National Park Service
U.S. Department of the Interior

Natural Resource Stewardship and Science

Plant Community Composition and Structure Monitoring for Scotts Bluff National Monument

2014 Annual Report

Natural Resource Data Series NPS/NGPN/NRDS—2015/764

ON THE COVER
Long-term monitoring plot PCM-0009 at Scotts Bluff National Monument, 2014
Photograph courtesy of the National Park Service

Plant Community Composition and Structure Monitoring for Scotts Bluff National Monument

2014 Annual Report

Natural Resource Data Series NPS/NGPN/NRDS—2015/764

Michael Prowatzke
Stephen K. Wilson

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

February 2015

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. These reports are of interest and applicability to a broad audience in the National Park Service and others in natural resource management, including scientists, conservation and environmental constituencies, and the public.

The Natural Resource Data Series is intended for the timely release of basic data sets and data summaries. Care has been taken to assure accuracy of raw data values, but a thorough analysis and interpretation of the data has not been completed. Consequently, the initial analyses of data in this report are provisional and subject to change.

All manuscripts in the series receive the appropriate level of peer review to ensure that the information is scientifically credible, technically accurate, appropriately written for the intended audience, and designed and published in a professional manner.

This report received informal peer review by subject-matter experts who were not directly involved in the collection, analysis, or reporting of the data. Data in this report were collected and analyzed using methods based on established, peer-reviewed protocols and were analyzed and interpreted within the guidelines of the protocols.

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

This report is available in digital format from Northern Great Plains Inventory & Monitoring website (http://science.nature.nps.gov/im/units/ngpn/monitor/plants.cfm), and the Natural Resource Publications Management website (http://www.nature.nps.gov/publications/nrpm/). To receive this report in a format optimized for screen readers, please email irma@nps.gov**.**

Please cite this publication as:

Prowatzke, M. and S. K. Wilson. 2015. Plant community composition and structure monitoring for Scotts Bluff National Monument: 2014 annual report. Natural Resource Data Series NPS/NGPN/NRDS—2015/764. National Park Service, Fort Collins, Colorado.

NPS 317/128100, February 2015

Contents

Page

Figures....iv

Tables....iv

Abstract....v

Acknowledgments....vi

Introduction....1

Methods....3

Sample Design....3

Plot Layout and Sampling....3

Legacy Monitoring....4

Data Management and Analysis....6

Reporting on Natural Resource Condition....6

Results and Discussion....9

Legacy Plots....13

Summary....14

Literature Cited....15

Appendix A: Field journal for plant community monitoring in SCBL for the 2014 season....17

Appendix B: List of plant species found in 2014 at SCBL....19

Figures

Page

Figure 1. Map of Scotts Bluff National Monument (SCBL) and plant community monitoring plots. 2

Figure 2. Long-term monitoring plot layout used for sampling vegetation in Scotts Bluff National Monument. 4

Figure 3. Observed and 30-year (1981-2010) normal precipitation near Scotts Bluff National Monument. Timing of NGPN visit is shown by vertical gray bar... 9

Figure 4. Average cover by lifeform in eight plant community monitoring plots in Scotts Bluff National Monument in 2014. 9

Figure 5. The average absolute cover of the 10 most common native (green) and exotic (red) plants recorded at Scotts Bluff National Monument in 2014. 11

Figure 6. Long-term monitoring site PCM-0024, site of the greatest native diversity in 2014. 13

Tables

Page

Table 1. Exotic species surveyed for at Scotts Bluff National Monument as part of the early detection and rapid response program within the Northern Great Plains Network. 5

Table 2. Rare species that were surveyed for during the 2014 field season at Scotts Bluff National Monument. 5

Table 3. Key to the symbols used in the Natural Resource Condition Table. 7

Table 4. Natural resource condition summary table for upland plant communities in Scotts Bluff National Monument 10

Table 5. Average plant species richness in eight plots at Scotts Bluff National Monument in 2014. 12

Table 6. Characteristics of the plant community at eight plots in Scotts Bluff National Monument in 2013 including average cover of annual bromes, exotic plant cover, and area of disturbance. 12

Table 7. Characteristics of the plant community at restored and mixed-grass prairie plots in Scotts Bluff National Monument in 2014. 14

Abstract

This report presents the results of vegetation monitoring efforts in 2014 at Scotts Bluff National Monument (SCBL) by the Northern Great Plains Inventory and Monitoring Network (NGPN).

During the fourth full year of field work, crew members from NGPN visited eight plant community monitoring plots to collect data on the vegetation at SCBL. This is part of a long-term monitoring effort that will sample eight of 20 randomly located upland plots every year, so that each plot is visited for two consecutive years and then rested for three years, on a five-year rotating basis. Additionally, NGPN staff also visited four plots which had been established by the Heartland Inventory and Monitoring Program in 1997. At all plots, NGPN staff captured data relating to species richness, herb-layer height, abundance of individual native and non-native species, ground cover, and site disturbance.

Our 2014 findings can be summarized as follows: The crew observed 91 vascular plant species in upland plots, with an average of 5.2 native species occurring within any given 1 m^2 quadrat sampled. While native species diversity is still at a moderate level, non-native species represented 50.8% of cover, and present extreme management challenges. Cheatgrass (*Bromus tectorum*) was a dominant species throughout the park.

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 SCBL, particularly R. Manasek, for providing logistical support and performing safety checks. The 2014 NGPN vegetation field crew of M. Prowatzke, K. Legner, S. Rockwood, R. Manuel, F. Sewell, L. Mickelson, D. Pinigis, and K. Paintner-Green collected all the data included in this report. Finally, we thank the Heartland Inventory & Monitoring Network for providing over ten years of legacy data.

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. Within Nebraska, greater than 77% of the area of native mixed grass prairie has been lost since European settlement (Samson and Knopf 1994). The National Park Service (NPS) plays an important role in preserving and restoring some of the last pieces of intact prairies within its boundaries. The stewardship goal of the NPS is to "preserve ecological integrity and cultural and historical authenticity" (NPS 2012); however, resource managers struggle with the grim reality that there have been fundamental changes in the disturbance regimes, such as climate, fire, and 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.

