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Natural Resource Stewardship and Science

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
Long-term monitoring plot PCM_002 at Knife River Indian Villages National Historic Site, 2012.
Photograph by: NGPN

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

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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.

The Natural Resource Technical Report Series is used to disseminate results of scientific studies in the physical, biological, and social sciences for both the advancement of science and the achievement of the National Park Service mission. The series provides contributors with a forum for displaying comprehensive data that are often deleted from journals because of page limitations.

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.

Views, statements, findings, conclusions, recommendations, and data in this report do not necessarily reflect views and policies of the National Park Service, U.S. Department of the Interior. Mention of trade names or commercial products does not constitute endorsement or recommendation for use by the U.S. Government.

This report is available from the Northern Great Plains Inventory & Monitoring Network website http://science.nature.nps.gov/im/units/ngpn/monitor/plants.cfm and the Natural Resource Publications Management website (http://www.nature.nps.gov/publications/nrpm/).

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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.

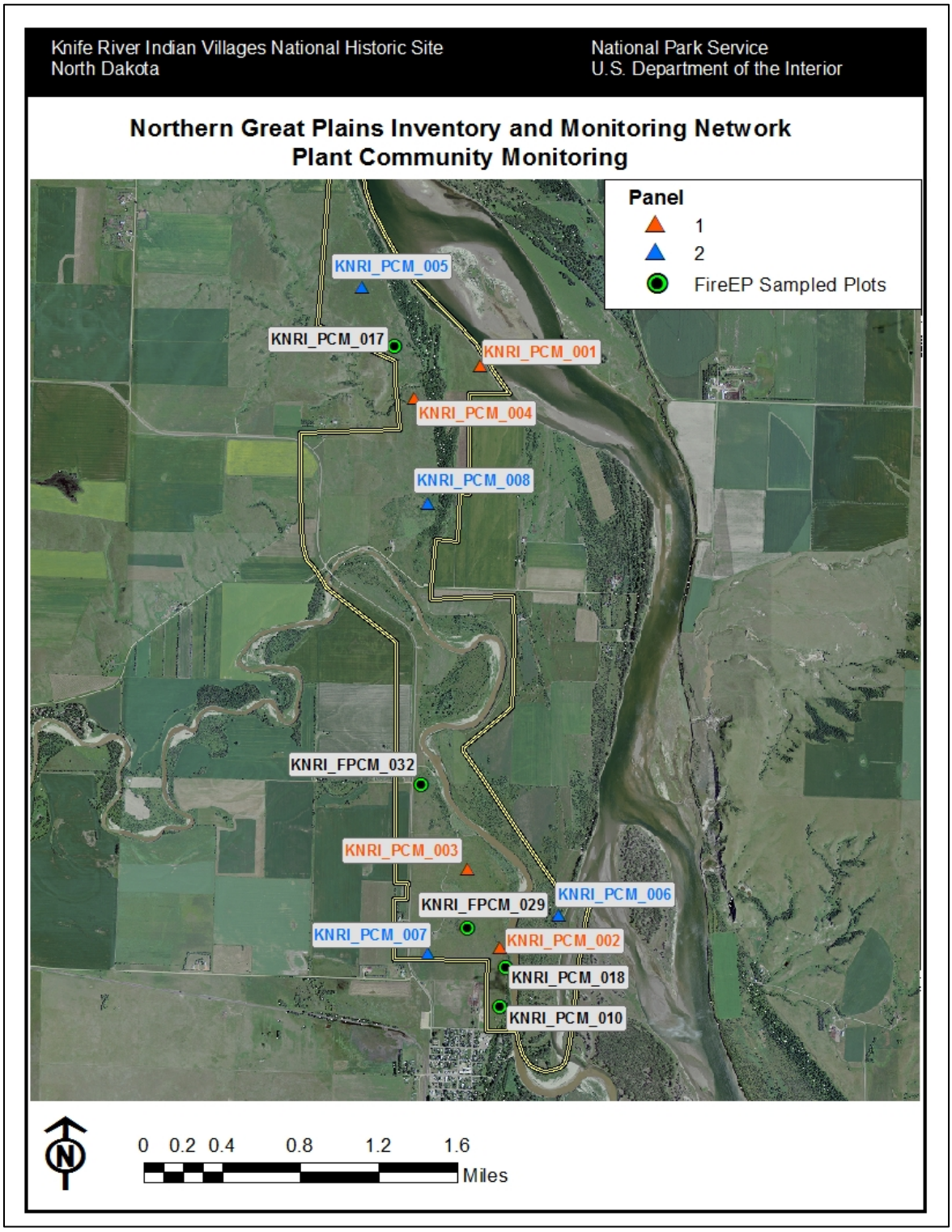


Figure 1. Map of plant community monitoring plots at Knife River Indian Villages National Historic Site (KNRI) surveyed in 2012. Plant community monitoring plots in Panel 1 (orange) and Panel 2 (blue) plots were surveyed by NGPN, and the Fire Ecology Program surveyed 5 additional plots (green and black).

