National Park Service
U.S. Department of the Interior

Natural Resource Stewardship and Science

Fort Union Trading Post National Historic Site Plant Community Composition and Structure Monitoring

2011 Annual Report

Natural Resource Technical Report NPS/NGPN/NRTR—2012/528

ON THE COVER
A view of plant community monitoring transect at Fort Union Trading Post National Historic Site, 2011
Photograph by: NGPN, NPS

Fort Union Trading Post National Historic Site Plant Community Composition and Structure Monitoring

2011 Annual Report

Natural Resource Technical Report NPS/NGPN/NRTR—2012/528

Isabel W. Ashton
Michael Prowatzke
Michael R. Bynum
Tim Shepherd
Stephen K. Wilson
Kara Paintner-Green

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

January 2012

U.S. Department of the Interior
National Park Service
Natural Resource Stewardship and Science
Fort Collins, Colorado

The National Park Service, Natural Resource Stewardship and Science office in Fort Collins, Colorado publishes a range of reports that address natural resource topics 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.

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.

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

Please cite this publication as:

Ashton, I. W., M. Prowatzke, M. Bynum, T. Shepherd, S. K. Wilson, K. Paintner-Green. 2012. Fort Union Trading Post National Historic Site plant community composition and structure monitoring: 2011 annual report. Natural Resource Technical Report NPS/NGPN/NRTR—2012/528. National Park Service, Fort Collins, Colorado.

NPS 436/112513, January 2012

Contents

Figures

Tables

Executive Summary

The Northern Great Plains Inventory & Monitoring Network (NGPN) was established to develop and provide scientifically credible information on the current status and long-term trends of the composition, structure, and function of ecosystems in thirteen parks located in North and South Dakota, eastern Wyoming, and Nebraska. NGPN identified upland plant communities, exotic plant early detection, and riparian lowland communities as vital signs that can be used to better understand the condition of terrestrial park ecosystems. Upland and riparian ecosystems are important targets for vegetation monitoring because the status and trends in plant communities provide critical insights into the status and trends of other biotic components within those ecosystems.

In 2011, NGPN began plant community monitoring in Fort Union Trading Post National Historic site (FOUS). We sampled vegetation at 6 long-term monitoring plots between July 29th and August 1st and recorded a total of 104 vascular plant species. This effort was the first year in a multiple-year venture to understand the status of upland plant communities in FOUS. At the end of 5 years, there will be an in-depth report describing the status of the plant community. In this report, we provide a simple summary of our results from sampling in 2011. We found the following:

- Absolute vascular plant cover was high due to a wet spring and grasses and sedges made up the bulk of vascular plant cover at all sites.

- The sites at FOUS had a moderate diversity of vascular plants. Average native species richness in the 10 m^2 quadrats was 9.5 ± 6.78 species (mean ± standard deviation) as compared to a range of 15-20 species seen in grasslands of Theodore Roosevelt National Park.

- Two exotic grasses, smooth brome and created wheatgrass, were common across the plots we visited. However, total cover of exotic species was relatively low.

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 thank the Northern Great Plains Fire Management team for ongoing assistance with fieldwork and development of methods. We greatly appreciate the staff at FOUS for providing logistical support. The 2011 NGPN vegetation field crew of Michael Bynum, Timothy Pine, Lauren Baur, and Daina Jackson collected the data included in this report. We thank Amy Symstad for helping us with data collection in the field. We thank Timothy Shepherd for invaluable support and instruction on managing data in the FFI database and Stephen Wilson for assistance with the GIS data. We thank Andy Banta for providing comments on a draft of this report.

Introduction

One of the objectives of the National Park Service (NPS) Inventory & Monitoring (I&M) Program is to develop and provide scientifically credible information on the current status and long-term trends of the composition, structure, and function of park ecosystems, and to determine how well current management practices are sustaining those ecosystems. The Northern Great Plains I&M Network (NGPN) includes 13 parks located in 5 northern Great Plains states across 6 ecoregions (Figure 1) and vary widely in size, amount of visitor use, and management context.

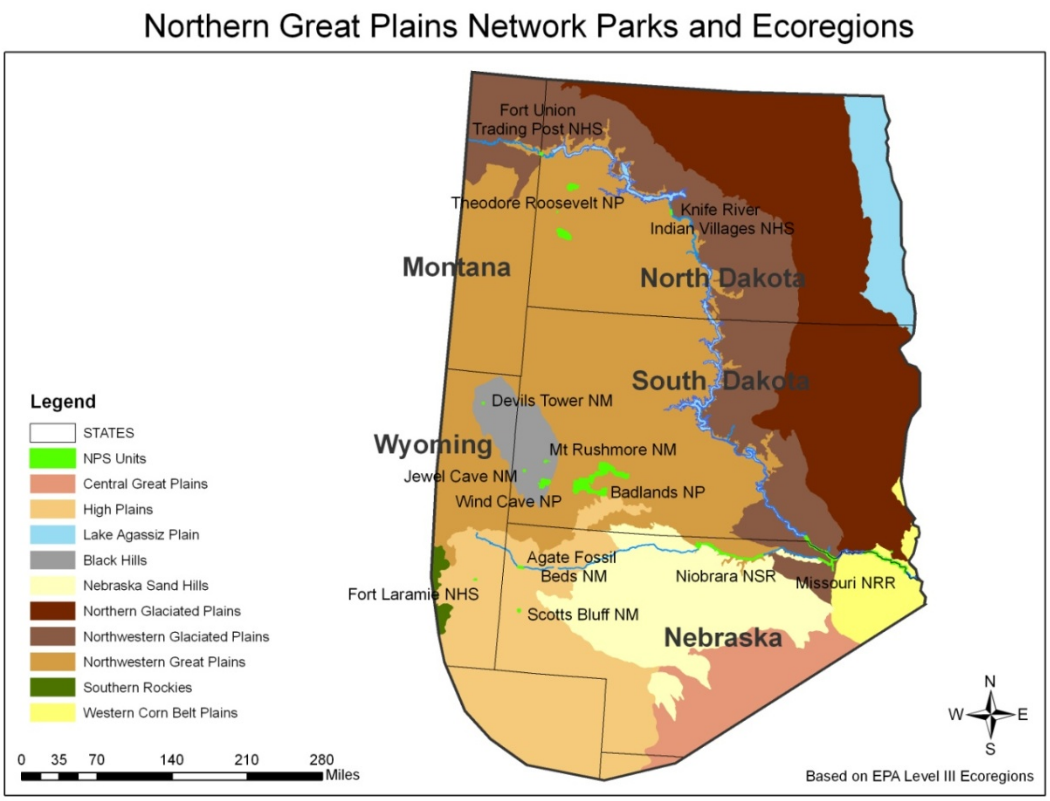

Figure 1. Parks and ecoregions of the Northern Great Plains Network. Based on the U.S. Environmental Protection Agency's Level III ecoregions classes (Omernik 2007).

