



Plant Community Composition and Structure Monitoring for Wind Cave National Park

2014 Annual Report

Natural Resource Data Series NPS/NGPN/NRDS—2015/765



ON THE COVER

Long-term monitoring plot PCM-018 at Wind Cave National Park, 2014
Photograph courtesy of the National Park Service

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March 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.

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Please cite this publication as:

Prowatzke, M. and S. K. Wilson. 2015. Plant community composition and structure monitoring for Wind Cave National Park: 2014 annual report. Natural Resource Data Series NPS/NGPN/NRDS—2015/765. National Park Service, Fort Collins, Colorado.

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Abstract

This report presents the results of vegetation monitoring efforts in 2014 at Wind Cave National Park (WICA) by the Northern Great Plains Inventory and Monitoring Network (NGPN).

During the fourth full year of field work, crew members from NGPN visited 14 plant community monitoring plots to collect data on the vegetation at WICA. This is part of a long-term monitoring effort that will sample 14 of 35 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. NGPN staff captured data relating to species richness, herb-layer height, abundance of native and non-native species, ground cover, and site disturbance on each of the 14 plots.

Our 2014 findings can be summarized as follows: The crew observed 242 vascular plant species in upland plots, with an average of 12.4 native species occurring within any given 1 m² quadrat sampled. Grasses, sedges, and forbs made up the bulk of the plant cover, while non-native species represented about 24.0% of cover. Three tree species were recorded in a total of four plots, and both tree densities and fuel loads were consistent with historical values. Overall, WICA plant communities appear to have high native diversity and are being maintained in good condition, though exotic plants are of concern to the park.

Acknowledgments

We thank all 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 WICA, particularly K. Kovacs, for providing logistical support. We thank M. Bynum, B. Burkhart, K. Kovacs, Z. Mergen, R. Ritson, A. Hammer, and A. Jarding for help in the field. With their assistance, the 2014 NGPN vegetation field crew of M. Prowatzke, K. Legner, S. Rockwood, R. Manuel, F. Sewell, L. Mickelson, and D. Pinigis collected all the data included in this report.

Introduction

The Black Hills is a 1.5 million ha refuge of ponderosa pine (*Pinus ponderosa*) forest surrounded by the mixed-grass prairies of western South Dakota and eastern Wyoming. The Black Hills is a unique ecosystem composed of species from the western Rocky Mountains, eastern deciduous forests, northern boreal forests, and the surrounding Great Plains (Larson and Johnson 2007). The National Park Service (NPS) plays an important role in preserving and restoring ponderosa woodlands and mixed-grass 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 reality that there have been fundamental changes in the disturbance regimes, such as climate, fire, and large ungulate grazing, that have historically maintained ponderosa woodlands and native prairies, and there is the continual pressure of exotic invasive species. In recent years, mountain pine beetle (*Dendroctonus ponderosae*) outbreaks have been of particular concern because they are increasing throughout the Black Hills and have caused 100% mortality of ponderosa pines in some areas (Hocking et al. 2010). Long-term monitoring in national parks is essential to sound management because it can provide information on environmental quality and condition, benchmarks of ecological integrity, and early warning of declines in ecosystem health.

Wind Cave National Park (WICA) is located in the southern Black Hills with a purpose to protect the unique Wind Cave resources and preserve and enhance the mixed-grass prairie and native wildlife, while providing for the enjoyment of the public. The 33,851 acres of WICA is a mosaic of ponderosa pine forest and mixed-grass prairie, with approximately 30% covered by ponderosa pine forests. While some areas have high exotic species cover, the native plant communities within the upland areas of WICA are considered to be in good condition (Komp et al. 2011). The Northern Great Plains Inventory & Monitoring Program (NGPN) began vegetation monitoring efforts in WICA in 2011 (Ashton et al. 2012). Vegetation monitoring protocols and plot locations were chosen to represent the entire park (based on the 2010 boundary) and to coordinate efforts with the Northern Great Plains Fire Ecology Program (FireEP). There is a separate effort to monitor streambank condition because riparian communities are an important resource for the park (Burkhart and Kovacs 2013). Additional upland plots were added to represent the 2011 Addition to the park property; however, time was not available to visit these plots this year. The long-term objectives of the NGPN plant community monitoring effort (Symstad et al. 2012b) in WICA 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 park-wide status (at 5-year intervals) and long-term trends of tree density by species, height class, diameter class, and fuel loads.
3. Improve our understanding of the effects of external drivers and management actions on plant community species composition and structure by correlating changes in vegetation composition and structure with changes in climate, landscape patterns, atmospheric chemical composition, fire, and invasive plant control.

