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Natural Resource Condition Assessment, Homestead National Monument of America

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National Park Service
U.S. Department of the Interior

Natural Resource Stewardship and Science

Natural Resource Condition Assessment

Homestead National Monument of America

Natural Resource Report NPS/HOME/NRR—2019/2049

ON THE COVER
Homestead National Monument, view looking east toward the Visitor's Center
Photo by Dave Jones, Colorado State University

Natural Resource Condition Assessment

Homestead National Monument of America

Natural Resource Report NPS/HOME/NRR—2019/2049

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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 formal peer review by subject-matter experts who were not directly involved in the collection, analysis, or reporting of the data, and whose background and expertise put them on par technically and scientifically with the authors of the information.

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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 (map) products.

Congress established the Homestead National Monument of America (hereafter referred to as HOME, Monument, or park) in 1936 under the stewardship of the NPS to "retain for posterity a proper memorial emblematical of the hardships and the pioneer life through which early settlers passed in the settlement, cultivation and civilization of the Great West." On September 25, 1970, Congress added the Freeman School parcel to "further the interpretation and commemoration of the pioneer life of early settlers of the West." The mission of the Monument is to maintain a memorial that commemorates and interprets the Homestead Act and its influence upon the country. The mission is to maintain the 160-acre original homestead and the Freeman School addition in a manner that provides visitors an approximate perspective of the influences and impacts upon the land in its transition from its natural state to cultivation and agriculture.

The NRCA for HOME began in 2012. This study employed a scoping process involving Colorado State University, Park and NPS staffs to discuss the NRCA framework, identify important park 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, nine addressing biological attributes, and one addressing integrated natural/cultural resources.

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 park and many natural resources, and can be stressors on resources. Land cover analysis incorporated spatial data for landcover classes, natural vs. converted landcover, impervious surfaces, population and housing trends and conservation (i.e., protection) status for buffer areas outside the park. Land ownership in the region is overwhelmingly private. Some of the land cover and land use-related stressors at HOME 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 HOME 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 for a more heterogeneous fire regime with occasional high severity. Fire regime within the bur oak community was discussed—the lack of fire within that system appears to be degrading its condition and contributing to a declining trend.

The supporting chemical and physical environment at the park includes its air quality, water quality and stream hydrology/geomorphology. The condition of these resources can affect visitor experience such as visibility and scenery as well as biological components such as vegetation health and stream biota. Air quality and stream hydrology/geomorphology warranted significant concern, while water quality warranted moderate concern. Conditions were estimated to be unchanging for air quality and stream hydrology/geomorphology, with an unknown trend for water quality due to a lack of data. Air quality and water quality in Cub Creek are significantly impacted by land uses outside the park boundary. Impacts to air quality appear to be largely from distant sources that are affecting regional air quality, or local sources produced by ecologically necessary prescribed burns. Both stream geomorphology and water quality appear to be significantly impacted by cattle grazing and upstream land uses. Incision of Cub Creek is a legacy of historical land uses as well as conversion of natural systems to agriculture.

The floral biological components examined included prairie vegetation, invasive exotic plants and the mesic bur oak community (Table 5.1-1). The tallgrass prairie at HOME is considered an excellent example of a restored tallgrass prairie, and is one of the oldest restorations of its kind in the U.S. The vegetation composition is thought to be similar to that of presettlement vegetation, although forb species richness is still below expected levels. Enhanced management of prescribed fire and continued invasive plant management would likely increase the heterogeneity of vegetation and overall habitat quality. Grazing of native ungulates such as bison would likely have ecological benefits but their management is not considered practical for the small site. The bur oak community is considered an excellent example of this rare type in Nebraska. Historic cutting and disturbances, the lingering effects of those events, lack of fire, and dominance of undesirable tree species continue to impact this community, which warrants moderate concern. Challenges related to invasive plant management and fire regime contribute to management concerns. Although the prairie is rated in good condition, there is some risk associated with potential expansion of nonnative invasive plants. Intensive, park-wide surveys occur regularly and management is driven by the monitoring results. Maintenance of a desirable fire regime can help control woody plants and promote floristic diversity, but is challenging due to the park’s location within an ex-urban area and limited implementation of prescribed burns.

The faunal biological components examined included aquatic macroinvertebrates, terrestrial invertebrates, birds, fish, herptiles and mammals. Two of the six resources examined were found to be in good condition with an unchanging trend. Aquatic macroinvertebrates are being impacted by poor water quality and altered stream flows/hydrology that originate upstream outside the boundary. The fish and mammal communities warranted moderate concern. The herptile community warrants significant concern. The bird community is in good condition. Trends for faunal resources examined are unchanging or unknown. Because of the small size of the park and the predominance of developed and agricultural land uses, opportunities to support a diverse faunal assemblage at HOME, including a variety of herpetofauna, carnivores, ungulates and other species is limited. Many animals have been lost from the landscape and are no longer present in the park. Nonetheless, the park still provides an island of restored prairie and bottomland forest that provides habitat for native animals. The role of connectivity and partnering with other landowners will be critical to maintain and enhance the fauna at HOME.

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 Monument managers to develop near-term management priorities, engage in watershed or landscape-scale collaboration and education efforts, conduct park planning, and report program performance.

Ecosystem stressors impacting park resources and their management exist both inside and outside park boundaries. Altered disturbance regimes such as fire and flooding, conversion and fragmentation of natural habitats, spread of invasive exotic plants 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, commercial wind energy development and traffic. Many of the resources were found to have interrelated stressors, the most common being invasive plants, altered fire regime, and stream alteration.

Regional and park-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.

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, Mission and Purpose

In March 1936, Congress established the Homestead National Monument of America (HOME) under the stewardship of the NPS to "retain for posterity a proper memorial emblematical of the hardships and the pioneer life through which early settlers passed in the settlement, cultivation and civilization of the Great West." On September 25, 1970, Congress added the Freeman School parcel to "further the interpretation and commemoration of the pioneer life of early settlers of the West."

The mission of Homestead National Monument of America is to maintain a memorial that commemorates and interprets the Homestead Act and its influence upon the country. The mission is to maintain the 160-acre original homestead and the Freeman School addition in a manner that provides visitors an approximate perspective of the influences and impacts upon the land in its transition from its natural state to cultivation and agriculture (NPS 1997). The purpose of the Monument is to:

- Interpret the history of the country resulting in and from the Homestead Act;
- Preserve literature; preserve agricultural implements; and construct a suitable museum to interpret settlement, cultivation, and development of the "Great West;"
- Commemorate the people whose lives were forever altered by the Homestead Act and the settlement of the West;
- Protect the setting, provide access to the Freeman School, and maintain a visual relationship between the Freeman School and the rest of the Monument (NPS Midwest Regional Office 1999).

2.1.2. Location, Size and Geographic Setting

The Monument is located in Gage County, Nebraska, approximately 50 miles south of Lincoln, Nebraska (Figure 2.1-1). The Monument is situated 3.5 miles west of the town of Beatrice (pop. 12,452 (2011)) (http://www.city-data.com accessed 4/18/2013). The Monument consists of approximately 211 ac, which includes the original Daniel Freeman homestead. The Freeman homestead was the first homestead claim entered in Nebraska and one of the first in the nation (NPS 1999).

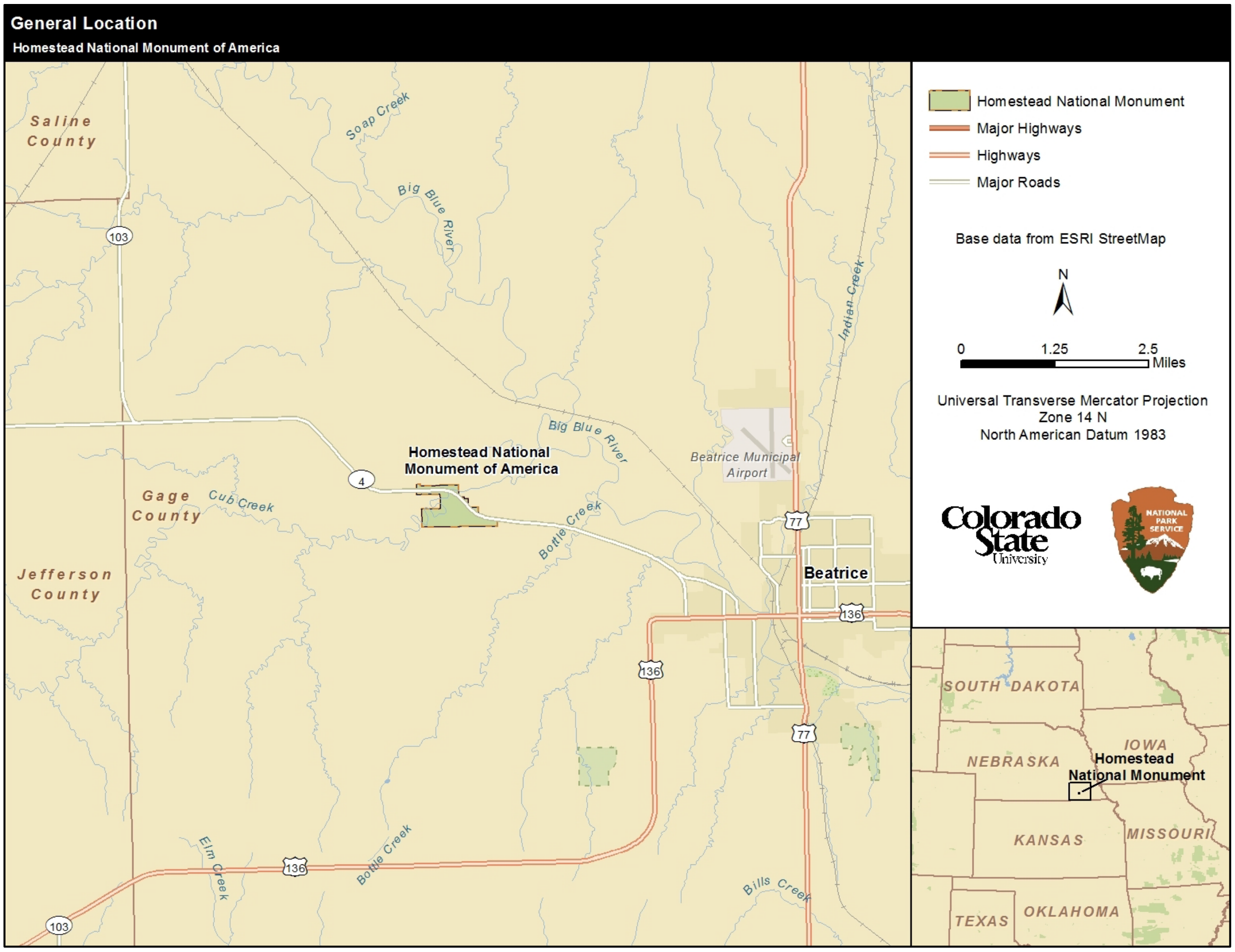

Figure 2.1-1. General location of Homestead National Monument of America (CSU, NPS).

2.1.3. Park Significance

According to the Monument's General Management Plan (NPS 1999), the Monument is significant because:

- It encompasses a 160-acre homestead claim established on the first day of the 1863 Homestead Act's implementation that is commemorative of all homesteads.
- The Freeman School is an original structure that represents the role of one-room schools throughout the Homestead Era.
- The Homestead Act had a profound influence on American migration, immigration, agricultural development, industrial development, federal land policy, native cultures, and the landscape of the West.
- The reconstructed tallgrass prairie represents the second oldest prairie reconstruction in the nation and oldest within the national park system; portions thereof offer historic and scientific research value.

2.1.4. Visitation Statistics

Park visitors are a mixture of recreation and non-recreation travelers and local residents. Annual park recreation visitation has been increasing steadily and has roughly quadrupled since 1979 (Figure 2.1-2). Non-recreation visitation is approximately ten times the recreation visitation. Mean annual visitation for the five-year period ending 2012 was 78,096 recreation visitors and 420,220 non-recreation visitors per year. The spike in visitation in 2012 is attributed to special commemoration programs and events for the 150th Anniversary of the Homestead Act. Based on the results of a May-June 2009 visitor survey, the most common sites visited at HOME were the Heritage Center (88% of respondents) and the Education Center (72%) (Figure 2.1-3). Nature-based recreation activities included hiking trails (43%), viewing trailside exhibits (39%), attending ranger-led talks (22%), nature study (18%) and picnicking (10%) (Papadogiannaki et al. 2010). Monthly visitation is highest from May to October (Figure 2.1-4). From 2008–2012, car traffic at the Heritage Center averaged 60 cars per day during May-October and 26 cars per day during the low season months of November-April. At the Education Center, car traffic averaged 75 cars per day during May-October and 44 cars per day during the low season months of November-April. (NPS 2013).

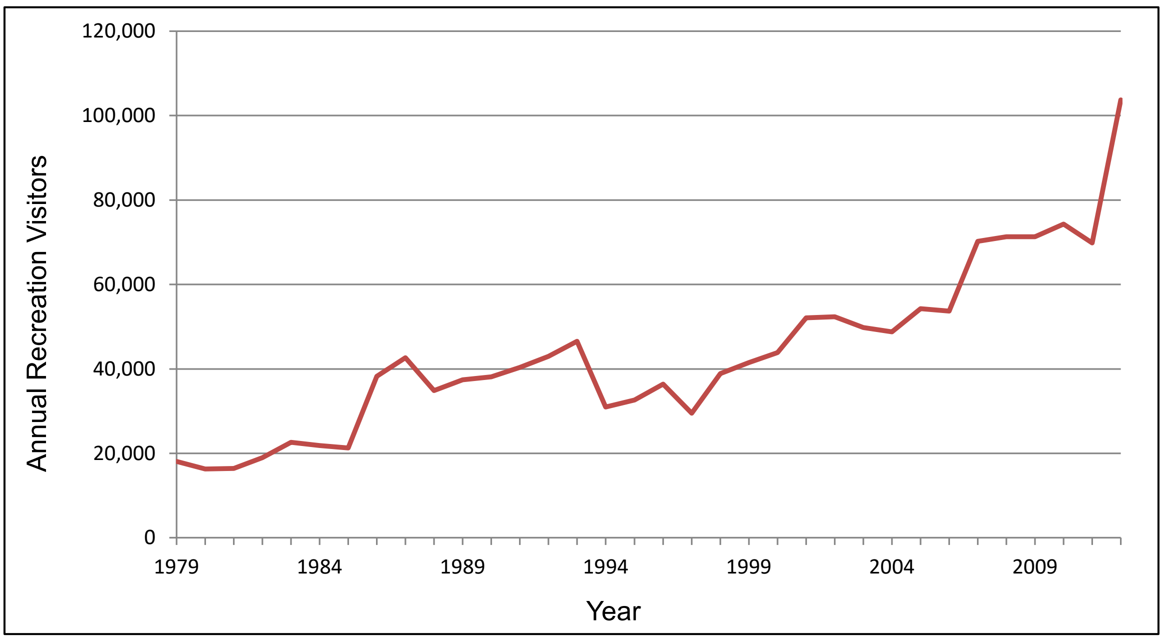

Figure 2.1-2. Annual HOME recreation visitation for 1979–2012 (NPS 2013).

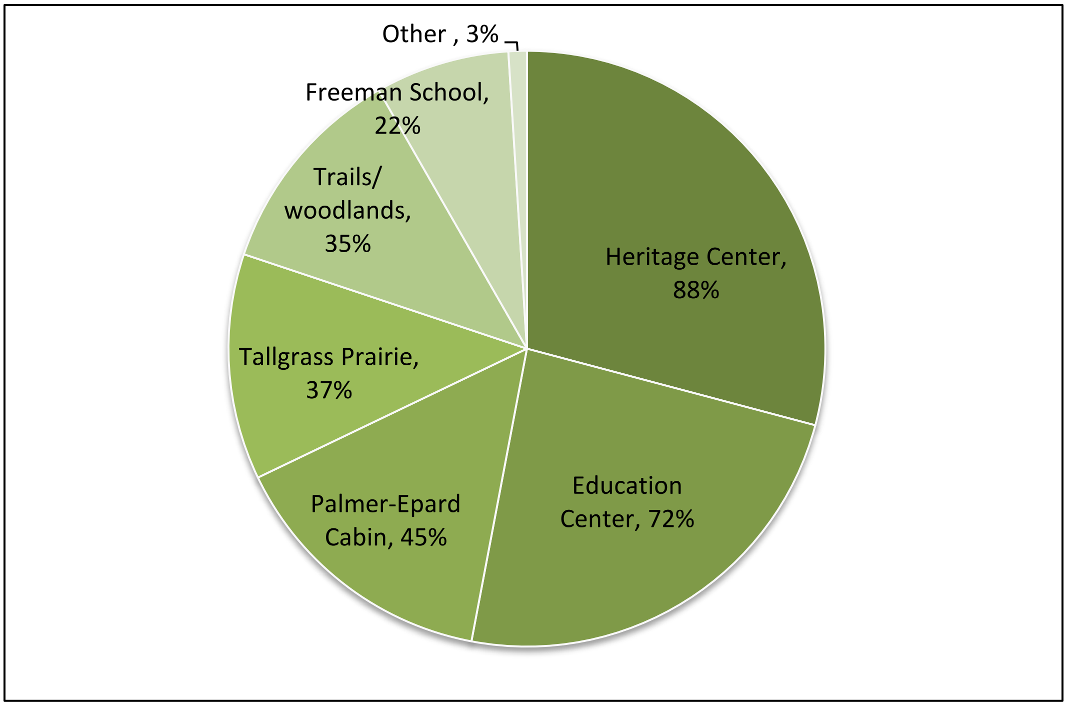

Figure 2.1-3. Percentage of visitors visiting HOME sites (Papadogiannaki et al. 2010).

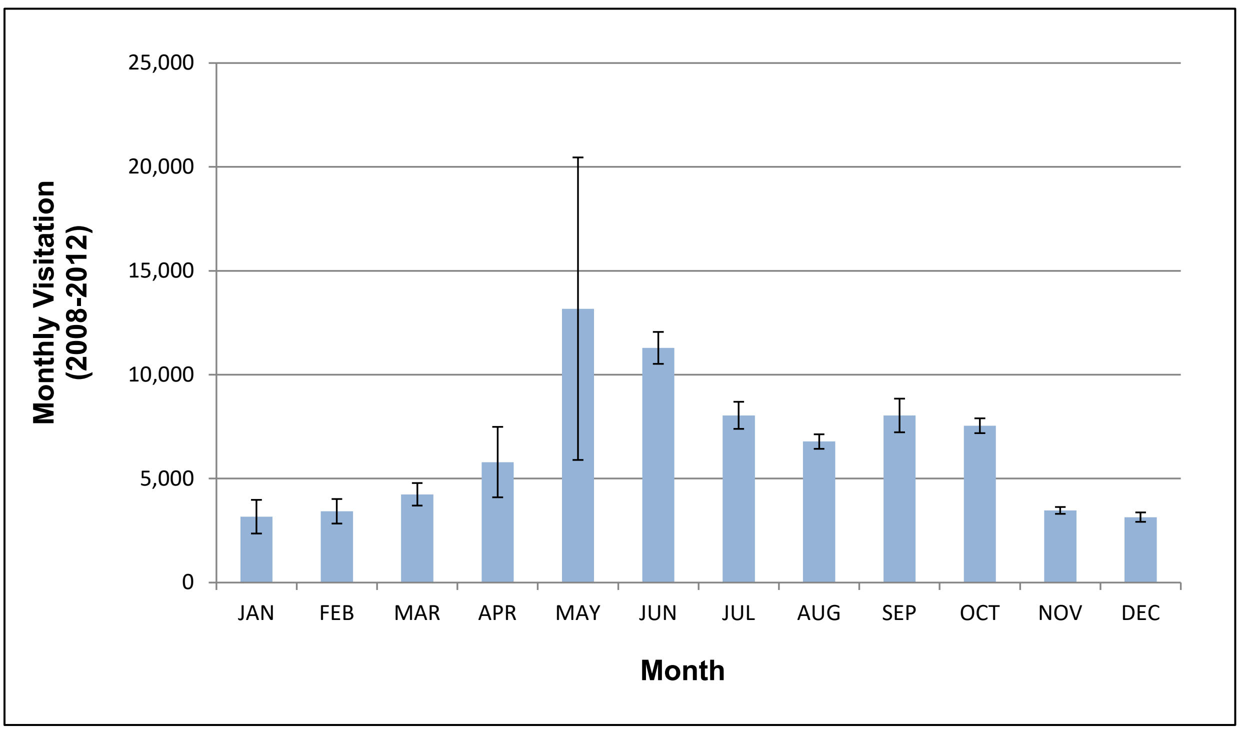

Figure 2.1-4. Mean monthly recreation visitation for HOME for 2008–2012 (NPS 2013). Error bars represent 90% confidence intervals.

2.2. Natural Resources Overview

2.2.1. Climate

Nebraska weather is notable for its wide seasonal variations in temperature, precipitation, and humidity. The average low temperature in nearby Beatrice, Nebraska is 12 degrees Fahrenheit in January, and the average high is 90 degrees Fahrenheit in July. Nebraska receives cool, dry air from the Rocky Mountains in the west, as well as warm, moist air from the Gulf of Mexico in the south. The interaction of these air masses produces frequent and sometimes violent thunderstorms, particularly from April through September. Precipitation averages 28 inches per year in Beatrice. Tornadoes are common in spring months. Climate and climate change at HOME are further examined in section 4.5, *Climate Change*.

2.2.2. Geology and Soils

The underlying geology of Nebraska shows a distinct grade from east to west: the oldest rocks, part of the Pennsylvanian and Permian formations, are in the southeastern corner of Nebraska. These formations reflect the sediments laid down under prehistoric seas. Gage County and HOME have this ancient underlying geology. Going west, the geology reflects the more recent terrigenous origins associated with the formations of the Rocky Mountains to the west and other geologic processes, like volcanic activity (http://geology.about.com/od/maps/ig/stategeomaps/NEgeomap.htm, accessed 1/6/2014).

The soils of Nebraska similarly show a gradient from east to west. The soils of eastern Nebraska, including those underlying HOME, are alluvial as well as glacial. They indicate the influence of the rivers in the eastern part of the state, including the Missouri River. Furthermore, they also show the influence of past glacial activity. To the west, sandy soils reflect wind-driven sandy deposition (Graham 2011, Kuzila undated).

2.2.3. Hydrology

The primary hydrologic feature of Homestead National Monument of America is Cub Creek, within the Tuttle Creek watershed. Cub Creek enters the Monument from the southwest and winds its way across the Monument in a northeasterly direction. Cub Creek drains into the Big Blue River, which flows into Kansas. Water from Tuttle Creek Lake not only serves as one of the primary inflows to the Kansas River but also provided drinking water for cities like Kansas City, Topeka, and Lawrence (NPS 2014a).

The ecosystem health and environmental quality of Cub Creek provides a key indicator of resource condition for HOME. The creek drains over 92,000 ac of primarily agricultural land in Gage and Jefferson counties (NPS 2014a), and as such potentially serves as a transport corridor for nutrients, bacteria, and chemical contaminants into and through the Monument. Changes in resource condition are tracked by monitoring aquatic macroinvertebrates, fish, and physical properties. Aquatic invertebrates have been employed to suggest the condition of Cub Creek since 1989, and fish have been sampled in the same habitat since 2004. Both indicators are used to infer the resource condition of the creek, a primary and critical hydrologic resource and a large part of the historical landscape for HOME.

2.2.4. Air Quality

HOME is designated as a Class II airshed by the Clean Air Act of 1997. Because of this designation, air quality within the Monument is protected by less stringent standards than in other parks and protected areas around the country. Air quality at HOME is not directly measured within the Monument but instead inferred from other instrumentation located around the region.

The air quality at HOME reflects regional air quality characteristics. For example, wet and dry deposition of nitrogen and sulfur estimates for HOME reflect the rural and agricultural character of southeastern Nebraska (NPS 2014b), while ozone concentrations generally mirror regional ones and do not indicate significant ozone concerns. These specific resource issues as well as visibility are addressed in Chapter 4, and have consequences for the health and condition of natural communities as well the quality of the visitor experience.

2.2.5. Land Use

HOME was created to interpret and understand the importance of the homesteading movement in the development of America, and exemplifies what happened to the Midwestern landscape as it changed from the homelands of Native Americans to supporting a westward moving and agricultural European American population. What was once miles upon miles of tallgrass prairie was converted to grazing and agricultural lands by homesteaders. The landscape around HOME shows this historical trend, with much of the lands in southeastern Nebraska supporting intensive agricultural production. The restoration efforts within HOME to recreate the tallgrass prairie and the increasingly-rare bur oak bottomland forest now counter the trend in the region of simple but efficient ecosystems converting sunlight into human and livestock food.

Land-use change surrounding HOME and in the larger region is a key indicator of the pressures to the health and condition of natural resources within parks like HOME.

2.2.6. Wildlife

The varied habitats at HOME support a variety and diversity of wildlife, many of which have been inventoried and are currently monitored by the Heartland Network I&M program. For example, the tallgrass prairie and woodland habitats support over 100 species of birds, a network vital sign. In addition to bird fauna, mammals are an important indicator of resource condition. Fish species are tracked to evaluate the condition of Cub Creek, while amphibians and reptiles have also been inventoried (Fogell 2004). The results of Fogell (2004) indicate that some portions of the Monument continue to host a rich abundance and diversity of reptiles and amphibians.

Like other NPS units protecting and preserving tallgrass prairie habitat, HOME likely has lost some species both before park creation and since then. Bison used to roam the tallgrass prairie, but their numbers and range were drastically reduced during westward expansion. Fogell (2004) also found that there were herpetofauna most likely extirpated from the park.

2.2.7. Vegetation

With the abundant rainfall available in southeastern Nebraska, the land was once covered by tallgrass prairie. The tallgrass prairie at HOME is considered an excellent example of a restored tallgrass prairie, and is one of the oldest restorations of its kind in the U.S. Depending on its elevation and distance from Cub Creek, the prairie would have been dominated by either little bluestem (*Schizachyrium scoparium*) at the higher (dryer) elevations or big bluestem (*Andropogon gerardii*) and other taller grasses at the lower (wetter) sites (Murie 1940). Like most of the tallgrass prairie that once covered the Midwest, the prairie that once covered HOME was converted to crop agriculture and grazed, and the natural fire regime was suppressed. Beginning shortly after its establishment, NPS managers have painstakingly restored 100 ac of native tallgrass prairie community to resemble its pre-homestead state (James 2011).

The riparian area along Cub Creek provides the right physical conditions for hardwood forests, common along streams and creeks in prairie country. HOME was once and is currently home to a critically imperiled Nebraska riparian community, the lowland bur oak forest (Rohlfsmeier 2007). This forest type, found mostly in the northern part of the park, was known from pre-homestead surveys (Rohlfsmeier 2007), and while altered, the basic elements of this historic association are present within HOME (James 2011).

Like tallgrass prairie habitat at other parks in this region, the tallgrass prairie at HOME relies on a prescribed fire regime in order to maintain tallgrass species and reduce the numbers of woody species. The natural fire regime would burn the tallgrass prairie every 5 to 10 years (NPS 2014c). The park uses fire to burn each of the six management units approximately twice within a 7-year period (NPS 2014c), to maintain native prairie and eliminate ecosystem threats like exotic species.

2.3. Resource Stewardship

2.3.1. Management Directives and Planning Guidance

Under the General Management Plan (NPS 1999) there are four primary management zones:

Historic Zone. This zone consists of approximately 150 ac on the original Freeman homestead, the Freeman School and the school grounds. Nearly 100 ac of the original homestead currently are reconstructed prairie and the remaining area is riparian woodland.

Historic Agricultural Practices Demonstration Subzone. This subzone encompasses approximately 12 ac within the Monument’s Historic Zone. This area is used to demonstrate historic agricultural practices, tools and equipment relating to the homesteading era.

Development Zone. This zone of approximately 6 ac includes the Education Center (formerly Visitor’s Center)/ administrative complex and maintenance area and the Heritage Center and surrounding grounds.

Special-Use Zone. This area encompasses approximately 30 ac protected by scenic easements along the Monument’s north boundary and along the north and south side of State Highway 4. These lands are currently used for agriculture.

2.3.2. Management Concerns Overview

Regional Great Plains ecosystem stressors that can impact park 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, excess deer browsing, altered hydrology and channel degradation of streams, sedimentation and pollution of streams, and poorly-sited utility-scale wind turbines (Schneider et al. 2011).

Park management concerns highlighted in the *General Management Plan* (NPS 1999) and by Park staff during the scoping process consist of natural and cultural resource-related issues as well as stressors from outside the park. Primary resource management concerns within the park and beyond park boundaries are briefly described below.

Prairie Quality and Natural Processes

Woody plant encroachment competes with native prairie vegetation and alters the character of the natural and cultural landscape. The primary tools used to manage the prairie are active restoration, weed management and prescribed fire. Nonnative invasive plants have been introduced and have spread throughout the region via agriculture other human disturbances and practices. Invasive exotic plants are a concern because of their potentially detrimental effects on the native and restored tallgrass prairie. An aggressive program to control invasive exotic plants and woody plant encroachment on the prairie is in place at HOME. Prairie conservation is challenging, especially with respect to natural processes such as fire.

Faunal Resources

All types of fauna within the park have been significantly impacted by habitat fragmentation, agriculture and development outside the park and within the region. The park is an island of intact restored prairie and hardwood riparian forest, but there is little habitat connectivity enabling movement and colonization by native animals. There will be limits to what managers at HOME can achieve in this regard.

Scenic Resources

Views from the park have changed since the park's creation in 1972. Easements have protected some views but development has encroached to some degree. The potential for wind energy development and its associated visual impacts are a major management concern. The views are variable, consisting of urban and commercial elements, energy and communication lines and structures, roads and highways, exurban and urban development, agriculture, and natural or natural-appearing settings. When HEHO was created, the town of West Branch and other nearby towns and cities were considerably smaller than they are today. Surrounding lands were agricultural and where the terrain allowed, there were few obstructions to views from the park all the way to the horizon. As development in the surrounding communities and the highway interchange have grown closer to the park and as inconsistent visual elements have appeared within view, the sense of open, extensive rural landscape is more difficult to experience. Much of the development surrounding the park is inconsistent with the landscape character associated with the park mission and purpose.

Other Impacts of Land Uses on Visitor/Cultural Experience

The sights, sounds and landscape associated with the park environs have changed over time as human population has increased and uses of the area have become more intensive or changed over time. Land-use changes and development outside the park impact the visitor experience with regard to altered scenery, excessive and unnatural noise, light pollution and solitude. The juxtaposition of development inside and outside the park with cultural features and landscapes degrades the visitor experience.

Water Quality and Stream Hydrology

Cub Creek water quality and its watershed are highly degraded due to overwhelming upstream alterations including extensive farming, urbanization, little buffering of riparian corridors, drain tiling and ditching, and upstream impoundments. The stream channel through the park is incised with unstable stream banks, and flooding is a concern.

2.3.3. 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 park, published and unpublished reports and articles, and other outside experts noted in the individual resource sections.

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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, park staff, Water Resources Division (NRCA proponent), and National Resource Stewardship and Science 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 park. Vital signs previous identified and prioritized for the park were the basis for a preliminary list of focal resources to support initial NRCA discussions with park and other NPS staff. A site visit and initial meetings took place September 20–21, 2012 at Homestead N.M. Headquarters. NPS participants included Mark Engler (Superintendent), Merrith Baughman (Chief of Interpretation and Resource Management), Jesse Bolli (Natural Resources Specialist), and Carmen Thomson (Midwest Region Inventory and Monitoring Program Manager). Colorado State University participants included Dave Jones, John Sovell, and Roy Cook. 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 park staff);
- Provide an overview of park 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 park 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 park (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 park 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 park, 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 nine addressing biological attributes, and one addressing an integrated natural/cultural topic.

3.2.2. Reporting Areas

The reporting area for all resources is generally the entire area within the park boundary. In some cases indicators were analyzed using subsets based on geographic or ecological strata within the park, e.g., grassland birds and woodland birds. The results for those subsets were then combined into single park-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 park 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).

Table 3.2-1. Homestead National Monument 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 park roads
	Scenery and Views	Integrity of landscape views from key view points Housing densities surrounding the park 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 (prairie)	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
	Mesic Bur Oak Community	Extent of vegetation at HOME classified as bur oak bottomland woodland Structure and composition of Cub Creek bottomland woodlands Disturbance regime of bottomland woodlands

Table 3.2-2 (continued). Homestead National Monument natural resource condition assessment framework.

Ecosystem Attributes	Focal Resources	Indicators and Measures of Condition
Biological – Animals	Aquatic Macroinvertebrates	Richness and diversity metrics Hilsenhoff Biotic Index
	Terrestrial Invertebrates	Native species richness (S)
	Birds	Native species richness (S) Bird index of biotic integrity (IBI) Occurrence and status of bird species of conservation concern
	Fish Community	Native species richness Fish index of biotic integrity (IBI)
	Herptiles (limited)	Proportion of the expected species present
	Mammals	Proportion of the expected species present
Integrated Natural/Cultural	Osage Orange Hedgerow	Percentage of historic hedgerow restored relative to management objectives

3.2.3. General Approach and Methods

General Approach

This study employed a scoping process involving Colorado State University, Park and NPS staffs to discuss the NRCA framework, identify important Park 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 park 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 and 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 park were obtained from myriad sources. The primary sources for park-specific resource data were park 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 park-related resources. Park 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 park or other agency staff. Spatial data were provided by the park, 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 resource 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, park 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 park 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 is 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 influencing 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.

Symbology and Scoring[1]

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.

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.

[1] Adapted from NPS-NRCA Guidance Update dated January 14, 2014.

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

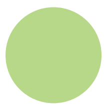
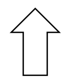
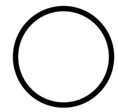
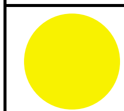
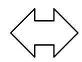
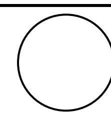
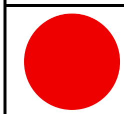
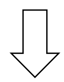
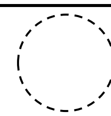
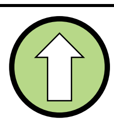
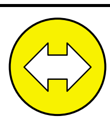
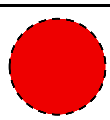
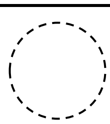
Condition Status		Trend in Condition		Confidence in Assessment	
Condition Icon	**Condition Icon Definition**	**Trend Icon**	**Trend Icon Definition**	**Confidence Icon**	**Confidence Icon Definition**
	Resource is in Good Condition		Condition is Improving		High
	Resource warrants Moderate Concern		Condition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

Table 3.3-3. 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 cannot be determined 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.

Organization of Focal Resource Assessments

Background and Importance

This section provides information regarding the relevance of the resource to the park 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).

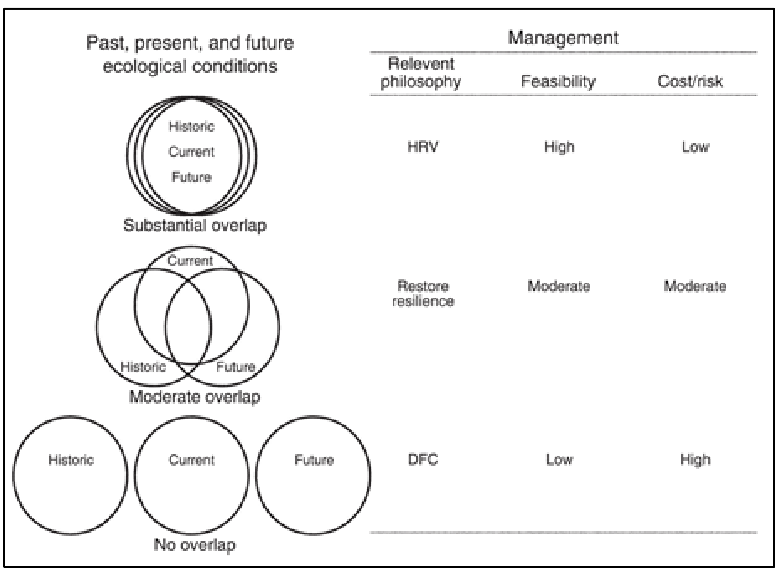


Figure 3.2-1. Illustration of three possible cases of the extent to which current ecosystem conditions in a place differ from historic conditions and from projected future conditions. Circles denote the range of variability for each time period. Also shown are the expected management criteria for each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

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.

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

Ecosystem attributes and focal resources described in this chapter are in Table 4-1 below.

Table 4-1. Outline of ecosystem attributes and focal resources for each section in Chapter 4 of this report.

Ecosystem Attribute	Focal Resource	Section Number
Landscape Context – System and Human Dimensions	Land Cover and Land Use	4.1
	Night Sky	4.2
	Soundscape	4.3
	Scenery and Views	4.4
	Climate Change	4.5
	Fire Disturbance Regime (prairie)	4.6
Chemical and Physical	Air Quality	4.7
	Stream Hydrology and Geomorphology	4.8
	Water Quality	4.9
Biological – Plants	Prairie Vegetation	4.10
	Invasive Exotic Plants	4.11
	Mesic Bur Oak Forest and Woodland Community	4.12
Biological – Animals	Aquatic Macroinvertebrates	4.13
	Terrestrial Invertebrates	4.14
	Bird Community	4.15
	Fish Community	4.16
	Herptiles	4.17
Integrated Natural/Cultural	Mammals	4.18
	Osage Orange Hedgerow	4.19

4.1. Land Cover and Land Use

4.1.1. Background and Importance

This section places park 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 park resources, and underscores the conservation value of the park to the surrounding region. The synthesis of national data uses a series of straightforward spatial analyses for areas within and surrounding the park. 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 park has little influence over activities occurring outside park 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 park, 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 park and outside the park are not examined.

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.

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)

4.1.2. 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 park were compared to resource conditions in the broader region surrounding the park. Landscape attributes important to park resources often vary with scale or spatial extent. Relevant scales or areas of analysis (AOAs) include the landscape within the park itself (i.e., the reporting unit used for many focal resources in this report), the "boundary" area immediately adjacent to the park (e.g., 3 km (1.8 mi) buffer), the local area surrounding a park (e.g., within 30 km (18 mi) of the park boundary), the watershed area(s) upstream from the park influencing park 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 park 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 landscape context measures, designated by "X."

		Areas of Analysis				
Indicators	**Measures**	**3 km Buffer around Park**	**Park + 30 km Buffer**	**Contributing Upstream Watershed**	**Counties Overlapping with Park + 30 km Buffer**	**Tallgrass Prairie Region**
Land cover and use	Anderson Level I	X	X	X	–	–
	natural vs. converted land cover	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	–	–

Table 4.1-1 (continued). Areas of analysis used for landscape context measures, designated by "X."

Indicators	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
Conservation status	Protected areas (ownership) and biodiversity conservation status	X	X	–	–	X

Land Cover

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 30m pixel resolution. NLCD change detection is a very powerful tool because it follows 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). We present the 2006 NLCD data. 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.

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.

Table 4.1-3. 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	Anderson Level II	Natural/Converted
Open Water	–	Natural
Developed	–	Converted
Barren/Quarries/Transitional	–	Natural
Forest	–	Natural
Shrub/Scrub	–	Natural

Table 4.1-4 (continued). 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	Anderson Level II	Natural/Converted
Grassland/Herbaceous	–	Natural
Agriculture	pasture/hay vs. cultivated agriculture	Converted
Wetlands	–	Natural

Human Population and Housing

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 (18 mi) park buffer, and U.S Census Bureau block data from 1990, 2000 and 2010 for population density. Population density (number of people per square kilometer) classes follow NPScape guidance (NPS 2014b).

Conservation Status

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 (CBI 2013). 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 Nebraska; the accounting of the acreage of NGO-held easements in Nebraska is also currently estimated at approximately 90% complete.

Level of Protection

The United States Geological Survey 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 NECD 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, Nature Conservancy 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(18 mi) buffer of the park boundary. GAP biodiversity protection values were summarized for NCED and PAD-US parcels by ownership type within the 30 km (18 mi) buffer areas of interest. Protected areas data were 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.

4.1.3. Condition and Trend

Land Cover and Use

Extent of Anderson Level I Classes 2006

In the immediate vicinity of HOME (3 km (1.8 mi) buffer) over 70% of land acreage is used for agriculture, and nearly 5% is developed (Table 4.1-3, Figure 4.1-1). Within the 30 km (18 mi) buffer, nearly 69% of the acreage is agricultural and 5% is developed. Land cover of the contributing upstream watershed is over 69% agriculture, partially explaining the moderately impaired condition of water quality in Cub Creek. The interaction between agricultural acreage and housing development, which is an important aspect of land cover and land use surrounding HOME, is discussed in the *Population and Housing* section. After agriculture, the next most prevalent land cover class for all AOA's is grassland/herbaceous. These grassland areas are small and very fragmented, and likely have lost most of their ecological function (Figure 4.1-2).

Within the Western Corn Belt Region, which encompasses portions of Minnesota, Iowa, Nebraska, South Dakota and North Dakota an accelerated rate of conversion of grasslands (including native and anthropogenically modified grassland types) to croplands such as corn and soybeans was documented between 2006 and 2011 (Wright and Wimberly 2013). Results indicated a net decline in grass-dominated land cover totaling nearly 530,000 ha (> 1.3 million ac) over the five-year time period, with annual conversion rates varying from 1.0–5.4%. In Nebraska, the net loss of grassland to corn and soybeans was estimated at 25,000 ha (62,000 ac). This trend will reduce the amount of native prairie and other pasture and hay fields, reduce connectivity among grassland patches, and reduce wildlife habitat value while further altering watershed characteristics and water quality.

Table 4.1-5. Anderson Level 1 land cover classes within 3 km and 30 km of the park boundary, and within the contributing upstream watershed of the park.

	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	273	2.54%	8,944	1.22%	1,034	1.20%
Developed	521	4.84%	36,729	5.01%	3,607	4.18%
Barren/Quarries/Transitional	0	0.00%	51	0.01%	6	0.01%
Forest	957	8.88%	32,145	4.38%	3,224	3.74%
Scrub/Shrub	< 1	0.01%	116	0.02%	12	0.01%
Grassland/Herbaceous	1,196	11.11%	148,884	20.30%	18,345	21.26%
Agriculture	7,724	71.69%	504,417	68.77%	59,835	69.35%
Wetlands	103	0.95%	2,233	0.30%	218	0.25%
Total	**10,774**	–	**733,519**	–	**86,282**	–

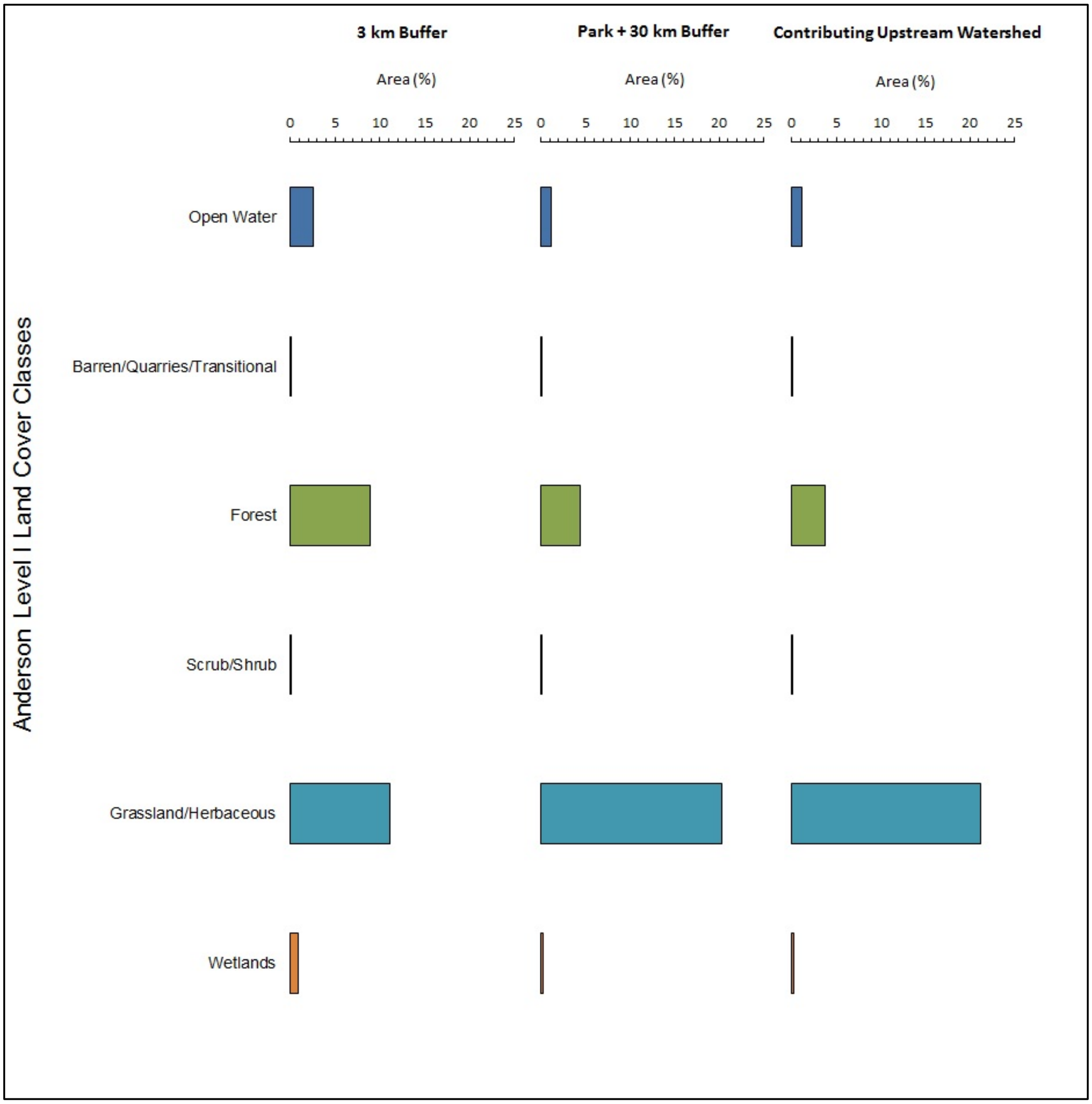

Figure 4.1-1. Anderson Level 1 land cover class proportions within 3 km and 30 km of the park boundary, and within the contributing upstream watershed of the park. Developed and agriculture land cover classes are omitted here to improve the scale of the graphic.

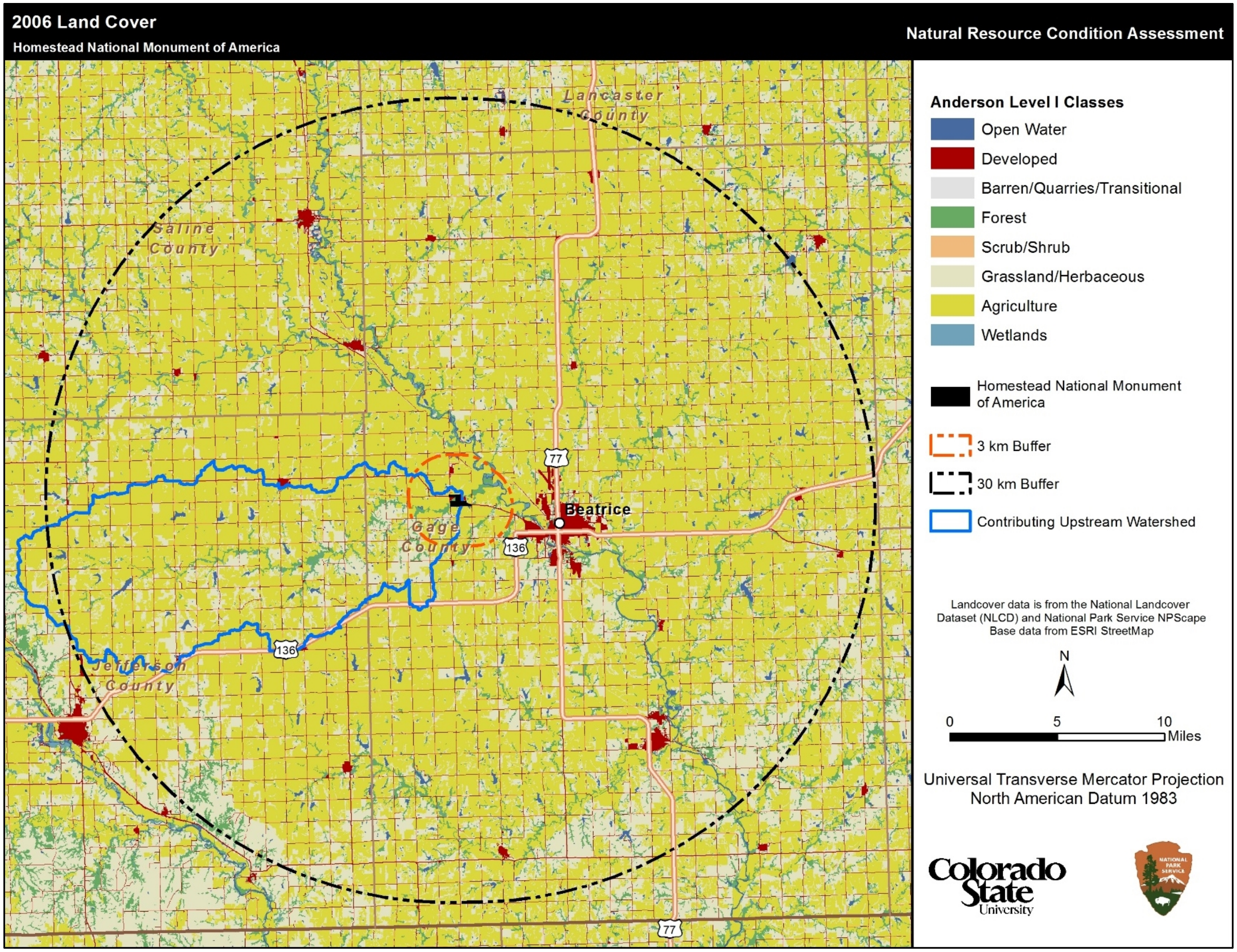

Figure 4.1-2. Anderson Level 1 land cover classes within 3 km and 30 km of the park boundary, and within the contributing upstream watershed of the park. National Land Cover Dataset data provided by NPS NPScape Program.

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 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 HOME is higher than in the Tallgrass Prairie ecoregion as a whole (Table 4.1-4). Within 30 km (18 mi) of the park boundary and in the contributing upstream watershed, 26% of the area is classified as natural (Figure 4.1-3). The low proportion of natural acreage is largely attributed to the heavy agricultural use of the surrounding area, both for pasture and crops (Figure 4.1-3).

Table 4.1-6. Natural vs. converted acreage within 3 km and 30 km of the park boundary, within the contributing upstream watershed of the park, and within the Tallgrass Prairie Ecoregion.

	Natural		Converted	
AOA	**Acres**	**% of Area**	**Acres**	**% of Area**
3 km	2,535	23.52%	8,245	76.48%
Park + 30 km Buffer	192,374	26.23%	541,146	73.77%
Contributing Upstream Watershed	22,840	26.47%	63,442	73.53%
Tallgrass Prairie Ecoregion	63,104,955	32.73%	129,810,610	67.27%

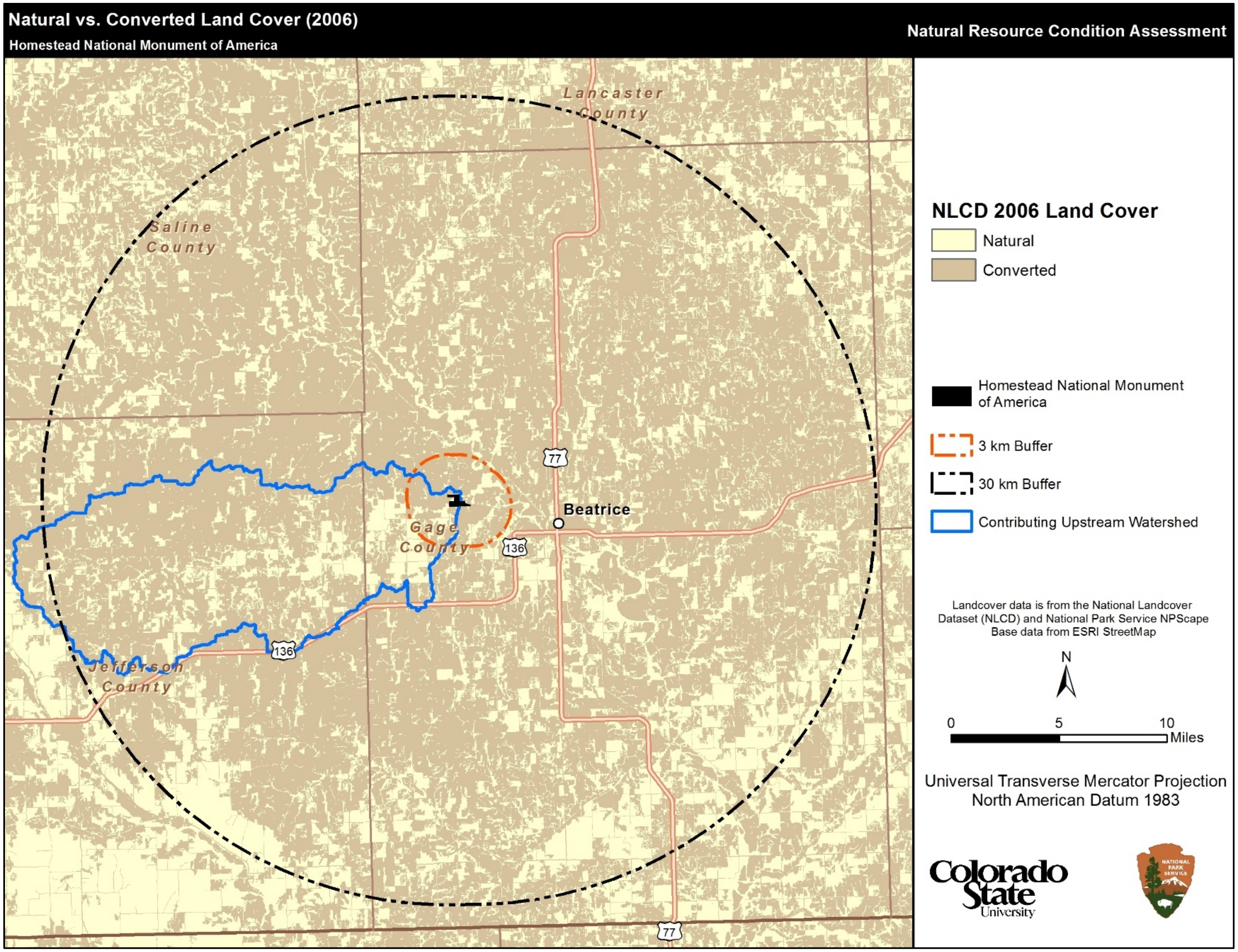

Figure 4.1-3. Natural vs. converted land cover classes within 3 km and 30 km of the park boundary, and within the contributing upstream watershed of the park. 2006 National Land Cover Dataset data provided by NPS NPScape Program.

Impervious Surface Area

Impervious surfaces include Anderson Level I developed classes, including bare rock, paved roads, and areas covered with asphalt or concrete. 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 HOME's contributing upstream watershed is in the lowest imperviousness class (0–2% impervious surfaces) (Table 4.1-5, Figure 4.1-4). There is a low degree of imperviousness in relation to other parks in the region. This is most likely attributable to the fact that although the area is highly converted, most of the converted acreage is agricultural land, which retains a significant amount of its permeability. As a benchmark for future analysis, approximately 0.3% of the contributing upstream watershed of the park was classified as having > 25% impervious surfaces (Table 4.1-5).

Table 4.1-7. Percent impervious surfaces acreage based on Anderson land cover classes within the contributing upstream watershed of the park.

Percent Impervious Surface	Acres	% of Area
0%–2%	83,159	96.38%
2%–4%	634	0.74%
4%–6%	435	0.50%
6%–8%	396	0.46%
8%–10%	338	0.39%
10%–15%	612	0.71%
15%–25%	444	0.51%
25%–50%	228	0.26%
50%–100%	36	0.04%
Total	**86,282**	–

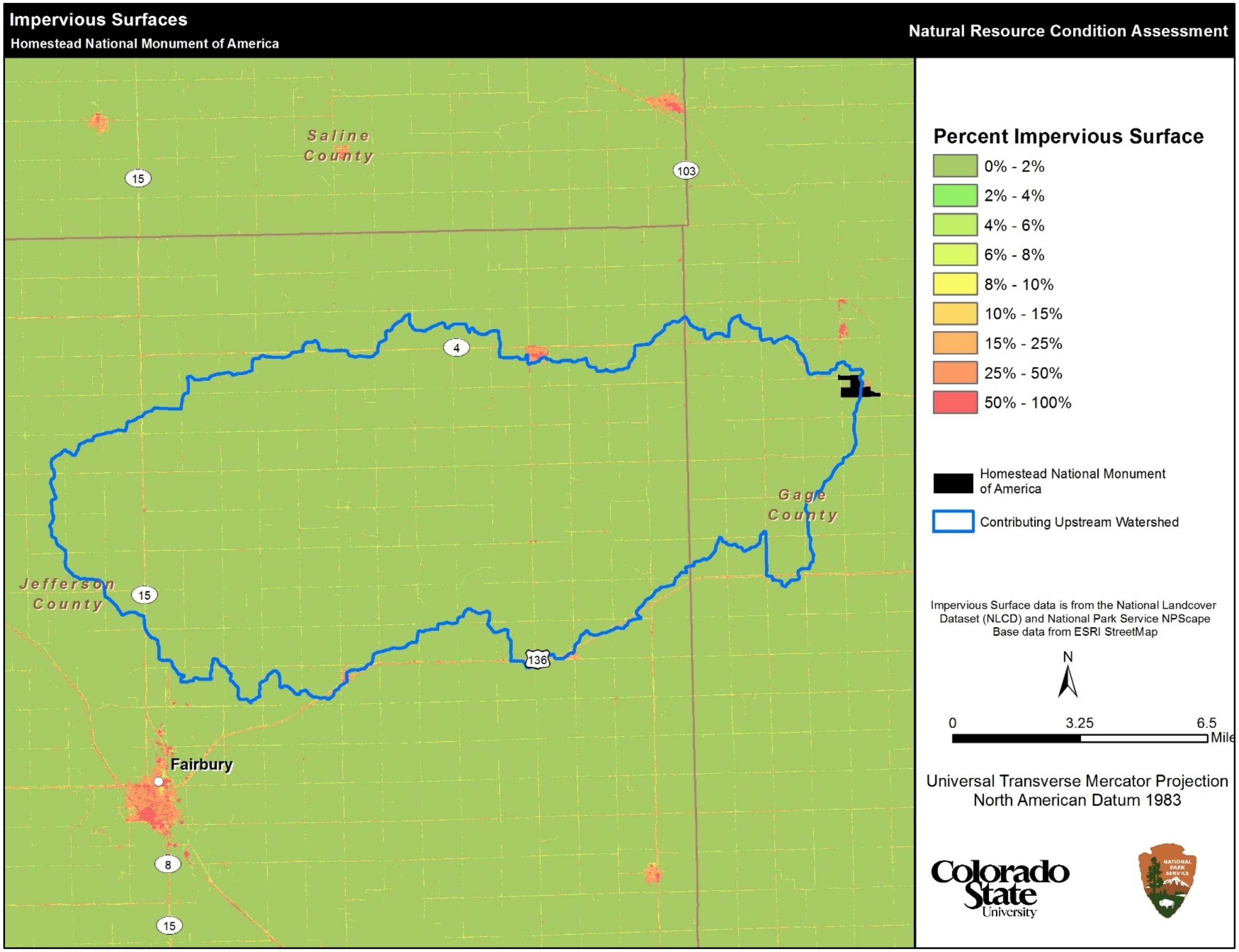

Figure 4.1-4. Percent impervious surfaces based on Anderson land cover classes within 3 km and 30 km of the park boundary, and within the contributing upstream watershed of the park. National Land Cover Dataset data provided by NPS NPScape Program.

Population and Housing

Historic and Projected Population

High human population density has been shown to adversely affect the persistence of habitats and species (Kerr & 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 (18 mi) of the Monument's boundary is low, with most of the area within this 30 km (18 mi) radius having a density of 1–20 people/km^2 (Table 4.1-6, Figure 4.1-5) and consisting of agricultural fields. Historically, population has been relatively constant with the exception of Lancaster County (Figure 4.1-6), which contains the City of Lincoln, NE.

There appears to be a trend in conversion of rural (agricultural) land to exurban housing developments. Moreover, a large portion of the acreage surrounding HOME is private agricultural land, which is more readily converted to housing than other types of land coverage (Hansen and Gryskiewicz 2003). The small reduction in population density from 1990 to 2000 in Table 4.1-6 is due to the combining of census blocks, as evident in Figure 4.1-5. Notice some of the higher density blocks in the northwest and southeast sections of the 30 km (18 mi) buffer were assimilated into lower density blocks.

Table 4.1-8. Population density classes and acreage for 1990, 2000, and 2010 by census block group for the park and surrounding 30 km buffer.

Population Density (#/km^2)	1990		2000		2010	
	Acres	% of Area	Acres	% of Area	Acres	% of Area
1–20	694,422	94.67%	705,939	96.24%	706,012	96.25%
21–75	36,383	4.96%	26,407	3.60%	26,333	3.59%
76–150	0	0.00%	0	0.00%	0	0.00%
151–300	1,907	0.26%	440	0.06%	440	0.06%
301–750	147	0.02%	0	0.00%	0	0.00%
751–1200	73	0.01%	367	0.05%	367	0.05%
1201–1500	73	0.01%	0	0.00%	0	0.00%
1501–2000	440	0.06%	367	0.05%	367	0.05%
2001–3000	73	0.01%	0	0.00%	0	0.00%
> 3000	0	0.00%	0	0.00%	0	0.00%

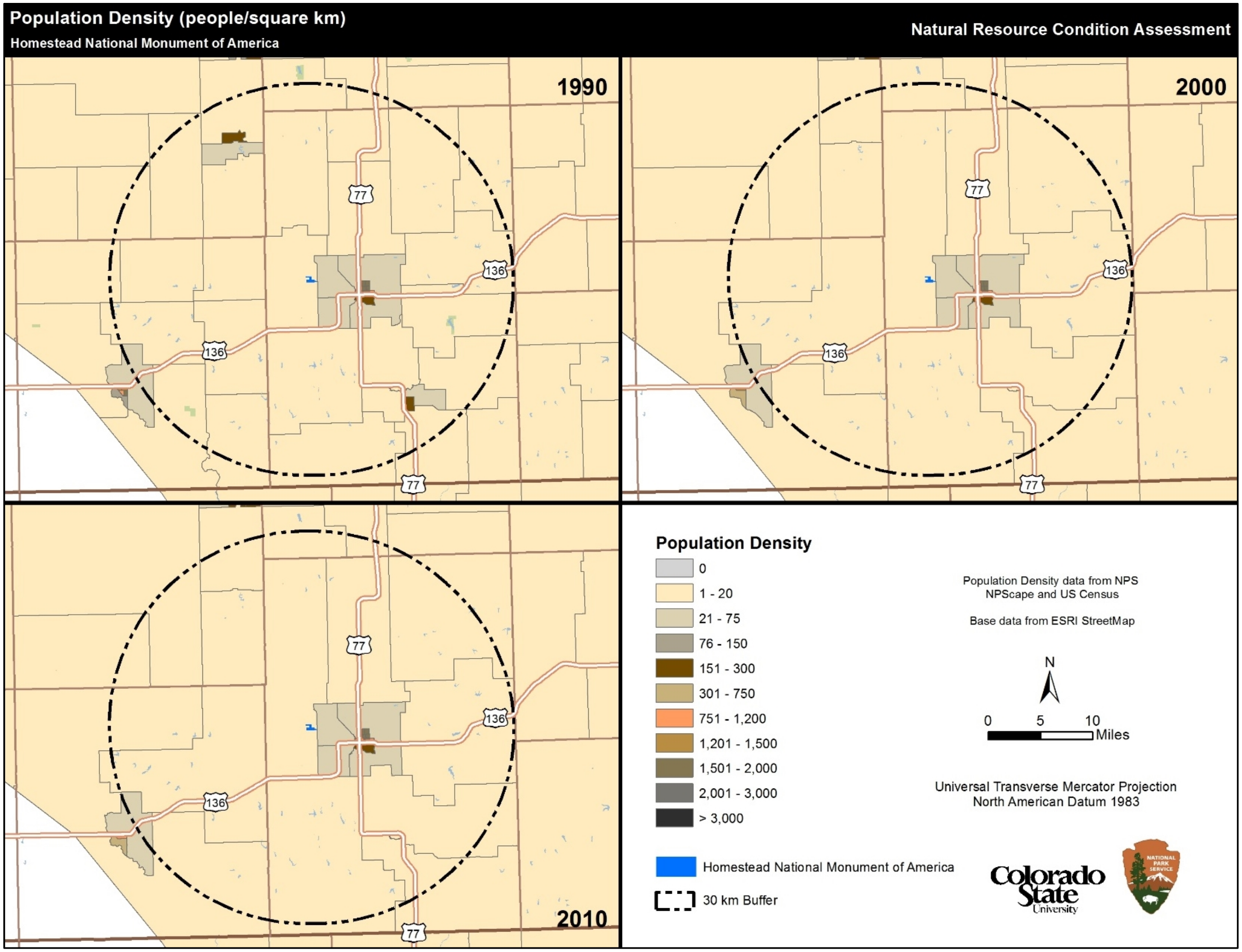

Figure 4.1-5. Population density for 1990, 2000, and 2010 by census block group for the park and surrounding 30 km buffer. U.S. Census data provided by NPS NPScape Program.