NGPN identified upland plant communities, exotic plant early detection, and riparian lowland communities as vital signs that can be used to better understand the condition of terrestrial park ecosystems (Gitzen et al. 2010). Network-wide land cover is dominated by native upland grassland, but some small parks are dominated by old fields and recent prairie plantings (Symstad et al. 2011). Other major land cover types include barren or sparsely vegetated areas (portions of Badlands and Theodore Roosevelt national parks) and ponderosa pine forests and woodlands in Black Hills parks. Riparian hardwood forests comprise a small portion of the area but have disproportionately large ecological significance because of their value to wildlife species.

The NGPN selected upland and riparian ecosystems as an important vegetation monitoring target because knowing the status and trends in plant communities of any terrestrial ecosystem is critical to understanding the status and trends in most other biotic components of that ecosystem. Not only are plants the source of food for most other organisms, but they also provide other organisms cover from predators and the elements, structure for basic life-history processes (e.g., nest sites), and substrate on which to grow. Plant communities influence local, regional, and global climate through evapotranspiration, albedo, and greenhouse gas emissions and absorption (Smith et al. 1997). Fire regimes (D'Antonio and Vitousek 1992) and flood behavior (Anderson et al. 2006) are in part mediated by the species that comprise plant communities and the structure that they create. Plants are the major source of organic inputs into soil and aquatic systems. Finally, vegetation is a large part of the scenery that visitors to NPS units come to enjoy.

The long-term objectives of our plant community monitoring effort (Symstad et al. 2011) in FOUS are to:

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

2. 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 for our initial sampling efforts in 2011 at FOUS. We visited 6 plots in a rotating panel design and it will take 4 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 (i.e., visit and sample every plot in the park twice, following a rotating panel design that stipulates 2 years of visitation and 3 years of rest per 5-year period). Reports, spatial data, and data summaries can also be provided as needed for park management and interpretation.

Methods

The NGPN Plant Community Composition and Structure Monitoring Protocol (Symstad et al. 2011) describes in detail the methods used for sampling upland and riparian vegetation in 11 parks of the network. Below, we briefly describe the general approach, sample frame, plot locations, and sampling methods. For those interested in more detail, please see Symstad et al. 2011, available at http://science.nature.nps.gov/im/units/ngpn/monitor/plants/plants.cfm.

Sample design

NGPN has implemented a survey to monitor vegetation in FOUS using a Generalized Random Tessellation Stratified (GRTS) sampling design (Stevens and Olsen 2003, 2004). Probability-based surveys provide unbiased estimation of both status and, with repeated visits, trend across a resource (Larsen et al. 1995). 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). The goal of our probability-based design is to determine the *status* of vegetation after 5 years and from then on, the *trend* in vegetation.

The methods for the development of the survey design and site selection are described in detail in Symstad et al. 2011. In brief, a probability-based survey design consists of implementing the following steps prior to field sampling: defining a resource or target population and any subpopulations of interest, creating a sample frame within the target population, selecting sites to visit within the sample frame, and determining when to sample. For all parks, we exclude the following areas from the sample frame: administrative areas, roads, canals, or utility lines and an appropriate buffer, areas within 10 m of a park boundary, paved trails, areas with little to no potential for terrestrial vegetation (e.g. large areas of bare rock), areas that are dangerous or prohibitively difficult to access or work on, and areas that are not owned by the park. The sample frame for FOUS includes 2 distinct strata, the Bodmer Overlook Unit and the upland terraces surrounding the fort (i.e., the Fort Unit). It does not include riparian areas north of the Missouri River or terraces south of the river. The final design includes 15 randomly located upland sites representing the park where vegetation will be sampled close to peak phenology (late July) (Figure 2).

An ideal revisit design would consist of a large number of sites distributed throughout a park being sampled every year. Limited resources, as well as the danger of plot wear-out (trampling and other effects of sampling), precluded this design. Instead, NGPN intensive plant community composition and structure monitoring uses a connected [2-x] rotating-panel design: every park is visited every year, but sites are grouped into panels where each panel (and the plots therein) is measured for 2 consecutive years followed by 3 or more years without sampling. Because only a subset of panels (and therefore plots) are visited each year, this allows more sites than can be visited in 1 year to be included in the sample design, while including revisitation of sites to address annual variability. Compared to the always-revisit design, connected panel designs, in which each panel is revisited periodically, sacrifice little power for detecting trend (Urquhart and Kincaid 1999) but provide much greater spatial coverage, and thus improved precision in estimates of status. At FOUS, we will visit 2 panels in each sampling unit, for a total of 6 sites, every year and after 5 we will have visited all sites twice (Figure 3). In 2011, we visited sites in panel 1 and panel 5 (Figure 2).

