Plant Community Composition and Structure Monitoring for Knife River Indian Villages National Historic Site

2012 Annual Report

Natural Resource Technical Report NPS/NGPN/NRTR—2013/682
ON THE COVER
Photograph by: NGPN
Plant Community Composition and Structure Monitoring for Knife River Indian Villages National Historic Site

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Isabel W. Ashton
Michael Prowatzke
Dan Swanson
Phil Graeve
Stephen K. Wilson

National Park Service
Northern Great Plains Inventory & Monitoring Network
231 East Saint Joseph St.
Rapid City, SD 57701

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

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All manuscripts in the series receive the appropriate level of peer review to ensure that the information is scientifically credible, technically accurate, appropriately written for the intended audience, and designed and published in a professional manner. This report received informal peer review by subject-matter experts who were not directly involved in the collection, analysis, or reporting of the data. Data in this report were collected and analyzed using methods based on established, peer-reviewed protocols and were analyzed and interpreted within the guidelines of the protocols.

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Executive Summary

Knife River Indian Villages National Historic Site (KNRI) protects 1758 acres of northern mixed-grass prairie and riparian forests. The Northern Great Plains Inventory & Monitoring Network and Fire Ecology Program surveyed 13 long-term monitoring plots in KNRI in 2012 as part of an effort to better understand the condition of plant communities in the park. We measured plant diversity, vegetative cover, and tree density; looked for the presence of exotic species that are of concern to park management; and evaluated the amount of human and natural disturbance at all plots. This effort was the second year in a multiple-year venture to document the current status and long-term trends in plant communities in KNRI. At the end of five years, there will be an in-depth report describing the status of the plant community. In 2014, there will also be a large survey completed in the park to estimate the condition of the riparian forests. In this report, we provide a simple summary of our results from sampling in 2012.

KNRI protects and manages a small remnant of northern mixed-grass prairie. A history of extensive human-use has led to low native species richness and a landscape dominated by exotic species. Smooth brome and Kentucky bluegrass are particularly abundant. To retain ecological integrity it is important to continue efforts to reduce the cover of invasive plants. Allowing for natural disturbances such as fire may be critical to maintaining plant diversity in KNRI, but it should be balanced with the need to protect intact native communities and prevent further invasions of exotic species in areas where native diversity is high. Continued monitoring efforts will be critical to track changes in the condition of the vegetation communities in KNRI.
Acknowledgments

We thank all the authors of the NGPN Plant Community Monitoring Protocol, particularly Amy Symstad, for outstanding guidance on data collection and reporting. We greatly appreciate the staff at KNRI, particularly John Moeykens for providing logistical support and safety checks. The 2012 NGPN vegetation field crew of Michael Prowatzke, Anine Smith, Daina Jackson, and Ryan Manuel collected the NGPN data included in this report. The 2012 Northern Great Plains Fire Ecology Program crew of Phil Graeve, Dan Swanson, Valena Hoffman, Marcus Lund, and Ellery Watson collected data on the Fire Ecology plots included in this report. We thank Stephen Wilson for invaluable support and instruction on managing data in the FFI database and for assistance with the GIS data.
Introduction

During the last century, much of the prairie within the Northern Great Plains has been plowed for cropland, converted to livestock pasture, or otherwise developed, making it one of the most threatened ecosystems in the United States. Within North Dakota, greater than 71% of the area of native mixed-grass prairie has been lost since European settlement (Samson and Knopf 1994). The National Park Service (NPS) plays an important role in preserving and restoring some of the last pieces of intact prairies within its boundaries. The stewardship goal of the NPS is to “preserve ecological integrity and cultural and historical authenticity” (NPS 2012); however, resource managers struggle with the grim reality that there have been fundamental changes in the disturbance regimes, such as climate, fire, and large ungulate grazing, that have historically maintained prairies, and there is the continual pressure of exotic invasive species. Long-term monitoring in national parks is essential to sound management of prairie landscapes because it can provide information on environmental quality and condition, benchmarks of ecological integrity, and early warning of declines in ecosystem health.

Knife River Indian Villages National Historic Site (KNRI) was established in 1974 with a mission to commemorate the culture and history of the Northern Great Plains Indian peoples and to preserve, study, and interpret the historic and archeological resources. KNRI sits on 1758 acres of upland mixed-grass prairie and riparian forests, much of which has a long history of human use. As a result, exotic species play a major role in the makeup of the park’s current vegetation (DeKeyser and Krabbenhoft 2006). The Northern Great Plains Inventory & Monitoring Program (NGPN) began vegetation monitoring at KNRI in 2011 (Ashton et al. 2012). Vegetation monitoring protocols and plot locations were chosen to represent the park and to coordinate efforts with the Northern Great Plains Fire Ecology Program (FireEP). The long-term objectives of the NGPN plant community monitoring effort (Symstad et al. 2012b) in KNRI are to:

1. Determine park-wide status and long-term trends in vegetation species composition (e.g., exotic vs. native) and structure (e.g., cover, height) of herbaceous and shrub species.

2. Determine status (at 5-year intervals) and long-term trends of tree density by species, height class, and diameter class in the riparian forest.

3. Improve our understanding of the effects of external drivers and management actions on plant community species composition and structure by correlating changes in vegetation composition and structure with changes in climate, landscape patterns, atmospheric chemical composition, fire, and invasive plant control.