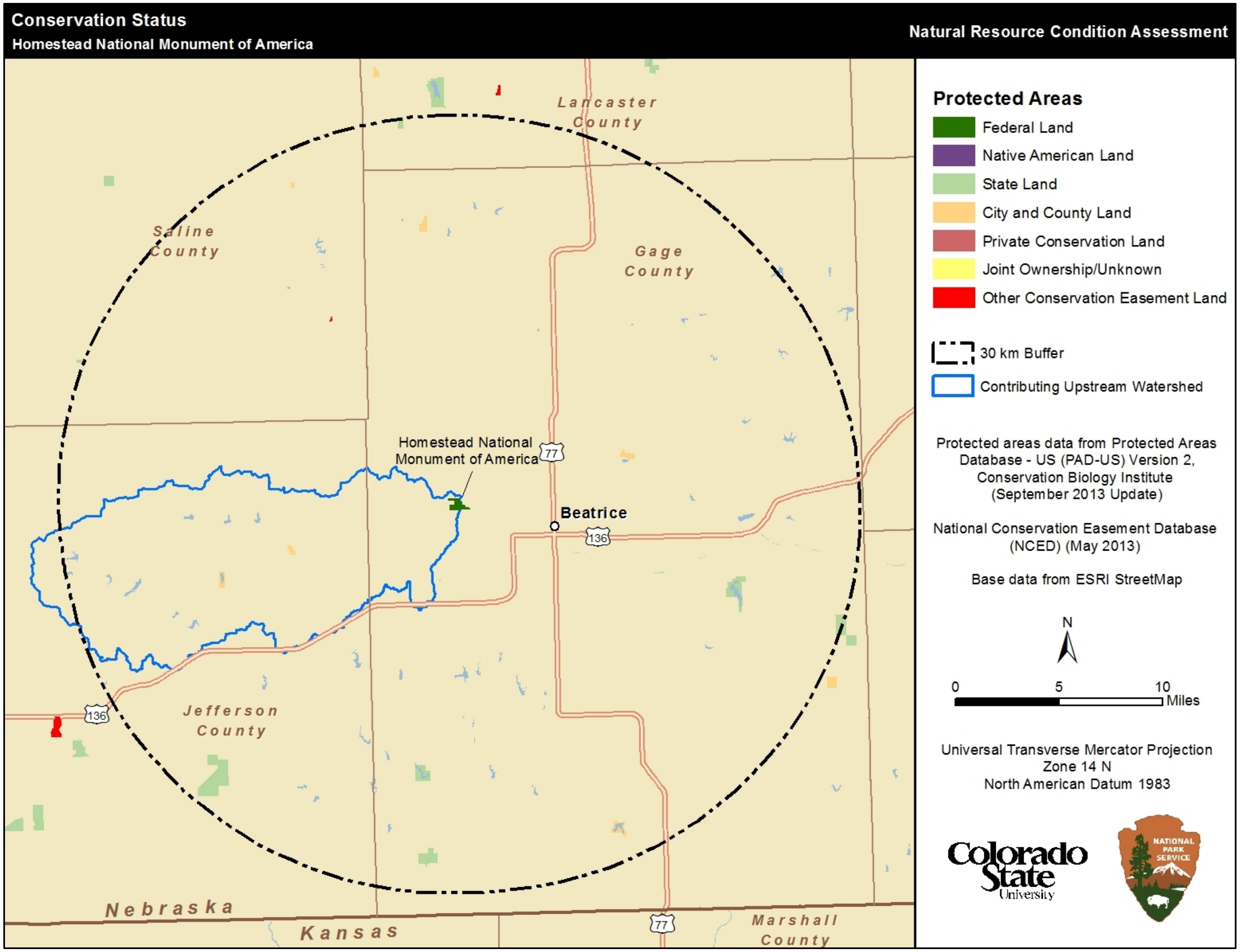

Figure 4.1-6. Conservation status of lands within 30 km of the boundary of Homestead National Monument. Map classes combine ownership from the NCED database and biodiversity conservation status from the PAD-US protected areas database.

Conservation Status

Spatial data from the Protected Areas Database-US (PAD-US) Version 2 (Conservation Biology Institute 2013) and the National Conservation Easement Database (NCED) were consolidated to show comprehensive protection status for areas of interest while using compatible database attributes such as ownership type and agency (Figure 4.1-7). The analysis illustrates the paucity of protected areas near the park and in the larger region.

Ownership

Across the tallgrass prairie region, over 95% of land is privately held and has no formal conservation protection status (Table 4.1-7, Table 4.1-8). Within the 30 km (18 mi) park buffer and the Tallgrass Prairie ecoregion, most protected land is owned by the state government.

Table 4.1-7. Acreage of lands within 30 km of the boundary of HOME, within the contributing upstream watershed of the park, and within the Tallgrass Prairie ecoregion having some level of conservation protection. Percentages are the proportion of total AOA area.

	Park + 30 km Buffer		Contributing Upstream Watershed		Tallgrass Prairie Ecoregion	
Ownership	**Acres**	**% of Area**	**Acres**	**% of Area**	**Acres**	**% of Area**
Federal	224	0.03%	224	0.26%	2,697,850	1.40%
Native American	0	0.00%	0	0.00%	1,342,495	0.70%
State	2,665	0.36%	0	0.00%	2,642,484	1.37%
City and County	721	0.10%	206	0.24%	253,233	0.13%
Private Conservation	0	0.00%	0	0.00%	202,828	0.11%
Joint Ownership/Unknown	0	0.00%	0	0.00%	148,056	0.08%
Other Conservation Easement	14	< 0.01%	0	0.00%	874,316	0.45%
Total	**3,623**	0.49%	**430**	0.50%	**8,161,263**	4.23%

Level of Protection

There are differences in the inferred protection status of lands within each of the AOA's. Within 30 km (18 mi) of the park, there is substantial land area within each biodiversity protection status level with the exception of Status I (Table 4.1-8). All of the protected acreage in the contributing upstream watershed is Status II or III. For comparison, more than half of the protected acreage in the Tallgrass Prairie ecoregion is Status IV, the default, low-level protections status for private lands or those with unknown conservation status. More than 95% of land area in each of the AOA's is not protected, which highlights the importance of HOME and other occasional parcels that do provide biodiversity protection in the region. Moreover, in protected areas such as Homestead National Monument, 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.

Table 4.1-8. Biodiversity protection status of lands within 30 km of the park boundary, within the contributing upstream watershed of the park, and within the Tallgrass Prairie ecoregion [PAD-US (CBI 2013) and NCED (2013) data]. Percentages are the proportion of total AOA area.

	Park + 30 km Buffer		Contributing Upstream Watershed		Tallgrass Prairie Ecoregion	
Protection Level	**Acres**	**% of Area**	**Acres**	**% of Area**	**Acres**	**% of Area**
I	0	0.00%	0	0.00%	241,924	0.13%
II	1,652	0.23%	357	0.41%	1,069,131	0.55%
III	1,761	0.24%	73	0.09%	2,359,903	1.22%
IV	211	0.02%	0	0.00%	4,490,304	2.33%
Total	**3,623**	0.49%	**430**	0.50%	**8,161,263**	4.23%

Land Cover and Land Use Summary

Summary notes for the landscape context indicators are provided in Table 4.1-9. Overall, the park has similar threats and stressors to other parks in the Tallgrass Prairie ecoregion. Most of these land cover and land use-related stressors 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 relative to cropland. This trend in land development, coupled with the lack of significantly-sized and linked protected areas, is of significant concern to the conservation of natural resources of Homestead National Monument to also include dark night skies, natural sounds and scenery. This summary of land cover and land use metrics provides a useful context of known stressors, supports resource planning and management within the park, and provides a foundation for collaborative conservation with other landowners in the surrounding area.

4.1.4. Uncertainty and Data Gaps

There are several sources of uncertainty associated with our analysis. The first is related to the single point in time (2006) that was examined for in land cover and land use using NLCD data. The inclusion of 2011and 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).

Table 4.1-9. Summary for landscape context indicators, Homestead National Monument.

Land Cover and Land Use	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 HOME is agricultural land. After grassland, the next most prevalent land use is developed, most of which is housing developments.
	Extent of impervious surface area	HOME's contributing upstream watershed has less imperviousness than other parks in the region. Although the watershed is highly converted, most of the converted acreage is agricultural land, which retains a significant amount of its permeability.
	Extent of natural vs. converted land cover	The proportion of converted acreage surrounding HOME is high in relation to the Tallgrass Prairie Ecoregion as a whole. This can be attributed to the heavy agricultural use of the surrounding area, both for pasture and crops.
Population and Housing	Historic and projected population total and density	Population density within 30 km of the Monument's boundary is low, with most of the area having a density of 1–20 people/km^2. The low population density is attributable to the prevalence of agriculture surrounding the park. Historically, county populations in the surrounding area have been relatively stable with the exception of Lancaster County.
	Housing density	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 existing urban centers such as Lincoln, NE.
Conservation Status	Protected area extent and biodiversity protection status	Only a small portion of the acreage in the region surrounding the park is protected through ownership or conservation easements. The vast majority of land surrounding HOME is private agricultural land, which generally has a low biodiversity protection level, limited conservation value, and is more readily developed than some other types of land. The rarity of protected lands within the region underscores the critical value of the park as a conservation island within a highly altered predominantly agricultural landscape.

4.1.5. 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.

4.1.6. Literature Cited

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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. Dark night skies are rated as “extremely important” 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 Monument’s 1999 General Management Plan (GMP) identifies the presence of Highway 4, a permitted right-of-way for the Nebraska Department of Roads, as a significant intrusion on the historic character of the Monument and a potential threat to the quality of visitor experiences (NPS

1999, p. 17). The GMP also states that the historic setting of the Monument has been impacted by encroachment from external sources, such as suburban sprawl in the form of residential subdivisions and industrial development from local fertilizer plants (NPS 1999, p. 51). The GMP describes the potential adverse effects of these external stressors on the existing character of the Monument's historic rural environment (NPS 1999, p. 52).

<u>Threats and Stressors</u>
The primary threats to dark night skies at Homestead National Monument of America include light originating from modern transportation within and beyond the Monument's boundaries, artificial lighting in the Monument, and commercial, industrial, urban, and exurban development. Specific threats include light from vehicles on Highway 4, artificial lighting from residential development in the nearby town of Beatrice and more distant urban centers, and industrial development from local fertilizer plants. These artificial light sources are a distinct threat to the natural and historic lightscape of the Monument, 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 Monument 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 Monument.

<u>Indicators and Measures</u>
- Artificial night sky brightness

4.2.2. Data and Methods
The NPS Natural Sounds and Night Skies Division (NSNSD) conducted night sky monitoring during a site visit to Homestead National Monument of America in September 2010. Various metrics of lightscape condition were collected during this monitoring visit. However, monitoring data were not available to include in this assessment. Artificial night sky brightness was assessed at HOME using a CCD camera system developed by NPS NSNSD. A CCD system takes pictures of the night sky using a mosaic of up to over 100 images. Sensors assign a brightness value to each pixel. The full resolution mosaic is then summarized according to the brightness values. CCD data are used to calculate the anthropogenic light rating (ALR). 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 are used for these calculations. A copy of the stitched image was obtained for this assessment but raw pixel data was not available. Therefore, we simply evaluate the CCD image for the quality of the night sky and major sources of light pollution in proximity to the Monument. The NSNSD also developed a nation-wide model of ambient light levels. Modeling was applied to all NPS units, including the entire area of the Monument and the surrounding region. Once the modeling results are available, this analysis will permit estimation of the impact of anthropogenic light pollution on the darkness of night skies in the Monument. In lieu of NSNSD modeled data, we also evaluated ambient light maps for the region developed by Cinzano et al. (2001). Cinzano et al. (2001) provides an alternate data source in the form of an atlas that displays artificial night sky

brightness worldwide. A geospatial data layer of the Cinzano data was acquired to examine the park and surrounding region.

Other possible indicators not applied here include the anthropogenic light ration (ALR) derived from CCD data, the Bortle Dark Sky Scale (Bortle 2001), limiting magnitude, sky brightness (highly correlated with ALR), and modeled ambient light level. No data is available for those indicators at this time.

4.2.3. Reference Conditions

The reference condition for the night sky in Homestead National Monument of America is one in which the intrusion of artificial light into the night scene is minimized. Natural sources of light (such as moonlight, starlight, and the Milky Way) will be more visible from the Monument than anthropogenic sources. As little outdoor lighting as is necessary to maintain a safe environment for visitors and employees will be utilized. HOME 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. To help the Monument achieve its cultural mission, it is important that the night sky retains its historic character.

4.2.4. Condition and Trend

There are many sources of light influencing sky brightness at HOME, with near and far anthropogenic sources of varying sizes along the horizon in all directions (Figure 4.2-1). Starting from the north (extreme left and right sides of Figure 4.2-1), the Heritage Center is the dark area in the foreground and the Beatrice Municipal Airport and businesses in north Beatrice create a light dome in the background. At left center (to the east and southeast), we see trees in the foreground and downtown Beatrice in the background. Artificial light is least prominent to the south and west.

The image from the Cinzano et al. (2001) atlas of artificial night sky brightness for North America and the region surrounding HOME is shown in Figure 4.2-2. The region surrounding the Monument (Figure 4.2-1, bottom) has some pockets of darker night skies to the south and west. However, there are also several nearby sources of significant light pollution, such as the cities of Omaha to the northwest, Lincoln to the north, and Beatrice immediately to the southeast. These urban areas pose the greatest threat to the quality of the night sky in the Monument. Many constellations, planets and the Milky Way cannot be consistently observed at this location.

Based on these results, the condition of dark night skies at HOME warrants moderate concern with a deteriorating trend (Table 4.2-1). Confidence in the assessment is medium due to the lack of quantitative data and the use of only a single indicator.

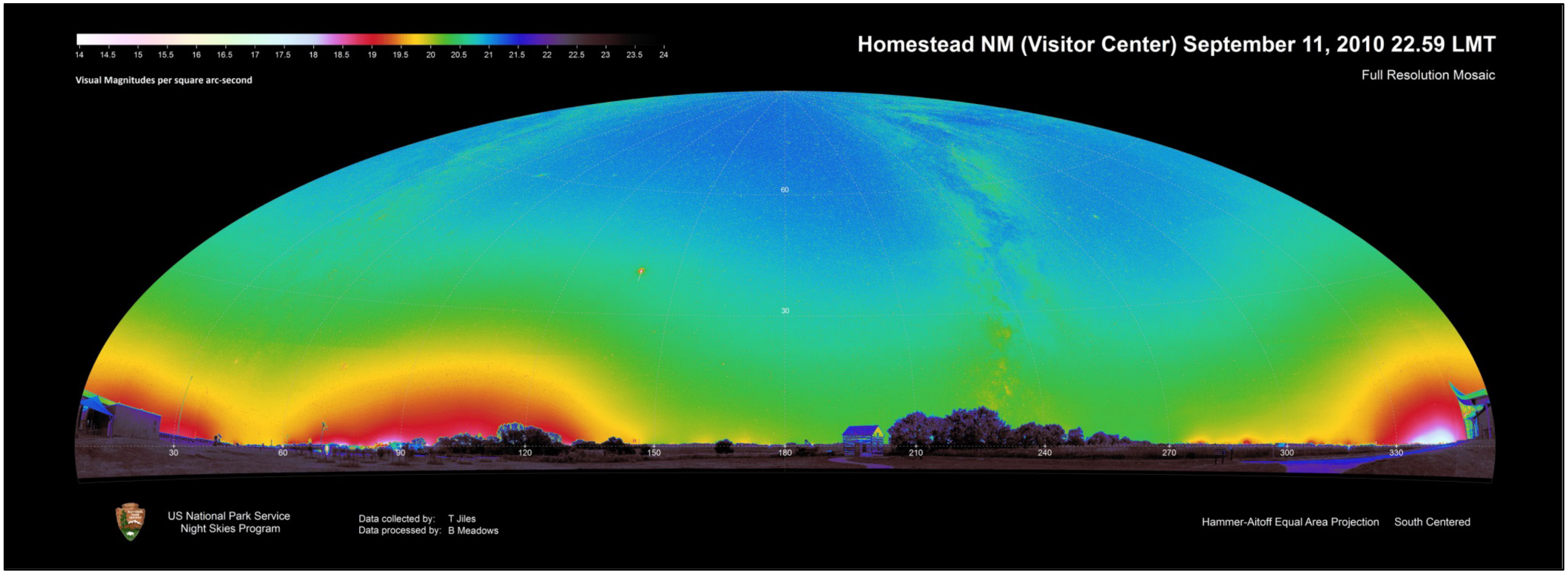


Figure 4.2-1. Panoramic view of the night sky at Homestead National Monument of America using CCD technology. The center of the image points due south (source NPS NSNSD).

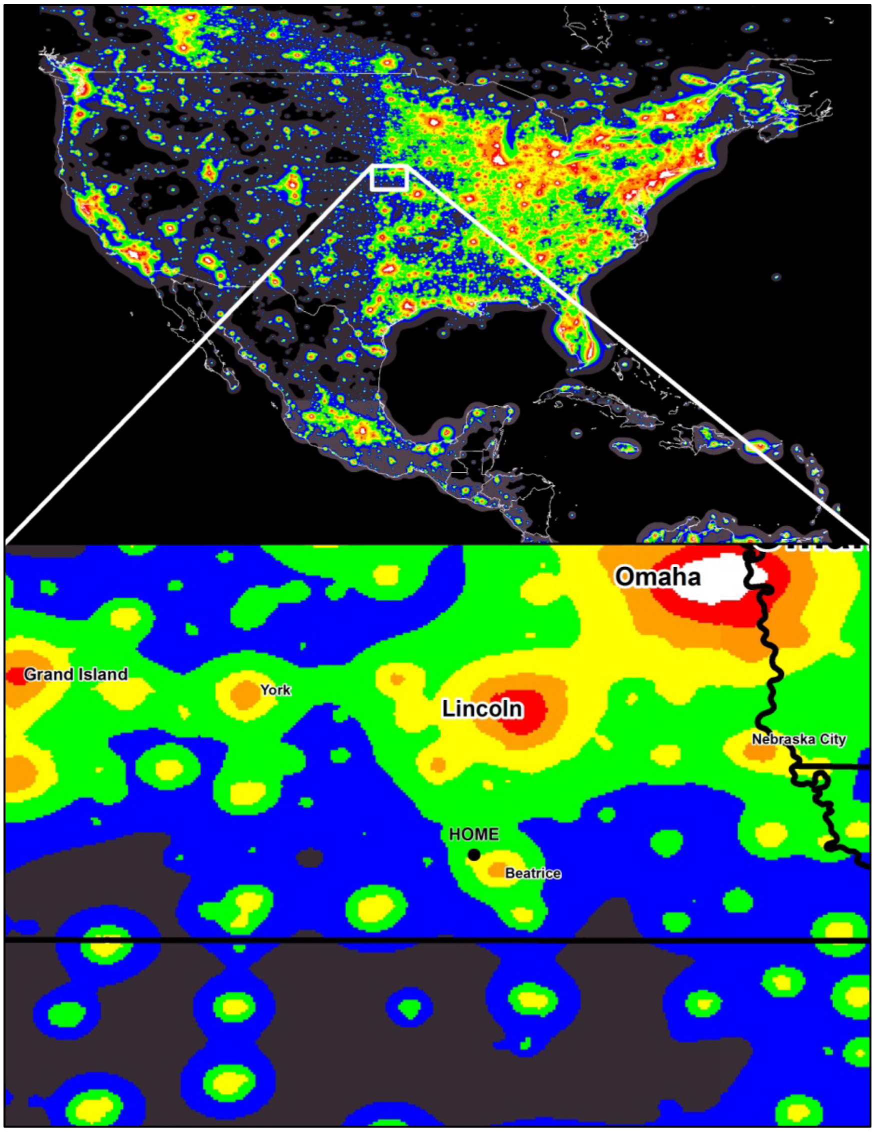
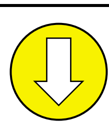
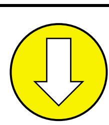


Figure 4.2-2. Artificial night sky brightness across the contiguous U.S. (top) and for the region surrounding Homestead National Monument of America (bottom) (Cinzano et al. 2001).

Table 4.2-1. Condition assessment summary for dark night skies at Homestead National Monument of America.

Indicator	Condition Status/Trend	Rationale
Artificial Night Sky Brightness		Darker areas can be found south and west of the Monument, but several nearby urban areas produce significant light pollution that affects the quality of the Monument’s night skies.
Dark Night Skies overall		The condition warrants moderate concern with a deteriorating trend. Confidence in the assessment is medium.

4.2.5. Uncertainty and Data Gaps

The NPS NSNSD has conducted night sky monitoring studies in Homestead National Monument of America to measure ambient light levels and the darkness of the night sky. The NSNSD has also developed a nation-wide model of ambient light levels. These data were not available during preparation of this assessment.

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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4.3. Soundscape

4.3.1. Background and Importance

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 Monument and is presented in the *Land Cover and Land Use* section within this chapter. Some land use parameters can be highly correlated with ambient sound levels. Therefore changes in these factors can have significant impacts on the soundscape of the Monument.

The primary mission of the Monument is to maintain the 160-acre original homestead and the Freeman School in a manner that provides visitors an approximate perspective of the influences and impacts upon the land in its transition from its natural state to cultivation and agriculture (NPS 1997). The desired setting is one dominated by natural sounds and those associated with 19th century homesteads and small farms. HOME's *General Management Plan* (GMP) identifies the presence of Highway 4, a permitted right-of-way for the Nebraska Department of Roads, as a significant intrusion on the historic character of the Monument and a potential threat to the quality of visitor experiences (NPS 1999, p. 17). The GMP also states that the historic setting of the Monument has been impacted by encroachment from external sources, such as suburban sprawl in the form of residential subdivisions and industrial development from local fertilizer plants (NPS 1999, p. 51). The GMP describes the potential adverse effects of these external stressors on the existing character of the Monument's historic rural environment (NPS 1999, p. 52). Thus, noise originating from modern transportation, suburban housing developments, modern agriculture, and industrial activities represents a distinct threat to the natural and historic soundscape of HOME, as well as the quality of visitor experiences that can be offered to the public.

Threats and Stressors

Primary threats to the natural soundscape include noise originating from modern transportation within and beyond the Monument's boundaries and from commercial, industrial, urban and exurban development. Noise from park management activities has been minimized over time through the use of best management practices. Aircraft noise is typically one of the most pervasive threats to natural sounds in NPS units and is a notable source of anthropogenic noise at HOME. Major nearby airports include Kansas City, Kansas and Omaha, Nebraska. A majority of the high elevation air traffic is from Denver to Omaha and points further east (FlightAware 2014). There is little regional propeller airplane traffic feeding larger airport hubs near HOME (University of Nebraska Omaha 2014). Government reports indicate that 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).

Indicators and Measures

- Anthropogenic sources of noise – presence/absence and relative noise level
- Traffic volume on State Highway 4 – vehicle counts
- Noise impacts for State Highway 4 (modeled) – loudest-hour noise level impacts, speech interference models

- Percent time above specified levels –35, 45, 52, and 60 dBA
- Exceedance levels – L_{90}, L_{50}, L_{10}
- Sounds levels by frequency
- Anthropogenic sound level impacts (modeled) – minimum, 1st quartile, median, 3rd quartile, maximum

4.3.2. Data and Methods

The condition of the soundscape at HOME was evaluated based on existing data provided by the Monument (NPS 2012). The Monument conducted acoustical monitoring during 7 different periods at 4 sites in HOME in 2011 and 2012. Two monitoring sites (HOME001 and HOME 003) were located near Highway 4, in areas being considered for an outdoor education classroom. The other monitoring sites were located near the Freeman School and Highway 4 (HOME002) and in a representative woodland area further from Highway 4 (HOME004) (Figure 4.3-1). Monitoring occurred at three out of four sites during two opposite seasons, either summer and winter, or spring and fall. Each monitoring period lasted approximately 25 days. Various metrics of soundscape condition were collected during these monitoring periods and are described below. In addition, the NPS Natural Sounds and Night Skies Division (NSNSD) provided results from nation-wide modeling of ambient sound levels (Mennitt et al. 2013). Modeling was applied to all NPS units, including the entire area of HOME and the surrounding region. This analysis permitted estimation of the impact of anthropogenic noise on natural sound levels in the Monument. 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 Monument. Qualitative data from HOME staff are also presented in this assessment. Staff members were asked to identify natural and human-caused (extrinsic or intrinsic to the park's values) sounds present at HOME. Staff members were also asked to describe the desired soundscape conditions for HOME, including anthropogenic cultural sounds that could potentially be considered appropriate for the Monument's mission and purpose.

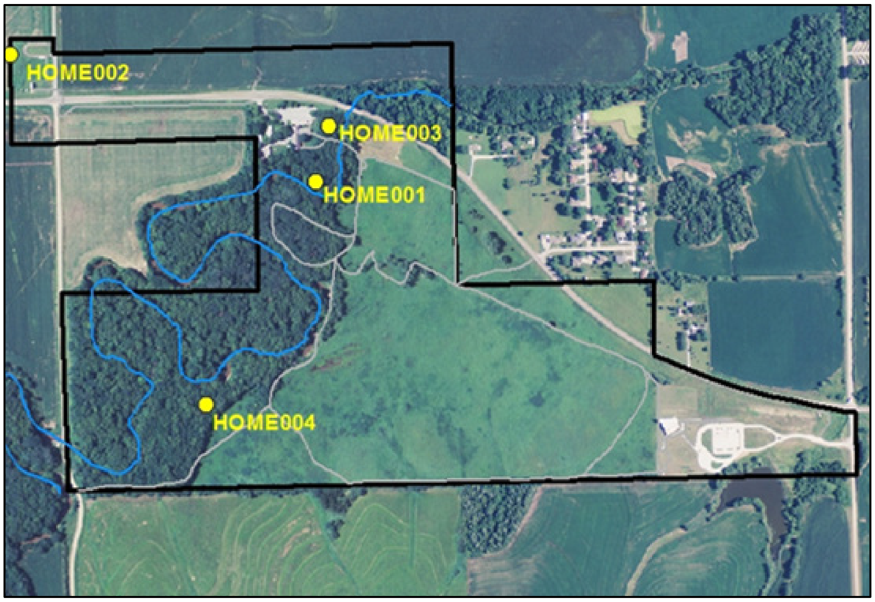


Figure 4.3-1. Location of acoustical monitoring sites at HOME. Location data provided by NPS NSNSD. Background imagery from ArcGIS background image.

<u>Decibel Scale</u>
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 HOME is one dominated by natural sounds that are intrinsic to the Monument, such as the sounds of wind, birds, insects, and weather. Anthropogenic noise sources will not interfere with interpretive programs or the ability of the Monument to provide

quality visitor experiences. The Monument will be treated as an Activity Category A location for the Federal Highway Administration's Noise Abatement Criteria. "Category A includes lands on which serenity and quiet are of extraordinary significance and serve an important public need and where the preservation of those qualities is essential if the area is to continue to serve its intended purpose" (FHWA 2011).

Monument managers have identified natural sound sources that are no longer present in HOME, such as the locally extirpated wildlife species bison, wolves, elk, and prairie chickens, as well as the everyday sounds produced by the homesteaders (J. Bolli, personal communication, September 18, 2013). A reference condition rating system for soundscape indicators is presented in Table 4.3-2.

Table 4.3-2. Reference condition ratings framework for soundscape indicators at HOME.

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.	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 monthly traffic volumes of approximately 73,000 vehicles (State Highway 4); no increase in the proportion of heavy commercial trucks. Based on 2006–2013 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.
Road Traffic Noise Impacts	Not exceeding 2002 loudest-hour noise level of 56+ dBA at 184 feet from State Highway 4.	Loudest-hour noise level of 56+ dBA at 184–250 feet from State Highway 4	Loudest-hour noise level of 56+ dBA > 250 feet from State Highway 4
Percent Time Above Specified Levels	Percent time above 52 dBA (level of speech interference for interpretive programs) ≤10%.	Percent time above 52 dBA (level of speech interference for interpretive programs) is > 10%-< 25%.	Percent time above 52 dBA (level of speech interference for interpretive programs) ≥25%.
Exceedance Levels	L_{50} ≤ 35 dBA (sound level exceeded 50% of the time is less than or equal to 35 dBA)	35 dBA < L_{50} < 45 dBA (sound level exceeded 50% of the time is between 35 and 45 dBA)	L_{50} ≥ 45 dBA (sound level exceeded 50% of the time is greater than or equal to 45 dBA)
Anthropogenic Sound Level Impacts	Median impact ≤ 3 dBA Maximum impact ≤ 7.5 dBA	3 dBA < Median impact < 5 dBA 7.5 dBA < Maximum impact < 10 dBA	Median impact ≥ 5 dBA Maximum impact ≥ 10 dBA

4.3.4. Condition and Trend

<u>Anthropogenic Sources of Noise</u>

The following common sources of anthropogenic noise were identified by staff members at HOME (J. Bolli, personal communication, July 24, 2013): vehicles on the adjacent highway; Monument maintenance activities; heating, cooling and ventilation systems from Monument facilities;

agricultural equipment used in demonstrations (including steam engines and tractors); and the sounds of visitors. The condition of this indicator warrants moderate concern with a medium confidence level (Table 4.3-4). No trend data is available.

Traffic Volume: State Highway 4

According to the Nebraska Department of Roads, the average daily traffic volume in 2011 on State Highway 4 southeast of HOME was 2,745 vehicles. This traffic count occurred where State Highway 4 turns north at the intersection with Sherman Street on the western edge of the town of Beatrice (Nebraska Department of Roads 2012).

The Monument also collects data on traffic volumes by means of a traffic counter located on State Highway 4, just west of the Cub Creek Bridge (J. Bolli, personal communication, September 19, 2013). The traffic counter records eastbound vehicles only, so estimates of total monthly traffic volumes are calculated by doubling the recorded traffic counts. Monthly traffic volumes from 2006–2013 (data available through August of 2013) are displayed in Figure 4.3-2. The average monthly volume over the 8 years of traffic counts is nearly 73,000 vehicles, with a low of 62,525 vehicles in 2013 and a high of 84,243 vehicles in 2010. Variations in monthly traffic volume do not appear to follow a consistent pattern. The condition of this indicator warrants moderate concern, with an unchanging trend and a high confidence level (See Table 4.3-4 at the end of this section).

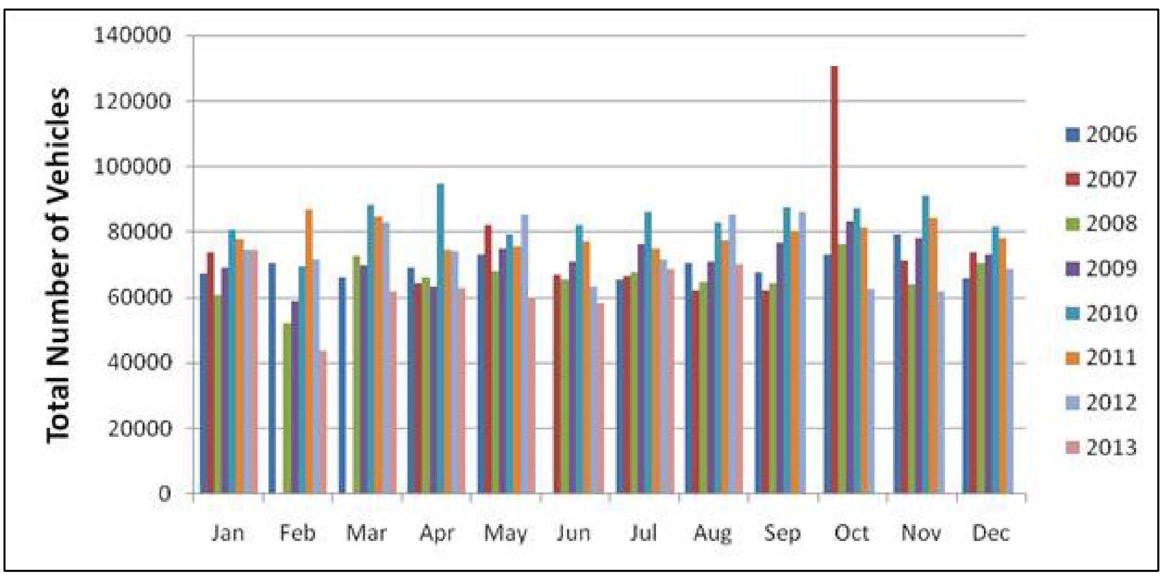


Figure 4.3-2. Monthly traffic volume on State Highway 4 west of Cub Creek Bridge (2006–2013). Data provided by HOME (September 2013).

Modeled Noise Impacts: State Highway 4

A traffic noise analysis conducted in HOME in 2002 determined that existing traffic conditions produced noise impacts (defined as loudest-hour noise levels exceeding 56 dBA) 184 ft (56 m) from State Highway 4. Moreover, projections of future conditions extended the range of impact to 250 ft (76.2 m) by 2025. The spatial extent of these impacts affects several sites where educational or interpretive activities take place (with all sites being affected by 2025). Speech interference was also analyzed in this study, and it was determined that in order to maintain normal speech intelligibility at a distance of 75 ft (23 m) (i.e., between an interpreter and a larger audience), the road would need to be located at least 3000 ft (914 m) from the program in order to maintain good communication when trucks pass by (Harris, Miller, Miller, and Hanson, Inc. 2002). The condition of this indicator warrants significant concern, with an unchanging trend and a high confidence level (See Table 4.3-4 at the end of this section).

Percent Time Above Specified Levels

The Monument conducted acoustical monitoring during 7 different periods at 4 sites in HOME in 2011 and 2012 (NPS 2012). Percent time above specific sound pressure (decibel) levels was determined for 2 frequency ranges: 20–1250 Hz (low frequency range) and 12.5–20,000 Hz (full frequency range). The low frequency range includes common transportation noise but excludes higher frequency sounds, such as those produced by birds and insects. Sound pressure levels measured in the Monument were compared to levels that are known to produce functional effects in humans, including blood pressure and heart rate increases in sleeping humans at 35 dBA (Haralabidis et al. 2008), the World Health Organization's recommended maximum noise level inside bedrooms at 45 dBA (Berglund et al. 1999), speech interference for interpretive programs at 52 dBA (EPA 1974), and speech interruption for normal conversation at 60 dBA (EPA 1974). Table 4.3-3 summarizes the percent time above results from the 7 monitoring periods and 4 sites. Results varied by monitoring location and season of collection. For HOME004 (the woodland area site furthest removed from developed roads and facilities), sound pressure levels exceeded 52 dBA less than 1% of the time. For HOME003 (one of the sites located closer to Highway 4), sound pressure levels exceeded 52 dBA between approximately 10% and 25% of the time during most of the sampling periods (for the full frequency range). For HOME001 and HOME002 (also located closer to Highway 4 and park infrastructure), the percent time above data were more variable, depending on the season, time of day, and frequency range employed. However, both sites included sampling periods with sound pressure levels that exceeded 52 dBA more than 50% of the time. Despite the variability in these results across different areas of the Monument, it is apparent that the road corridor and park facilities have a significant impact on this indicator. Therefore, the condition of this indicator warrants moderate concern, with an unknown trend and a high confidence level (See Table 4.3-4 at the end of this section). Some variability in sound levels may be attributed to insects.

Table 4.3-3. Percent time above various sound pressure levels and exceedance levels for various percentages of time (Data from NPS 2012).

Site/ Season	Time of Day*	Frequency Range (Hz)	Percent Time Above (%)				Exceedance Levels (dBA)		
			35 dBA	45 dBA	52 dBA	60 dBA	L_{90}	L_{50}	L_{10}
HOME001/ WINTER	Day	20–1250	88.2	15.8	1.7	0.0	35.2	40.1	45.5
	Day	12.5–20,000	92.0	18.8	2.2	0.1	35.8	40.7	46.4
	Night	20–1250	83.4	9.3	0.5	0.0	35.7	38.8	43.3
	Night	12.5–20,000	85.2	11.1	0.6	0.0	35.9	39.2	43.7
HOME001/ SUMMER	Day	20–1250	93.9	10.7	1.6	0.0	36.0	39.1	44.6
	Day	12.5–20,000	100.0	99.9	73.8	0.3	51.9	53.6	55.2
	Night	20–1250	69.1	2.8	0.2	0.0	34.8	36.6	40.3
	Night	12.5–20,000	100.0	100.0	91.8	28.5	57.9	59.0	60.0
HOME002/ FALL	Day	20–1250	87.7	30.5	6.2	0.4	35.1	41.7	49.7
	Day	12.5–20,000	99.9	84.2	51.0	15.2	45.4	50.2	55.7
	Night	20–1250	66.2	14.9	3.1	0.2	31.4	36.4	45.0
	Night	12.5–20,000	81.7	24.1	6.2	0.5	35.2	39.7	48.7
HOME003/ WINTER	Day	20–1250	92.7	49.8	16.2	2.3	37.0	43.9	53.3
	Day	12.5–20,000	94.8	56.2	20.3	3.1	38.1	45.0	54.4
	Night	20–1250	72.1	19.4	5.4	0.6	33.9	38.5	47.2
	Night	12.5–20,000	77.6	22.2	7.5	0.8	34.5	39.1	49.3
HOME003/ SUMMER	Day	20–1250	40.3	9.5	1.7	0.2	31.0	34.6	44.3
	Day	12.5–20,000	99.7	65.5	32.3	3.8	42.0	47.2	54.3
	Night	20–1250	79.7	27.1	6.9	0.9	34.1	40.8	49.7
	Night	12.5–20,000	99.4	67.1	24.3	2.9	42.0	48.0	54.6
HOME004/ SPRING	Day	20–1250	71.3	5.1	0.2	0.0	33.8	37.8	42.1
	Day	12.5–20,000	84.4	10.3	0.6	0.0	35.2	38.9	43.6
	Night	20–1250	38.2	1.3	0.1	0.0	31.1	34.3	38.2
	Night	12.5–20,000	43.9	2.6	0.2	0.0	31.9	34.9	39.1
HOME004/ FALL	Day	20–1250	52.6	2.9	0.2	0.0	32.4	36.0	40.3
	Day	12.5–20,000	73.8	7.3	0.7	0.0	34.7	38.4	43.5
	Night	20–1250	41.9	0.7	0.0	0.0	30.3	33.1	37.4
	Night	12.5–20,000	58.8	1.4	0.1	0.0	33.3	36.5	39.9

* Day period is 0700h-1900h; Night period is 1900h-0700h.

Exceedance Levels

The Monument also calculated the sound pressure levels that were exceeded a certain percentage of the time during the monitoring period (i.e., L_{50} is the dBA value that is exceeded 50% of the stated time period), (NPS 2012). Analysis was performed for the low and full frequency ranges, as well as for daytime and nighttime hours. Table 4.3-3 summarizes the exceedance level results from the 7 monitoring periods and 4 sites. Although the sound level exceeded 50% of the time is between 35 and 45 dBA for most of the monitoring stations and seasons, there are several instances where L_{50} levels are above 45 dBA (at all sites except for HOME004). The condition of this indicator warrants significant concern, with an unknown trend and a high confidence level (See Table 4.3-4).

<u>Sound Levels by Frequency</u>

The full frequency spectrum derived from acoustic monitoring can be divided into 33 smaller frequency bands (each representing a single one-third octave range). The Monument created plots of the daytime and nighttime sound pressure levels for each frequency band in order to demonstrate the distribution of lower- and higher-frequency sounds occurring in HOME throughout the day for each sampling period. Plots from the 7 monitoring periods and 4 sites are displayed in Figures 4.3-3 through 4.3-9 (NPS 2012). Although these plots can be informative when combined with other metrics, they are not useful indicators of soundscape quality on their own. Furthermore, it is challenging to select a reference condition for this indicator. Sound levels by frequency are included here for reference and may be used in future assessments; a condition rating is not assigned.

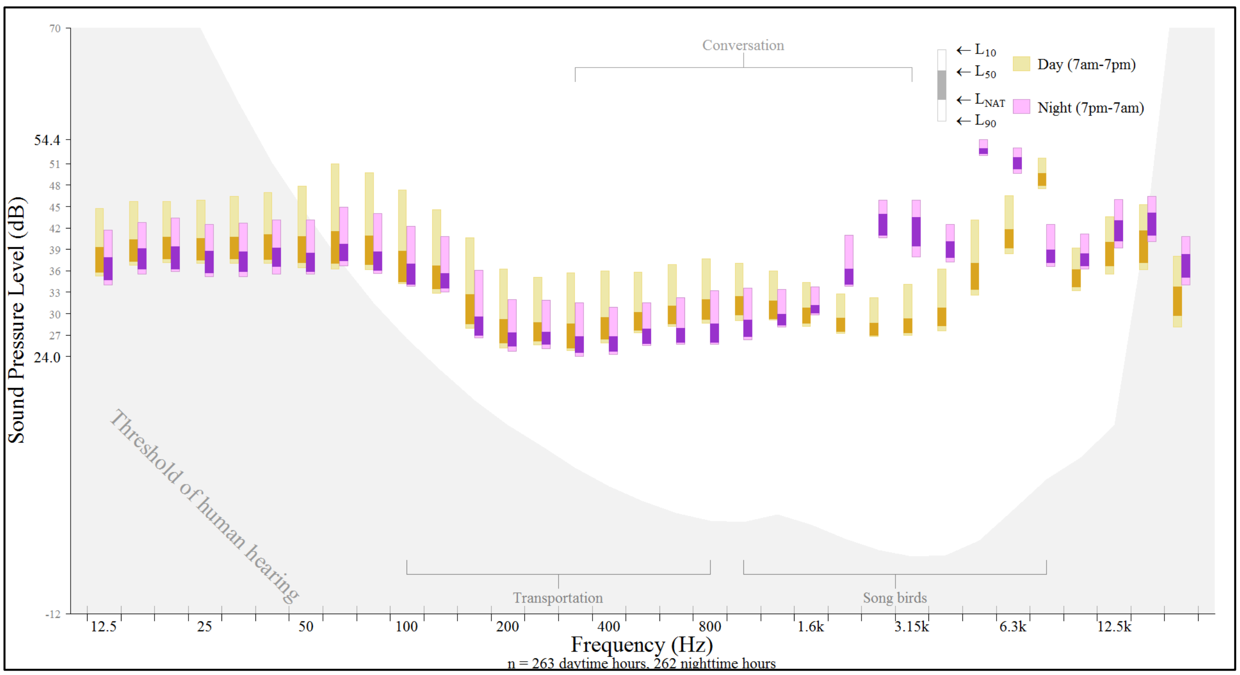


Figure 4.3-3. Daytime and nighttime sound pressure levels for 33 one-third octave frequency bands (HOME001/SUMMER). Graphic provided by HOME (June 2013).

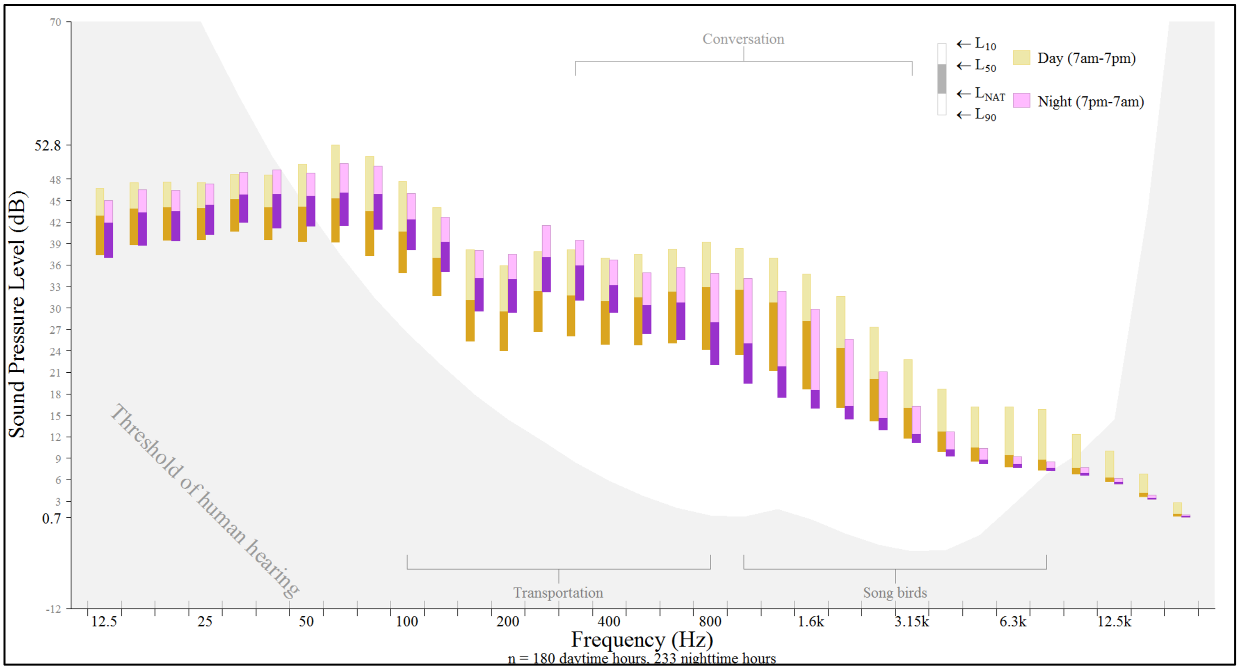


Figure 4.3-4. Daytime and nighttime sound pressure levels for 33 one-third octave frequency bands (HOME001/WINTER). Graphic provided by HOME (June 2013).

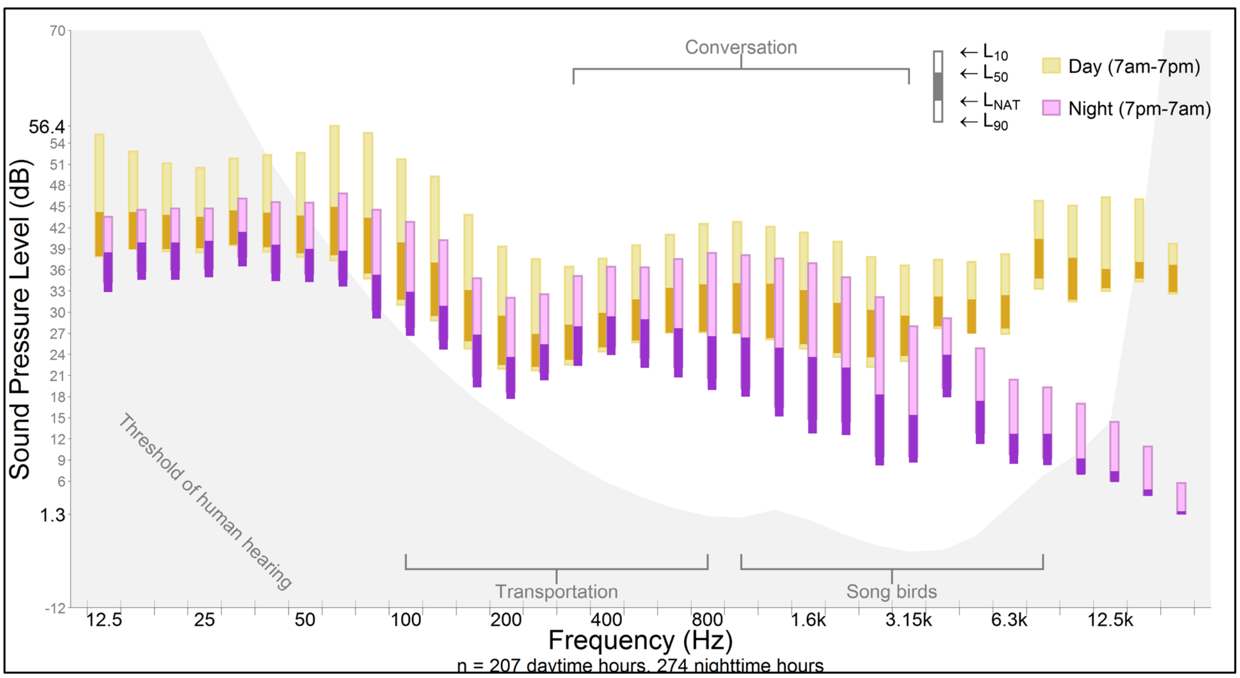


Figure 4.3-5. Daytime and nighttime sound pressure levels for 33 one-third octave frequency bands (HOME002/FALL). Graphic provided by HOME (June 2013).

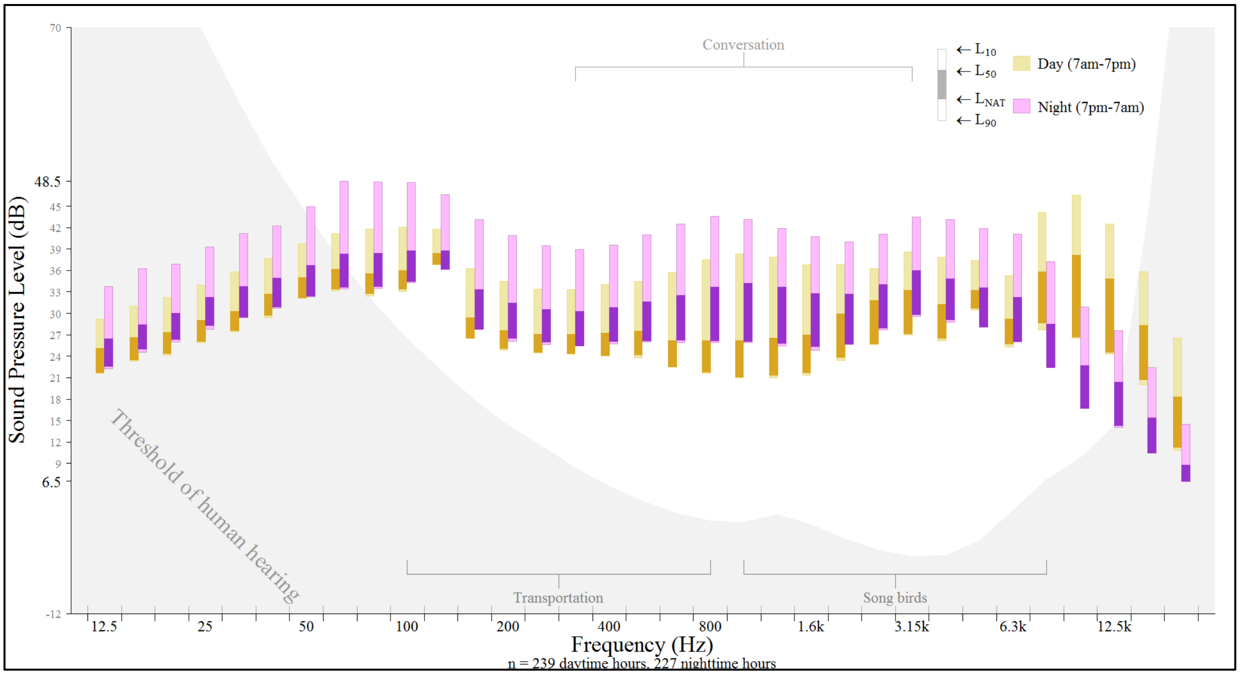


Figure 4.3-6. Daytime and nighttime sound pressure levels for 33 one-third octave frequency bands (HOME003/SUMMER). Graphic provided by HOME (June 2013).

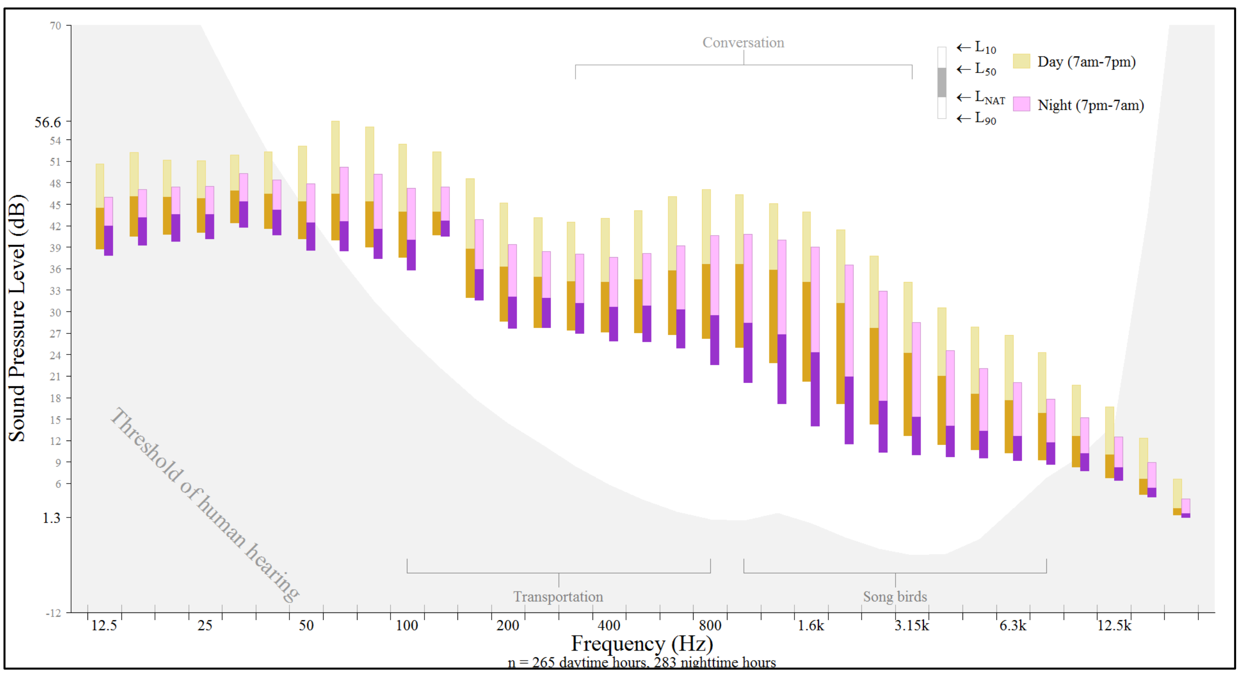


Figure 4.3-7. Daytime and nighttime sound pressure levels for 33 one-third octave frequency bands (HOME003/WINTER). Graphic provided by HOME (June 2013).

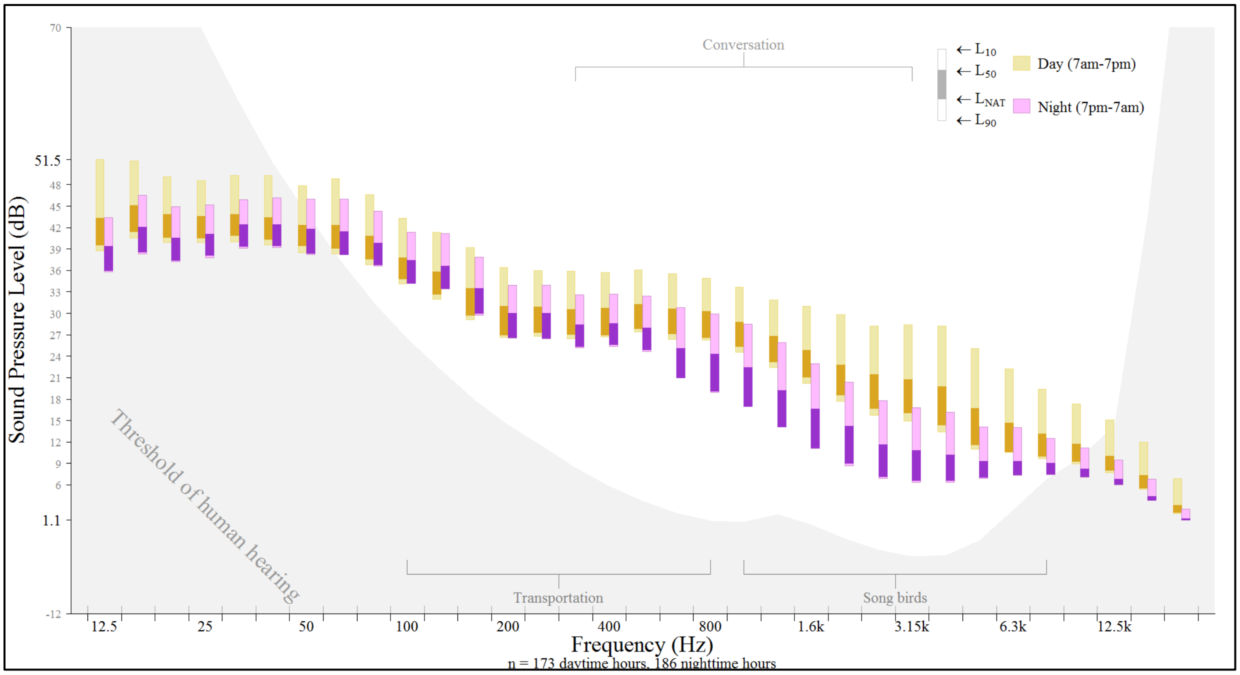


Figure 4.3-8. Daytime and nighttime sound pressure levels for 33 one-third octave frequency bands (HOME004/SPRING). Graphic provided by HOME (June 2013).

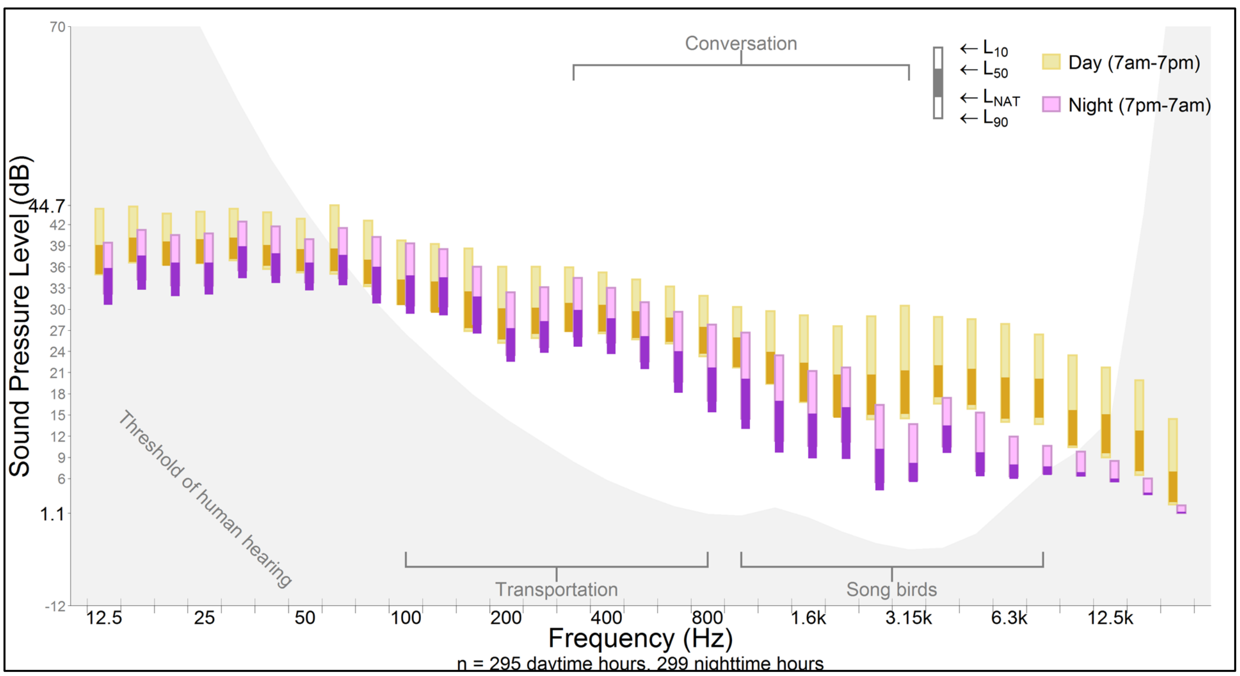


Figure 4.3-9. Daytime and nighttime sound pressure levels for 33 one-third octave frequency bands (HOME004/FALL). Graphic provided by HOME (June 2013).

<u>Anthropogenic Impacts on Ambient Sound Level</u>

The NSNSD has used acoustic modeling to estimate the anthropogenic impact to the ambient sound level in HOME, 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 Monument. In HOME, the mean impact was 8.8 dBA. Additional metrics describing a range of impacts within the Monument were also obtained. Minimum impact (minimum sound level impact in the Monument) was 6.2 dBA, 1st quartile impact (25% of points in the Monument have this level of impact or less) was 7.6 dBA, median impact (50% of the Monument has this impact or less) was 8.9 dBA, 3rd quartile impact (75% of the Monument has this impact or less) was 9.8 dBA, and maximum impact (maximum impact value inside Monument boundaries) was 11.0 dBA. Modeled mean impacts in the area immediately surrounding HOME as well as the larger region are shown in Figure 4.3-10. Estimated sound level impacts in the northern end of the Monument are slightly higher compared to modeled impacts in the southern end of the Monument and in the prairie and woodland core.

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 HOME by just 3 dB, the ability of listeners to hear the sounds around them is effectively cut in half. Furthermore, an increase of 7 dB leads to an approximate decrease in listening area of 80%, and an increase of 10 dB decreases listening area approximately 90%. Therefore, the mean impact of anthropogenic noise is reducing the listening area of visitors (and wildlife) by over 80%. The condition of this indicator warrants significant concern with a medium confidence level (see Table 4.3-4 at the end of this section). No trend data is available.

