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Natural Resource Stewardship and Science

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

2011-2016 Summary Report

Natural Resource Report NPS/NGPN/NRR—2017/1391

ON THIS PAGE
Photograph of riparian forest at Knife River National Historic Site, 2015.
Photograph courtesy of the National Park Service.

ON THE COVER
Photograph of a long-term plot at Knife River National Historic Site, 2015.
Photograph courtesy of the National Park Service.

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

2011-2016 Summary Report

Natural Resource Report NPS/NGPN/NRR—20171391

Christopher J. Davis
Isabel W. Ashton

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

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Executive Summary

The Northern Great Plains Inventory & Monitoring Program and Fire Effects Program have been monitoring vegetation in Knife River Indian Villages National Historic Site for over 18 years. While methods have changed slightly, this report summarizes data from 57 locations from 1998-2016. Below, we list the questions we asked and provide a summarized answer. For more details see the Results and Discussion section. We conclude with a Natural Resource Condition Table (Table ES-1) that summarizes the current status and trends of a few key vegetation metrics.

1. **What is the current status of plant community composition and structure of KNRI grasslands (species richness, cover, and diversity) and how has this changed from 1998 to 2016?**

   A long history of agriculture and a change in the natural disturbance regimes at KNRI has led to low native species richness when compared to more intact mixed-grass prairies in the region (Table ES-1), but diversity is spatially variable. In general, sites within the northern prairie area support a diversity of native species typical of intact mixed grass prairie. We found no significant trends in native diversity or evenness from 1998 to 2016, but both are threatened by the large abundance of smooth brome and Kentucky bluegrass. Smooth brome has not increased over time (Figure 6), but where it is present there are very few native species. Kentucky bluegrass, on the other hand, has been increasing since the 1990s (Figure 6). Continued control efforts will be necessary to maintain native prairie and reduce exotic species cover within KNRI.

2. **How have plots in restored and reseeded areas changed over time?**

   Several long-term monitoring plots were located in sites that were reseeded with native grass and forb species in 2004 or 2010. Since this time, exotic species cover has declined in these areas. Native graminoid cover increased from 2007 and 2010 in both sites and native species richness remained consistent during this period. These observations suggest that seeding has increased native grass establishment and abundance in these areas, potentially preventing an increase in Kentucky bluegrass cover that has been observed in other areas of the park.

3. **What, if any, rare plants were found in KNRI long-term monitoring plots?**

   Three rare plants were observed in NGPN monitoring plots: blue wildrye (*Elymus glaucus*), maiden blue-eyed-Mary (*Collinsia parviflora*), and upright carrionflower (*Smilax ecirrhata*). We recommend close examination and collection of voucher specimens for these species when encountered in future field seasons so their identification and location can be confirmed.

4. **What is the composition and structure of riparian forests at KNRI**?

   The riparian forest in KNRI is a dominated by green ash and box elder trees. Cottonwood and willow species are rare. Future range expansion of the emerald ash borer into North Dakota could have large impacts on these forests because it can cause rapid mortality of green ash trees. Seedlings of many tree species are common, but it is unclear whether these will survive to maturity because many are covered by thick layers of smooth brome. Exotic forbs are common in the understory of the forest, particularly Canada thistle and dame's rocket, and continuing control efforts will be necessary to prevent their spread. Revisiting these forested sites in 2019 will provide a better picture of how these forests may be changing over time.

Table ES-1. Natural resource condition summary table for plant communities in Knife River Indian Villages National Historic Site (KNRI). Current values are based on data from 2012-2016 and trends are based on data from 1998-2016.

Indicator of Condition	Specific Measures	Current Value (mean ± SE)	Reference Condition and Data Source	Condition Status/Trend	Rationale for Resource Condition
Upland Plant Community Structure and Composition	Native species richness ($1m^2$ quadrats)	4.7 ± 0.4 species	8-18 species		KNRI protects and manages small remnants of northern mixed-grass prairie and supports an active prairie restoration program. There is 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.
	Evenness (native species point-intercept transects)	0.73 ± 0.03	To be determined		
Exotic Plant Early Detection and Management	Relative cover of exotic species	55.4 ± 3.5%	A reduction in exotic cover over time		KNRI manages a landscape with a very high cover of exotic species. Smooth brome and Kentucky bluegrass are particularly abundant, and their cover should be reduced to retain native plant diversity. Total exotic cover and the cover of Kentucky bluegrass have increased over time since 1998. Despite restoration efforts in some areas, there has been no change in the cover of smooth brome throughout the park over this time period.
	Kentucky bluegrass cover	24.4 ± 1.9%	A reduction in Kentucky bluegrass over time		
	Smooth brome cover	22.8 ± 2.7%	A reduction in smooth brome cover over time		
Riparian Forest	Green ash stem density	66 ± 21 stems/ha	66 ± 21 stems/ha		The riparian forests of KNRI are dominated by green ash and box elder. Only 2 of 20 plots contained cottonwood trees. The riparian forests in KNRI have large densities of other native tree and shrub seedlings. Forest surveys will be repeated every 5 years in KNRI and this will allow us to detect trends in condition.
	Average native deciduous seedlings	85%	To be determined		

Acknowledgments

We thank the authors of the NGPN Plant Community Monitoring Protocol, particularly A. Symstad, for outstanding guidance on data collection and reporting. Thank you to the staff at KNRI, particularly C. Hansen, for providing logistical support and performing safety checks. The NGPN and NGPFire vegetation field crews collected all the data included in this report. This report was improved thanks to comments from M. Davis, S. Rockwood, C. Hansen, J. Schiferl, and C. Prosser.

Introduction

During the last century, much of the prairie within the Northern Great Plains has been plowed for cropland, planted with non-natives to maximize livestock production, or otherwise developed, making it one of the most threatened ecosystems in the United States (Samson and Knopf 1994). Within North Dakota, it was estimated that two decades ago greater than 71% of the area of native mixed grass prairie had been lost since European settlement (Samson and Knopf 1994). More recently, the high prices for corn and soybean have accelerated rates of loss (Wright and Wimberly 2013). 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 grazing by large, native herbivores, 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 of the site. KNRI sits on 1,758 acres of upland mixed-grass prairie and riparian forests, much of which has a long history of human use. As a result of its agricultural legacy and a loss of natural disturbance regimes, exotic species play a major role in the makeup of the park's current vegetation (DeKeyser and Krabbenhoft 2006). Vegetation monitoring began in 1997 by the Northern Great Plains Fire Ecology Program (NGPFire; Wienk et al. 2010). In 2010, KNRI was incorporated into the Northern Great Plains Inventory & Monitoring Network (NGPN). At that time, vegetation monitoring protocols and plot locations were shifted to better represent the entire park and to coordinate efforts with NGPFire (Symstad et al. 2012b). A total of 37 plots were established by NGPFire and NGPN in KNRI and the combined sampling efforts began in 2011(Ashton et al. 2012). In 2014, an additional 20 plots were established in the riparian forest to assess forest condition. In this report, we use the data from 2011-2016 to assess the current condition of park vegetation and we use data from 1998-2016 to look at longer-term trends.

Using 19 years of plant community monitoring data in KNRI, we explore the following questions:

1. What is the current status of plant community composition and structure of KNRI grasslands (species richness, exotic plant cover, and diversity) and how has it changed from 1998-2016?
2. How have plots in reseeded areas of the park changed over time?
3. What, if any, rare plants were found in KNRI long-term monitoring plots?
4. What is the composition and structure of riparian forests at KNRI?

Methods

Two different sets of methods and protocols have been used to monitor long-term vegetation plots at KNRI since 1997: the NGPN monitoring protocol (Symstad et al. 2012b, a) and the Fire Monitoring Handbook (NPS 2003). Below, we briefly describe both methods, but focus on the NGPN monitoring protocol, which is the current standard and was used to collect most of the data in this report.

NGPN and NGPFire Monitoring Plots 2011-2016

The NGPN and NGPFire 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, NGPN selected 20 randomly located sites within KNRI to become Plant Community Monitoring plots (PCM plots; Figure 1). The NGPN visits 8 PCM plots every year using a rotating sampling scheme where 4 sites were visited in the previous year and 4 sites are new visits. After 5 years (2011-2015), most of the PCM plots were visited at least twice during the last week of July. When a PCM plot fell within an active burn unit, NGPFire added additional visits based on a 1, 2, 5, and 10 year sampling schedule. NGPFire also established and monitored a number of new sites focused in active burn units (Fire Plant Community Monitoring plots) using the same GRTS sampling schema. From 2011-2016, 8 Fire Plant Community Monitoring (FPCM) plots were established. Finally, using the same set of random sites, NGPN selected 9 additional PCM plots that fell within the riparian forest or on forest edges. These riparian forest plots plus 11 of the above PCM plots that included trees were monitored in 2014 to assess forest condition (20 total plots). The Fire Program has since expanded monitoring at one of these forest sites (PCM_050). A total of 37 plots were established by NGPFire and NGPN in 2011-2016.

At each of the grassland sites we visited, we 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 and herb-layer (≤ 2 m) height and plant cover were collected on two 50 m transects (the long sides of the plot) using a point-intercept method (Figure 3). At 100 locations along the transects (every 0.5 m) a pole was dropped to the ground and all species that touched the pole were recorded, along with ground cover, and the height of the canopy (Figure 3). Using this method, absolute canopy cover can be greater than 100% (particularly in wet years and productive sites) because we record multiple layers of plants. Species richness data from the point-intercept method were supplemented in the 20 NGPN plots with species presence data collected in five 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). In 2016, we discontinued the use of all but the 1m^2 quadrats, which is more commonly used by vegetation ecologists. This was done to save time, but still maintain diversity data at the 1m^2 area. In this report, we present only the data from the 1m^2 and 10m^2 quadrats.

When woody species were also 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. For

each tree, the species, DBH, status (live or dead), and condition (e.g., leaf-discoloration, insect-damaged, etc.) were recorded. Mean values included zeroes for plots where no trees were present.

