recent surveys provided mixed results. EPT richness was low for each stream suggesting severe impairment, but EPT ratio, and moderate tolerance indices (HBI) for both streams do not indicate severe impairment. Results are generally comparable to those observed for other regional streams, and suggest the data for Fox and Palmer creeks fall within a normal range for the region. Confidence in the assessment is low due to lack of monitoring data over time and uncertainty associated with reference conditions.
	Bird Community		The values for the metrics of native species richness, the bird IBI, and the number of species of concern present in 2012 indicate that the grassland and woodland bird communities are in good condition, with a number of obligate grassland birds and a community structure that is representative of a moderately disturbed landscape (Table 4.13-5). The woodland IBI value warranted moderate concern.
	Bison		Multiple indicators for ecosystem stewardship and processes, herd health and genetics, herd size and demographics, and visitor access were examined. Genetic diversity and herd size warrant moderate concern but have an improving trend. Results indicate a robust and healthy herd within a framework that supports both national and local NPS and TNC goals. Perhaps the most obvious challenge to bison management at TAPR is the administrative limit placed on the acreage available to bison, which constrains the extent of ecosystem benefits from bison within the preserve.

Table 5.1-1 (continued). Summary of focal resource condition and trend for Tallgrass Prairie National Preserve.

Category	Resource	Condition and Trend	Rationale for Overall Condition/Trend Rating
Biological – Animals (continued)	Butterflies		Native species richness, diversity, evenness and the number of species of conservation concern indicate that the butterfly community is in good condition. There are four vulnerable butterfly species present and a community structure that is representative of a moderately disturbed landscape. The large population of regal fritillary at TAPR indicates that the preserve is providing high-quality habitat. Confidence in the assessment is medium, but within-year precision is low, year to year variability is moderately high and the biological relevance of the reference condition is unknown.
	Fish Community		Native species richness, the fish IBI, and the number of species of concern present indicate that the native fish communities warrant moderate concern. The fish community structure appears representative of a moderately disturbed landscape. The federally endangered Topeka shiner is present.
	Great Prairie-Chicken		Population and breeding success estimates indicate the condition of the greater prairie-chicken warrants moderate concern, with an unchanging trend. The subspecies appears not vulnerable/presumed stable under climate change through 2050. Continued and enhanced use of a diversified fire and grazing regime that is favorable to habitat needs of the prairie-chicken should help to increase populations over time.
	Herptiles (limited)		Surveys in 2002–2003 found 100% of expected amphibians and 85% of expected reptiles. Overall, 31 species were confirmed out of 35 expected species for an 88% confirmation rate, which indicates good condition. Additional monitoring is recommended.
	Topeka shiner		Topeka shiner abundance and the relative abundance of predaceous fish present in 2011 indicate that resource warrants moderate concern. The Topeka shiner is present and a community of predaceous fish that prey upon the Topeka shiner is very abundant. By 2050, the species is estimated to be highly vulnerable to climate change within Kansas and moderately vulnerable at TAPR. There are concerns that moderate vulnerability to climate change within the preserve could result in declining populations.

5.1.1. Landscape Context –System and Human Dimensions

Landscape context – system and human dimensions included land cover and land use, night sky, soundscape, scenery, climate change and fire disturbance regime (Table 5.1-1). Climate change and land cover/land use were not assigned a condition or trend—they provide important context to the preserve and many natural resources, and can be stressors. Some of the land cover and land use-related stressors at TAPR and in the larger region are related to the development of rural agricultural land and increases in population/housing over time. The trend in land development, coupled with the lack of significantly-sized and linked protected areas, presents significant challenges to the conservation of natural resources of TAPR to also include dark night skies, natural sounds and scenery. Climate change is happening and is affecting resources, but is not considered *good* or *bad* per se. The information synthesized in that section is useful in examining potential trends in the vulnerability of several sensitive biological resources below. The fire regime is included here because in this region fire is a key natural process under which many biological components have evolved. Therefore, it is deemed a critical component of the long-term persistence of prairie species and the ecological integrity of the system. The fire regime warranted moderate concern with an unchanging trend, and might be significantly ameliorated via planning, programmatic and budgetary measures.