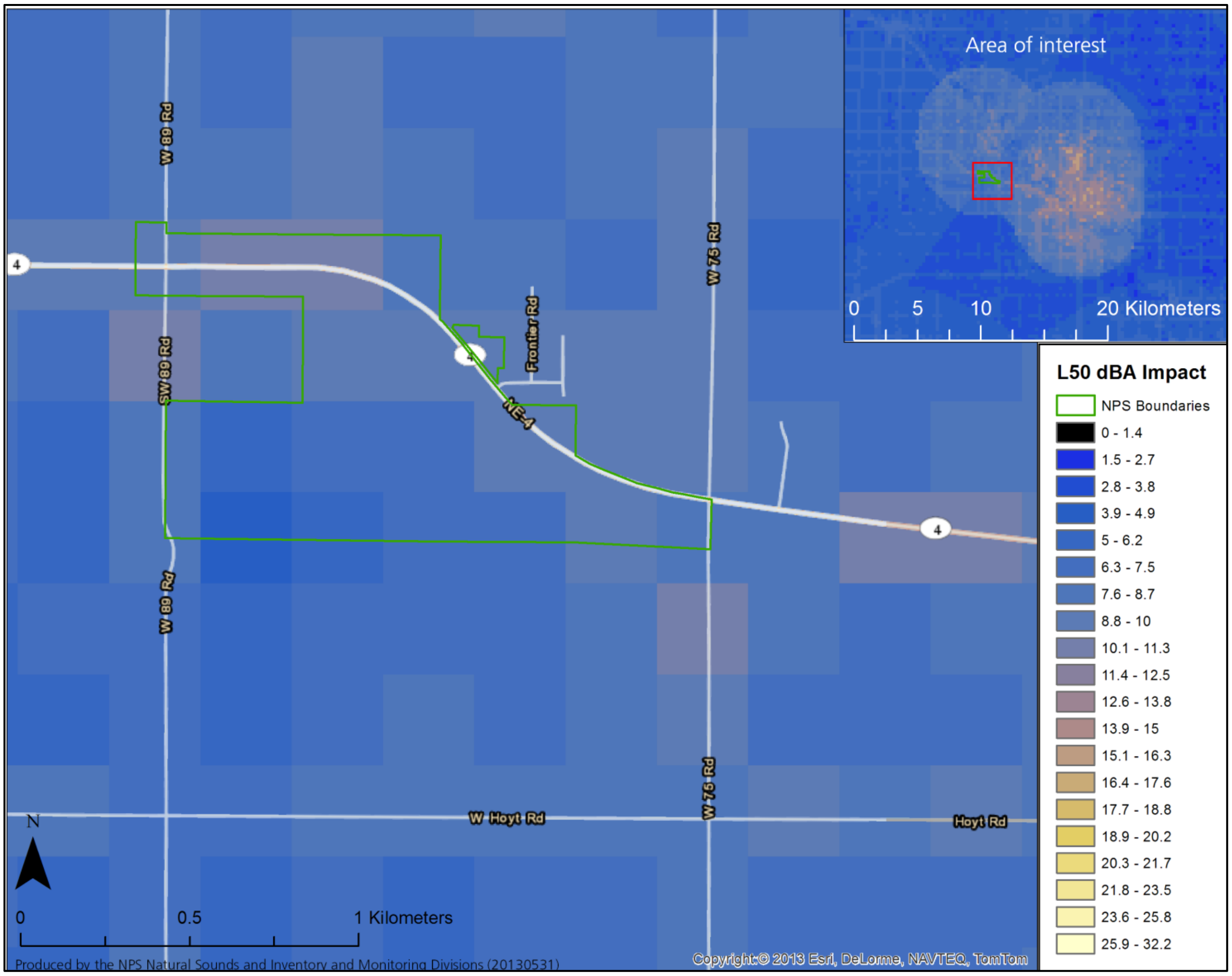
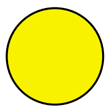
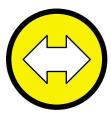
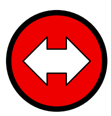
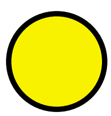
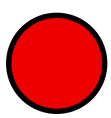
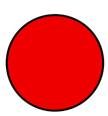
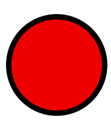


Figure 4.3-10. Modeled mean sound level impacts in the area immediately surrounding HOME and in the larger region (inset). Graphic provided by NSNSD (May 2013).

Overall Condition

The data presented above suggest that the condition of the soundscape in HOME warrants significant concern, with an unknown trend. The confidence associated with the overall rating is high due to the wide range of measures used and the availability of high-quality quantitative data. The sound pressure level associated with physiological changes in humans (35 dBA) was exceeded 74% to 100% (40% to 94% for the low frequency range) of the time in the Monument during the day (depending on site and season) and 44% to 100% (38% to 83% for the low frequency range) of the time during the night. Sound pressure levels exceeded 45 dBA only 1% of the time at night in the fall but as much as 100% of the time both day and night in the summer (for the full frequency range). Sound pressure levels also exceeded 52 dBA (the level at which speech interference occurs for interpretive programs) as much as 92% of the time at one site during the summer. The mean exceedance levels in the Monument (L_{50} for the full frequency range) varied from 38.4 dBA (fall) to 53.6 dBA (summer) during the day and 34.9 dBA (spring) to 59.0 (summer) dBA at night. These levels represent moderate to very high values for L_{50}. The nationwide modeling of anthropogenic sound level impacts indicates that modern noise intrusions are substantially increasing the existing ambient sound level above the natural ambient sound level of the Monument (mean impact = 8.8 dBA). The condition of the soundscape in HOME is highly dependent on the season, with more significant anthropogenic impacts during the summer. As long as noise from vehicles on the adjacent highway, maintenance activities, and facilities remains pervasive in the Monument, the condition of the soundscape may continue to deteriorate. Table 4.3-4 summarizes the status and trend for each of the soundscape and natural sounds indicators.

Table 4.3-4. Condition assessment interpretation for the soundscape at Homestead National Monument of America.

Indicator	Condition Status/Trend	Rationale
Anthropogenic Sources of Noise		Noise from anthropogenic sources is common, especially noise from encroaching suburban sprawl and industrial development.
State Highway 4 Traffic Volume		Traffic volumes have been recorded since 2006, and there does not appear to be a trend toward higher volumes in recent years. Average monthly traffic volume was lowest in 2013 (62,525 vehicles) and highest in 2010 (84,243 vehicles). If highway traffic volumes are stable, then impacts to the Monument's soundscape from traffic noise should remain near current levels.
State Highway 4 Noise Impacts		Projections of future conditions suggest that the range of impact of noise (loudest-hour noise levels of 56+ dBA) from the highway will be spatially extended from 184 feet in 2002 to 250 feet by 2025, which will affect several sites where educational or interpretive activities currently take place in HOME.
Percent Time Above Specified Levels		Sound pressure levels varied across sample sites and seasons. For some frequencies at some stations, pressure levels exceeded 52 dBA either 10–25% of the time or greater than 25% of the time.
Exceedance Levels		Measured L_{50} varies between 35 and 59 dBA, depending on the sampling period and site. Although a value of 35 dBA for L_{50} can be considered a relatively good condition, a value of 59 dBA for L_{50} warrants significant concern.
Anthropogenic Impacts on Ambient Sound Level		Anthropogenic noise is significantly increasing the existing ambient sound level above the natural ambient sound level of the Monument (median impact > 5.0 dBA and maximum impact > 10.0 dBA). Ground and air traffic are expected to increase over time.
Soundscape and Natural Sounds overall		The condition of the soundscape warrants significant concern, with an unknown trend and a high level of confidence.

4.3.5. Uncertainty and Data Gaps

The NPS has conducted acoustical monitoring studies at 4 sites over several time periods in HOME to measure ambient sound levels and the audibility of different intrinsic and extrinsic sound sources in the Monument. However, evaluative research has not been collected to determine the social impacts of existing soundscape conditions on visitor experiences in HOME.

4.3.6. Sources of Expertise

- Emma Lynch, Acoustical Resource Specialist, NPS Natural Sounds and Night Skies Division
- Jesse Bolli, Resource Management Specialist, Homestead National Monument of America

4.3.7. Literature Cited

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4.4. Scenery and Views

4.4.1. Background and Importance

Visual resources or scenery has important value in terms of historic and cultural context, aesthetics, and tourism and health (Figure 4.4-1). 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 wild life therein and to 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. Current NPS *Management Policies* (NPS 2006) do not provide guidance regarding service-wide policies or practices for scenery conservation.

Figure 4.4-1. View across the restored tallgrass prairie to the west toward Cub Creek from the Freeman grave site in 1957 (top – NPS photo) and in 2013 (bottom – CSU photo).

Scenery is consistently rated as a top priority by park visitors, and is increasingly addressed in General Management Plans, Resource Management Plans and Cultural Landscape Plans/Reports. 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 increasingly impact visual landscapes supporting natural and historic views.

The HOME enabling legislation of 1936 aims to “retain for posterity a proper memorial emblematical of the hardships and the pioneer life through which early settlers passed in the settlement, cultivation and civilization of the Great West.” The Monument’s mission is to commemorate and interpret the Homestead Act and its influence upon the country. The mission is to maintain the 160-acre original homestead and the Freeman School addition in a manner that provides visitors an approximate perspective of the influences and impacts upon the land in its transition from its natural state to cultivation and agriculture, while maintaining a visual relationship between the Freeman School and the rest of the Monument (NPS 1999). A survey study at the Monument conducted in 2009 ranked natural scenic views among the top-ranked attributes for that park. 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).

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 park.

Concerns about scenery degradation are not new at HOME. The development of fertilizer plants to the north in the 1960s and other development prompted acquisition of scenic easements to the north across State Highway 4. A scenic value assessment from 1988 recommended acquiring more land or additional easements to protect park views (Mark Engler, personal communication August 2013). Most recently, the park is very concerned about the approval and imminent development of the Volkswind energy project approximately four miles to the southwest. This proposed facility would directly impact park views from the Heritage Center and other important viewpoints.

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 Visual Resource Program within the NPS Air Resources Division. Other federal agencies such as the Bureau of Land Management and the U.S. Forest Service also have established programs to promote scenery conservation. Important components of these initiatives include scenery inventory, evaluation of non-aesthetic concerns such as visitor use consideration, and in the case of NPS, viewshed impacts both within and beyond park boundaries.

Threats and Stressors

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

- Air pollution/haze affects visitors’ ability to see features, color and detail in distant views

- Suburban/exurban development
- Industrial development – large/tall structures are more important than acreage occupied. Industrial development is also related to other incompatible elements such as transmission lines, visible smoke/steam/dust, roads, increased traffic and noise
- Other-made structures, including farms that have larger structures (e.g., outbuildings, silos) and more mechanized equipment relative to the homesteading era
- Roads and traffic
- Energy development and infrastructure (e.g., wind turbines and power transmission structures)
- Communications structures

<u>Indicators and Measures</u>

- Scenic quality of landscape views
- Housing densities in the surrounding 30 km (18 mi) area
- Potential visibility of new wind turbines
- Air quality – visibility

4.4.2. Data and Methods

Measures supporting this assessment include both quantitative and qualitative assessments. The assessment framework integrates ground-based measures of scenic quality from key viewpoints with two GIS –based measures: housing density and potential visibility of wind structures. 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 would depend on the viewer's eyesight, and on the object's size, shape, color, reflectivity, and orientation to the viewer; the lighting that falls on the object; and the presence of haze and other factors (USDI 2013).

<u>Scenic Quality</u>

Previous Examination of Scenery

An evaluation of black and white photos and color slides taken from five locations was undertaken by Sutton et al. (1984). Three of these locations roughly coincide with views identified as currently important for the park: the view from the planned interpretive patio, the view from the south boundary trail junction near the hedgerow, and the view from the Freeman School road intersection. Visual quality ratings were based on three design and visual principles: 1) vividness – the memorability and uniqueness of what is seen; 2) unity – the repetition of basic design elements such as color, form, texture and space; and 3) intactness –high intactness consisting of undisturbed and unchanged natural and cultural elements. "Undisturbed prairie" was selected as the most intact state.

The principles of vividness, unity, and intactness were rated with respect to vegetation and features found in the landscape.

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 and identified as part of the NRCA scoping process and a workshop conducted by the NPS Visual Resource Program at the park in August 2013. Four primary viewpoints and six associated views considered important and/or having high levels of visitation were evaluated by HOME staff and the authors (Figure 4.4-2).

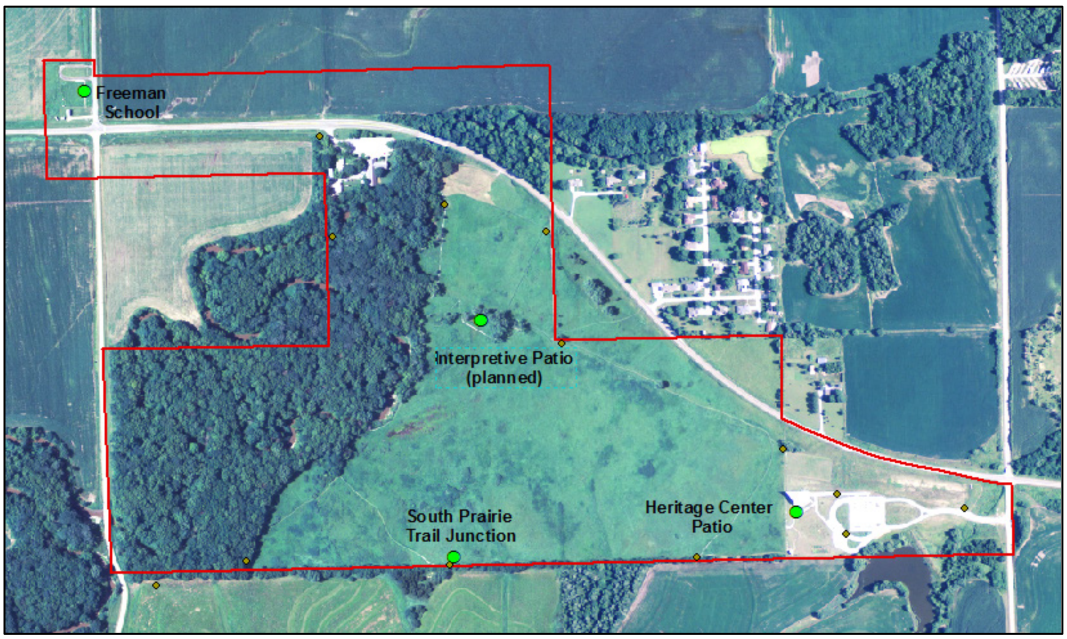


Figure 4.4-2. Location of primary viewpoints at Homestead National Monument. Viewpoint location data developed by Colorado State University. Background imagery from ArcGIS background image.

Panoramic photos for some points were taken by CSU staff in 2013 and are included here, while other view photographs were taken by park staff and volunteers. CSU panoramic photos were taken manually with a Canon G10 camera using a 50–55 mm focal length and an image resolution of 14.6 megapixels. Each high-resolution panorama consisted of five to six overlapping photos that were combined using Gigapan Stitch software. Resulting photos had a field of view approximately 110–130 degrees wide and 25–30 degrees tall. Mean panorama size was approximately 16,000 x 35,000 pixels, and were exported as .tiff graphics ranging from 65–110 megabytes in size. Original and stitched panoramic photographs and associated location data will be delivered to the park with the NRCA.

Each point was evaluated by HOME Resource Management Specialist Jesse Bolli and/or volunteers during 2013 and 2014 using methodology and field data sheets developed by the NPS Visual

Resource Program, Air Resources Division and presented at a workshop at HOME in August 2013. The visual resource inventory process has evolved considerably since the work done at HOME in 2013 but we present those results since they represent the only available information. Using the 2013 NPSP methodology, a landscape character type was assigned to each view. Types include natural/natural appearing, pastoral, agricultural, rural, suburban, urban and industrial. Primary landscape types present at HOME are natural/natural-appearing and agricultural landscapes. Landscape character types are described in NPS Visual Resource Program 2014a. For each view, landscape character elements and landscape design elements were characterized and evaluated within the foreground, middle-ground and background. Landscape character integrates considerations related to both cultural and natural qualities and elements.

The distance zones are based on visibility of features rather than specific, fixed distances from the observer (Figure 4.4-3). 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 Visual Resource Program 2014a).

Figure 4.4-3. 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, vividness, and visual harmony to determine an overall scenic quality score. Landscape character integrity 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 drive this component of the scenic quality rating. Vividness of the view is determined by evaluating focal points (i.e., prominent features that attract or hold your attention), forms and lines (e.g., to what extent do land, water, or other forms contribute to the visual interest of the view?), and colors. Visual harmony examines spatial relationships (e.g., the location, spacing and patterns of elements), the scale (e.g., the relative size and balance among view elements), and colors present in the view. 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 (18 mi) area surrounding the park. A comprehensive examination of land cover, land use, population and housing density is presented in Section 4.1 of this assessment. The results for housing densities in the region surrounding the park are used here as an indicator of condition and changes in one of the threats to park views. 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

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 2012 (the last year for which there are tabulated data), there was over 60,000 MW installed production capacity in the United States, generating enough power to supply 15 million American homes (AWEA 2014). The installation of wind energy capacity in 2012 outstripped all other energy production installations in America (AWEA 2014) and is anticipated to expand, prompted by both environmental and economic forces. The analysis used here uses a turbine hub height of 80 m (262.5 ft) and a rotor diameter of 100 m (328 ft) to represent a windmill that would produce 2.2–3.0 megawatts.

Wind turbines (and other associated tall structures, including transmission and meteorological towers) introduce strong vertical elements into what was once primarily a horizontal landscape. These visible 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, USDI 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).

The Upper Great Plains Programmatic Environmental Impact Statement (UGP PEIS) is an attempt by the Western Area Power Administration (WAPA) and the US Fish and Wildlife Service (FWS) to create a comprehensive strategy for addressing emerging wind development projects in six states in the upper Midwest (DOE 2013). The draft PEIS addresses the impacts of wind development on visual resources similarly to USDI (2013). Homestead National Monument lies within an area of Nebraska with high potential for wind development, suggesting that the pressure on Homestead's scenic resources will continue to grow (DOE 2013, NREL 2013).

A spatial analysis of visibility of wind turbines from the main interpretive deck of the Heritage Center was completed by the NPS Midwest Geospatial Support Center in support of this assessment. Viewshed analysis produced several data layers used here: areas where an 80m tall windmill hub would be visible, areas where a 130 m (426 ft) tall windmill blade would be visible and the percent vertical visibility of the 80 m (262.5 ft) structure where it would be visible. The analysis used a 10 m (33 ft) DEM, considered earth curvature, and was performed on bare earth (i.e., did not consider the effects of vegetation or other non-terrain obstructions). 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 that the facilities could be major sources of visual contrast at up to 16 km (10 mi).

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 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 40^{th} and 60^{th} percentiles (NPS ARD 2013a). Five-year interpolated averages are used in the contiguous US.

4.4.3. Reference Conditions

The scenic and historic integrity at the park overlap considerably, and are integrated within the scenic quality evaluation. The reference state is based on a range of natural conditions and historic elements that would have existed in the period referenced by the park's mission. In accordance with the park mission and purpose, the reference condition for park views combines a natural prairie and riparian woodland setting with elements of agrarian landscapes associated with the early Homesteading era and small-scale, non-mechanized farming. When the earliest homesteaders arrived in this region, they would have seen a natural landscape unmodified by agriculture and without human structures such as cabins and outbuildings. The landscape would have been characterized by open vistas dominated by tallgrass prairie vegetation consisting of diverse grasses, forbs and occasional patches of shrubs with woodland corridors along perennial streams. Later homesteaders passing through or filing claims in the 1860s and later would have seen remnant prairie areas as well as farm fields, farm buildings, livestock, fences, fencerows and hedgerows, and occasional dirt roads. As per the Homestead Act, a minimum of one cabin and outbuildings would have been present on each 160-acre claim. The homesteaded landscape may have also included wooden and metal windmills, and beginning in the 1870s, barbed wire fencing would have been used in some areas. No electrical or communication wires or mechanized equipment would have been present until well after the turn of the century.

Inconsistent landscape elements within views can be inside or outside the park. Examples of inconsistent landscape elements include:

- Paved roads and high density of dirt roads and/or high traffic volumes;
- Urban, suburban and exurban development;
- Industrial-era farm structures such as large silos;
- Energy and communication infrastructure, including wind turbines, electrical and phone transmission lines, and communication towers such as cell phone towers;
- Fencing;
- Commercial and industrial structures;
- Irrigation structures;
- Commercial advertisement elements such as billboards and excessive signage;
- Vegetation that is inconsistent with the reference condition and landscape character type; and
- Park structures and infrastructure.

A summary of reference conditions and condition class rating for scene quality, housing density, and visibility indicators is shown in Table 4.4-2, Table 4.4-3, and Table 4.4-4, respectively. Due to the uncertainties in viewshed modelling and the lack of previous research on the effects of wind turbine development on the perceived viewshed quality of a landscape, an objective condition rating system was not created for visibility of wind turbines.

Table 4.4-2. Condition rating framework for scenic quality at Homestead National Monument (modified from NPS Visual Resource Program 2014b).

Component	Good Condition	Warrants Moderate Concern	Warrants Significant Concern
Landscape character elements	Most or all important elements of the designated landscape character are plainly visible (e.g., natural features, land use types, structures, etc.).	Some important landscape features are present, but some important elements are missing.	Few important character elements are plainly visible and/or many important elements are missing.
Quality and condition of elements	Most elements are of high quality and in good condition, such as 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.	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 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.
Inconsistent elements	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.	Some inconsistent landscape character elements are plainly visible.	Many or major inconsistent elements are plainly visible and may be dominant features in the view.

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. 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

Scenery and views from the park are variable, consisting of urban and industrial elements, energy and power structures, communication lines and structures, exurban and urban development, agriculture, and natural settings. Some views are dominated by within-park landscapes and elements, while others are influenced by midground and background elements and landscapes outside park boundaries.

Scenic Quality from Primary Viewpoints

Scenic quality associated with the 4 viewpoints and six views was summarized by Bolli (2014). A description of each view and notes on scenic quality and view importance from the Bolli report is presented below. All viewpoints were assigned a high value, so the scenic quality scores figure most heavily in the overall quality rating for each point. View data is on file with HOME.

View 1 – Heritage Center Patio Looking South

Scenic Quality Score = 30/45

The view analyzed is looking south from the patio on the southwest corner of the Heritage Center (Figure 4.4-4). The area is framed by the Palmer-Epard cabin and Osage orange hedgerow to the right and the trees around Graff Pond to the left. In the foreground is an area of lawn containing the orchard, farm implements and cabin. A wide concrete pathway dominates the foreground. Directly behind the cabin is a fence, behind which are row crops such as corn and beans. Electrical transmission lines and poles are in the midground. The background consists of distant trees and crop fields on the horizon. The primary feature in the view is the Palmer-Epard Cabin surrounded by implements from the 1800s and early 1900s. To the east of the cabin is a fenced community garden and north east of the cabin is an orchard that contains 24 apple, plum, cherry, peach and pear trees.

The cabin, implements, garden and orchard in the foreground with the modern corn field in the background form a cohesive agricultural view. Although the cabin is a great focal point, the uniform color and level landscape decrease the vividness of the scenery. There are several power lines and farms structures visible in the middle-ground. The view importance is very high because of the high visitation to the point, as almost every visitor who visits the Heritage Center will go to the patio to enjoy the view. The Palmer-Epard Cabin, farm implements, garden and orchard all work together to give the visitor a glimpse of what early homesteads in this area may have looked like.

Figure 4.4-4. Panoramic photo looking south from the Heritage Center patio (viewpoint HOME_003, view HOME_003 HC Patio S). CSU Photo August 2013.

View 2 – Heritage Center Patio Looking West

Scenic Quality Score = 30/45

This view, considered the most important view in the park, is looking west from the patio on the southwest corner of the Heritage Center (Figure 4.4-5). To the right it is framed by the Heritage Center and to the left it is framed by the Osage orange hedgerow. The foreground is enclosed by a fence with lawn between the patio and the fence. Beyond the fence is restored tallgrass prairie that stretches about ¾ of a mile to the Cub Creek woodland. Three antennas and some power lines are visible in the background.

The view is of the Daniel Freeman Homestead claim. When it became a NPS site, this claim was restored to tallgrass prairie and riparian woodland to give visitors a glimpse of what the first homesteaders would have encountered. The view shows a very good natural landscape which is interrupted by development as your eyes drift to the north. The landscape is fairly uniform with various shades of green. The view importance is very high as it is a view that all visitors see from the Heritage Center foyer looking out of the western glass wall of the building. The view was a foundational element in the design of the Heritage Center and is used to show visitors what the first homesteaders would have encountered. On the patio the interpretive panels discuss the view and orient the visitors to the west.

Figure 4.4-5. Panoramic photo looking west from the Heritage Center patio (viewpoint HOME_003, view HOME_003 HC Patio W). CSU Photo August 2013.

View 3 – Freeman School Boardwalk – All Directions

Scenic Quality Score = 30/45

This view was analyzed from the boardwalk at the Freeman School between the parking area and the school (Figure 4.4-6 to 4.4-8). The School is in its original location on the northwest corner of the intersection of Nebraska State Hwy 4 and County Road Southwest 89. The view was evaluated as a 360° view (i.e., in all directions), however the view to the northwest is the most important as it is the view that the visitors are guided toward when they are examining the waysides. The main focal point of the view is the historic 1872 one room schoolhouse. The school is surrounded by row crop agricultural fields, which fit with the historic setting. Electrical transmission lines follow the roads north, south, and west. There are two sets of transmission lines with one set being large, high voltage lines leading to the industrial plants north of the site. There is an abundance of highway signs that are in the view.

The Freeman School is a very strong focal point. However, inconsistent features such as the industrial sized power lines and signs for the fertilizer plants detract from the view. A number of modern features are visible: road sign and parking sign, wooden utility poles in foreground and background, one center pivot irrigation line, a brick and wood wall/screen west of the schoolhouse, and one grain silo about 1 mile away to the west. Sound and movement from the highway was also distracting when taking in the views at the Freeman School. The Freeman School is on the list of classified structures and it is the only structure within the Monument that Daniel Freeman may have helped to build or visited at some point. The view importance is lower than other sites because the location is less visited than other viewpoints associated with park trails and Heritage Center.

Figure 4.4-6. Panoramic photo looking east from the boardwalk approach to the Freeman School (viewpoint HOME_015, view HOME_009 Freeman School E). CSU Photo August 2013.

Figure 4.4-7. Panoramic photo looking south from the boardwalk approach to the Freeman School (viewpoint HOME_015, view HOME_009 Freeman School S). CSU Photo August 2013.

Figure 4.4-8. Panoramic photo looking west from the boardwalk approach to the Freeman School (viewpoint HOME_015, view HOME_009 Freeman School W). CSU Photo August 2013.

View 4 – South Boundary Trail along Hedgerow Looking North
Scenic Quality Score = 31/45

The foreground drops away toward the bottom below you, covered by restored prairie (Figures 4.4-9, 4.4-10). The prairie is enclosed by deciduous forest along the fencerow and Cub Creek bottom. The background is dotted with farm houses and buildings, industrial development and grain storage facilities. Most notable are the Beatrice Power Plant operated by Nebraska Public Power, the Koch fertilizer plant and Farmers Co-Op elevator near Hoag.

This view from the trail looking north is an excellent view of prairie and woodlands, however it is lacking strong focal points and the colors of the prairie are generally muted; the cottonwood trees in the middle of the prairie seem out of place. Visitation on the Upland Loop trail is limited, although improvements such as benches and interpretive waysides invite visitors to spend extra time enjoying the views.

Figure 4.4-9. Panoramic photo looking northwest from Park Viewpoint 4 near the south trail junction along the fence line (viewpoint HOME_010, viewpoint HOME_010 S boundary NW). CSU Photo August 2013.

Figure 4.4-10. Panoramic photo looking northeast from Park Viewpoint 4 near the south trail junction along the fence line (viewpoint HOME_010, viewpoint HOME_010 S boundary NE). CSU Photo August 2013.

View 5 – Prairie Patio Looking South

Scenic Quality Score = 35.5/45

This view is enclosed by deciduous forest on the right, the Osage orange hedgerow to the south and the nearby cottonwood trees to the left (Figure 4.4-11). The grassland appears diverse, the land is fairly flat, and there is a hill to the left. The patches of woody thickets break up the uniform appearance. Two areas of the hedgerow in the midground have trees missing.

This view looking south showcases the tallgrass prairie. The linearity of the hedgerow to the south encloses the view and helps to direct your view to the southwest. Even though the hedgerow was planted to mark a boundary, it may appear to the casual observer to be a natural element. It also helps block the view of the agricultural background, making the observer feel that they are in a larger natural area. The shades of green blend well together giving the view harmony, however as with many prairie views it lacks vividness.

The importance of this view is very high because of the construction of the Prairie Plaza and installation of the interpretive waysides. The main historic feature visible in the view is the Osage orange hedgerow. It is anticipated that most visitors walking the trail will stop at this location to enjoy the view.

Figure 4.4-11. Panoramic photo looking southwest from near the cottonwood grove where a new interpretive patio is planned (viewpoint HOME_009, view HOME_009 prairie patio SW). CSU Photo August 2013.

View 6 – Prairie Patio Looking North (no photo available)
Scenic Quality Score = 27/45

Restored prairie dominates the foreground. Deciduous forest and housing development dominate the midground, with sporadic traffic on State Highway 4. There is no background.

This view looking north scores much lower because of the ways it has been impacted by industrial and residential development. The cars moving through the view also detract from the experience. There are no strong focal points within the view.

View Point Discussion

Scenery and some specific views associated with HOME have been discussed and documented in HOME Cultural Landscapes Reports (QE/A and LCA 2000, 2005) and in the *Homestead National Monument Vegetation Survey and Management Recommendations* (Sutton et al. 1984). Three of the views examined here were also evaluated by Sutton et al. (1984) using photos from 1982. Condition ratings for the primary views are presented in Table 4.4-5. The view from the planned interpretive patio is at a location close to historic NPS photo plot 4. Out of six views, it ranked number one in landscape feature quality because of the "long, panoramic views, less visible evidence of man's intrusion, and strong spatial enclosure." The view from the south boundary trail junction is at a location close to historic NPS photo plot 5. Out of six views, it ranked fifth in landscape feature quality. Poor landscape feature quality was attributed to significant intrusions of manmade features to the north, including the fertilizer plant, grain elevator, and housing. The view to the west was described as more natural and defined by the forest edge along Cub Creek. The view from the Freeman School is at a location close to historic NPS photo plot 6. Out of six views, it ranked sixth in landscape feature quality. The low rating was attributed to "short views and the overwhelming dominance of manmade forms such as Highway 4, the fence enclosure, and row crops."

Despite some views that ranked high quality, the authors concluded that many of the views experienced by visitors at HOME are strongly influenced by off-site elements that are incompatible with park cultural and natural themes. An evaluation of the scenic quality associated with the Freeman School in 2005 states: "The views of the Freeman schoolhouse site are strongly shaped by road alignments. SH4 traffic and overhead utility lines to the south of the site, Blakely Township traffic to the east, as well as rural farmhouses and power transmission lines all detract from the historic setting of the schoolhouse. Views from the schoolhouse area are also influenced by the new addition of a NPS bus turn-around and parking area directly north of the schoolhouse. Billboards on the corner opposite the school also affect the quality of views and interrupt views toward the homestead site" (QE/A and LCA 2005).

Table 4.4-5. Summary of primary view scenic quality condition ratings at Homestead National Monument.

Viewpoint/Views	**Landscape Character Elements**	**Quality and Condition of Elements**	**Inconsistent Elements**	**Scenic Quality Rating**
View 1 – Heritage Center patio (viewpoint 1) looking south	good	good	moderate concern	good
View 2 – Heritage Center patio (viewpoint 1) looking west	good	good	good	good
View 3 – Freeman School (Viewpoint 3) looking in all directions	good	good	significant concern	moderate concern
View 4 – South boundary prairie overlook (viewpoint 4) looking north	good	good	moderate concern	good

Table 4.4-5 (continued). Summary of primary view scenic quality condition ratings at Homestead National Monument.

Viewpoint/Views	Landscape Character Elements	Quality and Condition of Elements	Inconsistent Elements	Scenic Quality Rating
View 5 – Planned Prairie Plaza (viewpoint 5) looking south	good	good	good	good
View 6 – Planned Prairie Plaza (viewpoint 5) looking north	good	good	moderate concern	moderate concern

Both Sutton et al (1984) and QE/A and LCA (2000) describe the natural and historic scenic quality from within the park as being highly variable depending on the viewpoint location. Our evaluation of data collected by the park and additional observations confirms this. The views from the lowland prairie of the southern boundary ridge and hedgerow are generally undisturbed, and the views from the eastern, upland ridge offer excellent panoramic views to the southwest. However, from the elevated eastern ridge and close to Highway 4, as well as from some lowland areas, views to the east, north and northwest are dominated by Highway 4 and the Pioneer Acres subdivision. While development immediately adjacent to the boundary has not changed considerably since the 1980s, the new Heritage Center location and orientation ameliorates some of these scenery problems by re-orienting the dominant views to the west and south and effectively blocking some of the less desirable views to the north and east. For example, the approach to the prairie from the old Visitor's Center across the Cub Creek Bridge presented a view that included Highway 4, the off-park subdivision and other incompatible elements. Now, as most visitors experience the park through the Heritage Center entrance, the initial prairie views are to the west and are dominated by largely compatible natural and cultural elements seen from the Heritage Center Patio and other points looking south and west.

Housing Densities

Within a 30 km (18 mi) radius of the park, housing density showed marked patterns of change between 1970 and 2010 (Table 4.4-6). The most notable trends were slight increases in exurban areas (< 10%) and a corresponding decrease in rural acreage in unincorporated areas, including areas close to towns and major roads. Little further change in any density class is projected between now and 2050. Additional details are presented in the Land Cover/Land Use chapter of this assessment. Locally, the protection of the Friend's parcel to the south will help ensure that development or alterations to the views immediately to the south are protected for the long term. Although the housing density is predominantly rural, small concentrated areas of higher densities exist close to the park, are visible from some key view points and are relatively conspicuous. Based on this information, this indicator warrants moderate concerns for views, with an unchanging trend and high level of confidence (See Table 4.4-8).

Table 4.4-6. Housing densities within 30 km of Homestead National Monument in 2010 (data provided by NPS NPScape Program).

Density Class	Area (hectares)	Percent of 30 km Buffer Area
Rural (0–0.0618 units/ha)	625,838	85.32%
Exurban (0.0618–1.47 units/ha)	101,519	13.84%
Suburban (1.47–10.0 units/ha)	3,154	0.43%
Urban (> 10.0 units/ha)	880	0.12%
Commercial/Industrial	2,274	0.31%

Potential Visibility of New Wind Turbines

Several wind farms are proposed or planned within 25 miles of the park. The park is most concerned about the planned wind farm to be developed by Volkswind between Beatrice and Fairbury north and south of Highway 136. Other projects are proposed for south of Diller approximately 17 miles south of the park and for near Crab Orchard approximately 20 miles northeast of the park. The Volkswind project would consist of 75–100 wind turbines having turbine hub heights of approximately 80m and rotor blade heights of approximately 120 m. The project area would be about 5–6 miles wide and 18 miles long. The Volkswind project would likely impact the south and southwest-facing scenic views and vistas. At a distance of 5 miles, the size, movement reflection and contrast of the structures would negatively impact current views. The western end of the Volkswind project would be less than ten miles away, and several miles closer than the Jansen Community Grain elevator, which at about 250 ft (76.2 m) tall is visible on the horizon above the Cub Creek woodland (personal comment Mark Engler, August 2013).

The National Renewable Energy Laboratory (NREL) has estimated the suitability for wind energy production for areas within the United States (DOE 2014). With average annual wind speeds exceeding 7.0 meters/second, the vicinity of the park is considered to have suitable and attractive wind resources for electricity production (DOE 2014). With assistance from the NPS Midwest Geospatial Support Center, the potential visibility of 80 m (262.5 ft) tall and 130 m (426 ft) tall wind turbine structures from view points within the park was examined relative to the NREL wind suitability data layer (Figure 4.4-12). The analysis addresses the following questions: 1) Where would construction of wind turbines potentially affect views from the park; and 2) How much of the area falls within suitable wind energy production areas?

Results show that 80 m (262.5 ft) turbine hubs could potentially be seen on a total of about 635,000 ac; 130m tall rotor blades could potentially be seen on a total of about 996,000 ac. Eighty-meter tall turbines would be visible approximately 10 mi to south but visible up to 25 mi to the northwest, while rotor blades (130 m; 426 ft) would be visible for approximately 5 additional miles in any direction (Figure 4.4-12). The degree of visibility of an 80 m (262.5 ft) tall turbine is show in Figure 4.4-13.

The Volkswind project area is within the 80m visibility area. The viewshed area to the east and north is generally classified as having fair or marginal wind power potential, whereas much of the area to the south, southwest, west and northwest is generally classified as having good wind power potential (Figure 4.4-12). The degree of visibility for structures built to the west and northwest would also be high, generally in the 50–100% visible range (Figure 4.4-13). Approximately 95% of the area where 80m and 130m blade rotors turbines would be visible falls in the fair or good wind suitability class (Table 4.4-7). This indicates that there is an enormous potential for future wind farm development to affect the park's most important views to the south and west. Results for this indicator warrant moderate concern for park views with a deteriorating trend (See Table 4.4-8 at the end of this section). 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.

Table 4.4-7. Area and percentage of viewshed within each NREL wind power suitability class for 80 m and 130 m structure heights.

	Acres (% of viewshed)					
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	0.0 (0%)	33,915 (5.3%)	442,690 (69.6%)	159,097 (25.0%)	0.0 (0%)	635,701
130 m structure	0.0 (0%)	616,025 (6.2%)	674,766 (67.8%)	259,543 (26.1%)	0.0 (0%)	995, 911

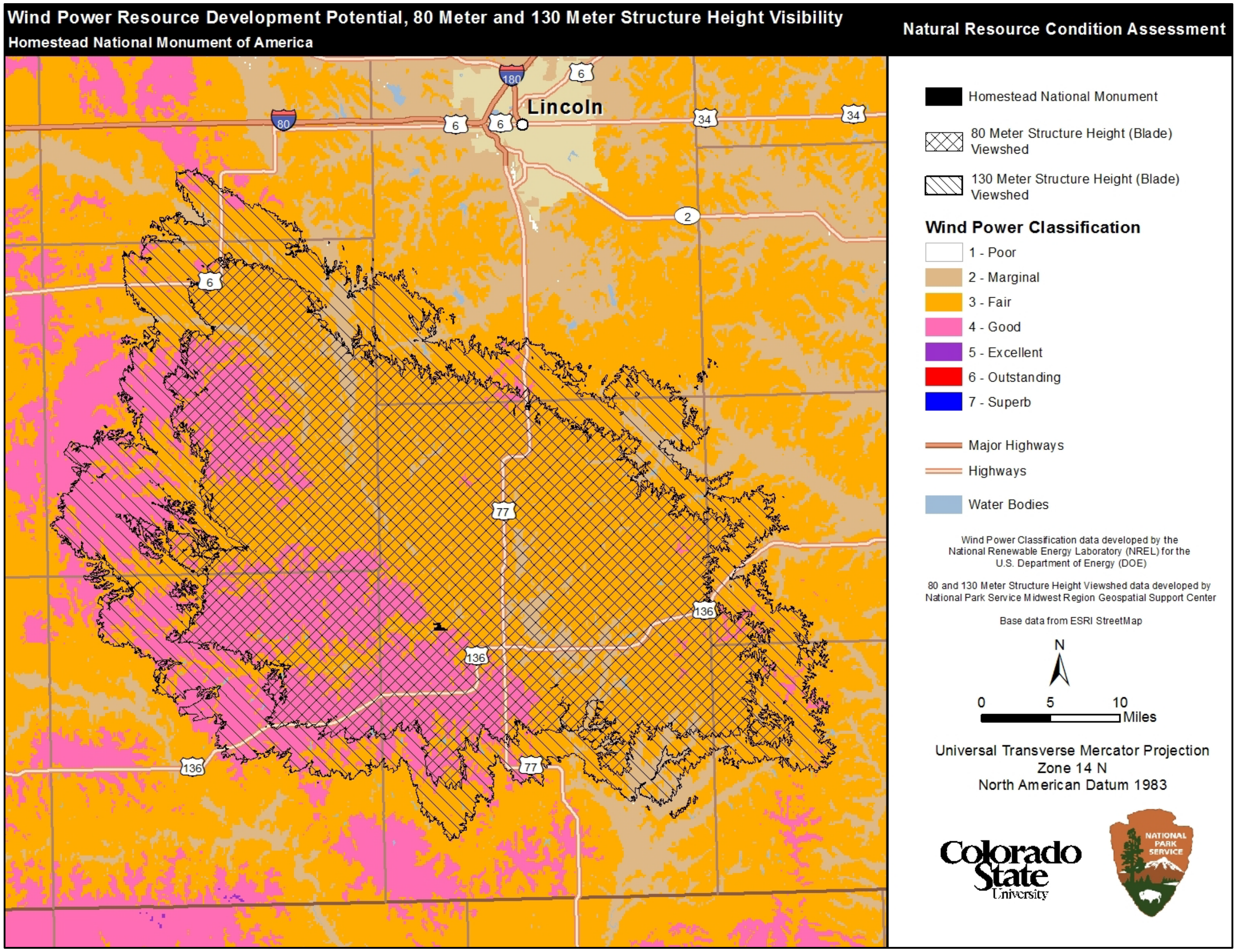


Figure 4.4-12. Areas potentially visible within the viewshed of key viewpoints within Homestead National Monument for 80m (turbine hub) and 130m (rotor blade) wind energy structure heights overlaid on NREL wind power resource development potential. Data sources are listed in the figure.

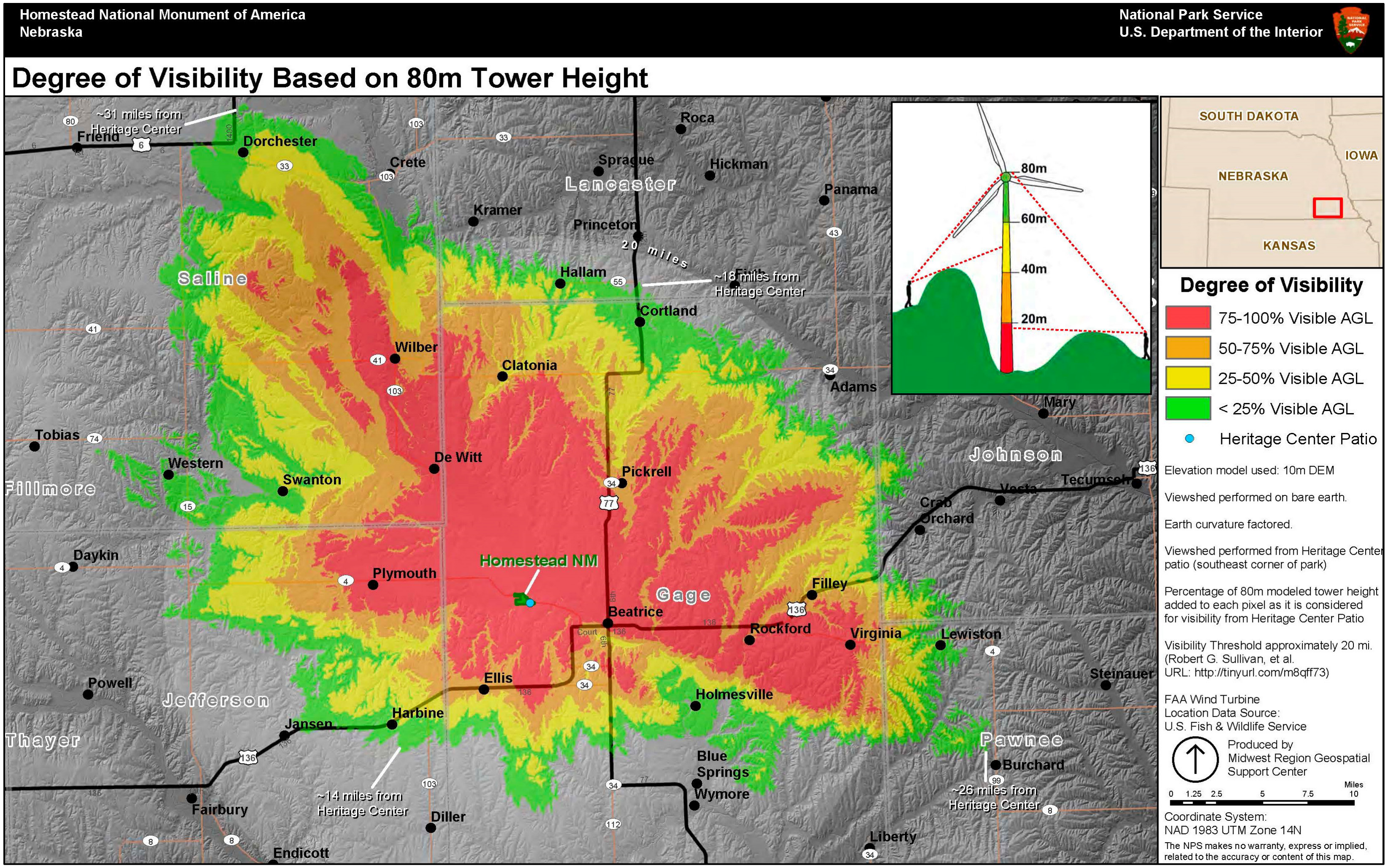


Figure 4.4-13. Degree of visibility from the Homestead National Monument Heritage Center interpretive deck, based on 80m turbine height (data and graphic provided by NPS Midwest Geospatial Support Center November 2013).

Air Quality – Visibility

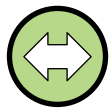
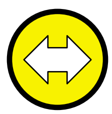
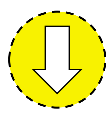
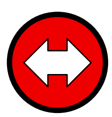
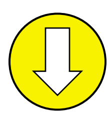
The five-year averages for visibility consistently fall in the NPS Air Resources Division poor condition category (Table 4.7-4) (NPS ARD 2013b). Visibility levels have been between 9.3 dv and 11.2 dv throughout the 2001–2010 period. The condition of the air quality visibility indicator warrants significant concern, with an unchanging trend (Table 4.4-8). Although the gently rolling topography and lack of high vantage points at HOME limits the observation of distant objects due to visual obstruction by trees, other objects and the curvature of the earth, the poor visibility rating is notable.

Overall Condition and Trend

Overall condition of views warrants moderate concern with a deteriorating trend (Table 4.4-8). Confidence in the assessment is medium. Condition of scenery is weighted most heavily toward the scenic quality ratings, which are based on actual views and human observations from defined vantage points. Less weight is given to the examination of housing densities and land cover, which illuminate larger landscape issues that may affect the park into the future and also impact secondary views in and around the park. The evaluation of potential visibility of new wind turbine developments highlights an issue that is of great concern to park managers, and illustrates geographically the park views that may be impacted. The wind energy results are therefore also assigned a lesser weight relative to the quality of on-the-ground views. However, the high likelihood of wind farm construction affecting views in the near term is considered in the trend rating. The confidence level is medium due to uncertainties related to wind farm development.

While some commercial and industrial development has occurred north of the park in the past few decades, with the exception of increased traffic on State Highway 4 development in the immediate vicinity of the park has been relatively static. NPS planning and design of the Heritage Center and other park infrastructure, orientation of visitors to desirable views, and proactive natural and cultural resources management over the past several decades have improved the views that the majority of visitors experience.

Table 4.4-8. Condition assessment summary for scenery at Homestead National Monument.

Indicator	Condition Status/Trend	Rationale
Scenic quality		Important views are generally dominated by desirable natural and cultural elements or features. The quality of the elements is also high. With the exception of views from the Freeman School, most inconsistent elements are in the background where they occur. The redesign of the park and new visitor patterns of use associated with Heritage Center help to focus views to the south and west, highlighting historic elements and views of the restored prairie and woodland bottom, while minimizing views associated with industrial and residential development and traffic to the north.
Housing densities in the surrounding 30 km area		Housing density in the area surrounding the park is predominantly rural with some pockets of exurban and suburban development. The Pioneer Acres subdivision impacts some views to the east, northeast and north. Relative to the rating framework, the condition falls between the moderate and good condition criteria.
Potential visibility of wind turbines		Extensive areas where wind turbine structures would be visible spread out from the Monument on all sides. The key views from the park to the south and west contain an extremely high proportion of acreage in the “good” NREL mapped wind energy potential class. The planned Volkswind project to the southwest is anticipated to significantly affect key park views (high confidence).
Air Quality – Visibility		The five-year averages for visibility consistently fall in the NPS Air Resources Division “Poor Condition” category. See Air Quality section of the NRCA for more details.
Scenery and Views overall		Condition warrants moderate concern with a deteriorating (anticipated) trend. Confidence in the assessment is medium.

4.4.5. Uncertainty and Data Gaps

With the exception of wind turbine visibility, park views data for HOME are extensive and recent. The potential visibility of wind turbines is of low confidence due to viewshed modeling assumptions.

4.4.6. Sources of Expertise

- Rob Bennets, Network Coordinator, Southern Plains I&M Network, NPS Inventory and Monitoring Division
- Doug Wilder and Matt Colwin, NPS Midwest Geospatial Support Center
- Mark Meyer and James Cheatham, Visual Resource Program, NPS Air Resources Division. Consulted on method sand provided helpful reviews

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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). Although no particular species of special concern are present, plant and animal resources at the park may be vulnerable to climate change, especially as a compounding agent with other stressors.

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 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).

The synopsis of potential changes to the park climate presented here characterizes the “exposure” component of resource vulnerability, the other components being resource sensitivity and adaptive capacity. Overall climate change vulnerability for a particular resource is estimated using a combination of exposure, sensitivity and adaptive capacity (Glick et al. 2011). 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 Park can do its part to mitigate greenhouse gas emissions and optimize the efficiency of park operations vis a vis greenhouse gases, climate change and its associated effects on park resources are largely out of the control of park managers. It is happening and will require an evaluation of the vulnerability of park resources. Moreover, specific and diverse adaptation measures for some park 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 park. 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 (18 mi) from the park boundary. Because the park is relatively small, geographic variation within the park is minimal and monthly values were averaged across the area of interest.

Two families of scenarios are generally used for future climate projections: the 2000 Special Report on Emission Scenarios (SRES) and the 2010 Representative Concentration Pathways (RCP). Results for both of these families are presented here. The SRES scenarios are named by family (A1, A2, B1, and B2) and the RCP scenarios are numbered according to the change in radiative forcing (from +2.6 to +8.5 watts per square meter) anticipated by 2100. Comparing carbon dioxide concentrations and global temperature change between the SRES and RCP scenarios, SRES A1fI 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).

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. Examination of historic climate data used PRISM (4 km; 2 mi) 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., at least several months). Monthly PSDI values were obtained from the National Climatic Data Center (NCDC 2013a). 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 (7 mi) 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). Two greenhouse gas emissions scenarios – High (A2) and Medium (A1B) 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. If precipitation decreases or temperature increases (increasing PET) moisture deficit 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. MODIS land products include two Vegetation Indexes (VI) derived from the remotely sensed fraction of photosynthetically active radiation detected every one to two days by the MODIS sensors (Gao et al. 2008). 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 (Tan et al, 2011). 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. 2010). Phenology data for pixels within the park 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 park, since most areas outside the park are not prairie or other forms of native vegetation.

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 HOME (Figure 4.5-1). The earlier period corresponds to a timeframe that is generally associated with nominal change in climate or a slower rate of change compared to 1980 or later. At HOME, mean minimum monthly temperatures increased very significantly over time during 1895–1980 ($p < 0.01$) but did not increase significantly from 1980–2012 ($p=0.67$). The model results for mean monthly maximum temperature over time were not statistically significant for either period (p values of 0.624 and 0.932, respectively).

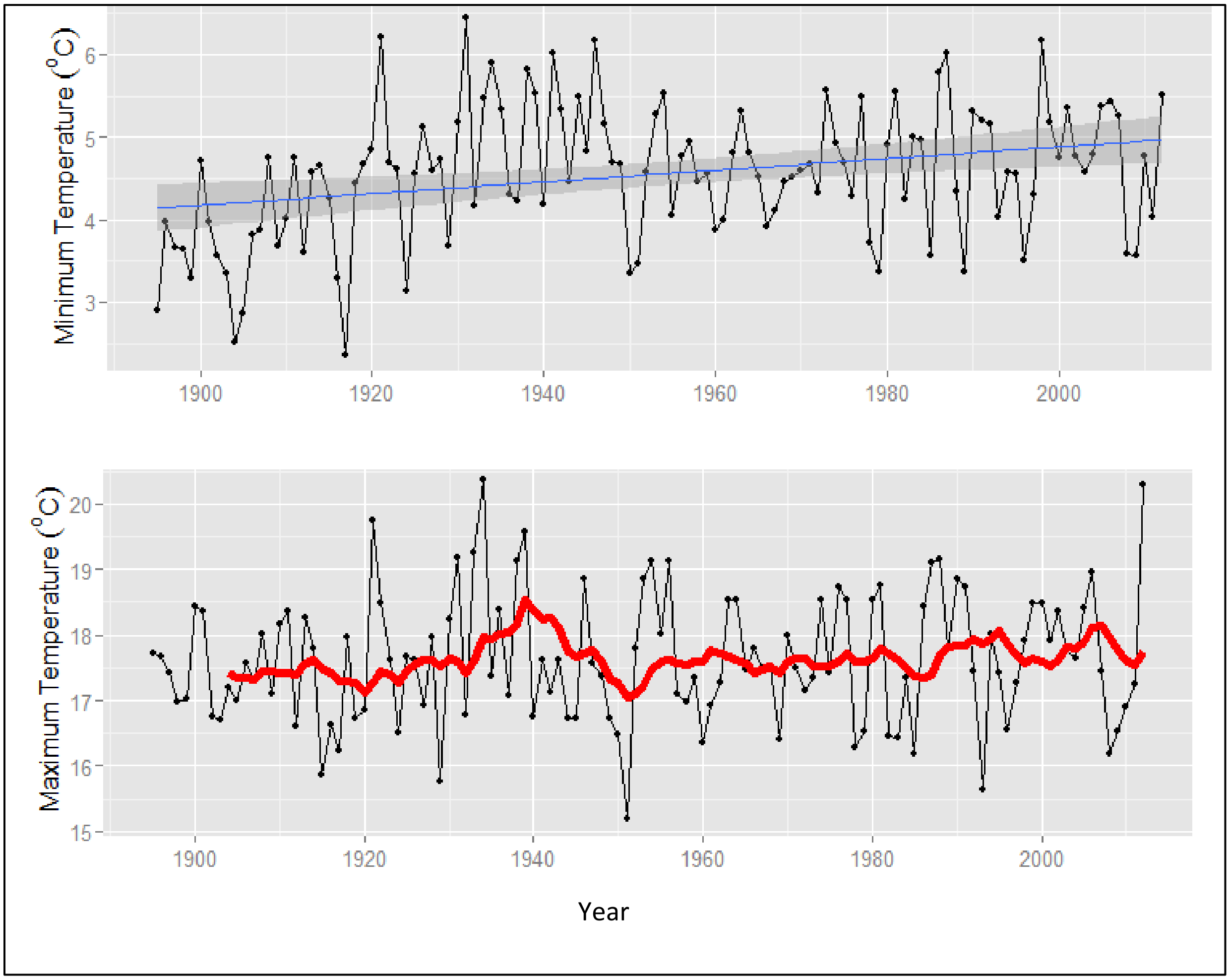

Figure 4.5-1. Historic PRISM data for monthly minimum temperature showing significant linear model fit (top) and monthly maximum temperature with a five year lag running mean (bottom), Homestead National Monument. (Data and graphic prepared by NCCSC).

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), 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 1930 or so compared to more recent years (Figure 4.5-2 top). High temperatures associated with severe droughts that occurred in the 1930s, 1950s, 1980s and 2010s are evident 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 1920 or so being 0.5–1.5 deg C above the long term average (Figure 4.5-3). Monthly data was also grouped by season into model quartiles for minimum temperature (Figure 4.5-4). Seasonal data shows higher minimum temperatures in spring and summer over the past several decades and variable changes in fall and winter minimum temperatures during the same period.

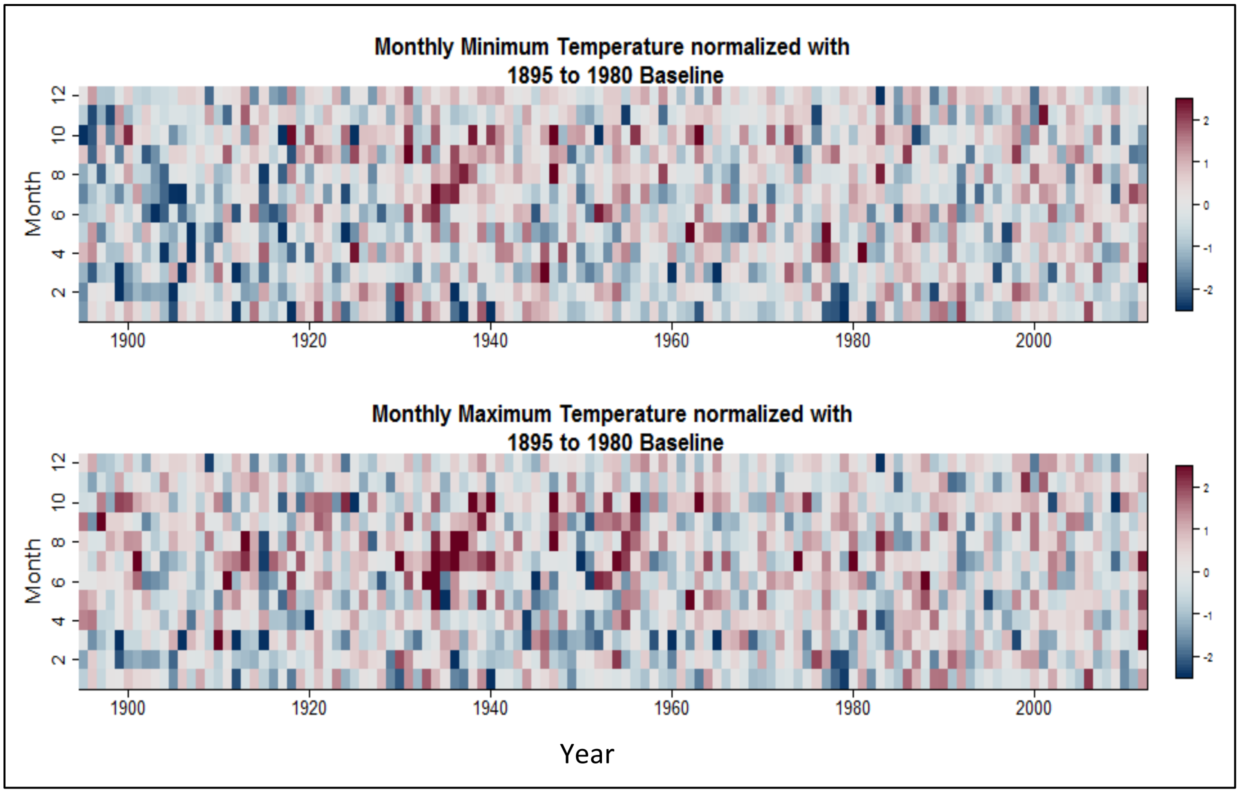

Figure 4.5-2. Mean monthly minimum temperature (top) and monthly maximum temperature (bottom) showing the normalized difference from a baseline (1895–1980) period for each month and year for Homestead National Monument. The baseline is calculated monthly within the specified year range. The pixels are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

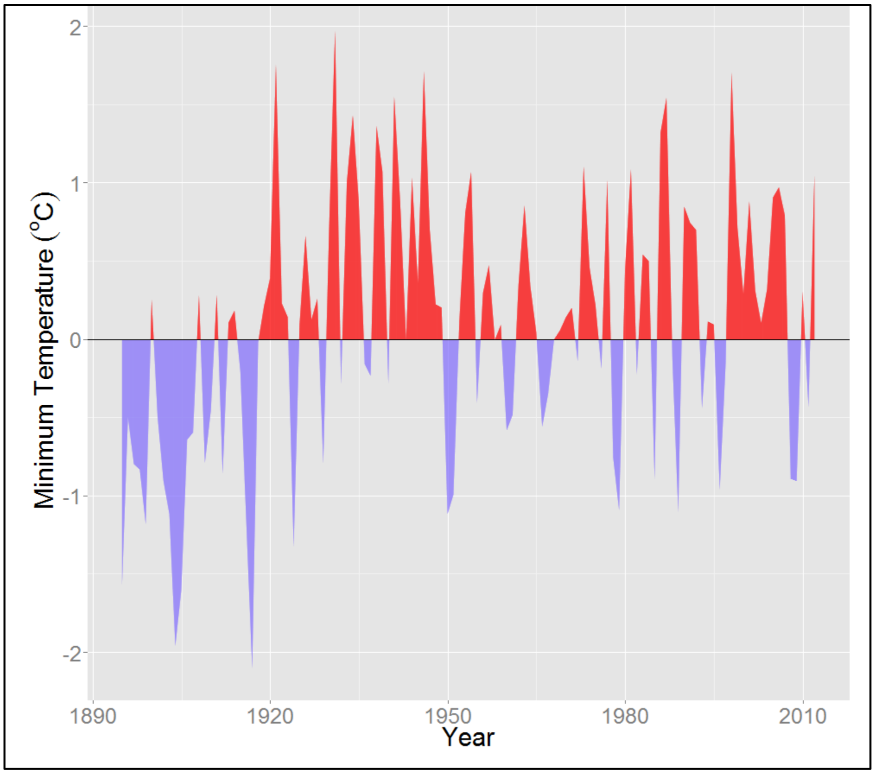

Figure 4.5-3. Anomaly plot for mean minimum temperature showing the difference between individual years from 1895 to 2012 and a baseline (1895 to 1980 average) for Homestead National Monument. (Data and graphic prepared by NCCSC).

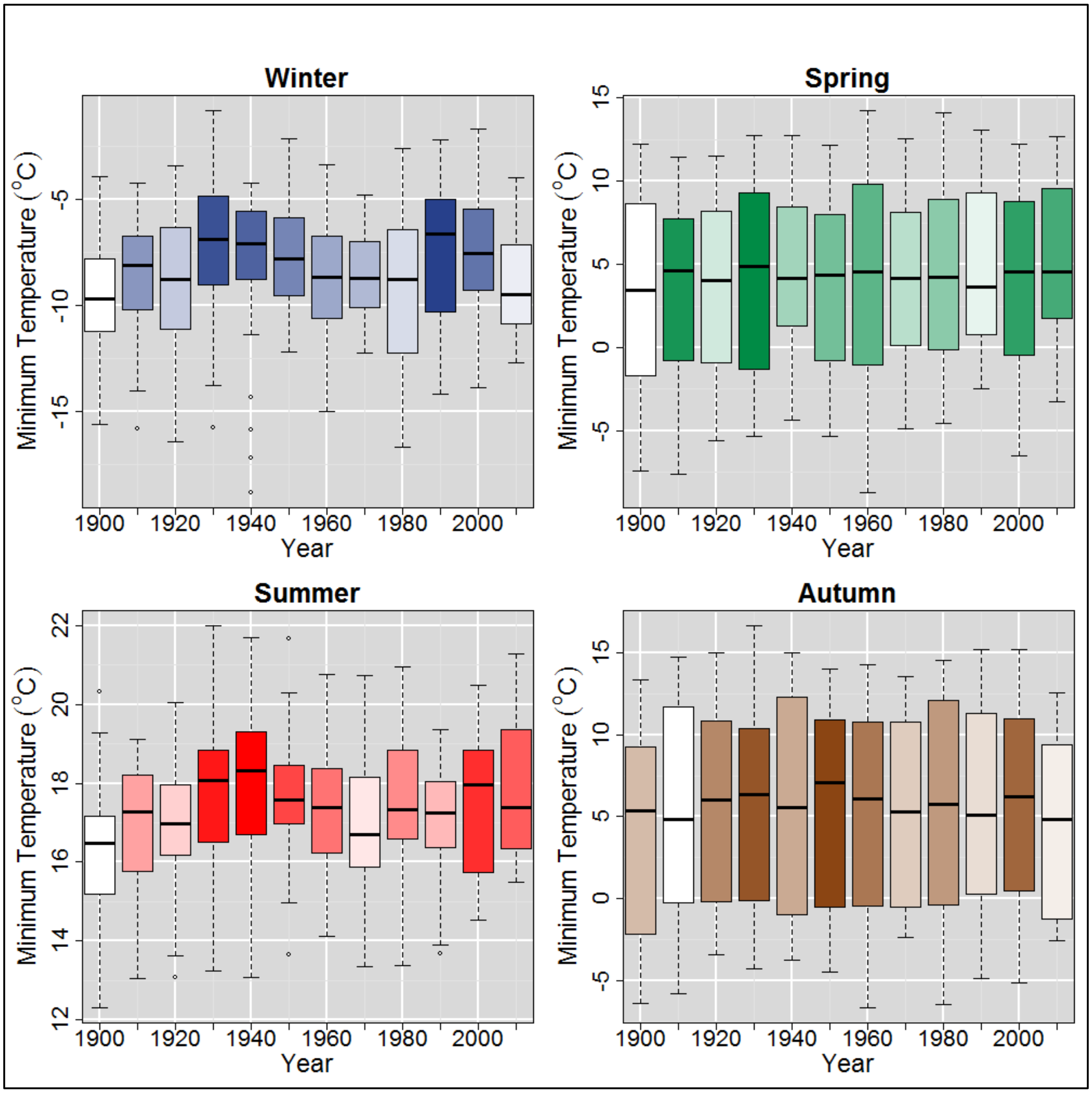

Figure 4.5-4. Seasonal historic mean minimum temperature quartiles using PRISM data at Homestead National Monument. Within a season, darker colors represent higher temperatures. (Data and graphic prepared by NCCSC).