This report is intended to provide a timely release of basic data sets and data summaries from our sampling efforts at KNRI in 2012, our second year of sampling. NGPN visited 8 plots, and FireEP visited 5 plots (Figure 1). Not all plots are visited every year, and we expect it will take 3 more years to visit every plot in the park. We expect to produce reports with more in-depth data analysis and interpretation when we complete 5 years of sampling. In the interim, reports, spatial data, and data summaries can be provided for park management and interpretation upon request.
Figure 1. Map of plant community monitoring plots at Knife River Indian Villages National Historic Site (KNRI) surveyed in 2012. Plant community monitoring plots in Panel 1 (orange) and Panel 2 (blue) plots were surveyed by NGPN, and the Fire Ecology Program surveyed 5 additional plots (green and black).
Methods

The NGPN Plant Community Composition and Structure Monitoring Protocol (Symstad et al. 2012b, a) describes in detail the methods used for sampling long-term plots. Below, we briefly describe the general approach. For those interested in more detail please see Symstad et al. 2012, available at http://science.nature.nps.gov/im/units/ngpn/monitor/plants.cfm

Sample design
NGPN implemented a survey to monitor plant community structure and composition in KNRI using a spatially balanced probability design (Generalized Random Tessellation Stratified [GRTS]; Stevens and Olsen 2003, 2004). Using a GRTS design, we selected 20 randomly located sites within KNRI. We split these 20 sites into 5 panels with 4 sites each. We visit 2 panels (8 sites) every year, and after 5 years (2015) we will have visited all 20 sites twice. In 2012, we visited sites in Panel 1 and Panel 2 (Figure 1) in late July.

When implemented successfully, probability-based survey designs allow for unbiased inference from sampled sites to un-sampled elements of the resource of interest (Hansen et al. 1983), and with repeat visits it allows for discerning trends in that resource (Larsen et al. 1995). In other words, after 5 and again at 10 years, we can use data from our randomly selected sites to estimate the ecological integrity of vegetation communities for the whole park.

The FireEP aims to understand how prescribed and wildland fires affect the vegetation in national park units in this region. Where possible, the same sites as above are used to assess vegetation response. However, in many cases there are not enough plots in burn units within the first 20 plots or the scheduled visits don’t fall within the FireEP’s monitoring schedule. For this reason, the initial GRTS designs included many more sites that can be visited as needed by NGPN or FireEP. These extra sites are referred to as ‘overdraws’. In 2012, FireEP visited 3 plant community monitoring sites from panel 1-5 (PCM_010, PCM_017, and PCM_018) and 2 overdraw sites (FPCM_029 and FPCM_032; Figure 1).

Plot layout and sampling
At each of the sites we visited, NGPN and FireEP recorded plant species cover and frequency in a rectangular, 50 m x 20 m (0.1 ha), permanent plot (Figure 2). Data on ground cover, herb-layer height ≤ 2 m, and plant cover were collected on two 50 m transects (the long sides of the plot) using a point-intercept method. Species richness data from the point-intercept method were supplemented with species presence data collected in 5 sets of nested square quadrats (0.01 m², 0.1 m², 1 m², and 10 m²) located systematically along each transect (Figure 2). FireEP did not sample the largest quadrats (10 m²) at the 5 sites they visited. In 2012, sampling at KNRI by NGPN took a 4-person crew approximately 131 crew hours with travel time (see Appendix A for a detail of activities each day).

Plant species were identified in the field to species level and not to lower taxonomic groupings (e.g., subspecies or variety). This was a change from the data collected in 2011 by NGPN where plants were identified to the lowest taxonomic level possible. The change was made in coordination with the FireEP because it better reflects the botanical skills of the crew and simplifies data management and analysis. When we were unable to identify a plant, the plant was assigned a unique identifier and collected or photographed. Most of these unknowns were
subsequently identified in the office; however, in some cases identification was impossible. In these cases, the species was classified by growth form and, where possible, lifecycle (e.g., annual graminoid).

When woody species were present, tree regeneration and tall shrub density data were collected within a 10 m radius subplot centered in the larger 50 m x 20 m plot (Figure 2). Trees with diameter at breast height (DBH) > 15 cm, located within the entire 0.1 ha plot, were mapped and tagged. Only 2 of the 13 plots visited were in forested areas. Using these methods, a more thorough assessment of forest structure and health (20 plots) is scheduled to be conducted in 2014.

Figure 2. Long-term monitoring plot used for sampling vegetation in Knife River Indian Villages National Historic Site.
At all plots, we also surveyed the area for common disturbances and target species of interest to the park. Common disturbances included such things as rodent mounds, animal trails, and fire. For all plots, the type and severity of the disturbances were recorded. The target species lists were developed in cooperation with the park and NGPN staff during the winter and spring prior to the field season. Usually, these are invasive and/or exotic species that are not currently widespread in the park, but pose a significant threat if allowed to establish. For each target species that was present at a site, an abundance class was given on a scale from 1-5 where 1 = one individual, 2 = few individuals, 3 = cover of 1-5%, 4 = cover of 5-25%, and 5 = cover > 25% of the plot. The information gathered from this procedure is critical for early detection and rapid response to such threats. In addition, this method tracks the presence of plant species that are considered rare or vulnerable to loss in North Dakota, and may occur in KNRI. The KNRI target species list for 2012 can be found in Table 1.