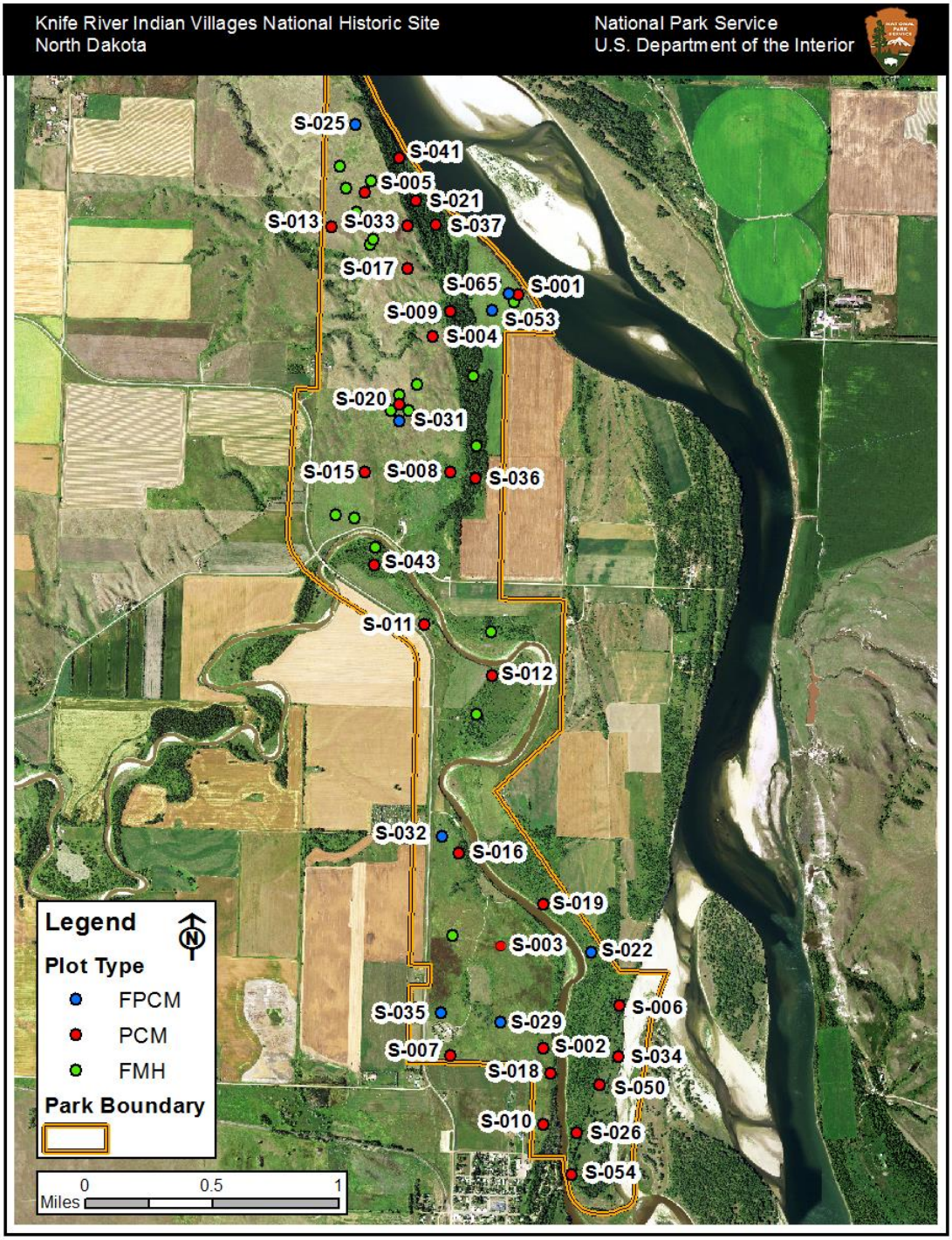


Figure 1. Map of Knife River Indian Villages National Historic Site (KNRI) plant community monitoring plots, 1998-2016. Twenty-nine long-term plots were established by the Northern Great Plains Inventory & Monitoring Program (NGPN) and the Fire Effects Program (NGPFire) between 2011 and 2015 (red). An extra 8 plots were established to better understand the effects of prescribed fire (blue). An additional 20 Fire Monitoring Handbook (FMH) plots (green) were monitored from 1997-2011 by NGPFire.

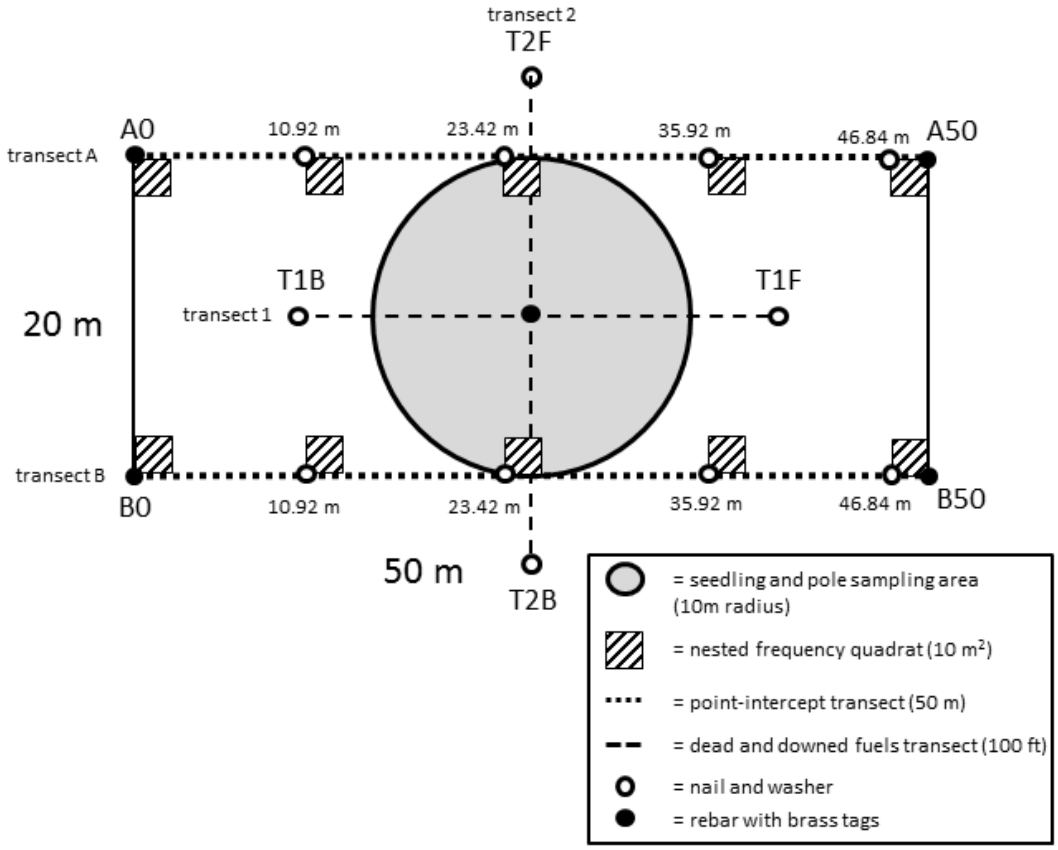


Figure 2. Long-term monitoring plot layout used for sampling vegetation in Knife River Indian Villages National Historic Site.

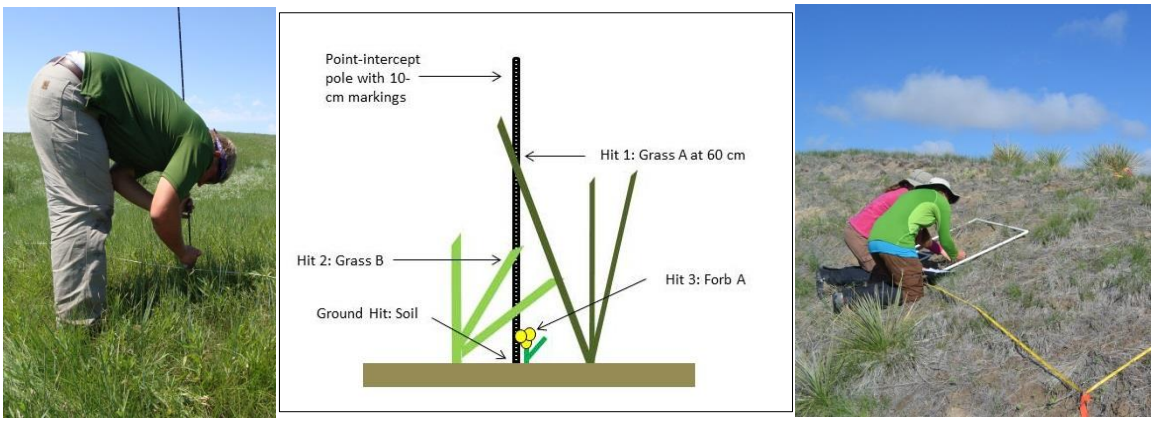


Figure 3. The Northern Great Plains Inventory & Monitoring vegetation crew used point-intercept (left and center panel) and quadrats (right panel) to document plant diversity and abundance.

NGPN completed a survey of riparian forests in KNRI in the second week of September 2014 using a set of 20 forested sites. In this case, trees, seedlings and poles were measured as described above, however trees (DBH >15cm) were not tagged and only measured within the 10 m radius subplot. Dead and downed woody fuel load data were collected at these forested plots along two

perpendicular, 100 foot (30.49 m) transects with midpoints at the center of the plot (Figure 2), following Brown's Line methods (Brown 1974, Brown et al. 1982). These data were not reported because grasses dominated the fuel layer.

At all PCM plots, but not the FPCM 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. We also surveyed the area for exotic species that have the potential to spread into the park and cause significant ecological impacts (Table 1). These species were chosen in collaboration with the Midwest Invasive Plant Network, the Exotic Plant Management Team, park managers, and local weed experts. 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.

Table 1. Exotic species surveyed for at Knife River Indian Villages National Historic Site as part of the early detection and rapid response program within the Northern Great Plains Network. ND Status of Noxious indicates the species is on North Dakota's state list of noxious weeds.

Scientific Name	Common Name	Habitat	ND Status
Alliaria petiolata	garlic mustard	Riparian	
Polygonum cuspidatum; P. sachalinense; P. x bohemicum	knotweeds	Riparian	
Pueraria montana var. *lobata*	kudzu	Riparian	
Iris pseudacorus	yellow iris	Riparian	
Ailanthus altissima	tree of heaven	Riparian	
Lepidium latifolium	perennial pepperweed	Riparian	
Arundo donax	giant reed	Riparian	
Rhamnus cathartica	common buckthorn	Riparian	
Heracleum mantegazzianum	giant hogweed	Riparian	
Centaurea solstitialis	yellow star thistle	Upland	
Hieracium aurantiacum; H. caespitosum	orange and meadow hawkweed	Upland	
Isatis tinctoria	Dyer's woad	Upland	
Taeniatherum caput-medusae	medusahead	Upland	
Chondrilla juncea	rush skeletonweed	Upland	
Gypsophila paniculata	baby's breath	Upland	
Centaurea virgata; C.diffusa	knapweeds	Upland	Noxious
Linaria dalmatica; L. vulgaris	toadflax	Upland	Noxious
Euphorbia myrsinites & E. cyparissias	myrtle spurge	Upland	
Dipsacus fullonum & D. laciniatus	common teasel	Upland	
Salvia aethiopis	Mediterranean sage	Upland	
Ventenata dubia	African wiregrass	Upland	

Other Monitoring Plots (1997-2016)

In 1997, NGPFire began monitoring plots within KNRI to evaluate the effectiveness of prescribed burns. Starting in 1998, data collection followed the NPS National Fire Ecology Program protocols (NPS 2003): in grassland plots vegetation cover and height data were collected using a point-intercept method, with 100 points evenly distributed along a single 30 m transect. In forested sites, plots are 0.1 ha (20 x 50 m) in size and point-intercept data were collected along the two 50 m sides. For each live tree with a DBH > 15 cm located within the 0.1 ha plot, the species and DBH were recorded. The densities of smaller trees (2.54 cm ≤ DBH ≤ 15 cm) were measured within a subset of the plot area. NGPFire plot locations were located randomly within major vegetation types within areas planned for prescribed burning (burn units) in the near future. The plots were then sampled 1, 2, 5, and 10 years after a prescribed burn. The data were not collected using these protocols in 1997, so this year was excluded from analyses. Hereafter, we refer to these plots as Fire Monitoring Handbook (FMH) plots. These FMH plots are being retired after the10 year visit (e.g. the rebar will be removed) and replaced with the FPCM plots described above.

Data Management and Analysis

We 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 2015). 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. This report uses common names after the first occurrence in the text, but scientific names can be found in Appendix A.

After data for the sites were entered, 100% of records were verified to the original data sheet to minimize transcription errors. A further 10% of records were reviewed a second time. After all data were entered and verified, automated queries were used 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/or the FFI database as needed. Summaries were produced using the FFI reporting and query tools and statistical summaries, and graphics were generated using R software (version 3.2.3).

Plant life forms (e.g., shrub, forb) were based on definitions from the USDA Plants Database (USDA-NRCS 2015). The conservation status rank of plant species in North Dakota was determined by cross-referencing our species list with the NatureServe conservation status list (http://www.natureserve.org/conservation-tools/conservation-status-assessment). For the purpose of this report, a species was considered rare if its global conservation status rank was considered critically imperiled (G1), imperiled (G2), or vulnerable (G3) or if it was considered rare in North Dakota and had a conservation status rank of S1, S2, or S3 (Table 2). The state of North Dakota also maintains a list of exotic plants considered noxious due to their ability to rapidly spread and impact

ecological and economic resources (https://www.nd.gov/ndda/program/noxious-weeds) which we compared with our species list.

Table 2. Definitions of state and global species conservation status ranks.

Status Rank*	Category	Definition
S1/G1	Critically imperiled	Due to extreme rarity (5 or fewer occurrences) or other factor(s) making it especially vulnerable to extirpation.
S2/G2	Imperiled	Due to rarity resulting from a very restricted range, very few populations (often 20 or fewer), steep declines, or other factors making it very vulnerable to extirpation.
S3/G3	Vulnerable	Due to a restricted range, relatively few populations (often 80 or fewer), recent widespread declines, or other factors making it vulnerable to extirpation.
S4/G4	Apparently secure	Uncommon but not rare; some cause for concern due to declines or other factors.
S5/G5	Secure	Common, widespread and abundant.
S#S#/ G#G#	Range rank (e.g. S2S3)	Used to indicate uncertainty about the status of the species or community. Ranges cannot skip more than one rank.