Modeled Future Changes

Models indicate that temperatures at the park 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 2.1–2.4 °C by the 2040s, and by approximately 3.0–5.1 °C by the 2080s, depending on the scenario (Figure 4.5-5).

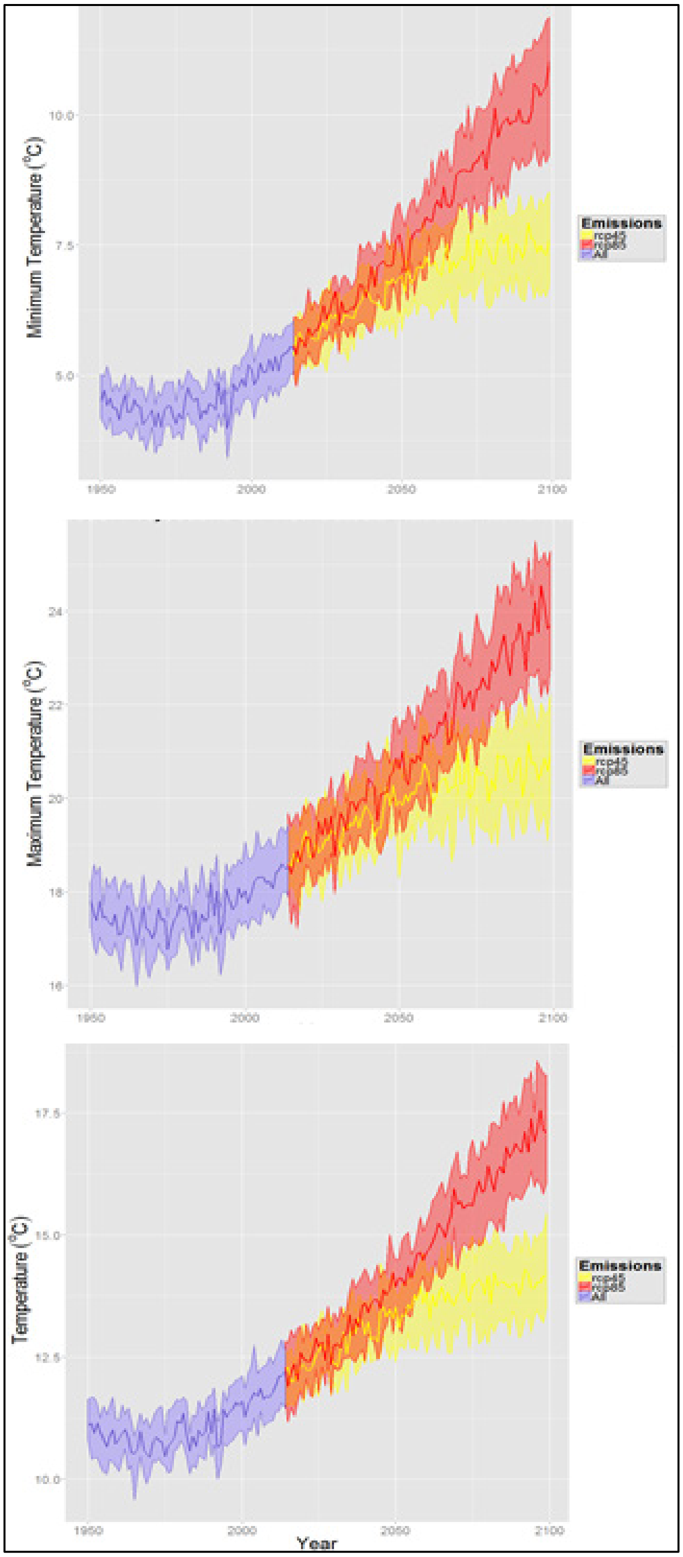

Figure 4.5-5. Projections for annual minimum (top), maximum (middle) and mean temperature (bottom) with median, 25 and 75% quantiles grouped by emissions scenario for Homestead National Monument. (Data and graphic prepared by NCCSC).

Precipitation

Historic Trends

Historic trends in monthly and annual precipitation for 1895–2010 were examined to understand patterns and variability. Mean monthly precipitation is variable over time and patterns or trends in seasonality are not clear (Figure 4.5-6). Linear regression of mean monthly precipitation with time were not significant for the 1895–1980 period (p=0.462) or the 1980–2012 period (p=0.454) (Figure 4.5-7). Variability in seasonal and annual precipitation is relatively high.

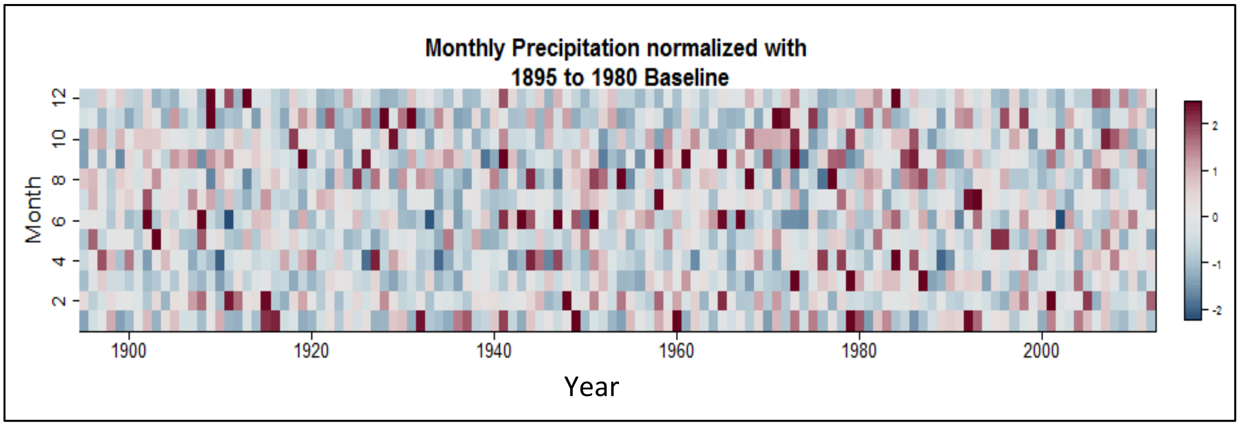

Figure 4.5-6. Mean monthly precipitation showing the normalized difference from a baseline (1895–1980) period for each month and year for Homestead National Monument. The baseline is calculated monthly within the specified year range. The pixels are normalized by month and colors range from +/- 2.5 standard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

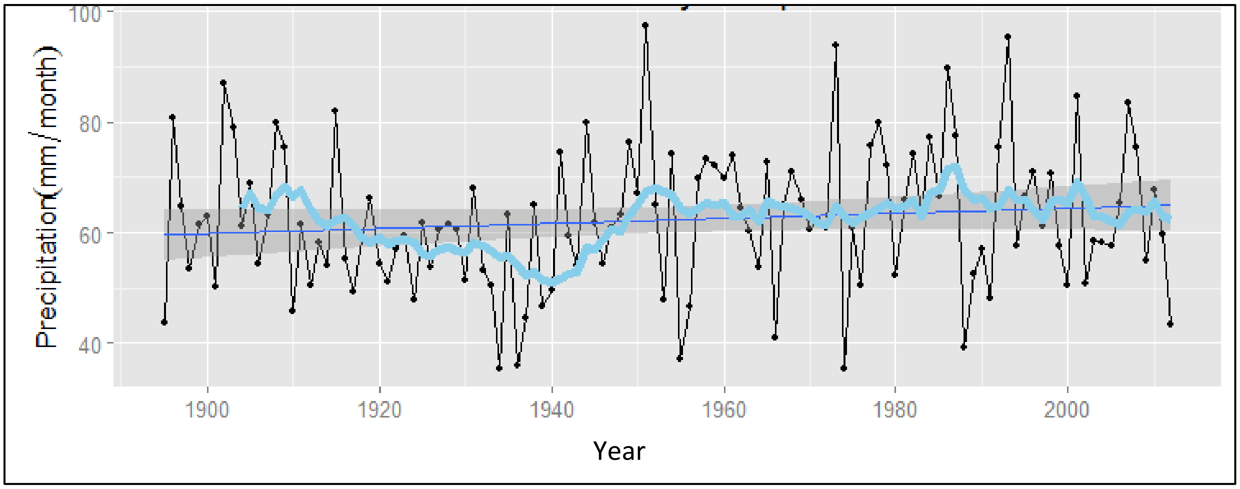

Figure 4.5-7. Historic PRISM data for precipitation at Homestead National Monument showing linear model fit and a five year lag running mean (Data and graphic prepared by NCCSC).

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 Homestead National Monument indicate a 20 to 30% or more increase in the annual amount of precipitation falling in very heavy events over the past few decades (Figure 4.5-8).

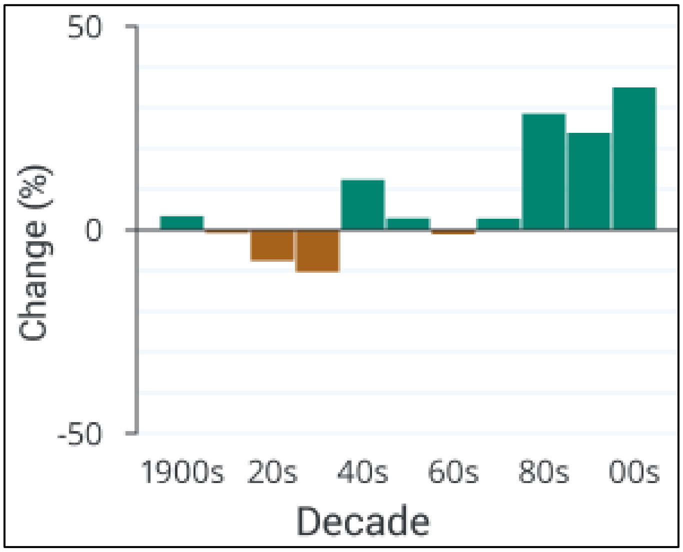

Figure 4.5-8. Percent changes in the annual amount of precipitation falling in very heavy events compared to the 1901–1960 average for the Midwest region. A very heavy event is defined as the heaviest 1% of all daily events from 1901 to 2012. The far right bar is for 2001–2012 (Kunkel et al. 2013 as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

Modeled Future Changes

Modeled climate through the 2080s 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 2.5–4.1 mm (0.10–0.16 in) per month or approximately 30–49.2 mm (1.18–1.94 inches) per year by the 2040s and 3.2–5.0 mm (0.13–0.20 in) per month or 38.4–60 mm (1.51–2.36 inches) per year by the 2080s.

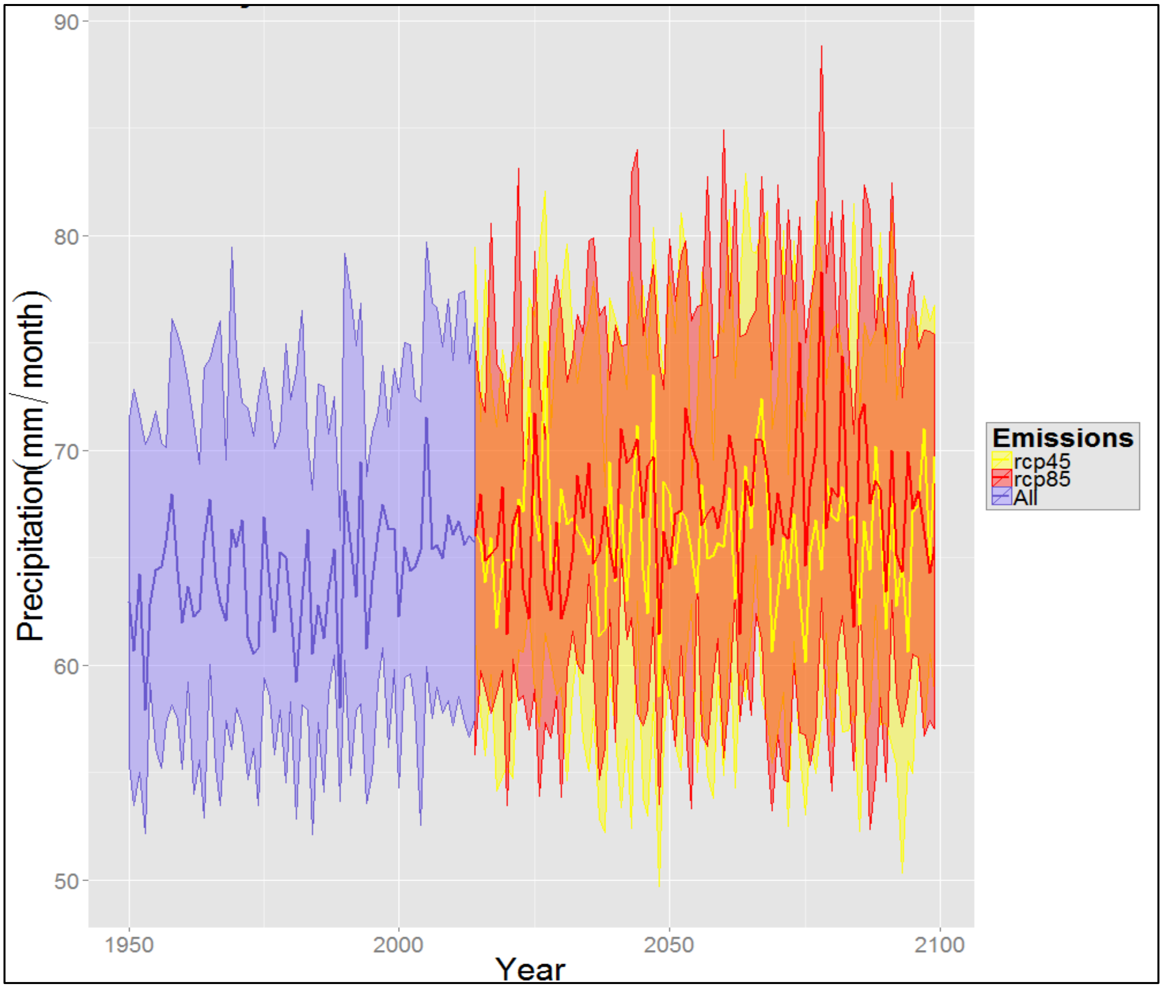

Figure 4.5-9. Projections for precipitation/month with mean, 25% and 75% quantiles grouped by emissions scenario for Homestead National Monument (Data and graphic prepared by NCCSC).

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, HOME PDSI data shows periodic moderate to severe drought lasting 2–8 years occurring every 5 to 15 years since about 1920.

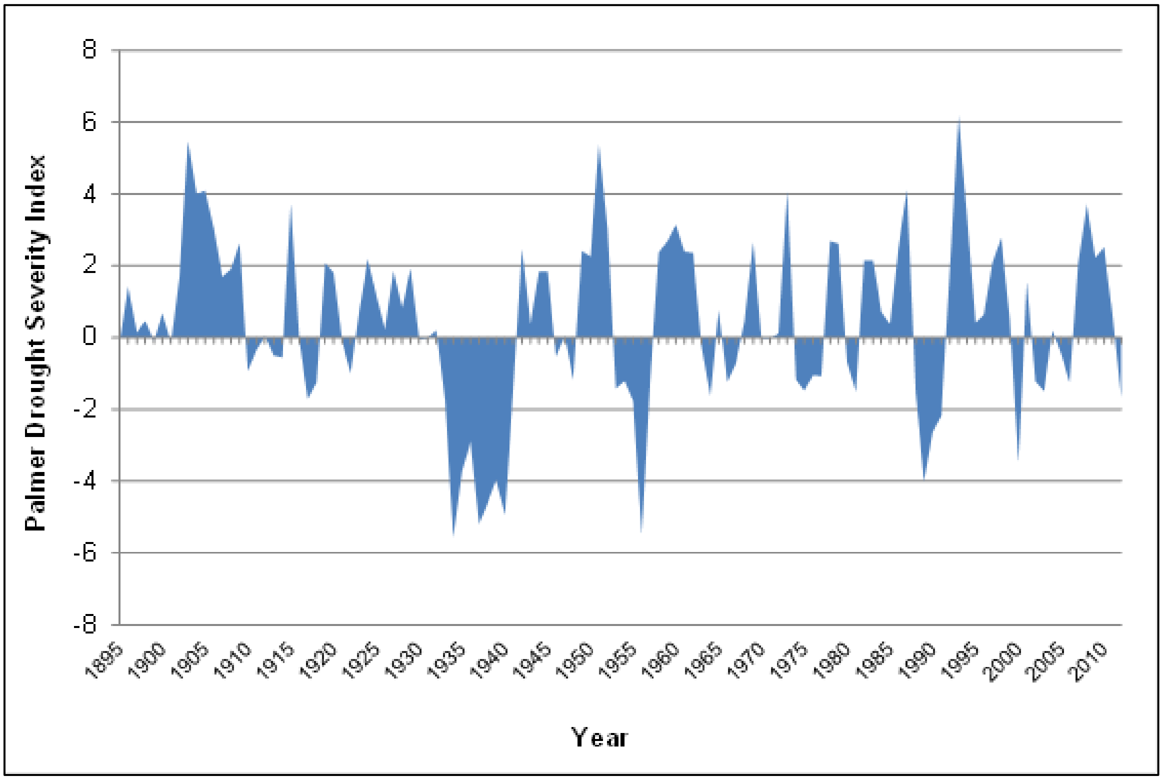

Figure 4.5-10. Palmer Drought Severity Index from 1895 –2011 for Homestead National Monument. Negative values represent dry conditions and positive values represent moist conditions (NCDC 2013a).

Modeled Future Changes

Moisture deficit results for HOME were modeled using the Climate Wizard Custom Tools (http://climatewizardcustom.org/). Modeled results varied by emissions scenario and season were highly variable across global circulation models (Figure 4.5-11). By 2050, annual moisture deficit is projected to be between 127 mm (5.0 in) per year (moderate emissions scenario 50th percentile value) and 97 mm (3.8 in) per year (high emissions scenario 50th percentile value). By 2095, annual moisture deficit is projected to be between 221 mm (8.7 in) per year (moderate emissions scenario 50th percentile value) and 95 mm (3.7 in) per year (high emissions scenario 50th percentile value) (Figure 4.5-11). Seasonal changes under both scenarios show relatively unchanged moisture deficits in winter and spring, moderate deficits in summer, and moderately moist autumn conditions.

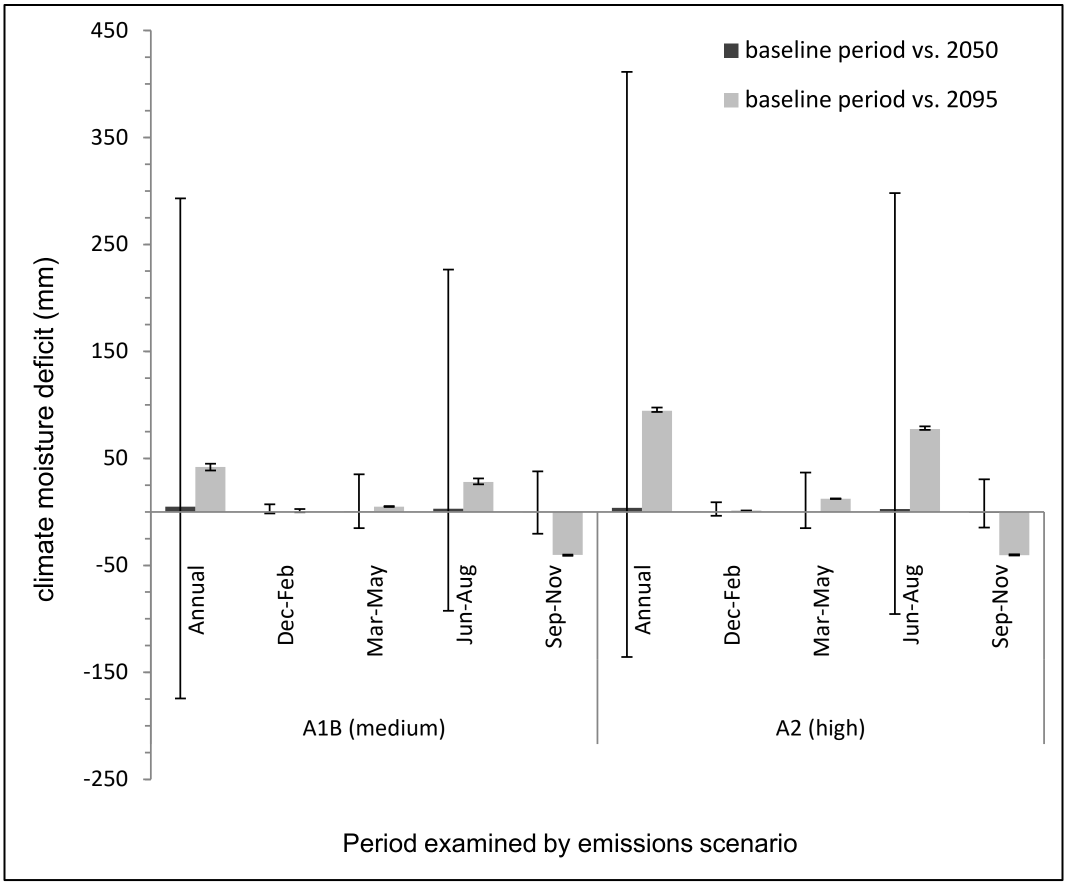

Figure 4.5-11. Annual and seasonal climatic moisture deficit for 2040–2060 and 2090–2099 compared to the baseline 1961–1980 period under two emission scenarios for a 30 X 30 km area surrounding Homestead National Monument. Higher positive values indicate increasing aridity. Median values with 25% and 75% quartile limits. Analysis was done using the Climate Wizard Custom tools (The Nature Conservancy, University of Washington and University of Southern Mississippi 2014).

Plant Phenology and Frost-Free Period

Plant Phenology

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 park 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 (ORNL DAAC 2012). For the 11-year baseline period of record, the mean greenup date was April 4 (90% confidence interval of +/- 4.6 days), mean vegetation greenness peaked on July 17 (90% confidence interval of +/- 2.5 days) and mean onset of minimum greenness was November 21 (90% confidence interval of +/- 8.7 days) (Figure 4.5-12). Dates for maximum greenness were most consistent from year to year (i.e., had the lowest variance), 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.

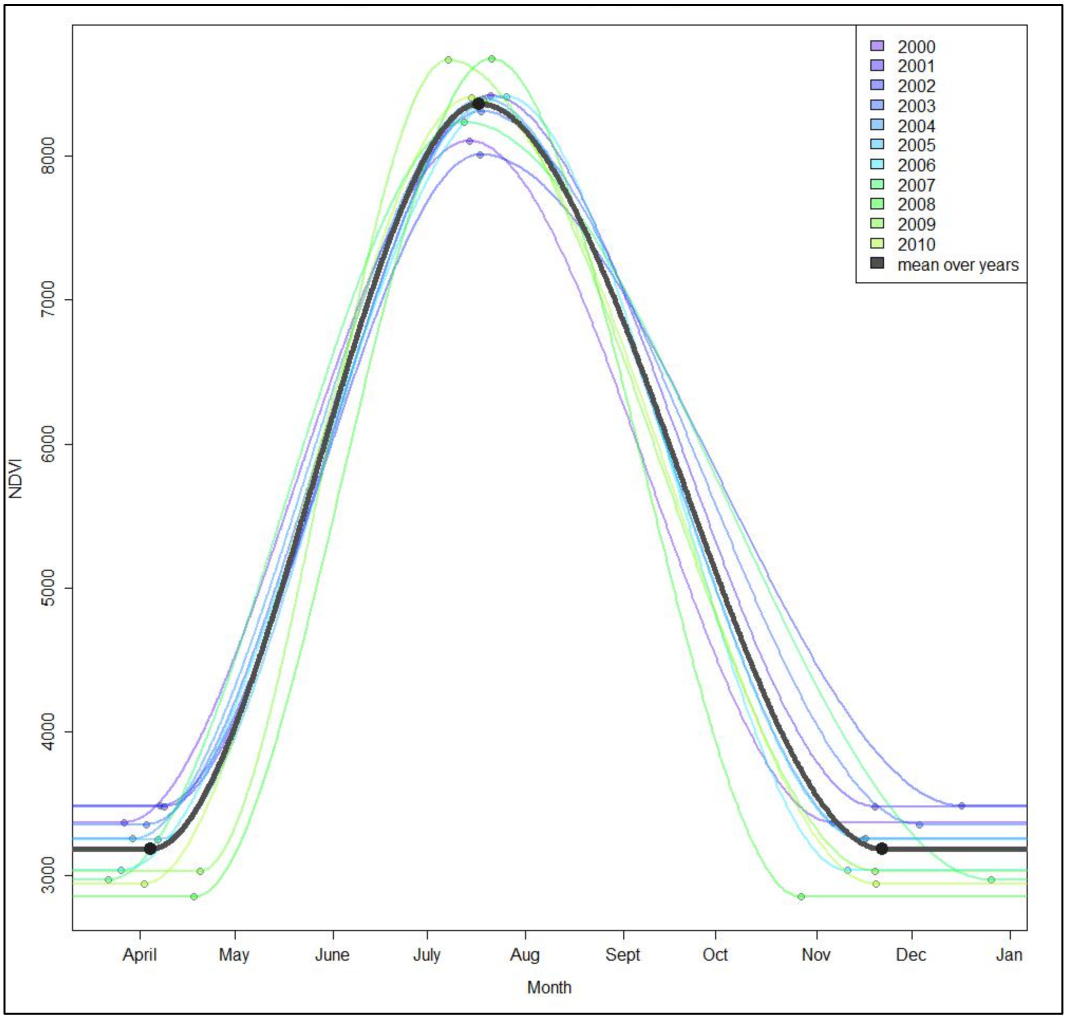

Figure 4.5-12. Phenology curves for Homestead National Monument based on MODIS imagery vegetation indices. The graph shows dates for greenup initiation (left), maximum greenness (center), and the end of vegetation senescence or onset of minimum greenness (browndown end) (right) for the period of record.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

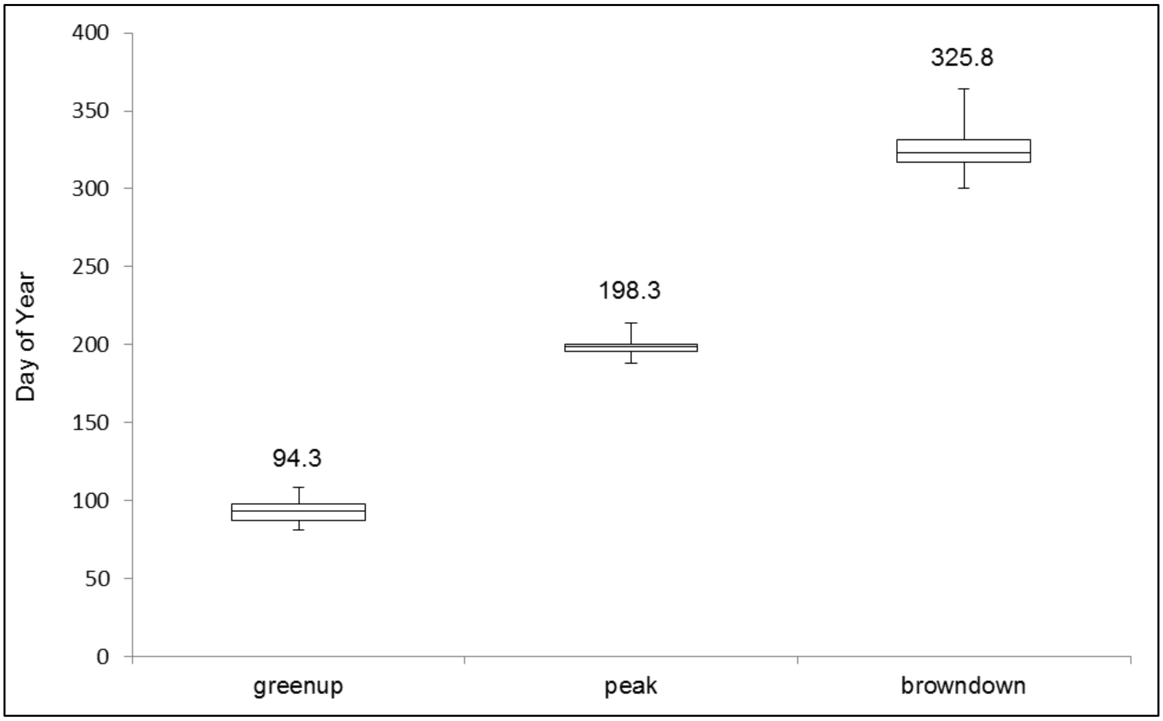

Figure 4.5-13. Box plots for the base period for dates associated with onset of vegetation greenup, maximum greenness and onset of minimum greenness, based on MODIS EVI data for Homestead National Monument. Lines represent median values, boxes represent the limits of 25th and 75th percentile values and whiskers represent remaining values. Numbers above box plots are means for each phenological period. Data visualization provided by Kevin James, Heartland I&M Network.

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 park 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 to potentially 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 HOME 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 increases in precipitation in the region are 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).

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 park, 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 park natural resources goes beyond the scope of this NRCA, a preliminary evaluation of the vulnerability of targeted park 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 park-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 park 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 park boundaries (Heller and Zavaleta 2009).

4.5.7. Sources of Expertise

- Jeffrey Morisette, Director, DOI North Central Climate Science Center
- Marian Talbert, Biostatistician, DOI North Central Climate Science Center
- John Gross, Climate Change Ecologist, NPS Inventory and Monitoring Program National Office

- Kevin James, Plant Ecologist, Heartland I&M Program

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4.6. Fire Disturbance Regime (Prairie)

4.6.1. Background and Importance

According to *NPS Management Policies* (NPS 2006a), 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 2006 *NPS Management Policies* specifically mentions 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 2006b). At HOME, 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 the principal disturbance on the landscape at Homestead National Monument, both historically and currently. 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 characterized as 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 plant and animal species, or vulnerability to unnaturally severe wildland fire (NPS 2006a). In recent years, scientists and land managers have recognized the importance of creating heterogeneity in 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). 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).

Under the current Fire Management Plan (NPS 2006b) the Monument uses prescribed fires to manage the prairie in conjunction with mechanical and chemical exotic vegetation control. The Monument is organized into five burn units (Figure 4.6-1). The two fire seasons at the Monument are spring (April 1 through May 31) and fall (September 1 through early November before first snowfall). The burn units are burned on a 2–4 year rotation intended to include spring and fall burns. Managed fire frequency aims to be shorter than the historical average (Wright and Bailey 1982), as frequent fire is recommended by the Homestead Fire Management Plan (NPS 2006b) and the scientific literature to prevent and reduce exotic and woody vegetation during prairie restoration. Mowed lines are established prior to each burn to prevent accidental ignition of non-target areas.

Individual burn plans are prepared and approved for the implementation of each prescribed fire. All wildland fires are immediately suppressed.

Settlement by European emigrants in the mid-1800s led to fire suppression in the region (NPS 2006b). Fire played an integral role in the ecological functioning of the tallgrass prairie system. Fire once helped maintain this tallgrass prairie in eastern Nebraska, where ample precipitation exists for woody plant succession. Tallgrass prairie dominated this area for at least 8000 years prior to Euro-American settlement.

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 "resource" shaping the Monument. The fire regime is characterized by fire frequency, seasonality, extent and severity.

Fire Frequency

Before the advent 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 the ample and unbroken 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. 2011, Wright and Bailey 1982).

Lack of frequent fire 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. 2002, Collins et al. 1995), 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 to minimize, and in some cases push back, woody encroachment.

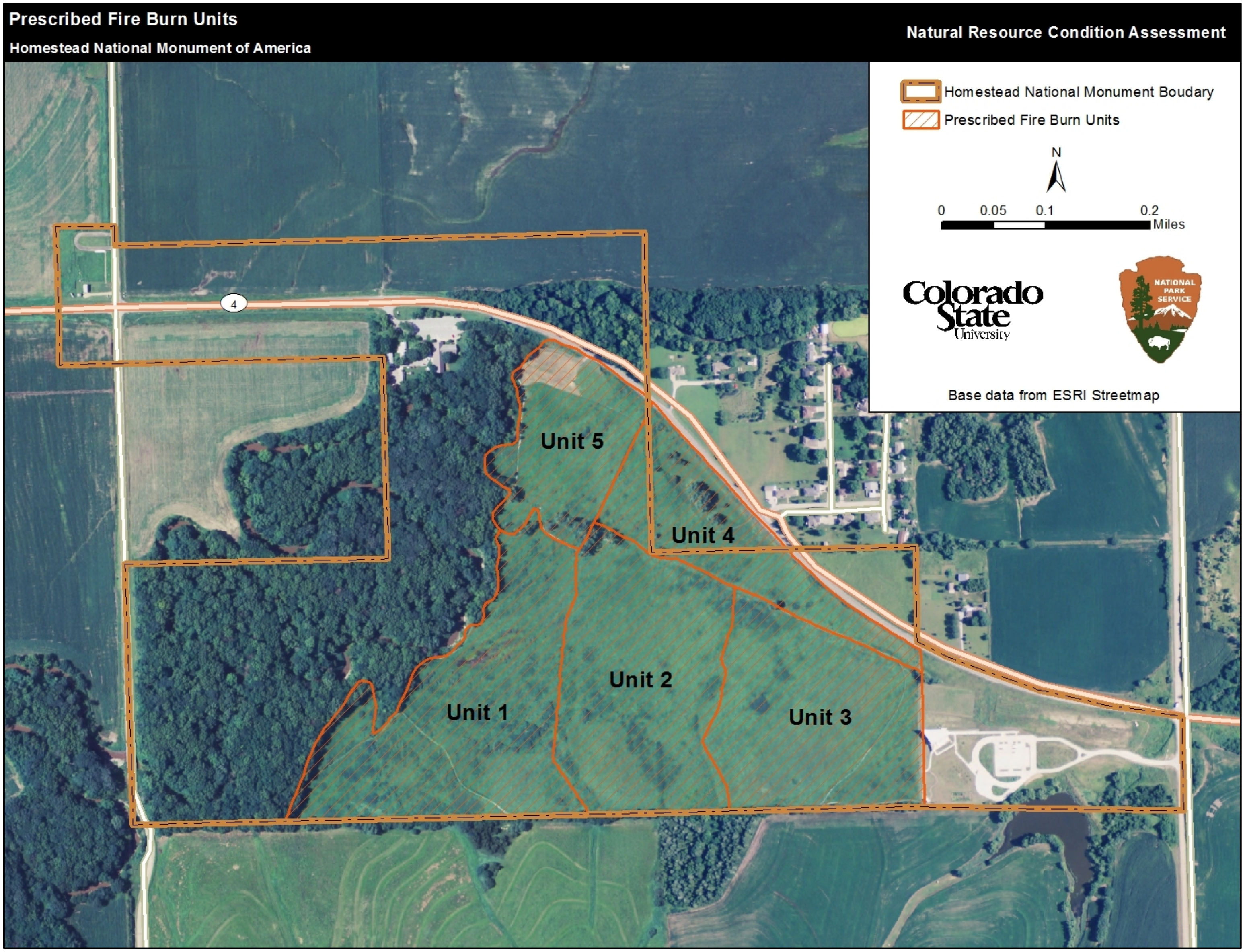


Figure 4.6-1. Homestead National Monument burn unit schematic (CSU, NPS).

Fire Seasonality

The timing of burns is generally accepted to be the most important factor dictating vegetation response (Towne and Owensby 1984, Engle and Bidwell 2001, Towne and Kemp 2003). The timing of the burn in relation to the growth stage of any species of interest will often largely determine whether there is a positive or negative species response. 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).

Prior to European settlement, most acreage burned during drought years (Anderson et al. 1970). The 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 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 both were altered by European settlers.

Seasonality of prescribed burn programs is often determined by containment considerations and often differs from pre-historic norms. In grassland communities, this may alter species composition due to the timing of burns with greenup and seed set. 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 C-4 grasses (Howe 1994, Howe 1995, Howe 2000). However, managers currently contend with invasive species and public relations issues that may constrain their ability to burn in seasons other than spring.

Fire Severity

Fire severity in grasslands is usually low due to the limited fuel and the 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 with time since burn and where shrubs or woody debris is present, as both of these represent increases in fuel loads.

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.

In terms of present day fire management, bigger fires are not always better, and fires of the extent of 200 years ago no longer occur. The park is an island of prairie surrounded for miles by agricultural land or degraded prairie. Therefore, the needs of prairie species must be met to the greatest extent possible using habitat within the park 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 park have not been modeled or examined in detail. A comprehensive summary of historic climate variation and climate change projections for the park and surrounding area is presented in Section 4.5. Results for precipitation, temperature, aridity, and growing season vary by emissions scenario, future time period and sometimes by season. In general, the climate at HOME 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. Both minimum and maximum temperatures are expected to increase by approximately 2.1–2.4 ^{o}C by the 2040s, and by approximately 3.0–5.1 ^{o}C by the 2080s, depending on the emissions scenario. Precipitation is projected to increase by approximately 2.5–4.1 mm per month (0.10–0.16 inches) or 30–49.2 mm (1.18–1.94 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 95–221 mm (3.74–8.70 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 depending on the emissions scenario.

Specific implications of climate change on the park'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 park is virtually non-existent. Small-scale prescribed burning outside the park occurs occasionally on private and public lands. The fire regime at the park 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 park 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 park to reach prescribed burn acreage/frequency objectives, especially when the park 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

- Virtual elimination of fire outside of the Monument as this reduces the possibility of fire spread into the Monument
- Continued alteration of the natural fire regime within the Monument, which now emphasizes low fire frequency and severity with little temporal and spatial variation
- Encroachment of development outside the Monument boundary that may place additional constraints on burning due to fire risk and smoke

Indicators and Measures

- Fire frequency
- Fire seasonality
- Fire severity

4.6.2. Data and Methods

Fire history from park 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 park 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 park and the Heartland I&M Network. Current fire data are limited to the year, size, and generalized season of the fire (winter, spring, summer, or fall). Thus, analysis of current fire management is limited to fire return interval (i.e., fire frequency), seasonality, and extent of burning within park boundaries and fire severity is extrapolated from these data.

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 conflicting management objectives, relationships with the wide variety of stakeholders involved with most National Parks, smoke management and fire containment concerns, budgetary issues, and management of rare species as well as invasive species. 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. The condition rating framework for fire indicators at Homestead National Monument is shown in Table 4.6-1.

Table 4.6-1. Condition rating framework for fire indicators at Homestead National Monument.

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 through 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 Extent	• 75–100% of annual burn acreage goals achieved on average	• 50–75% of annual burn acreage goals achieved on average	• < 50% of burn annual acreage goals achieved on average
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 Homestead National Monument includes an active prescribed burn program that burns a portion of the Monument nearly every year. Within the period for which data is available, starting in 1982, the fire return interval was generally three years or less, which compares well with the reference condition (Figures 4.6-2 and 4.6-3), and is, in fact, probably more frequent than reference conditions. In the past 10 years for which data is available (through 2011) however, the return interval has increased, though it still falls within the range of the reference condition in all burn units except Unit 2 (Figure 4.6-4). Close to publication of this NRR, additional data was received regarding additional burns conducted since 2011. Burn units 1, 2, and 3 were burned in April of 2015. They had previously been burned in 2010, 2009 and 2007, respectively. Burn units 3 and 4 were burned in October 2015, and had last been burned in 2011. The most recent return interval for burn units 1–5 were 5, 6, 7, 4, and 4 years, respectively (Leis 2015, Leis and Wienk 2016).

Fire return interval currently varies within and among burn units (Figure 4.6-5). All units have high internal variability in regard to fire return interval. Overall, there is good variability spatially, with different burn units receiving differing fire return intervals. In regard to temporal variability, there appears to be a tendency to burn at 1 or 2 year intervals as these two intervals account for 68% of all fire return intervals. Most of the longest intervals occurred during the span from the late 1990s to the early 2000s, particularly in relation to two periods of little or no fire application from 1996 through

1998 and again from 2000 through 2005. Most of the shortest intervals occurred in the mid-1980s, when the burn intervals were almost all either one or two years. The most recent fire return intervals averaged nearly double the long-term average. The condition rating for this indicator is good, with a declining trend (Table 4.6-1). Confidence in this assessment is high due to the extensive amount of data available.

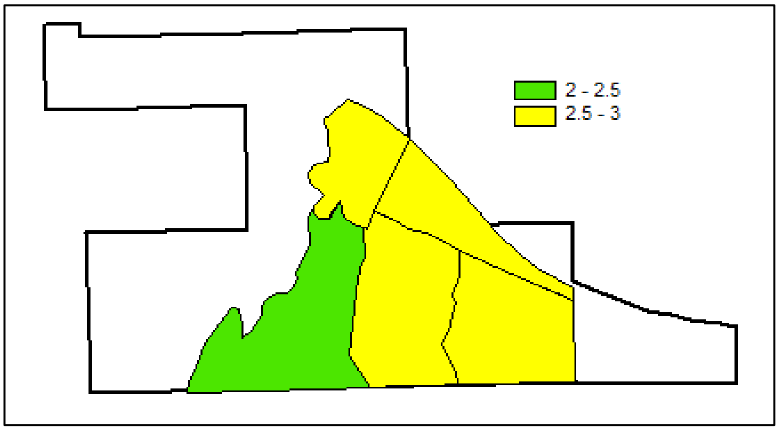


Figure 4.6-2. Average fire return interval, in years, from 1982 to 2011. Fire data provided by the Heartland I&M Network.

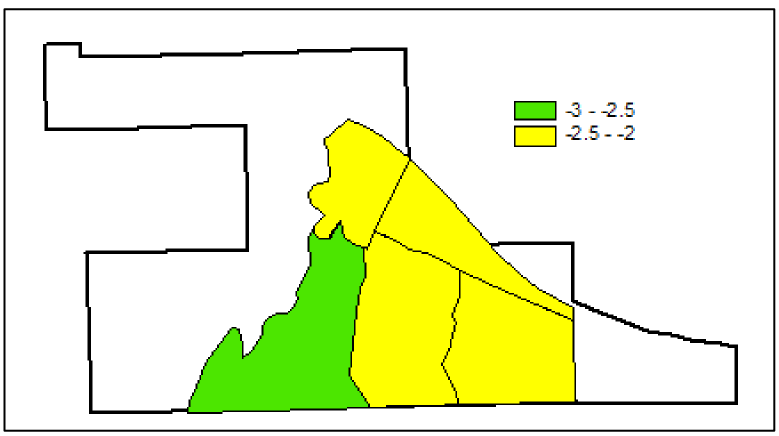


Figure 4.6-3. The historic return interval (5 years) subtracted from the average return interval. Fire data provided by the Heartland I&M Network.

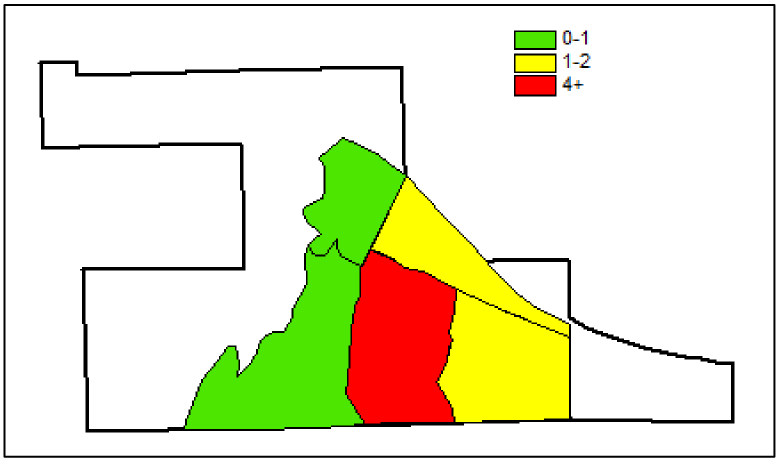


Figure 4.6-4. The average fire return interval of the last 10 years subtracted from the 1982–2011 average. Fire data provided by the Heartland I&M Network.

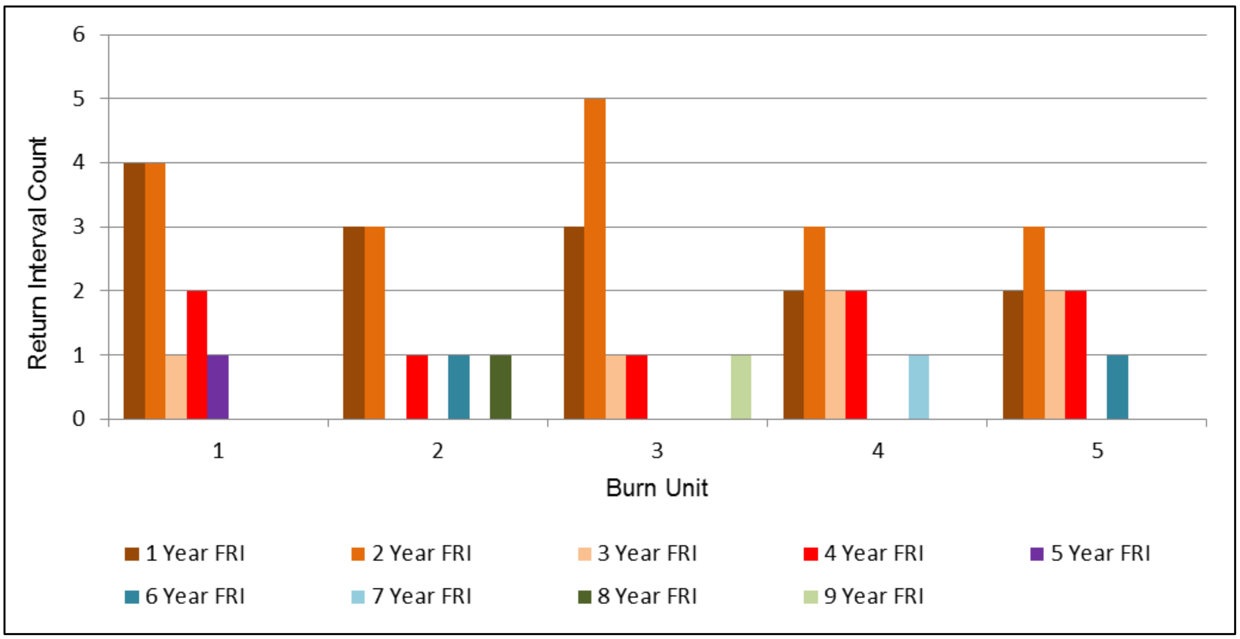


Figure 4.6-5. The count of return interval frequency in each burn unit of HOME from 1982 to 2011. FRI = Fire Return Interval. Fire data provided by the Heartland I&M Network.

Fire Seasonality

At HOME, most burns occur during the spring months with almost no variability in fire season. This is primarily driven by the presence of smooth brome (*Bromus inermis*), which should be burned in the late spring to maximize reductions in this target species (Sherry Leis, personal communication August 2017). There are records of burns occurring in summer and fall, but these are infrequent compared to the number of spring burns. Including the most recent data reported for fires in 2015 (see section return interval section above) only 7 years had fall burns out of the 30 years of records). A preponderance of spring burns will tend to benefit warm season grasses at the expense of cool season grasses and some forbs (Towne and Kemp 2003, Towne and Owensby 1984) and likely differs from the variability in seasonality of burn that was experienced under reference conditions. The condition rating for fire seasonality warrants moderate concern with an unchanging trend (Table 4.6-1).

Fire Severity

Fire severity data associated with prescribed burns have been collected by the HTLN Fire Ecology Program since 2017 (Sherry Leis, personal communication 2017). For example, prescribed fires at HOME in April 2014 and October 2015 produced fire severities in the low to moderate range (Leis 2015, Leis and Wienk 2016). Given that burn frequencies generally falls within the range of the reference condition, and is perhaps even more frequent, it can be extrapolated that burn severity is probably consistent with 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 relatively low intensity if the prescription was for low winds, moderate humidity and moderate temperature. The absence of even occasional high fire severity warrants moderate concern for this indicator with an unchanging trend. The condition rating for fire severity warrants moderate concern with an unchanging trend and medium confidence level (Table 4.6-1).

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 Monument. 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 prairie fire regime at Homestead National Monument.

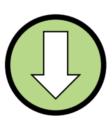
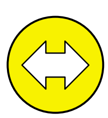
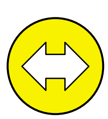
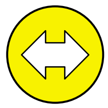
Indicator	Condition Status/Trend	Rationale
Fire Frequency		Results indicate the fire return interval over the past several decades has been within the range of the reference condition. There is high variability in the fire frequency within and among burn units. Although still within range, fire return interval has been increasing since 2002.
Fire Seasonality		Data is complete but coarse. The timing within a season is important to post-fire responses. The current predominance of spring 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, especially summer burns.
Fire Severity		HTLN fire effects data suggest that fire severity falls is low to medium and 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 but not high-severity fires. Therefore, high-severity fires are likely occurring less often than under presettlement conditions. The current trend appears to be unchanging.

Table 4.6-2 (continued). Condition and trend summary for prairie fire regime at Homestead National Monument.

Indicator	Condition Status/Trend	Rationale
Fire Regime overall		The condition of the fire regime warrants moderate concern with an unchanging trend. Confidence in the assessment is medium due to coarse or missing data for fire seasonality and severity.

4.6.5. Uncertainty and Data Gaps

Prescribed burns are well documented and fire effects data are collected by the Heartland I&M Network.

4.6.6. Sources of Expertise

- Draft was reviewed by Sherry Leis, Heartland I&M Network.

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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 ac (2,428 ha), national wilderness areas, national memorial parks over 5,000 ac (2,023 ha), or international parks in existence as of August 7, 1977 (NPS ARD 2013). 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 2013). Based on these classifications of airsheds, Homestead National Monument of America (HOME) 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 (O_3), nitrogen (nitrate – NO_3 and ammonia – NH_3), and sulfur (sulfate – SO_3) as being the three main causes of ecosystem effects. Ozone is taken up by plant leaves and can reduce growth and survival by damaging leaf function. Nitrogen and sulfur deposition can cause acidification of soils and water bodies reducing habitat quality. Nutrient effects from nitrogen deposition can cause changes to soil nutrient cycling and lead to a fertilization effect that changes the species composition of plant communities. 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 June 2017, the HOME area was not listed by the EPA as an area of nonattainment for any air quality indicators (EPA 2017a). HOME experiences “High” exposure to atmospheric Nitrogen (N) enrichment and has been described as being highly at risk from N enrichment (Sullivan et al 2011a). HOME also has “High” exposure to acidic deposition from Sulfur (S) and N emissions and has been described as being at moderate risk from acidic deposition (Sullivan et al 2011b).

<u>Threats and Stressors</u>

Atmospheric deposition of nitrogen and sulfur from the cities of Lincoln, Nebraska and Kansas City, Kansas/Missouri metropolitan areas and industrial pollution from energy and other sources is an ongoing threat to park air quality. As with other NPS units in the region, the prescribed burning of grasslands and pastures as well as wildfires contribute to ground-level ozone, reduced visibility due to smoke, and can effect human health (NDEQ 2013, EPA 2017b). Reduced visibility from smoke is a concern when pertaining to vehicular or airport safety, and for aesthetic value of the landscape.

Indicators and Measures

- Ozone: human health risk
- Ozone: vegetation health risk
- Atmospheric wet deposition of nitrogen
- Atmospheric wet deposition of sulfur
- Visibility haze index

4.7.2. Data and Methods

The condition of air quality within HOME was assessed using methodology developed by the NPS ARD for use in Natural Resource Condition Assessments (NPS ARD 2015). NPS ARD uses all available data from NPS, EPA, state, and/or tribal monitoring stations to interpolate air quality values, with a specific value assigned to the maximum value within each park. Even though the data are derived from all available monitors, data from the closest stations "outweigh" the rest.

Trends are computed from data collected over a 10-year period at on-site or nearby representative monitors. Trends are calculated for sites that have at least six years of annual data and an annual value for the end year of the reporting period. Currently, there are no representative monitoring stations for ozone, wet deposition, or visibility located near HOME to assess 10-year trends. The nearest ozone monitoring station is located in Davey, Nebraska, about 50 mi north of HOME. Wet deposition is monitored at two stations in the region; one is located in Mead, Nebraska (60 mi north of the Monument) and the other at Konza Prairie (70 mi south of HOME) (NPS ARD 2001). There are no Interagency Monitoring of Protected Visual Environments (IMPROVE) visibility monitoring stations within 100 mi of HOME (NPS ARD 2001).

Conditions and trends data were retrieved from the NPS Air Quality Conditions and Trends by Park database (NPS ARD 2017b).

4.7.3.Reference Conditions

Reference conditions are based on regulatory standards, best available scientific knowledge, or have been recommended by NPS ARD (2017a). 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 (NPS ARD 2017a).

Air Quality Indicator	Specific Measure	Good Condition	Warrants Moderate Condition	Warrants Significant Concern
Ozone	Human Health: Annual 4th-highest 8hr concentration	≤ 54 ppb	55–70 ppb	≥ 71 ppb
	Vegetation Health: 3-month maximum 12hr W126	< 7 ppm-hrs	7–13 ppm-hrs	> 13 ppm-hrs
Visibility	Haze Index	< 2 dv	2–8 dv	> 8 dv
Nitrogen	Wet Deposition	< 1 kg/ha/yr	1–3 kg/ha/yr	> 3 kg/ha/yr
Sulfur	Wet Deposition	< 1 kg/ha/yr	1–3 kg/ha/yr	> 3 kg/ha/yr

Ozone: Human Health Risk

The primary National Ambient Air Quality Standard (NAAQS) for ground-level ozone is set by the EPA and is based on human health effects. The 2008 NAAQS for ozone was set at 75 ppb for the 3-year average of the 4th-highest daily maximum 8-hour average ozone concentration. On October 1, 2015, the EPA strengthened the national ozone standard by setting the new level at 70 ppb. The NPS ARD benchmarks for the human health risk from ozone status are based on the updated Air Quality Index (AQI) breakpoints. The status for human health risk from ozone is based on the estimated 5-year average of the 4th-highest daily maximum 8-hour average ozone concentration compared to benchmarks. Ozone concentrations greater than or equal to 71 ppb are assigned a warrants significant concern category. Ozone concentrations from 55–70 ppb are assigned warrants moderate concern category. A resource in good condition category is identified when ozone concentrations are less than or equal to 54 ppb (Table 4.7-1) (NPS ARD 2017a).

Ozone: Vegetation Health Risk

The W126 metric is a biologically relevant measure that focuses on plant response to ozone exposure. This measure is a better predictor of vegetation response than the metric used for the human health standard. The W126 metric equation preferentially weights the higher ozone concentrations that are more likely to cause plant damage. It sums all of the weighted concentrations during daylight hours as this is when the majority of gas exchange occurs between the plant and the atmosphere. The highest 3-month period that occurs during the growing season is reported in parts per million-hours (ppm-hrs).

The status for vegetation health risk from ozone is based on the estimated 5-year average of the 3-month 12-hour W126 index compared to benchmarks. A W126 index greater than 13 ppm-hrs is assigned a warrants significant concern status. A W126 index from 7–13 ppm-hrs is assigned warrants moderate concern status. Resource is in good condition if the W126 index is less than 7 ppm-hrs (Table 4.7-1) (NPS ARD 2017a).

Wet Nitrogen Deposition

The NPS ARD (2017a) considers parks that receive less than 1 kg/ha/yr of nitrogen each as being in good condition. Parks receiving between 1–3 kg/ha/yr are ranked as moderate condition. Those parks which receive greater than 3 kg/ha/yr are ranked as poor condition (Table 4.7-1) (NPS ARD 2017a).

Wet Sulfur Deposition

The NPS ARD (2017a) considers parks that receive less than 1 kg/ha/yr of sulfur each as being in good condition. Parks receiving between 1–3 kg/ha/yr are ranked as moderate condition. Those parks which receive greater than 3 kg/ha/yr are ranked as poor condition (Table 4.7-1) (NPS ARD 2017a).

Visibility

Visibility is measured using the Haze Index in deciviews (dv). Visibility conditions are the difference between the mid-range day visibility and estimated average natural visibility, where the mid-range days natural visibility is the mean between the 40^{th} and 60^{th} percentiles (NPS ARD 2017a). Five-year interpolated averages are used in the contiguous US. Visibility is considered to be in good condition if visibility is less than 2 dv, moderate condition if between 2–8 dv, and poor condition if greater than 8 dv (Table 4.7-1) (NPS ARD 2017a).

4.7.4. Condition and Trend

Ozone: Human Health Risk

Ozone causes problems for human health, including difficulty breathing, chest pain, coughing, inflamed airways, and making lungs more susceptible to infection (EPA 2012). From 2011–2015, HOME experienced a 4^{th} highest 8-hr ozone average concentration of 63.7 parts per billion (ppb) (NPS ARD 2017b). This most recent air quality data indicates moderate condition for ozone levels and medium confidence due to the regional and modeled nature of the data.

Ozone: Vegetation Health Risk

In addition to being a concern to the health of park staff and visitors, long-term exposures to ground-level ozone can cause injury to ozone-sensitive plants (Bell *In Review*). There are 14 plant species identified within HOME that are sensitive to ozone (Table 4.7-2). Ozone is able to enter leaves through stomata and causes chlorosis and necrosis of leaves (Figure 4.7-1), 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).

Based on the 2011–2015 estimated W126 metric of 6.7 ppm-hrs, the vegetation health risk from ground-level ozone is in good condition with medium confidence due to the regional and modeled nature of the data (NPS ARD 2017b).

Table 4.7-2. HOME plant species sensitive to ozone (NPS ARD 2017c).

Scientific Name	Common Name
Achillea millefolium	Common yarrow
Acer negundo	Boxelder
Ageratina altissima	Tall ageratina
Apocynum cannabinum	Hemp dogbane
Artemisia ludoviciana	White sage
Asclepias syriaca	Common milkweed
Fraxinus pennsylvanica	Green ash
Parthenocissus quinquefolia	Virginia creeper
Populus deltoides	Eastern cottonwood
Prunus americana	Wild plum
Prunus virginiana	Chokecherry
Rhus aromatica	Squawbush
Solidago canadensis	Common goldenrod
Solidago gigantea	Giant goldenrod

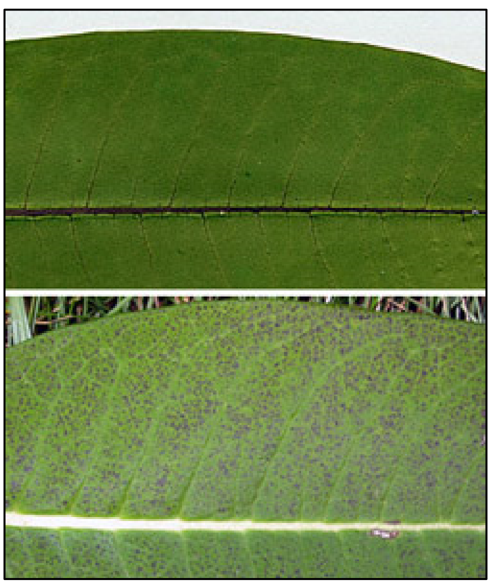

Figure 4.7-1. *Asclepias syriaca* normal leaf (top) and ozone-injured leaf (bottom). Photo: NPS ARD.

Wet Nitrogen Deposition

Based on the 2011–2015 estimated wet nitrogen deposition of 6.1 kg/ha/yr, wet nitrogen deposition falls in the poor condition with medium confidence due to the regional and modeled nature of the data (NPS ARD 2017b).

Wet Sulfur Deposition

Based on the 2011–2015 estimated wet sulfur deposition of 2.1 kg/ha/yr, wet sulfur deposition falls in the moderate condition category with medium confidence due to the regional and modeled nature of the data (NPS ARD 2017b).

Visibility

Based on the 2011–2015 estimated visibility on mid-range days of 8.2 dv), the visibility condition falls in the poor condition category with medium confidence due to regional and modeled nature of data (NPS ARD 2017b).

Overall Condition

Based on the evaluation of air quality indicators, air quality condition warrants moderate concern, with no trend (Table 4.7-3). 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 produced by ecologically necessary prescribed burns.

Table 4.7-3. Condition assessment summary for air quality at Homestead National Monument.

Indicator	Measure	Condition Status/Trend[1]	Rationale[2]
Ozone	Human Health: Annual 4th-highest 8hr concentration		Human health risk from ground-level ozone warrants moderate concern at Homestead. This status is based on NPS Air Resources Division benchmarks and the 2011–2015 estimated ozone of 63.7 parts per billion (ppb).
	Vegetation Health: 3-month maximum 12hr W126		Vegetation health risk from ground-level ozone is in good condition at Homestead. This status is based on NPS Air Resources Division benchmarks and the 2011–2015 estimated W126 metric of 6.7 parts per million-hours (ppm-hrs). The W126 metric relates plant response to ozone exposure. A risk assessment concluded that plants in at Homestead were at low risk for ozone damage (Kohut 2007).
Visibility	Haze Index		Visibility warrants significant concern at Homestead. This status is based on NPS Air Resources Division benchmarks and the 2011–2015 estimated visibility on mid-range days of 8.2 deciviews (dv) above estimated natural conditions[3].

[1] Condition assessments for contiguous U.S. parks use the Inverse Distance Weighted (IDW) interpolation method is used to estimate 5-year average (2011–2015) values. Trend analyses use 10 years (2006–2015) of data from on-site or nearby monitors.

[2] For all indicators and measures: No trend information is available because there are not sufficient on-site or nearby monitoring data. The degree of confidence at Homestead is medium because estimates are based on interpolated data from more distant monitors.

[3] Natural visibility conditions are those estimated to exist in a given area in the absence of human-caused visibility impairment. Estimated annual average natural condition on mid-range days is 7 deciviews (dv) at Homestead.

Table 4.7-3 (continued). Condition assessment summary for air quality at Homestead National Monument.