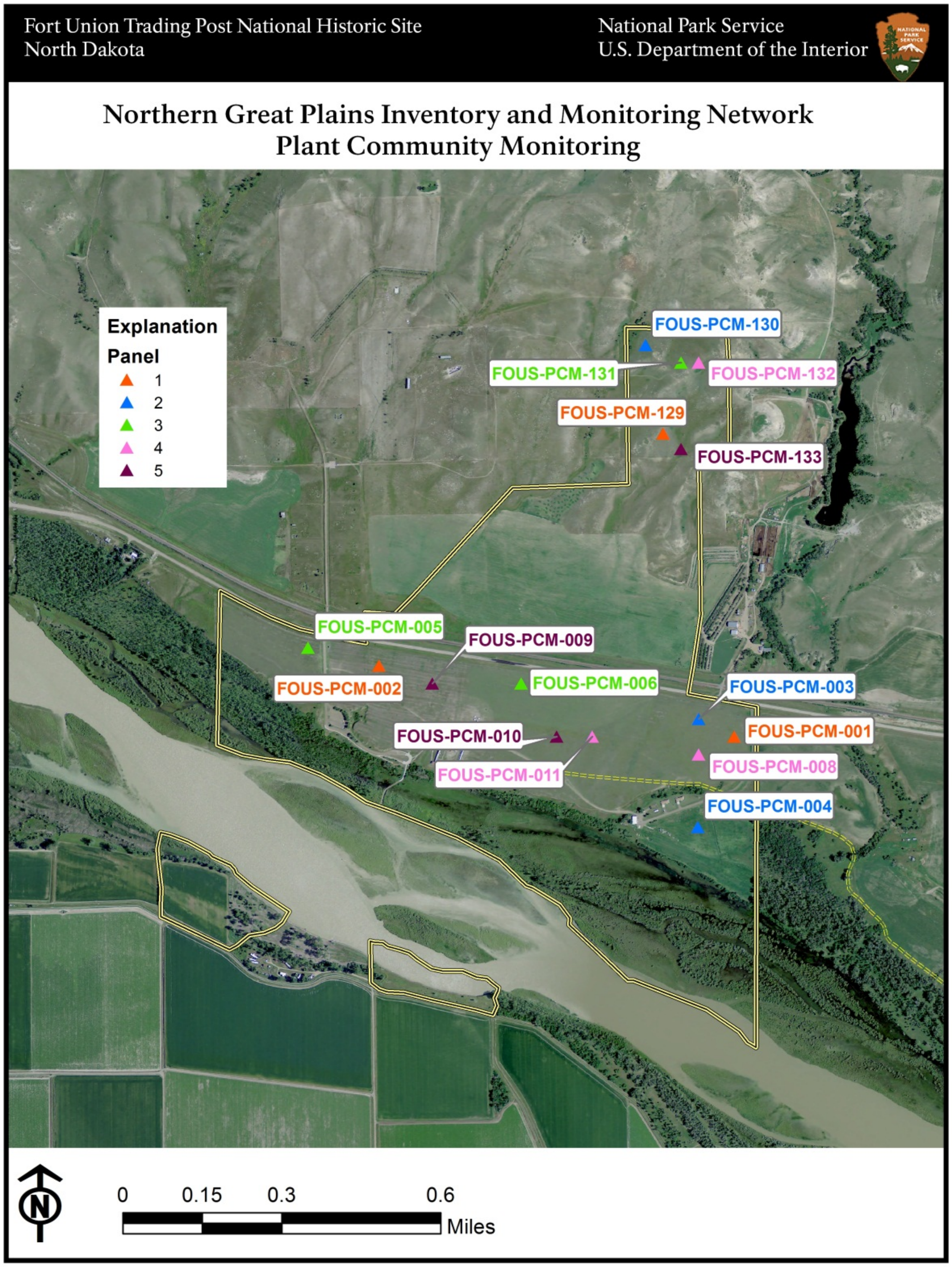

Figure 2. Map of FOUS and plant community monitoring plots. Plots in Panel 1 (orange) and Panel 5 (purple) were visited in 2011.

Year↓ / Panel→	P1	P2	P3	P4	P5
2011	3				3
2012	3	3			
2013		3	3		
2014			3	3	
2015				3	3
2016	3				3
2017	3	3			
2018		3	3		
2019			3	3	
2020				3	3
2021	3				3

Figure 3. [2-3] revisit design for intensive plant community composition and structure monitoring at most NGPN parks. Five panels are used in the park. Data are collected in all the plots of a given panel, 2 of every 5 years. Blank cells indicate no plots in the panel are visited that year; at FOUS there are 3 plots in a panel. Thus, 6 plots (2 panels) are sampled each year and the total sample size is 15.

The number of plots allocated to each park and to strata within parks is influenced by a combination of factors, including field work logistics, statistical power estimations (see Symstad et al. 2011), and conformity to the desired revisit design. Plot numbers across parks are allocated roughly proportional to the size of the sample frame for that park, although the minimum number of plots per park was set at 15. At FOUS, there are currently 15 monitoring plots; 10 in the upland area surrounding the fort and 5 in the Bodmer unit.

Plot layout and sampling

The primary sample unit for intensive plant community composition and structure monitoring in the NGPN consists of a rectangular, 50 m x 20 m (0.1 ha), permanent plot (Figure 4). These are hereafter referred to as "intensive plots". In 2011, sampling at FOUS took a 5 person crew approximately 35 hours with travel time (see Appendix A for a detail of activities each day). We visited additional plots to evaluate and establish them for future monitoring. Below, we briefly describe the methods we used for marking and sampling the plots.

Establishing, Marking, and Photographing Long-term Monitoring Plots

Locations of all intensive plots are determined before monitoring begins in the site evaluation process. At this time, a single plot marker, marked with a metal tag identifying the plot and the marker as the center (C), is driven into the ground at the center of the plot (Figure 5). At plot establishment (which may be done prior to the first visit for data collection), 2 permanent transects are marked by driving rebar markers into the ground at the end points of each transect. A metal tag imprinted with the park code, plot ID, corner name (A0, A50, B0, or B50), and establishment date is attached to each marker. Each transect is also marked with large nails and washers sunk flush with the ground at 10.92 m, 23.42 m, 35.92 m, and 46.84 m from the 0 end of each transect. Figure 6 is a photographic sample of the tags and washers used by NGPN.

At each transect end, a photograph is taken down the length of the transect. When trees and/or tall shrub species are present in or near the plot, the ends of 2 additional perpendicular, 100-ft (30.48 m) transects centered at the C plot marker are marked with large nails and washers (Figure 4). One of these transects (T1) is parallel to the herb-layer transects and the second (T2) is perpendicular to that transect.