Table 1. Exotic species of management concern at Knife River Indian Villages National Historic Site and rare species that were surveyed for during the 2012 field season.

<table>
<thead>
<tr>
<th>Exotic Species</th>
<th>Scientific Name</th>
<th>Common Name</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Artemisia absinthium</em></td>
<td>absinth wormwood</td>
<td></td>
</tr>
<tr>
<td><em>Carduus nutans</em></td>
<td>musk thistle</td>
<td></td>
</tr>
<tr>
<td><em>Centaurea stoebe</em></td>
<td>spotted knapweed</td>
<td></td>
</tr>
<tr>
<td><em>Cirsium arvense</em></td>
<td>Canada thistle</td>
<td></td>
</tr>
<tr>
<td><em>Cirsium vulgare</em></td>
<td>bull thistle</td>
<td></td>
</tr>
<tr>
<td><em>Convolvulus arvensis</em></td>
<td>field bindweed</td>
<td></td>
</tr>
<tr>
<td><em>Cynoglossum officinale</em></td>
<td>houndstongue</td>
<td></td>
</tr>
<tr>
<td><em>Elaeagnus angustifolia</em></td>
<td>Russian olive</td>
<td></td>
</tr>
<tr>
<td><em>Gypsophila paniculata</em></td>
<td>babysbreath</td>
<td></td>
</tr>
<tr>
<td><em>Kochia scoparia</em></td>
<td>kochia</td>
<td></td>
</tr>
<tr>
<td><em>Linaria dalmatica</em></td>
<td>Dalmatian toadflax</td>
<td></td>
</tr>
<tr>
<td><em>Linaria vulgaris</em></td>
<td>yellow toadflax</td>
<td></td>
</tr>
<tr>
<td><em>Lonicera tatarica</em></td>
<td>tatarian honeysuckle</td>
<td></td>
</tr>
<tr>
<td><em>Rhamnus cathartica</em></td>
<td>European buckthorn</td>
<td></td>
</tr>
<tr>
<td><em>Rhaponticum repens</em></td>
<td>Russian knapweed</td>
<td></td>
</tr>
<tr>
<td><em>Tamarix spp.</em></td>
<td>tamarisk</td>
<td></td>
</tr>
<tr>
<td><em>Tanacetum vulgare</em></td>
<td>common tansy</td>
<td></td>
</tr>
<tr>
<td><em>Verbascum thapsus</em></td>
<td>common mullein</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Rare Species</th>
<th>Scientific Name</th>
<th>Common Name</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Carex gravida</em></td>
<td>heavy sedge</td>
<td>-------------</td>
</tr>
</tbody>
</table>
Figure 3. Orange plastic plot marker used to replace rebar and nails in long-term monitoring plot PCM_005 and PCM-008.

Due to concerns that the metal rebar and nails that are used to mark plots may interfere with archeological research, NGPN replaced metal at plots PCM_008 and PCM_005 with orange stakes provided by KNRI (Figure 3). At plot PCM_008, 2 pieces of rebar (A0 and B0) were left in place to facilitated finding the plot with a metal detector. At PCM_005, 1 piece of rebar was left in place (A0). In 2013, we plan to revisit these plots and determine whether we can easily relocate our monitoring points without the use of a metal detector. If this pilot effort is successful, we may replace the plot markers at other sites in the future.

Data Management and Analysis
NGPN used FFI (FEAT/FIREMON Integrated; http://frames.gov/ffi/) as the primary software environment for managing our sampling data. FFI is used by a variety of agencies (e.g., NPS, USDA Forest Service, U.S. Fish and Wildlife Service), has a national-level support system, and generally conforms to the Natural Resource Database Template standards established by the Inventory and Monitoring Program.

Species scientific names, codes, and common names are from the USDA Plants Database (USDA-NRCS 2012). However, nomenclature follows the Integrated Taxonomic Information System (ITIS) (http://www.itis.gov). In the few cases where ITIS recognizes a new name that was not in the USDA PLANTS database, the new name was used and a unique plant code was assigned.

After data for the sites were entered, 100% of records were verified to the original datasheet to minimize transcription errors. A further 10% of records were reviewed a second time. After all data were entered and verified, automated queries were developed to check for errors in the data. When errors were caught by the crew or the automated queries, changes were made to the original datasheets and the FFI database as needed.

Plant life forms (e.g., shrub, forb) were based on definitions from the USDA Plants Database (USDA-NRCS 2012). Summaries were produced using the FFI reporting and query tools, and statistical summaries and graphics were generated using R software (version 2.15.1).
We measured diversity at the plots in 3 ways: species richness, the Shannon Index, and Pielou’s Index of Evenness. Species richness is simply a count of the species recorded in an area. The Shannon Index, H’, is a measure of the number of species in an area and how even abundances are across the community. It typically ranges between 0 (low richness and evenness) to 3.5 (high species richness and evenness). Peilou’s Index of Evenness, J’, measures how even abundances are across taxa. It ranges between 0 and 1, where lower numbers indicate that a community is not even or that just a few species make up the majority of the total cover.

**Reporting on Natural Resource Condition**

Results were summarized in a Natural Resource Condition Table based on the templates from the State of the Park report series ([http://www1.nrintra.nps.gov/im/stateoftheparks/index.cfm](http://www1.nrintra.nps.gov/im/stateoftheparks/index.cfm)). The goal of the Natural Resource Condition Table is to improve park priority settings and to synthesize and communicate complex park condition information to the public in a clear and simple way. By focusing on specific indicators, such as exotic species cover or total fuel loads, it will be possible and straightforward to compare conditions in subsequent years. The status, trend, and confidence of assessments for each indicator is scored and assigned a corresponding symbol based on the key found in Table 2.