Indicator	Measure	Condition Status/Trend[1]	Rationale[2]
Nitrogen	Wet Deposition	(red circle)	Wet nitrogen deposition warrants significant concern at Homestead. This status is based on NPS Air Resources Division benchmarks and the 2011–2015 estimated wet nitrogen deposition of 6.1 kg/ha/yr. Ecosystems in the park were rated as having high sensitivity to nutrient-enrichment effects relative to all Inventory & Monitoring parks (Sullivan et al. 2011a; Sullivan et al. 2011b). Nitrogen deposition may disrupt soil nutrient cycling and affect biodiversity of some plant communities, including grassland and wetland.
Sulfur	Wet Deposition	(yellow circle)	Wet sulfur deposition warrants moderate concern at Homestead. This status is based on NPS Air Resources Division benchmarks and the 2011–2015 estimated wet sulfur deposition of 2.1 kg/ha/yr. Ecosystems in the park were rated as having low sensitivity to acidification effects relative to all Inventory & Monitoring parks (Sullivan et al. 2011a; Sullivan et al. 2011b).
Air Quality overall		(yellow circle)	The condition of air quality indicators warrants moderate concern with no trend available. Confidence in the assessment is medium.

[1] Condition assessments for contiguous U.S. parks use the Inverse Distance Weighted (IDW) interpolation method is used to estimate 5-year average (2011–2015) values. Trend analyses use 10 years (2006–2015) of data from on-site or nearby monitors.

[2] For all indicators and measures: No trend information is available because there are not sufficient on-site or nearby monitoring data. The degree of confidence at Homestead is medium because estimates are based on interpolated data from more distant monitors.

[3] Natural visibility conditions are those estimated to exist in a given area in the absence of human-caused visibility impairment. Estimated annual average natural condition on mid-range days is 7 deciviews (dv) at Homestead.

4.7.5. Uncertainty and Data Gaps

Monitoring stations located within HOME would better document specific air quality conditions at the Monument. Estimated values based on geospatial interpolations are adequate, but can misrepresent park conditions due to modeling errors. Monitoring of air quality conditions within HOME or nearby would reduce 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, can provide air quality analysis and expertise relevant to air quality topics.

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4.8. Stream Hydrology and Geomorphology

4.8.1. Background and Importance

Cub Creek meandering through a mixed mesic bottomland forest in the southwest part of the Monument. Cub Creek photo point 1-1, April 2011 (NPS photo).

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. These 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). These park 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. Existing planning and management documents for the Monument do not contain specific management objectives or targets for Cub Creek.

Cub Creek is a perennial, low-gradient prairie stream that meanders through riparian woodlands at Homestead National Monument (HOME) for approximately one mile (Figure 4.8-1). The stream is highly sinuous and deeply incised with steep banks, with much evidence of lateral channel migration (Mott and Braumiller 2005). The bottomland along Cub Creek and its tributaries was wooded prior to historic settlement beginning in the 1860s. Uplands were formerly tallgrass prairie but nearly all prairie vegetation in the region has been converted to agriculture. Vegetation communities associated with Cub Creek in the Monument include the Mesic Bur Oak Forest community. The mesic bur oak forest along Cub Creek at Homestead is considered the best-preserved example of this rare community in Nebraska (Rolfsmeier and Steinauer 2010).

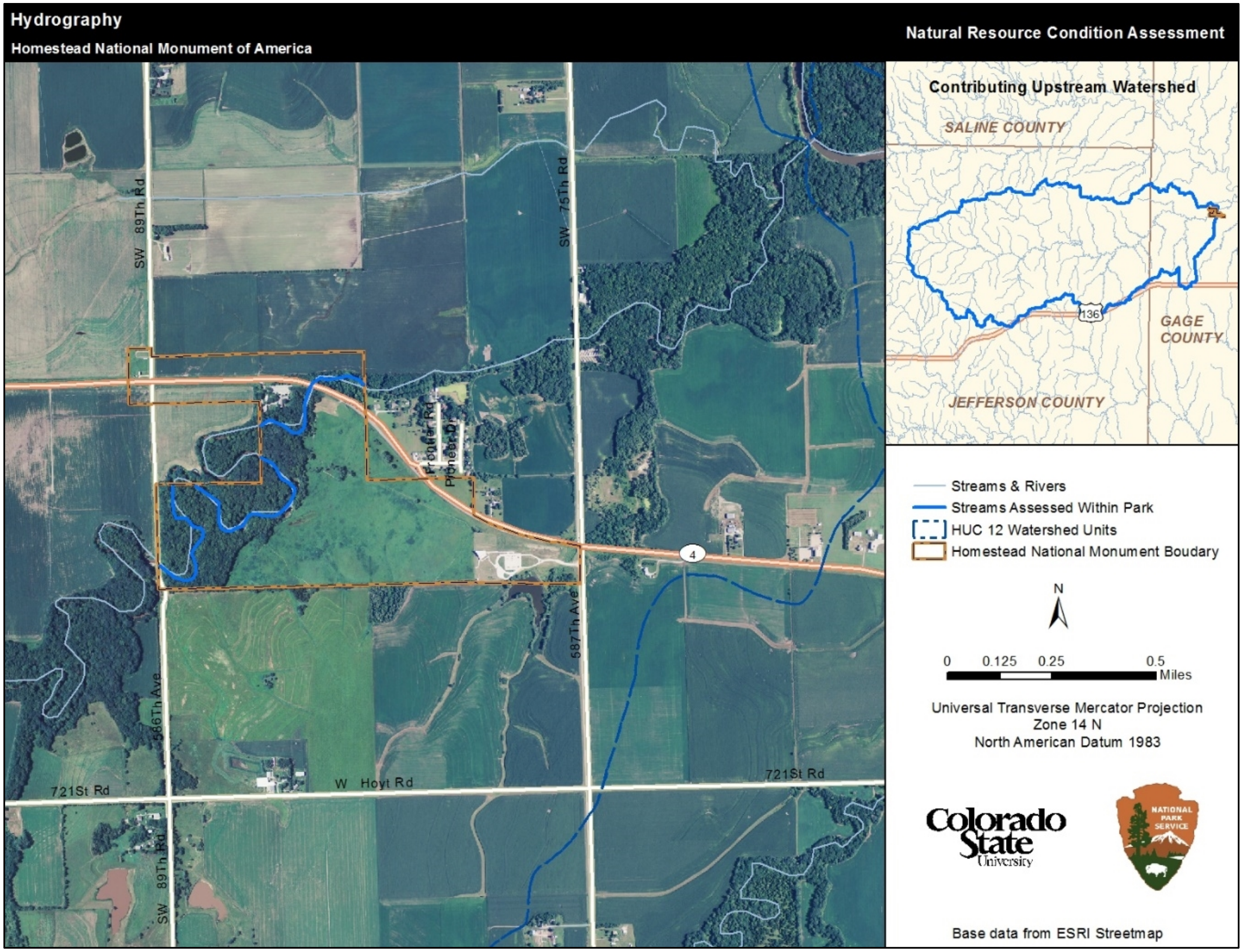


Figure 4.8-1. Streams in the vicinity of Homestead National Monument, Nebraska. Stream data provided by NPS. Catchment data generated by Colorado State University. Imagery from ArcGIS background image.

Approximately 96% of HOME's contributing upstream watershed is classified as having 0–2% impervious surfaces. Approximately 0.3% of the contributing upstream catchment of the park was classified as having > 25% impervious surfaces, the vast majority of which is concentrated near the park itself. Land cover and land use characteristics of HOME's contributing upstream watershed are examined in detail in the *Land Cover and Land Use* section of this chapter.

Approximately 60% of HOME lies within the 100-year floodplain of Cub Creek and the Big Blue River (NPS 1999). The park is located about 2 km (1.5 mi) above the confluence of Cub Creek and the Big Blue River near the bottom of the Cub Creek watershed. In addition to periodic flooding from upstream inputs, Cub Creek backs up from the confluence and floods one or two times a year at HOME when discharge is high in the Big Blue River. Periodic flooding has damaged and/or threatened historic and modern structures within the Monument for many years. The new Heritage Center containing historic collections, homestead records, educational exhibits, media, museum, and the Palmer-Epard Cabin are located outside of the 100-year floodplain.

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.

The objective of this assessment is to examine the hydrology and geomorphology within Homestead National Monument to determine the current condition of Cub Creek relative to a defined reference condition.

<u>Threats and Stressors</u>

- Development and agriculture within the watershed affecting impervious surfaces, stream flows, and hydrologic response to precipitation events
- Upstream ponds, sediment-control and flood-control structures that alter flow seasonality, amounts and sediment loads
- Historic degradation of stream stability resulting in channel incision, headcutting and slumping resulting in continued channel and bank instability and accelerated erosion
- Climate change may increase the incidence of extreme runoff events, which may impact stream condition and recovery

<u>Indicators and Measures</u>

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

4.8.2. Data and Methods

Thirteen photo points were established along Cub Creek in April of 2011. Up to two photos were taken at each location to document streambank characteristics and characterize the landscape. Geospatial data and photos associated with these points may be useful for examining changes over time but are not used to determine condition and trend in this assessment.

Cub Creek was visually assessed for Proper Functioning Condition (PFC) (BLM 1998) and Channel Evolution Model (CEM) stage (Schumm et al. 1984) along its course within the park. 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 that 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. 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. CEM scores of I, III, and V might 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).

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 would be assigned. CEM stage scores ranged from Stage 1 to Stage 5 in 0.5 increments.

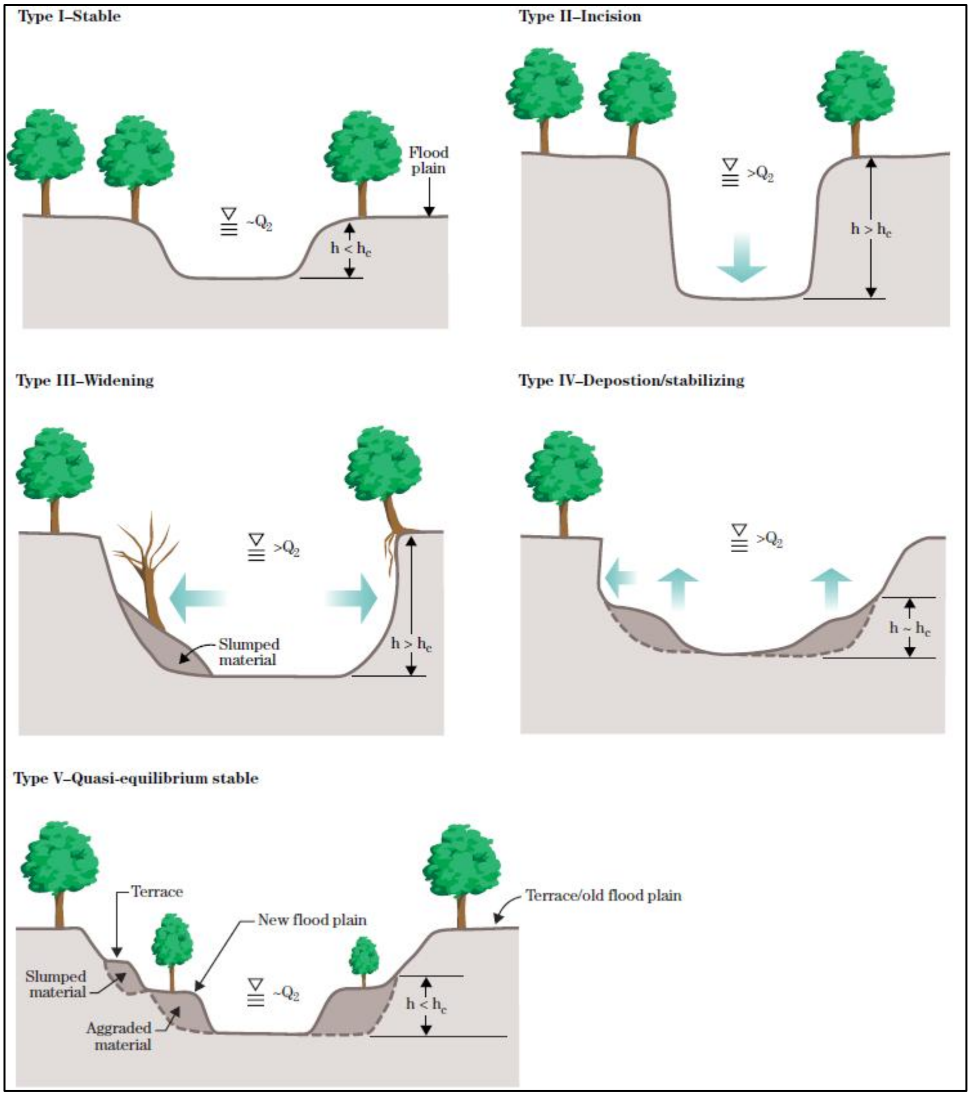


Figure 4.8-2. Cross-section view of the five types of channels in the CEM (NRCS 2007).

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.

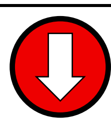
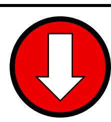
Resource warrants moderate concern – Functional At-Risk rating often with a downward or no apparent trend CEM Type II, or with an upward or no apparent trend CEM Type IV channel.

Resource warrants significant concern – Nonfunctional PFC rating often with CEM Type III channel.

4.8.4. Condition and Trend

A condition summary for Cub Creek is presented is Table 4.8-1. Cub Creek received a PFC rating of nonfunctional. Sixteen criteria were rated negatively and one rated N/A for beaver presence. The channel is deeply incised and over-widened with steep banks 15- to 30-ft high in some places. Bank vegetation is sparse or not present. Upland plant species are dominant on banks that are not bare but they do not have the root density to stop bank erosion. Banks are undercut or failing in every bend and in some runs. The surrounding riparian area consists of densely-wooded forest. Trees are falling into the channel along failed banks and acting as sediment traps. It is unclear whether the woody debris is helping slow bank erosion or accelerate it in areas. Bank failures appear accelerated in areas not bordered by trees. Aggradation is occurring throughout the reach with large point bars not revegetating at the same rate as bank erosion and failure on the outside of bends. Point bars consist of mostly fine sediment with little to no vegetation. Incision could possibly continue with deposited sand and fines comprising the top 2 ft. of channel bed. Backwater conditions can exist on Cub Creek during high-flow events when water backs up from where Cub Creek enters the Big Blue River. These backwater conditions may slow velocities during large flood events; however, observations of large woody debris piled up at the upstream bridge within the Monument and the extent of undercutting and bank failures indicate that velocities are high enough to create channel instability despite any backwater conditions that may occasionally be present. The creek was scored CEM Stage 3 as the channel was degraded with failing banks throughout most of the reach.

Table 4.8-1. Condition assessment rating for stream hydrology and geomorphology at Homestead National Monument, Nebraska.

Indicator	Condition Status/Trend	Rationale
Proper Functioning Condition/CEM		The stream was rated nonfunctional using PFC methodology and was assigned a CEM stage 3 channel with incised streambed and failing banks.
Stream Hydrology and Geomorphology overall		Condition warrants significant concern with a deteriorating trend. Confidence in the assessment is high.

Cub Creek runs a sinuous path through Homestead National Monument bordered by dense woodlands in most areas. Areas without bordering trees had more accelerated bank failures. Widespread instability is occurring throughout the reach and in part is propagated further by the channel disconnection from the floodplain creating higher velocity flows within the channel. The incision is deep enough in areas that large tree roots are being undermined causing trees to fall into the river. These can act both as a sediment trap creating bars that can revegetate but they can also deflect high-velocity flow, creating more erosion along the opposite bank. Most bank material consisted of a clay-dominated layer overtopped with a more silt layer (Figure 4.8-3). Bed material was mostly sand with some small gravel, indicating that it is being transported from upstream due to its absence in local bank material. Sources for the sand and gravel may be coming from upstream bank material, runoff from surrounding agricultural fields, and from the many gravel road crossings that showed excess material piled against the edge of bridges falling directly into the stream below (Figure 4.8-4). Within the Monument, multiple outflow pipes enter the creek near the Monument facilities but localized erosion has been mostly stopped by riprap. A gabion structure placed into the bank near the foot bridge has been undermined and is beginning to be compromised. The structure was installed in 1982, indicating there has been some channel adjustments occurring since that time.

Figure 4.8-3. Typical mass wasting occurring within the watershed resulting in trees falling into the channel. Note the two distinct bank material horizons. Photo by Johannes Beebee, Colorado State University.

Figure 4.8-4. Sand-and-gravel roads cross Cub Creek and its tributaries frequently throughout the watershed, leading to some deposition directly into the channel at bridge crossings. Photo by Johannes Beebee, Colorado State University.

Although no streamflow gages are present on Cub Creek, the hydrology has been historically affected by changing land uses and the construction of sediment and flood-detention basins. Cub Creek watershed was formerly dominated by a tallgrass prairie landscape with woodlands bordering the creek itself. The land was then tilled for its rich soils and agriculture became the dominant land use. Agriculture has been shown to change the infiltration and runoff of the land surface which can directly and indirectly affect the delivery of water and sediment to the stream channel (Winter et al. 1998, Poff et al. 2006). During the 1960s, seventeen sediment and flood control dams and twelve grade-control structures were placed on tributaries of Cub Creek upstream of the Monument. These structures have directly altered the flow regime and sediment supply of Cub Creek. Dams reduce peak flows but also have been shown to increase the duration of low to moderate flows. These longer duration low to moderate flows, in combination with sediment starved water, can increase channel erosion (Williams and Wolman 1984, Roesner et al. 2001). With approximately 40% of the watershed upstream of the control basins, it is possible that this hydrologic alteration has led to the increased erosion, incision, and bank failures downstream.

4.8.5. Uncertainty and Data Gaps

Continuous recording of discharge on Cub Creek would allow for analysis of the flow regime, especially regarding backwater conditions and how this may relate bank erosion within the Monument. It is too late to discern the differences in flow regime pre- and post-flood control structures in Cub Creek; however, nearby Turkey Creek does have a gaging station with discharge data starting in 2002. In 2009, the Lower Turkey Creek Watershed Project installed the first of seven dams that will control flood and sediment on 31% of the watershed. Studying the impact of sediment and flow modification on Turkey Creek may allow for some insight into how Cub Creek has been affected by its sediment and flood structures.

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4.9. Water Quality

4.9.1. Background and Importance

Cub Creek is the only surface water body within Homestead National Monument (HOME) (Figure 4.9-1). Cub Creek flows west to east until it merges with the Big Blue River. Cub Creek provides drainage for 92,350 ac between Gage and Jefferson counties, Nebraska (NPS 2013a). The majority of the land use around Cub Creek is agricultural with corn, soybeans, wheat, and alfalfa being the primary crops. HOME has partnered with the Environmental Alliance for Senior Involvement (EASI), the Volunteer Senior Range Corps (VSRC), the Beatrice Middle School (BMS), and the Nebraska Department of Environmental Quality (NDEQ) to conduct an ongoing study of water quality of Cub Creek within the Monument. Data from the study is used to evaluate the effectiveness of management practices (NPS 2013a).

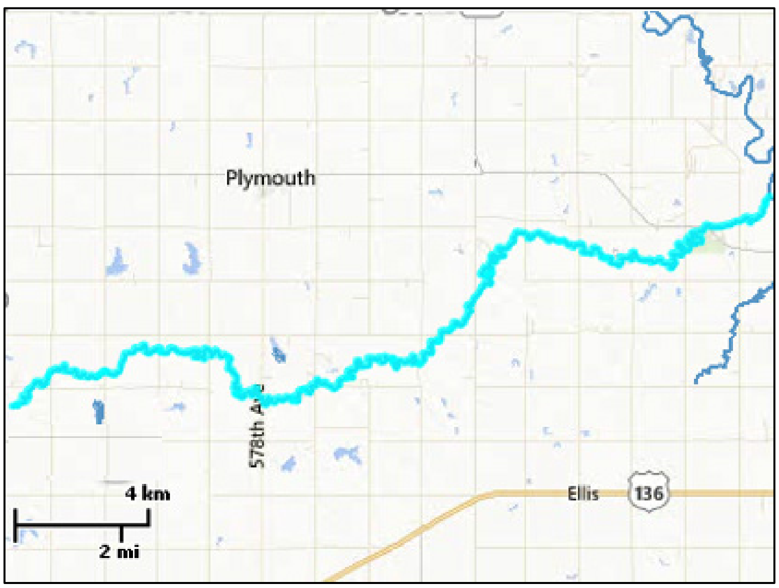


Figure 4.9-1. Cub Creek flows west to east and passes through HOME roughly 2 miles before draining into the Big Blue River (EPA 2013a).

The federal Clean Water Act (as amended 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. Cub Creek currently has no impaired reaches along its 34.5 mile length (EPA 2013a).

Many species of fish and amphibians can be found in and along Cub Creek within HOME. There are 39 species of fish that are known to occur in Cub Creek, with 31 species that are known or presumed to occur within HOME boundaries (NPS 2013b). There are 14 species of amphibians that are known to occur in Cub Creek with 6 species that are known or presumed to occur within HOME boundaries (NPS 2013b). There are several species of fish in Cub Creek that are considered threatened or endangered by the state of Nebraska; the Black-nose shiner (*Notropis heterolepis*) is considered a state endangered species and the Northern redbelly dace (*Phoxinus eos*) and Finescale dace (*Phoxinus neogaeus*) are considered state threatened species (NPS 2013b). The presence of these species is unconfirmed within HOME boundaries.

<u>Threats and Stressors</u>

Major threats and stressor factors for Cub Creek and HOME are agricultural practices and recreational usage upstream of HOME. There are a number of reservoirs upstream of HOME which feed into Cub Creek and may impact the water quality of Cub Creek and create unnatural flow regimes. Climate change may be another stressor to water quality at HOME. Drought years and high temperatures may reduce the volume of water, lower DO concentrations, and help concentrate pollutants.

<u>Indicators and Measures</u>

Temperature

Water temperature determines the rate at which biological and chemical processes occur. Most aquatic organisms require water temperature to be within a certain range for optimal health and reproductive ability. Temperatures outside this range can lead to stress or death of these organisms. Changes in water temperature can indicate problems within the waterbody itself or within the contributing watershed (EPA 2017a).

pH

pH measures the hydrogen ion activity (acidity) of a sample. pH is important in biological and chemical processes. Changes in pH can decrease the bioavailability of nutrients, making them more difficult for organisms to use, as well as increase the bioavailability of heavy metals, making them more toxic (USGS 2017).

Total dissolved solids

Total dissolved solids (TDS) indicates the total concentration of dissolved substances in water (SDWF 2013). TDS may consist of inorganic minerals, or salts, in ionic and organic material. Common sources of TDS include natural sources, such as mineral springs, and urban runoff but 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 2013c).

Conductivity

Conductivity is the measure of a sample of water to pass an electrical current (EPA 2017b). The conductivity of streams is mostly affected by the geology of the area. Some waters may have naturally high conductivity, such as those that flow through areas with clay soils. Discharge of ions such as chloride, phosphate, and nitrate from sewage systems can increase conductivity, while oil spills will lower conductivity (oils and other organics do not conduct electrical current very well). Many aquatic organisms can only tolerate fairly narrow ranges in conductivity (EPA 2017b).

Chloride

Chloride is an inorganic salt 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).

Alkalinity

Alkalinity measures the ability of water to neutralize acids. Alkaline compounds in water (such as carbonates, bicarbonates, and hydroxides) remove hydrogen ions, lowering the acidity of water (EPA 2017c). This increased buffering capacity is important to aquatic organisms, many of which rely on specific pH ranges for optimal health.

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 reverse osmosis reject water, 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).

Phosphate

Phosphorus is an essential nutrient for plants and animals, yet most fresh waters are naturally deficient of this nutrient. As a limiting nutrient in fresh waters, even a small increase in phosphorus can cause accelerated plant grown, leading to toxic algae blooms, lowering dissolved oxygen, and stressing or killing aquatic animals (EPA 2017d). Phosphorus is rare, and is usually found in nature as phosphate. Sources of phosphate include soil and rocks, runoff from wastewater treatment, and fertilizer runoff (EPA 2017d).

Nitrate

Nitrate is a nutrient essential for plant growth, but as with phosphorus, can cause significant water quality degradation where found in excess. High levels of nitrates can lead to eutrophication, causing changes in dissolved oxygen, temperature and other water quality parameters that can be detrimental to aquatic organisms (EPA 2017e). Anthropogenic sources of nitrate are similar to those of phosphate.

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 holds more oxygen than warm water is able to (USGS 2013a). All forms of aquatic life use DO and therefore, DO is used to measure the "health" of lakes and streams. Depletion of DO from water bodies leads to eutrophication, or the "death" of a water body.

Turbidity

A measure of water clarity and suspended material within water, high turbidity can have negative effects on the suitability of a water body for aquatic organisms. High turbidity can cause water to absorb more heat, raising temperature and reducing dissolved oxygen. It can also reduce the penetration of light in the water column leading to decreased photosynthesis, which can also lower dissolved oxygen (EPA 2017f). Sources of turbidity include soil erosion, runoff from urban areas and waste treatment plants, and excessive algal growth (EPA 2017f).

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).

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 water quality (NYNRM 2013). Aquatic macroinvertebrates are a significant part of a water body because they are an essential part of the food chain in aquatic environments. They are sensitive to chemical, physical, and biological water conditions, and are a good indicator of water quality (EPA 2013b). Some aquatic macroinvertebrates are more sensitive to water quality than others, such as stonefly nymphs. Stonefly nymphs cannot survive low DO levels and their absence may indicate the "health" of a water body (EPA 2013b). 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 2013d). 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 2013d).

4.9.2. Data and Methods

The NPS (1999) had previously compiled surface-water quality data for HOME 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 HOME's boundary, stations from 3 miles upstream and 1 mile downstream were included—it should be noted that the NPS (1999) report includes many stations that are far outside of these indicated limits. The retrieval resulted in 12,913 observations at 54 different monitoring stations. There were 6 stations (HOME 0010, HOME 0042, HOME 0043, HOME 0044, HOME 0045, and HOME 0046) located within the park boundary. None of the 6 stations located within the park contained longer-term records, but their data is used here as a snapshot of water quality in the recent past. There are four stations (HOME 0007, HOME 0015, HOME 0053, and HOME 0008) in the study area that included longer-term data. However, each of these stations was too far outside of HOME's watershed to warrant using their data.

Peitz and Cribbs (2005) and Bowles and Clark (2012) conducted studies in Cub Creek evaluating aquatic invertebrates and in-stream conditions to determine water quality. Water quality measurements of dissolved oxygen, pH, conductivity, turbidity, and water temperature were taken prior to sampling for aquatic invertebrates. Water quality data from these studies is used to examine the condition of water quality in Cub Creek in 2002/2003 (Peitz and Cribbs 2005, data were summarized for both years), 2006, 2007, and 2010 (Bowles and Clark 2012).

Dodd and Cribbs (2012) conducted a study in Cub Creek evaluating fish community metrics and in-stream conditions to determine water quality. Water quality parameters measured were the same as the previously mentioned aquatic invertebrate studies. Water quality data from this study is used to examine the condition of water quality in Cub Creek for 2004, 2006, 2008, and 2011.

The Cub Creek Water Quality Monitoring Project (CCWQP) website (NPS 2013a) contains publicly available data for dissolved oxygen, conductivity, pH, alkalinity, sulfates, phosphates, nitrates, and turbidity for years 2002 to 2006.

The Nebraska Department of Environmental Quality (NDEQ) monitors fecal coliform levels at the Cub Creek at Homestead National Monument (SBB1CUBCK107) monitoring location. Data from this station is available only for 2012.

4.9.3. Reference Conditions

The reference conditions for water quality indicators are the Nebraska Department of Environmental Quality (NDEQ) 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). Standards listed are for aquatic life unless otherwise noted.

Table 4.9-1. NDEQ and EPA standards for surface-water quality (NDEQ 2012, EPA 2013e).

Parameter	NDEQ Standard	EPA Standard
Temperature	0–32 °C	n/a[1]
pH	6.5–9	6.5–9[2]
Total dissolved solids	n/a	≤ 250 mg/L
Conductivity	2000 µmhos/cm [3]	n/a
Chloride	≤ 860 mg/L[4]	≤ 860 mg/L[5]
Alkalinity	≥ 20 mg/L	≥ 20 mg/L
Sulfate	n/a	≤ 250 mg/L[5]
Phosphate	n/a[6]	n/a
Nitrate	≤ 100 mg/L[3]	n/a
Dissolved oxygen	≥ 6.5 mg/L[7]	≥ 4.0 mg/L
Turbidity	n/a[8]	n/a[8]
Coliform bacteria	126 CFU/100ml[9]	≤ 200 CFU/100mL

[1] Species dependent.

[2] Fresh water chronic standard.

[3] Agricultural standard.

[4] One-time measurement.

[5] Standard for drinking water.

[6] Standards for lakes and impounded waters only; CCWQP suggests ≤ 0.1 mg/l for rivers and streams.

[7] Seven day mean, April 1–June 30.

[8] Although no state or federal standard exists, < 10 NTU during dry weather flows is considered acceptable to support aquatic life (Brown and Czarnezki undated).

[9] Geometric mean of a minimum 5 samples over a 30 day period.

4.9.4. Condition and Trend

Temperature

Temperature records for Cub Creek are fairly extensive and have completed relatively recently (2011). All records fall within the range provided for aquatic life for the State of Nebraska (Table 4.9-2). This measure is in good condition, with no determinable trend and medium confidence in the assessment.

Table 4.9-2. Water temperature measurements including minimum, maximum, and mean values (°C) (NPS 1999, NPS 2013a, Peitz and Cribbs 2005, Bowles and Clark 2012, Dodd and Cribbs 2012).

Station	Period of Record	# Observations	Minimum	Maximum	Mean
HOME 0010	6/73	2	20	24	22
HOME 0042	6/89–3/90	4	0.5	22.5	11.75
HOME 0043	9/95–9/97	5	16	20	17
HOME 0044	9/87–7/89	12	0.5	27	20.3
HOME 0045	6/89–3/90	4	0.5	22	11.4
HOME 0046	9/95–9/97	5	16	20	17
CCWQP[1]	2002–2006	–	0	25.6	–
Peitz and Cribbs 2005[2]	2002/2003	–	25.5	26.4	25.8
Bowles and Clark 2012[3]	2006, 2007, & 2010	–	18.6	30	19.94–29.2
Dodd and Cribbs 2012[4]	2004, 2006, & 2011	–	–	–	16.1–23.6

[1] Raw data not provided, results are from line graphs and summary tables publicly available online. Minimum and maximum were estimated; any results for number of observations or mean would be highly inaccurate and have been left out.

[2] Data are from summary table within report. Number of observations was not provided.

[3] Data are from summary table within report. Number of observations was not provided. Mean is the range of means provided for sampling years 2006, 2007, and 2010.

[4] Data are from summary table within report. Number of observations and minimum/maximum were not provided. Mean is the range of means provided for sampling years 2004, 2006, and 2011.

pH

pH measurements for Cub Creek are extensive and come from several sources. Although two measurements by CCWQP in February of 2006 were found to be greater than the upper standard of 9, all other data are well within the limits for this measure (Table 4.9-3). The pH of Cub Creek is in "good" condition, with no determinable trend and medium confidence in the assessment.

Table 4.9-3. pH measurements including minimum, maximum, and mean values (NPS 1999, NPS 2013a, Peitz and Cribbs 2005, Bowles and Clark 2012, Dodd and Cribbs 2012).

Station	Period of Record	# Observations	Minimum	Maximum	Mean
HOME 0010	6/73	2	8.2	8.3	8.3
HOME 0042	6/89–3/90	4	7.5	7.9	7.8
HOME 0043	4/95–10/96	4	7.4	8.2	7.9
HOME 0044	7/88	1	7.9	7.9	7.9
HOME 0045	6/89–3/90	4	7.5	7.8	7.6
HOME 0046	4/95–10/96	4	7.2	8.2	7.8
CCWQP[1]	2002–2006	67	7	9.7	8.0
Peitz and Cribbs 2005[2]	2002/2003	–	8.0	8.4	8.2
Bowles and Clark 2012[3]	2006, 2007, & 2010	–	7.5	8.2	7.5–8.1
Dodd and Cribbs 2012[4]	2004, 2006, & 2011	–	–	–	7.5–8.2

[1] Raw data not provided, results are from bar graphs and summary tables publicly available online. Number of observations, mean, minimum and maximum were estimated.

[2] Data are from summary table within report. Number of observations was not provided.

[3] Data are from summary table within report. Number of observations was not provided. Mean is the range of means provided for sampling years 2006, 2007, and 2010.

[4] Data are from summary table within report. Number of observations and minimum/maximum were not provided. Mean is the range of means provided for sampling years 2004, 2006, and 2011.

Total Dissolved Solids

There were no data collected for Total Dissolved Solids (TDS) at any of the HOME water quality monitoring locations. A current condition and trend cannot be determined.

Conductivity

All measurements are well below the recommended standard of 2000 µmhos/cm, indicating that conductivity at HOME warrants a good condition rating (Table 4.9-4). A trend could not be determined due to lack of data over time. Confidence in the rating is medium.

Table 4.9-4. Conductivity measurements including minimum, maximum, and mean values (NPS 1999, NPS 2013a, Peitz and Cribbs 2005, Bowles and Clark 2012, Dodd and Cribbs 2012).

Station	Period of Record	# Observations	Minimum	Maximum	Mean
HOME 0010	6/73	2	290	350	320
CCWQP[1]	2002–2006	67	150	780	456
Peitz and Cribbs 2005[2]	2002/2003	–	255	560	408
Bowles and Clark 2012[3]	2006, 2007, & 2010	–	219	520	231–520
Dodd and Cribbs 2012[4]	2004, 2006, & 2011	–	–	–	351–582

[1] Raw data not provided, results are from bar graphs and summary tables publicly available online. Number of observations, mean, minimum and maximum were estimated.

[2] Data are from summary table within report. Number of observations was not provided.

[3] Data are from summary table within report. Number of observations was not provided. Mean is the range of means provided for sampling years 2006, 2007, and 2010.

[4] Data are from summary table within report. Number of observations and minimum/maximum were not provided. Mean is the range of means provided for sampling years 2004, 2006, and 2011.

Chloride

There were no data collected for chloride at any of the HOME water quality monitoring locations. A current condition and trend cannot be determined.

Alkalinity

All measurements are above the recommended standard of 20 mg/L, indicating that alkalinity at HOME warrants a good condition rating (Table 4.9-5). A trend could not be determined due to lack of data over time. Confidence in the rating is low due to the length of time since the last measurement.

Table 4.9-5. Alkalinity measurements including minimum, maximum, and mean values (mg/L as $CaCO_3$) (NPS 1999, NPS 2013a).

Station	Period of Record	# Observations	Minimum	Maximum	Mean
HOME 0042	6/89–3/90	4	86	849	385
HOME 0043	4/95	1	220	220	220
HOME 0045	6/89–3/90	4	177	869	442
HOME 0046	4/95–10/96	4	210	240	225
CCWQP*	2002–2006	68	130	380	260

* Raw data not provided, results are from bar graphs and summary tables publicly available online. Number of observations, mean, minimum and maximum were estimated.

Sulfate

Most sulfate measurements for Cub Creek come from the CCWQP. All measurements are well below the federal drinking water standard of 250 mg/L, indicating that sulfates are low at HOME and warrant a “good” condition rating (Table 4.9-6). A trend could not be determined due to lack of data over time. Confidence in the rating is low due to the length of time since the last measurement.

Table 4.9-6. Sulfate measurements including minimum, maximum, and mean values (mg/L) (NPS 1999, NPS 2013a).

Station	Period of Record	# Observations	Minimum	Maximum	Mean
HOME 0044	6/88	1	31	31	31
CCWQP*	2002–2006	62	10	125	64

* Raw data not provided, results are from bar graphs and summary tables publicly available online. Number of observations, mean, minimum and maximum were estimated.

Phosphate

Most phosphate measurements for Cub Creek come from the CCWQP. All measurements are well above the recommended standard of 0.1 mg/L, indicating that phosphates are a concern at HOME and warrant a “poor” condition rating (Table 4.9-7). A trend could not be determined due to lack of data over time. Confidence in the rating is low due to the length of time since the last measurement.

Table 4.9-7. Phosphate measurements including minimum, maximum, and mean values (mg/L) (NPS 1999, NPS 2013a).

Station	Period of Record	# Observations	Minimum	Maximum	Mean
HOME 0046	9/92	1	1.8	1.8	1.8
CCWQP*	2002–2006	63	0.1	6.0	2.5

* Raw data not provided, results are from bar graphs and summary tables publicly available online. Number of observations, mean, minimum and maximum were estimated.

Nitrate

All measurements are below the recommended standard of 100 mg/L for agricultural use, indicating that nitrates are not a concern at HOME and warrant a “good” condition rating (Table 4.9-8). A trend could not be determined due to lack of data over time. Confidence in the rating is low due to the length of time since the last measurement.

Table 4.9-8. Nitrate measurements including minimum, maximum, and mean values (mg/L as N) (NPS 1999, NPS 2013a).

Station	Period of Record	# Observations	Minimum	Maximum	Mean
HOME 0010	6/73	2	1.2	1.4	1.3
HOME 0042	6/89–3/90	4	0.2	1.5	0.8
HOME 0043	4/95	1	1.6	1.6	1.6
HOME 0044	9/87–5/89	11	0.2	2	1.6
HOME 0045	6/89–3/90	4	0.5	1.5	1.0
HOME 0046	4/95–10/96	4	1	3.2	1.8
CCWQP*	2002–2006	57	0.0	11	1.8

* Raw data not provided, results are from bar graphs and summary tables publicly available online. Number of observations, mean, minimum and maximum were estimated.

Dissolved oxygen

DO has been routinely monitoring at HOME. This measure has regularly exceeded the state and federal standards during summer months, most likely due to low flows and high temperatures (Table 4.9-9). This condition of this measure warrants moderate concern, with no determinable trend and medium confidence in the assessment.

Table 4.9-9. Dissolved oxygen measurements from three monitoring stations including minimum, maximum, and mean values (mg/L) (NPS 1999, NPS 2013a, Peitz and Cribbs 2005, Bowles and Clark 2012, Dodd and Cribbs 2012).

Station	Period of Record	# Observations	Minimum	Maximum	Mean
HOME 0010	6/73	2	6.3	7.0	6.7
HOME 0044	9/87–7/89	12	5.1	9.3	7.4
CCWQP[1]	2002–2006	69	3.0	21.0	9.8
Peitz and Cribbs 2005[2]	2002/2003	–	8.15	8.55	8.35
Bowles and Clark 2012[3]	2006, 2007, & 2010	–	1.1	7.3	2.1–7.1
Dodd and Cribbs 2012[4]	2004, 2006, & 2011	–	–	–	7.0–9.3

[1] Raw data not provided, results are from bar graphs and summary tables publicly available online. Number of observations, mean, minimum and maximum were estimated.

[2] Data are from summary table within report. Number of observations was not provided.

[3] Data are from summary table within report. Number of observations was not provided. Mean is the range of means provided for sampling years 2006, 2007, and 2010.

[4] Data are from summary table within report. Number of observations and minimum/maximum were not provided. Mean is the range of means provided for sampling years 2004, 2006, and 2011.

Turbidity

For the units used for turbidity in this report (NTU) lower numbers indicate clearer water. Data from several studies indicates that the turbidity of Cub Creek is very high (Table 4.9-10). The condition of this measure at HOME is in the “poor” category, with no trend determined due to lack of data over time and medium confidence.

Table 4.9-10. Turbidity measurements including minimum, maximum, and mean values (NTU) (Peitz and Cribbs 2005, Bowles and Clark 2012, Dodd and Cribbs 2012).

Station	Period of Record	# Observations	Minimum	Maximum	Mean
Peitz and Cribbs 2005[1]	2002/2003	–	35	84	60
Bowles and Clark 2012[2]	2006 & 2007	–	139	183	231–520
Dodd and Cribbs 2012[3]	2006 & 2011	–	–	–	10–146

[1] Data are from summary table within report. Number of observations was not provided.

[2] Data are from summary table within report. Number of observations was not provided. Mean is the range of means provided for sampling years 2006, 2007, and 2010.

[3] Data are from summary table within report. Number of observations and minimum/maximum were not provided. Mean is the range of means provided for sampling years 2004, 2006, and 2011.

Coliform bacteria

There has been little historic monitoring of fecal coliforms but NDEQ began monitoring their station (SBB1CUBCK107) regularly beginning in 2012. Available data indicates levels of fecal coliforms that exceed the established standards, which warrant significant concern (Table 4.9-11). The sample levels are highly variable over time. A trend cannot be determined and the assessment is made with medium confidence due to the lack of more historical data.

Table 4.9-11. Total coliform measurements from five monitoring stations including minimum, maximum, and mean values (CFU/100ml) (NPS 1999).

Station	Period of Record	# Observations	Minimum	Maximum	Mean
HOME 0010	6/73	2	920	1100	1010
HOME 0044	7/88–7/89	2	10000	95000	52500
SBB1CUBCK107	5/12–9/12	28	62	2098	894

Overall Condition

The water quality for HOME warrants moderate concern with medium confidence due to the length of time since the last available data (Table 4.9-12).

Table 4.9-12. Water quality condition summary for Cub Creek at HOME.

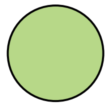
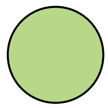
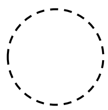
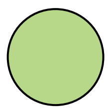
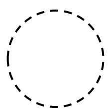
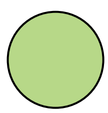
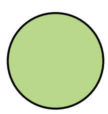
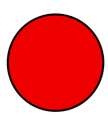
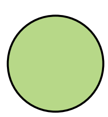
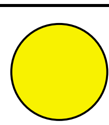
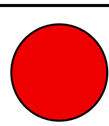
Indicator	Condition Status/Trend	Rationale
Temperature		All records fall within the range provided for aquatic life for the State of Nebraska. There is no determinable trend and medium confidence in the assessment.
pH		All but two measurements are within the state and federal limits. The two that exceeded the limit were taken within a single month. There is no determinable trend and medium confidence in the assessment.
Total dissolved solids		There is no available data for TDS in HOME
Conductivity		All measurements are well below the recommended standard of 2000 μmhos/cm. There is no determinable trend and medium confidence in the assessment.
Chloride		There is no available data for chloride in HOME
Alkalinity		All measurements are above the recommended standard of 20 mg/L. There is no determinable trend and medium confidence in the assessment.
Sulfate		All measurements are well below the federal drinking water standard of 250 mg/L. There is no determinable trend and medium confidence in the assessment.
Phosphate		All measurements are well above the recommended standard of 0.1 mg/L, indicating that phosphates are a concern at HOME. There is no determinable trend and medium confidence in the assessment.
Nitrate		All measurements are well below the recommended standard of 100 mg/L for agricultural use. There is no determinable trend and medium confidence in the assessment.
Dissolved oxygen		This measure has regularly exceeded the state and federal standards during summer months, most likely due to low flows and high temperatures.
Turbidity		Data from several studies indicates that the turbidity of Cub Creek is very high. There is no determinable trend and medium confidence in the assessment.

Table 4.9-12 (continued). Water quality condition summary for Cub Creek at HOME.

Indicator	Condition Status/Trend	Rationale
Total coliform		There is a small of amount of coliform data available for HOME. 2012 data from NDEQ indicates levels of coliforms greater than the established standards with significant historic peaks.
Water Quality overall		Overall water quality condition warrants moderate concern with unknown trend and a medium level of confidence

4.9.5. Uncertainty and Data Gaps

There are some data gaps and needs for HOME. Of the six EPA monitoring locations established within HOME there are none that contain long-term data. Flow data should be collected if possible. The NDEQ monitoring location is only being used to sample fecal coliforms and data is only available for 2012. The Monument and I&M network had been monitoring the streams within the park until at least until 2011, but no data is currently available beyond this sampling year.

4.9.6. Sources of Expertise

- The NPS Water Resources Division is the primary source of expertise for water quality within HOME. The Nebraska Department of Environmental Quality (NDEQ) is the secondary source of expertise for water quality of Cub Creek.
- Dave Ihrie, Planning Section, Water Division, Nebraska Department of Environmental Quality

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4.10. Prairie Vegetation

4.10.1. Background and Importance

Tallgrass prairie once covered some 570,000 km^2 (22,000 mi^2) of central North America, extending eastward from Nebraska and Kansas through the "Prairie Peninsula" of Iowa, Illinois, parts of Minnesota, Missouri, and 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 such as that at HOME.

Homestead National Monument represents one of the oldest prairie restorations of a human-altered landscape. The most similar example of prairie restoration from the era is the Curtis Prairie in Madison, Wisconsin from the 1930s, which represents the oldest U.S. prairie restoration. The reconstructed tallgrass prairie is recognized as a valuable tool for interpreting the homesteading story. Resource management practices work to support the Monument's legislated purpose while protecting and preserving the reconstructed tallgrass prairie's significant scientific and historic values (NPS 1999).

HOME lies within the Central Tallgrass Prairie ecoregion (Figure 4.10-1), where tallgrass prairies are most mesic, with deep rich soils (Comer et al. 2003). Tallgrass prairie vegetation on the deepest soils is characterized by tall (1–2 m) grass species such as big bluestem (*Andropogon gerardii*)*,* Indian grass (*Sorghastrum nutans*)*,* and switchgrass (*Panicum virgatum*). Drier or shallow-soiled areas are characterized by mid- to shortgrass species, such as little bluestem (*Schizachyrium scoparium*)*,* sideoats grama (*Bouteloua curtipendula*), prairie dropseed (*Sporobolus heterolepis*), and porcupinegrass (*Hesperostipa spartea*) (Sims and Risser 2000, NatureServe 2013). These tallgrass prairie communities also have a diverse forb component (TNC 2008).

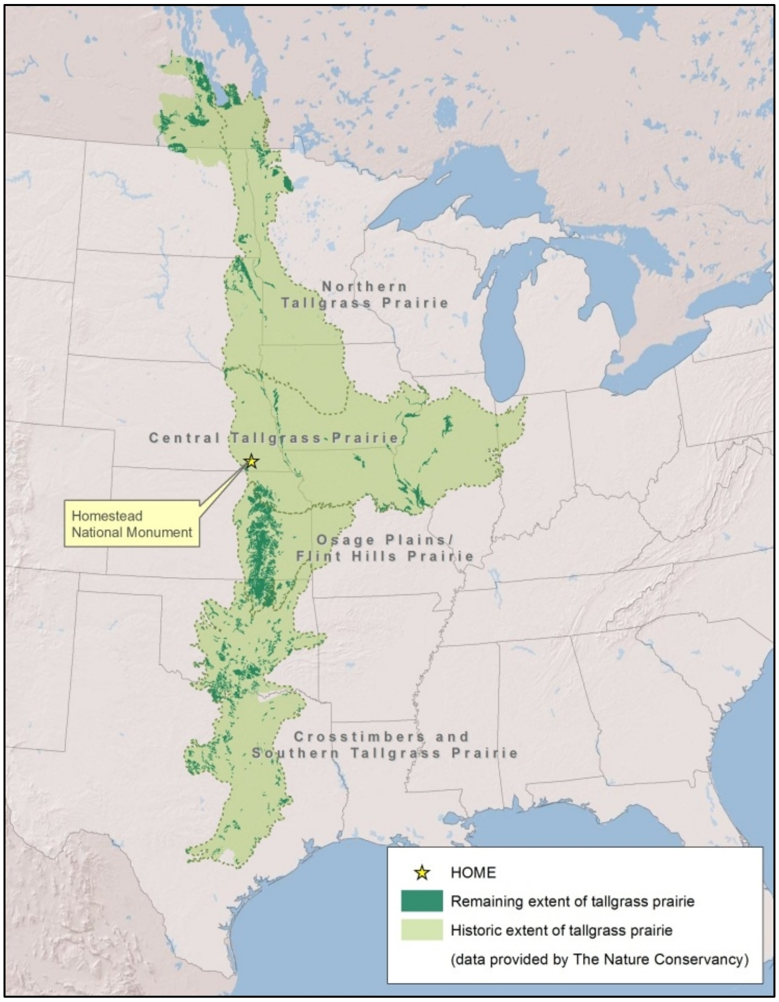


Figure 4.10-1. Location of Homestead National Monument within the tallgrass prairie region. (TNC undated).

Prior to the acquisition of the Freeman Homestead by the National Park Service, the prairie area had been heavily used for cultivated agriculture and grazing, resulting in significant erosion in some places. In order to reduce soil erosion and support the park mission, the decision was made to restore this area to tallgrass prairie, approximating the "appearance and species composition representative of the tallgrass prairie in the 19th Century" (NPS 2006). The area was restored by a combination of seeding a mix of native grasses, placement of native plant soil-plugs, and transplanting sod from local areas of unplowed prairie (NPS 2006). HOME also contains an unplowed remnant (~0.25 ac) of original tallgrass prairie at the Freeman school.

Most of the unwooded areas of what is now Homestead National Monument of America were plowed within a few years after being claimed by Daniel Freeman in 1863. These areas remained in cultivation through 1937, the year following the creation of the park. Early assessments of the park and restoration planning were undertaken by Adolph Murie, then NPS Wildlife Technician, in collaboration with Dr. J.E. Weaver from the University of Nebraska. Broad guidance for the restoration came from NPS Regional Historian E.A. Hummel, who recommended restoring conditions on the site to approximate native vegetation when the claim was filed by Mr. Freeman. This objective has been reiterated to some degree in the *Prairie Management Action Plan* (NPS 1993). A report prepared by Murie (1938) noted that nearly the entire non-wooded area had been cultivated, and that extensive topsoil loss and active erosion were widespread, especially on the southern and eastern slopes. He recommended using a combination of native prairie sod procured from other locations in Gage County and seeding of native grasses. Sod was favored because of the presence of diverse grasses and especially forbs in the flora and seed bank (Murie 1938).

The prairie community at HOME represents 93.27 ac of restored tallgrass prairie that has been managed for more than 60 years (Figure 4.10-2). The history of early prairie management at the park is described by Sutton et al. (1984) and Stubbendieck and Willson (1986, 1987). At least 40 ac of the site were under cultivation as late as November 1939. Park records indicate that the first seeding took place in 1939 with seed collected from a remnant prairie area approximately 5 miles to the west. The approximate seed mixture was 45% big bluestem, 50% little bluestem, and one percent each of Kentucky bluegrass (*Poa pratensis*), needle-and-thread grass (*Hesperostipa comata*), Indian grass (*Sorghastrum nutans*), prairie dropseed (*Sporobolus heterolepis*) and sideoats grama (*Bouteloua curtipendula*). The first sodding from an undocumented source also was completed in 1939 to control severe sheet, rill and gully erosion near the south boundary.

A summary of prairie restoration efforts from the 1940s to 1980s is provided by Stubbendiek and Willson (1987):

1942 – Additional seeding and sodding along with the construction of small check dams to slow erosion.

1943 – Weed control; sunflowers were mowed and bindweed was treated with sodium chlorate.

1947 – Sodding in upland gullies; seeding and local prairie hay mulch used in eroding areas.

1948 – Additional spot seeding; sod added to uplands; selective grazing suggested as a means to reduce fire hazard.

1949 – First use of herbicide (2,4-D) other than sodium chlorate.

1951 – 40 ac mowed.

1952 – Upland (S and SE) prairie hayed.

1953 – Bottomland (W and NW) prairie hayed.

1954 – Seeds harvested.

1955 – Smooth brome (Bromus inermis) infestation noted.

1963 – 2,4-D used for weed control.

1964 – Lowlands heavily infested with weeds. Dalopon used for smooth brome control and 2,4-D used for broadleaf weeds.

1965 – Prairie mowed to reduce thatch buildup.

1968 – Smooth brome mowed.

1969 – Between 7 and 11 ac of lowland seeded.

1970 – First prescribed burn, primarily to control eastern redcedar (Juniperus virginiana) and reduce thatch; 2,4-D applied.

1976 – 4 ac of lowland reseeded.

1979 – Woody plants sprayed with ammonium sulfamate; routine 2,4-D spraying program stopped.

1980 – 17-acre wildfire occurred.

1982 – Quantitative vegetation sampling begun, prescribed burn in April (8 ac); manual removal of musk thistle (Carduus nutans) and common mullein (Verbascum thapsus).

1983 – Entire prairie burned; 4 ac of weedy lowland mowed.

1984 – Weedy lowland mowed; fall burn of small overgrown sumac; herbarium established.

1986 – Lowland area sodded and planted with approximately 3,000 seedlings grown from locally collected seed.

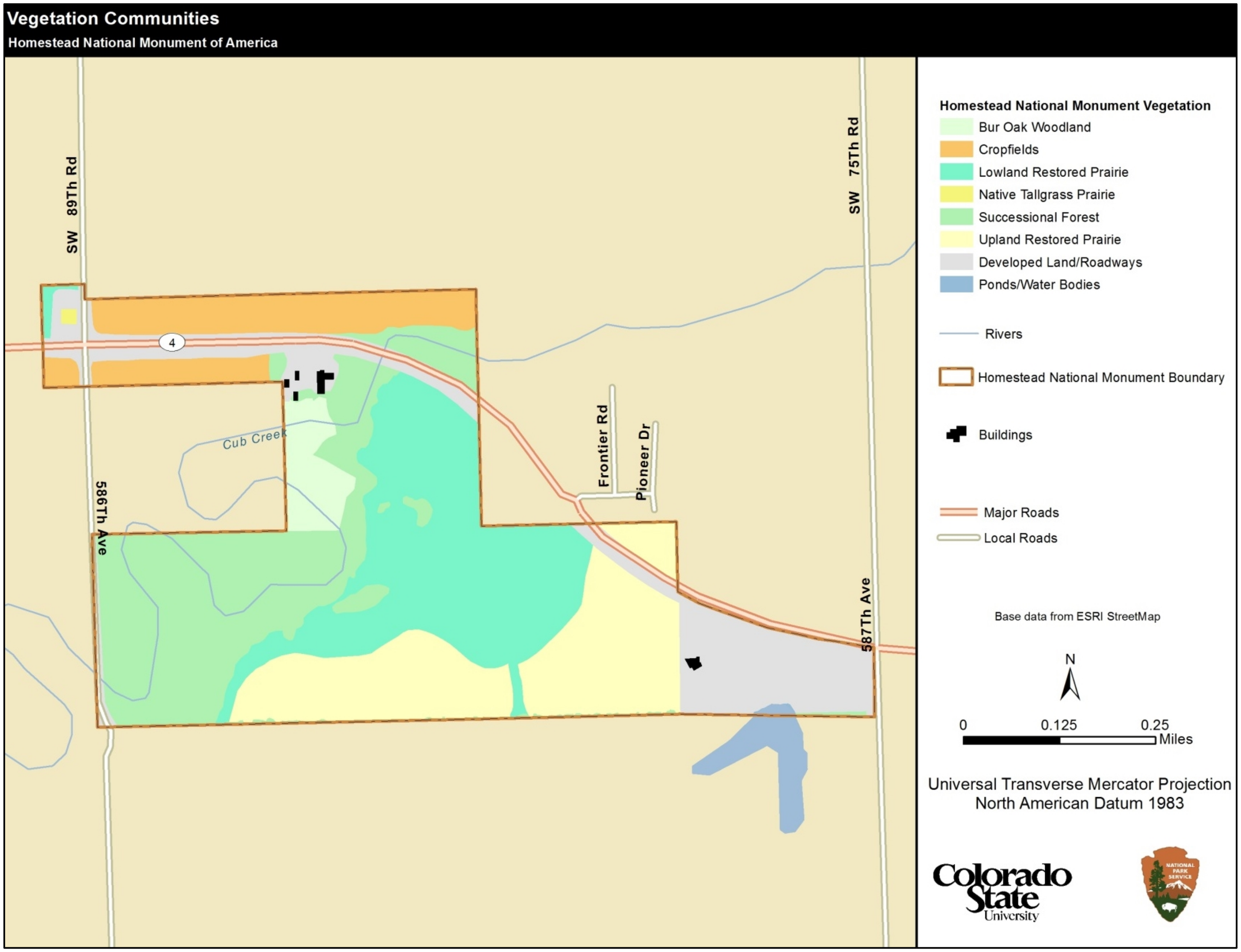


Figure 4.10-2. Current mapped vegetation communities, Homestead National Monument (data from Kindscher et al. 2011).

The management history shows a clear change in emphasis, challenges and applied management approaches as the erosion and stabilization efforts of the 1930s and 1940s were followed by herbiciding and mowing in the 1940s-1960s. Seeding and sodding efforts continued, with the bottomland area being especially difficult with respect to nonnative invasive plants. Fire emerged as a major management tool in 1970 and the increase in the use of prescribed fire coincided with the elimination of large-scale mowing and use of herbicides.

After decades of restoration and management, the tallgrass prairie at HOME is considered an excellent example of a restored tallgrass prairie. The vegetation composition is thought to be similar to that of presettlement vegetation, although forb species richness is still below expected levels (Kindscher et al. 2011). Dominant tallgrass species include big bluestem, Indian grass, switch grass, and little bluestem. Typical forb and sub-shrub species are sunflower (*Helianthus* spp.), goldenrod (*Solidago* spp.), milkweed (*Aslcepias* spp.), field pussytoes (*Antennaria neglecta*), and leadplant (*Amorpha canescens*). In mesic areas there are several thickets of shrubby species such as sumac, wild plum, and dogwood, which provide habitat for birds and other small animals (NPS 2006).

Threats and Stressors

Primary threats to the condition of the prairie vegetation at HOME 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) infrequent fire return interval, which exacerbates the first three listed threats.

Indicators and Measures

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

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

4.10.2. Data and Methods

The Heartland Inventory and Monitoring Network (HTLN) has been monitoring vegetation at HOME since 1998. Monitoring of five prairie sites occurred in 1998, 1999, 2000, 2002, 2005, and 2006. In 2009, two new sites were established bringing the total number of sites monitored in the prairie to seven, and the protocol was revised, with a change to a single sampling period instead of 2 sampling periods. Data are collected on two permanent parallel transects (50 m (164 ft) in length and 20 m (65 ft) apart), each with five 10 m^2 (107 ft^2) circular plots placed at 10 m (33 ft) intervals along the transect. Foliar cover is estimated in the 10 m^2 (107 ft^2) plot using a modified Daubenmire scale, and 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 the woody species greater than 5.0 cm dbh in the understory and overstory canopy layers. Summary data reported for each site (transect pair) are: 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 is described in that subsection within this chapter, and also used as an indicator for the condition of prairie vegetation here.

4.10.3. Reference Conditions

Because we can only indirectly address the condition of prairie vegetation within HOME, we used metrics that could be derived from the HTLN vegetation monitoring data to address condition. A resource condition rating framework integrating the reference condition concepts discussed below is shown in Table 4.10-1.

Table 4.10-1. Resource condition indicator rating framework for prairie vegetation indicators at Homestead National Monument.

Indicator	Good Condition	Warrants Moderate Concern	Warrants Significant Concern
Species 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
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 < 15%; extent of Category 1 thickets < 5% of prairie area	Woody plant cover 15–25%; extent of Category 1 thickets 5–10% of prairie area	Woody plant cover > 25%; extent of Category 1 thickets > 10% of prairie area

The ideal condition for HOME 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 of HOME, we instead 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 HOME 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% indicating good condition for native plant species cover 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, WANHP 2011), 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 HOME 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, downweighting the contribution of rare species and giving additional insight into the relative importance of each community member. Finally, 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 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.

To assist in decisions regarding thicket management, a mapping project was conducted in over 70 ac of the restored tallgrass prairie of HOME in the summer of 2000. Additional thicket surveys took place in 2005, 2010 and 2015 (Haack 2012, 2015). The primary objective of the thicket mapping project is to determine the total area occupied by woody shrub species in the restored prairie. Woody species cover indicator rating levels are based on long term average values for woody guild cover in prairies at the Monument and also by woody cover objectives articulated in the 2006 *Vegetation Management Action Plan 2004–2014* (NPS 2006), which specifically addresses encroachment of woody species in restored prairie. The plan states that the management of shrubs and trees in the restored prairie is considered necessary to maximize native prairie biodiversity. Moreover, a specific objective of the plan is to: "Maintain a healthy ratio of shrub cover to prairie cover so that no more than 15% is covered by shrubs of any density class and that no more than 5% is covered by Category 1 thickets, which are defined as areas of dense thickets with warm season grasses absent or nearly so; warm season grasses persist only along thicket perimeter; forbs are few with less than 25% cover; shrub cover is greater than 75%." Finally, because woody species are being actively controlled or killed, we expect that values should remain at or below 1998 levels.

4.10.4. Condition and Trend

Species Composition

The proportion of native plant species present at monitoring sites has been fairly consistent (Figure 4.10-3) with a mean of 80% or greater in all monitoring years reported here. The species composition metric indicates good condition with an unchanging trend and moderate confidence (See Table 4.10-2). Species-level analysis using historic (pre-1998) data could increase the confidence associated with the assessment.

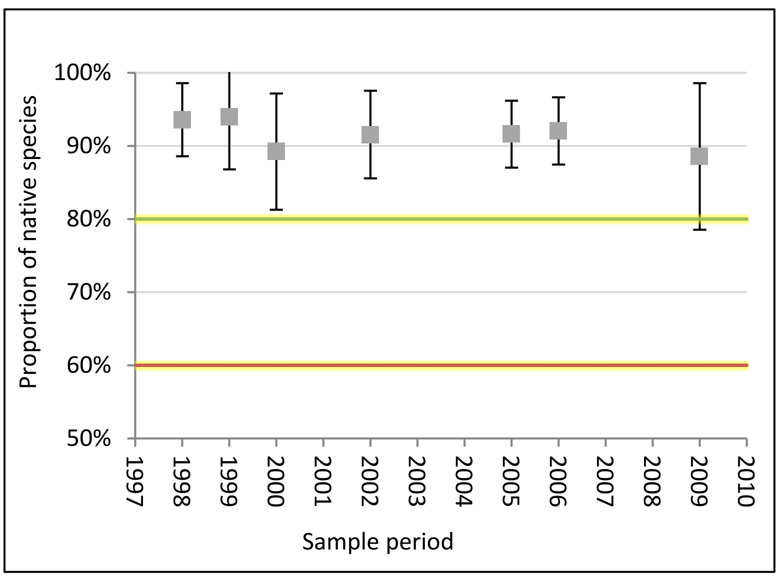


Figure 4.10-3. Mean proportion of native plant species by site during monitoring years 1998–2009. Error bars represent 90% confidence interval of the mean. Upper (green) line represents good condition threshold, lower (red) line represents significant concern threshold. Raw data provided by the Heartland I&M Network.

Native Species Diversity

Native species richness for prairie communities at HOME has fluctuated, but was reasonably stable during the monitoring period from 1998 to 2009, averaging between 34 and 44 species per site (Figure 4.10-4a). The lowest level was in 2009 with a mean of 34.9 species. Prairie communities at HOME have maintained a mean of at least 85% that of the 1998 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) with a slight suggestion of decreasing trend. In 2009, the mean of 11.4 fell below 85% of the 1998 mean, indicating moderate concern condition. Means for native species evenness as measured by Hill's E5 fell below 70% and 85% of 1998 mean in 1999 and 2000, respectively, and although subsequent years were above the 85% of 1998 level, they generally have large 90% confidence intervals (Figure 4.10-5c), indicating a condition of moderate concern. However, this metric shows an increasing trend, and was highest in 2009.