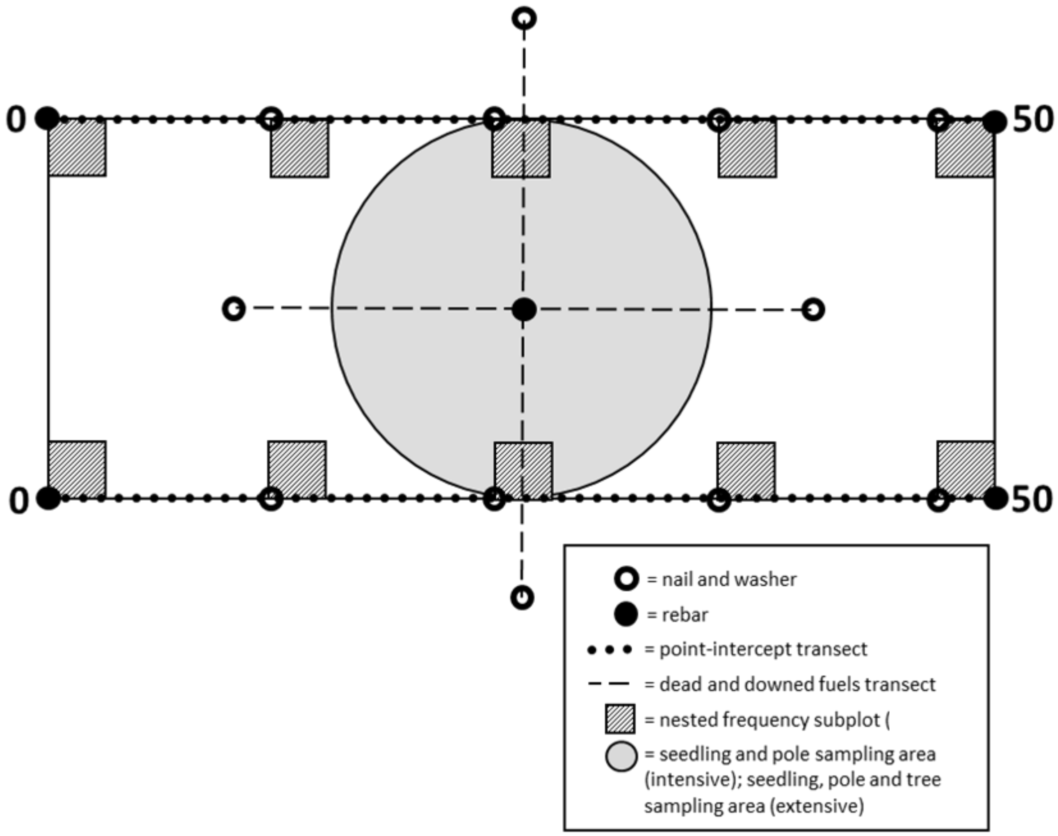

Figure 4. Layout for NGPN intensive plant community composition and structure plots.

Figure 5. A sample of the center marker at an NGPN long-term vegetation monitoring plot. The rebar is bent in the field with a brass tag noting the plot number, date of installation, and location. A compass is used for scale.

Figure 6. A sample of tags and washers used to mark long-term vegetation monitoring plots in the NGPN. From the top left and working clockwise: a center tag from PCM-08 in SCBL evaluated on May 5, 2009; a tag used to mark the end of the A transect at WICA PCM-01; a tag used to mark the center of an extensive plot in MORU; and a washer used to mark the beginning of the second tree transect. In all cases, the tags are close or flush to the ground. The brass tags are fixed to rebar with wire, and the washer is held in place by a large nail.

Plant Sampling

Data on ground cover and herb-layer (≤ 2 m height) height and foliar cover were collected on 2 50 m transects (the long sides of the plot) using a point-intercept method at each plot. Starting at the 0 end of each transect, a 50 m tape was stretched over the length of the transect, ensuring that it followed the path marked by the nails and washers (Figure 4). 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 7).

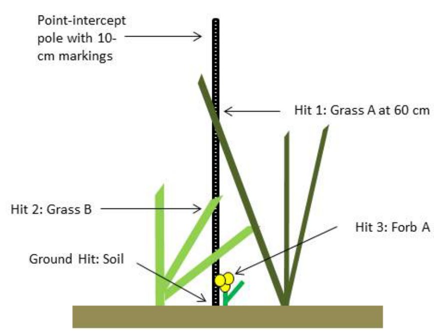

Figure 7. The NGPN point-intercept method captures multiple layers of the plant canopy.

Species richness data from this point-intercept method are 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; Figure 8) located systematically along each transect. Nested quadrats are located so that they occur inside the 20 m x 50 m plot (Figure 4). Beginning with the 0.01 m^2 quadrat, all species rooted in the quadrat are identified and recorded. Once all species in this quadrat are recorded, the observer moves onto the 0.1 m^2 quadrat, listing only species not observed in the 0.01 m^2 quadrat. This is repeated in the 1.0 m^2 and 10 m^2 quadrats. Only species rooted in a quadrat are included in the species list for that quadrat.

Unknown species were recorded in the field using a unique identifier and collected or photographed. Most of these unknowns were subsequently identified by M. Bynum. However, in some cases the plant was too small or difficult to identify. In these cases, the species was classified by growth form and, where possible, lifecycle (e.g., annual graminoid).

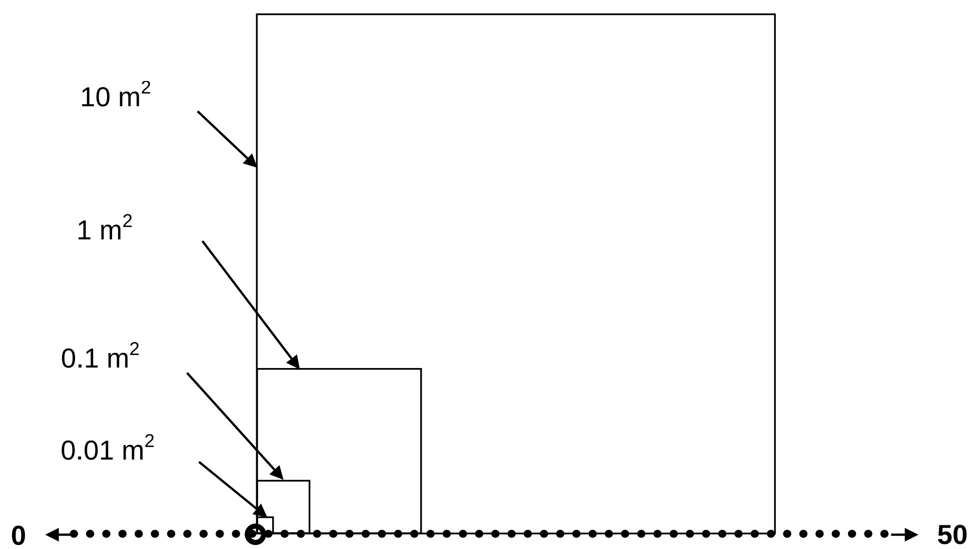

Figure 8. Arrangement of nested quadrats along tape used for point-intercept sampling. Open circle indicates permanent marker (nail and washer or, at 0 end of transect, rebar).