* Adapted from NatureServe status assessment table (http://www.natureserve.org/conservation-tools/conservation-status-assessment)

We measured diversity at the plots in two ways: species richness and Pielou's Evenness Index. Species richness is simply a count of the species recorded in an area. Peilou's Evenness Index, J', measures how even abundances are across taxa. It ranges between 0 and 1; values near 0 indicate dominance by a single species and values near 1 indicate nearly equal abundance of all species present. Plant richness was calculated for each plot using the total number of species intersected along the transects. Average height was calculated as the average height per plot using all species intersected on the transects. Height was measured because it is a non-destructive and quick metric that can correlate with productivity.

Climate data from the Garrison 1NNW, ND weather station (GHCND:USC00327585) were downloaded from NOAA's online database (NOAA 2015).

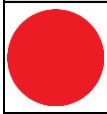
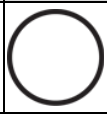
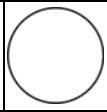
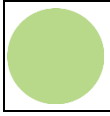
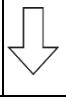
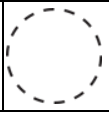
Reporting on Natural Resource Condition

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 is to improve park priority setting, 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, it will also be possible and straightforward to revisit the metric in subsequent years. The status and trend of 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: native species richness, evenness, relative cover of exotic species, and relative cover of Kentucky bluegrass

and smooth brome cover. Reference values were based on descriptions of historic condition and variation, past studies, and/or management targets. Current park condition was compared to a reference value, and status was scored as good condition, warrants moderate concern, or warrants significant concern based on this comparison (Table 3). 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. In some cases, reference conditions can be determined only after we have accumulated more years of data. When this is the case, we refer to these as "To be determined", or TBD, and estimate condition based on our professional judgment.

Table 3. 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://www.nps.gov/stateoftheparks/).

Condition Status		Trend in Condition		Confidence in Assessment	
	Warrants Significant Concern		Condition is Improving		High
	Warrants Moderate Concern		Condition is Unchanging		Medium
	Resource is in Good Condition		Condition is Deteriorating		Low

In this report, conditions are based on estimates for the whole park (i.e. the average of all plots randomly located across the park). The park encompasses many different vegetation communities (Salas and Pucherelli 2002) and Ecological Sites (https://www.nrcs.usda.gov/wps/portal/nrcs/detail /national/landuse/rangepasture/?cid=stelprdb1068392), but developing reference conditions for these finer land units is beyond the scope of our vegetation monitoring. Ecological Sites are a classification of land units based on soils and vegetation which could be a useful tool for defining reference conditions because their descriptions include a 'reference' plant community that we could compare our data to. Unfortunately, there is a mismatch between the scale of Ecological Sites in KNRI and our monitoring intensity (7 Ecological Sites across 20 plots). This is a common problem and efforts to group Ecological Sites across larger landscape scales to better reflect management needs and monitoring efforts is underway in some regions (Bestelmeyer et al. 2016, Duniway et al. 2016), but this has not been done in the Northern Great Plains.

Results and Discussion

Status & Trends in Community Composition and Structure of KNRI Vegetation

There are 285 plant species on the KNRI species list and we identified 269 species in monitoring plots from 1998-2016 at KNRI (Appendix A). Graminoids, which includes grasses, sedges, and rushes, accounted for most of the vegetative cover at KNRI, but forbs, vines, trees, shrubs and subshrubs (defined as low-growing shrubs usually shorter than 0.5m) were also present (Figure 4). We identified 49 exotic plant species at KNRI; four of which are considered noxious by the state of North Dakota due to their ability to spread rapidly and negatively impact ecological and economic resources in the state (Appendix A). Exotic graminoids were particularly abundant, averaging more than 75% absolute cover from 1997-2016 (Figure 4). Vines, shrubs, and subshrubs observed in KNRI were all native species. Exotic trees, such as Russian olive (*Elaeagnus angustifolia*), were present but rarely encountered (e.g. only 1 site).

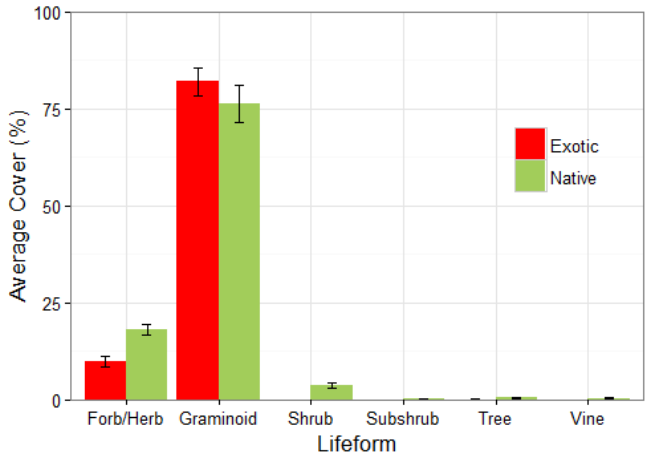


Figure 4. Average cover by lifeform of native (green) and exotic (red) plants recorded in monitoring plots in Knife River Indian Villages National Historic Site (1998-2016). Absolute cover can be greater than 100% because the point-intercept method records layers of overlapping vegetation.

Western wheatgrass (*Pascopyrum smithii*), needle and thread (*Heterostipa comata*), big bluestem (*Andropogon gerardii*) and threadleaf sedge (*Carex filifolia*) were the most abundant native graminoids and averaged between approximately 10 and 20% absolute cover (Figure 5). Kentucky bluegrass (*Poa pratensis*) and smooth brome (*Bromus inermis*), both cool-season perennial grasses, were the most pervasive exotics at KNRI. From 1998 to 2016, the average relative cover of Kentucky bluegrass was 21.5 ± 1.2% (mean ± standard error), and the average for the last 5 years was 24.4 ± 1.9%. Average smooth brome cover from 1998-2016 was 23.3 ± 1.9% and the average for the last 5 years was 22.8 ± 2.7%.While there are many other exotic plants within KNRI, they contribute relatively little to cover. The average cover of all exotic species in 2012-2016 was 55.4 ± 3.5%, meaning that about 80% of exotic cover is just 2 species: Kentucky bluegrass and smooth brome.

Recent studies have shown that Kentucky bluegrass and smooth brome are increasing in abundance in KNRI (DeKeyser et al. 2013) and their presence is often correlated with declines in native species

richness (Miles and Knops 2009). The U.S. Fish and Wildlife Service has begun an adaptive management program to control Kentucky bluegrass in South Dakota and North Dakota refuges (Grant et al. 2009). Their work suggests that Kentucky bluegrass can often spread and become a dominant component in mixed-grass prairie that is rested for long periods (e.g. neither burned nor grazed) (Grant et al. 2009). Our data are consistent with Dekeyser et al. (2013) and show that the cover of Kentucky bluegrass has been increasing over time within the park (Figure 6; $F_{1,17}$=23.9, P<0.001). However, across all the plots our data do not show a significant relationship between native plant diversity and Kentucky bluegrass. In contrast, we found no significant change over time in the cover of smooth brome (Figure 6). While there have been successful restoration efforts in KNRI (see section below), these have reduced smooth brome cover only in small areas and have not substantially reduced the park-wide cover. We did find a significant negative relationship between smooth brome cover and native species richness ($F_{1, 175}$=183.4, P<0.001). This strong relationship may result from areas where smooth brome was planted and native species have been slow to recolonize, or it may be driven by areas where smooth brome has spread and out-competed native species. In either case, reducing the cover of smooth brome at KNRI should result in an increase in native species cover.

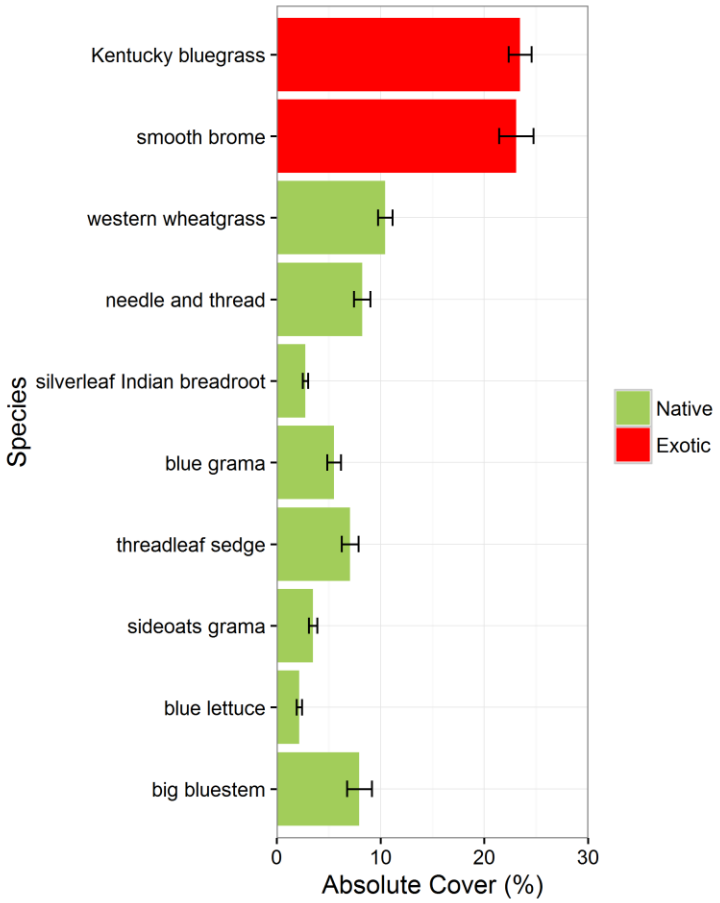


Figure 5. The average absolute cover of the 10 most common native (green) and exotic (red) plants recorded at Knife River Indian Villages National Historic Site in 1998-2016. Bars represent means ± one standard error.