This report is intended to provide a timely release of basic data sets and data summaries from our sampling efforts at WICA in 2014, in which NGPN visited 14 plots (Figure 1). A more thorough discussion of forest structure and health was completed in 2012 (Ashton et al. 2013a). We expect to produce reports with more in-depth data analysis and interpretation when we complete five years of sampling. In the interim, reports, spatial data, and data summaries can be provided for park management and interpretation upon request.

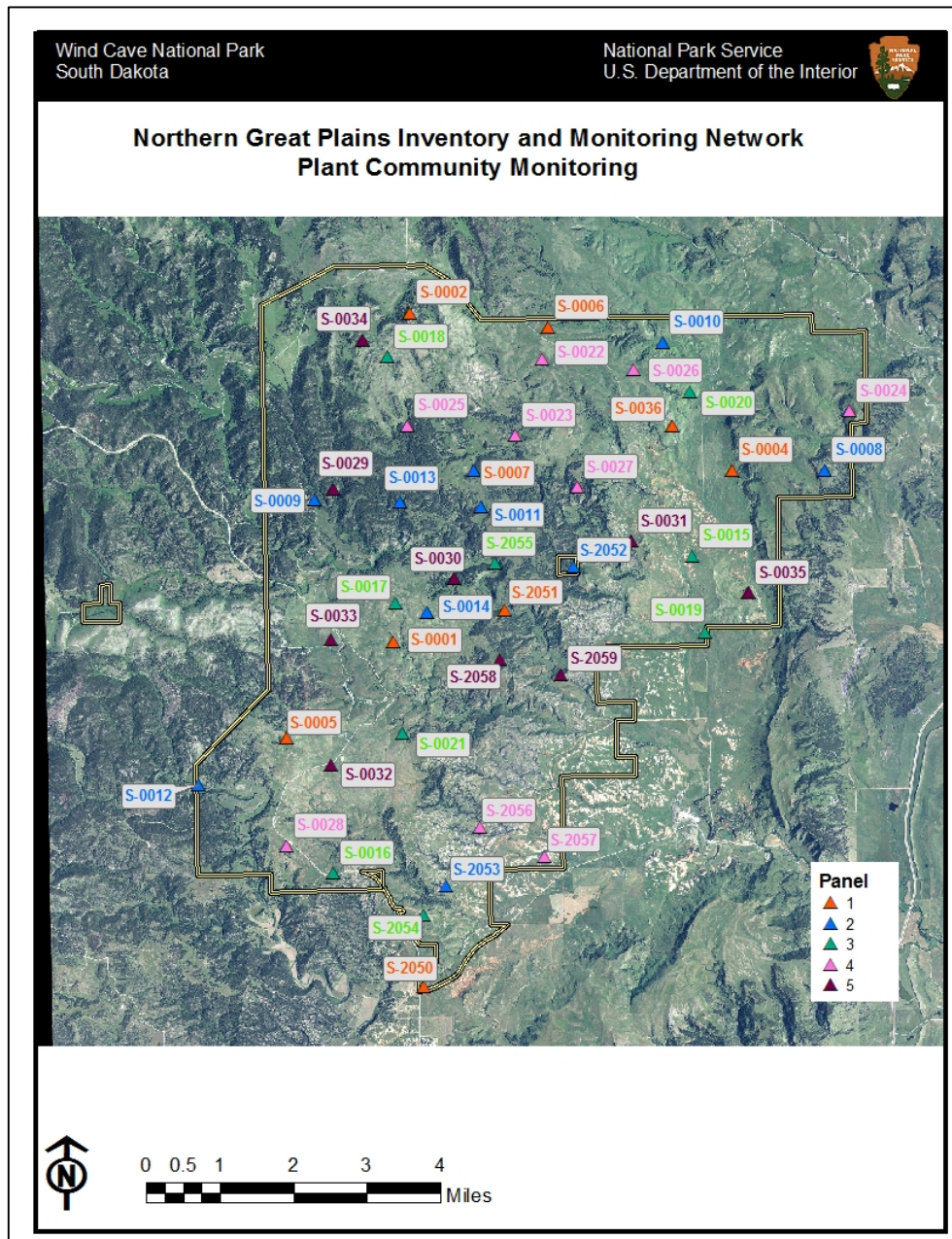


Figure 1. Map of Wind Cave National Park and plant community monitoring plots. Plots numbered from S-0015 to S-0028 in panel 3 (green) and panel 4 (pink) were visited in 2014.

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 WICA using a spatially balanced probability design (Generalized Random Tessellation Stratified [GRTS]; Stevens and Olsen 2003, 2004). Using a GRTS design, we selected 35 randomly located sites within WICA. We split these 35 sites into five panels with seven sites each (Figure 1). We visit two panels (14 sites) every year, and after five years we will have visited all 35 sites twice. In 2014, we visited sites in panel 3 and panel 4 during June and early July. Data from these randomly selected sites can be used to estimate condition of vegetation communities for the whole park and over time, can be used to discern trends in condition. In 2011, the park acquired new property. We have selected 10 sites (2 per panel) within the addition and will visit these on the same schedule as above when time allows. In 2014, we were not able to visit any of these additional sites.

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 m², 0.1 m², 1 m², and 10 m²) located systematically along each transect (Figure 2). In 2014, sampling at WICA took approximately 639 person-hours over seven days (see Appendix A for a detail of activities each day).