Scotts Bluff National Monument (SCBL), established in 1919 to protect and preserve two iconic bluffs and the associated heritage of western expansion, covers 3,003 acres and is dominated by mixed-grass prairie with smaller areas of juniper woodlands, badlands, and riparian forests. Vegetation monitoring began at SCBL in 1997 by the Heartland Inventory & Monitoring Program (James 2010) and the Northern Great Plains Fire Ecology Program (FireEP; Wienk et al. 2011). In 2010, SCBL was incorporated into the Northern Great Plains Inventory & Monitoring Network (NGPN). At this time, vegetation monitoring protocols and plot locations were shifted to better represent the entire park and to coordinate efforts with the FireEP (Symstad et al. 2012b), and sampling efforts began in 2011 (Ashton et al. 2011). The long-term objectives of the NGPN plant community monitoring effort in SCBL are to:

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

2. Determine status (at 5-yr intervals) and long-term trends of tree density by species, height class, and diameter class in lowland areas near targeted perennial streams.

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

This report is intended to provide a timely release of basic data sets and data summaries from our sampling efforts in 2014 at SCBL. We visited eight plots in a rotating panel design, and it will take one more year to visit every plot in the park twice (Figure 1). In addition, we surveyed vegetation in four plots that were first installed in 1997 by the Heartland Inventory & Monitoring Network. These plots are concentrated in the northeast corner of the park to evaluate the effectiveness of a golf course restoration project (Figure 1). We expect to produce reports with more in-depth data analysis and

interpretation when we complete our fifth year of sampling in 2015. In the interim, reports, spatial data, and data summaries can be provided for park management and interpretation upon request.

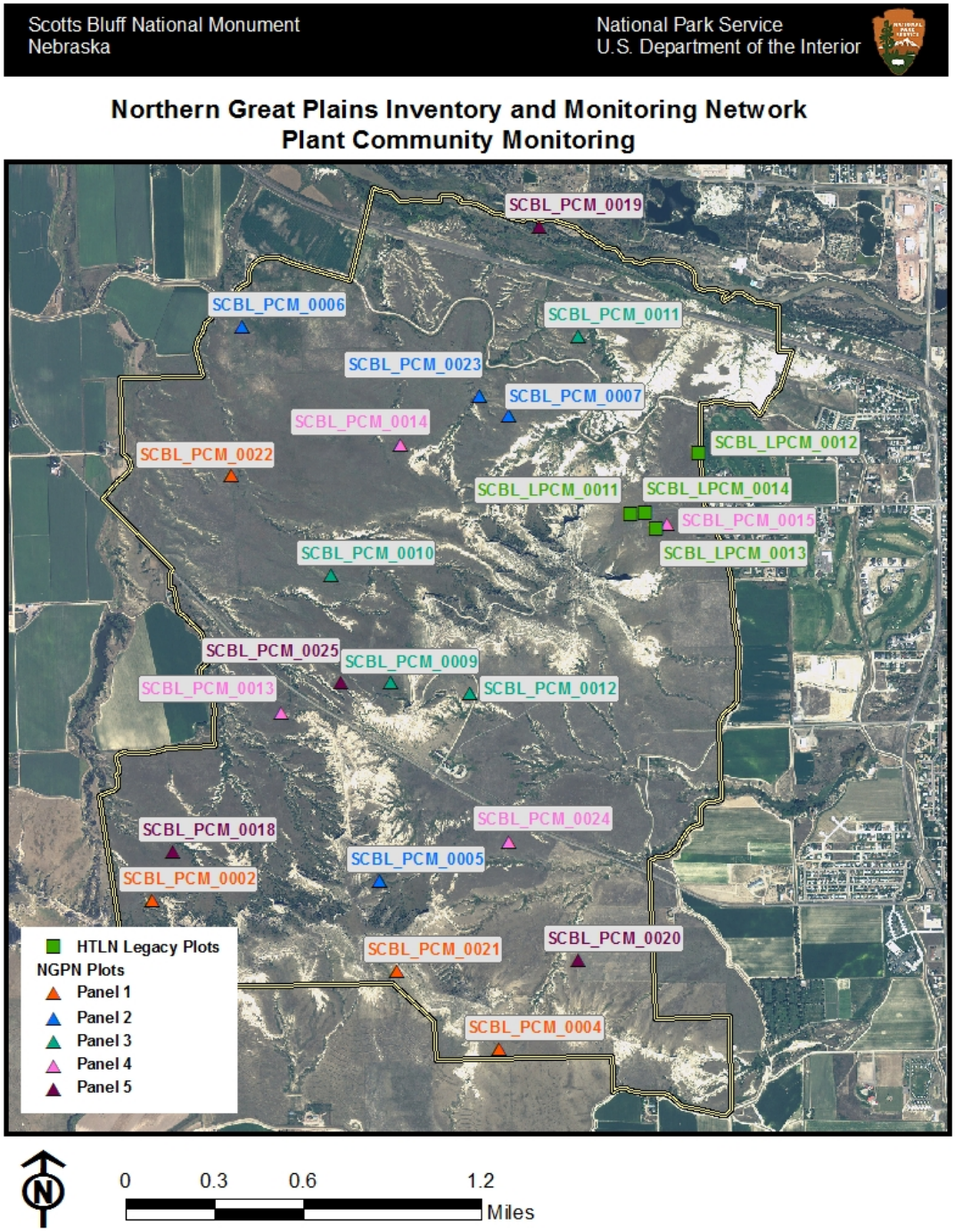

Figure 1. Map of Scotts Bluff National Monument (SCBL) and plant community monitoring plots. Plots in Panel 3 (green) and Panel 4 (pink) were visited in 2014. In addition, four plots established by the Heartland Monitoring Network (green squares) representing restored and native mixed-grass prairie were visited in 2014.