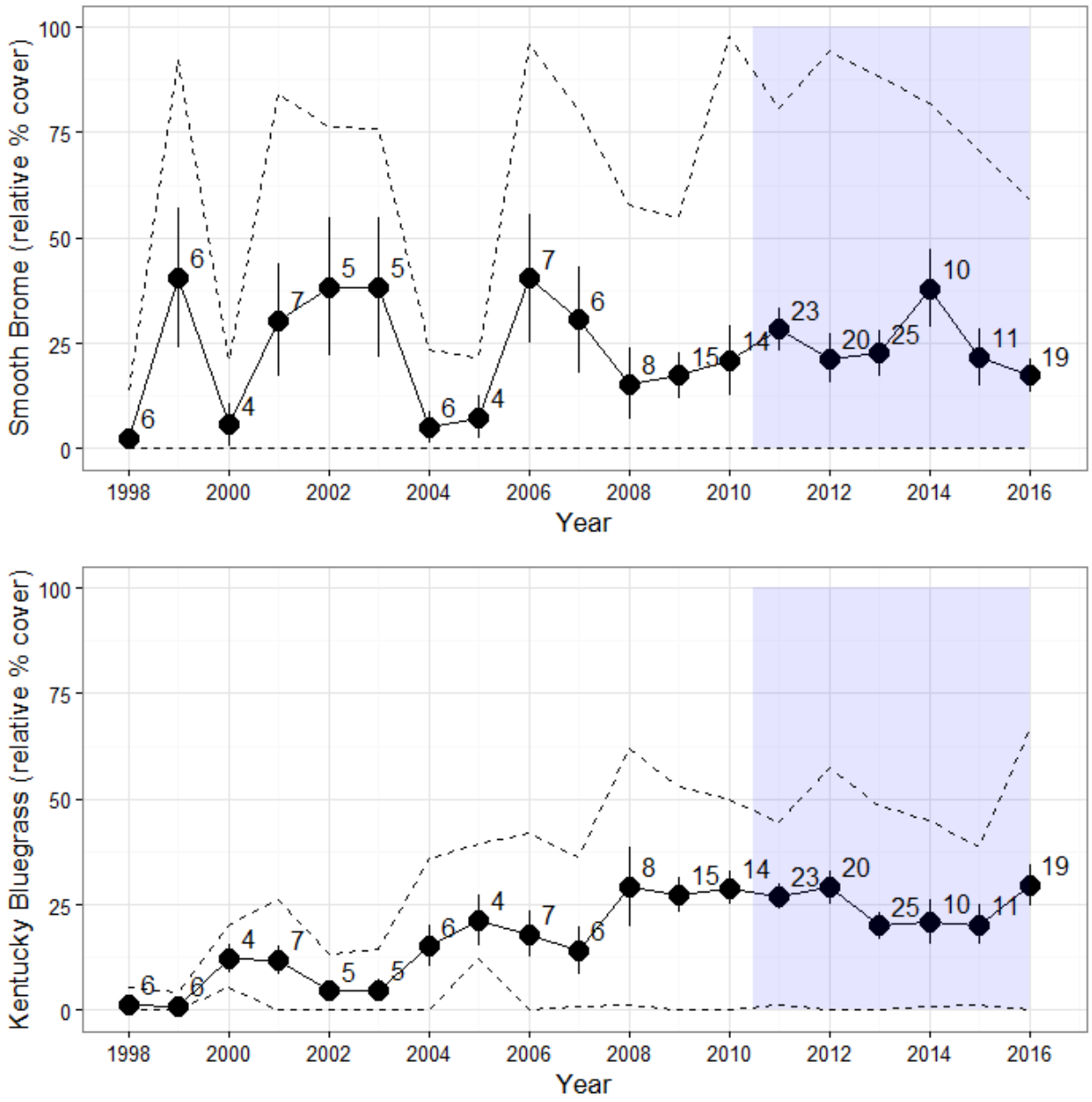


Figure 6. Trends in the relative cover of smooth brome and Kentucky bluegrass in Knife River Indian Villages National Historic Site from 1998-2016. Points represent mean ± one standard errors and sample size is to the right of the point. Years with fewer than 3 monitoring plots were excluded from the graph. The shaded area highlights the period from 2011-2016 when sampling methods were consistent and distribution of plots was more even across years. The dashed line represents the maximum and minimum cover values for each year.

Species Richness, Diversity, and Evenness

One of the ways the NPS can measure how effectively it has achieved its mission of 'preserving ecological integrity' is to examine trends in native plant diversity and evenness within park boundaries. Average species richness has been measured by point-intercept since 1998 and in 1 m^2 and 10 m^2 quadrats since 2011 (Table 4). However, to reflect the current status of native diversity we took the average of the most recent 5 years for the 1m^2 quadrats (Table 3). We could not do this for the 10m^2 quadrats, because these were not measured in 2016.

Table 4. Average plant species richness in monitoring plots at Knife River Indian Villages National Historic Site from 1998 to 2016. Values represent means ± one standard error found along the two 50m transects per plot or the ten 1 m^2 or 10 m^2 quadrats per plot.

Parameter	**Point-intercept** (1998-2016; n=50)	**1 m^2 quadrats** (2012-2016, n=73)	**10 m^2 quadrats** (2011-2015, n=39)
Species richness	20.7 ± 1.1	7.4 ± 0.4	10.5 ± 0.9
Native species richness	15.3 ± 1.2	4.7 ± 0.4	7.3 ± 0.9
Exotic species richness	6.1 ± 0.4	2.6 ± 0.1	3.1 ± 0.2
Graminoid species richness	10.6 ± 0.8	3.4 ± 0.2	3.7 ± 0.3
Forb species richness	8.8 ± 0.6	3.4 ± 0.2	5.6 ± 0.6

While there was some variation across the park, the plots we visited in KNRI tended to have a low diversity of native plants compared to other mixed-grass prairies. Species richness in the mixed-grass prairie is determined by numerous factors including fire regime, grazing, and weather fluctuations (Symstad and Jonas 2011). In KNRI, there is also a mixed history of past land-use practices that have affected current species richness. While it is difficult to define a reference condition for species richness, which naturally varies considerably across both space and time, the natural range of variation over long-time periods may be a good starting point (Symstad and Jonas 2014). 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 2014). The average native species richness falls below this natural range of variation for the park (Table 4). The highest diversity and some of the few plots within this range were in the northern prairie part of the park. For instance, plot PCM-004 averaged 11.4 native species m^{-2} (Figure 7) and PCM_017 averaged 10.4 species m^{-2}.

We did not find any trends in species richness or evenness (Figure 8). Native species richness in 1m^2 quadrats was fairly consistent from 2011 to 2016 and ranged from a low in 2011 of 3.5 ± 0.8 to a high of 5.8 ± 1.0 in 2015. In the longer record from point-intercept data (1998-2016; Figure 8: top) annual average native richness ranged between 6 and 15 species. Annual average evenness ranged from 0.58 to 0.81 during this time period, indicating the plots were not strongly dominated by a single species (Figure 8: bottom). There is a great deal of variation in species richness and evenness among sites within the park (dashed lines in Figure 8 represent the maximum and minimum values) which can make long-term trends in these metrics difficult to detect.

Figure 7. A photograph of long-term monitoring plot KNRI_PCM_004 which had an average native species richness of 11.4 species per square meter.

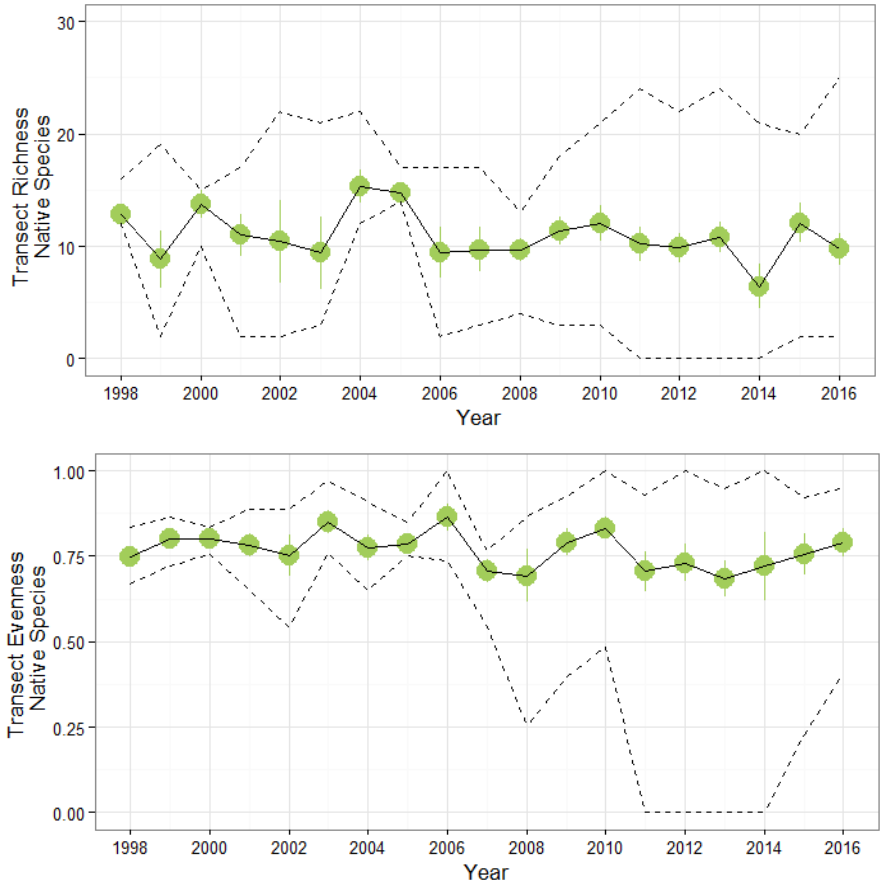


Figure 8. Trends in native species richness and evenness in Knife River Indian Villages National Historic Site, 1998-2015. Data shown are means ± one standard error and represent the values from two 50-m transects per plot. The dashed line indicates the maximum and minimum values for each year.

Disturbances resulting from grazing, prairie dogs, fire, and humans affect plant community structure and composition in mixed-grass prairie (Collins and Barber 1986). We estimated the approximate area affected by natural and human disturbances at each site we visited in 2011-2016 by surveying the area for ~ 5 minutes at the end of the plot visit. The most common disturbance in KNRI was from prescribed fire, but there was also evidence of deer trails and small mammal activity. The large variation in disturbances over space and time makes it difficult to discern patterns without a longer time series.

Climate also affects plant abundance and distribution (Sala et al. 1988, Walther 2010). The Northern Great Plains has a continental climate, with hot summers and very cold winters. The 30- year normal temperatures at a nearby weather station, Garrison 1NNW, ranged from average minimum monthly temperatures in January of -0.7° F to maximum monthly July temperatures of 81.3° F (based on 1981-2010). The 30-year normal annual precipitation totals 17.5 inches. Annual precipitation at KNRI in 1998-2015 was variable and ranged between 11.5 and 28.0 inches, in 2001 and 2013, respectively. Data from 2016 are still provisional, but after a dry winter and spring, drought conditions have relaxed (for up-to-date information see the US Drought Monitor http://droughtmonitor.unl.edu/home/regionaldroughtmonitor.aspx?high_plains). There were dry years in the early and mid-2000s (Figure 9). More recent years have been wetter than average, particularly 2013. The native vegetation is adapted to this variation, and productivity responds strongly to decreases in spring and summer precipitation (Yang et al. 1998, Smart et al. 2007). Species richness and diversity in regional grasslands are also sensitive to temperature and precipitation fluctuation, but the response is complex and less predictable (Jonas et al. 2015).

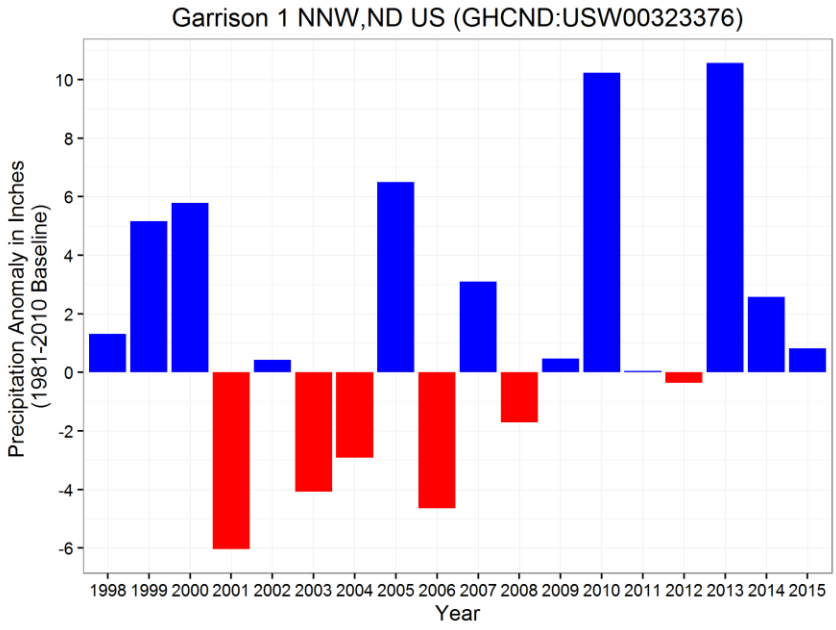


Figure 9. The total annual precipitation anomaly from 1998-2015 for Knife River Indian Villages National Historic Site. Positive values (blue) represent years wetter than and negative values (red) years drier than the 1981-2010 average. The anomaly is measured in inches and based on data from a nearby weather station.

Restoration Areas

Changes to disturbance regimes can alter plant community structure and increase exotic plant species dominance in grasslands (Smith and Knapp 1999), and the abundance of exotic plant species in KNRI is likely the result of agricultural activity, the removal of large grazing animals, and the suppression of wildfires in the park. Vegetation management efforts have focused on mowing around archaeological sites, eradicating invasive species through mechanical treatments and herbicide, and restoring disturbance through prescribed burning in select areas of the park. In 2004 and 2010 native plant seed was applied to areas of these exotic dominated grasslands to facilitate the recovery of native prairie plant communities (NGP-EPMT 2004, 2011). Although the NGPN monitoring protocol was not designed to measure effectiveness of restoration projects, seven NGPN long-term monitoring plots were located in the restored areas (Figure 10) and changes in plant communities in those sites over time are discussed here.