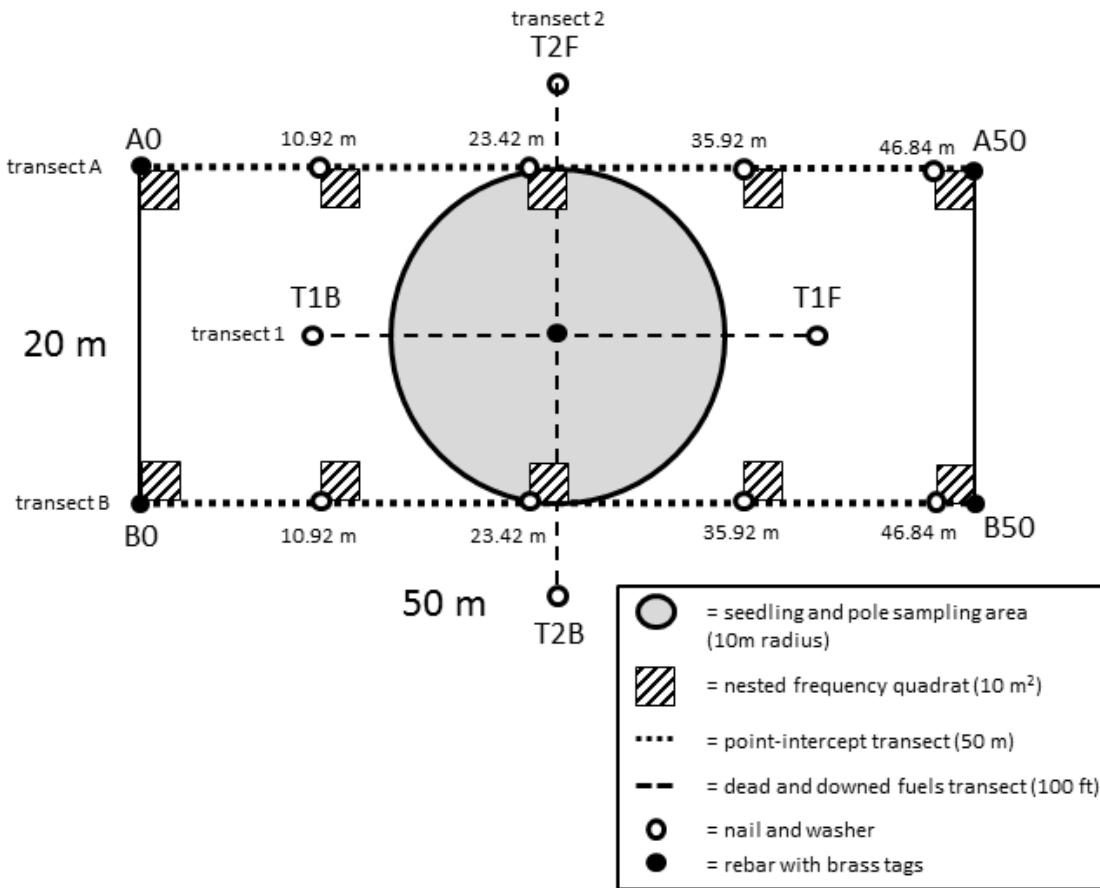


Figure 2. Long-term monitoring plot used for sampling vegetation in Wind Cave National Park.

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. Dead and downed woody fuel load data were collected on two perpendicular, 100 ft (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).

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 South Dakota, and which may potentially occur in WICA (Table 2).

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

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

Table 2. Rare species that were surveyed for during the 2014 field season at Wind Cave National Park.

Scientific Name	Common Name
<i>Achnatherum robustum</i>	sleepy grass
<i>Botrychium campestre</i>	prairie moonwort
<i>Botrychium lineare</i>	narrowleaf grapefern
<i>Botrychium simplex</i>	little grapefern
<i>Clematis hirsutissima</i>	hairy clematis
<i>Cryptantha cana</i>	silver-mounded candleflower
<i>Cypripedium parviflorum</i>	lesser yellow lady's slipper
<i>Echinocereus viridiflorus</i>	nylon hedgehog cactus
<i>Elymus diversiglumis</i>	interrupted wildrye
<i>Ericameria parryi</i>	Parry's rabbitbrush
<i>Erigeron acris</i>	bitter fleabane
<i>Erigeron ochroleucus</i>	buff fleabane
<i>Ipomopsis spicata</i>	spiked ipomopsis
<i>Phleum alpinum</i>	alpine timothy
<i>Physaria arenosa</i>	sidesaddle bladderpod
<i>Thelesperma megapotamicum</i>	Hopi tea
<i>Townsendia exscapa</i>	Easter daisy
<i>Townsendia hookeri</i>	Hooker's Townsend daisy
<i>Viburnum edule</i>	squashberry

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 developed to check for errors in the data. When errors were caught by the crew or the automated queries, changes were made to the original datasheets and the FFI database as needed.

Plant life forms (e.g., shrub, forb) were based on definitions from the USDA Plants Database (USDA-NRCS 2012). Warm-season grasses were identified primarily using a guide by Skinner (2010). 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). Pielou'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.

Disturbances were recorded in square meters and ranged from 0 (not present) to 2290 (the whole plot area) for each type of disturbance. We report the sum of all individual disturbances, so the value can be greater than 2290 m².

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://www.nps.gov/stateoftheparks/>). 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.

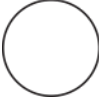
Condition Status		Trend in Condition		Confidence in Assessment	
	Warrants Significant Concern		Condition is Improving		High
	Warrants Moderate Concern		Condition is Unchanging		Medium
	Resource is in Good Condition		Condition is Deteriorating		Low

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/>).

Results and Discussion

Wind Cave National Park emerged from drought in October 2013 and continued to enjoy above average precipitation in 2014. At the time of NGPN's visits, precipitation for the year was about two inches above normal

(<http://www.ncdc.noaa.gov/cdo-web/datasets/GHCND/stations/GHCND:USC00399347/detail>; Figure 3).