Methods

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

Sample Design

We implemented a survey to monitor plant community structure and composition in SCBL using a spatially balanced probability design (Generalized Random Tessellation Stratified [GRTS]; Stevens and Olsen 2003, 2004). Using a GRTS design, we selected 20 randomly located sites within SCBL (Figure 1). We split these 20 sites into five panels with four sites each. We visit two panels (eight sites) every year, and after five years (2015) we will have visited all 20 sites twice. In 2011, we visited sites in panel 1 and panel 5, and in 2012 we visited sites in panel 1 and panel 2. In 2013, we visited sites in panel 2 and panel 3. In 2014, we visited sites in panel 3 and panel 4 during the penultimate week of May (Figure 1). Data from these randomly selected sites can be used to estimate condition of vegetation communities for the whole park; over time, data can be used to discern trends in condition.

Plot Layout and Sampling

At each of the 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, herb-layer height ≤ 2 m, and plant cover were collected on two 50 m transects (the long sides of the plot) using a point-intercept method. Species richness data from the point-intercept method were supplemented with species presence data collected in 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 2014, sampling at SCBL took a nine-person crew approximately 360 crew hours with travel time (see Appendix A for a detail of activities each day).

When woody species were present, tree regeneration and tall shrub density data were collected within a 10 m radius subplot centered in the larger 50 m x 20 m plot (Figure 2). Trees with diameter at breast height (DBH) > 15 cm, located within the entire 0.1 ha plot, were mapped and tagged. For each tree, the species, DBH, status, and condition (e.g., leaf-discoloration, insect-damaged, etc.) were recorded. In 2014, none of the plots surveyed had tree or tall shrub species present. An assessment of parkwide forest structure and health will be conducted after five years, when more data are available. In addition to upland plant community sampling, NGPN completed a survey of riparian forests in SCBL in the last week of August 2014. Results of this effort will be published separately, and the riparian forest survey is to be repeated every five years thereafter.

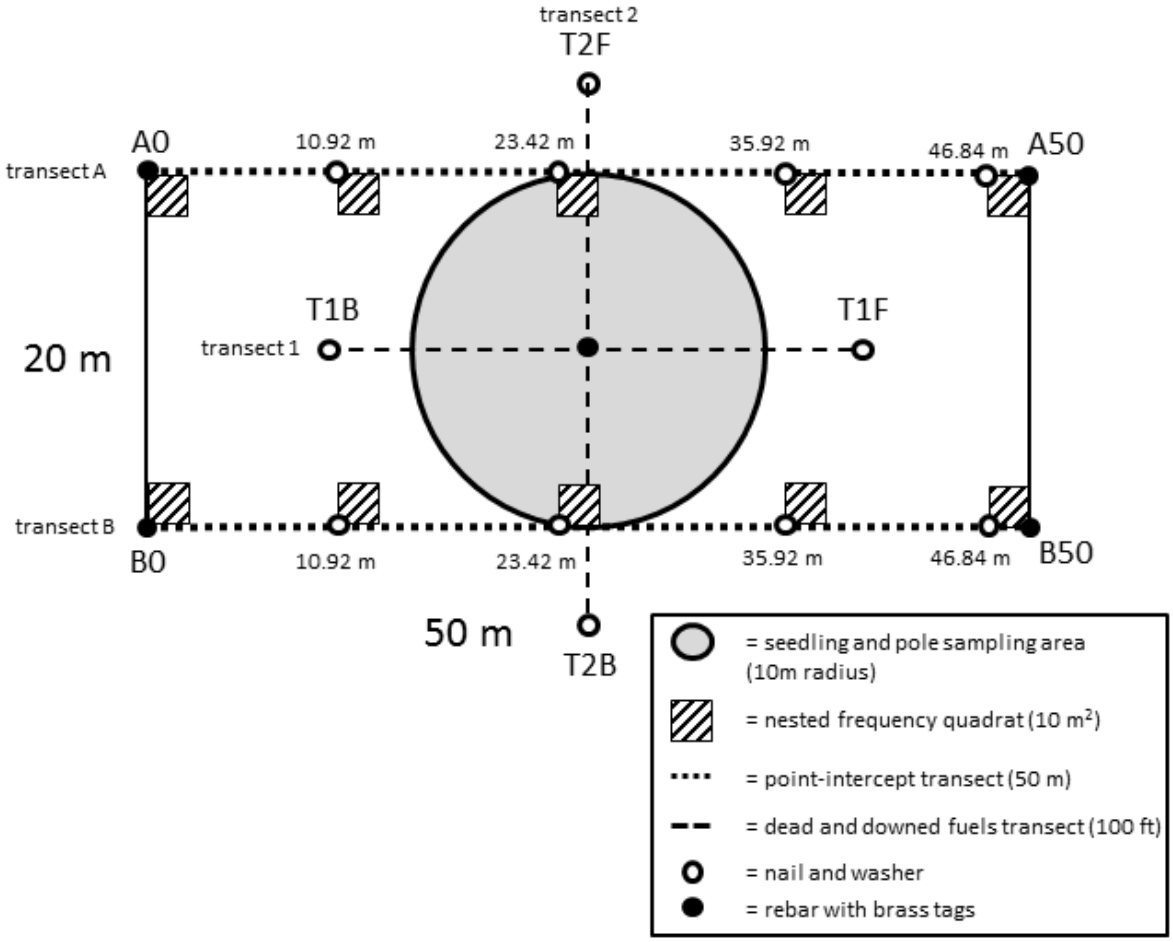

Figure 2. Long-term monitoring plot layout used for sampling vegetation in Scotts Bluff National Monument.

At all plots, we also surveyed the area for common disturbances and target species of interest to the park. Common disturbances included such things as roads, 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). For each target species that was present at a site, an abundance class was given on a scale from 1-5 where 1 = one individual, 2 = few individuals, 3 = cover of 1-5%, 4 = cover of 5-25%, and 5 = cover > 25% of the plot. The information gathered from this procedure is critical for early detection and rapid response to such threats. In addition, we noted the presence of plant species that are considered rare or vulnerable to loss in Nebraska and which may potentially occur in SCBL (Table 2).