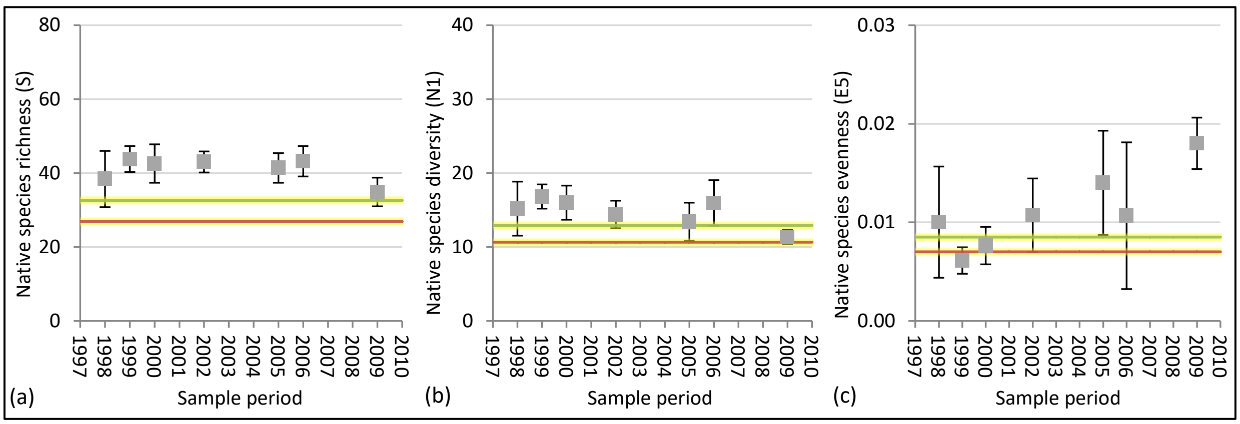


Figure 4.10-4. Estimates of (a) native species richness (b) native species diversity, and (c) evenness for HOME during monitoring years 1998–2009. Error bars represent 90% confidence intervals around the mean. Upper (green) line represents 85% of the 1998 mean, lower (red) line represents 70% of the 1998 mean. Raw data provided by the Heartland I&M Network.

Overall, the prairie vegetation condition as measured by native species diversity is good, with an unchanging trend (See Table 4.10-2). Confidence in the assessment is medium due to the relatively short period represented by the data, uncertainties related to reference condition, and low statistical inference due to small sample sizes and year to year variability.

Structure

Non-native forbs and graminoids are generally a minor component of prairie community structure at HOME. Native graminoids typically account for about 45% of the cover values of all native non-woody plant species combined. Relative proportions of native graminoids are variable between years, but with the exception of 2006, are within a range of 43–50% (Figure 4.10-5). In all years, the native graminoid / native forb split included at least 20% of each functional group, indicating good condition with an unchanging trend.

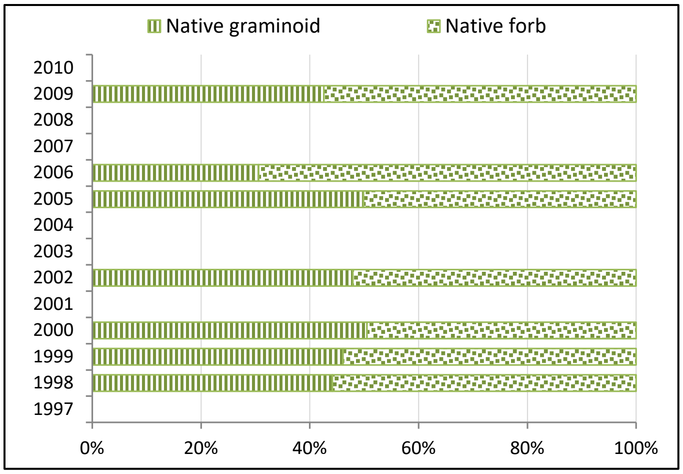


Figure 4.10-5. Percent cover of native forbs and graminoids at HOME as a proportion of the combined total cover of the two functional groups. Raw data provided by the Heartland I&M Network.

Woody species in prairie vegetation at HOME averaged 30% cover between 1997 and 2009 (Figure 4.10-6), with 90% confidence intervals for the monitoring period generally ranging between 10% and 40% woody plant cover. Values can change considerably from year to year. Mean values for all monitoring years prior to 2009 exceeded 25% cover. The most recent (2009) data indicates that mean woody cover lies somewhere between about 9 and 22 percent. Six of seven monitoring years exceeded this threshold. There appears to be an improving trend but confidence is low due to high variability in the data and interannual variability, some of which may be due to management activities.

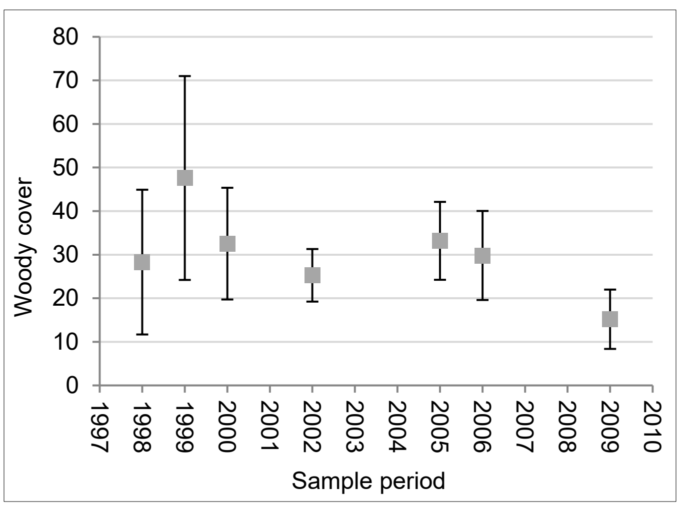


Figure 4.10-6. Percent woody cover at HOME during monitoring years 1998–2009. Error bars represent 90% confidence intervals around the mean. Raw data provided by the Heartland I&M Network.

Thicket mapping data shows a consistent decline in the density and extent of woody plant thickets within the core prairie restoration area. Total acreage of all thicket classes was 23.9 ac in 2000, 20.2 ac in 2005, 30.0 ac in 2010 and 16.0 ac in 2015. The largest and most dense thickets are decreasing in area. Cover of Category 1 shrub thickets varied between 2.4 and 4.9 ac between 2000 and 2005, and by 2015 was well below the 5% threshold specified in the management plan. Current data for the core prairie area shows the thickets are within the “good” condition criteria of 5% for Category 1 thickets.

Woody species are being actively controlled or killed using a combination of fire, mechanical controls and herbicides. Although the plot monitoring values have high variability and there is relatively high interannual variability, the evidence indicates that woody species are being effectively controlled within the core prairie area. Overall structure rating is good with an unchanging trend and medium confidence (See Table 4.10-2).

<u>Invasive Exotic Plants</u>
Invasive exotic plants at HOME are evaluated in section 4.11 and are applied here as an indicator of prairie vegetation condition. Due to the fact that smooth brome is present with high frequency and has an estimated cover range exceeding 25% of the total acreage of the Monument as well as the presence of one state-listed noxious weed, this indicator warranted moderate concern, with an unchanging trend (Table 4.10-2).

<u>Overall Condition</u>
Condition ratings for species composition and native species diversity are generally good. The condition of invasive exotic plants warranted moderate concern. All indicators had an unchanging trend and medium confidence. Overall, the prairie vegetation at HOME is in good condition, with an unchanging trend for the time period covered by this assessment (Table 4.10-2). Confidence in the assessment is medium.

Table 4.10-2. Condition rating framework for prairie vegetation, Homestead National Monument.

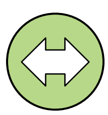
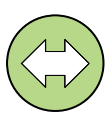
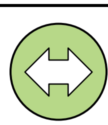
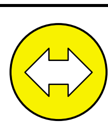
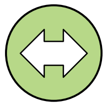
Indicator	Condition Status/Trend	Rationale
Community Composition		Prairie monitoring sites have maintained a mean of at least 80% cover of native plant species.
Native Species Diversity		Native species richness for prairie communities at HOME has remained reasonably stable, averaging 35–44 species per site, and about 11–17 abundant species. Species evenness may be increasing, but the overall trend appears to be unchanging.
Vegetation Structure		Native forbs and graminoids are well represented in all prairie sites. Levels of woody vegetation cover exceed 15%, which is on the threshold for moderate concern.
Invasive Exotic Plants		There is a high frequency and cover of smooth brome, and a state-listed noxious weed is present.

Table 4.10-2 (continued). Condition rating framework for prairie vegetation, Homestead National Monument.

Indicator	Condition Status/Trend	Rationale
Prairie Vegetation overall		The prairie vegetation is in good condition with an unchanging trend. Confidence in the assessment is medium.

4.10.5. Uncertainties and Data Gaps

Restoration and maintenance of prairie communities at HOME is extremely challenging given the effects of nonnative invasives and altered disturbance regimes. 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. Modifying the sampling design to increase statistical sensitivity to changes in the resource may better help managers to adapt approaches accordingly.

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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 the Heartland I&M Network. During the vital signs selection process in 2003, invasive exotic plants were identified as the most important management issue for HOME (Young et al. 2007). Invasive exotic plants are spread into NPS units by various pathways, including roads, trails, and riparian corridors (Young et al. 2007). The number of non-native plant species is correlated with visitation levels and extent of backcountry trails and riparian areas (Allen et al. 2009).

Invasive exotic plants are of concern for HOME because they are a threat to the restored prairie and riparian forest at the site. Highly invasive exotic plants have already become established include smooth brome (*Bromus inermis*) and bald brome (*Bromus racemosus*) in the prairie, and Osage orange (*Maclura pomifera*), reed canarygrass (*Phalaris arundinacea*), and white mulberry (*Morus alba*) in riparian forests (Young et al. 2010). In 2010–2012, the Heartland Network Exotic Plant Management Team worked with Monument staff in the early detection and control of garlic mustard (*Alliaria petiolata*) (Short et al. 2010, Beard and App 2012).

<u>Threats and Stressors</u>

Threats to the condition of HOME 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 HOME 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 Heartland I&M Network has developed an invasive exotic plant monitoring protocol (Young et al. 2007) that uses a prioritization database for species to be monitored on 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. HOME 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 park based on the NPSpecies database; 2) the park-established watch list, containing high priority species known to occur in the unit based on the NPSpecies database; and 3) the park-based watch list, which includes plants selected by park 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). Seven of the park-listed species are considered noxious weeds by the state of Nebraska: *Carduus nutans, Cirsium arvense, Euphorbia esula, Lythrum salicaria, Phragmites australis, Polygonum cuspidatum,* and *Tamarix ramosissima.* Of the seven species listed, *Carduus nutans* and *Cirsium arvense* were documented on HOME. 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, Homestead National Monument. List provided by Homestead National Monument.

Watch list	Scientific name	Common name
NPS Early Detection Watch List	*Ailanthus altissima*	Tree of heaven
	Alliaria petiolata	Garlic mustard
	Arctium minus	Lesser burdock
	Azolla spp.	Mosquitofern
	Bothriochloa bladhii	Caucasian bluestem
	Bromus tectorum	Cheatgrass
	Butomus umbellatus	Flowering rush
	Cardaria draba	Whitetop
	Centaurea biebersteinii	Spotted knapweed
	Centaurea solstitialis	Yellow star-thistle
	Cirsium arvense	Canada thistle
	Cynanchum louiseae	Louise's swallow-wort
	Cynoglossum officinale	Gypsyflower
	Dactylis glomerata	Orchardgrass
	Dipsacus fullonum	Fuller's teasel
	Dipsacus laciniatus	Cutleaf teasel
	Egeria densa	Brazilian waterweed

Table 4.11-1 (continued). Watch lists for invasive exotic plants, Homestead National Monument. List provided by Homestead National Monument.

Watch list	Scientific name	Common name
NPS Early Detection Watch List (continued)	*Elaeagnus angustifolia*	Russian olive
	Elaeagnus umbellata	Autumn olive
	Euphorbia esula	Leafy spurge
	Frangula alnus	Glossy buckthorn
	Glechoma hederacea	Ground ivy
	Humulus japonicus	Japanese hop
	Hyoscyamus niger	Black henbane
	Lespedeza cuneata	Sericea lespedeza
	Ligustrum vulgare	European privet
	Linaria dalmatica	Dalmatian toadflax
	Linaria vulgaris	Butter and eggs
	Lonicera japonica	Japanese honeysuckle
	Lonicera maackii	Amur honeysuckle
	Lonicera tatarica	Tatarian honeysuckle
	Lotus corniculatus	Bird's-foot trefoil
	Lotus tenuis	Narrow-leaf bird's-foot trefoil
	Lysimachia nummularia	Creeping jenny
	Lythrum salicaria	Purple loosestrife
	Myriophyllum spicatum	Eurasian watermilfoil
	Onopordum acanthium	Scotch cottonthistle
	Pastinaca sativa	Wild parsnip
	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. *lobata*	Kudzu
	Rhamnus cathartica	Common buckthorn
	Rhamnus davurica	Dahurian buckthorn
	Robinia pseudoacacia	Black locust
	Schedonorus phoenix	Tall fescue
	Schedonorus pratensis	Meadow fescue
	Securigera varia	Crownvetch
	Solanum dulcamara	Climbing nightshade

Table 4.11-1 (continued). Watch lists for invasive exotic plants, Homestead National Monument. List provided by Homestead National Monument.

Watch list	Scientific name	Common name
NPS Early Detection Watch List (continued)	*Sorghum halepense*	Johnsongrass
	Tamarix ramosissima	Saltcedar
	Torilis arvensis	Spreading hedgeparsley
	Typha angustifolia	Narrowleaf cattail
	Viburnum opulus	European cranberrybush
	Vinca minor	Common periwinkle
Park-Established Watch List	*Berberis thunbergii*	Japanese barberry
	Bromus inermis	Smooth brome
	Carduus nutans	Musk thistle
	Cirsium vulgare	Bull thistle
	Hesperis matronalis	Dames rocket
	Melilotus officinalis	Yellow sweetclover
	Morus alba	White mulberry
	Phalaris arundinacea	Reed canarygrass
	Poa pratensis	Kentucky bluegrass
	Rosa multiflora	Multiflora rose
	Ulmus pumila	Siberian elm
	Verbascum thapsus	Common mullein
Park-Based Watch List	*Bromus racemosus*	Bald brome
	Echinochloa crusgalli	Barnyardgrass
	Maclura pomifera	Osage orange

Sampling of invasive exotic plants at HOME took place in 2006 and 2009. For small parks such as HOME, the HTLN protocol specified that exotic plant search units be created by dividing park management units into search units that were generally 1–3 ac (0.4–1.2 ha) in size with a target size of 2 ac. At HOME, this resulted in 82 search units with a size range of 1.1- 3.0 ac and a mean size of 2.0 ac representing 164 ac within the park (Figure 4.11-1). Within each search unit, three equally spaced east-west belt transects of 3 to 12 m (9–39 ft) width are surveyed, and foliar cover classes estimated (Young et al. 2007).

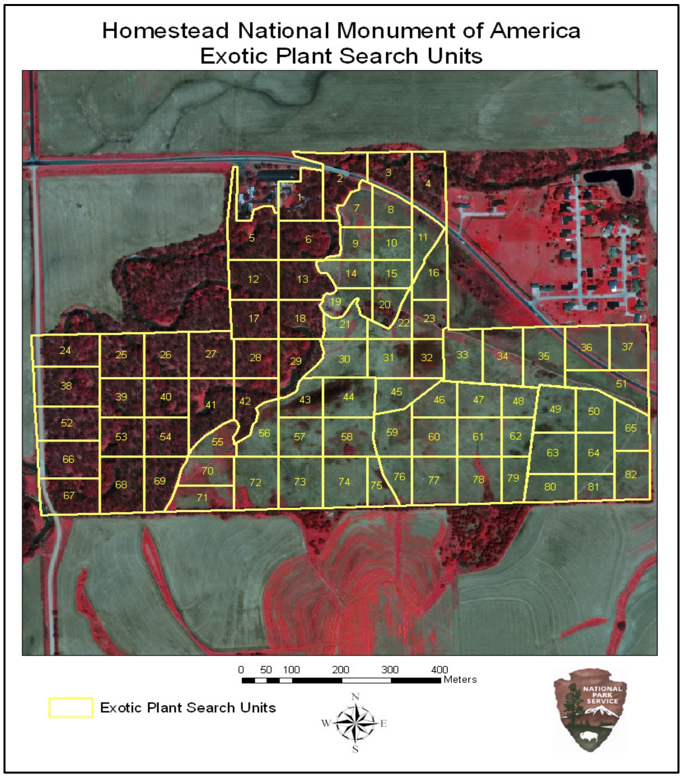


Figure 4.11-1. Exotic plant search units at Homestead National Monument (Young et al. 2007).

Cover classes were: 0=0, 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, and 7 $\geq$ 1,000 m^2). The widest belt possible given site conditions was used. Entire polygons were not searched. Park-wide frequency of invasive exotic plants was calculated as the percentage of occupied search units. A park-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 (65 ac or 40% of the Monument), resulting in a park-wide estimate of the lowest possible cover within the greatest possible area searched.

The maximum cover estimate was calculated as the sum of cover class upper endpoints divided by the calculated minimum area searched (16 ac or 10% of the Monument), 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 (Young et al. 2010). Monitoring began in 2006, was repeated in 2009 and will be repeated every five years.

Frequency and cover data were extracted from Young et al. (2010). Changes in cover by search unit were evaluated using data from INP_Accessv2.0.mdb database provided by Heartland I&M Network staff. Cover classes were converted to midpoints and summed across species for each search unit.

4.11.3. Reference Conditions

The ideal condition for HOME would be the complete absence of non-native species, representing conditions during pre-settlement times. Because this benchmark for condition is not feasible for a unit with the history of HOME we instead consider a baseline reference condition as conditions under which the integrity of park plant communities remains essentially unimpaired, and 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 Monument with reference to invasive plant species (Table 4.11-2). A good condition is achieved under conditions where IEP species are present but at generally low frequency and cover, and only in isolated patches. A situation where many IEP species are present with substantial cover for some species, and the problem is widespread indicates 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 (Table 4.11-3). 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 4.11-2. Reference condition rating framework for invasive exotic plants at HOME.

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 park area
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 park area

Table 4.11-3. Definitions of Improving, Unchanging, and Deteriorating conditions for invasive exotic plants in HOME.

Trend	Symbol	Change in IEP cover from 2006 to 2009
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

Frequency

A cumulative total of 14 IEP species were detected at HOME during the two monitoring periods. In the most recent (2009) period examined, several species previously detected (*Sorghum halepense*, *Berberis thunbergii*, and *Cirsium vulgare*) were not found. A single species (*Bromus inermis)* was present with frequency above 50% (Figure 4.11-2). Frequency for all species decreased from 2006 to 2009. Results for this indicator warrant moderate concern, with an improving trend and high confidence level.

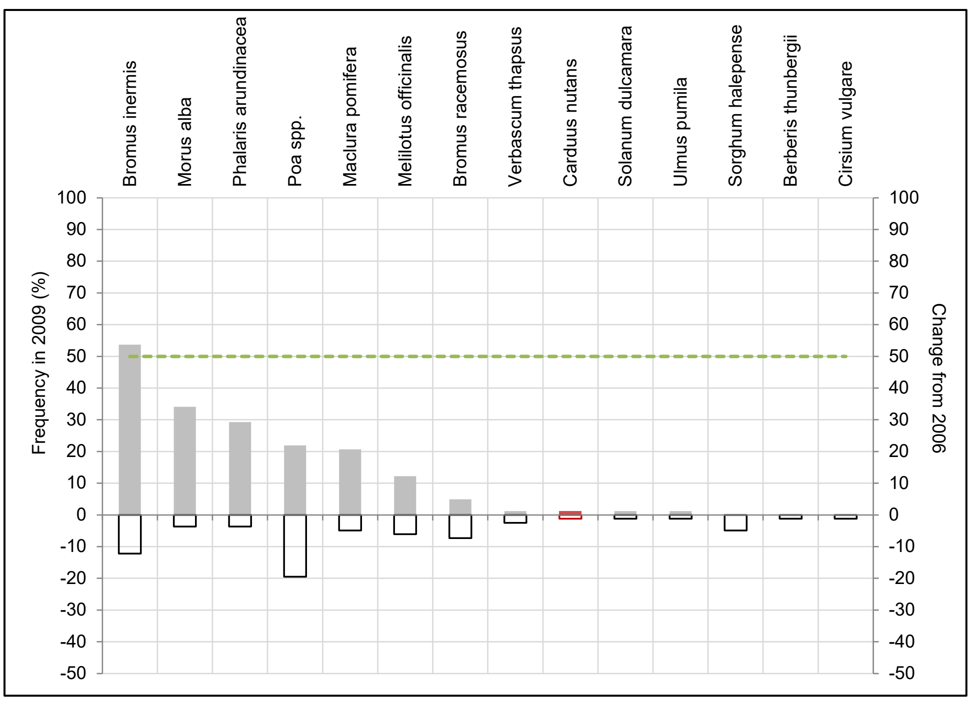


Figure 4.11-2. Frequency of IEP species at Homestead National Monument in 2009 (solid bars), and change in frequency from 2006 (open bars). Species are sorted by decreasing percent frequency. The 50% frequency threshold (see text) is indicated by a dashed line. Values for Nebraska state-listed noxious species are shown in red (*Carduus nutans*). Raw data provided by the Heartland I&M Network.

Abundance

Estimated cover ranges as reported by Young et al. (2010) indicate that *Bromus inermis* is the most abundant IEP species at HOME, with cover exceeding 15% of the total undeveloped acreage of the Monument in 2009 (Figure 4.11-3). Change in cover range was generally stable. Results for this indicator warrant moderate concern, with an unchanging trend and high confidence level.

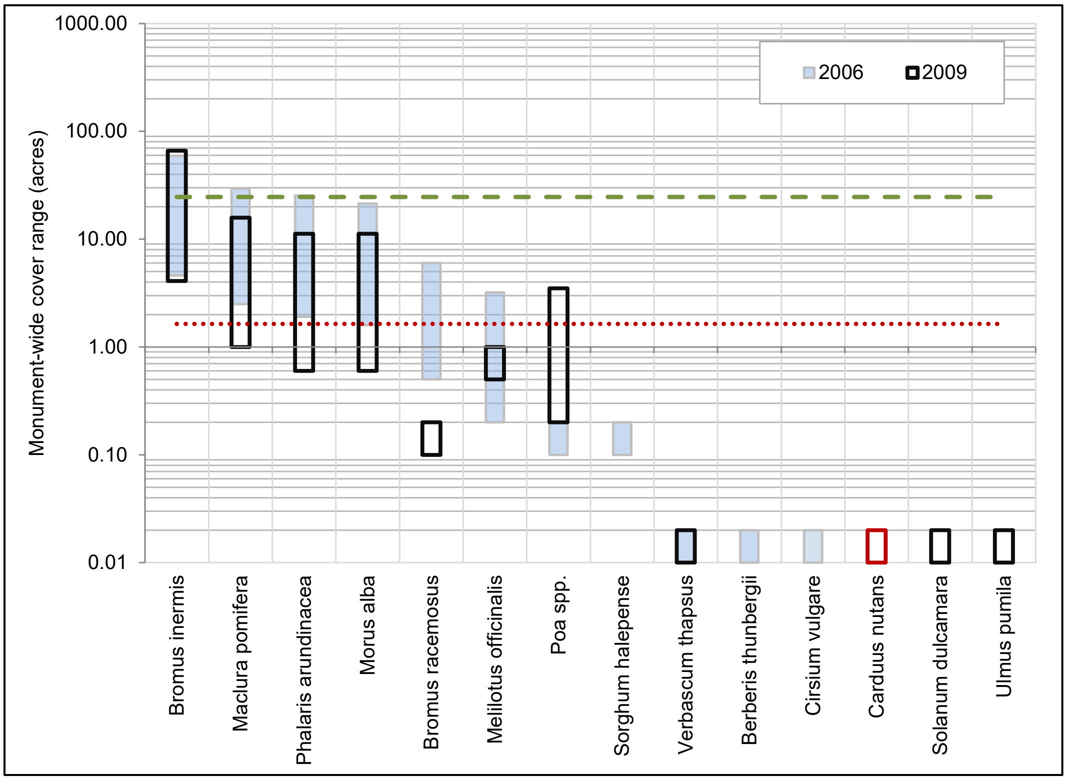


Figure 4.11-3. Cover ranges of IEP species at Homestead National Monument in 2006 and 2009. Species sorted by decreasing 2009 cover acreage (note log scale). The 15% cover threshold (24.6 acres) for all IEP species (see text) is indicated by a dashed line. Values for Nebraska state-listed noxious species are shown in red (*Carduus nutans*), and the 1% state-noxious cover threshold (1.6 acres) is shown as a dotted line. Raw data provided by the Heartland I&M Network.

Distribution

Thirteen percent of search units at HOME had no IEP species present in 2009 (Figure 4.11-4a). Over three quarters of all units (79%) have 1–5 IEP species. A single search unit had 6 IEP species, and none had higher levels. Six search units (7%) had a substantial increase in IEP cover (Figure 4.11-4b), and 14 search units (17%) had a substantial decrease in IEP cover. The majority of search units (70%) were stable. Results for this indicator show good condition, with an unchanging trend and high confidence level.

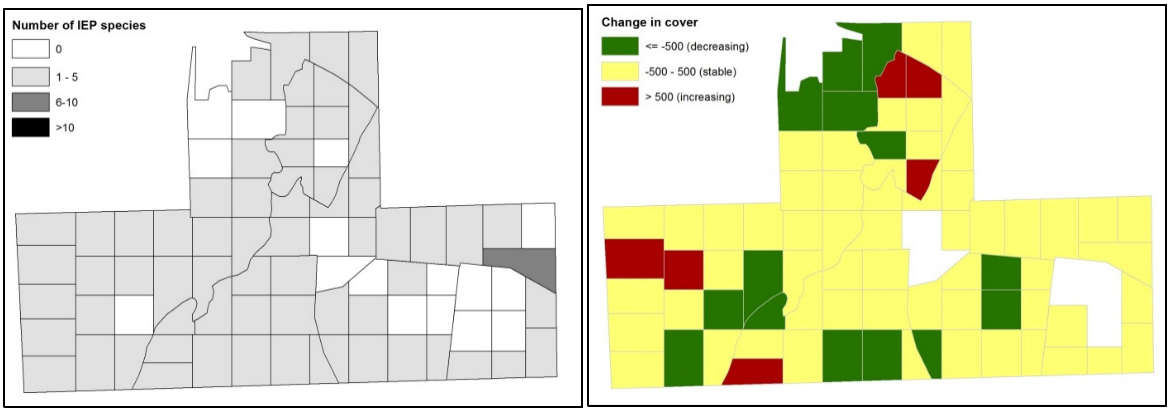


Figure 4.11-4. Number of IEP species by search unit in 2009 (left) and net change in cover class of each species (combined) between 2006 and 2009 (right). Raw data provided by the Heartland I&M Network.

<u>State Noxious Weeds</u>

One Nebraska state-listed noxious weed species (*Carduus nutans*) was present in 2009 (Figure 4.11-3) with cover of 0.01 ac, or < 0.01% of total Monument acreage. Results for this indicator warrant moderate concern, with an unchanging trend and high confidence level.

<u>Overall Condition and Trend</u>

The IEP monitoring data is rich in spatial and non-spatial information, and presents challenges in determining an overall rating for the Monument. 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, the condition of the park warrants significant concern with an unchanging trend (Table 4.11-4). Although there are only two survey periods, cover classes are moderately broad, and reference conditions are somewhat subjective, confidence in the assessment is high due to the comprehensive nature of the monitoring protocol.

Table 4.11-4. Condition assessment summary for invasive/exotic species at Homestead National Monument.

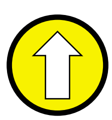
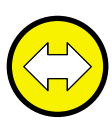
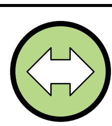
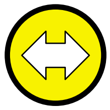
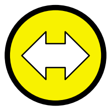
Indicator	Condition Status/Trend	Rationale
Frequency		One IEP species is present with high frequency. Smooth brome is present throughout the Monument, may degrade the function of native grasslands.
Abundance		One IEP species (smooth brome) has an estimated cover range exceeding 25% of the total acreage of the Monument. This invasive grass may affect capability of native grasslands to recover from disturbance in a characteristic fashion.
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.

Table 4.11-4 (continued). Condition assessment summary for invasive/exotic species at Homestead National Monument.

Indicator	Condition Status/Trend	Rationale
State noxious weeds		A single Nebraska state-listed noxious weed species (*Carduus nutans*) is present with very low cover.
IEP species		The overall condition for invasive exotic plants warrants moderate concern, with an unchanging trend; confidence in the assessment is high.

4.11.5. Uncertainties and Data Gaps

The available data reflects intensive surveys covering all areas of the park and addressing park-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. Mesic Bur Oak Forest and Woodland Community

4.12.1. Background and Importance

At acquisition in 1936, approximately 60 ac of forest and woodland occurred along Cub Creek at Homestead National Monument, remnants of a bur oak wooded community that was recorded occurring on the site in the Public Land Office survey of 1857 (Kindscher et al. 2011). Historically, this riparian forest was likely dominated by bur oak (*Quercus macrocarpa*) (Rolfsmeier 2007).

Prior to establishment of the park, the southern portion of the 100-yr floodplain had been heavily cut over (Figure 4.12-1). The cut area had some small oaks, but was described as denuded (Shevlin 1939). The condition was attributed to frequent fires from burning off adjacent fields, timbering, and grazing. Shortly after the park was established, approximately 10,000 *Quercus macrocarpa* (bur oak) and *Celtis occidentalis* (hackberry) saplings were planted in the cut over area (Mlekush & DeBacker 2003).

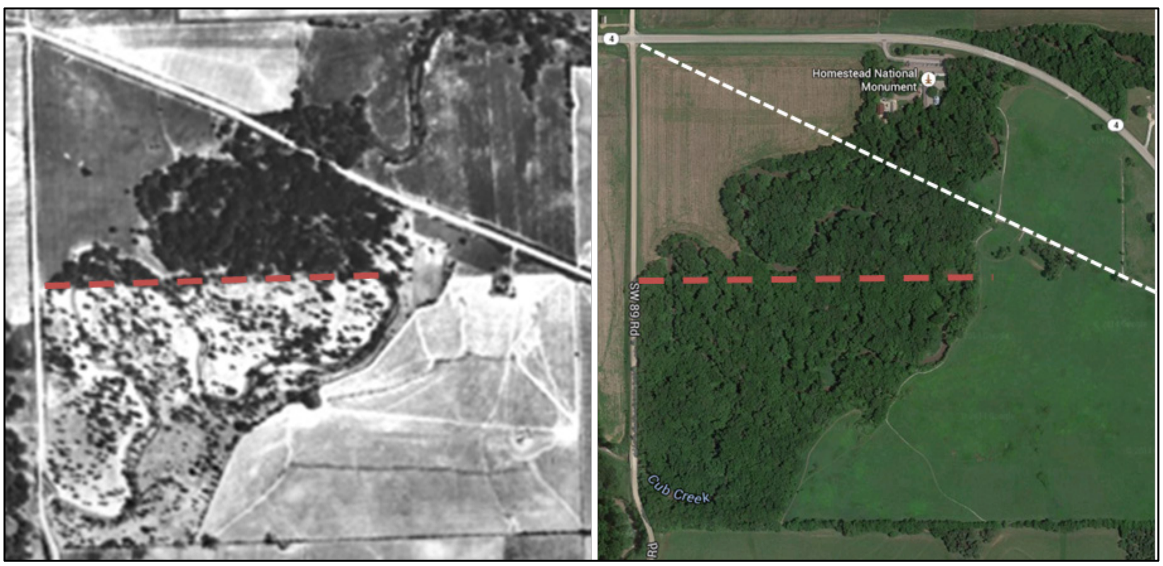


Figure 4.12-1. Area occupied by bottomland forest along Cub Creek. Aerial photo from 1937 (left) showing the area that was cut below the dashed line prior to creation of the park and 2013 image (right) showing the same area. The cut line from the 1930s (coarse dashed line) and the old freight road alignment (fine dashed line) are shown for reference. Historic photo provided by Homestead National Monument; 2013 image from ArcGIS.

The remnant bur oak vegetation community having large, old bur oaks in the northern section of the Cub Creek bottom was initially noted during 2002 field data collection by the Heartland I&M program (Mlekush & DeBacker 2003), and was subsequently documented and described in detail by Rolfsmeier and Steinauer (2010), who called it Mesic Bur Oak Forest and Woodland. Although this community is not explicitly included in the National Vegetation Classification System (NVCS) (usnvc.org), the concept most likely would be placed within the *Quercus macrocarpa – Corylus* spp. / *Carex* spp. Woodland Group (Great Plains Oak Woodland) and may share characteristics with the *Quercus macrocarpa / Cornus drummondii / Aralia nudicaulis* Forest Association (CEGL002072)—

a more closed canopy—and the *Quercus macrocarpa / Andropogon gerardii – Panicum virgatum Woodland Association* (CEGL002052) – a more open canopy (Rolfsmeier and Steinauer 2010).

The lowland mesic bur oak community is ranked critically imperiled (S1) in Nebraska. It has a NatureServe Global Conservation Status of G2 (Imperiled—At high risk of extinction due to very restricted range, very few populations (often 20 or fewer), steep declines, or other factors) and G3 (Vulnerable—At moderate risk of extinction due to a restricted range, relatively few populations (often 80 or fewer), recent and widespread declines, or other factors). Its ranking reflects the very high risk of extirpation or elimination due to extreme rarity (often 5 or fewer occurrences), very steep declines, or other factors. The Homestead National Monument stand within the Cub Creek floodplain is considered the best-preserved example of this community in Nebraska. Other representative occurrences are known from Lancaster, Pawnee, and Richardson counties (Rolfsmeier and Steinauer 2010).

As a distinctive and rare community, the lowland mesic bur oak community has been identified as an important element of the park. The desired future condition statement in the HOME *Vegetation Management Action Plan* (NPS 2004) speaks to this community and its importance: "The monument's natural resources are managed in such a way as to maintain a heterogeneous landscape composed of a mosaic of high quality remnant and restored tallgrass prairie, lowland bur oak forest and associated ecotones, as well as prairie streams and their hydrologic processes; that reflect the value of the site as a homestead, represents as accurately as possible the environment encountered by early settlers, and preserves native biodiversity." (NPS 2004).

Vegetation inventory and mapping by Kindscher et al. (2011) classified the Cub Creek wooded bottoms into two NVCS classes that were mapped individually (Figure 4.12-2). Woodland/forest dominated by bur oak was classified as Western Tallgrass Bur Oak Woodland (Scientific Name: *Quercus macrocarpa / Andropogon gerardii – Hesperostipa spartea* Woodland Association, or Bur Oak / Big Bluestem – Porcupine Grass Woodland, CEGL002053). Kindscher et al. acknowledge that the bur oak woodland community type assigned to HOME uses a broader NVCS type than that presented in Rolfsmeier and Steinauer (2010). The broader concept was likely applied to accommodate the range of variability observed within the mapped class. The remainder of the Cub Creek bottomland was mapped as "Successional Forest" and classified as Central Green Ash – Elm – Hackberry Forest (*Fraxinus pennsylvanica – Ulmus* spp. – *Celtis occidentalis* Forest Association, CEGL002014).

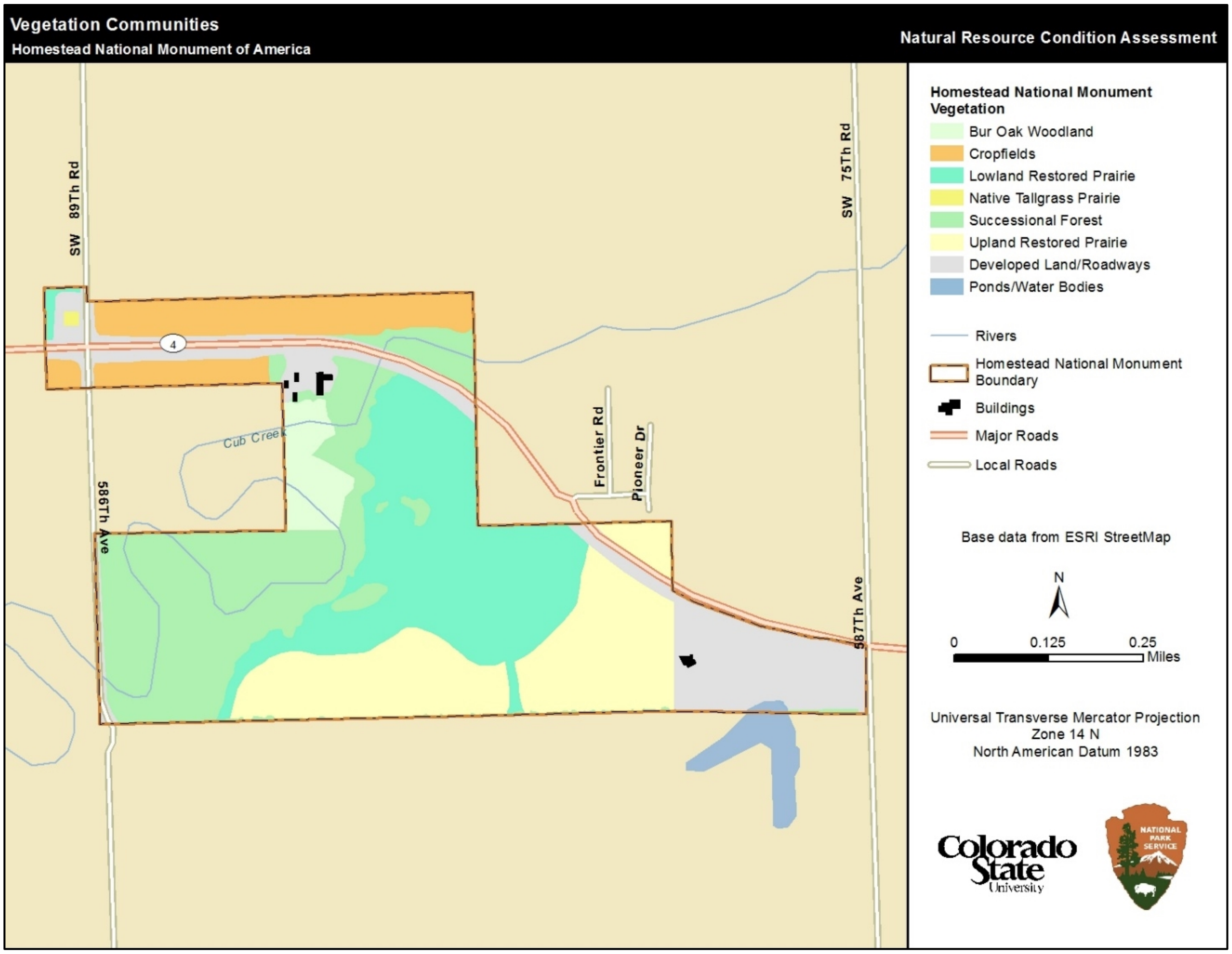


Figure 4.12-2. Vegetation communities mapped by Kindscher et al. (2011), showing the location of bur oak woodlands south of the administrative complex and north of the pre-acquisition cut line.

<u>Current Vegetation of the Cub Creek Forest and Woodlands</u>[2]

The 60 ac of wooded vegetation at Homestead National Monument primarily represents a closed-canopy forest that has been subject to varying degrees of logging, grazing, fire, and other disturbances since settlement. Some areas within the northern half of the site are relatively undisturbed. In the highest-quality portions of the site, the canopy is dominated by large spreading-crowned bur oaks about 60 ft. tall, with scattered large cottonwoods (*Populus deltoides*) and honey-locust (*Gleditsia triacanthos*) among them. A well-defined subcanopy is presently consisting mostly of hackberry (*Celtis occidentalis*) and slippery elm (*Ulmus rubra*) with silver maple (*Acer saccharinum*) conspicuous in lower places, especially along the stream banks (Figure 4.12-3). A short shrub layer of coralberry (*Symphoricarpos orbiculatus*) is frequently present, with an

[2] Description excerpted from Rolfsmeier (2007)

herbaceous layer dominated by wood nettle (*Laportea canadensis*), sedges (*Carex* spp.), wingstem (*Verbesina alternifolia*) and early wildrye (*Elymus macgregorii*).

Although they are prominent in some patches, bur oaks are not dominant throughout the canopy of the north portion. Immediately along the stream, oaks are absent and the dominant trees include a few large cottonwoods and some tall hackberry and black walnut (*Juglans nigra*). These areas also contain a ground layer with conspicuous patches of stinging nettle (*Urtica dioica*) and Jerusalem artichoke (*Helianthus tuberosus*).

The outer margins of the forest along the prairie margin also lack the characteristic bur oak canopy and are dominated by small to medium trees of hackberry, green ash (*Fraxinus pennsylvanica)*, honey-locust, American elm (*Ulmus americana*), and white mulberry (*Morus alba*). The herbaceous understory along the perimeter includes much Virginia wildrye (*Elymus virginicus*) and a lesser amounts of wood nettle and wingstem than are present under the oak canopy.

Figure 4.12-3. Shading, deer browsing, and infrequent fire favors increasing dominance by more mesic species such as elms (*Ulmus americana* and *rubra*), hackberry (*Celtis canadensis*), honey-locust (*Gleditsia triacanthos*) and ash (*Ulmus pennsylvanica*), which constitute the subcanopy in much of the Cub Creek bottom. CSU Photo.

The south portion of the forest was extensively logged prior to the establishment of the monument. At present, it has a 40–50 ft. high woody canopy dominated by hackberry and honey-locust, with a few large cottonwoods. Bur oak is present but large old bur oaks are absent (Kindscher et al 2011). The subcanopy and shrub layers are more poorly developed in this area, and the herbaceous understory is evidently less diverse (Mlekush & DeBacker 2003).

Quantitative sampling in 2002 revealed hackberry to be the most abundant tree in terms of basal area, followed by bur oak, green ash, white mulberry, slippery elm and black walnut. Hackberry was also by far the most abundant tree seedling and sapling encountered, followed by elms, bur oak, eastern red cedar (*Juniperus virginiana*) and honey-locust. Broadleaf herbs constitute the bulk of the herbaceous cover in the understory, with fall-flowering species such as wood nettle, stinging nettle, and wingstem most abundant. Among the ten most abundant non-tree species listed in the 2002 survey, three were vines (Virginia creeper (*Parthenocissus quinquefolia*), greenbrier (*Smilax hispida*), and poison ivy (*Toxicodendron radicans*). The herbaceous understory species with the largest mean cover values include wood nettle, stinging nettle, catchweed bedstraw (*Galium aparine*), wingstem, sedges, nodding fescue (*Festuca subverticillata*), Pennsylvania pellitory (*Parietaria pensylvanica*), Virginia wildrye, and violets (*Viola* spp.). A list of 116 species observed in the Cub Creek woods is included in Mlekush & DeBacker (2003).

Threats and Stressors

Historic land uses have resulted in the loss of mesic bur oak woodlands within the region and locally in the vicinity of HOME. Historic cutting and removal of bur oak as valuable fuel and timber species and conversion of bottomland sites to agriculture are the primary historic factors leading to the scarcity of the type. Contemporary threats to mesic bur oak woodlands at HOME include:

1. Invasion by exotic plant species;
2. Homogenization of the forest from increasing dominance by mesic eastern bottomland tree species;
3. Infrequent fire return interval, which exacerbates previously-listed threats;
4. Altered flooding and hydrological regime; and
5. Deer overabundance and resulting browsing pressure effects on tree regeneration.

Indicators and Measures

- Extent of vegetation at HOME classified as bur oak bottomland woodland
- Structure and composition of Cub Creek bottomland woodlands
- Disturbance regime of bottomland woodlands

4.12.2. Data and Methods

Available data to assess the condition and trend of the mesic bur oak community at HOME include historic aerial photographs; structural and floristic forest inventory data from the *Forest Inventory of Vascular Plants at Homestead National Monument of America and Annual Plant Community Monitoring Results, 2002* (Mlekush and Debacker 2003); and qualitative descriptions of the HOME stand relative to the broader community type within the region presented in *Homestead National Monument of America Bur Oak Forest Restoration Plan: Reference Condition and Management Considerations* (Rolfsmeier et al. 2007). The Mlekush and Debacker (2003) report summarized results for two long-term monitoring sites established randomly within the HOME bottomland forest in 2002. The Rolfsmeier report integrated data from the two plots to help characterize the current stand and discuss potential implications of past land uses and deviations from presettlement conditions. Vegetation classification and mapping of the park by Kindscher et al. 2011 was an additional source of plot data, classified and mapped the vegetation communities present, and described the mapped types in relation to the USNVC.

4.12.3. Reference Conditions

The reference condition for the lowland bur oak forest along Cub Creek was explored in depth by Rolfsmeier (2007). He describes several possible reference sites in Nebraska and Kansas, and describes a possible reference condition for the bur oak woodland at HOME:

> "The oak-wooded areas were probably patchy and varied in canopy cover. Overall they probably constituted open woodland with a canopy coverage of 40–67%, with some areas in the interior more shaded and approaching forest, with a canopy cover of > 67%. Bur oaks were the dominant tree, though American elm and black walnut may have formed a tall subcanopy and possibly also a short subcanopy after settlement. Hackberry may have become part of a short subcanopy after a time, but was probably not conspicuous in the 1860's. Slippery elm (*Ulmus rubra*) may also have been present, but honey-locust was probably absent at that time.
>
> Along the margins and in openings tall shrubs and perhaps some short trees would have been found. Wild plum was almost certainly present, with chokecherry also possible. Vines such as riverbank grape (*Vitis riparia*), Virginia creeper, greenbrier, and poison-ivy probably occurred with the shrubs. In the more shaded areas, a short shrub layer of coralberry and gooseberry was likely present, though were probably not especially dense due to occasional fire (probably < 25% cover). Herbaceous species in the shaded areas were probably similar to those found in less disturbed portions of the forest at present. In the openings, some forb species tolerant of shade (such as goldenrods [*Solidago* spp.]) may have been present as well."

This community occurs near floodplains. The herbaceous stratum can be similar to dry prairie and may support a variety of warm-season grasses and prairie forbs. Periodic fires kept the canopy from closing, and disruption of the fire regime may result in succession to other, more closed oak types (Lauver et al. 1999, Steinauer and Rolfsmeier 2000).

A qualitative framework for evaluating the condition of each indicator was developed (Table 4.12-1). Although the sparse quantitative data available within the Cub Creek bottom does not capture the range of variability among and within the forest types present, it has proved valuable in allowing vegetation structure and composition to be described. The framework relies heavily on the community type descriptions published in Rolfsmeier and Steinauer (2010), NatureServe (2016), Rolfsmeier (2007), Mlekush and Debacker (2003) and Kindscher et al. (2011) and may be refined over time as additional quantitative data are available and ecological thresholds are examined.

Table 4.12-1. Reference condition rating framework for bur oak woodland indicators at HOME.

Indicator	Good Condition	Warrants Moderate Concern	Warrants Significant Concern
Community extent	Acreage of the mesic bur oak community type has expanded measurably since HOME was created.	The acreage of the type has remained relatively static since acquisition.	The acreage of the type has measurably declined over time.
Vegetation structure and composition	Presettlement condition is estimated to be variable but generally consisting of an open to closed woodland with the canopy dominated by bur oak. Some tall subcanopy (American elm and black walnut) may have been present but a lower subcanopy would have been poorly developed. Low shrub cover may approach 25% in shady areas. The herbaceous layer is relatively diverse and can be similar to dry prairie with warm season grasses and prairie forbs. Invasive plants are not present.	Tree canopy cover is generally > 60% and there are few openings. Bur oak is subdominant in most areas and the canopy is dominated by hackberry, green ash, white mulberry, elms and black walnut. The subcanopy layer is pronounced. The seedling and sapling layers include some bur oak, but other species such as hackberry, elms, eastern red cedar and honey-locust are more common. The short shrub layer is more extensive on well-drained areas. The herbaceous understory has moderate to low diversity. Some invasive woody and herbaceous plants may be present.	This is a true closed forest with less variability and diversity. Bur oak is absent or uncommon and the canopy is dominated by hackberry, green ash, white mulberry, elms and black walnut. The seedling and sapling layers include species such as hackberry, elms, eastern red cedar and honey-locust are more common. The herbaceous understory has relatively low diversity. Invasive plants are common.
Disturbance regime/agents	• Relatively frequent fire return interval maintaining an open canopy and controlling seedlings and shrubs. • Frequent flooding and associated high water table and sediment deposition. • Tree seedling regeneration is not heavily impacted by deer browsing.	• Relatively infrequent fire return interval allows increasing canopy closure and increase in seedlings and shrubs. Prairie fires are suppressed at the forest edge. • Infrequent flooding, incised stream channel, lowered water table. • Tree seedling regeneration is moderately impacted by deer browsing.	• Very infrequent fire return interval promotes a homogeneous closed canopy, shade-tolerant tree understory and woody shrub layer. • Very infrequent flooding, incised stream channel, lowered water table. • Tree seedling regeneration is heavily impacted by deer browsing.

4.12.4. Condition and Trend

<u>Community Extent</u>

When HOME was created in 1936, approximately 60 ac of forest and woodland occurred along Cub Creek. The logging that occurred in the southern portion of the woodland shortly before acquisition is clearly evident from aerial photography from 1937 (Figure 4.12-1) and first-hand accounts. Based on recent characterization and mapping of the mesic bur oak community type, which by definition is dominated by bur oak and contains large old bur oaks, the remnant forest is confined to the original uncut area north of the 1930s cut line and south of Park Headquarters. This area was mapped by Kindscher et al. (2011) as a single polygon 7.4 ac in size. The successional forest type occupies 54.3 ac, and extends to the north and south portion of the Cub Creek bottom as well as along the eastern edge of the bur oak forest along the prairie margin. Because of the historic removal of bur oaks prior to acquisition, even with additional management efforts to remove undesirable trees, promote bur oak regeneration, and minimize invasive competition, it will take decades for the existing younger bur oaks in the successional forest to gain canopy dominance and large size. Therefore, this type has not likely changed in its extent since the park was created. However, it is anticipated that the acreage will increase over time through active restoration practices. Community extent is assigned a moderate concern rating with an improving trend.

Location of documented large bur oak trees (pink dots lower left) within the remnant stand (Mlekush and DeBacker 2003)

Vegetation Structure and Composition

Within the 7.4 ac mapped as bur oak woodland, forest structure and composition is variable (Kindscher et al. 2011). Some areas have a higher dominance of bur oak in the canopy, larger trees, and variable subcanopies, shrub layers and herbaceous components. Lack of fire within high-quality and low quality areas of bur oak woodlands will favor a more closed canopy, changes in species composition, and less dominance by bur oak. The canopy within the bur oak areas and the successional forest tend to have canopy closure greater that 60–70%. Both interior shaded areas and edges colonized by mesic hardwoods have become altered floristically. Although there is little data available, it seems there is little regeneration of bur oak seedlings within the floodplain. Rolsfsmeier (2007) notes that there is little bur oak regeneration, that deer are impacting the vegetation structure of the forest, and that deer browsing represents the greatest threat to protecting the biodiversity of the site.

Invasive plant species known or somewhat likely in this community include garlic mustard (*Alliaria petiolata*), common burdock (*Arctium minus*), Japanese barberry (*Berberis thunbergii*), ground-ivy (*Glechoma hederacea*), dame's-rocket (*Hesperis matronalis*), Amur honeysuckle (*Lonicera maackii*), Tartarian honeysuckle (*L. tatarica* and hybrids), common buckthorn (*Rhamnus cathartica*), multiflora rose (*Rosa multiflora*), and highbush cranberry (*Viburnum opulus*). Osage orange (*Maclura pomifera*), reed canarygrass (*Phalaris arundinacea*), and white mulberry (*Morus alba*) are highly invasive exotic plants that have become established in riparian forests at HOME (Young et al. 2010). In 2010, one small patch of garlic mustard was detected in the Cub Creek woodland and pulled. That same year a comprehensive search by park and Heartland Network staffs failed to find any additional plants (Short et al. 2010). Nonetheless, there is concern that this invasive species could become established within the park (J. Bolli personal comment, 2016).

Results from park-wide invasives monitoring is discussed in Section 4.11. Management actions such as treatment of invasive plants and removal of understory trees generally have been successful based on data from 2006–2009 (Young et al. 2010). Eleven "invasive exotic plants" (IEPs) were found park-wide in 2009. Of these, five species occurred in search units within the Cub Creek bottom (Figure 4.12-4).

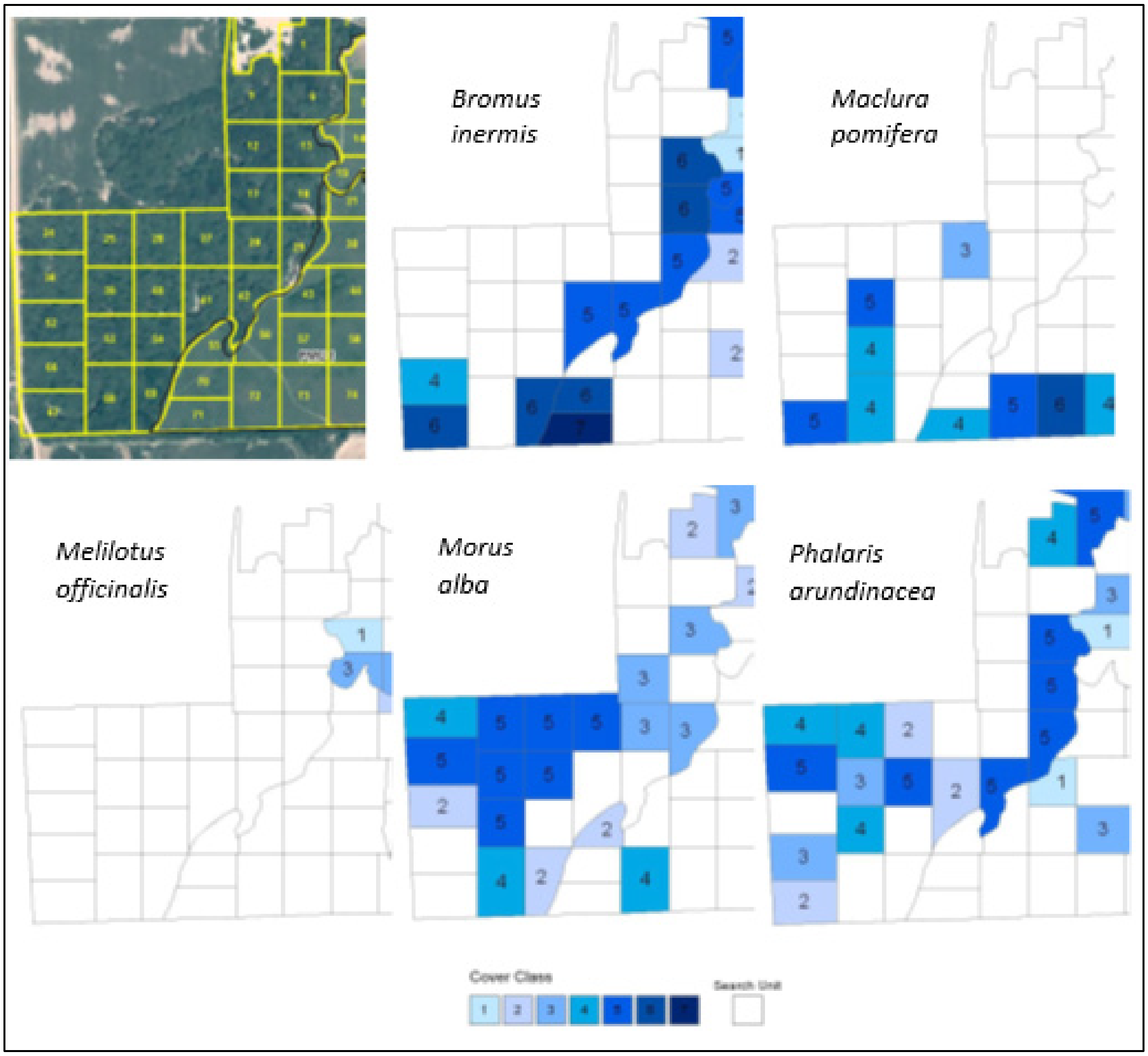


Figure 4.12-4. Abundance and distribution of invasive exotic plants occurring in Cub Creek woodlands in 2009 at Homestead National Monument of America. Cover classes are as follows: 1=0.1–0.9 m², 2=1–9.9 m², 3=10–49.9 m², 4= 50–99.9 m², 5=100–499.9 m², 6= 499.9–999.9 m², and 7 ≥ 1,000 m² (data and graphics from Young et al. 2010). For reference, the invasive exotic plant search units overlaid on an image showing forest vegetation is shown at upper left.

Osage orange (*Maclura pomifera*), reed canarygrass (*Phalaris arundinacea*), and white mulberry (*Morus alba*) are management concerns due to their invasiveness. Within the Cub Creek search units between 2006 and 2009, Osage orange was eradicated in some search units and had reduced abundance in others. The abundance of both white mulberry and reed canarygrass was significantly reduced in the mapped bur oak community but its extent and abundance generally increased in the southern portion of the successional forest. Using available descriptive information, the condition of the mesic bur oak woodland warrants moderate concern with a deteriorating trend. Prairie fires are controlled at the prairie edge. Despite some successes with invasive plant management, lack of fire in the system will likely overwhelm other management efforts over the long term.

Disturbance Regime

We consider fire regime, deer browsing, and flooding/hydrologic regime as the primary disturbance agents. Invasive plants are addressed above.

There is no prescribed or wildland fire occurring in the mesic bur oak forest or the successional forest portion of Cub Creek bottom. This has resulted in invasion by native and nonnative species and dominance by mesic hardwood tree species despite considerable presence of bur oak in the successional forest (Kindscher data).

Excessive deer browsing has been noted as a stressor on the bur oak community (Rolfsmeier et al. 2007, Mlekush and Debacker 2003). Deer populations are much higher than during presettlement times. Although ecological effects of excessive deer browsing are well documented in the Great Plains and eastern U.S., the impact of deer browsing on bur oak regeneration or on tree regeneration and stand structure in general has not been examined at HOME.

Hydrology and stream characteristics of Cub Creek are discussed in Section 12.4, Stream Hydrology and Geomorphology. The stream was rated nonfunctional using PFC methodology and was assigned a CEM stage 3 channel with incised streambed and failing banks. Stressors to Cub Creek functioning may include development and agriculture within the watershed affecting impervious surfaces, stream flows, and hydrologic response to precipitation events; upstream ponds, sediment-control and flood-control structures that alter flow seasonality, amounts and sediment loads; historic degradation of stream stability resulting in channel incision, headcutting and slumping resulting in continued channel and bank instability and accelerated erosion; climate change may increase the incidence of extreme runoff events, which may impact stream condition and recovery.

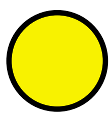
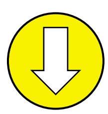
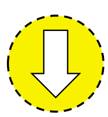
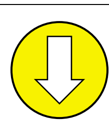
Flooding of the Cub Creek bottoms was documented in 1950 (October), 1957 (June), 1963 (June), 1968 (August), and 1982 (June) (Sutton et al. 1984). In addition to periodic flooding from upstream inputs, Cub Creek backs up from the confluence and floods one or more times per year at HOME when discharge is high in the Big Blue River. There continues to be periodic flooding of the floodplain, although the stream has become incised and groundwater levels are likely lower than at the time of settlement. Water availability for bur oaks at HOME was examined by Chimner and Resh (2010). The authors concluded that the river has become incised, which is a common condition for streams in the region. During the study period from 2007 to 2009, the depth to groundwater averaged approximately 7 m (22 ft) below the soil surface. They found that mature bur oaks at Homestead use deep groundwater sources, and are unlikely to be affected hydrologically by the current regional downcutting of the river. However, the authors note that downcutting and alteration of flooding regime can have major effects of floodplain vegetation communities and tree regeneration. Because stream downcutting and altered flooding regimes are linked to broad landuse patterns and disturbance, it is highly unlikely that the stream hydrology could be restored.

Based on available information, the disturbance regime factors associated with the mesic bur oak forest warrant moderate concern. Lack of fire is heavily weighted in this assessment.

Overall Condition

The results indicate that the condition of the mesic bur oak community warrants moderate concern (Table 4.12-2). Forest structure resembling the reference condition exists only in some portions of the mapped type. The canopy is closing, the abundance of other mesic tree species is increasing, large overstory bur oaks are uncommon and bur oak regeneration is impacted by deer browsing. The current forest community has been heavily impacted by past land uses and lack of fire, and the prospects for improved extent and condition of the community may be limited by continued lack of fire, land-use-driven changes to stream hydrology, impacts of deer browsing, and impacts of invasive exotic plants.

Table 4.12-2. Condition assessment summary for mesic bur oak forest and woodland community at Homestead National Monument of America.

Indicator	Condition Status/Trend	Rationale
Vegetation Community Extent		The remnant mesic bur oak forest appears to be confined to the original uncut area north of the 1930s cut line and south of Park Headquarters. This area was mapped by Kindscher et al. (2011) as a single polygon 7.4 acres in size. The successional forest type extends to the north and south portion of the Cub Creek bottom as well as along the eastern edge of the bur oak forest along the prairie margin. Lack of fire does not promote this type. Even with additional management efforts to remove undesirable trees, promote bur oak regeneration, and minimize invasive competition, it will take decades for the existing younger bur oaks in the successional forest to gain canopy dominance and large size needed to characterize the mesic bur oak woodland.
Vegetation Structure and Composition		The canopy within the bur oak areas tends to have canopy closure greater that 60–70%. Both interior shaded areas and edges colonized by mesic hardwoods have become altered floristically. Management actions such as treatment of invasive plants and removal of understory trees has been generally successful based on data from 2006–2009. Invasive exotic plants are being managed with some success. Non-oak tree succession, lack of fire and pressure from invasives will likely lead to a decline in desired structure and composition over time (low confidence on this trend).
Disturbance Regime		Periodic fire is thought to be a significant natural process that helps shape this community. A complete lack of fire in the system will make it extremely difficult to reach restoration goals and to maintain the remnant bur oak stand over the long term. The river is incised and the flooding regime has been altered—this regime may primarily impact bur oak regeneration. The impacts of deer browsing on this community at HOME are not documented but appear to be significant.
Mesic Bur Oak Woodland overall		The condition of the bur oak woodland community warrants moderate concern, with a deteriorating trend and a medium level of confidence.

4.12.5. Uncertainty and Data Gaps

The mesic bur oak community type is rare within Nebraska and the stand at HOME is considered perhaps the best example within the state. There is a foundation of descriptive work and floristic surveys, but little vegetation monitoring has been completed within the remnant older forest or the younger successional forest. Only several quantitative field plots have been established and sampled during the past 15 years, which includes the vegetation classification and mapping project. The impacts of altered flooding regimes and excessive deer browsing are not well understood for this type at HOME. The re-introduction of fire to the mapped bur oak type and the successional forest type would likely promote ecosystem restoration goals, in concert with deer control, continued invasive plant management, forest thinning and reintroduction of desirable species (Rolfsmeier 2007).

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4.13. Aquatic Macroinvertebrates

4.13.1. Background and Importance

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

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.

The various anthropogenic disturbances described in the following section have a significant potential for disrupting the ecological integrity and functioning of the Cub Creek ecosystem. Due in part to these disturbances, the National Park Service (NPS) began monitoring the aquatic macroinvertebrates of Cub Creek beginning in 1989 (Bowles and Clark 2012). From 1992–1995, the NPS Midwest Regional Office funded additional aquatic invertebrate sampling efforts within the creek. However, sampling was infrequent and collection mostly occurred outside the primary season of interest (summer) for this report. Intensive monitoring efforts began in 1996–1997 after the creation of the Prairie Cluster Prototype Long-term Ecological Monitoring Program, which is now known as the Heartland Inventory and Monitoring Network and Prairie Cluster Prototype Monitoring

Program. Peitz and Cribbs (2005) reported on the condition of the aquatic invertebrate community at HOME from 1989 through 2004, and Bowles (2009) reported on status and trends for 2005 to 2007. After the 2007 monitoring season, sampling frequency was decreased from three times every year to once every three years so that more parks within the network could be sampled (Bowles et al. 2008). This assessment examines the data collected at HOME from 1996 to 2011 and determines condition status and trends for individual aquatic invertebrate indicators and overall condition of the Cub Creek ecosystem.