At all plots, we also surveyed the area for common disturbances and target species of interest. Common disturbances included such things as roads, 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/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 1-5% of site, 4 = cover 5-25% of site, and 5 = cover > 25% of site. The information gathered from this procedure is critical for early detection and rapid response to such threats. The FOUS target species list for 2011 can be found in Table 1

Table 1. Target species in FOUS for the 2011 field season.

Invasives/noxious weeds/exotics		
Species Code	**Scientific Name**	**Common Name**
AGCR	*Agropyron cristatum* (L.) Gaertn.	crested wheatgrass
BRIN2	*Bromus inermis* Leyss.	Smooth brome
CIAR4	*Cirsium arvense*L.	Canada thistle
EUES	*Euphorbia escula* L.	Leafy spurge

Data Management and Analysis

After the field work was completed, field sheets were scanned and stored in fire-proof cabinets, and the data were entered by the NGPN seasonal vegetation crew. FFI (FEAT/FIREMON Integrated; http://frames.gov/ffi/) is the primary software environment used for managing NGPN plant community data. NGPN uses its components for data entry, data storage, and basic summary reports. 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.

After data for the sites were entered, the data were verified. This was done by comparing the entered data to the original field data sheets, and detected errors were corrected immediately. To minimize transcription errors, 100% of records were verified to their original source. A further 10% of records were reviewed a second time by I. Ashton or M. Prowatzke. When errors were found in the reviews, the entire data set was verified again. After all data were entered and verified, automated queries were developed to check for errors in the data. For instance, a query was developed that noted all plots where a species appeared twice within 1 nested quadrat. When errors were caught by the crew or the automated queries, changes were made to the original datasheets and the FFI database.

For analysis of data from intensive plots, the plot is used as the unit of replication and quadrats or transects are pooled or averaged. Data from each plot are summarized for a variety of variables including: relative cover of growth forms (shrubs, grasses, forbs), absolute cover of bare soil, total herb-layer foliar cover, density and basal area of trees, species richness and diversity, relative abundance of functional groups, and proportions of foliar cover and species richness that are non-native. Growth forms were based on definitions from the USDA Plants Database. Warm-season grasses were identified primarily using a guide by Skinner (2010). Summaries were done using FFI reports and statistical summaries were done using R software (version 2.11.0).

Results

In the 6 plots we visited in FOUS during 2011, we recorded 104 vascular plant species (Appendix B). The most common families were Asteraceae and Poaceae. In 5 year summary reports, the Bodmer Unit and upland terraces may be treated separately for analysis when sample sizes are larger. At this time, we have combined all 6 plots for the results presented below.

Absolute percent and relative cover

From the point-intercept data, we found 6 plots to average 141 ± 11.1 % (mean ± standard deviation) total herb layer cover and 29 ± 16.6 % bare ground. The absolute canopy cover can be greater than 100% because we record multiple layers of plants and it was a fairly wet year with abundant growth.

Graminoids, which includes grasses, sedges, and rushes, had an average cover of 134 ± 13.6%. This was much higher than other plant life-forms (Figure 9). Plant composition varied among the plots but there were 2 native grass species that were found at all 6 plots: western wheatgrass (*Pascopyrum smithii*; 40 ± 28.7 % absolute cover) and green needlegrass (*Nassella viridula*; 28 ± 26.6 %). Forbs, or broad leaved herbaceous plants, were more site-specific and none were found across more than 2 plots. The most abundant forb was horseweed (*Conyza canadensis*; 3 ± 2.1%).

Of the 6 plots at FOUS, the average relative percent cover of exotic species was 18 ± 16.8 %. We found the average relative percent cover of warm season graminoids to be 17 ± 23.0 %.

Species richness, diversity, and evenness

We measured diversity at the plots in 2 ways: the Shannon Index and Pielou's Index of Eveness. 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 another aspect of diversity-- how even abundances are across taxa. It ranges between 0 and 1, where higher numbers indicate that a community is not even or that just a few species make up the majority of the total cover. From the point-transect data, we found average plot diversity, H', to be 1.8 ± 0.70. Evenness, J', averaged 0.72 ± 0.13 across the plots. When including only native species, average diversity and evenness were 1.6 ± 0.71 and 0.79 ± 0.13, respectively. Species richness varies by the scale that it is examined. Table 2 presents average species richness for the point-intercept, 1 m^2 quadrats, and 10 m^2 quadrats for the 6 plots in 2011. In general, richness increases in the larger quadrat size. Graminoids have greater absolute cover and richness tended to be greater when compared to forbs. On average, there are about 3 exotic species found in each plot along the point-intercept (Table 2).

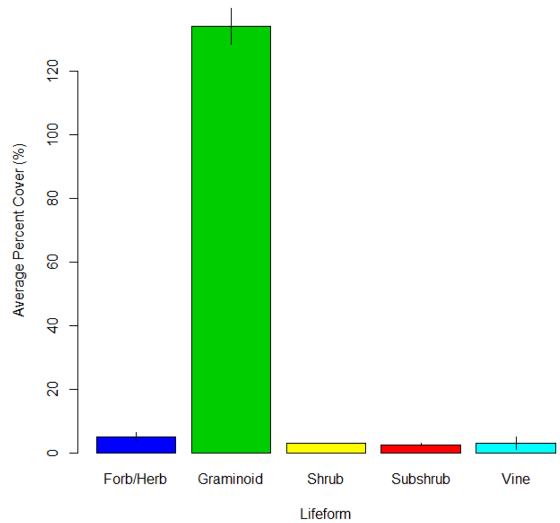

Figure 9. Absolute percent cover of different life-forms in 6 plant community monitoring plots in FOUS in 2011. Bars represent means across the 6 plots ± standard errors. Graminoids were the most abundant plant life-form across all plots at FOUS.

Table 2. Average plant species richness at 6 plots at FOUS in 2011. Values represent means ± standard deviation.