There are opportunities to mitigate the effects of local landscape context stressors through planning, management and mitigation. Stressors driven by more distant factors such as light pollution generated by urban centers and increase in regional transportation volumes affecting sights and sounds are more difficult to mitigate. Collectively, this context supports resource planning and management within the preserve, and provides a foundation for collaborative conservation with other landowners in the surrounding area.

5.1.2. Chemical and Physical Environment

The supporting chemical and physical environment at the preserve includes its air quality, water quality and stream hydrology/geomorphology (Table 5.1-1). The condition of these resources can a affect human dimensions of the preserve such as visibility and scenery as well as biological components such as vegetation health and stream biota. Air quality warranted significant concern, while water quality and stream hydrology/geomorphology warranted moderate concern.

Conditions were estimated to be unchanging for all three resources. Air quality and water quality in Fox Creek are significantly impacted by land uses outside the preserve boundary. Water quality in most streams evaluated have watershed within the preserve boundary. Both stream geomorphology and water quality appear to be significantly impacted by cattle grazing. Although trampling from cattle grazing appears to have a significant negative impact on some streams within the preserve, it is difficult to attribute stream bank and incision problems to current grazing management vs. historic overgrazing as recent as 2005. In some streams, recovery of streambank and channel stability was observed, but evidence of cattle impacts on riparian areas and streams is widespread.

5.1.3. Biological Component – Plants

The floral biological components examined included prairie vegetation and invasive exotic plants (Table 5.1-1). The preserve is an excellent example of tallgrass prairie and one of the largest protected parcels in the historic range of the community. In some areas, enhanced management of prescribed fire and cattle grazing (especially since grazing rights were acquired), bison introduction, and prairie restoration projects in the Fox Creek bottomlands are likely increasing the heterogeneity of vegetation and overall habitat quality. However, challenges related to invasive plant management and fire regime contribute to moderate ratings and some declining trends.

5.1.4. Biological Component – Animals

The faunal biological components examined included aquatic macroinvertebrates, birds, bison, butterflies, fish, greater prairie-chicken, herptiles and the Topeka shiner (Table 5.1-1). Half of the resources examined were found to be in good condition with an unchanging trend or no trend. Of the remaining four resources that warranted moderate concern, three are aquatic fauna that are being impacted by poor water quality, altered stream flows/hydrology and introduced warm-water species of fish. The bison reintroduction effort has been extremely successful. Although the herd is limited to occupying no more than 10% of the preserve, preserve managers are hoping to use bison to achieve ecological restoration objectives as well as objectives related to bison herd health and genetics, herd size and demographics, and visitor experience.

5.2. Data Gaps and Uncertainties

The identification of data gaps during the course of the assessment is an important outcome of the NRCA (Table 5.2-1). In some cases significant data gaps contributed to low confidence in the condition or trend assigned to a resource. Primary data gaps and uncertainties encountered were lack of recent survey data; uncertainties regarding reference conditions; availability of consistent, long-term data; and incomplete understanding of the ecology of rare resources.

Table 5.2-1. Data gaps identified for focal resources examined at Tallgrass Prairie National Preserve.

Ecosystem Attribute	Resource	Data Gaps
Landscape Context – System and Human Dimensions	Land Cover and Land Use	Condition/status of other protected lands in the region.
	Night Sky	No significant gaps were identified.
	Soundscape	Evaluation was based on modeled data. Inventory and monitoring using recorded data and listening would help refine data. Impacts of existing soundscape conditions on visitor experiences are unknown.
	Views and Scenery	Further examination of key views by preserve staff is recommended incorporating scenic quality protocols being developed by the NPS Scenery Conservation Program.
	Climate Change	Climate change projections are complex with inherently high uncertainty. More specific guidance for preserve adaptation is needed with regard to livestock and other resources.
	Fire Disturbance Regime	Burn severity data.
Chemical and Physical Environment	Air Quality	Local air monitoring stations vs. interpolated regional data would improve accuracy.
	Stream Hydrology and Geomorphology	Discharge data for low-order streams in the preserve and ponds would support better understanding of flow dynamics.
	Water Quality	No significant gaps were identified.