Average canopy cover was 203% (Table 4) in 2014, which was about 34% higher than the previous year (Ashton and Prowatzke 2014), and almost twice that of 2012 (Ashton et al. 2013b). There was a large amount of litter on the ground with ground cover at the sites averaging 87% plant litter.

We found 242 plant species in 2014 at WICA (Appendix B). Graminoids, which includes grasses, sedges, and rushes, accounted for most of the vegetative cover at WICA, but trees, forbs, vines, shrubs and subshrubs (defined as a low-growing shrub usually under 0.5m) were also present (Figure 4). We found 36 exotic species at the park. No exotic target species were found at any sites in 2014

There was some variation in species composition across the 14 sites. The most common species in the sites we visited were graminoids, and most were native species (Figure 5). We found one rare plant, nylon hedgehog cactus (*Echinocereus viridiflorus*) at two sites (PCM-019 and PCM-021). These sites were both visited in 2013, and the species was noted in those sites that year as well (Ashton and Prowatzke 2014).

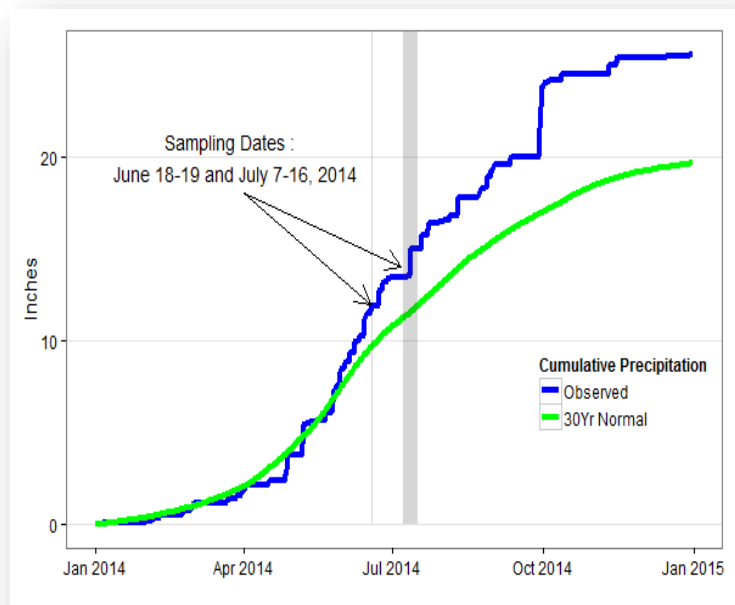


Figure 3. Observed and 30-year (1981-2010) normal precipitation in Wind Cave National Park. Timing of NGPN visit is shown by vertical gray bar.

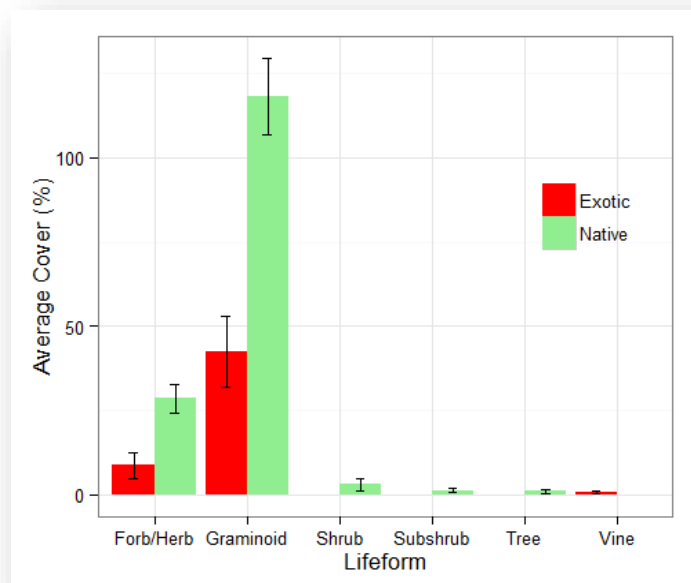


Figure 4. Average cover by lifeform in 14 plant community monitoring plots in Wind Cave National Park in 2014. Graminoids and forbs were the most abundant lifeforms found in the understory across the plots. Bars represent means $\pm$ standard errors.