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 $\leq$ 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 m^2, 0.1 m^2, 1 m^2, and 10 m^2) located systematically along each transect (Figure 2). FireEP did not sample the largest quadrats (10 m^2) 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 crewand 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.

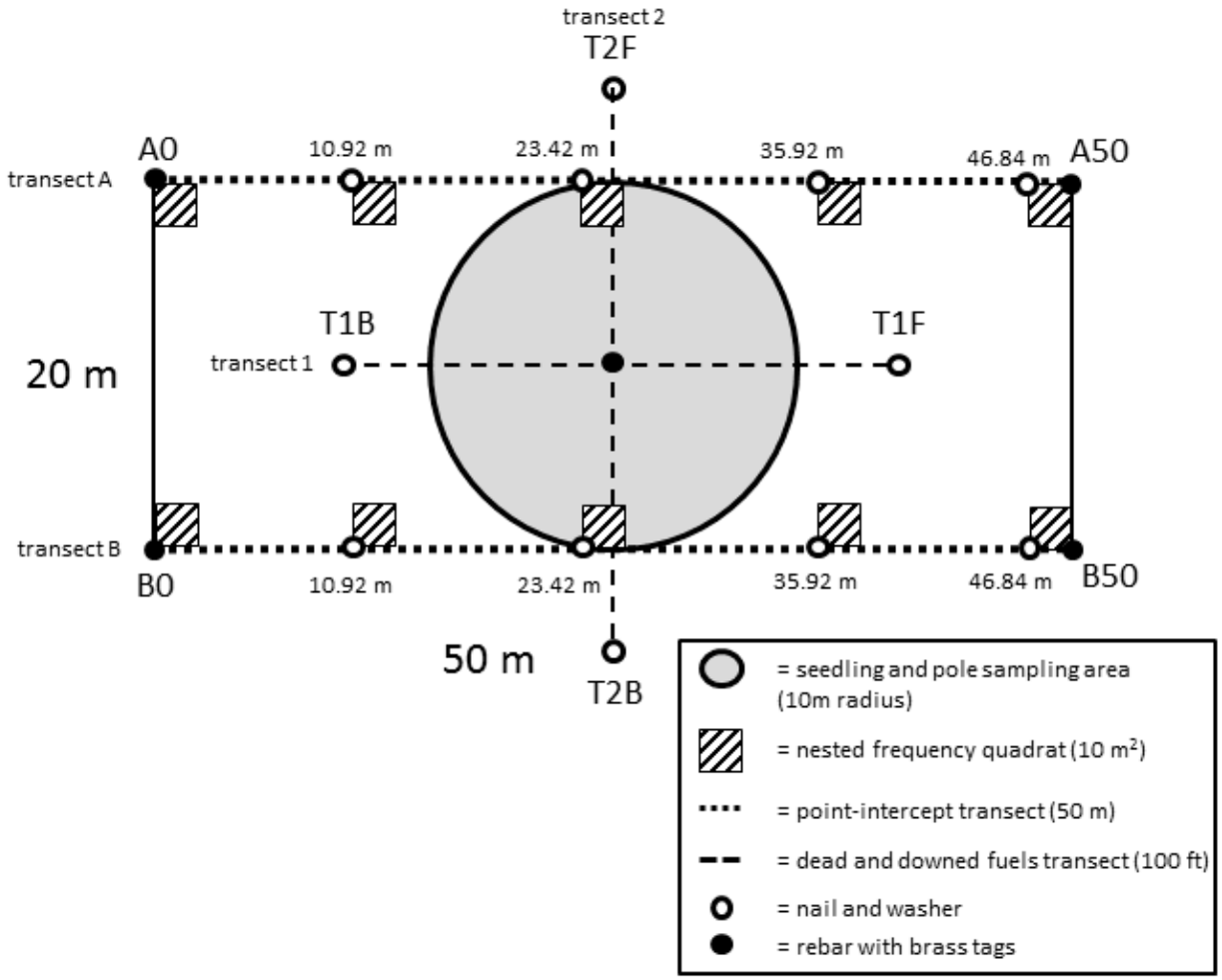


Figure 2. Long-term monitoring plot used for sampling vegetation in Knife River Indian Villages National Historic Site.