Table 5.2-1 (continued). Data gaps identified for focal resources examined at Tallgrass Prairie National Preserve.

Ecosystem Attribute	Resource	Data Gaps
Biological – Plants	Prairie Vegetation	High variability in sample data due to interannual weather differences, phenology and small sample sizes can make it difficult to interpret data and detect statistically significant changes over time.
	Invasive Exotic Plants	No gaps were identified. The available data reflects intensive surveys covering all areas of the preserve and addressing preserve-based watch lists. Spatial resolution of the data is high.
Biological – Animals	Aquatic Macroinvertebrates	Reference conditions are poorly defined in this region. Few years of data are available.
	Bird Community	Data on the abundance of migratory and wintering birds at TAPR was sparse or completely lacking and investigation of bird populations during these periods is an important need.
	Bison	No significant gaps were identified.
	Butterflies	Uncertainty in the analysis stems from limited years of data collected by multiple observers with varying identification expertise.
	Fish Community	Consistency in sampling design and efforts may increase the power of the data.
Biological – Animals (continued)	Great Prairie-Chicken	The biggest data gap is consistent and unbiased population monitoring data. Evaluation of methods and designs are recommended to optimize accuracy and precision.
	Herptiles	Data are very limited. Survey data were only available for a single time period and no monitoring data were available.
	Topeka shiner	Differences in sampling effort among sampling periods may increase variability in sample estimates for this relatively rare species. Shiner may be present in areas not sampled.

5.3. Conclusions

In recent years, scientists and land managers have recognized the importance of creating heterogeneity on the landscape to promote diversity, sustain species adapted to natural disturbance regimes, and foster a variety of faunal habitat structures (Wiens 1997, Fuhlendorf and Engle 2001, Reinking 2005). In tallgrass prairie, the primary disturbance agents of fire and grazing interact with other biotic and abiotic factors to maximize heterogeneity and species diversity on the landscape (Fuhlendorf et al. 2006, Hamilton 2007, Knapp et al. 1999). Under the current patch-burn grazing system used at TAPR, considerable heterogeneity is created, benefitting many ecosystem components. However, there is evidence that ecosystem diversity and heterogeneity would be enhanced by diversifying the burning and grazing program away from the predominance of spring burns followed by intensive grazing. A more varied disturbance regime would likely enhance the diversity of native grasses and forbs and reduce possible negative impacts to some fauna such as the prairie-chicken and herpetofauna.

Evidence of the relationship between historic settlement, land use, and natural resources is abundant over the extent of the preserve. This includes water-related factors that influenced the location of homesteads and ranch houses, the establishment of spring boxes to tap perennial springs, and the development of earthen dams along perennial and intermittent drainageways to form stock ponds. The division of the land into pastures for grazing livestock using stone walls is a reminder of the ranching legacy that is an important part of the preserve's mission (BVHA 2004). However, as with impacts associated with cattle grazing, additional management of historic stock ponds to reduce populations of warm water predatory species may be necessary to improve populations of the Topeka shiner and native fish communities. These are but several examples of the challenges in managing parks with significant natural resources within an historic context.

Regional and preserve-specific mitigation and adaptation strategies are needed to maintain or improve the condition of some resources over time. Success will require acknowledging a "dynamic change context" that manages widespread and volatile problems while confronting uncertainties, managing natural and cultural resources simultaneously and interdependently, developing broad disciplinary and interdisciplinary knowledge, and establishing connectivity across broad landscapes beyond park borders (National Park Service Advisory Board Science Committee 2012).

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