Table 4. Natural resource condition summary table for upland plant communities in Wind Cave National Park (WICA).

Indicator of Condition	Specific Measures	2014 Value (mean $\pm$ SE)	Reference Condition and Data Source	Condition Status/Trend	Rationale for Resource Condition
Upland Plant Community Structure and Composition	Absolute herb-layer canopy cover	203 $\pm$ 14.7%	TBD ⁽¹⁾		WICA has a high herbaceous canopy cover and a high diversity of native plants. The condition assessment for canopy cover and evenness is based on professional judgment, but as we collect more data and understand the natural range of variability our confidence in these assessments will increase. Future work is needed to determine if the reference condition for native species richness is relevant for Black Hills parks. Forest densities are similar to historic conditions and are characterized by a mosaic of open and closed canopy sites.
	Native species richness (based on average of 10 1m ² quadrats per plot)	12.5 $\pm$ 1.1 species	8-18 species ⁽²⁾		
	Evenness (based on point-intercept of 2-50m transects per plot)	0.77 $\pm$ 0.01	TBD ⁽¹⁾		
	Forest basal area	13.3 $\pm$ 8.6 m ² /ha	15.3 $\pm$ 2.7 m ² /ha ⁽³⁾		
Exotic Plant Early Detection and Management	Relative cover of exotic species	24.0 $\pm$ 4.9%	$\leq$ 10 % cover		In general, the sites in WICA had a high cover of exotic species. Only four of 14 sites had <10% exotic cover. Annual brome cover was lower than the management target, but is near the 10% threshold.
	Annual brome cover	8.6 $\pm$ 2.8%	$\leq$ 10 % cover		
Fire and Fuel Dynamics	Total downed fuel loads	11.0 $\pm$ 2.5 tons/acre	Between 2 and 10 tons/acre		The current fire ecology program aims to maintain fuel loads of less than 10 tons/acre. While we had a small sample size (only four plots contained woody fuels in 2014), the more comprehensive forest survey in 2012 revealed a similar average of 9.4 tons/acre.

References, Notes, and Data Sources:

1. To be determined when more data are available. 2. 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. Gutschpergen, editor. Application of threshold concepts in natural resource decision making. Springer Verlag. 3. Brown, P. M. and B. Cook. 2006. Early settlement forest structure in Black Hills ponderosa pine forests. Forest Ecology and Management 223:284-290.