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.

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

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.

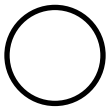
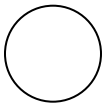
Reporting on Natural Resource Condition

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). 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).

Condition Status		**Trend in Condition**		**Confidence in Assessment**	
	Condition of resource warrants significant concern		Condition is Improving		High confidence in the assessment
	Condition of resource warrants moderate concern		Condition is Unchanging		Medium confidence in the assessment
	Resource is in good condition		Condition is Deteriorating		Low confidence in the assessment

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 ± 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).

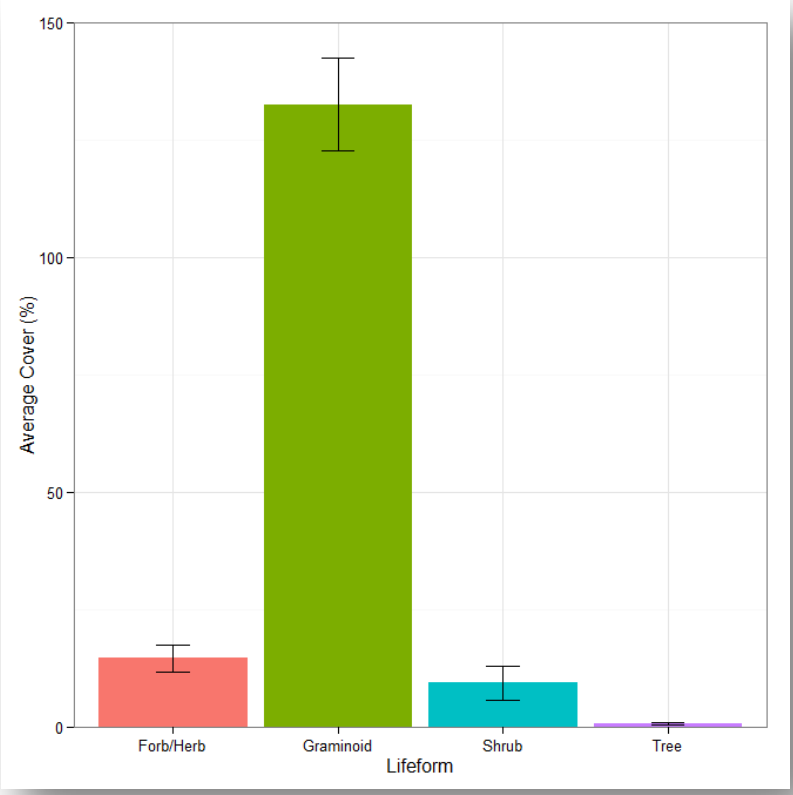


Figure 4. Average cover by life forms in 13 plant community monitoring plots in Knife River Indian Villages National Historic Site in 2012. Bars represent means ± standard errors. Graminoids were the most abundant life-form across all the plots at KNRI.

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).