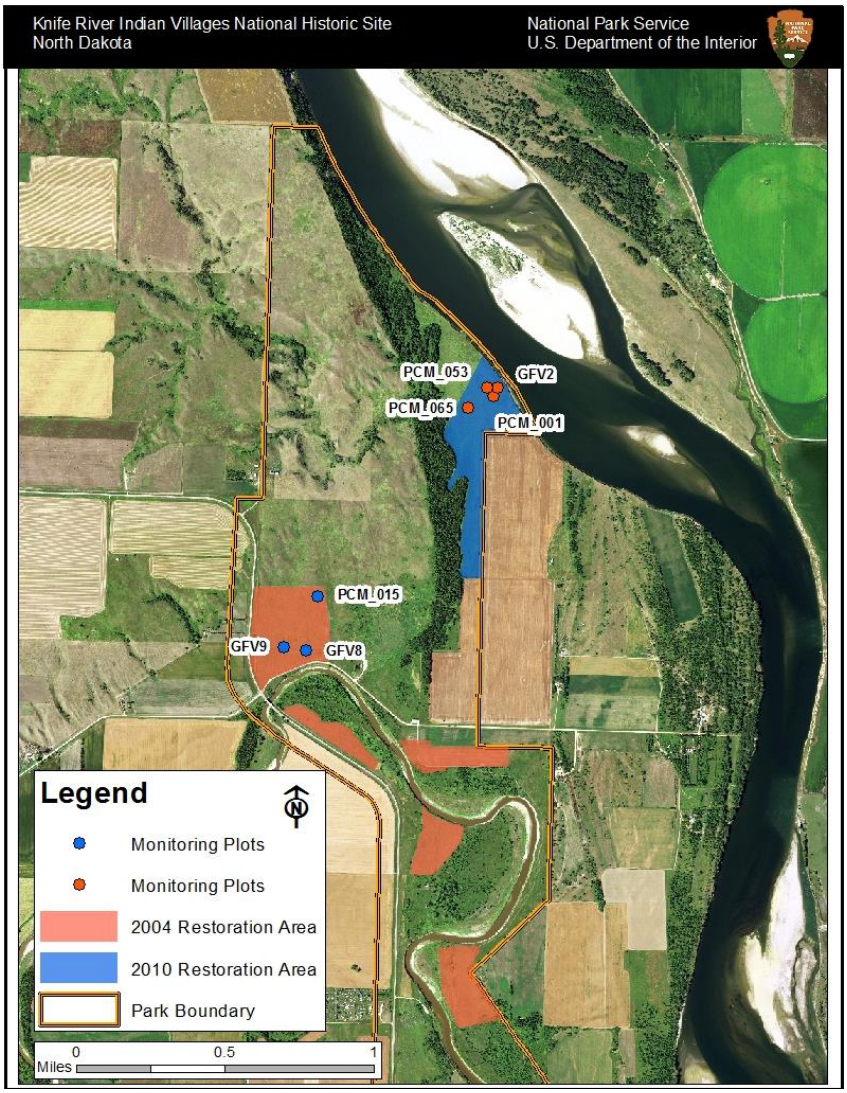


Figure 10. Long-term monitoring plots within revegetation project sites at Knife River Indian Villages National Historic Site. Three plots fell within the 2003 restoration area (red) and four plots were within the 2010 restoration area.

The restoration sites were primarily seeded with native grasses (75% and 90% of seed mix composition in 2004 and 2010, respectively), and native grasses were the dominant plant type in both sites by 2016 (Figure 11). Native graminoid species relative cover increased between 2007 and 2016 in both sites and relative cover of exotic species decreased during the same period (Figure 12). This decline in exotics is in contrast to cover of exotic species in the rest of KNRI, which have been increasing over time; particularly Kentucky bluegrass. While this dataset is small, our observations suggest that seeding and herbicide applications have likely resulted in increased native graminoid abundance and reduced exotic species cover over time. With continued prescribed fire and herbicide treatments, we expect that this pattern will continue and these areas can be maintained as native prairie. We recommend implementing a focused monitoring study to thoroughly evaluate the effectiveness of restoration on these sites to inform further management actions.

Figure 11. Photographs of two long-term plots within seeded areas of Knife River Indian Villages National Historic Site where native grasses are now a dominant component of the restored prairie.

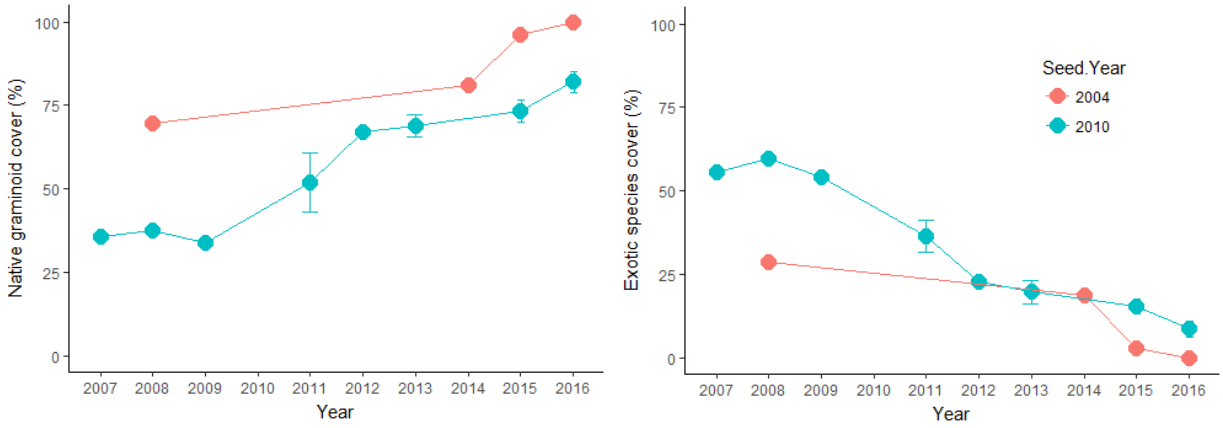


Figure 12. Relative cover of native graminoid and exotic species over time in long-term plots within restored areas of Knife River Indian Villages National Historic Site. Points are means ± one standard error.

Rare Plants

We observed three rare plant species in monitoring plots in KNRI. Blue wildrye (*Elymus glaucus*, S1) was observed in a single plot in 2005. This grass is known to occur in a single county in North Dakota and is more common in western and Pacific states. Maiden blue-eyed-mary (*Collinsia parviflora*, S2) was observed in two plots in 2004 and one plot in 2011. This forb occurs in two North Dakota counties and is also more common in western and Pacific states. Upright carrionflower (*Smilax ecirrhata*, S1S2) was observed in one plot in 1998 and two plots in 2002. This forb occurs in two North Dakota counties and is more common in several states east of North Dakota, including Minnesota, Wisconsin, and Illinois. We recommend close examination and collection of voucher specimens for these species when encountered in future field seasons so their identification and location can be confirmed.

One variety of a common species of locoweed (*Oxytropis campestris* var. *chartacea*) is only known to exist in a few sites on sandy shorelines in Wisconsin and is listed as a threatened species of the United States. This taxon is also included on the ND list of species of conservation concern, and we recommend close examination of *O. campestris* individuals located on seasonally wet or temporarily flooded sandy shores to confirm their identification as the common variety.

Finally, we recommend that a rare plant survey be conducted when funds are available. Our vegetation monitoring protocol is not designed to locate small or highly dispersed plant populations, and a full rare plant survey will be more likely to accurately quantify the status of rare plants found throughout the park; particularly in areas with no monitoring plots.

The Status of Riparian Forests in KNRI

In 2014, the NGPN established 20 plots in the forested area within KNRI to monitor status and trends in lowland riparian forest condition (Figure 13). The 20 monitoring plots were chosen randomly within the riparian forest corridor (~ 50% of the park area) and are located in both forested plots as well as plots along the transition zone between grassland and forest (Figure 14). The 2014 data provide a baseline dataset for future surveys and these plots will be revisted every five years (e.g. 2019, 2024, etc.). Generally the forest is dominated by green ash (*Fraxinus pennsylvanica*) with occasional stands of plains cottonwood (*Populus deltoides*) in the southern half of the park (Salas and Pucherelli 2002). There are also large areas of grassland comprised of Western wheatgrass (*Pascopyrum smithii*), big bluestem (*Andropogon gerardii*), indiangrass (*Sorghastrum nutans*), and blue grama (*Bouteloua gracilis*) (Figure 13, brown). Included in these grasslands are large extents of exotic smooth brome (*Bromus inermis*) dominated grassland. In 1985, the forests were generally considered in poor condition due to a lack of seedlings, and in those areas with seedlings, the thick carpet of smooth brome made it unlikely that they would survive to maturity (Clambey 1985).

In 2014, we found nine species of tree or tall shrub in 20 riparian forest plots at KNRI (Table 5). One plot (PCM_033) did not have any tree or tall shrub species present. Our data were generally consistent with the vegetation map (Salas and Pucherelli 2002) and the most abundant tree species were green ash, boxelder (*Acer negundo*), American elm (*Ulmus americana*), and plains cottonwood (Table 5 & Table 6). The density of large trees was greatest for green ash and boxelder and lower for American elm and plains cottonwood (Table 6). Similarly, small trees and seedlings were most

abundant for green ash and boxelder and substantially less abundant for American elm. Unlike Clambey (1985) we did find a substantial number of deciduous tree seedlings, but future surveys are needed to determine how many of these survive to maturity. We did not observe any cottonwood or willow (*Salix* spp.) young trees or saplings, suggesting little to no recruitment of cottonwoods or willows is occurring in these plots. This further suggests KNRI forests are following a typical successional trajectory where cottonwood and willow forests are most often replaced with green ash and box elder forests as they age (Johnson 1994). The dominance of ash trees suggests that these forests may become vulnerable to the spread of the emerald ash borer (*Agrilus planipennis*). The emerald ash borer is a beetle that is highly destructive to ash trees and, while it is not yet found in North Dakota, it has been spreading rapidly in neighboring states and is expected in the coming years (https://www.nd.gov/ndda/pest/emerald-ash-borer-eab). While there are many other threats to green ash trees (e.g. ice storms) the rapid spread and high mortality associated with the emerald ash borer mean infestations could have significant ecological impacts (Poland and McCullough 2006). Efforts to monitor trees and prevent the spread of the beetle into the park (via firewood) should be prioritized.