We chose a set of indicators and specific measures that can describe the condition of vegetation in the Northern Great Plains and the status of exotic plant invasions. The measures include: absolute herb-layer canopy cover, native species richness, evenness, and relative cover of exotic species. Reference values are based on descriptions of historic condition, natural variation, past studies, and professional judgment. Current park condition was compared to a reference value, and status was scored as good condition, caution, or significant concern based on this comparison (Table 2). Good condition was applied to values that fell within the range of the reference value, and significant concern was applied to conditions that fell outside the bounds of the reference value. Trend was scored in a similar fashion and categorized as improving, unchanging, deteriorating, or insufficient information.

Confidence in status and trend assessments within the Natural Resource Condition Table was scored as high, medium, or low. Confidence primarily reflects the quality of the data collected, rather than the quality of the reference condition. Confidence in the data summarizes three aspects of data quality: how well data represent the resource, quality of methods, and the length of the record.
Table 2. Key to the symbols used in the Natural Resource Condition Table. The background color represents the current status, the arrow summarizes the trend, and the thickness of the outside line represents the degree of confidence in the assessment. A symbol that does not contain an arrow indicates that there is insufficient information to assess a trend. Based on the State of the Park reports (http://www1.nrintra.nps.gov/im/stateoftheparks/index.cfm).

<table>
<thead>
<tr>
<th>Condition Status</th>
<th>Trend in Condition</th>
<th>Confidence in Assessment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Condition of resource warrants significant concern</td>
<td>Condition is Improving</td>
<td>High confidence in the assessment</td>
</tr>
<tr>
<td>Condition of resource warrants moderate concern</td>
<td>Condition is Unchanging</td>
<td>Medium confidence in the assessment</td>
</tr>
<tr>
<td>Resource is in good condition</td>
<td>Condition is Deteriorating</td>
<td>Low confidence in the assessment</td>
</tr>
</tbody>
</table>
Results and Discussion

We documented 117 plant species in 2012 at KNRI (Appendix B). Graminoids, which include grasses, sedges, and rushes, accounted for most of the vegetative cover at KNRI (Figure 4). Average plant canopy cover was $149 \pm 11.7\%$ (Table 3) in 2012 (it can be over 100% because we record multiple layers of vegetation). The productive summer in 2011 contributed to a large amount of standing litter on the ground (ground cover at sites averaged 82% plant litter).

![Figure 4. Average cover by life forms in 13 plant community monitoring plots in Knife River Indian Villages National Historic Site in 2012. Bars represent means ± standard errors. Graminoids were the most abundant life-form across all the plots at KNRI.](image)

There was a great deal of variation in species composition across the 13 sites. The most common species found from the point-intercept were graminoids, and most were native species (Figure 5), but the two most common exotic species, Kentucky blue grass (*Poa pratensis*) and smooth brome (*Bromus inermis*), accounted for most of the cover (Figure 5).
Figure 5. The average absolute cover of the 10 most common native (blue) and exotic (red) plants recorded at 13 sites at Knife River Indian Villages National Historic Site in 2012. Bars represent means ± standard errors. The two most common exotic species, smooth brome and Kentucky bluegrass, are more abundant than native species.
Table 3. Natural resource condition summary table for upland plant communities in Knife River Indian Villages National Historic Site (KNRI).

<table>
<thead>
<tr>
<th>Indicator of Condition</th>
<th>Specific Measures</th>
<th>2012 Value (mean ± SE)</th>
<th>Reference Condition and Data Source</th>
<th>Condition Status/Trend</th>
<th>Rationale for Resource Condition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Upland Plant Community Structure and Composition</td>
<td>Absolute herb-layer canopy cover</td>
<td>149 ± 11.7 %</td>
<td>TBD</td>
<td></td>
<td>KNRI protects and manages small remnants of northern mixed-grass prairie. A history of extensive human-use has led to low native species richness when compared to more intact mixed-grass prairies in the region. We do not have a reference condition or baseline for evenness or canopy cover, so we have low confidence in our estimate that current values indicate good condition. Future monitoring will help the park determine if the goal to maintain or increase native diversity is being met.</td>
</tr>
<tr>
<td></td>
<td>Native species richness (based on average of 10 1m$^2$ quadrats per plot)</td>
<td>4 ± 1.0 species</td>
<td>8-18 species (1)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Evenness (based on point-intercept of 2-50m transects per plot)</td>
<td>0.63 ± 0.04</td>
<td>TBD</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Exotic Plant Early Detection and Management</td>
<td>Relative cover of exotic species</td>
<td>67 ± 7.8 %</td>
<td>A decreasing trend in exotic cover (2)</td>
<td></td>
<td>KNRI manages a landscape with a very high cover of exotic species. Smooth brome and Kentucky bluegrass are particularly abundant. The KNRI prairie management plan describes the park goal as decreasing the cover of these two species and exotic species in general. At this point, we have only limited data over time, but they suggest a stable or increasing trend. As NGPN collects more data, we will be able to determine whether the park is meeting this goal.</td>
</tr>
<tr>
<td></td>
<td>Relative percent cover of smooth brome</td>
<td>31 ± 7.5 %</td>
<td>A decreasing trend in smooth brome cover (2)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

References and Data Sources:
Species richness varies by the scale on which it is examined. Table 4 presents average species richness, taken from the point-intercept method, 1 m² quadrats, and 10 m² quadrats for the monitoring plots in 2012. On average, there are about 3 exotic species found in each 10 m² quadrat (Table 4). We found a mix of forbs and graminoids along the transects and in the quadrats (Table 4). From the point-intercept data, we found average plot diversity, H′, to be 1.5 ± 0.16. Evenness, J’, averaged 0.63 ± 0.04 across the plots (Table 3). When including only native species, average diversity and evenness were 1.5 ± 0.2 and 0.70 ± 0.06, respectively.