Legacy Monitoring

In addition to the monitoring described above, four plots were visited in 2014 that were established in 1997 by the Heartland Inventory & Monitoring Program. At each of these plots, point-intercept,

disturbance, and target species data were collected as described above. To be consistent with prior years of data collection, plant frequency was measured using circular subplots as described in the Heartland Networks' vegetation monitoring protocol. (James et al. 2009). The four plots chosen represent native mixed-grass prairie in SCBL (LPCM-11 and 12) and a vegetation restoration effort in a former golf course (LCPM-13 and 14).

Table 1. Exotic species surveyed for at Scotts Bluff National Monument as part of the early detection and rapid response program within the Northern Great Plains Network.

Scientific Name	Common Name	Habitat
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
Linaria dalmatica; L. vulgaris	toadflax	Upland
Euphorbia myrsinites & E. cyparissias	myrtle spurge	Upland
Dipsacus fullonum & D. laciniatus	common teasel	Upland
Salvia aethiopis	Mediterranean sage	Upland
Ventenata dubia	African wiregrass	Upland

Table 2. Rare species that were surveyed for during the 2014 field season at Scotts Bluff National Monument.

Scientific Name	Common Name
Astragalus barrii	Barr's milkvetch
Astragalus pectinatus	narrowleaf milkvetch
Astragalus shortianus	Short's milkvetch
Boechara holboelli	limestone rockcress
Dalea cylindriceps	Andean prairie clover
Ericameria parryi	Parry's rabbitbrush
Fritillaria atropurpurea	spotted mission bells
Lappula cenchrusoides	stickseed
Linanthus caespitosus	matted prickly phlox
Lomatium nuttalli	Nuttall's biscuitroot
Mentzelia albicaulis	whitestem stickleaf
Paronychia sessiliflora	stemless nailwort
Phacelia hastata	spearhead phacelia
Physaria arenosa	sidesaddle bladderpod
Physaria brassicoides	double twinpod
Stephanomeria runcinata	desert skeletonplant

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 2012). However, nomenclature follows the Integrated Taxonomic Information System (ITIS) (http://www.itis.gov). In the few cases where ITIS recognizes a new name that was not in the USDA PLANTS database, the new name was used, and a unique plant code was assigned.

After data for the sites were entered, 100% of records were verified to the original 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.

Plant life forms (e.g., shrub, forb) were based on definitions from the USDA Plants Database (USDA-NRCS 2012). Summaries were produced using the FFI reporting and query tools and statistical summaries, and graphics were generated using R software (version 3.1.2).

We measured diversity at the plots in three ways: species richness, the Shannon Index, and Pielou's Index of Evenness. Species richness is simply a count of the species recorded in an area. The Shannon Index, H', is a measure of the number of species in an area and how even abundances are across the community. It typically ranges between 0 (low richness and evenness) to 3.5 (high species richness and evenness). Peilou's Index of Evenness, J', measures how even abundances are across taxa. It ranges between 0 and 1; values near 0 indicate dominance by a single species and values near 1 indicate nearly equal abundance of all species present.

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 3.

We chose a set of indicators and specific measures that can describe the condition of vegetation in the Northern Great Plains and the status of exotic plant invasions. The measures include: absolute herb-layer canopy cover, native species richness, evenness, relative cover of exotic species, and annual 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” 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

Results and Discussion

Scotts Bluff National Monument obtained some relief from an ongoing drought in 2014, with precipitation about four inches above average for the year (http://www.ncdc.noaa.gov/cdo-web/datasets/GHCND/stations/GHCND:USW00024028/detail; Figure 3). At the time of NGPN's visit, precipitation for the year was about one inch above average.

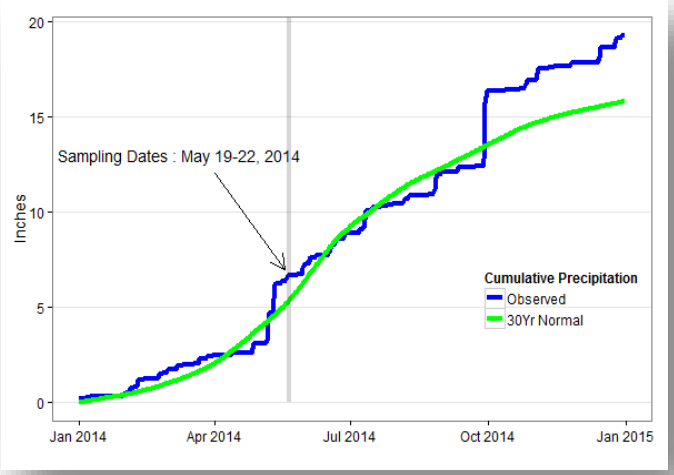

Figure 3. Observed and 30-year (1981-2010) normal precipitation near Scotts Bluff National Monument. Timing of NGPN visit is shown by vertical gray bar.

Average canopy cover was 162% (Table 4) in 2014, a substantial increase of 64% over the previous year (Ashton and Prowatzke 2013). Litter on the ground averaged 92% plant litter, an 11% relative increase over the previous year.

We found 91 plant species in 2014 at SCBL (Appendix B). Graminoids, which includes grasses, sedges, and rushes, accounted for most of the vegetative cover at SCBL, but forbs, shrubs and subshrubs (defined as a low-growing shrub usually under 0.5m) were also present (Figure 4). We found 18 exotic species at SCBL, all of which were either forbs or graminoids. The shrubs and subshrubs were all native species.