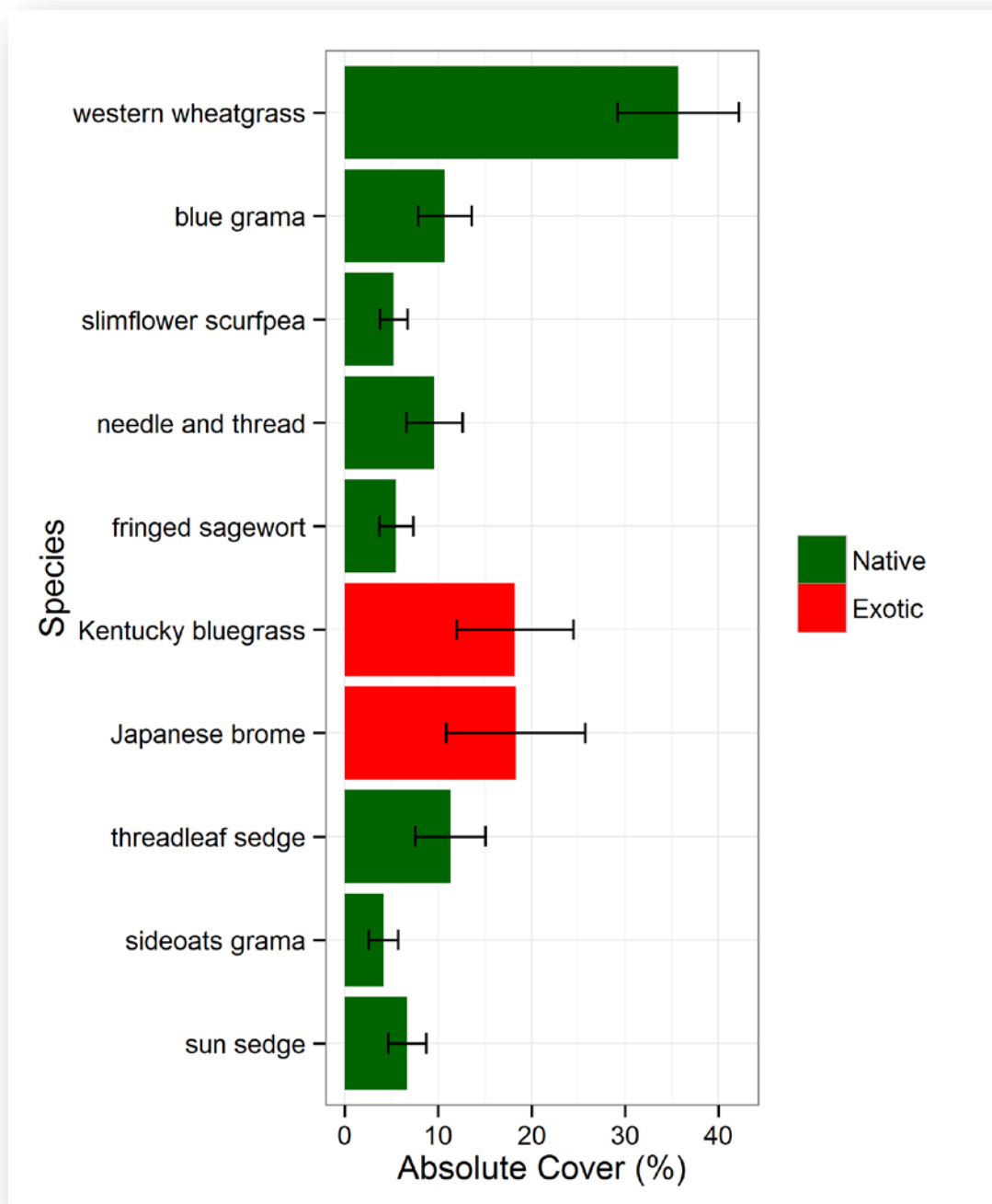


Figure 5. The average absolute cover of the 10 most common native (green) and exotic (red) plants recorded at Wind Cave National Park in 2014. Bars represent means $\pm$ standard errors.

Average species richness at each of the 14 plots was measured by point-intercept and in 1 m² and 10 m² quadrats (Table 5). On average, there are about two exotic species within the 1 m² quadrat (Table 5). From the point-intersect data, we found average plot diversity, H' , to be 2.5 ± 0.07 . Evenness, J' ,

averaged 0.77 ± 0.01 across the plots (Table 4). When including only native species, average diversity and evenness were 2.3 ± 0.07 and 0.78 ± 0.01 , respectively.

Table 5. Average plant species richness in 14 plots at Wind Cave National Park in 2014. Values represent means $\pm$ standard errors, $n=14$.

	Point-intercept	1 m ² quadrats	10 m ² quadrats
Species richness	25 ± 1.4	14 ± 1.1	26 ± 1.5
Native species richness	21 ± 1.4	12 ± 1.1	22 ± 1.5
Exotic species richness	4 ± 0.6	2 ± 0.2	4 ± 0.4
Graminoid species richness	13 ± 0.6	6 ± 0.4	8 ± 0.4
Forb species richness	11 ± 1.0	8 ± 0.8	16 ± 1.3

While there was some variation across sites, the plots we visited in WICA tended to have a high 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). 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 eastern Montana vary



Figure 6. Photo of plot PCM-0026. Though at first glance it appears to be “only grass”, this site recorded the highest number of native species per square meter

between 8 and 18 species per square meter over the course of 13 years (Symstad and Jonas 2014). Since there are no long-term records of mixed-grass prairie diversity within the Black Hills, we are relying on these data as a reference condition. Future work is needed to develop a robust reference condition for plant communities in the Black Hills. Compared to the nearby mixed-grass prairie, WICA is within the natural range (Table 4). The highest diversity was seen in site PCM-0026 (Figure 6), located in grasslands in the northeast corner of the park.