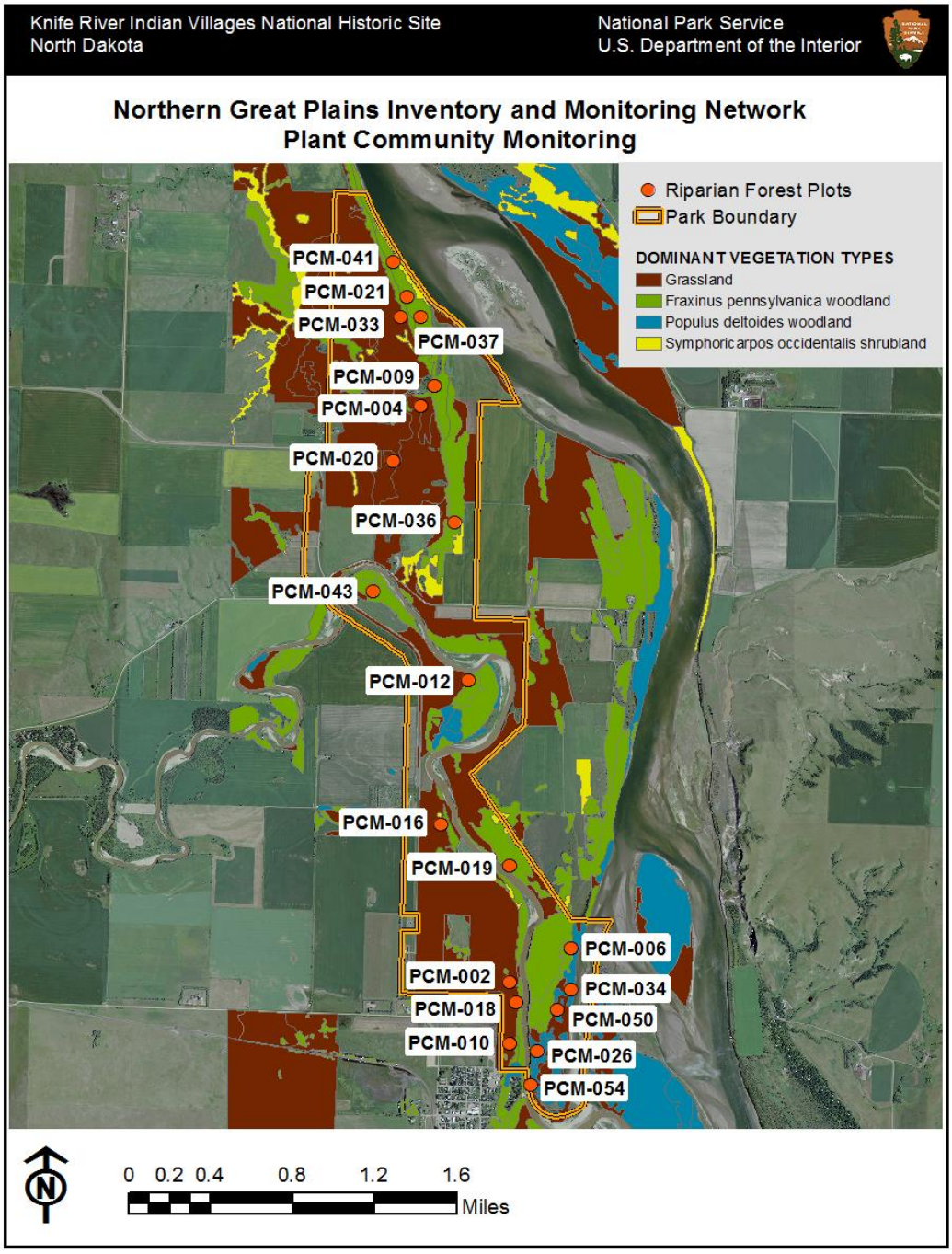


Figure 13. Map of plant community types within the riparian area of Knife River Indian Villages National Historic Site and the location of 20 long-term monitoring plots (red). Vegetation classification is based on the NPS Vegetation Mapping Program report (Salas and Pucherelli 2002).

Figure 14. Images of two long-term forest plots in Knife River Indian Villages National Historic Site. Plot PCM_002 (left) is in a forest/prairie transition zone and PCM-037 (right) is in a closed canopy forest.

Table 5. Tree and tall shrub occurrence in 2014 at 20 riparian forest plots in Knife River Indian Villages National Historic Site.

Species Name	Common Name	Number of plots with trees (DBH > 15 cm)	Number of plots with poles (2.5 cm ≤ DBH ≤ 15 cm)	Number of plots with seedlings (height < 137 cm)
Fraxinus pennsylvanica	green ash	12	6	15
Acer negundo	boxelder	11	6	10
Ulmus americana	American elm	3	2	2
Populus deltoides	plains cottonwood	2	0	0
Salix amygdaloides	peachleaf willow	1	0	0
Shepherdia argentea	silver buffaloberry	1	2	5
Ulmus pumila	Siberian elm	1	2	3
Amelanchier alnifolia	serviceberry	0	1	1
Prunus virginiana	chokecherry	0	2	7

Table 6. Tree basal area and density by size class for tree and shrub species in the riparian forest of Knife River Indian Villages National Historic Site. (Values: mean across 20 riparian forest monitoring plots ± standard error of the mean)

Species	Attribute	Value
Fraxinus pennsylvanica green ash	Basal Area (m^2/ha)	7.6 ± 2.5
	Tree Density (stems/ha)	66 ± 21
	Pole Density (stems/ha)	73 ± 42
	Seedling Density (stems/ha)	1957 ± 1360
	Snag Density (stems/ha)	13 ± 4
Acer negundo boxelder	Basal Area (m^2/ha)	4.9 ± 1.5
	Tree Density (stems/ha)	45 ± 13
	Pole Density (stems/ha)	51 ± 29
	Seedling Density (stems/ha)	313 ± 98
	Snag Density (stems/ha)	5 ± 2
Populus deltoides plains cottonwood	Basal Area (m^2/ha)	4.5 ± 4.4
	Tree Density (stems/ha)	7 ± 6
	Pole Density (stems/ha)	0 ± 0
	Seedling Density (stems/ha)	0 ± 0
	Snag Density (stems/ha)	0 ± 0
Ulmus americana American elm	Basal Area (m^2/ha)	0.2 ± 0.1
	Tree Density (stems/ha)	2 ± 2
	Pole Density (stems/ha)	8 ± 6
	Seedling Density (stems/ha)	65 ± 49
	Snag Density (stems/ha)	0 ± 0
Other native deciduous trees/shrubs	Basal Area (m^2/ha)	0.8 ± 0.7
	Tree Density (stems/ha)	7 ± 7
	Pole Density (stems/ha)	62 ± 54
	Seedling Density (stems/ha)	219 ± 142
	Snag Density (stems/ha)	2 ± 2
Ulmus pumila Siberian elm (non-native)	Basal Area (m^2/ha)	0.1 ± 0.1
	Tree Density (stems/ha)	3 ± 3
	Pole Density (stems/ha)	3 ± 2
	Seedling Density (stems/ha)	73 ± 45
	Snag Density (stems/ha)	2 ± 2

Exotic Species in Riparian Forests

The understory of the riparian forests in KNRI is a mix of native and exotic plants. The focus of the 2014 riparian forest survey was woody species, but field crews also surveyed for the presence of exotic species of management concern (e.g. musk thistle, poison hemlock) and potential early invaders (Table 1). Canada thistle, dame's rocket, and leafy spurge were found in at least half of the 20 plots (Table 7). On average, 3 exotic species were found in each plot. The only early detection species observed was common/yellow toadflax (*Linaria vulgaris*), which is also a North Dakota noxious species. A number of toadflax plants were found throughout a single plot in the southernmost region of the park KNRI_PCM_054 (Figure 1). Toadflax is an invasive plant that threatens grasslands and pastures in the Western US (Figure 15). Common toadflax is less widespread in North Dakota compared to other Western states like Wyoming and Montana.

The NGP Exotic Plant Management Team (EMPT) is aware of the presence of exotic plants in the riparian forest and much of their control efforts have been concentrated in this area during past field seasons (Hauk 2016). The EPMT focused on the control of Canada thistle (*Cirsium arvense*), leafy spurge (*Euphorbia esula*), and absinth wormwood (*Artemisia absinthium*). The NGP EPMT was notified of the common toadflax, but there has not yet been a concerted effort at eradication. Unfortunately, regularly disturbed soils and moist conditions will present a challenge for continued control and eradication efforts of exotic species in this area. Moreover, the river continues to provide an avenue for infestation.

Table 7. Exotic species detected in 20 riparian forest plots in Knife River Indian Villages National Historic Site and their corresponding abundance, cover class, and estimated percent cover.

Species	Common name	Number of Plots	Average Cover Class	Estimated Cover (%)
Cirsium arvense	Canada thistle	16	2.8 ± 0.2	1-5
Hesperis matronalis	Dame's rocket	10	2.3 ± 0.2	1-5
Euphorbia esula	Leafy spurge	10	2.5 ± 0.3	1-5
Artemisia absinthium	Common wormwood	9	1.9 ± 0.2	<1
Phalaris arundinacea	Reed canarygrass	2	3.5 ± 1.5	5-25
Melilotus officinalis	Sweetclover	2	4.0 ± 1.0	5-25
Cynoglossum officinale	Houndstongue	2	2.5 ± 0.5	1-5
Convolvulus arvensis	Field bindweed	2	2.5 ± 0.5	1-5
Lonicera tatarica	Tatarian honeysuckle	1	1.0 ± 0.0	<1
Linaria vulgaris	Yellow toadflax	1	3.0 ± 0.0	1-5
Cirsium vulgare	Bull thistle	1	1.0 ± 0.0	<1
Arctium minus	Lesser burdock	1	2.0 ± 0.0	<1

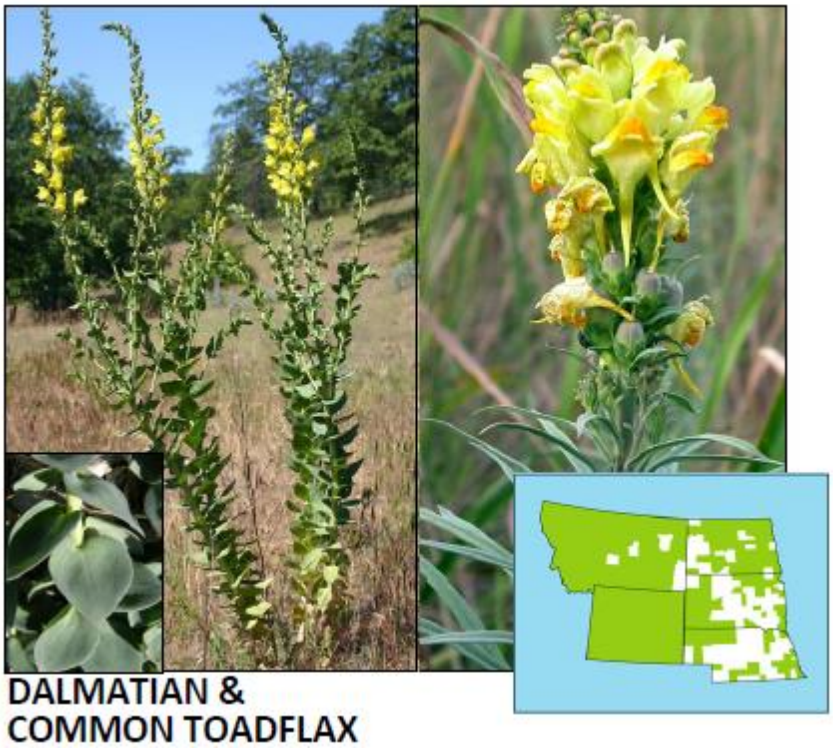


Figure 15. Common toadflax is an invasive plant that threatens grasslands and pastures in upland habitats across the Western US. For more information an early detection flyer on riparian invaders can be found on the NGPN website and on the NPS IRMA Portal: https://irma.nps.gov/App/Reference/Profile/2208791/).

Conclusion

The Northern Great Plains Inventory & Monitoring Program and Fire Effects Program have been monitoring vegetation in Knife River Indian Villages National Historic Site for over 18 years. While methods have changed slightly, this report summarizes data from 57 locations from 1998-2016. Below, we list the questions we asked and provide a summarized answer, for more details see the Results and Discussion section. We conclude with a Natural Resource Condition Table (Table 7) that summarizes the current status and trends in a few key vegetation metrics.

1. **What is the current status of plant community composition and structure of KNRI grasslands (species richness, cover, and diversity) and how has this changed from 1998 to 2016?**

   A long history of agriculture and a change in natural disturbance regimes at KNRI has led to low native plant species richness when compared to more intact mixed-grass prairies in the region (Table 8), but diversity is spatially variable. In general, sites within the northern prairie area support a diversity of native species more typical of intact mixed grass prairie. We found no significant trends in native diversity or evenness from 1998 to 2016, but both are threatened by the large abundance of smooth brome and Kentucky bluegrass. Smooth brome has not increased over time (Figure 6), but where it is present there are very few native species. Kentucky bluegrass, on the other hand, has been increasing since the 1990s (Figure 6). Continued control efforts will be necessary to maintain native prairie and reduce exotic species cover within KNRI.

2. **How have plots in restored and reseeded areas changed over time?**

   Several long-term monitoring plots were located in sites that were reseeded with native grass and forb species in 2004 or 2010. Since this time, exotic species cover has declined over time in these areas. Native graminoid cover increased from 2007 and 2010 in both sites and native species richness remained consistent during this period. These observations suggest that seeding has likely increased native grass establishment and abundance in these areas, potentially preventing an increase in Kentucky bluegrass cover that has been observed in other areas of the park.

3. **What, if any, rare plants were found in KNRI long-term monitoring plots?**

   Three rare plants were observed in NGPN monitoing plots: blue wildrye (*Elymus glaucus*), maiden blue-eyed-Mary (*Collinsia parviflora*), and upright carrionflower (*Smilax ecirrhata*). We recommend close examination and collection of voucher specimens for these species when encountered in future field seasons so their identification and location can be confirmed.