Table 4. Average plant species richness plant community monitoring plots at Knife River Indian Villages National Historic Site in 2012. Values represent means ± standard errors, n=13 for the point-intercept and 1m² quadrats and n=8 for the 10m² quadrats.

<table>
<thead>
<tr>
<th></th>
<th>Point-intercept</th>
<th>1 m² quadrats</th>
<th>10 m² quadrats</th>
</tr>
</thead>
<tbody>
<tr>
<td>Species richness</td>
<td>12 ± 1.6</td>
<td>7 ± 0.9</td>
<td>10 ± 2.0</td>
</tr>
<tr>
<td>Native species richness</td>
<td>9 ± 1.8</td>
<td>4 ± 1.0</td>
<td>7 ± 2.1</td>
</tr>
<tr>
<td>Exotic species richness</td>
<td>3 ± 0.4</td>
<td>2 ± 0.3</td>
<td>3 ± 0.5</td>
</tr>
<tr>
<td>Graminoid species richness</td>
<td>6 ± 0.8</td>
<td>4 ± 0.5</td>
<td>4 ± 0.8</td>
</tr>
<tr>
<td>Forb species richness</td>
<td>5 ± 0.8</td>
<td>3 ± 0.5</td>
<td>5 ± 1.2</td>
</tr>
</tbody>
</table>

Table 5. Characteristics of the plant community in 13 plots at Knife River Indian Villages National Historic Site in 2012 including average native species richness, exotic plant cover, smooth brome cover, and area of disturbance.

<table>
<thead>
<tr>
<th>Plot</th>
<th>Average native species richness 1 m² plots</th>
<th>Exotic cover (%)</th>
<th>Smooth brome cover (%)</th>
<th>Disturbance within site (m²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>KNRI_FPCM_029</td>
<td>3</td>
<td>67</td>
<td>20</td>
<td>-</td>
</tr>
<tr>
<td>KNRI_FPCM_032</td>
<td>5</td>
<td>36</td>
<td>0</td>
<td>-</td>
</tr>
<tr>
<td>KNRI_PCM_001</td>
<td>6</td>
<td>23</td>
<td>21</td>
<td>1000</td>
</tr>
<tr>
<td>KNRI_PCM_002</td>
<td>3</td>
<td>84</td>
<td>47</td>
<td>2318</td>
</tr>
<tr>
<td>KNRI_PCM_003</td>
<td>2</td>
<td>89</td>
<td>50</td>
<td>1000</td>
</tr>
<tr>
<td>KNRI_PCM_004</td>
<td>12</td>
<td>40</td>
<td>7</td>
<td>15</td>
</tr>
<tr>
<td>KNRI_PCM_005</td>
<td>7</td>
<td>61</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>KNRI_PCM_006</td>
<td>2</td>
<td>88</td>
<td>52</td>
<td>1010</td>
</tr>
<tr>
<td>KNRI_PCM_007</td>
<td>2</td>
<td>87</td>
<td>16</td>
<td>0</td>
</tr>
<tr>
<td>KNRI_PCM_008</td>
<td>1</td>
<td>100</td>
<td>94</td>
<td>105</td>
</tr>
<tr>
<td>KNRI_PCM_010</td>
<td>2</td>
<td>99</td>
<td>47</td>
<td>-</td>
</tr>
<tr>
<td>KNRI_PCM_017</td>
<td>10</td>
<td>21</td>
<td>0</td>
<td>-</td>
</tr>
<tr>
<td>KNRI_PCM_018</td>
<td>3</td>
<td>73</td>
<td>38</td>
<td>-</td>
</tr>
</tbody>
</table>

Species richness in the mixed-grass prairie is determined by numerous factors including fire regime, large ungulate grazing, prairie dog disturbance, and weather fluctuations (Symstad and Jonas 2011). While it is difficult to define a reference condition for species richness that can vary so much spatially and temporally, the natural range of variation over long time periods may be a good starting point (Symstad and Jonas in press). Long-term records of species diversity in mixed-grass prairie in a moderately grazed site in Montana ranged between 8 and 18 species per square meter (10-90th percentile range) between 1933-1945 (Symstad and Jonas in press).

Native species richness falls below the natural range of variation in all but two sites (PCM_004 and PCM_017). PCM_004 was the site with the most native species richness, but it still had a
significant cover of exotics (Figure 6). In contrast, PCM_008 had a very low number of native species and a high cover of exotics, particularly smooth brome (Figure 6).

Figure 6. Two long-term vegetation monitoring plots in Knife River Indian Villages National Historic Site that depict a gradient from high native species richness (top panel) to low native species richness (bottom panel).