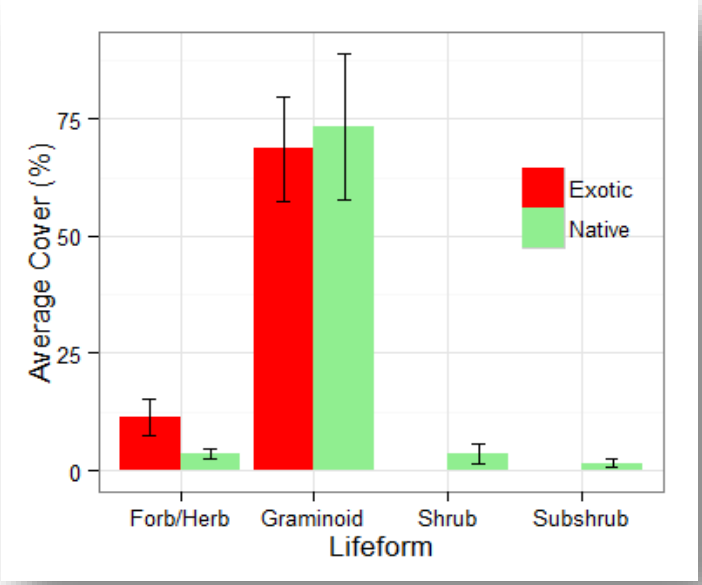

Figure 4. Average cover by lifeform in eight plant community monitoring plots in Scotts Bluff National Monument in 2014. Graminoids were by far the most abundant lifeform found in the understory. Bars represent means ± standard errors.

Cheatgrass (*Bromus tectorum*), western wheatgrass (*Pascopyrum smithii*), needle and thread (*Hesperostipa comata*), prickly Russian thistle (*Salsola tragus*), and blue grama (*Bouteloua gracilis*) were the only species found at all eight sites. The most common species in the sites we visited were graminoids, and most were native species (Figure 5). However, cheatgrass was dominant virtually everywhere; only two plots had less than 25% relative cover comprised of cheatgrass. We did not find any targeted exotic species, and we did not find any rare plants at the surveyed sites.

Table 4. Natural resource condition summary table for upland plant communities in Scotts Bluff National Monument (SCBL).

Indicator of Condition	Specific Measures	2014 Value (mean ± SE)	Reference Condition and Data Source	Condition Status/Trend	Rationale for Resource Condition
Upland Plant Community Structure and Composition	Absolute herb-layer canopy cover	162 ± 8.2%	TBD		SCBL plays a vital role in protecting and managing some of the last remnants of native mixed-grass prairie in the region. The park is characterized by low native species richness, but average richness is within a natural range of variability. The one plot that fell below the range (PCM-0015) was within the footprint of a former golf course restoration site.
	Native species richness (based on average of 10- 1m^2 quadrats per plot)	5.2 ± 0.6 species	3-15 species [(1)]		
	Evenness (based on point-intercept of 2-50m transects per plot)	0.65 ± 0.05	TBD		
Exotic Plant Early Detection and Management	Relative cover of exotic species	50.8 ± 8.1%	< 10 % cover		Many areas of SCBL have a high cover of exotic species, especially cheatgrass. Only one plot had less than 10% cheatgrass cover (PCM-0024, 9.9%) Annual bromes present the largest challenge to SCBL, and more research on effective management strategies in the mixed-grass prairie is greatly needed.
	Annual Brome cover	43.1 ± 8.1%	< 10 % cover		

References, Notes, and Data Sources:

1. Symstad, A. J. and J. L. Jonas. 2014. Using natural range of variation to set decision thresholds: a case study for Great Plains grasslands.in G. R. Gutenspergen, editor. Application of threshold concepts in natural resource decision making. Springer Verlag.