4. **What is the composition and structure of riparian forests at KNRI**?

   The riparian forest in KNRI is a dominated by green ash and box elder trees. Cottonwood and willow species are rare. Future range expansion of the emerald ash borer into North Dakota could have large impacts on these forests because green ash is increasingly abundant. Seedlings of many tree species are common, but it is unclear whether these will survive to maturity because many are covered by thick layers of smooth brome. Exotic forbs are common in the understory of the forest, particularly Canada thistle and dame's rocket, and continuing control efforts will be

necessary to prevent their spread. Revisiting these forested sites in 2019 will provide a better picture of how these forests may be changing over time.

Table 8. Natural resource condition summary table for plant communities in Knife River Indian Viallages National Historic Site (KNRI). Current values are based on data from 2012-2016 and trends are based on data from 1998-2016.

Indicator of Condition	Specific Measures	Current Value (mean ± SE)	Reference Condition and Data Source	Condition Status/Trend	Rationale for Resource Condition
Upland Plant Community Structure and Composition	Native species richness ($1m^2$ quadrats)	4.7 ± 0.4 species	8-18 species		KNRI protects and manages small remnants of northern mixed-grass prairie and supports an active prairie restoration program. 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.
	Evenness (native species point-intercept transects)	0.73 ± 0.03	To be determined		
Exotic Plant Early Detection and Management	Relative cover of exotic species	55.4 ± 3.5%	A reduction in exotic cover over time		KNRI manages a landscape with a very high cover of exotic species. Smooth brome and Kentucky bluegrass are particularly abundant, and their cover should be reduced to retain native plant diversity. Total exotic cover and the cover of Kentucky bluegrass have increased over time since 1998.There has been no change in the cover of smooth brome over this time period.
	Kentucky bluegrass cover	24.4 ± 1.9%	A reduction in Kentucky bluegrass over time		
	Smooth brome cover	22.8 ± 2.7%	A reduction in smooth brome cover over time		
Riparian Forest	Green ash stem density	66 ± 21 stems/ha	66 ± 21 stems/ha		The riparian forests of KNRI are dominated by green ash and box elder. Only 2 of 20 plots contained cottonwood trees. The riparian forests in KNRI have large densities of other native tree and shrub seedlings. Forest surveys will be repeated every 5 years in KNRI and this will allow us to detect trends in condition.
	Average native deciduous seedlings	85%	To be determined		

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Appendix A: List of plant species found at KNRI 1998-2016

Below is a list of all the plant species found in KNRI long-term plant community monitoring plots. The species are grouped by plant family. An "X" in the exotic column means that species is not native to the park or, in the case where only the genus was identified, there are some species within that genus that are exotic. An "ND" in the exotic column indicates that a species is declared "noxious" by the state of North Dakota due to their especially aggressive spread and impact to ecological and economic resources of the state.

Family	Symbol	Scientific Name	Common Name	Exotic	Rare
Aceraceae	ACNE2	*Acer negundo*	boxelder		
Amaranthaceae	AMRE	*Amaranthus retroflexus*	redroot amaranth		
Anacardiaceae	TORY	*Toxicodendron rydbergii*	western poison ivy		
Apiaceae	CIMA2	*Cicuta maculata*	spotted water hemlock		
	OSLO	*Osmorhiza longistylis*	longstyle sweetroot		
	PASA2	*Pastinaca sativa*	wild parsnip	X	
	SAMA2	*Sanicula marilandica*	Maryland sanicle		
Apocynaceae	APAN2	*Apocynum androsaemifolium*	spreading dogbane		
	APCA	*Apocynum cannabinum*	common dogbane		
Asclepiadaceae	ASCLE	*Asclepias*	milkweed	X	
	ASPU	*Asclepias pumila*	plains milkweed		
	ASSP	*Asclepias speciosa*	showy milkweed		
	ASST	*Asclepias stenophylla*	slimleaf milkweed		
	ASSY	*Asclepias syriaca*	common milkweed		
	ASVE	*Asclepias verticillata*	whorled milkweed		
	ASVI	*Asclepias viridiflora*	green comet milkweed		
Asteraceae	ACMI2	*Achillea millefolium*	common yarrow		
	AMPS	*Ambrosia psilostachya*	Cuman ragweed		
	AMTR	*Ambrosia trifida*	great ragweed		
	ANDI2	*Antennaria dimorpha*	low pussytoes		
	ANMI3	*Antennaria microphylla*	littleleaf pussytoes		
	ANPA4	*Antennaria parvifolia*	small-leaf pussytoes		
	ANTEN	*Antennaria*	pussytoes		
	ARAB3	*Artemisia absinthium*	absinth wormwood	ND	
	ARCA12	*Artemisia campestris*	field sagewort		
	ARDR4	*Artemisia dracunculus*	tarragon		
	ARFR4	*Artemisia frigida*	fringed sagewort		
	ARLU	*Artemisia ludoviciana*	white sagebrush		
	ARMI2	*Arctium minus*	common burdock	X	
	BREU	*Brickellia eupatorioides*	false boneset		
	CIAL2	*Cirsium altissimum*	tall thistle		
	CIAR4	*Cirsium arvense*	Canada thistle	ND	
	CIFL	*Cirsium flodmanii*	Flodman's thistle		
	CIRSI	*Cirsium*	thistle	X	
	CIUN	*Cirsium undulatum*	wavyleaf thistle		
	CIVU	*Cirsium vulgare*	bull thistle	X	
	COCA5	*Conyza canadensis*	horseweed		

Family	Symbol	Scientific Name	Common Name	Exotic	Rare
Asteraceae, cont.	CYXA2	*Cyclachaena xanthiifolia*	giant sumpweed		
	ECAN2	*Echinacea angustifolia*	blacksamson echinacea		
	ECPU	*Echinacea purpurea*	eastern purple coneflower		
	ERST3	*Erigeron strigosus*	prairie fleabane		
	GUSA2	*Gutierrezia sarothrae*	broom snakeweed		
	HEAN3	*Helianthus annuus*	common sunflower		
	HEHE5	*Heliopsis helianthoides*	smooth oxeye		
	HELIA3	*Helianthus*	sunflower		
	HEMA2	*Helianthus maximiliani*	Maximilian sunflower		
	HEPA19	*Helianthus pauciflorus*	stiff sunflower		
	HEVI4	*Heterotheca villosa*	hairy false goldenaster		
	LASE	*Lactuca serriola*	prickly lettuce	X	
	LILI	*Liatris ligulistylis*	Rocky Mountain blazing star		
	LIPU	*Liatris punctata*	dotted blazing star		
	LYJU	*Lygodesmia juncea*	rush skeletonplant		
	MUOB99	*Mulgedium oblongifolium*	blue lettuce		
	OLRI	*Oligoneuron rigidum*	stiff goldenrod		
	PAPL12	*Packera plattensis*	prairie groundsel		
	RACO3	*Ratibida columnifera*	upright prairie coneflower		
	SERA	*Senecio rapifolius*	openwoods ragwort		
	SOAR2	*Sonchus arvensis*	field sowthistle	X	
	SOGI	*Solidago gigantea*	giant goldenrod		
	SOLID	*Solidago*	goldenrod		
	SOMI2	*Solidago missouriensis*	Missouri goldenrod		
	SOMO	*Solidago mollis*	velvety goldenrod		
	SONE	*Solidago nemoralis*	gray goldenrod		
	SORI2	*Solidago rigida*	stiff goldenrod		
	SYER	*Symphyotrichum ericoides*	white heath aster		
	SYLA3	*Symphyotrichum laeve*	smooth blue aster		
	SYLA6	*Symphyotrichum lanceolatum*	white panicle aster		
	SYMPH4	*Symphyotrichum*	aster	X	
	SYOB	*Symphyotrichum oblongifolium*	aromatic aster		
	TAOF	*Taraxacum officinale*	common dandelion	X	
	TOGR	*Townsendia grandiflora*	largeflower Townsend daisy		
	TRDU	*Tragopogon dubius*	yellow salsify	X	
	XASP99	*Xanthisma spinulosum*	lacy tansyaster		
	XAST	*Xanthium strumarium*	cocklebur		
Boraginaceae	CYOF	*Cynoglossum officinale*	houndstongue		
	HADE	*Hackelia deflexa*	nodding stickseed		
	HAFL2	*Hackelia floribunda*	manyflower stickseed		
	LAOC3	*Lappula occidentalis*	flatspine stickseed		
	LIIN2	*Lithospermum incisum*	narrowleaf stoneseed		
	ONBE	*Onosmodium bejariense*	soft-hair marbleseed		
Brassicaceae	ALDE	*Alyssum desertorum*	desert madwort	X	
	ARABI2	*Arabis*	rockcress		

Family	Symbol	Scientific Name	Common Name	Exotic	Rare
Brassicaceae, cont.	ARHI	*Arabis hirsuta*	hairy rockcress		
	BEIN2	*Berteroa incana*	hoary alyssum	X	
	BOECH99	*Boechera*	rockcress		
	BOFE	*Boechera fendleri*	Fendler's rockcress		
	BOHO99	*Boechera holboellii*	Holboell's rockcress		
	BRASS2	*Brassica*	mustard	X	
	CAMI2	*Camelina microcarpa*	littlepod false flax	X	
	DEPI	*Descurainia pinnata*	western tansymustard		
	DESO2	*Descurainia sophia*	herb sophia	X	
	DRRE2	*Draba reptans*	Carolina draba		
	ERCA14	*Erysimum capitatum*	sanddune wallflower		
	ERCH9	*Erysimum cheiranthoides*	wormseed wallflower	X	
	ERYSI	*Erysimum*	wallflower	X	
	HEMA3	*Hesperis matronalis*	dames rocket	X	
	LEDE	*Lepidium densiflorum*	common pepperweed		
	PHAR99	*Physaria arenosa*	Great Plains bladderpod		
	SIAL2	*Sisymbrium altissimum*	tall tumblemustard	X	
	THAR5	*Thlaspi arvense*	field pennycress	X	
Cactaceae	ESVI2	*Escobaria vivipara*	spinystar		
	OPPO	*Opuntia polyacantha*	plains pricklypear		
Cannabaceae	HULU	*Humulus lupulus*	common hop		
Caprifoliaceae	LOTA	*Lonicera tatarica*	Tatarian honeysuckle	X	
Caprifoliaceae	SYOC	*Symphoricarpos occidentalis*	western snowberry		
Caryophyllaceae	GYPA	*Gypsophila paniculata*	baby's breath	X	
	MOLA6	*Moehringia lateriflora*	bluntleaf sandwort		
Celastraceae	CESC	*Celastrus scandens*	American bittersweet		
Chenopodiaceae	CHAL7	*Chenopodium album*	lambsquarters	X	
	CHBE4	*Chenopodium berlandieri*	pitseed goosefoot		
	CHDE	*Chenopodium desiccatum*	aridland goosefoot		
	CHENO	*Chenopodium*	goosefoot	X	
	CHPR5	*Chenopodium pratericola*	desert goosefoot		
	CHSI2	*Chenopodium simplex*	mapleleaf goosefoot		
	KOSC	*Kochia scoparia*	burningbush, kochia	X	
	SALSO	*Salsola*	Russian thistle	X	
	SATR12	*Salsola tragus*	prickly Russian thistle	X	
Commelinaceae	TROC	*Tradescantia occidentalis*	prairie spiderwort		
Convolvulaceae	COAR4	*Convolvulus arvensis*	field bindweed	X	
Cyperaceae	CABR10	*Carex brevior*	shortbeak sedge		
	CADU6	*Carex duriuscula*	needleleaf sedge		
	CAFI	*Carex filifolia*	threadleaf sedge		
	CAGR4	*Carex gravida*	heavy sedge		
	CAIN9	*Carex inops*	sun sedge		
	CAREX	*Carex*	sedge		
	CASP7	*Carex sprengelii*	Sprengel's sedge		
Elaeagnaceae	ELAN	*Elaeagnus angustifolia*	Russian olive	X	
	SHAR	*Shepherdia argentea*	silver buffaloberry		
Euphorbiaceae	EUES	*Euphorbia esula*	leafy spurge	ND	