The average relative cover of exotic species at sites in KNRI was very high (67%; Table 3). Like species richness, the cover of exotic species varied considerably across sites, but there were no sites with less than 20% cover (Table 5). Smooth brome was present at all but two sites in the park (Table 5). The most common target species found were Canada thistle and field bindweed (Table 6). We found Canada thistle at 6 of the 13 sites, and field bindweed was seen at 4 sites (Table 6). In general, all the target species were found in low abundance.

Disturbance from grazing, rodents, fire, and humans affects plant community structure and composition in mixed-grass prairie. For this reason, we measured the approximate area affected by natural and human disturbances at each site we visited. The most common disturbance was
from small mammal excavations (3 plots) and fire (4 plots). Other disturbances included animal beds, off road use, and garbage. There was not a clear correlation between disturbance and native species richness or exotic cover (Table 5), but as we collect more data in the future we hope to explore the relationship between disturbance and plant community composition.

Table 6. Cover class of target species at 13 plots at KNRI in 2012. 1 = one individual, 2 = few individuals, cover <1%, 3 = cover 1-5% of site, 4 = cover 5-25% of site, 5 = cover> 25% of site, present = present at site but cover was not assessed.

<table>
<thead>
<tr>
<th>Site</th>
<th>Canada Thistle</th>
<th>Absinth wormwood</th>
<th>Bull Thistle</th>
<th>Field bindweed</th>
<th>Babys-breath</th>
<th>European buckthorn</th>
</tr>
</thead>
<tbody>
<tr>
<td>KNRI_FPCM_029</td>
<td>present</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>KNRI_FPCM_032</td>
<td>present</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>present</td>
<td>-</td>
</tr>
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<td>KNRI_PCM_001</td>
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<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>KNRI_PCM_002</td>
<td>present</td>
<td>2</td>
<td>2</td>
<td>-</td>
<td>-</td>
<td>2</td>
</tr>
<tr>
<td>KNRI_PCM_003</td>
<td>-</td>
<td>1</td>
<td>4</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>KNRI_PCM_004</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>KNRI_PCM_005</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>KNRI_PCM_006</td>
<td>present</td>
<td>2</td>
<td>1</td>
<td>2</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>KNRI_PCM_007</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>1</td>
<td>-</td>
</tr>
<tr>
<td>KNRI_PCM_008</td>
<td>present</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>KNRI_PCM_010</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>KNRI_PCM_017</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>KNRI_PCM_018</td>
<td>present</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

In 2012, 2 of the 13 plots we visited in KNRI were forested (Table 7). We measured the density of boxelder (*Acer negundo*), green ash (*Fraxinus pennsylvanica*), American elm (*Ulmus americana*), silver buffaloberry (*Shepherdia argentea*), European buckthorn (*Rhamnus cathartica*), Eastern cottonwood (*Populus deltoides*), and peachleaf willow (*Salix amygdaloides*). Green ash seedlings were common in both PCM_002 and PCM_006. We did not find any adult buckthorn, but buckthorn seedlings were common in PCM_002. KNRI has devoted lots of resources in the past several years to eradicating buckthorn. PCM_002 lies at the northern fringe of a former heavy infestation of buckthorn. In 2014, we will conduct a more comprehensive survey of the riparian forests in KNRI. At that time, we will provide better estimates of forest health and condition.
Table 7. Tree and tall shrub density at 2 forested plots at KNRI in 2012.

<table>
<thead>
<tr>
<th>Plot</th>
<th>Species</th>
<th>Trees (stems hectare$^{-1}$)</th>
<th>Poles (stems hectare$^{-1}$)</th>
<th>Seedlings (stems hectare$^{-1}$)</th>
<th>Snags (stems hectare$^{-1}$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>PCM_002</td>
<td>Boxelder</td>
<td>20</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>Green Ash</td>
<td>30</td>
<td>32</td>
<td>573</td>
<td>148</td>
</tr>
<tr>
<td></td>
<td>American Elm</td>
<td>10</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>Silver buffaloberry</td>
<td>32</td>
<td>96</td>
<td>127</td>
<td>732</td>
</tr>
<tr>
<td></td>
<td>European buckthorn</td>
<td>-</td>
<td>-</td>
<td>477</td>
<td>-</td>
</tr>
<tr>
<td>PCM_006</td>
<td>Green Ash</td>
<td>-</td>
<td>-</td>
<td>1241</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>Cottonwood</td>
<td>190</td>
<td>-</td>
<td>477</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td>Peachleaf willow</td>
<td>10</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

In conclusion, KNRI protects and manages a small remnant of northern mixed-grass prairie. A history of extensive human use has led to low native species richness when compared to more intact mixed-grass prairies in the region. Exotic cover is high, and smooth brome and Kentucky bluegrass are particularly abundant. Reducing the cover of smooth brome will be critical to maintaining native diversity, and to retain ecological integrity it is important to continue efforts to reduce the cover of invasive plants. Allowing for natural disturbances such as fire may be critical to maintaining plant diversity in KNRI, but it should be balanced with the need to protect intact native communities and prevent further invasions of exotic species. Continued monitoring efforts will be critical to track changes in the condition of the vegetation communities in KNRI.
Literature Cited


DeKeyser, E. and K. Krabbenhoft. 2006. Prairie management plan for the Knife River Indian Villages National Historic Site. North Dakota State University, Fargo, ND.