Threats and Stressors[3]
The NPS previously reviewed water quality data (1960–1997) for Cub Creek in the general area of HOME (NPS Water Resources Division 1999). The review reported that water quality in Cub Creek had been adversely impacted by human activities. Potential anthropogenic sources of pollutants in Cub Creek include municipal and industrial wastewater discharge, agricultural practices, quarrying, storm-water runoff, and recreational use. Dissolved oxygen, pH, cadmium, copper, lead, and zinc all exceeded their respective EPA criteria for the protection of freshwater aquatic life (NPS Water Resources Division 1999). Chemical pollutants including nitrates, beryllium, cadmium, chromium, lead, nickel, bis (2-ethylhexyl) phthalate, and atrazine also exceeded their respective EPA drinking water criteria. Fecal-indicator bacteria concentrations and turbidity have also exceeded the NPS Water Resources Division screening limits for freshwater bathing and aquatic life, respectively. The turbidity levels measured at Cub Creek were greater than 140 NTU. Pollutants in runoff and sedimentation typically have detrimental effects on less pollution tolerant aquatic invertebrate species. Although streams of the Great Plains region historically had seasonally turbid flows, agricultural practices over the past 150 years have degraded many small, perennial streams, such as Cub Creek, into constantly turbid streams to the detriment of their resident faunas (Rabeni 1996).

Indicators and Measures

Richness and Diversity

- Taxa richness
- Taxa evenness
- EPT richness
- Shannon index

Pollution Tolerance

- Hilsenhoff biotic index (HBI)

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[3] Adapted from Bowles and Clark 2012.

4.13.2. Data and Methods

Since 2005, methods and procedures used for sampling aquatic macroinvertebrates at HOME follow Bowles et al. (2008). For sampling procedures prior to 2005, see Peitz and Cribbs (2005).

Five Hester-Dendy multiplate samplers (0.09 m^2; 9.6 ft^2) were used at each of two sampling sites on Cub Creek. Hester-Dendy samplers were placed in the stream for approximately 30 days, retrieved, and field processed by HOME staff. Samples were then sorted in the laboratory following a subsampling routine described in Bowles et al. (2008), and taxa were identified to the lowest practical taxonomic level (usually genus) and counted.

The primary interest in the analysis and interpretation of the data presented in this report is the magnitude of change rather than change per se (Bowles et al. 2008), and whether the change is thought to be biologically important. Null hypothesis significance testing in the strict sense may not be the best approach given these goals (Morrison 2007).

Data collected from 1996 to 2011 are compared with data collected in 1989. A trend analysis of invertebrate metrics data across years was conducted using a non-parametric Mann-Kendall trend test (α=0.10) (Time Trends software, version 3.0, NIWA 2010). The non-parametric Mann-Kendall test is directly analogous to linear regression, but it does not assume any particular distributional form and it tests whether Y values tend to increase or decrease with time (Esterby 1993, Helsel and Hirsch 2002, Stark and Fowles 2006). Stark and Fowles (2006) recommended the Mann-Kendall test over other trend tests for the evaluation of stream invertebrate samples. The Mann-Kendall test can detect either a positive or negative trend.

4.13.3. Reference Conditions

As previously mentioned, the data collected from HOME in 1989 will be used in this report as reference values for the aquatic macroinvertebrate indicators that follow. The baseline values for diversity and pollution tolerance are listed in Table 4.13-1. Summary data from 1989–2007 for invertebrate community metrics, including taxa richness; Ephemeroptera, Plecoptera, and Trichoptera (EPT) richness; Shannon diversity index; Shannon evenness index (taxa evenness), and Hilsenhoff Biotic Index (HBI) are excerpted from Bowles (2009).

Table 4.13-1. Means for aquatic invertebrate metrics collected from Cub Creek, Homestead National Monument in 1989. n=2 (Bowles 2009).

Metric	Site Mean
Taxa richness	11.90
EPT richness	0.80
Shannon index	1.20
Taxa evenness	0.57
Hilsenhoff biotic index	7.50

4.13.4. Condition and Trend

The framework for determining resource condition ratings is shown in Table 4.13-2. These ratings are based on reference values obtained from best available data.

Metric values from sampling in 2011 are shown in Table 4.13-3. The results of Mann-Kendall tests are shown in Table 4.13-4. The results of these tests are used to determine the statistical significance of trends. Results for individual indicators generally show that most annual means did not change substantially.

Table 4.13-2. Resource condition indicator rating framework for aquatic macroinvertebrate communities at Homestead National Monument.

Indicator	Good Condition	Warrants Moderate Concern	Warrants Significant Concern
Taxa richness[1]	> 15	7–15	< 7
EPT richness[2]	> 14	8–14	< 8
Shannon index[3]	> 2.5	1–2.5	< 1
Taxa evenness	Unknown	Unknown	Unknown
Hilsenhoff biotic index[4]	0.00–4.25	4.26–6.50	6.51–10.00

[1] Bowles 2009: values for these metrics were obtained by combining the author's valuation of Pipestone Creek (used as a proxy for Cub Creek) as "mildly impaired" with values of these metrics from 1989–2007

[2] Bukantis 1998

[3] Wilhm 1970

[4] Hilsenhoff 1988

Table 4.13-3. Means for aquatic macroinvertebrate metrics collected from Cub Creek, Homestead National Monument in 2011.

Metric	Site Mean (n=10)
Taxa Richness	13.10
EPT Richness	6.20
Shannon Index	1.71
Taxa Evenness	0.67
Hilsenhoff Biotic Index	5.90

Table 4.13-4. Results of Mann-Kendall testing for statistical significance of metric trends.

Metric	τ	*P*-value
Taxa Richness	1.08	0.28
EPT Richness	0.18	0.39
Shannon Index	1.04	0.30
Taxa Evenness	-1.85	0.06
Hilsenhoff Biotic Index	-1.94	0.05

Taxa Richness

Taxa richness is calculated as the mean number of invertebrate genera present in a replicate sample. Lower taxa richness may indicate habitat or water quality impairment (Resh and Grodhaus 1983). Means for taxa richness at HOME ranged from 6.19 to 13.10 between 1989 and 2011 (Figure 4.13-1). In 2011, estimated taxa richness was 13.10, indicating that the water quality and/or aquatic habitat condition of Cub Creek may be improving. However, this trend is not statistically significant.

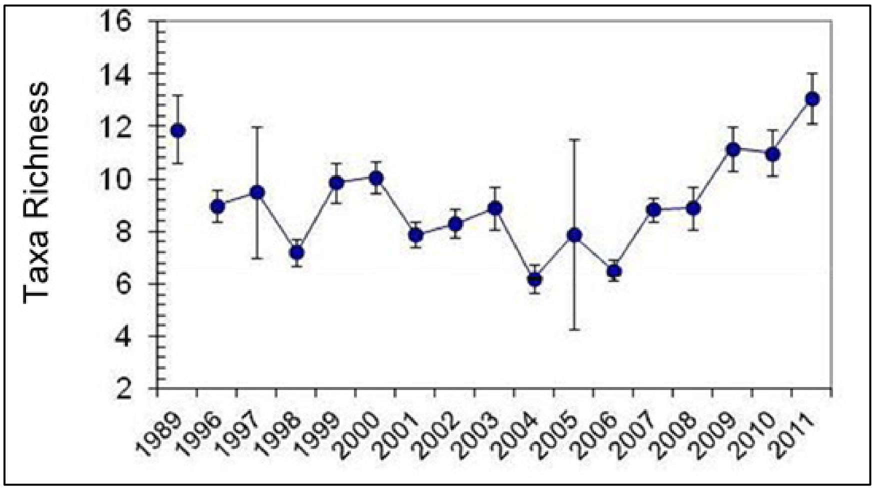


Figure 4.13-1. Yearly means and standard errors for taxa richness at Cub Creek (Bowles 2012).

EPT Richness

EPT richness is calculated as the total number of genera in the insect orders Ephemeroptera, Plecoptera, and Trichoptera (EPT). Lower richness may indicate stream impairment. Most taxa in these three orders are intolerant to pollution (Resh and Jackson 1993). Means for EPT richness at HOME ranged from 0.80 to 6.20 between the years 1989 and 2011 (Figure 4.13-2). There is no observable or statistical trend in the data.

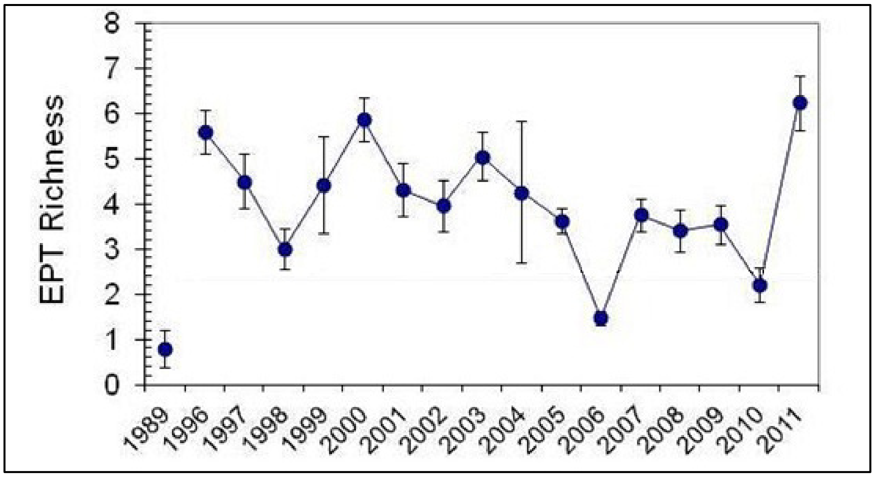


Figure 4.13-2. Yearly means and standard errors for EPT Richness at Cub Creek (Bowles 2012).

<u>Shannon Diversity Index</u>

The Shannon Index is a measure of taxa diversity that assesses how the total number of individuals in a sample is distributed among the total species in the sample. High diversity generally implies better stream condition and normally decreases with declining water quality because of reductions in both richness and evenness (Resh and Jackson 1993). Here we calculate the index using genus-level data. The calculation of this index at the family level was discontinued in 2005. Means for the Shannon Index at Homestead ranged from 0.90 to 1.71 between 1989 and 2011 (Figure 4.13-3). There is no observable or statistical trend in the data.

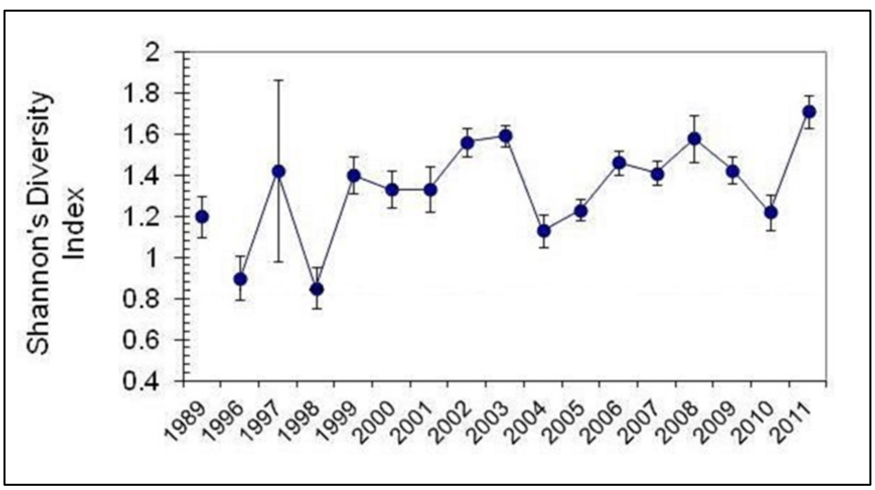


Figure 4.13-3. Yearly means and standard errors for Shannon index (genus level) at Cub Creek (Bowles 2012).

<u>Taxa Evenness</u>

Taxa evenness is a measure of how evenly the total number of individuals in a sample is distributed across genera. Lower taxa evenness may indicate that the water body has been subject to a disturbance and is being populated by fewer, pollution tolerant organisms (Peitz and Cribbs 2005).

This metric is calculated using the values of the Shannon Index. Means for taxa evenness at HOME ranged from 0.41 to 0.82 between 1996 and 2011 (Figure 4.13-4). The Mann-Kendall trend test suggests a statistically significant positive trend at the $\alpha=0.10$ level.

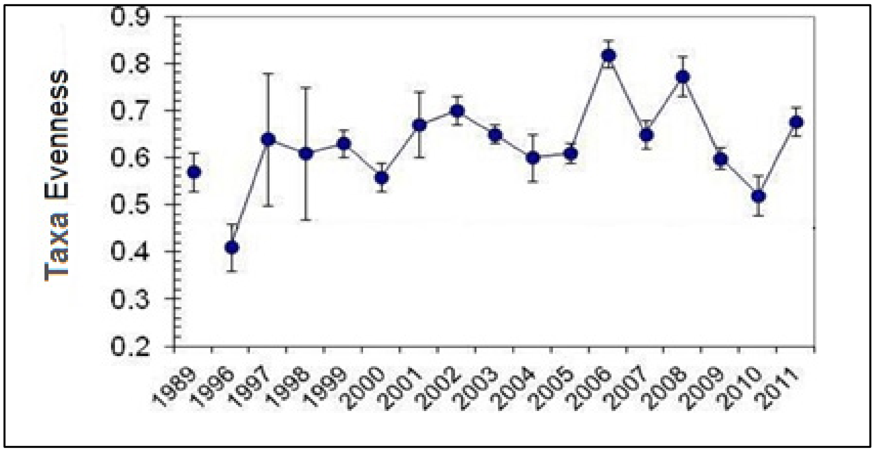


Figure 4.13-4. Yearly means and standard errors for taxa evenness at Cub Creek (Bowles 2012).

Hilsenhoff Biotic Index

The Hilsenhoff biotic index (HBI) was first developed by Hilsenhoff (1988) and subsequently modified by Hilsenhoff (1988). Each taxon is assigned a pollution tolerance value related to its assumed or known tolerance of water quality degradation. Tolerance values used in this report are adapted from Hilsenhoff (1988). HBI is an indicator of organic water pollution, such as from livestock or sewage. The HBI increases with increasing impairment.

Means for the HBI at HOME ranged from 5.90 to 7.50 between 1989 and 2011. In 2011, HBI was measured at 5.90, showing a slight decrease in this metric in the last several sample years (Figure 4.13-5). The decrease in this index may indicate a decrease in organic pollutants. The Mann-Kendall trend test suggests a statistically significant negative (decreasing impairment) trend at the $\alpha=0.10$ level.

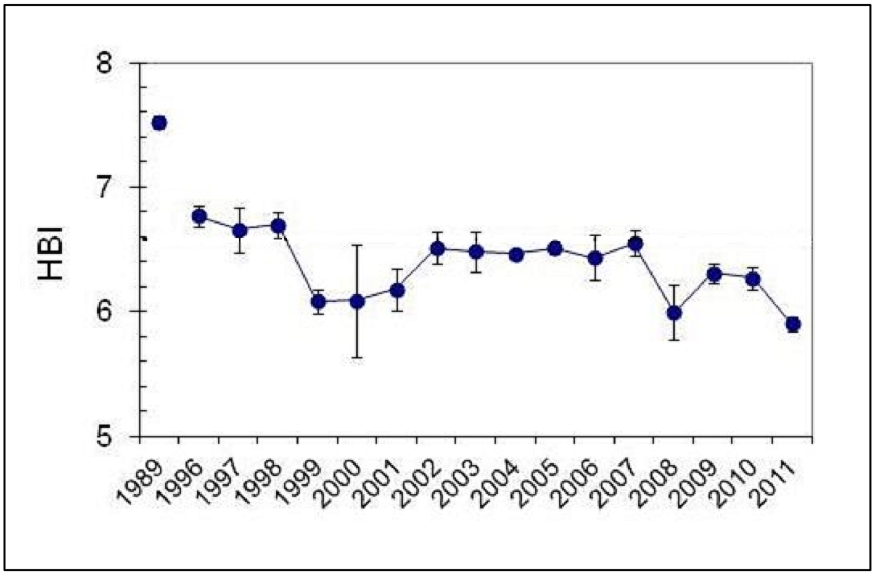


Figure 4.13-5. Yearly means and standard errors for Hilsenhoff biotic index (HBI) at Cub Creek (Bowles 2012).

Overall Condition

Based on the evaluation of aquatic macroinvertebrate metrics, condition of the resource warrants moderate concern with an unchanging trend (Table 4.13-5). Confidence in the assessment is medium. Impacts to aquatic macroinvertebrate communities appear to be largely from upstream sources that are out of NPS control.

Table 4.13-5. Condition and trend summary for the aquatic macroinvertebrate community at Homestead National Monument.

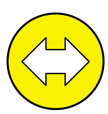
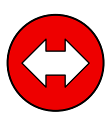
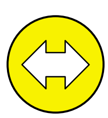
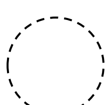
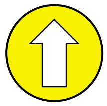
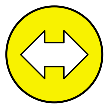
Metric	Condition Status/Trend	Rationale
Taxa Richness		There was a slight upward trend with a marked increase since 2006. However, this trend was not found to be statistically significant.
EPT Richness		Means and confidence intervals for this metric are sporadic with no trend.
Shannon Index		Means and confidence intervals for this metric are sporadic with no trend.
Taxa Evenness		Taxa evenness shows a positive trend. Current condition is unknown due to lack of availability of reference values for this metric.

Table 4.13-5 (continued). Condition and trend summary for the aquatic macroinvertebrate community at Homestead National Monument.

Metric	Condition Status/Trend	Rationale
Hilsenhoff Biotic Index (HBI)		The confidence intervals for this metric indicate that HBI was markedly higher in 1989 than it was in 2011. A decrease in this metric indicates a decrease in organic pollution. This decrease in impairment is statistically significant.
Aquatic Macroinvertebrate Community overall		Condition of the resource warrants moderate concern with an unchanging trend. Confidence in the assessment is medium.

4.13.5. Uncertainty and Data Gaps

Although indicator reference values are not generally available for Cub Creek, the use of reference values for similar systems allowed for a condition status valuation with medium confidence. The exception to this was for taxa evenness, where a low confidence was given in the assessment due to lack of a reliable reference value for this indicator.

Mann-Kendall's trend test for each metric from 1996–2011 showed that taxa evenness and HBI improved during this timeframe (Table 4.13-5). All other metrics were statistically insignificant at the α=0.10 level.

The trends for all indicators (with the exception of taxa evenness) were inferred with a robust level of certainty given the sampling range (more than 20 years) and use of the Mann-Kendall non-parametric test to provide a quantitative assessment of trend. According to NPS guidelines, when a resource or metric is not given a condition rating due to low confidence, that resource or metric should also not be given a trend due to this lack of confidence.

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4.14. Terrestrial Invertebrates

4.14.1. Background and Importance

The National Park Service (NPS) protects, preserves, and manages biological resources and related ecosystem processes within National Park boundaries. The NPS is responsible for preserving and restoring the natural abundances and diversity of animal populations within NPS units and aims to minimize human impacts to those animal populations. Grassland invertebrates are conspicuous components of prairie and grassland parks and compose an important natural resource in parks of the Heartland Inventory and Monitoring Network (HTLN). Terrestrial invertebrates enhance soil fertility, pollinate plants, control pests, and are key prey resources for other animals (Black et al. 2001, Losey and Vaughan 2006). Moreover, prairie grassland is considered one of the most endangered ecosystems in the United States with much of the prairie lost to conversion of grasslands to croplands, conversion of prairie to pasture, and to a lesser extent urbanization (Knopf and Samson 1996). Little data exists on the long-term population dynamics of grassland invertebrates within HTLN parks, but there is no doubt that they have been impacted by landscape changes since the early 20th century (Kimberling et al. 2001). Worldwide, one in five of the world's invertebrate species is threatened with extinction. The greatest threat is to freshwater and terrestrial invertebrates (Collen et al. 2012). Terrestrial invertebrates are often overlooked in management decisions, especially with regard to endangered species (Black et al. 2001).

Terrestrial invertebrates are also excellent indicators of environmental condition because they are ubiquitous; diverse; ecologically important as decomposers, predators, parasites, herbivores, and pollinators; and they respond rapidly to both natural and human induced environmental change (Kimberling et al. 2001, Gerlach et al. 2013). Because of their sensitivity as bioindicators, monitoring terrestrial invertebrates could help the Park Service understand the impacts and effectiveness of management actions on the preservation and restoration of the natural abundances and diversity of animal populations within national parks.

NPS lands provide some of the least impacted prairie habitat remaining in the Midwest, and grasslands at HOME offer quality habitat for native invertebrates. Terrestrial invertebrates are not specifically mentioned in the park's *General Management Plan* (NPS Midwest Regional Office 1999). Because of the rarity of non-agricultural lands in the region, HOME is especially valuable because it provides 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 Monument will negatively impact populations of some invertebrates resident to HOME, particularly intolerant species that have evolved within stable environments (Knopf and Samson 1996). Terrestrial invertebrate community composition and diversity should improve with restoration projects and the appropriate management of prescribed burns both within HOME and within the surrounding landscape (Kimberling et al. 2001).

<u>Threats and Stressors</u>

The major threat to terrestrial invertebrates within the grassland parks of the HTLN is habitat loss caused by development and agriculture. Prairie habitat throughout the Great Plains has been lost or fragmented by agricultural and urban development. Much of the area surrounding HOME has been cleared for agriculture and some areas have been developed for urban, commercial and industrial uses. Invertebrates are also likely impacted by pesticide use in the region and adjacent to the park.

Approximately 12% of the terrestrial invertebrates worldwide may be threatened by climate change (Collen et al. 2012). The impacts of this emerging threat have only recently been investigated in many invertebrate species and the true percentage is probably considerably higher. Therefore, improved ways of identifying those species at high risk of extinction or decline due to the impacts of climate change are needed (Foden et al 2009).

Indicators and Measures

- Native species richness (S)

4.14.2. Data and Methods

In 1983, Neil Dankert conducted an extensive qualitative survey of terrestrial invertebrates at HOME. He sampled all habitat types on the Monument to maximize the number of species found. Although the 1983 data are available, no report is available on the sampling effort nor is there any information on the sampling methods employed during the survey. Information for HOME insects from the NPS Museum Collection, extracted and provided by NPS staff in 2015 using the ANCS+ collections management system, contained 455 specimens, of which 284 were identified to family level and 171 were identified to species level. Some taxa had multiple collection records. The ANCS+ data was simply a list of taxa and did not include additional data about the collections. Therefore, the Dankert survey data is used to assess the status of terrestrial invertebrates at HOME.

4.14.3. Reference Conditions

There are no historical data against which to compare Dankert's results. However, diversity of the terrestrial invertebrate fauna at other prairies in the region can serve as a general reference benchmark. A list of terrestrial arthropods developed at the Konza Prairie Long-term Ecological Research (LTER) Site was identified as a reference benchmark. It is one of the best examples of remnant prairie in the tallgrass prairie region, and has been actively managed to emulate natural processes and dynamics. The Konza Prairie LTER list of terrestrial arthropods catalogued between 1977 and the present contains a total of 1038 taxa across 114 families, approximately 600 genera, and approximately 720 species (Joern 2017). Nearly all taxa listed are to the genus level.

Given that HOME is much smaller than Konza and the area surrounding HOME is dominated by converted agricultural (e.g., row-cropped) lands, we expect that the insect diversity would be considerably lower at HOME. Given the paucity of information available, the following general condition-rating framework was developed for HOME: the resource is thought to be in good condition if the number of taxa is at least 75% of the Konza value (> 778 taxa), warrants moderate concern if the number of species is 50–75% of the Konza benchmark (519–777 taxa), and warrants significant concern if the number of species present is less than 50% of the Konza benchmark (< 519 taxa).

4.14.4. Condition and Trend

Approximately 370 species of terrestrial invertebrates were recorded in 1983 at HOME. This is approximately 52% of species recorded to date from the Konza Prairie LTER Site. No trend assessment is currently possible for this measure of condition due to the single sample period dating to over two decades ago. Changes in the condition of habitats and other factors could have changed terrestrial diversity at HOME since then. Although these results would produce a condition rating that warrants significant concern, because of the age of the data, poor documentation regarding the survey methods and effort, low confidence in the reference condition framework, and the likelihood that additional surveys would indeed find additional species, the authors are not confident assigning a condition rating to this resource (Table 4.14-1).

Table 4.14-1. Condition and trend summary for terrestrial invertebrates at Homestead National Monument of America.

Indicator	Condition Status/Trend	Rationale
Species Richness		Terrestrial invertebrate species richness documented in 1983 was approximately 52%, the taxa richness documented at the Konza Prairie LTER. Because of the age of the data, lack of more recent surveys, and uncertainties related to the reference framework, a condition rating was not assigned. Assigning a trend was not possible because only one period of sampling data was available for analysis and the data is considered incomplete.
Terrestrial Invertebrates overall		Condition and trend cannot be determined with available data.

4.14.5. Uncertainty and Data Gaps

Terrestrial invertebrate data were extremely limited for HOME. Survey data were only available for a single time period and no monitoring data were available. Additional survey work and research on regional diversity of insects is needed to better understand this resource at HOME and within a regional context.

4.14.6. Sources of Expertise

- Merrith Baughman, Chief of Interpretation and Resource Management, Homestead National Monument.
- Jesse Bolli, Resource Management Specialist, Homestead National Monument. Jesse has conducted numerous biological surveys at HOME including monitoring surveys for aquatic macroinvertebrates.
- David Bowles, Heartland I&M Network. Mr. Bowles provided helpful technical reviews and input to reference condition discussions.

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4.15. Bird Community

4.15.1. 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 and bottomland riparian forest found at HOME support wintering, feeding, and breeding populations of both resident and migrating avian species. Because of the rarity of non-agricultural lands in the region, HOME 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 park will negatively impact populations of some bird species resident to HOME, 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 HOME and within the surrounding landscape (Johnson 2006, Boren et al. 1999).

<u>Threats and Stressors</u>

The threats at HOME to the bird community include the conversion of habitats to agricultural and urban uses including cultivation and livestock grazing and residential, commercial, and industrial development (Hansen and Gryskiewicz 2003). These uses result in habitat loss, habitat fragmentation, water pollution and the disruption of hydrologic flow regimes on properties adjacent to and near the park. In turn, these modifications disrupt ecological functions important to ecosystem integrity and important to conserving native bird species and communities at HOME (Jorgensen and Müller 2000). Consequently, the ecological functioning of HOME is linked to the existence of suitable habitats outside the park boundaries. Landscape-level changes in land use are linked to ecological function by five mechanisms (Hansen and Gryskiewicz 2003):

1. Land use activities reduce the functional size of a reserve, eliminating important ecosystem components lying outside the Monument's boundary;
2. Land use activities alter the flow of energy or materials across the landscape irrespective of the Monument's political boundary, disrupting the ecological processes dependent upon those flows both outside and inside the Monument 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)
- Bird Index of Biotic Integrity (IBI)
- Occurrence and status of bird species of conservation concern

4.15.2. Data and Methods

In 2009, the NPS Heartland Inventory and Monitoring Network (HTLN) began systematic surveys of breeding birds and their habitats at HOME. 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). Monitoring was conducted every year at a subsample of 48 permanent sites arranged in a systematic grid of 100 x 100 meter cells (originating from a random start point) (Peitz 2010). This grid was rotated 45 degrees from north to avoid station survey points from being impacted by roads, fences and other structures (Figure 4.15-1). Thirty of the sample sites were classified as grassland and 18 sites were classified as woodland. Data from the 30 grassland sample sites were used to determine the condition of the grassland bird community while the other 18 sites were used to determine condition of the woodland bird community. The number of sites sampled per year varied, ranging from 27 to 30 for the grassland sites and 14 to 17 for the woodland sites. Variable circular plot methodology was used, wherein all birds seen or heard at plots during a 5-minute sampling period were recorded, along with their corresponding distance from the observer (Peitz et al. 2008). The 5-minute surveys were partitioned at 3 minutes to allow comparison to Breeding Bird Survey data. The mean annual values of the indicators per sample site were used to assess condition and trend in the bird community.

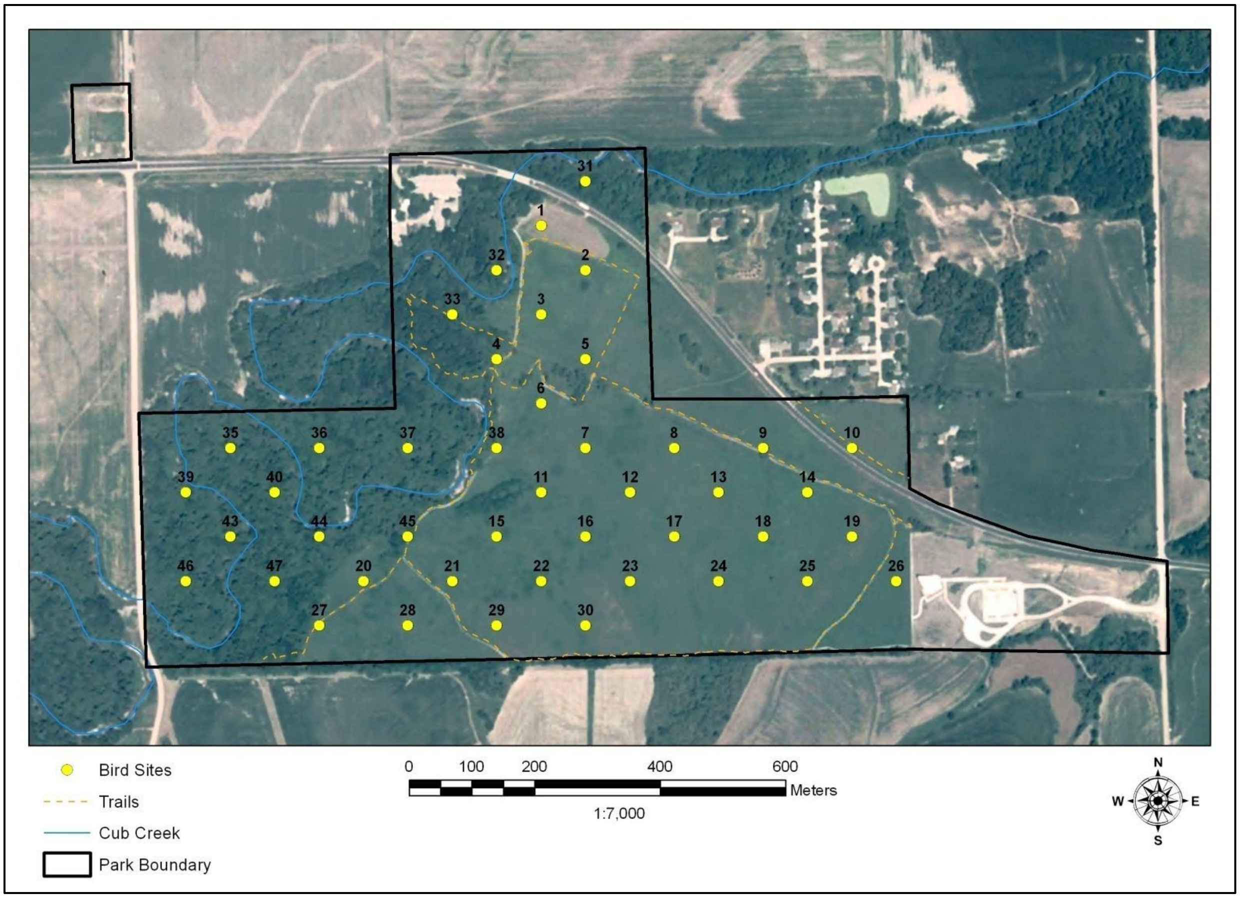


Figure 4.15-1. Bird plot locations on Homestead National Monument of America, Nebraska. After Peitz (2010).

Species Richness and IBI

To evaluate trend over time, we compared data from 2009 and 2012 surveys. We compared native species richness between the two years separately for the grassland and woodland sample sites. Only native species were included in calculations of species richness, as 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.

The biotic or ecological "condition" described by the bird IBI moves along a disturbance gradient from relatively intact, extensive, mature grassland or woodland communities that receive high IBI scores to more disturbed, developed or urban grassland or woodland communities that are assigned low IBI scores. Some woodland forest birds were recorded at the grassland sample sites. However, forest guilds (e.g., 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 4.15-1.

Table 4.15-1. Bird species guilds used to calculate the IBI score at Homestead National Monument of America.

Community	Biotic Integrity Element	Guild Category	Response Guild	Number of Species in Guild	Guild Classification
Grassland IBI	Functional	Trophic	omnivore	24	generalist
	Functional	Insectivore Foraging Behavior	grassland ground gleaner	5	specialist
	Compositional	Origin	exotic/non-native	3	generalist
	Compositional	Migration Status	resident	20	generalist
	Compositional	Migration Status	temperate migrant	17	generalist
	Compositional	Number Of Broods	single-brooded	26	specialist
	Compositional	Population Limiting	nest predator/brood parasite	3	generalist

Table 4.15-1 (continued). Bird species guilds used to calculate the IBI score at Homestead National Monument of America.

Community	Biotic Integrity Element	Guild Category	Response Guild	Number of Species in Guild	Guild Classification
Grassland IBI (continued)	Structural	Nest Placement	grassland ground nester	3	specialist
	Structural	Nest Placement	shrub nester	12	generalist
	Structural	Primary Habitat	grassland dependent	2	specialist
Woodland IBI	Functional	Trophic	omnivore	22	generalist
	Functional	Insectivore Foraging Behavior	bark prober	6	specialist
	Functional	Insectivore Foraging Behavior	upper canopy forager	4	specialist
	Functional	Insectivore Foraging Behavior	lower canopy forager	7	specialist
	Functional	Insectivore Foraging Behavior	aerial sallier	4	specialist
	Functional	Insectivore Foraging Behavior	aerial screener	2	specialist
	Compositional	Origin	exotic/non-native	1	generalist
	Compositional	Migration Status	resident	20	generalist
	Compositional	Migration Status	temperate migrant	19	generalist
	Compositional	Number Of Broods	single-brooded	31	specialist
	Compositional	Population Limiting	nest predator/brood parasite	5	generalist
	Structural	Nest Placement	canopy nester	16	specialist
	Structural	Nest Placement	forest ground nester	1	specialist
	Structural	Nest Placement	shrub nester	13	generalist
	Structural	Primary Habitat	forest generalist	19	generalist
	Structural	Primary Habitat	interior forest obligate	7	specialist
	Structural	Primary Habitat	riparian dependent	2	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 HOME are considered as species of concern at either a national or local scale, to assess the current status (occurrence) of those species at the Monument, and to evaluate the potential for the Monument to play a role in conserving those species. This analysis was restricted to those species that were either breeding at the Monument or that were residents. Those species occurring at the Monument 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 HOME that are of national conservation priority.

PIF has also adopted Bird Conservation Regions (BCRs) after the North American Bird Conservation Initiative (USFWS 2008). 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. HOME is within the Central Mixed-grass Prairie physiographic area and although no PIF bird conservation plan exists for this area there are numerous priority bird species listed on the PIF webpage for this physiographic area. The PIF priority species for the Central Mixed-grass Prairie were referenced for this assessment to identify those bird species that are of conservation priority within the local area, but may not be of national concern (Fitzgerald et al. 1998).

4.15.3. Reference Conditions

Little historic survey data exists for HOME. Bird surveys using the point count method at nine sample points were conducted at HOME in 1998 (Powell 2000). A more comprehensive and statistically rigorous sample using methods described in Peitz et al. (2008) was first implemented in 2009. Bird reference condition for both the grassland and woodland sample sites is based on the initial HTLN 2009 bird survey results, using data from that survey as a baseline. 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 rating system for departure from good condition is shown in Table 4.15-2.

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 HOME 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 "generalist guilds" being detected, respectively. Similarly calculated, the theoretical maximum and minimum woodland bird IBI scores at HOME 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.

Table 4.15-2. Resource condition rating framework for birds at Homestead National Monument.

Indicator	Community	Good Condition	Warrants Moderate Concern	Warrants Significant Concern
Native Species Richness (S)	Grassland birds	> 85–100+ % of 2009 value	70–85% of 2009 value	< 70% of 2009 value
	Woodland birds	> 85–100+ % of 2009 value	70–85% of 2009 value	< 70% of 2009 value
Index of Biotic Integrity	Grassland birds	29.1–44.0	22.1–29.0	10.0–22.0
	Woodland birds	58.1–86	45.1–58.0	23.5–45.0
Bird Species of Conservation Concern	Grassland birds	85–100+ % of 2009 value	70–85% of 2009 value	< 70% of 2009 value
	Woodland birds	85–100+ % of 2009 value	70–85% of 2009 value	< 70% of 2009 value

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 HOME 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. The woodland bird IBI 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 HOME bird IBI (Table 4.15-2) using a three-tiered rating system.

We also compared the candidate list of species of concern to the actual list of species observed at HOME during the 2012 survey. We used the number of species of concern recorded in the initial survey year of 2009 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 park more.

4.15.4. Condition and Trend

Grassland Birds

Species Richness

A total of 40 native species and 41 species in total, were recorded at grassland sampling stations in 2012. The most common species was the Dickcissel (Spiza *americana*). The red-winged blackbird (*Agelaius phoeniceus*) and American goldfinch (*Carduelis tristis*) were also moderately common (Table 4.15-3). The 40 native species observed in 2012 is more than the 33 native and 34 total species recorded during the 2009 bird survey at HOME (Table 4.15-3).

Table 4.15-3. Bird species recorded in 2012 and 2009 at prairie survey stations on Homestead National Monument of America.

			Number Observed	
Common Name	**Species Name**	**AOU code**	**2012**	**2009**
American crow	*Corvus brachyrhynchos*	AMCO	20	1
American goldfinch	*Carduelis tristis*	AMGO	33	20
American robin	*Turdus migratorius*	AMRO	15	11
Bank swallow	*Carpodacus mexicanus*	BANS	0	1
Barn swallow	*Hirundo rustica*	BARS	6	0
Blue jay	*Cyanocitta cristata*	BLJA	2	1
Brown thrasher	*Toxostoma rufum*	BRTH	4	8
Brown-headed cowbird	*Molothrus ater*	BHCO	23	26
Cedar waxwing	*Bombycilla cedrorum*	CEDW	0	1
Chipping sparrow	*Spizella passerina*	CHSP	1	0
Common yellowthroat	*Geothlypis trichas*	COYE	23	21
Dickcissel*	*Spiza americana*	DICK	63	18
Downy woodpecker	*Picoides pubescens*	DOWO	0	2
Eastern (Rufous-side) towhee	*Pipilo erythrophthalmus*	EATO	4	2
Eastern kingbird	*Tyrannus tyrannus*	EAKI	7	3
Eastern meadowlark	*Sturnella magna*	EAME	3	0
Eastern phoebe	*Sayornis phoebe*	EAPH	2	0
Eastern wood-pewee	*Contopus virens*	EAWP	2	0
Field sparrow	*Spizella pusilla*	FISP	15	2
Grasshopper sparrow	*Ammodramus savannarum*	GRSP	2	1
Gray catbird	*Dumetella carolinensis*	GRCA	22	5
Great blue heron	*Ardea herodias*	GBHE	1	0
House wren	*Troglodytes aedon*	HOWR	8	1
Killdeer	*Charadrius vociferus*	KILL	1	1
Least flycatcher	*Empidonax minimus*	LEFL	0	1

* PIF Priority Species for Physiographic Area 40 – The Northern Tallgrass Prairie (also highlighted).

Table 4.15-3 (continued). Bird species recorded in 2012 and 2009 at prairie survey stations on Homestead National Monument of America.

Common Name	Species Name	AOU code	Number Observed 2012	Number Observed 2009
Mourning dove	*Zenaida macroura*	MODO	13	3
Northern (Baltimore) oriole	*Icterus galbula*	BAOR	5	2
Northern (Yellow-shafted) flicker	*Colaptes auratus*	YSFL	3	3
Northern bobwhite	*Colinus virginianus*	NOBO	18	4
Northern cardinal	*Parus bicolor*	NOCA	7	1
Northern rough-winged swallow	*Stelgidopteryx serripennis*	NRWS	1	0
Orchard oriole	*Icterus spurius*	OROR	2	0
Red-bellied woodpecker	*Melanerpes carolinus*	RBWO	5	0
Red-headed woodpecker	*Melanerpes erythrocephalus*	RHWO	1	3
Red-tailed hawk	*Chordeiles minor*	RTHA	0	1
Red-winged blackbird	*Agelaius phoeniceus*	RWBL	59	20
Ring-necked pheasant	*Phasianus colchicus*	RPHE	21	5
Rose-breasted grosbeak	*Pheucticus ludovicianus*	RBGR	2	1
Ruby-throated hummingbird	*Archilochus colubris*	RTHU	1	0
Song sparrow	*Melospiza melodia*	SOSP	1	0
Spotted (Rufous-side) towhee	*Pipilo maculatus*	SPTO	2	–
Turkey vulture	*Thryothorus ludovicianus*	TUVU	1	2
Warbling vireo	*Vireo gilvus*	WAVI	3	0
Wild turkey	*Meleagris gallopavo*	WITU	0	1
Wood duck	*Aix sponsa*	WODU	0	1
Yellow warbler	*Setophaga petechia*	YWAR	4	2
Yellow-bellied sapsucker	*Sphyrapicus varius*	YBSA	0	1
Yellow-throated vireo	*Vireo flavifrons*	YTVI	2	0

* PIF Priority Species for Physiographic Area 40 – The Northern Tallgrass Prairie (also highlighted).

The slope of the linear regression line for mean native grassland bird species richness per sample site over time was positive, but not statistically significant ($r^2 = 0.16$, $p = 0.6$), suggesting an unchanging trend in the richness of the grassland bird community at HOME. The 90 percent confidence intervals for the years 2009 to 2012 also suggest stability in native species richness since 2009 (Figure 4.15-2). In 2012, the mean number of native grassland bird species recorded at sampling sites was 9.4, greater than the management target of 85 percent of 4.6, the number recorded in 2009 when monitoring was initiated at HOME. The mean native grassland bird species richness per site recorded in 2012, when compared to the 2009 value, indicates the resource is in good condition (Table 4.15-2).

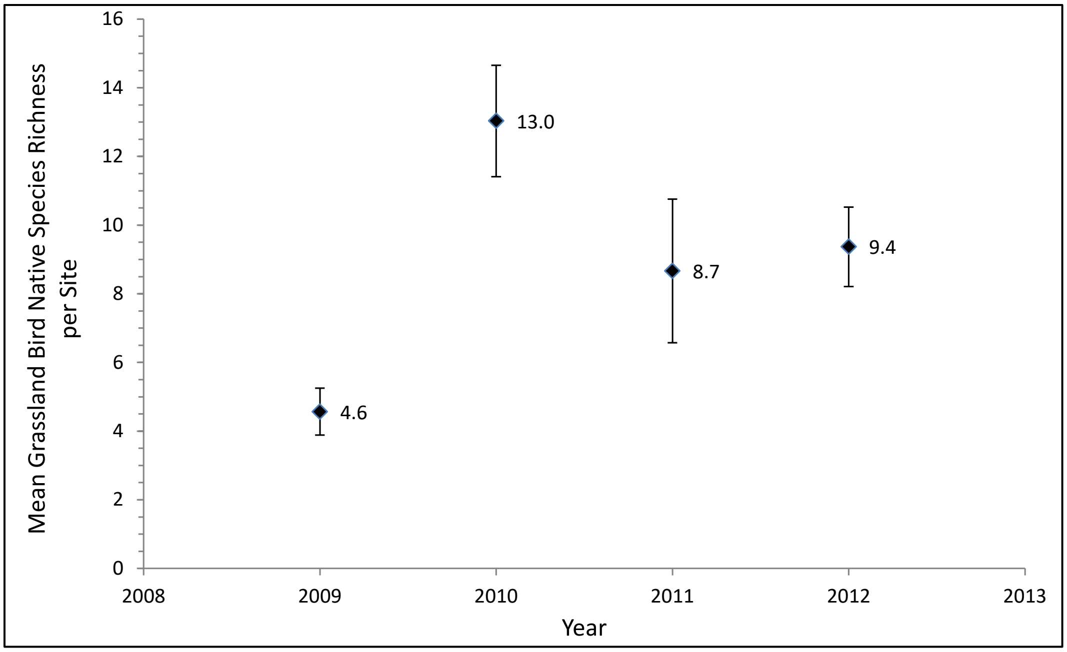


Figure 4.15-2. Means and 90 percent confidence intervals for native grassland bird species richness at Homestead National Monument from 2009 to 2012. Raw data provided by the Heartland I&M Network.

Index of Biotic Integrity

The grassland bird IBI score in 2012 was 27.5, more than the 2001 score of 24.4 and a score indicating that composition of the grassland bird community at HOME is of medium integrity (Table 4.15-3). The slope of the linear regression line for the grassland bird IBI scores was positive, and nearly significant at a 90% confidence level ($r^2 = 0.80$, $p = 0.11$), suggesting a potential increase in the biotic integrity of the bird community between 2009 and 2012. Additionally, the 90 percent confidence intervals for the scores indicate the 2012 IBI score was greater than scores for the preceding three years, a further indication that the biotic integrity of the bird community may have increased since 2009, when monitoring was first initiated at HOME (Figure 4.15-3). In 2012, the mean grassland IBI score per sample site at HOME was 27.5, a score that warrants moderate concern (Figure 4.15-3).

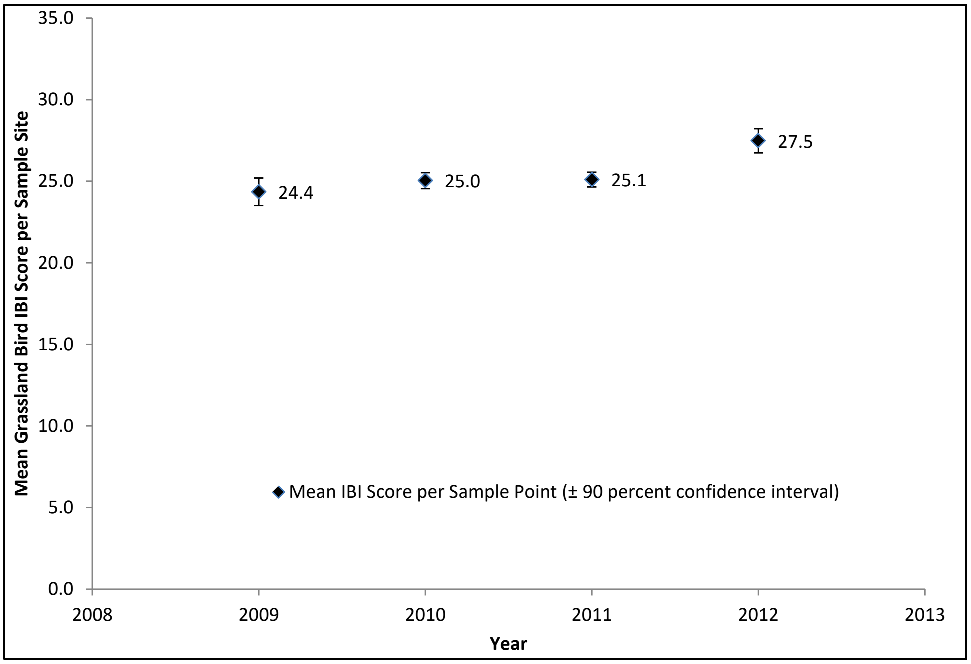


Figure 4.15-3. Mean IBI scores with 90 percent confidence intervals at Homestead National Monument of America from 2001 to 2012. Raw data provided by the Heartland I&M Network.

Species of Concern

Seven species recorded during the 2012 grassland bird survey are listed as Partner in Flight birds of concern (Rich et al. 2004), which is more than the six species of concern reported in 2009 (Table 4.15-3). Two grassland obligate species were recorded at HOME in 2012 including the Dickcissel (*Spiza americana*) and grasshopper sparrow (*Ammodramus savannarum*). These are the same two grassland obligate species recorded in 2009. The most common species of concern recorded and their habitats at HOME in 2012 were the Dickcissel (tallgrass prairie or weedy fields) and red-winged blackbird (wetlands, sedge meadows or old fields). Most of the species of concern increased in number from the 2009 survey to the 2012 survey (Table 4.15-3).

The slope of the linear regression line for the mean number of grassland bird species of concern per sample site was positive, but not statistically significant ($r^2 = 0.16$. $p = 0.6$), suggesting an unchanging trend in the number of bird species of concern present at HOME. The 90 percent confidence intervals for the mean number of species of concern also suggest an unchanging trend since 2009 (Figure 4.15-4). In 2012, the mean number of bird species of concern at HOME was 1.8, greater than the management target of 85 percent of 1.1, the number recorded in 2009 when monitoring was initiated at HOME. The mean number of grassland bird species of concern per site recorded in 2012, when compared to the 2009 value, indicates the resource is in good condition (Figure 4.15-4).

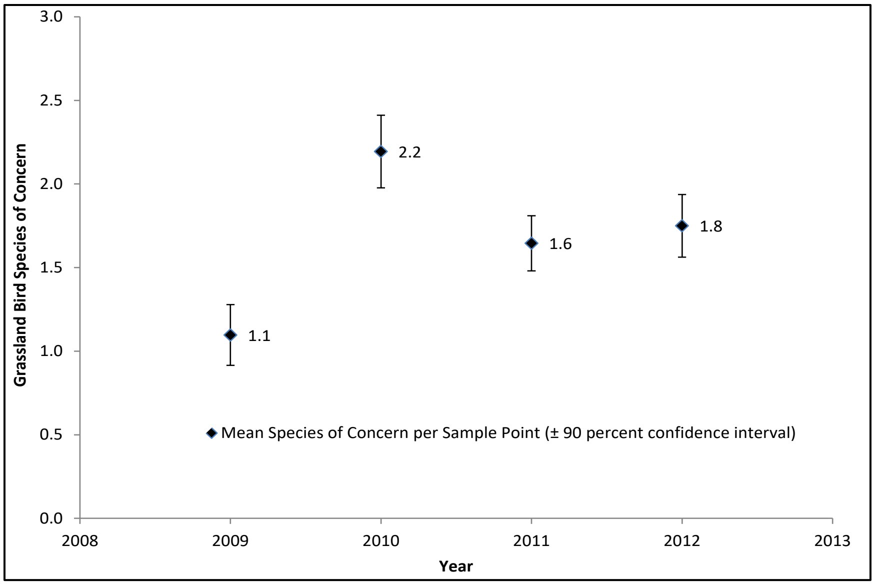


Figure 4.15-4. Means with 90 percent confidence intervals for number of grassland bird species of concern at HOME from 2001 to 2012. Raw data provided by the Heartland I&M Network.

Woodland Birds

Species Richness

There were 32 native species and 33 species in total recorded at woodland sampling stations in 2012. The most common species was the house wren (*Troglodytes aedon*). The American crow (*Corvus brachyrhynchos*) and red-bellied woodpecker (*Melanerpes carolinus*) were moderately common (Table 4.15-4). The 32 native species observed in 2012 is greater than the 29 native and total species that were recorded during the 2009 bird survey at HOME (Table 4.15-4).

Table 4.15-4. Bird species recorded in 2012 and 2009 at woodland survey stations on Homestead National Monument of America. Raw data provided by the Heartland I&M Network.

Common Name	Species Name	AOU code	Number Observed	
			2012	**2009**
American crow	*Corvus brachyrhynchos*	AMCO	18	0
American goldfinch	*Carduelis tristis*	AMGO	4	0
American redstart	*Setophaga ruticilla*	AMRO	0	1
American robin	*Turdus migratorius*	AMRO	7	0
Barn swallow	*Hirundo rustica*	BARS	1	0
Barred owl	*Strix varia*	BOOW	0	2
Black-capped chickadee	*Poecile atricapillus*	BCCH	0	1
Blue jay	*Cyanocitta cristata*	BLJA	13	0
Brown creeper	*Certhia americana*	BRCR	1	0

[1] Partners in Flight species considered of continental importance (also in bold).

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

Table 4.15-4 (continued). Bird species recorded in 2012 and 2009 at woodland survey stations on Homestead National Monument of America. Raw data provided by the Heartland I&M Network.

Common Name	Species Name	AOU code	Number Observed	
			2012	**2009**
Brown thrasher[1]	***Toxostoma rufum***	**BRTH**	**0**	**1**
Brown-headed cowbird	*Molothrus ater*	BHCO	0	4
Common yellowthroat	*Geothlypis trichas*	COYE	1	1
Dickcissel[1,2]	***Spiza americana***	**DICK**	**5**	**2**
Eastern (Rufous-side) towhee	*Pipilo erythrophthalmus*	EATO	11	2
(Eastern) Tufted titmouse[1]	***Baeolophus bicolor***	**ETTI**	**0**	**1**
Eastern phoebe	*Sayornis phoebe*	EAPH	2	0
Eastern wood-pewee	*Contopus virens*	EAWP	8	0
Field sparrow	*Spizella pusilla*	FISP	1	0
Grasshopper sparrow[1]	***Ammodramus savannarum***	**GRSP**	**1**	**0**
Gray catbird	*Dumetella carolinensis*	GRCA	3	0
Great crested flycatcher	*Myiarchus crinitus*	GCFL	2	4
House wren	*Troglodytes aedon*	HOWR	49	16
Indigo bunting[1]	***Passerina cyanea***	**INBU**	**2**	**4**
Mourning dove	*Zenaida macroura*	MODO	1	2
Northern (Baltimore) oriole	*Icterus galbula*	BAOR	2	4
Northern bobwhite	*Colinus virginianus*	NOBO	9	0
Northern cardinal	*Parus bicolor*	NOCA	7	4
Red-bellied woodpecker[1]	***Melanerpes carolinus***	**RBWO**	**15**	**3**
Red-eyed vireo	*Vireo olivaceus*	REVI	1	1
Red-headed woodpecker[1]	***Melanerpes erythrocephalus***	**RHWO**	1	6
Red-tailed hawk	*Chordeiles minor*	RTHA	0	1
Red-winged blackbird	*Agelaius phoeniceus*	RWBL	7	1
Ring-necked pheasant	*Phasianus colchicus*	RPHE	3	0
Rose-breasted grosbeak	*Pheucticus ludovicianus*	RBGR	8	7
Song sparrow	*Melospiza melodia*	SOSP	1	2
Summer tanager	*Piranga rubra*	SUTA	0	2
Warbling vireo	*Vireo gilvus*	WAVI	1	0
White-breasted nuthatch	*Sitta carolinensis*	WBNU	6	2
Wild turkey	*Archilochus colubris*	RTHU	1	0
Wood duck	*Melospiza melodia*	SOSP	1	1
Worm-eating warbler[1]	***Pipilo maculatus***	**SPTO**	**0**	**1**
Yellow warbler	*Setophaga petechia*	YWAR	1	7

[1] Partners in Flight species considered of continental importance (also in bold).

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

Table 4.15-4 (continued). Bird species recorded in 2012 and 2009 at woodland survey stations on Homestead National Monument of America. Raw data provided by the Heartland I&M Network.

Common Name	Species Name	AOU code	Number Observed	
			2012	2009
Yellow-bellied sapsucker[1]	***Vireo gilvus***	**WAVI**	**0**	**2**
Yellow-throated vireo[1]	***Meleagris gallopavo***	**WITU**	**0**	**1**

[1] Partners in Flight species considered of continental importance (also in bold).

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

The slope of the linear regression line for mean native woodland bird species richness per sample site was positive, but not statistically significant ($r^2 = 0.16$, $p = 0.6$), suggesting an unchanging trend in the richness of the woodland bird community at HOME. The 90 percent confidence intervals for mean native species richness per sample site for the years 2009 to 2012 also suggest stability in native species richness since 2009 (Figure 4.15-5). In 2012, 7.5 mean native woodland bird species per sample site were recorded at HOME, greater than the management target of 85 percent of 4.9, the number recorded in 2009 when monitoring was initiated at HOME. The mean species richness per site recorded in 2012, when compared to the 2009 value, indicates the resource is in good condition (Figure 4.15-5).

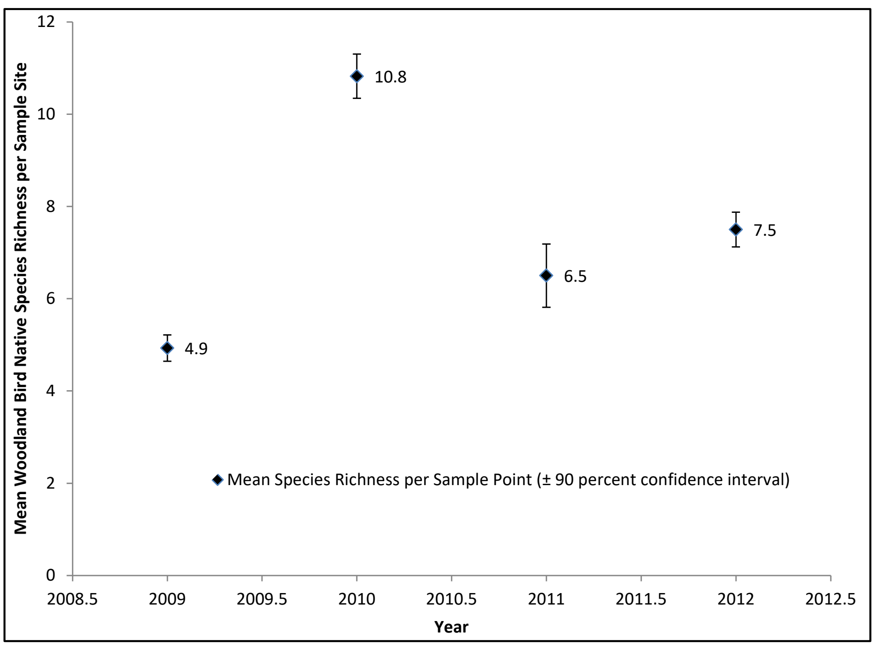


Figure 4.15-5. Woodland bird species richness at Homestead National Monument of America from 2009 to 2012 with 90 percent confidence intervals. Raw data provided by the Heartland I&M Network.

Index of Biotic Integrity

The mean woodland bird IBI score per sample site in 2012 of 44.5 was less than the 2009 score of 48.6 and a score indicating composition of the riparian woodland bird community at HOME is of low integrity (Table 4.15-2). The slope of the linear regression line for the grassland bird IBI scores is negative, but not statistically significant ($r^2 = 0.43$, $p = 0.3$) suggesting an unchanging trend in the IBI scores at HOME. The 90 percent confidence intervals for the mean scores per sample site for the years 2009 to 2012 also suggest stability in native species richness since 2009. In 2012, the woodland IBI score at HOME was 44.5, a score that warrants significant concern (Figure 4.15-6).

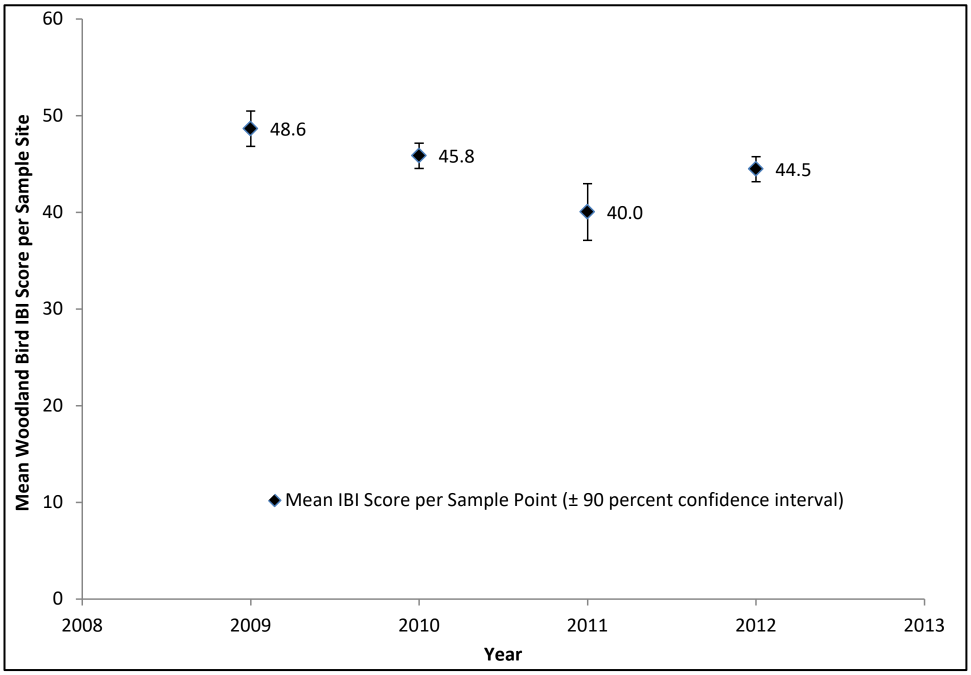


Figure 4.15-6. Mean IBI scores and 90 percent confidence intervals for woodland samples at Homestead National Monument of America from 2009 to 2012. Raw data provided by the Heartland I&M Network.

Species of Concern

Four species found at HOME during the 2012 woodland bird survey are listed as Partner in Flight birds of concern (Rich et al. 2004). This is less than the eight species of concern recorded in 2009, the initial year of monitoring at HOME (Table 4.15-4). Two riparian obligate species were recorded at HOME in 2012, the red-winged blackbird (*Agelaius phoeniceus*) and wood duck (*Melospiza melodia*). These two species were also the only riparian obligate species observed at HOME in 2009. The most common species of concern recorded at woodland sites and its habitat at HOME in 2012 was the red-bellied woodpecker (*Melanerpes carolinus*), which is found in mature hardwoods, heavily timbered bottomlands, and swampy woods. Another PIF species of concern, the brown thrasher (*Toxostoma rufum*), although present in 2009 was not recorded in 2012 (Table 4.15-4).

The slope of the linear regression line for the mean number of woodland bird species of concern per sample site was negative, but not statistically significant ($r^2 = 0.50$, $p = 0.29$), suggesting an unchanging trend in the number of woodland bird species of concern at HOME. The 90 percent confidence intervals for the mean number of species of concern also suggest an unchanging trend since 2009 (Figure 4.15-7). The mean number of woodland bird species of concern per sample site recorded at HOME in 2012 was 1.6, which is equal to the management target of 85 percent of 1.9, the value recorded in 2009 when monitoring was initiated at HOME. The mean number species of concern per site recorded in 2012, when compared to the 2009 value, indicates the resource is in good condition (Figure 4.15-7).

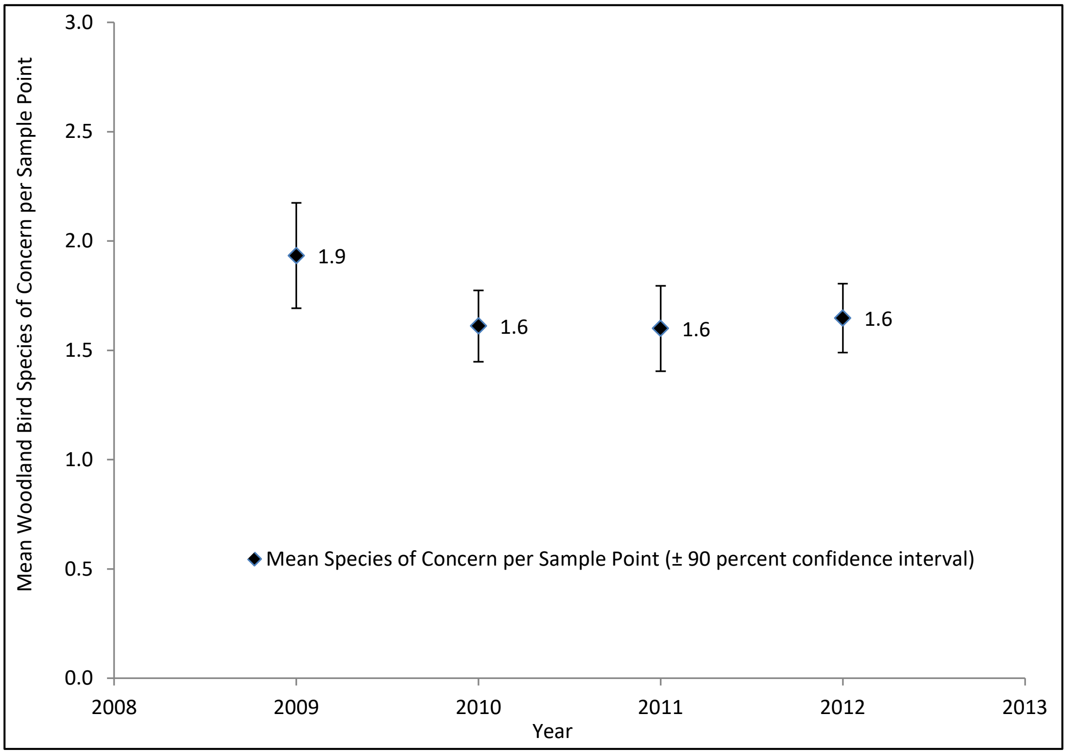
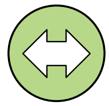
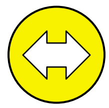
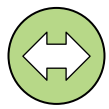
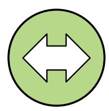
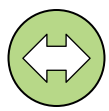
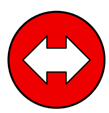
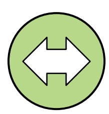
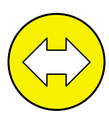
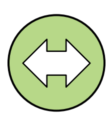


Figure 4.15-7. The trend in woodland bird species of concern at Homestead National Monument of America from 2009 to 2012 with 90 percent confidence intervals. Raw data provided by the Heartland I&M Network.