Family	Symbol	Scientific Name	Common Name	Exotic	Rare
Euphorbiaceae, cont.	EUGL3	*Euphorbia glyptosperma*	ribseed sandmat		
	EUPHO	*Euphorbia*	spurge, sandmat	X	
	EUPR3	*Euphorbia prostrata*	prostrate sandmat		
	EUSE5	*Euphorbia serpyllifolia*	thymeleaf sandmat		
	EUSP	*Euphorbia spathulata*	warty spurge		
Fabaceae	ACAM99	*Acmispon americanus*	American bird's-foot trefoil		
	AMBR2	*Amphicarpaea bracteata*	American hogpeanut		
	AMCA6	*Amorpha canescens*	leadplant		
	AMNA	*Amorpha nana*	dwarf false indigo		
	ASAM3	*Astragalus americanus*	American milkvetch		
	ASBI2	*Astragalus bisulcatus*	twogrooved milkvetch		
	ASCR2	*Astragalus crassicarpus*	groundplum milkvetch		
	ASGI5	*Astragalus gilviflorus*	plains milkvetch		
	ASLA27	*Astragalus laxmannii*	Laxmann's milkvetch		
	ASMI10	*Astragalus missouriensis*	Missouri milkvetch		
	ASTRA	*Astragalus*	milkvetch		
	DACA7	*Dalea candida*	white prairie clover		
	DAPU5	*Dalea purpurea*	purple prairie clover		
	GLLE3	*Glycyrrhiza lepidota*	American licorice		
	MELU	*Medicago lupulina*	black medick	X	
	MEOF	*Melilotus officinalis*	yellow sweetclover	X	
	MESA	*Medicago sativa*	alfalfa	X	
	OXCA4	*Oxytropis campestris*	field locoweed		
	OXLA3	*Oxytropis lambertii*	purple locoweed		
	OXYTR	*Oxytropis*	locoweed		
	PEAR6	*Pediomelum argophyllum*	silverleaf Indian breadroot		
	PSLA3	*Psoralidium lanceolatum*	lemon scurfpea		
	PSTE5	*Psoralidium tenuiflorum*	slimflower scurfpea		
	TRPR2	*Trifolium pratense*	red clover	X	
	VIAM	*Vicia americana*	American vetch		
Grossulariaceae	RIAM2	*Ribes americanum*	American black currant		
	RIBES	*Ribes*	currant	X	
	RIOX	*Ribes oxyacanthoides*	Canadian gooseberry		
Hydrophyllaceae	ELNY	*Ellisia nyctelea*	Aunt Lucy		
Iridaceae	SIMO2	*Sisyrinchium montanum*	strict blue-eyed grass		
Juncaceae	JUBA	*Juncus balticus*	Baltic rush		
Lamiaceae	HEHI	*Hedeoma hispida*	rough false pennyroyal		
	HEPU	*Hedeoma pulegioides*	American false pennyroyal		
	LECA2	*Leonurus cardiaca*	common motherwort	X	
	LYAS	*Lycopus asper*	rough bugleweed		
	MOFI	*Monarda fistulosa*	wild bergamot		
	NECA2	*Nepeta cataria*	catnip	X	
	SCLA2	*Scutellaria lateriflora*	blue skullcap		
	STPI6	*Stachys pilosa*	hairy hedgenettle		
Liliaceae	ALTE	*Allium textile*	textile onion		
Lilaceae, cont.	ASOF	*Asparagus officinalis*	garden asparagus	X	
	MAST4	*Maianthemum stellatum*	starry false lily of the		

Family	Symbol	Scientific Name	Common Name	Exotic	Rare
			valley		
Linaceae	LILE3	*Linum lewisii*	Lewis flax		
	LIRI	*Linum rigidum*	stiffstem flax		
Malvaceae	SPCO	*Sphaeralcea coccinea*	scarlet globemallow		
Nyctaginaceae	MIHI	*Mirabilis hirsuta*	hairy four o'clock		
	MILI3	*Mirabilis linearis*	narrowleaf four o'clock		
Oleaceae	FRPE	*Fraxinus pennsylvanica*	green ash		
Onagraceae	OECU2	*Oenothera curtiflora*	velvetweed		
	OESE3	*Oenothera serrulata*	yellow sundrops		
	OESU99	*Oenothera suffrutescens*	scarlet beeblossom		
Oxalidaceae	OXST	*Oxalis stricta*	common yellow woodsorrel		
Plantaginaceae	PLMA2	*Plantago major*	common plantain	X	
	PLPA2	*Plantago patagonica*	woolly plantain		
Poaceae	AGCR	*Agropyron cristatum*	crested wheatgrass	X	
	AGROP2	*Agropyron*	wheatgrass	X	
	ANGE	*Andropogon gerardii*	big bluestem		
	ARPU9	*Aristida purpurea*	purple threeawn		
	BOCU	*Bouteloua curtipendula*	sideoats grama		
	BOGR2	*Bouteloua gracilis*	blue grama		
	BOHI2	*Bouteloua hirsuta*	hairy grama		
	BRIN2	*Bromus inermis*	smooth brome	X	
	BRJA	*Bromus japonicus*	Japanese brome	X	
	BRTE	*Bromus tectorum*	cheatgrass	X	
	CALO	*Calamovilfa longifolia*	prairie sandreed		
	DICHA2	*Dichanthelium*	rosette grass		
	DIOL	*Dichanthelium oligosanthes*	Heller's rosette grass		
	DISP	*Distichlis spicata*	saltgrass		
	DIWI5	*Dichanthelium wilcoxianum*	fall rosette grass		
	ELCA11	*Elymus caninus*	bearded wheatgrass	X	
	ELCA4	*Elymus canadensis*	Canada wildrye		
	ELGL	*Elymus glaucus*	blue wildrye		S1
	ELRE4	*Elymus repens*	quackgrass	X	
	ELTR7	*Elymus trachycaulus*	slender wheatgrass		
	ELVI	*Elymus villosus*	hairy wildrye		
	ELVI3	*Elymus virginicus*	Virginia wildrye		
	ELYMU	*Elymus*	wildrye	X	
	HECO26	*Hesperostipa comata*	needle and thread		
	HESP11	*Hesperostipa spartea*	porcupinegrass		
	HOJU	*Hordeum jubatum*	foxtail barley		
	KOMA	*Koeleria macrantha*	prairie Junegrass		
	MUCU3	*Muhlenbergia cuspidata*	plains muhly		
	MURA	*Muhlenbergia racemosa*	marsh muhly		
	NAVI4	*Nassella viridula*	green needlegrass		
	PACA6	*Panicum capillare*	witchgrass		
	PANIC	*Panicum*	panicgrass	X	
	PASM	*Pascopyrum smithii*	western wheatgrass		

Family	Symbol	Scientific Name	Common Name	Exotic	Rare
Poaceae, cont.	PAVI2	*Panicum virgatum*	switchgrass		
	PEGL2	*Pennisetum glaucum*	pearl millet	X	
	PHAR3	*Phalaris arundinacea*	reed canarygrass		
	POA	*Poa*	bluegrass	X	
	POPR	*Poa pratensis*	Kentucky bluegrass	X	
	SCSC	*Schizachyrium scoparium*	little bluestem		
	SEVI4	*Setaria viridis*	green foxtail	X	
	SONU2	*Sorghastrum lythrum*	Indiangrass		
	SPCR	*Sporobolus cryptandrus*	sand dropseed		
	SPPE	*Spartina pectinata*	prairie cordgrass		
	THIN6	*Thinopyrum intermedium*	intermediate wheatgrass	X	
Polemoniaceae	PHHO	*Phlox hoodii*	spiny phlox		
Polygalaceae	POAL4	*Polygala alba*	white milkwort		
	POVE	*Polygala verticillata*	whorled milkwort		
Polygonaceae	ERIOG	*Eriogonum*	buckwheat		
	ERPA9	*Eriogonum pauciflorum*	fewflower buckwheat		
	FACO	*Fallopia convolvulus*	black bindweed	X	
	PORA3	*Polygonum ramosissimum*	bushy knotweed		
	RUAL4	*Rumex altissimus*	pale dock		
	RUCR	*Rumex crispus*	curly dock	X	
Primulaceae	ANOC2	*Androsace occidentalis*	western rockjasmine		
	LYCI	*Lysimachia ciliata*	fringed loosestrife		
Ranunculaceae	ANCA8	*Anemone canadensis*	Canadian anemone		
	ANCY	*Anemone cylindrica*	candle anemone		
	ANEMO	*Anemone*	anemone		
	ANPA19	*Anemone patens*	eastern pasqueflower		
	AQCA	*Aquilegia canadensis*	red columbine		
	CLLI2	*Clematis ligusticifolia*	western white clematis		
	RAAB	*Ranunculus abortivus*	littleleaf buttercup		
	THDA	*Thalictrum dasycarpum*	purple meadow-rue		
Rhamnaceae	RHCA3	*Rhamnus cathartica*	common buckthorn	X	
Rosaceae	AMAL2	*Amelanchier alnifolia*	Saskatoon serviceberry		
	CRCH	*Crataegus chrysocarpa*	fireberry hawthorn		
	FRVE	*Fragaria vesca*	woodland strawberry		
	GEAL3	*Geum aleppicum*	yellow avens		
	POPE8	*Potentilla pensylvanica*	Pennsylvania cinquefoil		
	POTEN	*Potentilla*	cinquefoil	X	
	PRAM	*Prunus americana*	American plum		
	PRUNU	*Prunus*	plum		
	PRVI	*Prunus virginiana*	chokecherry		
	ROAR3	*Rosa arkansana*	prairie rose		
	ROSA5	*Rosa*	rose		
	ROWO	*Rosa woodsii*	Woods' rose		
Rubiaceae	GAAP2	*Galium aparine*	stickywilly		
	GABO2	*Galium boreale*	northern bedstraw		
	GATR3	*Galium triflorum*	fragrant bedstraw		
Salicaceae	PODE3	*Populus deltoides*	eastern cottonwood		

Family	Symbol	Scientific Name	Common Name	Exotic	Rare
Salicaceae, cont.	SAAM2	*Salix amygdaloides*	peachleaf willow		
	SAEX	*Salix exigua*	narrowleaf willow		
	SALIX	*Salix*	willow		
Saxifragaceae	HERI	*Heuchera richardsonii*	Richardson's alumroot		
Scrophulariaceae	COPA3	*Collinsia parviflora*	maiden blue eyed Mary		S2
	LIVU2	*Linaria vulgaris*	yellow toadflax	ND	
	PEAL2	*Penstemon albidus*	white penstemon		
	PEGR5	*Penstemon gracilis*	lilac penstemon		
	PENST	*Penstemon*	beardtongue		
	VEHE2	*Veronica hederifolia*	ivyleaf speedwell	X	
	VETH	*Verbascum thapsus*	common mullein	X	
Selaginellaceae	SEDE2	*Selaginella densa*	lesser spikemoss		
Smilacaceae	SMEC	*Smilax ecirrhata*	upright carrionflower		S1S2
	SMHE	*Smilax herbacea*	smooth carrionflower		
	SMLA3	*Smilax lasioneura*	Blue Ridge carrionflower		
Solanaceae	PHVI5	*Physalis virginiana*	Virginia groundcherry		
Ulmaceae	ULAM	*Ulmus americana*	American elm		
	ULPU	*Ulmus pumila*	Siberian elm	X	
Urticaceae	PAPE5	*Parietaria pensylvanica*	Pennsylvania pellitory		
	URDI	*Urtica dioica*	stinging nettle		
Verbenaceae	PHLE5	*Phryma leptostachya*	American lopseed		
	VEBR	*Verbena bracteata*	bigbract verbena		
	VEST	*Verbena stricta*	hoary verbena		
Violaceae	VIAD	*Viola adunca*	hookedspur violet		
	VICA4	*Viola canadensis*	Canadian white violet		
	VINU2	*Viola nuttallii*	Nuttall's violet		
	VIOLA	*Viola*	violet	X	
Vitaceae	PAVI5	*Parthenocissus vitacea*	woodbine		
	VIRI	*Vitis riparia*	riverbank grape		
	VITIS	*Vitis*	grape		

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.

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U.S. Department of the Interior

Natural Resource Stewardship and Science
1201 Oakridge Drive, Suite 150
Fort Collins, CO 80525

www.nature.nps.gov