Appendix A: Field journal for plant community monitoring in KNRI for the 2012 season

Plant community composition monitoring in JECA was completed using a crew of 4 people working 2.5 10-hour days. We spent 131 total crew hours at KNRI.

<table>
<thead>
<tr>
<th>Date</th>
<th>Day of week</th>
<th>Approximate Travel Time (hrs)</th>
<th>Housing</th>
<th>Sites Completed</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jul 23, 2012</td>
<td>Monday</td>
<td>7</td>
<td>Rough Rider Motor Inn Hazen, ND</td>
<td>PCM-003</td>
<td>1 plot read</td>
</tr>
<tr>
<td>Jul 24, 2012</td>
<td>Tuesday</td>
<td>1</td>
<td>Rough Rider Motor Inn Hazen, ND</td>
<td>PCM-002, PCM-007</td>
<td>2 plots read</td>
</tr>
<tr>
<td>Jul 25, 2012</td>
<td>Wednesday</td>
<td>1</td>
<td>Rough Rider Motor Inn Hazen, ND</td>
<td>PCM-001, PCM-005, PCM-008</td>
<td>3 plots read; installed plastic stake markers at PCM-005 and PCM-008</td>
</tr>
<tr>
<td>Jul 26, 2012</td>
<td>Thursday</td>
<td>7</td>
<td>N/A</td>
<td>PCM-004, PCM-006</td>
<td>2 plots read</td>
</tr>
</tbody>
</table>
Appendix B: List of plant species found in 2012 at KNRI

Species found in monitoring plots at Knife River Indian Villages National Historic Site in 2012. Species in bold are not on the park’s certified species list.