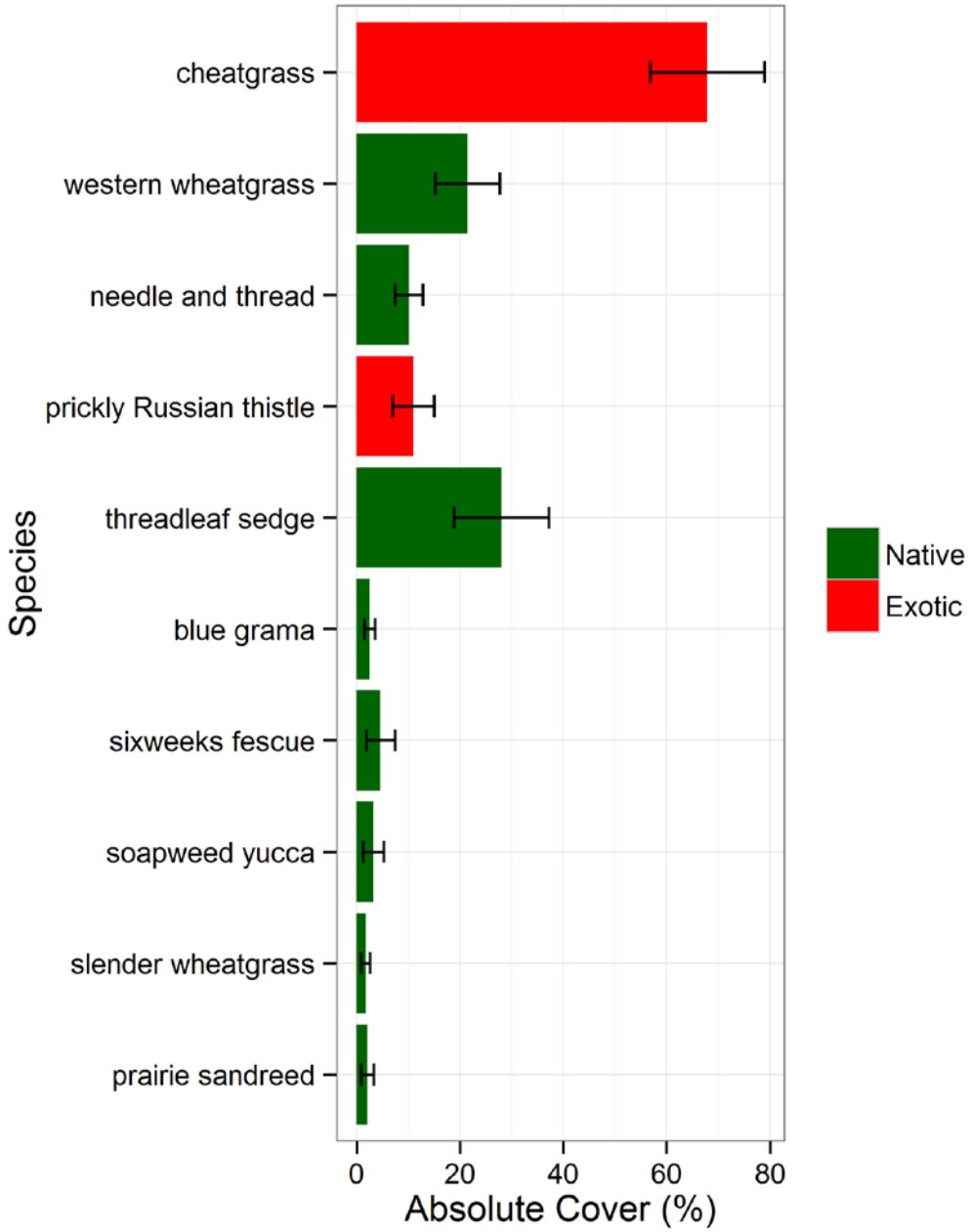

Figure 5. The average absolute cover of the 10 most common native (green) and exotic (red) plants recorded at Scotts Bluff National Monument in 2014. Bars represent means ± standard errors.

Average species richness at each of the eight plots was measured by point-intercept and in 1 m^2 and 10 m^2 quadrats (Table 5). On average, there are about two exotic species within the 1 m^2 quadrats. From the point-intersect data, we found average plot diversity, H', to be 1.4 ± 0.18. Evenness, J', averaged 0.65 ± 0.05 across the plots (Table 3). When including only native species, average diversity and evenness were 1.6 ± 0.1 and 0.73 ± 0.03, respectively.

Table 5. Average plant species richness in eight plots at Scotts Bluff National Monument in 2014. Values represent means ± standard errors, n=8.

	Point-intercept	1 m^2 quadrats	10 m^2 quadrats
Species richness	11 ± 0.9	8 ± 0.6	13 ± 1.1
Native species richness	9 ± 1.0	5 ± 0.6	9 ± 1.0
Exotic species richness	3 ± 0.5	2 ± 0.1	4 ± 0.2
Graminoid species richness	7 ± 0.4	4 ± 0.3	5 ± 0.3
Forb species richness	3 ± 0.6	3 ± 0.5	6 ± 0.8

While there was some variation across sites, the plots we visited in SCBL 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, prairie dog disturbance, and weather fluctuations (Symstad and Jonas 2011). In SCBL, there is also a mixed history of past land-use practices that have affected current species richness. For instance, the site PCM-0015 lies in the northeastern part of the park and was once part of a golf course. While it is difficult to define a reference condition for species richness that can vary so much spatially and temporally, the natural range of variation over long-time periods may be a good starting point (Symstad and Jonas 2014). Long-term records of species diversity in mixed-grass prairie from a relatively undisturbed site in Kansas vary between 3 and 15 species per square meter over the course of 30 years (Symstad and Jonas 2014). Compared to this, SCBL is within the natural range (Table 4) but is on the low end of the range, and site PCM-0015 falls below this reference condition.

Table 6. Characteristics of the plant community at eight plots in Scotts Bluff National Monument in 2013 including average cover of annual bromes, exotic plant cover, and area of disturbance.

Plot	Native species richness in 1 m^2	Exotic cover (%)	Annual brome cover (%)	Disturbance within site (m^2)
PCM_0009	6	22	20	10.5
PCM_0010	4	71	64	10
PCM_0011	6	47	38	15
PCM_0012	6	28	28	0
PCM_0013	5	60	56	0
PCM_0014	6	73	55	10
PCM_0015	2	78	74	1
PCM_0024	7	27	10	0
Park Average	*5.2 ± 0.6*	*51 ± 8.1*	*43 ± 8.1*	-

The average relative cover of exotic species at sites in SCBL was high, averaging 50.7 ± 8.1%. Only one site had less than 25% relative cover of exotic species, and three plots had greater than 70% exotic cover (Table 6). Cheatgrass accounted for a vast majority of the exotic cover. The presence of annual bromes in mixed grass prairie is associated with decreased productivity and altered nutrient cycling (Ogle et al. 2003), and there is strong evidence from regions further west that cheatgrass alters fire regimes and the persistence of native species (D'Antonio and Vitousek 2003). Reducing the cover of annual bromes remains a major challenge for the park, as it has been for the past 15 years.

Figure 6. Long-term monitoring site PCM-0024, site of the greatest native diversity in 2014. Though not found within the site, the rare spotted fritillary (*Fritilaria atropurpurea*), is regularly found in the vicinity.

Disturbance from grazing, prairie dogs, fire, and humans affects plant community structure and composition in mixed-grass prairie. For this reason, we measured the approximate area affected by natural and human disturbances at each site we visited. In 2014, the most common disturbance was from small rodents and prairie dogs, but there was also evidence of deer trails and grazing. With this small sample size, we found no correlation with disturbance and native richness or exotic cover.

Legacy Plots

Four plots that were established in 1997 by the Heartland Inventory & Monitoring Program were visited by NGPN in 2014. The two plots that were part of a restoration project after reclaiming a golf course had much higher exotic cover than nearby control plots in mixed-grass prairie (Table 7). This pattern is similar to that found from 1998-2009 (James 2010); however, non-native grass cover was considerably higher in 2014 than in 1998-2009 or in 2013 (Ashton and Prowatzke 2013).

Table 7. Characteristics of the plant community at restored and mixed-grass prairie plots in Scotts Bluff National Monument in 2014.