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 HOME is in good condition, with a number of obligate grassland birds and a community structure that is representative of a moderately disturbed landscape (Table 4.15-5). Additionally, the values for these metrics calculated for the years 2009 to 2012, suggest an unchanging trend in bird community diversity and structure at HOME.

Table 4.15-5. Condition and trend summary for birds at Homestead National Monument of America.

Community	Indicator	Condition Status/Trend	Rationale
Grassland Birds	Native Species Richness (S)		Mean native grassland bird species richness per sample site has fluctuated between 4.6 and 9.4 species from 2009 to 2012 with richness equaling 9.4 in 2012, greater than the management target of 85 percent of 4.6.
	Bird Index of Biotic Integrity		In 2012, the mean grassland bird IBI score per sample site was 27.5 (warrants moderate concern). Analysis of the grassland bird IBI scores indicates an unchanging trend in the biotic integrity of the bird community between 2009 and 2012.
	Species of Conservation Concern		The mean number of bird species of concern per sample point fluctuated between 1.1 and 2.2 species between 2009 and 2012 with 1.8 species of concern present in 2012.
	Grassland Birds overall		–
Woodland Birds	Native Species Richness (S)		Mean native woodland bird species richness has fluctuated between 4.9 and 10.8 species from 2009 to 2012 with richness equaling 7.5 in 2012, greater than the management target of 85 percent of 4.9.
	Bird Index of Biotic Integrity		In 2012, the mean woodland bird IBI score per sample site was 44.5 (warrants significant concern).
	Species of Conservation Concern		The number of woodland bird species of concern fluctuated between 1.6 and 1.9 species from 2009 to 2012 with 1.6 species of concern present in 2012, equal to the management target of 85 percent of 1.9.
	Woodland Birds overall		–
Birds 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 and the confidence in the trend analyses is low. The key uncertainty related to the assessment of the bird community at HOME is in the limited years of data upon which the assessment is based. 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.

4.15.6. Sources of Expertise

- David Peitz, Wildlife Biologist at the Heartland I&M Network, is responsible for collecting the monitoring data at HOME 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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4.16. 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 decline 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, HOME 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 park will negatively impact populations of some fish species resident to HOME, 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 HOME and in the surrounding landscape (Gido et al. 2010).

Threats and Stressors

Native aquatic communities are well adapted to withstanding periods of drought, but biological diversity is threatened as streams are further stressed by flow alterations and excessive water appropriations. Diversion of water from streams and rivers during drought can reduce the amount of deep-water refugia available to fish and raises water temperatures that can result in fish and invertebrate mortality. Pumping of groundwater for irrigation, municipal and other uses lowers water table levels that would otherwise supplement stream flows through hot and dry periods. 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). In conjunction with these stressors, exurban development and conversion of prairies to agriculture (nonnative pasture and crop lands) have degraded Cub Creek through sedimentation, nutrient loading, chemical pollution, channel dewatering, altered stream flows, channelization and habitat fragmentation.

Agriculture and development in the surrounding landscape have resulted in changes to the detriment of aquatic resources at HOME (NPS 1999). The combined and interacting effects of these influences have resulted in population declines and range reduction of freshwater fish not only at HOME, but also in the area surrounding the Monument.

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). The modifications to the surrounding landscape disrupt ecological functions important to ecosystem integrity and important to maintaining the community and composition of species at HOME comparable to that of the natural habitat of the region (Jorgensen and Müller 2000). Consequently, the ecological functioning of HOME depends upon maintaining the natural systems outside the Monument's boundaries. These changes in land use are linked to ecological function at HOME by five mechanisms (Hansen and Gryskiewicz 2003):

1. Land use activities reduce the functional size of a reserve, eliminating important ecosystem components lying outside the Monument's boundary;
2. Land use activities alter the flow of energy or materials across the landscape irrespective of the Monument's political boundary, disrupting the ecological processes dependent upon those flows both outside and inside the Monument 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 HOME (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. This helps 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). In 2004, the HTLN began systematic surveys of fish and their habitat in Cub Creek at HOME as part of the HTLN monitoring program (Dodd and Cribbs 2012). One stream reach within Chub Creek was sampled in 2004, 2006, 2008 and again in 2011 (Figure 4.16-1). Fish sampling was conducted in August and September using a common sense seine. All fish were counted and identified to species. Starting in 2006, 30 individuals per species were also measured and weighed, and any diseases or anomalies were recorded. Data from this single sample reach was used to determine the condition of the fish community at HOME. Because only one stream reach was sampled it is not possible to estimate the confidence we have in the value of the condition indicators being used to assess the fish population at HOME.

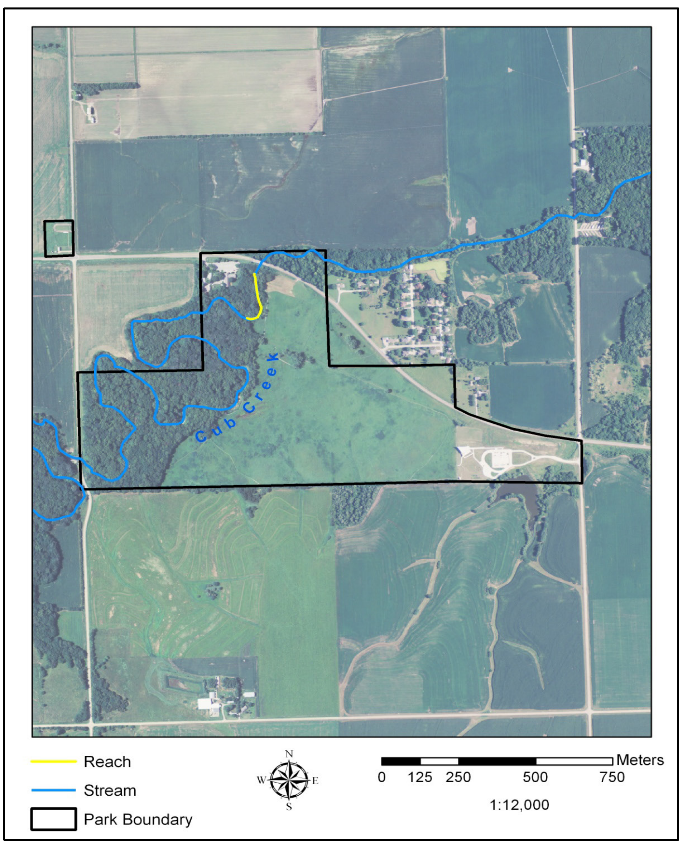


Figure 4.16-1. Location of the reach sampled biannually from 2008 and in 2011 at Homestead National Monument of America. Stream reach data provided by the Heartland I&M Network. Background image provided by ArcGIS.

To evaluate trends over time, we compared the occurrence of species detected during the initial survey conducted at HOME in 2004 to species detected during the 2011 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.

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 HOME. 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 HOME 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 (Smogor and Angermeier 1999).

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	3	negative
	Trophic composition	percent invertivorous	2	positive
	Trophic composition	percent carnivorous	1	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	1	positive
Physical Condition	Fish Health	percent with black spot or an anomaly	6	negative
Structural	Reproductive Behavior	Number of lithophilic spawning species	6	positive

A broader fish conservation context was evaluated by examining the native fish community to determine which species that occur at HOME are considered species of conservation concern either nationally or in Nebraska, to assess the current status (occurrence) of those species at the Monument, and to evaluate the potential for the Monument to play a role in the conservation of those species. *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 HOME listed on the Nebraska 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 survey data exists for HOME. In 2004, the HTLN began systematic surveys of fish and their habitat at HOME as part of the HTLN Inventory and Monitoring Program (Dodd and Cribbs 2012). The 2004 fish survey results are used as the reference condition. The goal is to maintain or exceed the level of biodiversity as defined by initial calculation of species richness, the number of at-risk species (i.e., species of conservation concern) and the quality of the fish community composition as defined by the initial IBI score.

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 HOME 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 HOME (Table 4.16-2).

We compared the candidate list of species of concern observed during the 2004 fish survey at HOME to the actual list of species observed during the 2011 survey. We used the number of species of concern recorded in the initial survey year of 2004 as the reference condition for comparison. A rating condition framework integrating reference condition concepts for native fish is shown in Table 4.16-2.

Table 4.16-2. Resource condition rating framework for fish at Homestead National Monument of America, Nebraska.

Indicator	Good Condition	Warrants Moderate Concern	Warrants Significant Concern
Native Species Richness (S)	> 85–100+ % of 2004 value	70–85% of 2004 value	< 70% of 2004 value
Index of Biotic Integrity	60.1–100.0	40.1–60.0	0–40.0
Fish Species of Conservation Concern	85–100+ % of 2004 value	70–85% of 2004 value	< 70% of 2004 value

4.16.4. Condition and Trend

Species Richness

A total of five native species were recorded at stream sampling stations in 2011. Among all species (native and non-native), the two most common fishes were the sand shiner (*Notropis ludibundus*) and the common carp (*Cyprinus carpio*) (Table 4.16-3). The five fish species recorded in 2004 was less than one half of the 12 species recorded during the 2004 fish survey at HOME (Table 4.16-3). Both the recorded number of species and the number of fish per species declined between 2004 and 2011 (Table 4.16-3). The most common species, the common carp declined by 78 percent while the total number of fish counted declined by 51%. However, counts of the sand shiner increased by 260 percent from 92 in 2004, to 331 in 2011. Therefore the condition status for native species richness warrants significant concern, with a deteriorating trend. Confidence in the assessment is medium.

Table 4.16-3. Fish species recorded in 2011 and 2004 at fish survey stations on Homestead National Monument of America.

Common Name	Species Name	Number Observed		USFS and Federal ESA List Status[1]	NatureServe Global Rank	State List Status[2]
		2011	2004			
Bluegill	*Lepomis macrochirus*	0	3	none	G5	none
Bluntnose minnow	*Pimephales notatus*	0	1	none	G5	none
Central stoneroller	*Campostoma anomalum*	0	9	none	G5	none
Channel catfish	*Ictalurus punctatus*	13	39	none	G5	none
Common carp	*Cyprinus carpio*	195	901	none	G5	none
Creek chub	*Semotilus atromaculatus*	0	9	none	G5	none
Fathead minnow	*Pimephales promelas*	11	48	none	G5	none
Green sunfish	*Lepomis cyanellus*	0	16	none	G5	none
Sand shiner	*Notropis ludibundus*	331	92	none	G5	none
Stonecat	*Noturus flavus*	0	7	none	G5	none
Suckermouth minnow	*Phenacobius mirabilis*	1	4	none	G5	none
Yellow bullhead	*Ameiurus natalis*	0	1	none	G5	none

[1] U. S. Fish and Wildlife Service Federal Status – LE = listed endangered, LT = listed threatened, P = proposed, C = candidate.

[2] State Status – SE = state endangered, ST = state threatened, SC = state special concern.

Native fish species richness declined at HOME between 2004 and 2011 (Figure 4.16-2). The slope of the linear regression line for native fish species richness was negative and significant ($r^2 = 0.92$, $p = 0.04$), suggesting a declining trend in the richness of the native fish community over time. Because only one stream reach cite was sampled (n=1), it is not possible to assess the precision of calculated values for species richness at HOME.

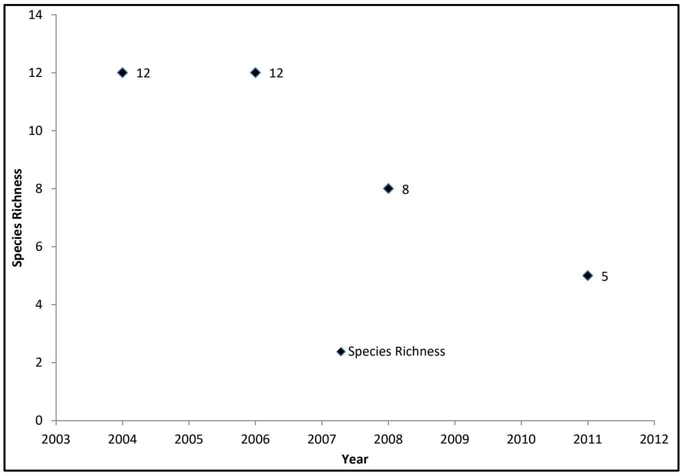


Figure 4.16-2. The trend in native fish species richness for the single stream reach at Homestead National Monument of America that was sampled biannually from 2004 to 2008 and again in 2011. Raw data provided by the Heartland I&M Network.

Index of Biotic Integrity

The fish IBI score in 2011 was 56.54 compared to the 2004 score of 70.2. This IBI score indicates that composition of the fish community at HOME in 2011 warrants moderate concern (Table 4.16-2). The values for the fish IBI scores declined from 2004 to 2011 (Figure 4.16-3). The slope of the linear regression line for the fish IBI scores was negative, but not statistically significant ($r^2 = 0.39$, $p = 0.38$), suggesting an unchanging trend in the biotic integrity of the fish community at HOME. The lack of multiple samples from numerous stream reaches on Cub Creek makes it impossible to assess confidence in the calculated values of the fish IBI at HOME.

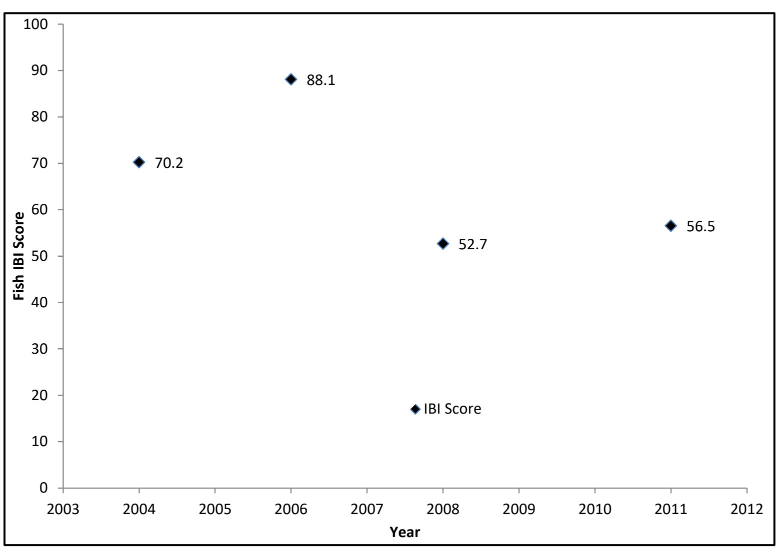


Figure 4.16-3. Fish IBI scores for the single stream reach at Homestead National Monument of America that was sampled biannually from 2004 to 2008 and again in 2011. Raw data provided by the Heartland I&M Network.

Species of Conservation Concern

No species of conservation concern were recorded at HOME, either during the 2004 survey or during any other sample year including the 2011 survey. The absence of these rare species suggests that their essential habitats no longer exist either at HOME, or potentially, within the surrounding ecosystem. This suggests that the ecosystem within which HOME occurs no longer contains the ecological functions necessary to support these rare species. To save species of conservation concern the integrity of the ecosystems, that is ecosystem composition and functions, must be maintained (Scudder 1999). This means that protected areas must be manage within a framework of ecological integrity, and this can only be accomplished in a regionally based management plan that maintains ecological function within riparian and stream communities both within and outside of the boundaries of HOME (Scudder 1999). The absence of species of interest makes it impossible to assess trends or confidence in the number of species of conservation concern at HOME.

Overall Condition and Trend

Native species richness and the fish IBI score were lower in 2011 compared to 2004, suggesting a decline in fish community diversity and quality at HOME. The declining IBI values indicate that the species still present in 2011 represent different trophic levels and guilds than in 2004, and that their abundances were skewed towards more tolerant fish species. Essentially, there were more generalist fish species present at HOME in 2011 and fewer of the specialist species that were present in 2004.

The values for the metrics of native species richness, the fish IBI, and the number of species of conservation concern present in 2011 indicate that condition of the fish community at HOME warrants moderate concern, with a community structure that is representative of a landscape in moderate condition (Table 4.16-4). Although the condition indicators suggest that condition is either stable or possibly declining, a trend was not assigned due to the limited number of indicators and differences among trends of the indicators.

Table 4.16-4. Condition and trend summary for fish at Homestead National Monument of America.

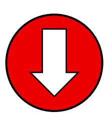
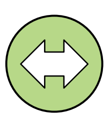
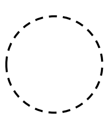
Indicator	Condition Status/Trend	Rationale
Native Species Richness (S)		Native fish species richness at the single stream reach sampled has fluctuated between 5 and 12 species from 2004 to 2011 with richness equaling 5 in 2011 (warrants significant concern), less than the management target of 85 percent of 12. Analysis of the fish monitoring data indicates a declining trend in native species richness from 2004 to 2011.
Fish Index of Biotic Integrity		In 2011, the fish IBI score at the single stream reach sampled was 56.5 (warrants moderate concern). Analysis of the fish IBI scores indicates an unchanging trend in the biotic integrity of the fish community between 2004 and 2011.
Species of Conservation Concern		No fish species of special concern were documented at the one stream reach sampled in any sample year.

Table 4.16-4 (continued). Condition and trend summary for fish at Homestead National Monument of America.

Indicator	Condition Status/Trend	Rationale
Fish overall		Condition warrants moderate concern with an unknown trend. Confidence in the assessment is medium.

4.16.5. Uncertainty and Data Gaps

The key uncertainty related to the assessment of the fish community at HOME is in the limited years of data upon which the assessment is based and the lack of multiple independent samples from numerous stream reaches of Cub Creek within HOME. Ideally, assessments of ecological change would use long-term data spanning a period longer than the 2004–2011 available for this assessment (Holmes 2010, Magurran et al. 2010). Comprehensive data collected from numerous stream reaches along Cub Creek within HOME and over an extended time period is needed to assess the natural temporal fluctuation of the condition indicators used in this assessment and to 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, Fisheries Biologist, Heartland I&M Network and Prairie Cluster Prototype Programs. Hope is responsible for collecting the monitoring data at HOME 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. Herptiles

4.17.1. 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 are components of these terrestrial and aquatic systems and are important components of grassland parks of the Heartland Inventory and Monitoring Network (HTLN). Additionally, 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 also widely 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 condition because they are sensitive to habitat changes including wetland filling or draining, urbanization, and clearcutting or other watershed activities that can affect hydrologic conditions, making their assemblages indicative of habitat quality (Pechmann et al. 1991, Blaustein et al. 1994 Fontenot et al. 1996). In 2002 and 2003, NPS conducted herpetofauna surveys at Homestead National Monument (HOME). Prior to this survey effort the status of herpetofauna at HOME 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 Cub Creek, both on and off HOME, may offer important habitat for native herpetofauna (Fogell 2004). Because of the rarity of non-agricultural lands in the region, HOME is especially valuable by providing relatively undisturbed patches of habitat critical for sustaining native prairie within a highly altered agricultural landscape (Hansen and Gryskiewicz 2003). Habitat fragmentation and conversion of native vegetation to agricultural and urban landscapes outside the park can negatively impact populations of some herpetofauna species resident to HOME, 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 restoration projects such as native prairie restoration, flow management, dam removal, or cessation of groundwater pumping both within HOME and in the surrounding landscape (Gido et al. 2010).

<u>Threats</u>

The herpetofauna community at HOME has been affected by habitat conversion, degradation, modification, and fragmentation (Hansen and Gryskiewicz 2003). Agriculture and development in the surrounding landscape have resulted in the loss of both terrestrial and aquatic habitat (Hansen and Gryskiewicz 2003). The combined and interacting effects of these influences have resulted in population declines and range reduction of herpetofauna not only at HOME, but also in the area surrounding the Monument.

Modifications to the surrounding landscape disrupt ecological functions important to ecosystem integrity and important to maintaining the community and composition of species at HOME comparable to that of the natural habitat of the region (Jorgensen and Müller 2000). Consequently, the ecological functioning of HOME depends upon maintaining the natural systems outside the

Monument's boundaries. These changes in land use are linked to ecological function at HOME 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 Monument's boundary;
2. Land use activities alter the flow of energy or materials across the landscape irrespective of the Monument's political boundary, disrupting the ecological processes dependent upon those flows both outside and inside the Monument 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

- Percent of the expected species present

4.17.2. Data and Methods

Herpetofauna were surveyed at HOME from May to July in 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, 26 species of herpetofauna potentially occur within HOME. These species include 1 species of salamander, 7 frogs and toads, 4 species of turtles, 1 lizard and 13 species of snakes (Table 4.17-1). Multiple sampling techniques were employed at HOME including visual encounter, artificial cover boards, drift fence with funnel traps, anuran-calling, and turtle traps in order to sample the spatial variation and habitats available within the park (Fogell 2004) (Figure 4.17-1). Of these five techniques, the primary method used to survey amphibians and reptiles was the visual encounter survey (Fogell 2004).

Table 4.17-1. Herpetofauna species and number observed in the 2003–2005 surveys (Fogell 2004).

Herpetological Group	Common Name	Species Name	Number Observed	
			2002	2003
Amphibians	Bullfrog	*Rana catesbeiana*	3	14
	Cope's Gray treefrog	*Hyla chrysoscelis*	3	21
	Cricket frog	*Acris crepitans*	10	60
	Eastern tiger salamander	*Ambystoma tigrinum*	0	0
	Northern Leopard Frog	*Rana pipiens*	0	0
	Plains leopard frog	*Rana blairi*	13	5
	Western chorus frog	*Pseudacris triseriata*	50	50
	Woodhouse's toad	*Bufo woodhousii*	3	7

Table 4.17-1 (continued). Herpetofauna species and number observed in the 2003–2005 surveys (Fogell 2004).

Herpetological Group	Common Name	Species Name	Number Observed	
			2002	2003
Reptiles	Brown snake	*Storeria dekayi*	0	3
	Common garter snake	Thamnophis sirtalis	2	5
	Common kingsnake	Lampropeltis getula	0	0
	Corn snake	Elaphe guttata	0	0
	Gopher snake	Pituophis melanoleucus	1	1
	Lined snake	Tropidoclonion lineatum	0	4
	Milk snake	Lampropeltis triangulum	0	0
	Northern water snake	Nerodia sipedon	0	1
	Osage copperhead	Agkistrodon contortrix	0	0
	Painted turtle	Chrysemys picta	0	5
	Plains garter snake	Thamnophis radix	2	5
	Prairie skink	Eumeces septentrionalis	0	0
	Racer	Coluber constrictor	4	1
	Ringneck snake	Diadophis punctatus	0	0
	Smooth softshell	Apalone mutica	0	0
	Snapping turtle	Chelydra serpentina	1	3
	Spiny softshell	Apalone spinifera	0	4
	Timber rattlesnake	Crotalus horridus	0	0

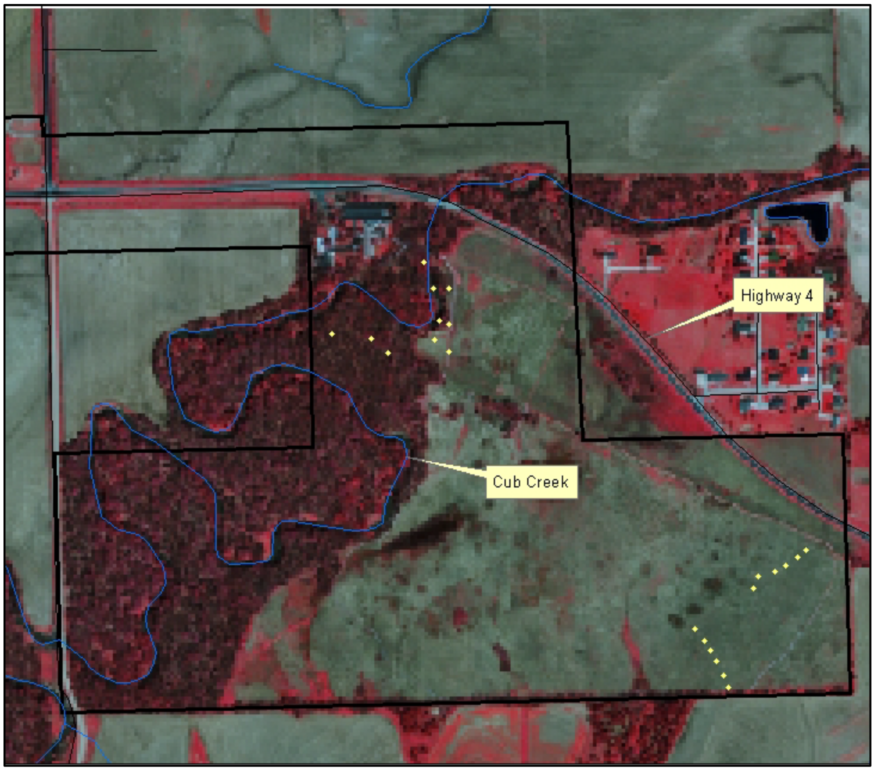


Figure 4.17-1. Location of cover boards (small light-colored dots) at Homestead National Monument of America (figure from Fogell 2004).

4.17.3. Reference Conditions

Reference condition was linked to the number of species with the potential to occur within the Monument. These species were identified by Fogell (2004), are listed in the NPSpecies database, or are from other published reports documenting known occurrences in the area. Fogell (2004) also accounted for suitable habitat within the Monument 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 specific species or the herpetofauna group as a whole are not supported by the available data. However, the Fogell (2004) study does allow us to make some inference regarding the condition of herpetofauna within the Monument and can be used as a baseline for comparisons with future monitoring efforts. A condition rating framework for herpetofauna is shown in Table 4.17-2.

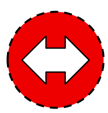
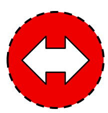
Table 4.17-2. Resource condition rating framework for herptiles at Homestead National Monument of America, Nebraska.

Indicator	Good Condition	Warrants Moderate Concern	Warrants Significant Concern
Percent of Expected Species Confirmed	> 85–100+% of expected	70–85% of expected	< 70% of expected

4.17.4. Condition and Trend

The herpetofauna community score warrants significant concern as a large number of species with the potential to occur at HOME were not confirmed. The inventory survey completed in 2002–2003 found 75% of expected amphibians and 56% of expected reptiles. Overall there was a 62% confirmation rate for the 16 species confirmed of the 26 expected within the Monument, which warrants significant concern (Table 4.17-3). Ratios of observed to expected species were as follows: 6/7 frogs and toads (86%); 0/1 salamander (0%); 3/4 turtles (75%); 0/1 lizard (0%); and 7/13 snakes (54%). The lack of a species observation may be an artifact of the sampling design or sampling season. No trend assessment is currently possible for this measure of condition due to the single sample period. Data is only available for the single sample period, dating to over a decade ago and changes in the intervening period to the condition of the Monument's habitats could have changed herpetofauna diversity at HOME. For these reasons the confidence in the assessment is low.

Table 4.17-3. Condition assessment interpretation for herpetofauna at Homestead National Monument of America.

Indicator	Condition Status/Trend	Rationale
Percent of Expected Species Confirmed		Herpetofauna species confirmed from 2002 and 2003 represented 62% of expected species, less than the management target of 85 percent of 26 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.

4.17.5. Uncertainty and Data Gaps

Herpetofauna data were limited for HOME. 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 Monument because results were available for only a single survey effort. Comprehensive surveys from numerous sites within HOME and over an extended time period are recommended to assess condition and trends in the herptile community.

4.17.6. Sources of Expertise

- Daniel Fogell, a herpetologist and science instructor, Southeast Community College, Lincoln, Nebraska. Mr. Fogell is responsible for collecting the monitoring data at HOME upon which this assessment is based (Fogell 2004). His research interests focus on the biogeography of rare herpetofauna in Nebraska.

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4.18. Mammals

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 resources. Mammals are components of these terrestrial systems and are important components of grassland parks of the Heartland Inventory and Monitoring Network (HTLN). Additionally, mammal* species are considered effective indicators of environmental quality and condition. *In 2004, NPS conducted a mammal survey at HOME. Prior to this survey effort the status of mammals at HOME was unknown (Robbins 2005).*

Mammal populations, especially small mammals, are excellent indicators of environmental condition because they respond to changes in vegetation structure, respond rapidly to habitat changes, can move about freely and leave disturbed and unsuitable sites, and they are ubiquitous and fecund making them suitable for landscape-level studies (Klenner and Sullivan 2009, Leis et al. 2008). For this reason, *mammal community composition offers an indication of environmental health.*

NPS lands provide some of the least impacted habitat remaining in the Midwest serving as refugia for some species and may offer habitat for native mammals (Robbins 2005). Because of the rarity of non-agricultural lands in the region, HOME is especially valuable by providing relatively undisturbed patches of habitat critical for sustaining native prairie within a highly altered agricultural landscape (Hansen and Gryskiewicz 2003). Habitat fragmentation and conversion of native vegetation to agricultural and urban landscapes occurring outside the park can negatively impact populations of some mammal species resident to HOME, particularly intolerant species that have evolved within stable environments (Knopf and Samson 1996, Leis et al. 2008). Mammal community composition and diversity should improve with restoration projects, such as native prairie restoration both within HOME and within the surrounding landscape (Leis et al 2008). Today HOME supports a diverse community of mammals with more than 40 species of mammals with potential to occur in the Monument (Robbins 2005).

<u>Threats</u>

The mammal community at HOME has been affected by habitat conversion, degradation, modification, and fragmentation (Hansen and Gryskiewicz 2003). Agriculture and development in the surrounding landscape have resulted in the loss of both terrestrial and aquatic habitat (Hansen and Gryskiewicz 2003). The combined and interacting effects of these influences have resulted in population declines and range reduction of mammals not only at HOME, but also in the area surrounding the Monument.

Modifications to the surrounding landscape disrupt ecological functions important to ecosystem integrity and important to maintaining the community and composition of species at HOME comparable to that of the natural habitat of the region (Jorgensen and Müller 2000). Consequently, the ecological functioning of HOME depends upon maintaining the natural systems outside the Monument's boundaries. These changes in land use are linked to ecological function at HOME 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 Monument's boundary;
2. Land use activities alter the flow of energy or materials across the landscape irrespective of the Monument's political boundary, disrupting the ecological processes dependent upon those flows both outside and inside the Monument 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

- Percent of the expected species present

4.18.2. Data and Methods

Mammals were surveyed at HOME from May to June in 2004. Based on distribution maps and historic records of species occurrence, 41 species of mammals are thought to potentially occur within the park (Robbins 2005). These species include the armadillo, white-tailed deer, opossum, 7 species of bats, 10 species of carnivores, and 17 species of rodents (Table 4.18-1).

Multiple sampling techniques were employed at HOME including visual encounter, pitfall traps, live-traps, mist nets, and camera traps in order to sample the spatial variation and habitats available within the park (Figure 4.18-1). Of these five techniques, the most successful method used to survey mammals was live-trapping (Robbins 2005).

Table 4.18-1. Mammalian species that could potentially occur at Homestead National Monument of America (Robins 2005).

Mammal Class	Common Name	Species Name	Confirmation Status
Artiodactyla	White-tailed deer	*Odocoileus virginianus*	confirmed
Carnivora	Badger	*Taxidea taxus*	confirmed
	Bobcat	*Lynx rufus*	unconfirmed
	Coyote	*Canis latrans*	confirmed
	Gray fox	*Urocyon cinereoargenteus*	unconfirmed
	Least weasel	*Mustela nivalis*	confirmed
	Long-tailed weasel	*Mustela frenata*	unconfirmed
	Mink	*Mustela vison*	confirmed
	Racoon	*Procyon lotor*	confirmed
	Red fox	*Vulpes vulpes*	confirmed
	Striped skunk	*Mephitis mephitis*	confirmed

Table 4.18-1 (continued). Mammalian species that could potentially occur at Homestead National Monument of America (Robins 2005).

Mammal Class	Common Name	Species Name	Confirmation Status
Chiroptera	Big brown bat	*Eptesicus fuscus*	confirmed
	Eastern pipistrelle bat	*Pipistrellus subflavus*	unconfirmed
	Eastern red bat	*Lasiurus borealis*	confirmed
	Evening bat	*Nycticeius humeralis*	confirmed
	Hoary bat	*Lasiurus cinereus*	unconfirmed
	Northern myotis	*Myotis septentrionalis*	confirmed
	Silver-haired bat	*Lasionycteris noctivagans*	unconfirmed
Cingulata	Nine banded armadillo	*Dasypus novemcinctus*	confirmed
Insectivora	Eastern mole	*Scalopus aquaticus*	confirmed
	Least shrew	*Cryptotis parva*	unconfirmed
	Masked shrew	*Sorex cinereus*	confirmed
Lagomorpha	Eastern cottontail	*Sylvilagus floridanus*	confirmed
Marsupialia	Virginia opossum	*Didelphis virginiana*	confirmed
Rodentia	Beaver	*Castor canadensis*	confirmed
	Deer mouse	*Peromyscus maniculatus*	confirmed
	Fox squirrel	*Sciurus niger*	confirmed
	Franklin's ground squirrel	*Spermophilus franklinii*	unconfirmed
	Harvest mouse	*Reithrodontomys megalotis*	confirmed
	House mouse	*Mus musculus*	unconfirmed
	Meadow jumping mouse	*Zapus hudsonius*	confirmed
	Meadow vole	*Microtus pennsylvanicus*	confirmed
	Muskrat	*Ondatra zibethicus*	confirmed
	Norway rat	*Rattus norvegicus*	confirmed
	Plains pocket gopher	*Geomys bursarius*	confirmed
	Prairie vole	*Microtus ochrogaster*	confirmed
	Short-tailed shrew	*Blarina brevicauda*	confirmed
	Southern flying squirrel	*Glaucomys volans*	unconfirmed
	Thirteen-lined ground squirrel	*Spermophilus tridecemlineatus*	confirmed
	White-footed mouse	*Peromyscus leucopus*	confirmed
	Woodchuck	*Marmota monax*	confirmed

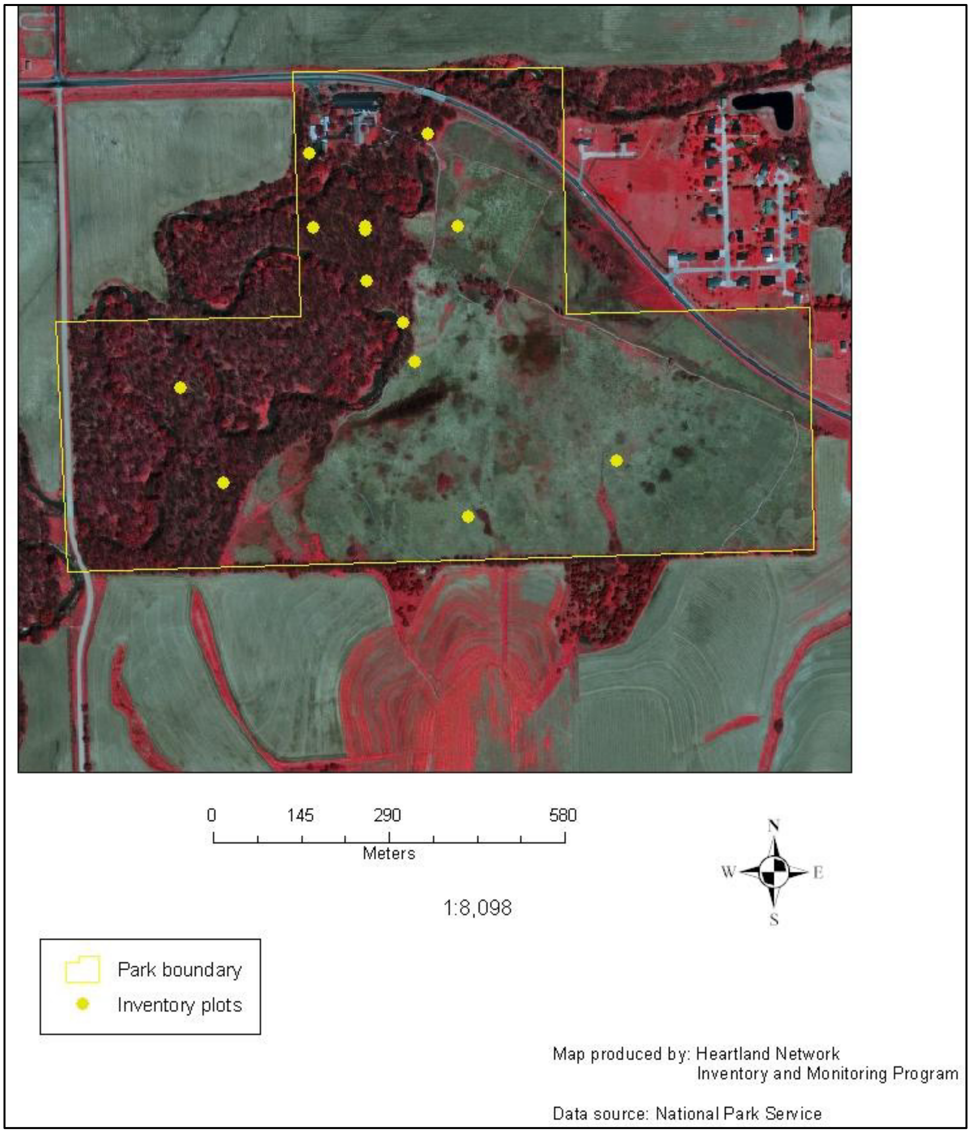


Figure 4.18-1. Location of sampling sites at Homestead National Monument of America (Robbins 2005).

4.18.3. Reference Conditions

Reference condition was set to the number of species with potential to occur within the Monument. These species were identified from the NPSpecies database and other published reports with known occurrences in the area. Robbins (2005) also accounted for suitable habitat within the Monument that was available for each species. Other quantitative metrics and thresholds describing the population dynamics of specific species or the mammal group as a whole are not supported by existing information. However, the Robbins study does allow us to make some inference regarding the condition of mammals within the Monument and can be used as a baseline for comparison with future monitoring efforts. A condition rating framework for mammals is shown in Table 4.18-2.

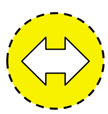
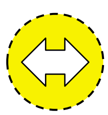
Table 4.18-2. Resource condition rating framework for mammals at Homestead National Monument of America, Nebraska.

Indicator	Resource is in Good Condition	Warrants Moderate Concern	Warrants Significant Concern
Percent of Expected Species Confirmed	> 85–100+% of expected	70–85% of expected	< 70% of expected

4.18.4. Condition and Trend

76% or 31 of the 41 species expected within the Monument were documented, which warrants moderate concern (Table 4.18-3). Ratios of observed to expected species were as follows: 1 of 1 species each confirmed or 100% for the armadillo, white-tailed deer and opossum groups; 4/7 bats (57%); 7/10 carnivores (70%); and 14/17 rodents (82%). The lack of a species observation may be an artifact of the sampling design or sampling season. No trend assessment is currently possible for this metric due to the single sample period. Data is only available for the single sample period, dating to nearly a decade ago. Changes to the condition of the park's habitats in the intervening period could have since changed the composition of the mammal community at HOME. For these reasons the confidence in the assessment is low.

Table 4.18-3. Condition and trend summary for mammals at Homestead National Monument of America.

Indicator	Condition Status/Trend	Rationale
Percent of Expected Species Confirmed		The percent of expected mammal species confirmed in 2004 was 76% (warrants moderate concern), less than the management target of 85 percent of 41 expected species. Analysis of the mammal data for trend was not possible because only one year of sampling data was available for analysis.
Mammals overall		Condition warrants moderate concern with an unknown trend. Confidence in the assessment is low.

4.18.5. Uncertainty and Data Gaps

Mammal data were limited for HOME. 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 the mammal community within the Monument because results were available for only a single survey effort.

Inventory and monitoring surveys should be conducted at regular intervals to establish trend data for species of interest. Assessments of ecological change should use long-term data spanning decades rather than the one period of sampling data available for this assessment (Holmes 2010 and Magurran et al. 2010). Comprehensive data collected from numerous sites within HOME and over an extended time period is needed to assess the natural temporal fluctuation of the condition indicator used in this assessment and to ensure the accuracy of the assessment (Dornelas et al. 2012). The implementation of a monitoring program for mammals at HOME should avoid differences in sampling effort among the years monitored.

4.18.6. Sources of Expertise

- Lynn Robins, a mammologist and professor of biology, Southwest Missouri University, Springfield, Missouri. Lynn is responsible for collecting the monitoring data at HOME upon which this assessment is based (Robbins 2005). His research interests focus on the biogeography of rare bats and on the use of Anabat II bat detectors to accurately identify free flying bats.

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4.19. Osage Orange Hedgerow

4.19.1. Background and Importance

The protection of the cultural landscape is a specific management prescription of the General Management Plan (NPS Midwest Regional Office 1999). The Plan requires that cultural landscape and historic integrity are protected, to the greatest extent practicable, from external encroachment and its historic features are accurately represented to the public. The *Cultural Landscape Report for Homestead National Monument of America* (Quinn Evans Architects and Land and Community Associates 2000) recognizes the Osage orange hedgerow along the southern boundary of the park as an important contributing element to the landscape. Cultural landscape treatment recommendations for rehabilitation of the historic Osage orange hedge include: 1) selective removal of existing trees and planting of new Osage orange trees along the length of the south HOME boundary; 2) maintenance and improvement of the hedge through propagation, grafting and replanting; and 3) elimination of invasive eastern red cedar (*Juniperus virginiana*) and shrubs within the hedge (Quinn Evans Architects and Land and Community Associates 2000). A Hedgerow Management Plan (Sutton 2005) was developed in response to the recommendations in the Cultural Landscape Report, and is the foundation for much of the knowledge surrounding Osage orange hedgerows at HOME. From a cultural standpoint, the hedgerow represents an imaginary line delineating the boundary of the original homestead (Mark Engler, personal communication October 2012). The National Register of Historic Places nomination for HOME lists the Osage orange hedgerow as contributing element.

The hedgerow is a significant social, historical, and cultural feature at HOME. Osage orange hedgerows are an excellent example of how settlers adapted and developed innovations that integrated plants, animals, technology and social systems. Hedgerows require management as a dynamic, living resource that is part of a cultural landscape (Sutton 2006).

<u>Hedgerow History</u>

Prior to settlement by Europeans, the native range of Osage orange (*Maclura pomifera*) was restricted to eastern Texas, southeastern Oklahoma, southwestern Arkansas, and northeastern Louisiana. It is a small native deciduous tree that averages 30 ft in height. The branches are thorny and often intertwine. Osage orange that has escaped cultivation often colonizes native forests, occurs as thickets along fencerows and ditches, in ravines, and in overgrazed pastures (U.S. Forest Service 2014).

Osage orange played an important role in the settlement of the prairies and plains (Winberry 1979). In the mid 1800s, U.S. settlers began turning to the English practice of using hedges to form a “living fence.” By the late 1840s, Osage orange seeds were being sent northward to prairie states. Osage-orange grew quickly on poor, exposed sites and responded to hedging whereby sprouts are encouraged and then pruned and woven into an impenetrable barrier using a technique called plashing (Overman 1858). By the 1850s, Osage orange was recognized as the most cost-effective fencing available, and was planted widely throughout the Midwest and into the western plains (Winberry 1979, Steavenson et al. 1943). In 1855, it was estimated that 9000 miles of Osage orange hedge were planted in Iowa alone (Danhof 1944).

Osage orange hedgerows were used extensively to mark ownership boundaries and provide fencing for livestock. Hedgerows were also a source of fence posts and fuelwood, and protected fields and soil from the wind (Hewes and Jung 1981). Loss of hedgerows in the non-forested Midwest began after settlement, partly due to the advent of barbed wire for fencing in the 1870s, with significantly higher rates of removal beginning in the mid 1900s (Baltensperger 1978). The great burden of maintaining hedges made this a somewhat logical change. Annual clipping was necessary to keep the hedges within bounds and constant pruning, patching and weaving was necessary to repair openings in the living fence. Without trimming, the plants would form a wider barrier, would lose their ability to restrict passage by livestock, and would encroach on adjacent agricultural fields. Significant factors affecting removal of hedgerows were development of center pivot irrigation systems, urban expansion, and the desire to maximize tillable acreage and construction or improvement of roads (Baltensperger 1978).

Historic Hedgerow at HOME

The historic Osage orange hedgerow at HOME was planted by Daniel Freeman around 1875 on the southern boundary of the homestead claim (Sutton 2005). The hedgerow begins on the east end of the claim near the Palmer-Epard cabin and extends approximately 3,180 ft west along the restored prairie edge to the bottomland forest wood line. Osage orange trees continue in a scattered fashion for an additional 730 ft or so on the boundary line along the southern edge of the mixed mesic bottomland forest to the western boundary along Blakely Township Road (Figure 4.19-1).

Figure 4.19-1. Aerial photograph from 1985. The Osage-orange hedgerow is the left to right linear feature toward the bottom of the image between the cross symbols. North is up (from Sutton 2005).

Maintenance of the hedgerow probably ended around 1920 (Quinn Evans Architects and Land and Community Associates 2000). There is evidence that the hedgerow was cut heavily in the 1930s prior to creation of the park, most likely to harvest valuable fencepost materials (Sutton 2005). A firebreak is currently maintained along the northern side of most of the hedgerow (Figure 4.19-2).

Figure 4.19-2. Clockwise from upper left: view of firebreak north of the hedgerow looking west; Osage orange seedlings planted in a gap between existing trees circa 2013; close up of young planted Osage orange. CSU photos.

The Hedgerow Management Plan (Sutton 2005) developed management recommendations to restore and rehabilitate most sections of the historic hedgerow, with specific timelines and prescriptions for 17 management units along the length of the hedgerow. Primary activities are removal of undesirable trees and shrubs, cutting of existing Osage orange trees to promote sprouting, propagation and planting, pruning and weaving, and shearing. Over 5 years following planting may be required to begin forming the desired hedge character. Recent acquisition of the land parcel immediately south of the hedgerow will greatly facilitate restoration efforts.

<u>Threats and Stressors</u>

Primary threats and stressors include lack of Osage orange regeneration within the hedgerow, threat of tree damage and mortality from fire, shading of hedgerows by overhanging trees, invasion by other woody plants into the hedgerow, and loss of hedge character in the context of livestock fencing.

<u>Indicators and Measures</u>

- Percentage of historic hedgerow restored relative to management objectives.

4.19.2. Data and Methods

Osage orange trees (271 total) were catalogued and mapped and canopy/dripline areas were mapped (11 polygons totaling 2 ac) along the southern fenceline (Sutton 2005). The demographic and spatial data formed the basis for management recommendations. The historic hedgerow extended 970 m (3,180 ft) along the restored prairie and 225 m (740 ft) along the edge of the bottomland forest on the western edge of the park.

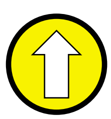
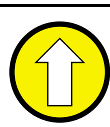
4.19.3. Reference Conditions

Reference conditions would approximate hedgerow conditions during the settlement period when the homestead was being actively farmed and occupied. The hedgerow would be primarily Osage orange, planted, pruned and maintained as a living fence capable of preventing passage by livestock and effectively delineating the property boundary. Larger trees would be periodically cut to stimulate sprouting and promote vigor of the hedge. The hedgerow would be contiguous along the southern boundary, although management prescriptions may vary by management unit segment.

4.19.4. Condition and Trend

The historic hedgerow has been comprehensively inventoried. Following preparation of the *Hedgerow Management Plan*, park managers began implementing restoration activities. These have included plant propagation and planting, invasive and undesirable woody plant management along the hedgerow, and tree removal. Planting of over 250 young plants is planned. Fifty seedlings were planted in hedgerow gaps in 2010. Pruning and training of the 2010 planting began in 2014–2015. With continued management, it is anticipated that the restoration will be highly successful (Jesse Bolli, personal comment 2015), although the timeline for full implementation is unknown. A condition assessment summary is shown in Table 4.19-1.

Table 4.19-1. Condition assessment summary for the Osage orange hedgerow at Homestead National Monument of America.

Indicator	Condition Status/Trend	Rationale
Percentage of Hedgerow Restored Relative to Objectives		The resource has been inventoried, a management plan has been prepared, and active restoration efforts have begun. Park managers anticipate that steady progress will being made be made toward restoration goals over the next 10–20 years.
Osage Orange Hedgerow overall		The condition of the Osage orange hedgerow warrants moderate concern, with an improving trend and a high level of confidence.

4.19.5. Uncertainty and Data Gaps

Effective approaches for managing smooth brome adjacent to and in hedgerow need to be explored.

4.19.6. Sources of Expertise

- Richard Sutton, Professor, University of Nebraska at Lincoln
- Merrith Baughman, Resources Chief, Homestead National Monument of America

- Jesse Bolli, Natural Resources Specialist, Homestead National Monument of America

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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, nine addressing biological attributes, and one addressing integrated natural/cultural attributes. Status and trend assigned to each focal resource and a brief synopsis of supporting rationale are presented in Table 5.5-1.

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 park and many natural resources, and can be stressors on resources. Some of the land cover and land use-related stressors at HOME 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 HOME 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. Fire regime within the bur oak community was discussed—the lack of fire within that system appears to be degrading its condition and contributing to a declining trend.

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 park, and provides a foundation for collaborative conservation with other landowners in the surrounding area.

Table 5.1-1. Summary of focal resource condition and trend for Homestead National Monument of America.

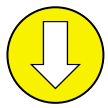
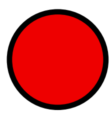
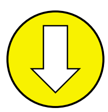
Ecosystem Attribute	Resource	Condition and Trend	Rationale for Overall Condition/Trend Rating
Landscape Context – System and Human Dimensions	Land Cover and Land Use	**condition and trend not assigned**	Most land cover and land use-related stressors at HOME and in the larger region are related to the 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. A lack of significantly-sized and linked protected areas would help to conserve natural resources at the park to include dark night skies, natural sounds and scenery.
	Night Sky		Darker areas can be found south and west of the Monument, but several nearby urban areas produce significant light pollution that affects the quality of the Monument's night skies.
	Soundscape		Nationwide modeling of anthropogenic sound level impacts indicates that anthropogenic noise is increasing the existing ambient sound level above the natural ambient sound level of the Monument. Based on these estimates, traffic volumes on roads adjacent to the Monument, and the number and type of anthropogenic noise sources that are audible within the Monument, the soundscape in HOME is in poor overall condition, with an unknown trend.
	Scenery and Views		Overall condition of views warrants moderate concern with a deteriorating trend. Confidence in the assessment is medium. The evaluation of potential visibility of new wind turbine developments highlights an issue that is of great concern to park managers, and illustrates geographically the park views that may be impacted. The wind energy results are therefore also assigned a lesser weight relative to the quality of on-the-ground views. However, the high likelihood of wind farm construction affecting views in the near term is considered in the trend rating.
	Climate Change	**condition and trend not assigned**	The park 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 park scale.

Table 5.1-1 (continued). Summary of focal resource condition and trend for Homestead National Monument of America.

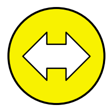
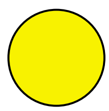
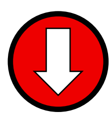
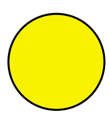
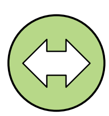
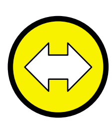
Ecosystem Attribute	Resource	Condition and Trend	Rationale for Overall Condition/Trend Rating
Landscape Context – System and Human Dimensions (continued)	Fire Disturbance Regime		The condition of the fire regime warrants moderate concern with an unchanging trend. The trend is weighted more heavily toward fire frequency than the other indicators. Fire regime components vary in their ability to meet reference conditions for the Monument. 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.
Chemical and Physical Environment	Air Quality		Based on the evaluation of air quality indicators, air quality condition warrants moderate concern, with no trend. 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 produced by ecologically necessary prescribed burns.
	Stream Hydrology and Geomorphology		Cub Creek received a PFC rating of nonfunctional. Sixteen criteria were rated negatively and one rated N/A for beaver presence. The channel is deeply incised and over-widened with steep banks 15- to 30-ft high. Bank vegetation is sparse or not present. Upland plant species are dominant on banks that are not bare but they do not have the root density to stop bank erosion. Banks are undercut or failing in every bend and in some runs.
	Water Quality		The water quality for HOME is assessed as warranting moderate concern with medium confidence due to the data that is currently available.
Biological – Plants	Prairie Vegetation		Condition ratings for species composition, native species diversity and plant structure are generally good. The condition of invasive exotic plants warranted moderate concern. All indicators had an unchanging trend and medium confidence. Overall, the prairie vegetation at HOME is in good condition, with an unchanging trend for the time period covered by this assessment.
	Invasive Exotic Plants		Based on the four indicators evaluated, the condition of the park warrants significant concern with an unchanging trend. Although there are only two survey periods, cover classes are moderately broad, and reference conditions are somewhat subjective, confidence in the assessment is high due to the comprehensive nature of the monitoring protocol. *Bromus inermis* is the primary concern regarding invasive exotic plant species at HOME.

Table 5.1-1 (continued). Summary of focal resource condition and trend for Homestead National Monument of America.

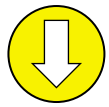
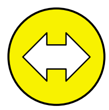
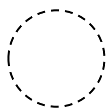
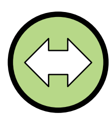
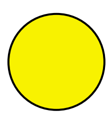
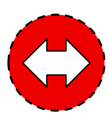
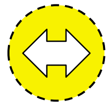
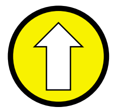
Ecosystem Attribute	Resource	Condition and Trend	Rationale for Overall Condition/Trend Rating
Biological – Plants (continued)	Mesic Bur Oak Community		Forest structure resembling the reference condition exists only in some portions of the mapped type. The canopy is closing, the abundance of other mesic tree species is increasing, large overstory bur oaks are uncommon and bur oak regeneration is impacted by deer browsing. The current forest community has been heavily impacted by past land uses and lack of fire, and the prospects for improved extent and condition of the community may be limited by continued lack of fire, land-use-driven changes to stream hydrology, impacts of deer browsing, and impacts of invasive exotic plants.
Biological – Animals	Aquatic Macroinverte-brates		Based on the evaluation of aquatic macroinvertebrate metrics, condition of the resource warrants moderate concern with an unchanging trend. Confidence in the assessment is medium. Impacts to aquatic macroinvertebrate communities appear to be largely from upstream sources that are out of NPS control.
	Terrestrial Invertebrates		Terrestrial invertebrate species richness documented in 1983 was approximately 52%, the taxa richness documented at the Konza Prairie LTER. Because of the age of the data, lack of more recent surveys, and uncertainties related to the reference framework, a condition rating was not assigned. Also, changes in the condition of habitats and other factors could have changed terrestrial insect diversity at HOME since then. Assigning a trend was not possible because only one period of sampling data was available for analysis and the data is considered incomplete.
	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 HOME is in good condition, with a number of obligate grassland birds and a community structure that is representative of a moderately disturbed landscape.
	Fish Community		Native species richness and the fish IBI score were lower in 2011 compared to 2004, suggesting a decline in fish community diversity and quality at HOME. The declining IBI values indicate that the species still present in 2011 represent different trophic levels and guilds than in 2004, and that their abundances were skewed towards more tolerant fish species.
	Herptiles		Herpetofauna species confirmed from 2002 and 2003 represented 62% of expected species, less than the management target of 85 percent of 26 expected species. Analysis of the herpetofauna data for trend was not possible because only one period of sampling data was available for analysis.

Table 5.1-1 (continued). Summary of focal resource condition and trend for Homestead National Monument of America.

Ecosystem Attribute	Resource	Condition and Trend	Rationale for Overall Condition/Trend Rating
Biological – Animals (continued)	Mammals		The percent of expected mammal species confirmed in 2004 was 76% (warrants moderate concern), less than the management target of 85 percent of 41 expected species. Analysis of the mammal data for trend was not possible because only one year of sampling data was available for analysis.
Integrated Natural/Cultural	Osage Orange Hedgerow		The resource has been inventoried, a management plan has been prepared, and active restoration efforts have begun. Park managers anticipate that steady progress will being made be made toward restoration goals over the next 10–20 years.

5.1.2. Chemical and Physical Environment

The supporting chemical and physical environment at the park includes its air quality, water quality and stream hydrology/geomorphology (Table 5.1-1). The condition of these resources can affect human dimensions of the park such as visibility and scenery as well as biological components such as vegetation health and stream biota. Stream hydrology/geomorphology warranted significant concern, while air and water quality warranted moderate concern. Conditions were estimated to be unchanging for stream hydrology/geomorphology, with an unknown trend for air and water quality due to a lack of data. Air quality and water quality in Cub Creek are significantly impacted by land uses outside the park boundary. Impacts to air quality appear to be largely from distant sources that are affecting regional air quality, or local sources produced by ecologically necessary prescribed burns. Both stream geomorphology and water quality appear to be significantly impacted by cattle grazing and upstream land uses. Incision of Cub Creek is a legacy of historical land uses as well as conversion of natural systems to agriculture.

5.1.3. Biological Component – Plants

The floral biological components examined included prairie vegetation, invasive exotic plants and the mesic bur oak community (Table 5.1-1). The tallgrass prairie at HOME is considered an excellent example of a restored tallgrass prairie, and is one of the oldest restorations of its kind in the U.S. The vegetation composition is thought to be similar to that of presettlement vegetation, although forb species richness is still below expected levels. Enhanced management of prescribed fire and continued invasive plant management would likely increase the heterogeneity of vegetation and overall habitat quality. Grazing of native ungulates such as bison would likely have ecological benefits but their management is not considered practical for the small site. The bur oak community is considered an excellent example of this rare type in Nebraska. Historic cutting and disturbances, the lingering effects of those events, lack of fire, and dominance of undesirable tree species continue to impact this community. The extent of the forest classified as mesic bur oak woodland has not increased appreciably since the park was created. Exclusion of fire from the Cub Creek woodlands will make restoration of the forest more challenging or impossible.

Challenges related to invasive plant management and fire regime contribute to management concerns. Although the prairie is rated in good condition, there is some risk associated with potential expansion of nonnative invasive plants. Intensive, park-wide surveys occur regularly and management is driven by the monitoring results. Maintenance of a desirable fire regime can help control woody plants and promote floristic diversity, but is challenging due to the park's location within an ex-urban area and sometimes inconsistent implementation of prescribed burns.

5.1.4. Biological Component – Animals

The faunal biological components examined included aquatic macroinvertebrates, terrestrial invertebrates, birds, fish, herptiles and mammals (Table 5.1-1). One of the six resources examined (birds) were found to be in good condition. Aquatic macroinvertebrates are being impacted by poor water quality and altered stream flows/hydrology that originate upstream outside the boundary. The fish and mammal communities warranted moderate concern. The herptile community warrants significant concern. The status and trend of terrestrial insects could not be determined. Trends for faunal resources examined are unchanging or unknown. Because of the small size of the park and the predominance of developed and agricultural land uses, opportunities to support a diverse faunal assemblage at HOME, including a variety of herpetofauna, carnivores, ungulates and other species is limited. Many animals have been lost from the landscape and are no longer present in the park. Nonetheless, the park still provides an island of restored prairie and bottomland forest that provides habitat for native animals. The role of connectivity and partnering with other landowners will be critical to maintain and enhance the fauna at HOME.

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 Homestead National Monument of America. See reports sections for additional details.

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.
	Scenery and Views	With the exception of wind turbine visibility, park views data for HOME are extensive and recent. The potential visibility of wind turbines is of low confidence due to viewshed modeling assumptions.

Table 5.2-1 (continued). Data gaps identified for focal resources examined at Homestead National Monument of America. See reports sections for additional details.

Ecosystem Attribute	Resource	Data Gaps
Landscape Context – System and Human Dimensions (continued)	Climate Change	Climate change projections are complex with inherently high uncertainty.
	Fire Disturbance Regime	Burn severity data.
Chemical and Physical Environment	Air Quality	Local air monitoring stations vs. interpolated data would provide more accurate data.
	Stream Hydrology and Geomorphology	Discharge data for Cub Creek would support better understanding of flow dynamics.
	Water Quality	No available data has been collected since 2011 making assessment of current conditions difficult. Flow data should be collected if possible. The NDEQ monitoring location is only being used to sample fecal coliforms and data is only available for 2012.
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 park and addressing park-based watch lists. Spatial resolution of the data is high.
	Mesic Bur Oak Community	Little vegetation monitoring has been completed within the remnant older forest or the younger successional forest. The impacts of altered flooding regimes and excessive deer browsing are not well understood for this type at HOME.
Biological – Animals	Aquatic Macroinvertebrates	Well-documented reference values have not been established for Cub Creek.
	Terrestrial Invertebrates	Terrestrial invertebrate data were limited for HOME and no recent survey data were available. Survey data were only available for a single time period and no monitoring data were available.
	Bird Community	Limited years of data.
	Fish Community	There are few years of data available. Multiple independent samples from numerous stream reaches of Cub Creek within HOME are lacking.
	Herptiles	Data are very limited. Survey data were only available for a single time period and no monitoring data were available.
	Mammals	Survey data were only available for a single time period and no monitoring data were available. The absence of a species may be an artifact of the sampling design or the seasonal timing of the survey.
	Osage Orange Hedgerow	Effective approaches for managing smooth brome adjacent to and in hedgerow.

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 prescribed burn program at HOME, some heterogeneity is created across the prairie burn units, benefitting many ecosystem components. Despite the absence of significant numbers of native grazers, a high-quality prairie has been created and maintained through judicious use of fire, weed management, and restoration activities. However, there is evidence that ecosystem diversity and heterogeneity would be enhanced by diversifying the burning program away from the predominance of spring burns and maintaining high fire frequency. 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 herpetofauna. Prescribed fire is perhaps the single most important agent influencing the park landscape. Exclusion of fire within the bur oak woodland and forest may limit the park's ability to reach restoration goals for that community.

Because the regional landscape is dominated by private land and agricultural land uses, the HOME setting provides an important place for visitors to experience the outdoors. The historic context is therefore buffered to some degree and complemented by the natural areas surrounding the core visitation area. Nonetheless, the landscape immediately surrounding the park and in the broader region continues to change significantly in ways that degrade or stress park natural resources and impact visitor experience elements such as natural sounds, night skies and air and water quality. Fragmentation of surrounding lands and the paucity of protected areas in the region also present challenges to maintaining diverse animal and plant communities and natural processes.

Management 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). Homestead National Monument faces challenges that are compounded by its small size and isolation with regard to other protected natural areas. Regional and park-specific mitigation and adaptation strategies are needed to maintain or improve the condition of some resources over time in response to stressors such as weeds, altered hydrology and undesirable effects of urban and exurban encroachment.

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