	Point-intercept	**1 m^2 quadrats**	**10 m^2 quadrats**
Species richness	13.1 (6.17)	8.0 (4.11)	13.2 (6.94)
Native species richness	9.8 (6.18)	5.9 (3.77)	9.5 (6.78)
Exotic species richness	3.3 (2.16)	2.5 (1.33)	3.9 (2.19)
Graminoid species richness	8.8 (3.60)	5.1 (2.48)	6.9 (3.35)
Forb species richness	3.0 (2.00)	2.9 (1.68)	5.5 (3.54)

Target species assessments and disturbance

We recorded disturbance and exotic target species occurrence at 6 plots in FOUS in 2011. The most common disturbance was from small mammal excavations- this occurred at 3 plots but always in small patches. There was evidence of grazing in the Bodmer unit and mowing at 2 plots in the upland areas surrounding the fort.

Three exotic target species appeared in the plots we visited in 2011 (Table 3): smooth brome (*Bromus inermis*), crested wheatgrass (*Agropyron cristatum*), and Canada thistle (*Cirsium arvense*. At least 2 target species were found in all the plots (Table 3). Canada thistle was less common than the 2 exotic grasses.

Table 3. Cover class of target species at 6 plots at FOUS in 2011. 1 = one individual, 2 = few individuals, 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.

Unit	Site	Smooth brome	Crested wheatgrass	Canada thistle
Fort	FOUS_PCM_001	3	2	-
	FOUS_PCM_002	present	-	-
	FOUS_PCM_009	present	present	present
	FOUS_PCM_010	2	3	-
Bodmer	FOUS_PCM_129	-	present	-
	FOUS_PCM_133	3	5	-

Discussion

The goal of our plant community monitoring efforts in FOUS is to determine the status and trend in vegetation composition and structure and to understand how natural and anthropogenic disturbance and management decisions influence vegetation. As of 2011, we have completed the first year of field work; while we have increased our understanding of vegetation composition and structure, we cannot yet describe park-wide status or trends. Below, we summarize the results from above and highlight some of the most interesting aspects of the plant community monitoring.

There was considerable variation among plots, but on average absolute vascular plant cover was 141 %; productivity was high due to a wet spring. The sites at FOUS had a moderate to low diversity of vascular plants. Average native species richness in the 10 m^2 quadrats was 9.5 species (Table 2). We found an average of 3.9 exotic plants in every 10 m^2 quadrat. Graminoids, which includes all grasses, sedges, and rushes, made up the bulk of cover at all sites (Figure 9). Forbs, or broad-leaved herbaceous plants, were less abundant and less diverse than graminoids at the scale of the quadrats. Shrubs, vines, and subshrubs were not a large component of the cover at the sites we visited (Figure 9).

Graminoids can be further classified by their photosynthetic pathway. Warm season graminoids have a photosynthetic pathway (C4) that particularly adapts them to hot climates and an atmosphere low in carbon dioxide. These warm season graminoids grow primarily during the hot summer months and tend to be very drought tolerant. Cool season graminoids are C3 plants that tend to grow best in cooler temperatures. For example, junegrass (*Koeleria macrantha*) is a cool season grass and blue grama (*Bouteloua gracilis*) is a warm season grass. From the average across these 6 sites, 17% of the relative cover was made up of warm-season grasses. Examining the trend over time in warm-season graminoid cover and climate trends may elucidate whether warm-season grasses are increasing in abundance due to warmer and drier conditions after taking into account plantings and revegetation actions by the park.

Relative cover of exotics species averaged 18% across the plots, which was fairly low compared to other small parks in the region. However, target exotic species were found in all 6 plots we visited (Table 3). Smooth brome and crested wheatgrass were both common, appearing at 5 of the 6 plots.

Results from our vegetation monitoring can be summarized in a “connect-the-dots” or a resource condition summary table (Table 4). These tables can be used to describe the status and trend in vital signs or other indicators of ecosystem health. We chose a handful of the key metrics representing 2 vital signs, which we will continue to monitor over time at FOUS. The current value is based on sampling in 2011 and the level of inference is simply the number of sites where we sampled that attribute. After 1 complete rotation in the FOUS sampling design (5 years), a current value will represent a 5-year mean and the level of inference will be unit-wide. At such time, we will also be able to estimate baseline reference values and begin to estimate trends in these key metrics. Over time, the vegetation data collected at these sites will greatly add to our understanding and documentation of change in the upland plant communities at FOUS.

Table 4. Natural resource condition summary table for plant communities in FOUS.

Vital Sign	Metric	Current Value (mean ± SD)	Level of inference	Reference Value	Rationale
Exotic Plant Early Detection	% of sites where target species were encountered	100%	6 sites	TBD	Early detection of exotic species
	Number of sites where crested wheatgrass > 5%	1	6 sites	TBD	Effectiveness of exotic species management
Upland Plant Communities	Mean absolute herb-layer cover	141 ± 11.1 %	6 sites	TBD	Forage availability, climatic trends, erosion potential, habitat for small mammals and birds
	Ground-layer bare soil cover	29 ± 16.6 %	6 sites	TBD	
	Mean relative percent cover of exotic species	18 ± 16.8 %	6 sites	TBD	Effectiveness of exotic species management
	Percent of graminoid cover that is warm season	17 ± 23.0 %	6 sites	TBD	Climatic trends
	Mean native species richness in 10 m^2 quadrats	9.5 ± 6.78 species	6 sites	TBD	Diversity maintenance

Literature Cited

Anderson, B. G., I. D. Rutherfurd, and A. W. Western. 2006. An analysis of the influence of riparian vegetation on the propagation of flood waves. Environmental Modelling & Software 21:1290-1296.

D'Antonio, C. M. and P. M. Vitousek. 1992. Biological invasions by exotic grasses, the grass/fire cycle, and global change. Annual Review of Ecology and Systematics 23:63-87.

Gitzen, R. A., M. Wilson, J. Brumm, M. Bynum, J. Wrede, J. J. Millspaugh, and K. J. Paintner. 2010. Northern Great Plains Network vital signs monitoring plan. Natural Resource Report NPS/NGPN/ NRR-2010/186.

Hansen, M. H., W. G. Madow, and B. J. Tepping. 1983. An evaluation of model-dependent and probability-sampling inferences in sample-surveys. Journal Of The American Statistical Association 78:776-793.

Larsen, D. P., N. S. Urquhart, and D. L. Kugler. 1995. Regional-scale trend monitoring of indicators of trophic condition of lakes. Water Resources Bulletin 31:117-140.

Omernik, J. M. 2007. Level III Ecoregions of the Continental United States. U.S. EPA National Health and Environmental Effects Laboratory, Corvallis, Oregon.