Plot	**Native species richness in 1 m^2**	**Exotic cover (%)**	**Annual brome cover (%)**	**Species richness in 10 m^2**
Native mixed-grass				
LPCM_11	6	26	25	13
LPCM_12	5	1	1	10
Restored community				
LPCM_13	2	79	72	7
LPCM_14	4	53	49	11

Summary

SCBL plays a vital role in protecting and managing some of the last remnants of native mixed-grass prairie in the area. Some areas of the park are highly impacted by human activities and former land use, but almost all areas seem to be struggling with exotic species, particularly cheatgrass. Native plant diversity is currently at a moderate level, but to retain ecological integrity it is important to continue efforts to reduce the cover of invasive plants. Annual bromes present the largest challenge to SCBL, and more research on effective management strategies in the mixed-grass prairie is greatly needed. Continued monitoring efforts will be critical to track changes in the condition of the vegetation communities in SCBL.

Literature Cited

Ashton IW and Prowatzke M. 2013. Plant community composition and structure monitoring in Scotts Bluff National Monument: 2013 annual report. Natural Resource Data Series. NPS/NGPN/NRDS—2013/570. National Park Service. Fort Collins, CO.

Ashton, I., M. Prowatzke, M. Bynum, T. Shepherd, S. K. Wilson, and K. Paintner-Green. 2011. Scotts Bluff National Monument plant community composition and structure monitoring: 2011 annual report. Natural Resource Technical Report NPS/NGPN/NRTR—2011/519. National Park Service, Fort Collins, CO.

D'Antonio, C. M. and P. M. Vitousek. 2003. Biological invasions by exotic grasses, the grass/fire cycle, and global change. Annual Review of Ecology and Systematics 23:63-87.

James, K. M. 2010. Vegetation community monitoring at Scotts Bluff National Monument, Nebraska: 1997-2009. Natural Resource Technical Report NPS/HTLN/NRTR—2010/364. National Park Service, Fort Collins, CO.

James, K. M., M. D. DeBacker, G. A. Rowell, J. L. Haack, and L. W. Morrison. 2009. Vegetation community monitoring protocol for the Heartland Inventory and Monitoring Network. Natural Resource Report NPS/HTLN/NRR—2009/141. National Park Service, Fort Collins, CO.

NPS. 2012. Revisiting Leopold: Resource stewardship in the National Parks: A report of the National Park System Advisory Board Science Committee. http://www.nps.gov/calltoaction/PDF/LeopoldReport_2012.pdf.

Ogle, S. M., W. A. Reiners, and K. G. Gerow. 2003. Impacts of exotic annual brome grasses (*Bromus* spp.) on ecosystem properties of northern mixed grass prairie. The American Midland Naturalist 149:46-58.

Samson, F. and F. Knopf. 1994. Prairie conservation in North America. BioScience 44:418-421.

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. and J. L. Jonas. 2011. Incorporating biodiversity into rangeland health: plant species richness and diversity in Great Plains grasslands. Rangeland Ecology & Management 64:555-572.

Symstad, A. J. and J. L. Jonas. 2014. Using natural range of variation to set decision thresholds: a case study for Great Plains grasslands.*in* G. R. Gutenspergen, editor. Application of threshold concepts in natural resource decision making. Springer Verlag.

Symstad, A. J., R.A. Gitzen, C. L. Wienk, M. R. Bynum, D. J. Swanson, A. D. Thorstenson, and K. J. Paintner. 2012a. Plant community composition and structure monitoring protocol for the Northern Great Plains I&M Network-Standard Operating Procedures: version 1.01. Natural Resource Report NPS/NGPN/ NRR-2012/489.1.

Symstad, A. J., R.A. Gitzen, C. L. Wienk, M. R. Bynum, D. J. Swanson, A. D. Thorstenson, and K. J. Paintner. 2012b. Plant community composition and structure monitoring protocol for the Northern Great Plains I&M Network: version 1.01. Natural Resource Report NPS/NGPN/ NRR-2012/489.

USDA-NRCS. 2012. The PLANTS Database (http://plants.usda.gov, 24 January 2012). National Plant Data Team, Greensboro, NC 27401-4901 USA.

Wienk, C., A. Thorstenson, J. Freeman, and D. Swanson. 2011. Northern Great Plains Fire Ecology Program review: 1997-2007. Natural Resource Report NPS/NRDS/NRDS—2010/112. National Park Service, Fort Collins, CO.

Appendix A: Field journal for plant community monitoring in SCBL for the 2014 season

Plant community composition monitoring in Scotts Bluff National Monument was completed using a crew of eight people working four 10-hour days. We spent 320 total crew hours.

Date	**Day of week**	**Approximate Travel Time (hrs)**	**Housing**	**Sites Completed**
May 19, 2014	Monday	4.5	Monument Inn and Suites	PCM-012
May 20, 2014	Tuesday	N/A	Monument Inn and Suites	PCM-009 PCM-010 PCM-013 PCM-024
May 21, 2014	Wednesday	N/A	Monument Inn and Suites	PCM-015 LPCM-11 LPCM-12 LPCM-13 LPCM-14
May 22, 2014	Thursday	4.5	N/A	PCM-011 PCM-014