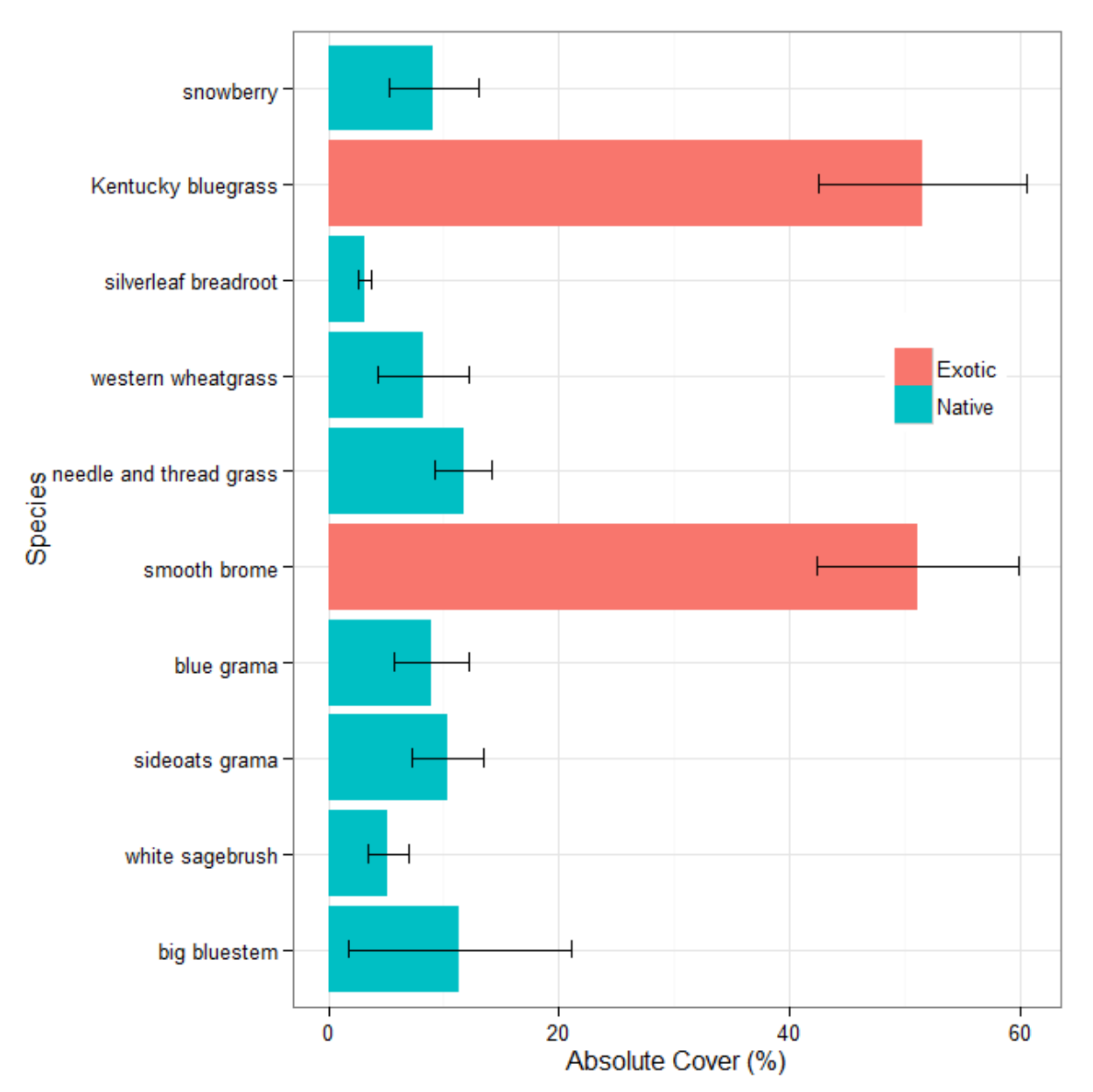
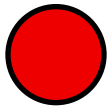
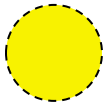
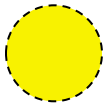


Figure 5. The average absolute cover of the 10 most common native (blue) and exotic (red) plants recorded at 13 sites at Knife River Indian Villages National Historic Site in 2012. Bars represent means ± standard errors. The two most common exotic species, smooth brome and Kentucky bluegrass, are more abundant than native species.

Table 3. Natural resource condition summary table for upland plant communities in Knife River Indian Villages National Historic Site (KNRI).

Indicator of Condition	Specific Measures	2012 Value (mean ± SE)	Reference Condition and Data Source	Condition Status/Trend	Rationale for Resource Condition
Upland Plant Community Structure and Composition	Absolute herb-layer canopy cover	149 ± 11.7 %	TBD		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.
	Native species richness (based on average of 10 1m^2 quadrats per plot)	4 ± 1.0 species	8-18 species [(1)]		
	Evenness (based on point-intercept of 2-50m transects per plot)	0.63 ± 0.04	TBD		
Exotic Plant Early Detection and Management	Relative cover of exotic species	67 ± 7.8 %	A decreasing trend in exotic cover [(2)]		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.
	Relative percent cover of smooth brome	31 ± 7.5 %	A decreasing trend in smooth brome cover [(2)]		

References and Data Sources:

1. Symstad, A. J. and J. L. Jonas. *in press*. Using natural range of variation to set decision thresholds: a case study for Great Plains grasslands.in G. R. Gutenspergen, editor. Application of threshold concepts in natural resource decision making. Springer Verlag. 2. DeKeyser, E. and K. Krabbenhoft. 2006. Prairie management plan for the Knife River Indian Villages National Historic Site. North Dakota State University, Fargo, ND.