Skinner, Q. D. 2010. Field guide to Wyoming grasses. Education Resources Publishing, Cumming, GA.

Smith, T. M., H.H. Shugart, and F. I. Woodward, editors. 1997. Plant functional types: their relevance to ecosystem properties and global change. Cambridge University Press, Cambridge, UK.

Stevens, D. L. and A. R. Olsen. 2003. Variance estimation for spatially balanced samples of environmental resources. Environmetrics 14:593-610.

Stevens, D. L. and A. R. Olsen. 2004. Spatially balanced sampling of natural resources. Journal Of The American Statistical Association 99:262-278.

Symstad, A. J., R.A. Gitzen, C. L. Wienk, M. R. Bynum, D. J. Swanson, A. D. Thorstenson, and K. J. Paintner. 2011. Plant community composition and structure monitoring protocol for the Northern Great Plains I&M Network: version 1.00. Natural Resource Report NPS/NGPN/ NRR-2011/291.

Urquhart, N. S. and T. M. Kincaid. 1999. Designs for Detecting Trend from Repeated Surveys of Ecological Resources. Journal of Agricultural, Biological, and Environmental Statistics 4:404-414.

Appendix A: Field journal for plant community monitoring in FOUS for the 2011 season

Plant community composition monitoring in FOUS was completed using a crew of 5 people working 3.5 10-hour days. The total mileage for 2 vehicles was 1290 miles. We spent a total of 140 crew hours in FOUS in 2011 and 33 hours of other USGS staff time. In addition to the 6 monitoring plots in panel 1 and 5, the crew evaluated 6 other plots and established 2 of these for use in future years.

Date	Day of week	Approximate Travel Time (hrs)	Housing	Sites Completed	Notes
Jul 29, 2011	Friday	2	Missouri Flats Inn, Williston, ND	PCM_002 PCM_009	Drove from THRO
Jul 30, 2011	Saturday	NA	Missouri Flats Inn, Williston, ND	PCM_129 PCM_133	evaluate 1 additional plot
Jul 31, 2011	Sunday	NA	Missouri Flats Inn, Williston, ND	PCM_001 PCM_010	Install 2 additional plots; evaluate 4 additional plots
August 1, 2011	Monday	6.5	NA		Changed tags and other plot maintenance

Appendix B: List of plant species found in 2011 at FOUS

Family	Code	Scientific Name	Common Names
Apocynaceae	APCA	*Apocynum cannabinum*	common dogbane, dogbane, hemp dogbane, Indian hemp, Indian-hemp, Indianhemp, prairie dogbane
Asteraceae	ACMI2	*Achillea millefolium*	bloodwort, carpenter's weed, common yarrow, hierba de las cortaduras, milfoil, plumajillo, western yarrow, yarrow (common)
	ARDR4	*Artemisia dracunculus*	tarragon
	ARFR4	*Artemisia frigida*	fringed sagebrush, fringed sagewort, prairie sagewort
	CIAR4	*Cirsium arvense*	Californian thistle, Canada thistle, Canadian thistle, creeping thistle, field thistle
	CIUN	*Cirsium undulatum*	wavyleaf thistle
	COCA5	*Conyza canadensis*	Canada horseweed, Canadian horseweed, horseweed, horseweed fleabane, mares tail, marestail
	ECAN2	*Echinacea angustifolia*	Blacksamson, blacksamson echinacea
	GUSA2	*Gutierrezia sarothrae*	broom snakeweed, Broomsnakeweed, broomweed, perennial snakeweed, stinkweed, turpentine weed, yellow top
	HEMA2	*Helianthus maximiliani*	Maximilian sunflower
	HENUR	*Helianthus nuttallii ssp. rydbergii*	Rydberg's sunflower
	HEPE	*Helianthus petiolaris*	prairie sunflower
	HEVIV	*Heterotheca villosa var. villosa*	hairy false goldenaster
	LASE	*Lactuca serriola*	China lettuce, prickly lettuce, wild lettuce
	LIPU	*Liatris punctata*	dotted blazing star
	LYJU	*Lygodesmia juncea*	rush skeletonplant
	MUOB	*Mulgedium oblongifolium*	blue lettuce
	PACA15	*Packera cana*	woolly groundsel
	RACO3	*Ratibida columnifera*	Prairie coneflower, prairie coneflower (upright), prairieconeflower, redspike Mexican hat, upright prairie coneflower
	RUHI2	*Rudbeckia hirta*	blackeyed Susan
	SOMI2	*Solidago missouriensis*	Missouri goldenrod
	SOOL	*Sonchus oleraceus*	common sowthistle
	SYERE	*Symphyotrichum ericoides var. ericoides*	white heath aster
	SYOB	*Symphyotrichum oblongifolium*	aromatic aster
	TAOF	*Taraxacum officinale*	blowball, common dandelion, dandelion, faceclock
	TEACA2	*Tetraneuris acaulis var. acaulis*	stemless four-nerve daisy
	TRDU	*Tragopogon dubius*	common salsify, goat's beard, goatsbeard, meadow goat's-beard, salsifis majeur, salsify, Western goat's beard, western salsify, wild oysterplant, yellow goat's beard, yellow salsify
	XASP	*Xanthisma spinulosum*	lacy tansyaster, cut-leaf ironplant, spiny goldenweed
	XAST	*Xanthium strumarium*	rough cockleburr
Boraginaceae	LIIN2	*Lithospermum incisum*	fringed gromwell, Fringed puccoon, narrowleaf gromwell, narrowleaf pucoon, narrowleaf stoneseed, trumpet stoneseed
Brassicaceae	DEPI	*Descurainia pinnata*	western tansymustard
	DRRE2	*Draba reptans*	Carolina draba
	ERCAC	*Erysimum capitatum var.*	sanddune wallflower