Appendix B: List of plant species found in 2014 at SCBL

Family	Code	Scientific Name	Common Name	Exotic
Agavaceae	YUGL	*Yucca glauca*	soapweed yucca	
Amaranthaceae	AMARA	*Amaranthus* sp.	pigweed	*
Anacardiaceae	RHTR	*Rhus trilobata*	skunkbush sumac	
	TORY	*Toxicodendron rydbergii*	western poison ivy	
Apiaceae	CYGL99	*Cymopterus glomeratus*	plains springparsley	
Asteraceae	AMPS	*Ambrosia psilostachya*	Cuman ragweed	
	ARFI2	*Artemisia filifolia*	sand sagebrush	
	ARFR4	*Artemisia frigida*	prairie sagewort	
	COCA5	*Conyza canadensis*	Canadian horseweed	
	DYPA	*Dyssodia papposa*	fetid marigold	
	GUSA2	*Gutierrezia sarothrae*	broom snakeweed	
	HEAN3	*Helianthus annuus*	common sunflower	
	HEVI4	*Heterotheca villosa*	hairy false goldenaster	
	LASE	*Lactuca serriola*	prickly lettuce	*
	LIPU	*Liatris punctata*	dotted blazing star	
	LYJU	*Lygodesmia juncea*	rush skeletonplant	
	MUOB99	*Mulgedium oblongifolium*	blue lettuce	
	RACO3	*Ratibida columnifera*	upright prairie coneflower	
	SERI2	*Senecio riddellii*	Riddell's ragwort	
	SOCA6	*Solidago canadensis*	Canada goldenrod	
	SOMI2	*Solidago missouriensis*	Missouri goldenrod	
	SYMPH4	*Symphyotrichum*	aster	
	TAOF	*Taraxacum officinale*	common dandelion	*
	TRDU	*Tragopogon dubius*	yellow salsify	*
	XASP99	*Xanthium spinulosum*	lacy tansyaster	
Boraginaceae	CRCE	*Cryptantha celosioides*	buttecandle	
	LAOC3	*Lappula occidentalis*	flatspine stickseed	
	LIIN2	*Lithospermum incisum*	narrowleaf stoneseed	
Brassicaceae	ALDE	*Alyssum desertorum*	desert madwort	*
	CAMI2	*Camelina microcarpa*	littlepod false flax	*
	DEPI	*Descurainia pinnata*	western tansymustard	
	DRRE2	*Draba reptans*	Carolina draba	
	ERCA14	*Erysimum capitatum*	sanddune wallflower	
	LEDE	*Lepidium densiflorum*	common pepperweed	
	SIAL2	*Sisymbrium altissimum*	tall tumblemustard	*
Cactaceae	ESVI2	*Escobaria vivipara*	spinystar	
	OPMA2	*Opuntia macrorhiza*	twistspine pricklypear	
	OPPO	*Opuntia polyacantha*	plains pricklypear	
Chenopodiaceae	CHENO	*Chenopodium* sp.	goosefoot	*
	KRLA2	*Krascheninnikovia lanata*	winterfat	
	SATR12	*Salsola tragus*	prickly Russian thistle	*
Commelinaceae	TROC	*Tradescantia occidentalis*	prairie spiderwort	
Convolvulaceae	COAR4	*Convolvulus arvensis*	field bindweed	*
Cyperaceae	CADU6	*Carex duriuscula*	needleleaf sedge	
	CAFI	*Carex filifolia*	threadleaf sedge	
Euphorbiaceae	CRTE4	*Croton texensis*	Texas croton	
	EUPHO	*Euphorbia* sp.	spurge	*

Family	Code	Scientific Name	Common Name	Exotic
Fabaceae	ASGR3	*Astragalus gracilis*	slender milkvetch	
	ASTRA	*Astragalus* sp.	milkvetch	
	DACA7	*Dalea candida*	white prairie clover	
	LAPO2	*Lathyrus polymorphus*	manystem pea	
	MELU	*Medicago lupulina*	black medick	*
	MEOF	*Melilotus officinalis*	yellow sweetclover	*
	PEES	*Pediomelum esculentum*	large Indian breadroot	
	PSLA3	*Psoralidium lanceolatum*	lemon scurfpea	
	PSTE5	*Psoralidium tenuiflorum*	slimflower scurfpea	
	THRH	*Thermopsis rhombifolia*	prairie thermopsis	
Liliaceae	LEMO4	*Leucocrinum montanum*	common starlily	
Loasaceae	MEDE2	*Mentzelia decapetala*	tenpetal blazingstar	
Malvaceae	SPCO	*Sphaeralcea coccinea*	scarlet globemallow	
Melanthiaceae	TOVE2	*Toxicoscordion venenosum*	meadow deathcamas	
Nyctaginaceae	MIHI	*Mirabilis hirsuta*	hairy four o'clock	
	MILI3	*Mirabilis linearis*	narrowleaf four o'clock	
Onagraceae	OESE3	*Oenothera serrulata*	yellow sundrops	
	OESU99	*Oenothera suffrutescens*	scarlet beeblossom	
Poaceae	AGCR	*Agropyron cristatum*	crested wheatgrass	*
	BOCU	*Bouteloua curtipendula*	sideoats grama	
	BODA2	*Bouteloua dactyloides*	buffalograss	
	BOGR2	*Bouteloua gracilis*	blue grama	
	BRIN2	*Bromus inermis*	smooth brome	*
	BRTE	*Bromus tectorum*	cheatgrass	*
	CALO	*Calamovilfa longifolia*	prairie sandreed	
	ELLA3	*Elymus lanceolatus*	thickspike wheatgrass	
	ELTR7	*Elymus trachycaulus*	slender wheatgrass	
	HECO26	*Hesperostipa comata*	needle and thread	
	KOMA	*Koeleria macrantha*	prairie Junegrass	
	NAVI4	*Nassella viridula*	green needlegrass	
	PASM	*Pascopyrum smithii*	western wheatgrass	
	POSE	*Poa secunda*	Sandberg bluegrass	
	SCSC	*Schizachyrium scoparium*	little bluestem	
	SPCR	*Sporobolus cryptandrus*	sand dropseed	
	VUOC	*Vulpia octoflora*	sixweeks fescue	
Polemoniaceae	PHAN4	*Phlox andicola*	prairie phlox	
	PHHO	*Phlox hoodii*	spiny phlox	
Polygonaceae	ERPA9	*Eriogonum pauciflorum*	fewflower buckwheat	
	RUSA	*Rumex salicifolius*	willow dock	
Rosaceae	ROWO	*Rosa woodsii*	Woods' rose	
Solanaceae	PHHI8	*Physalis hispida*	prairie groundcherry	
Unknown Family	UNKFORB	Unknown forb	unknown forb	*
	UNKFORBANN	Unknown annual forb	unknown annual forb	*
Violaceae	VINU2	*Viola nuttallii*	Nuttall's violet	

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 317/128100, February 2015

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