Species richness varies by the scale on which it is examined. Table 4 presents average species richness, taken from the point-intercept method, 1 m^2 quadrats, and 10 m^2 quadrats for the monitoring plots in 2012. On average, there are about 3 exotic species found in each 10 m^2 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 1m^2 quadrats and n=8 for the 10m^2 quadrats.

	Point-intercept	**1 m^2 quadrats**	**10 m^2 quadrats**
Species richness	12 ± 1.6	7 ± 0.9	10 ± 2.0
Native species richness	9 ± 1.8	4 ± 1.0	7 ± 2.1
Exotic species richness	3 ± 0.4	2 ± 0.3	3 ± 0.5
Graminoid species richness	6 ± 0.8	4 ± 0.5	4 ± 0.8
Forb species richness	5 ± 0.8	3 ± 0.5	5 ± 1.2

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.

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

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.

	Target Species (abundance class)					
Site	**Canada Thistle**	**Absinth wormwood**	**Bull Thistle**	**Field bindweed**	**Babys-breath**	**European buckthorn**
KNRI_FPCM_029	present	-	-	-	-	-
KNRI_FPCM_032	present	-	-	present	-	-
KNRI_PCM_001	-	-	-	-	-	-
KNRI_PCM_002	present	2	-	2	-	2
KNRI_PCM_003	-	1	-	4	-	-
KNRI_PCM_004	-	-	-	-	-	-
KNRI_PCM_005	-	-	-	-	-	-
KNRI_PCM_006	present	2	1	2	-	-
KNRI_PCM_007	-	-	-	-	1	-
KNRI_PCM_008	present	-	-	-	-	-
KNRI_PCM_010	-	-	-	-	-	-
KNRI_PCM_017	-	-	-	-	-	-
KNRI_PCM_018	present	-	-	-	-	-

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.

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

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.

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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.

Date	Day of week	Approximate Travel Time (hrs)	Housing	Sites Completed	Notes
Jul 23, 2012	Monday	7	Rough Rider Motor Inn Hazen, ND	PCM-003	1 plot read
Jul 24, 2012	Tuesday	1	Rough Rider Motor Inn Hazen, ND	PCM-002 PCM-007	2 plots read
Jul 25, 2012	Wednesday	1	Rough Rider Motor Inn Hazen, ND	PCM-001 PCM-005 PCM-008	3 plots read; installed plastic stake markers at PCM-005 and PCM-008
Jul 26, 2012	Thursday	7	N/A	PCM-004 PCM-006	2 plots read

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.

Family	Species Code	Scientific Name	Common Name	Exotic
Aceraceae	ACNE2	*Acer negundo*	boxelder	
Anacardiaceae	TORY	*Toxicodendron rydbergii*	western poison ivy	
Asclepiadaceae	ASPU	*Asclepias pumila*	plains milkweed	
Asclepiadaceae	**ASSP**	***Asclepias speciosa***	**showy milkweed**	
Asclepiadaceae	ASVE	*Asclepias verticillata*	whorled milkweed	
Asclepiadaceae	ASVI	*Asclepias viridiflora*	green milkweed	
Asteraceae	ACMI2	*Achillea millefolium*	yarrow	
Asteraceae	AMPS	*Ambrosia psilostachya*	western ragweed	
Asteraceae	ARAB3	*Artemisia absinthium*	absinth wormwood	*
Asteraceae	ARDR4	*Artemisia dracunculus*	tarragon	
Asteraceae	ARFR4	*Artemisia frigida*	fringed sagebrush	
Asteraceae	ARLU	*Artemisia ludoviciana*	white sagebrush	
Asteraceae	BREU	*Brickellia eupatorioides*	false boneset	
Asteraceae	CIAR4	*Cirsium arvense*	Canada thistle	*
Asteraceae	CIFL	*Cirsium flodmanii*	Flodman thistle	
Asteraceae	**CIUN**	***Cirsium undulatum***	**wavyleaf thistle**	
Asteraceae	**CIVU**	***Cirsium vulgare***	**bull thistle**	*****
Asteraceae	ECAN2	*Echinacea angustifolia*	blacksamson echinacea	
Asteraceae	ERST3	*Erigeron strigosus*	prairie fleabane	
Asteraceae	HEVI4	*Heterotheca villosa*	hairy goldenaster	
Asteraceae	LIPU	*Liatris punctata*	dotted blazing star	
Asteraceae	LYJU	*Lygodesmia juncea*	rush skeletonplant	
Asteraceae	MUOB99	*Mulgedium oblongifolium*	blue lettuce	
Asteraceae	RACO3	*Ratibida columnifera*	prairie coneflower	
Asteraceae	SOMI2	*Solidago missouriensis*	Missouri goldenrod	
Asteraceae	SOMO	*Solidago mollis*	velvety goldenrod	
Asteraceae	SORI2	*Solidago rigida*	stiff goldenrod	
Asteraceae	SYER	*Symphyotrichum ericoides*	white heath aster	
Asteraceae	SYLA3	*Symphyotrichum laeve*	smooth blue aster	
Asteraceae	**SYLA6**	***Symphyotrichum lanceolatum***	**white panicle aster**	
Asteraceae	**SYOB**	***Symphyotrichum oblongifolium***	**aromatic aster**	
Asteraceae	TAOF	*Taraxacum officinale*	common dandelion	*
Asteraceae	TRDU	*Tragopogon dubius*	common salsify, goatsbeard	*
Asteraceae	XASP99	*Xanthisma spinulosum*	lacy tansyaster	