<table>
<thead>
<tr>
<th>Family</th>
<th>Species Code</th>
<th>Scientific Name</th>
<th>Common Name</th>
<th>Exotic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aceraceae</td>
<td>ACNE2</td>
<td>Acer negundo</td>
<td>boxelder</td>
<td></td>
</tr>
<tr>
<td>Anacardiaceae</td>
<td>TORY</td>
<td>Toxicodendron rydbergii</td>
<td>western poison ivy</td>
<td></td>
</tr>
<tr>
<td>Asclepiadaceae</td>
<td>ASPU</td>
<td>Asclepias pumila</td>
<td>plains milkweed</td>
<td></td>
</tr>
<tr>
<td>Asclepiadaceae</td>
<td>ASSP</td>
<td>Asclepias speciosa</td>
<td>showy milkweed</td>
<td></td>
</tr>
<tr>
<td>Asclepiadaceae</td>
<td>ASVE</td>
<td>Asclepias verticillata</td>
<td>whorled milkweed</td>
<td></td>
</tr>
<tr>
<td>Asclepiadaceae</td>
<td>ASVI</td>
<td>Asclepias viridiflora</td>
<td>green milkweed</td>
<td></td>
</tr>
<tr>
<td>Asteraceae</td>
<td>ACMI2</td>
<td>Achillea millefolium</td>
<td>yarrow</td>
<td></td>
</tr>
<tr>
<td>Asteraceae</td>
<td>AMPS</td>
<td>Ambrosia psilostachya</td>
<td>western ragweed</td>
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<tr>
<td>Asteraceae</td>
<td>ARAB3</td>
<td>Artemisia absinthium</td>
<td>absinth wormwood</td>
<td></td>
</tr>
<tr>
<td>Asteraceae</td>
<td>ARDR4</td>
<td>Artemisia dracunculus</td>
<td>tarragon</td>
<td></td>
</tr>
<tr>
<td>Asteraceae</td>
<td>ARFR4</td>
<td>Artemisia frigida</td>
<td>fringed sagebrush</td>
<td></td>
</tr>
<tr>
<td>Asteraceae</td>
<td>ARLU</td>
<td>Artemisia ludoviciana</td>
<td>white sagebrush</td>
<td></td>
</tr>
<tr>
<td>Asteraceae</td>
<td>BREU</td>
<td>Brickellia eupatorioides</td>
<td>false boneset</td>
<td></td>
</tr>
<tr>
<td>Asteraceae</td>
<td>CIAR4</td>
<td>Cirsium arvense</td>
<td>Canada thistle</td>
<td></td>
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<tr>
<td>Asteraceae</td>
<td>CIFL</td>
<td>Cirsium flodmanii</td>
<td>Flodman thistle</td>
<td></td>
</tr>
<tr>
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<td>CIUN</td>
<td>Cirsium undulatum</td>
<td>wavyleaf thistle</td>
<td></td>
</tr>
<tr>
<td>Asteraceae</td>
<td>CIVU</td>
<td>Cirsium vulgare</td>
<td>bull thistle</td>
<td></td>
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<tr>
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<td>ECAN2</td>
<td>Echinacea angustifolia</td>
<td>blacksamson echinacea</td>
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</tr>
<tr>
<td>Asteraceae</td>
<td>ERST3</td>
<td>Erigeron strigosus</td>
<td>prairie fleabane</td>
<td></td>
</tr>
<tr>
<td>Asteraceae</td>
<td>HEVI4</td>
<td>Heterotheca villosa</td>
<td>hairy goldenaster</td>
<td></td>
</tr>
<tr>
<td>Asteraceae</td>
<td>LIPU</td>
<td>Liatris punctata</td>
<td>dotted blazing star</td>
<td></td>
</tr>
<tr>
<td>Asteraceae</td>
<td>LYJU</td>
<td>Lygodesmia juncea</td>
<td>rush skeletonplant</td>
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<tr>
<td>Asteraceae</td>
<td>MUOB99</td>
<td>Mulgedium oblongifolium</td>
<td>blue lettuce</td>
<td></td>
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<tr>
<td>Asteraceae</td>
<td>RACO3</td>
<td>Ratibida columnifera</td>
<td>prairie coneflower</td>
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</tr>
<tr>
<td>Asteraceae</td>
<td>SOMI2</td>
<td>Solidago missouriensis</td>
<td>Missouri goldenrod</td>
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</tr>
<tr>
<td>Asteraceae</td>
<td>SOMO</td>
<td>Solidago mollis</td>
<td>velvety goldenrod</td>
<td></td>
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<td>Asteraceae</td>
<td>SORI2</td>
<td>Solidago rigida</td>
<td>stiff goldenrod</td>
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<td>Asteraceae</td>
<td>SYER</td>
<td>Symphyotrichum ericoides</td>
<td>white heath aster</td>
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<td>SYLA3</td>
<td>Symphyotrichum laeve</td>
<td>smooth blue aster</td>
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<td>SYLA6</td>
<td>Symphyotrichum lanceolatum</td>
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<td>SYOB</td>
<td>Symphyotrichum oblongifolium</td>
<td>aromatic aster</td>
<td></td>
</tr>
<tr>
<td>Asteraceae</td>
<td>TAOF</td>
<td>Taraxacum officinale</td>
<td>common dandelion</td>
<td></td>
</tr>
</tbody>
</table>
| Asteraceae     | TRDU         | Tragopogon dubius            | common salsify, goatsbeard |  *
<p>| Asteraceae     | XASP99       | Xanthisma spinulosum         | lacy tansyaster        |        |</p>
<table>
<thead>
<tr>
<th>Family</th>
<th>Species Code</th>
<th>Scientific Name</th>
<th>Common Name</th>
<th>Exotic</th>
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<td>Onosmodium bejariense</td>
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<td>Berteroa incana</td>
<td>hoary alyssum</td>
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<td>Brassicaceae</td>
<td>HEMA3</td>
<td>Hesperis matronalis</td>
<td>dames rocket</td>
<td>*</td>
</tr>
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<td>Caprifoliaceae</td>
<td>SYOC</td>
<td>Symphoricarpus occidentalis</td>
<td>western snowberry</td>
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<tr>
<td>Caryophyllaceae</td>
<td>GYPA</td>
<td>Gypsophila paniculata</td>
<td>baby's breath</td>
<td>*</td>
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<td>Chenopodiaceae</td>
<td>CHAL7</td>
<td>Chenopodium album</td>
<td>lambsquarters goosefoot</td>
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<td>Chenopodiaceae</td>
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<td>Chenopodium berlandieri</td>
<td>pitseed goosefoot</td>
<td></td>
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<tr>
<td>Chenopodiaceae</td>
<td>CHPR5</td>
<td>Chenopodium pratericola</td>
<td>desert goosefoot</td>
<td></td>
</tr>
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<td>Convolvulaceae</td>
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<td>Convolvulus arvensis</td>
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<td>Carex</td>
<td>sedge</td>
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<td>Carex brevior</td>
<td>shortbeak sedge</td>
<td></td>
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<td>Carex filifolia</td>
<td>threadleaf sedge</td>
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<td>CAIN9</td>
<td>Carex inops</td>
<td>long-stolon sedge</td>
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<tr>
<td>Elaeagnaceae</td>
<td>SHAR</td>
<td>Shepherdia argentea</td>
<td>silver buffaloberry</td>
<td></td>
</tr>
<tr>
<td>Euphorbiaceae</td>
<td>EUES</td>
<td>Euphorbia esula</td>
<td>leafy spurge</td>
<td>*</td>
</tr>
<tr>
<td>Euphorbiaceae</td>
<td>EUSE5</td>
<td>Euphorbia serpyllifolia</td>
<td>thymeleaf sandmat</td>
<td></td>
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<tr>
<td>Fabaceae</td>
<td>ACAM99</td>
<td>Acmispon americanus</td>
<td>American bird’s-foot trefoil</td>
<td></td>
</tr>
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<td>Fabaceae</td>
<td>AMNA</td>
<td>Amorpha nana</td>
<td>dwarf false indigo</td>
<td></td>
</tr>
<tr>
<td>Fabaceae</td>
<td>ASBI2</td>
<td>Astragalus bisulcatus</td>
<td>two groove milkvetch</td>
<td></td>
</tr>
<tr>
<td>Fabaceae</td>
<td>ASMI10</td>
<td>Astragalus missouriensis</td>
<td>Missouri milkvetch</td>
<td></td>
</tr>
<tr>
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<td>DACA7</td>
<td>Dalea candida</td>
<td>white prairie clover</td>
<td></td>
</tr>
<tr>
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<td>DAPU5</td>
<td>Dalea purpurea</td>
<td>violet prairie clover</td>
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<tr>
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The Department of the Interior protects and manages the nation’s natural resources and cultural heritage; provides scientific and other information about those resources; and honors its special responsibilities to American Indians, Alaska Natives, and affiliated Island Communities.

NPS 468/119752, February 2013