Family	Code	Scientific Name	Common Names
		capitatum	
Cactaceae	OPFR	*Opuntia fragilis*	brittle pricklypear
	OPMA2	*Opuntia macrorhiza*	twistspine pricklypear
	OPPO	*Opuntia polyacantha*	plains pricklypear
Chenopodiaceae	CHBE4	*Chenopodium berlandieri*	pitseed goosefoot
	CHPR5	*Chenopodium pratericola*	desert goosefoot
	KOSC	*Kochia scoparia*	common kochia, fireweed, kochia, Mexican burningbush, Mexican fireweed, Mexican-fireweed, mock cypress, Summer cypress
	KRLA2	*Krascheninnikovia lanata*	winterfat
	SATR12	*Salsola tragus*	prickly Russian thistle
Convolvulaceae	COAR4	*Convolvulus arvensis*	creeping jenny, European bindweed, field bindweed, perennial morningglory, smallflowered morning glory
Cyperaceae	CADU6	*Carex duriuscula*	needleleaf sedge
	CAFI	*Carex filifolia*	threadleaf sedge
Euphorbiaceae	CHSES	*Chamaesyce serpyllifolia ssp. serpyllifolia*	thymeleaf sandmat
Fabaceae	ASFL2	*Astragalus flexuosus*	flexile milkvetch
	ASGI5	*Astragalus gilviflorus*	plains milkvetch
	ASMI10	*Astragalus missouriensis*	Missouri milkvetch
	ASPE5	*Astragalus pectinatus*	narrowleaf milkvetch
	DACA7	*Dalea candida*	slender white prairieclover, white dalea, white prairie clover, white prairie-clover, white prairieclover
	DAPU5	*Dalea purpurea*	Purple prairieclover, violet dalea, violet prairie clover, violet
	MELU	*Medicago lupulina*	black medic, black medic clover, black medick, hop clover, hop medic, nonesuch, yellow trefoil
	MESA	*Medicago sativa*	alfalfa
	MEOF	*Melilotus officinalis*	yellow sweet-clover, yellow sweetclover
	VIAM	*Vicia americana*	American deervetch, American vetch
Lamiaceae	HEHI	*Hedeoma hispida*	false pennyroyal, rough false pennyroyal, rough falsepennyroyal, rough pennyroyal
	MOFI	*Monarda fistulosa*	wild bergamot
Liliaceae	ALTE	*Allium textile*	textile onion
Linaceae	LILEL2	*Linum lewisii var. lewisii*	prairie flax
	LIRI	*Linum rigidum*	orange flax, Stiff flax, stiffstem flax
Malvaceae	SPCO	*Sphaeralcea coccinea*	copper mallow, orange globemallow, red falsemallow, scarlet globemallow
Nyctaginaceae	MILI3	*Mirabilis linearis*	narrowleaf four o'clock
Onagraceae	CASE12	*Calylophus serrulatus*	yellow sundrops
	GACO5	*Gaura coccinea*	scarlet beeblossom
	OEBI	*Oenothera biennis*	common evening-primrose
Plantaginaceae	PLPA2	*Plantago patagonica*	woolly Indianwheat, woolly plantain, woolly plantian, wooly Indianwheat, wooly plantain
Poaceae	AGCR	*Agropyron cristatum*	crested wheatgrass
	ANGE	*Andropogon gerardii*	big bluestem
	ARPUL	*Aristida purpurea var. longiseta*	Fendler threeawn

Family	Code	Scientific Name	Common Names
	BOCU	*Bouteloua curtipendula*	sideoats grama
	BOGR2	*Bouteloua gracilis*	blue grama
	BRIN2	*Bromus inermis*	awnless brome, smooth brome
	BRJA	*Bromus japonicus*	Japanese brome, Japanese bromegrass, Japanese chess
	CALO	*Calamovilfa longifolia*	prairie sandreed
	ELCA4	*Elymus canadensis*	Canada wildrye
	ELLAL	*Elymus lanceolatus ssp. lanceolatus*	thickspike wheatgrass
	ELTRS	*Elymus trachycaulus ssp. subsecundus*	slender wheatgrass
	ELTRT	*Elymus trachycaulus ssp. trachycaulus*	slender wheatgrass
	HECOC8	*Hesperostipa comata ssp. comata*	needle and thread, needleandthread
	HOJU	*Hordeum jubatum*	foxtail barley
	KOMA	*Koeleria macrantha*	junegrass, prairie Junegrass
	MUCU3	*Muhlenbergia cuspidata*	plains muhly
	NAVI4	*Nassella viridula*	green needlegrass
	PACA6	*Panicum capillare*	annual witchgrass, common panic grass, common witchgrass, panicgrass, ticklegrass, tumble panic, tumbleweed grass, witches hair, witchgrass
	PAVI2	*Panicum virgatum*	switchgrass
	PASM	*Pascopyrum smithii*	pubescent wheatgrass, western wheatgrass
	POPR	*Poa pratensis*	Kentucky bluegrass
	PSSP6	*Pseudoroegneria spicata*	bluebunch wheatgrass
	SCPA	*Schedonnardus paniculatus*	tumblegrass
	SCSC	*Schizachyrium scoparium*	little bluestem
	SEVI4	*Setaria viridis*	bottle grass, green bristle grass, green bristlegrass, green foxtail, pigeongrass, wild millet
	SONU2	*Sorghastrum nutans*	Indiangrass
	SPCR	*Sporobolus cryptandrus*	sand dropseed
Polemoniaceae	PHAL3	*Phlox alyssifolia*	alyssum-leaf phlox, alyssumleaf phlox, phlox
	PHHO	*Phlox hoodii*	Hood's phlox, spiny phlox
Polygalaceae	POAL4	*Polygala alba*	white milkwort
Polygonaceae	ERFL4	*Eriogonum flavum*	alpine golden buckwheat, yellow eriogonum
	ERPA9	*Eriogonum pauciflorum*	fewflower buckwheat
Ranunculaceae	ANMUM3	*Anemone multifida var. multifida*	Pacific anemone
	ANPAM	*Anemone patens var. multifida*	cutleaf anemone, eastern pasqueflower
Rosaceae	ROAR3	*Rosa arkansana*	Arkansas rose, prairie rose, prairie wildrose, wild rose, wildrose (prairie)
Santalaceae	COUM	*Comandra umbellata*	bastard toadflax
Scrophulariaceae	PEGR5	*Penstemon gracilis*	lilac penstemon
Unknown Family	UNKFORB	*Unknown forb*	Unknown forb
Verbenaceae	VEST	*Verbena stricta*	hoary verbena

The Department of the Interior protects and manages the nation's natural resources and cultural heritage; provides scientific and other information about those resources; and honors its special responsibilities to American Indians, Alaska Natives, and affiliated Island Communities.

NPS 436/112513, January 2012

National Park Service
U.S. Department of the Interior

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

www.nature.nps.gov

EXPERIENCE YOUR AMERICA ™