Family	Species Code	Scientific Name	Common Name	Exotic
Boraginaceae	LIIN2	*Lithospermum incisum*	fringed puccoon	
Boraginaceae	**ONBE**	***Onosmodium bejariense***	**soft-hair marbleseed**	
Brassicaceae	**BEIN2**	***Berteroa incana***	**hoary alyssum**	*****
Brassicaceae	HEMA3	*Hesperis matronalis*	dames rocket	*
Caprifoliaceae	SYOC	*Symphoricarpos occidentalis*	western snowberry	
Caryophyllaceae	**GYPA**	***Gypsophila paniculata***	**baby's breath**	*****
Chenopodiaceae	CHAL7	*Chenopodium album*	lambsquarters goosefoot	*
Chenopodiaceae	CHBE4	*Chenopodium berlandieri*	pitseed goosefoot	
Chenopodiaceae	CHPR5	*Chenopodium pratericola*	desert goosefoot	
Convolvulaceae	COAR4	*Convolvulus arvensis*	field bindweed	*
Cyperaceae	CAREX	*Carex*	sedge	
Cyperaceae	CABR10	*Carex brevior*	shortbeak sedge	
Cyperaceae	CAFI	*Carex filifolia*	threadleaf sedge	
Cyperaceae	CAIN9	*Carex inops*	long-stolon sedge	
Elaeagnaceae	SHAR	*Shepherdia argentea*	silver buffaloberry	
Euphorbiaceae	EUES	*Euphorbia esula*	leafy spurge	*
Euphorbiaceae	EUSE5	*Euphorbia serpyllifolia*	thymeleaf sandmat	
Fabaceae	ACAM99	*Acmispon americanus*	American bird's-foot trefoil	
Fabaceae	AMNA	*Amorpha nana*	dwarf false indigo	
Fabaceae	ASBI2	*Astragalus bisulcatus*	two groove milkvetch	
Fabaceae	ASMI10	*Astragalus missouriensis*	Missouri milkvetch	
Fabaceae	DACA7	*Dalea candida*	white prairie clover	
Fabaceae	DAPU5	*Dalea purpurea*	violet prairie clover	
Fabaceae	MELU	*Medicago lupulina*	black medic	*
Fabaceae	MESA	*Medicago sativa*	alfalfa	*
Fabaceae	MEOF	*Melilotus officinalis*	yellow sweetclover	*
Fabaceae	PEAR6	*Pediomelum argophyllum*	silverleaf scurfpea	
Fabaceae	PSLA3	*Psoralidium lanceolatum*	dune scurfpea	
Fabaceae	PSTE5	*Psoralidium tenuiflorum*	slimflower scurfpea	
Fabaceae	VIAM	*Vicia americana*	American vetch	
Iridaceae	**SIMO2**	***Sisyrinchium montanum***	**mountain blue-eyed grass**	
Lamiaceae	HEHI	*Hedeoma hispida*	false pennyroyal	
Lamiaceae	MOFI	*Monarda fistulosa*	wild bergamot	
Lamiaceae	NECA2	*Nepeta cataria*	catnip	*
Lamiaceae	STPI6	*Stachys pilosa*	hairy hedgenettle	
Liliaceae	ASOF	*Asparagus officinalis*	asparagus	*
Linaceae	LILE3	*Linum lewisii*	blue flax	
Malvaceae	SPCO	*Sphaeralcea coccinea*	scarlet globemallow	
Oleaceae	FRPE	*Fraxinus pennsylvanica*	green ash	
Onagraceae	OESE3	*Oenothera serrulata*	yellow sundrops	

Family	Species Code	Scientific Name	Common Name	Exotic
Onagraceae	OESU99	*Oenothera suffrutescens*	scarlet beeblossom	
Oxalidaceae	OXST	*Oxalis stricta*	yellow woodsorrel	
Plantaginaceae	PLMA2	*Plantago major*	common plantain	*
Poaceae	ANGE	*Andropogon gerardii*	big bluestem	
Poaceae	ARPU9	*Aristida purpurea*	purple threeawn	
Poaceae	BOCU	*Bouteloua curtipendula*	sideoats grama	
Poaceae	BOGR2	*Bouteloua gracilis*	blue grama	
Poaceae	BOHI2	*Bouteloua hirsuta*	hairy grama	
Poaceae	BRIN2	*Bromus inermis*	smooth brome	*
Poaceae	CALO	*Calamovilfa longifolia*	prairie sandreed	
Poaceae	DIWI5	*Dichanthelium wilcoxianum*	fall rosette grass	
Poaceae	ELYMU	*Elymus*	wildrye	*
Poaceae	ELCA4	*Elymus canadensis*	Canada wildrye	
Poaceae	ELRE4	*Elymus repens*	quackgrass	*
Poaceae	ELTR7	*Elymus trachycaulus*	slender wheatgrass	
Poaceae	ELVI	*Elymus villosus*	hairy wild rye	
Poaceae	HECO26	*Hesperostipa comata*	needle and thread	
Poaceae	HESP11	*Hesperostipa spartea*	porcupinegrass	
Poaceae	KOMA	*Koeleria macrantha*	junegrass	
Poaceae	MUCU3	*Muhlenbergia cuspidata*	plains muhly	
Poaceae	NAVI4	*Nassella viridula*	green needlegrass	
Poaceae	PACA6	*Panicum capillare*	common witchgrass	
Poaceae	PASM	*Pascopyrum smithii*	western wheatgrass	
Poaceae	POA	*Poa*	bluegrass	*
Poaceae	POPR	*Poa pratensis*	Kentucky bluegrass	*
Poaceae	SCSC	*Schizachyrium scoparium*	little bluestem	
Poaceae	SEVI4	*Setaria viridis*	green bristlegrass	*
Poaceae	**SONU2**	***Sorghastrum nutans***	**Indiangrass**	
Poaceae	SPCR	*Sporobolus cryptandrus*	sand dropseed	
Poaceae	THIN6	*Thinopyrum intermedium*	intermediate wheatgrass	*
Polygalaceae	POAL4	*Polygala alba*	white milkwort	
Polygonaceae	**ERPA9**	***Eriogonum pauciflorum***	**fewflower buckwheat**	
Ranunculaceae	ANCY	*Anemone cylindrica*	candle anemone	
Ranunculaceae	AQCA	*Aquilegia canadensis*	American columbine	
Rhamnaceae	RHCA3	*Rhamnus cathartica*	European buckthorn	*
Rosaceae	PRVI	*Prunus virginiana*	chokecherry	
Rosaceae	ROAR3	*Rosa arkansana*	prairie wildrose	
Salicaceae	PODE3	*Populus deltoides*	plains cottonwood	
Salicaceae	SAAM2	*Salix amygdaloides*	peachleaf willow	
Solanaceae	PHVI5	*Physalis virginiana*	Virginia groundcherry	

Family	Species Code	Scientific Name	Common Name	Exotic
Ulmaceae	ULAM	*Ulmus americana*	American elm	
Unknown family	UNKFORB	*Unknown forb*	unknown forb	*
Urticaceae	PAPE5	*Parietaria pensylvanica*	Pennsylvania pellitory	
Urticaceae	URDI	*Urtica dioica*	stinging nettle	
Verbenaceae	**VEBR**	***Verbena bracteata***	**bigbract verbena**	
Violaceae	VICA4	*Viola canadensis*	Canada violet	
Vitaceae	PAVI5	*Parthenocissus vitacea*	Virginia creeper	

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