The average relative cover of exotic species at sites in WICA was fairly high ($24.0 \pm 4.9\%$) and higher than the cover seen in 2013 ($19 \pm 3.5\%$; Ashton and Prowatzke 2014) or 2012 ($11 \pm 2.7\%$; Ashton et al. 2013b). However, like species richness, cover of exotic species varied considerably among sites (Table 6). Exotic cover at five plots was below a proposed management target of 10%, but the other nine sites surveyed were above this threshold. The highest cover of exotic species was 56%, found at PCM-0016, a site near the highway that struggles with Kentucky bluegrass (*Poa pratensis*) and smooth brome (*Bromus inermis*). Not surprisingly, this site also featured the lowest native species richness per m² among plots surveyed, less than 1/3 of the highest plot (Table 6). Annual bromes (*B. tectorum* and *B. japonicus*) are also threatening the park, representing 8.6%

relative cover in 2014. Annual bromes are known to respond strongly to climatic factors, especially precipitation (Mack and Pyke 1984), and 2013 and 2014 were good years for them. More data is needed to determine whether the increase in abundance in annual bromes correlates with expansion into areas of the park that had not previously been invaded. Regardless, reducing the cover of annual bromes remains a major challenge for many of the parks in the region.

Table 6. Characteristics of the plant community in 14 plots at Wind Cave National Park in 2014 including average native species richness, exotic plant cover, cover of annual bromes, and area of disturbance.

Plot	Native species richness in 1 m ²	Relative exotic cover (%)	Relative annual brome cover (%)	Relative Kentucky blue-grass cover (%)	Disturbance within site (m ²)
PCM-0015	7	38	2	18	500
PCM-0016	6	56	0	32	320
PCM-0017	15	10	1	6	80
PCM-0018	18	19	14	0	273
PCM-0019	14	24	14	9	25
PCM-0020	12	0	0	0	0
PCM-0021	13	27	15	11	270
PCM-0022	13	35	32	2	0
PCM-0023	8	0	0	0	0
PCM-0024	10	36	28	9	0
PCM-0025	15	31	1	1	1030
PCM-0026	19	5	4	0	0
PCM-0027	8	51	5	36	0
PCM-0028	17	5	4	1	50
<i>Park Average</i>	<i>12.4 ± 1.1 species</i>	<i>24.0 ± 4.9%</i>	<i>8.6 ± 2.8%</i>	<i>8.8 ± 3.2%</i>	-

Disturbance from grazing, small mammals, 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 grazing, but there was also evidence of bison wallows, animal trails, prairie dogs, and human trails.

Trees and/or seedlings were present in four of the 14 sites we visited in 2014. A more thorough assessment of forest structure was completed in 2012 (Ashton et al. 2013a); however, the 2014 data provide a snapshot of condition at a subset of the plots. Ponderosa pine (*Pinus ponderosa*) seedlings were only found in 3 plots (Table 7). The highest density of pine seedlings and trees was found at PCM-0027 (Figure 7). Overall, basal area at the four sites (13.3 ± 8.6 m²/ha) was only slightly less than estimates of historic condition (Table 4) and corresponded well with park-wide estimates in 2012 of between 10 and 14 m²/ha (Ashton et al. 2013a). We measured dead and downed woody fuels at four sites and found fuel loads were only slightly above the range that the Fire Ecology Program prescribes (11.0 ± 2.5 tons/acre; Table 4). This is slightly above, but close to the 2012 park-wide estimate (Ashton et al. 2013a). In 2017, NGPN is scheduled to repeat the thorough assessment of forest structure, fuel loads, and health.

Table 7. Seedling, pole, and tree densities at four plots in Wind Cave National Park in 2014.

Plot	Seedling Density (seedlings/hectare)			Tree Density (trees/hectare)		
	Pine	Juniper	Birch	Pine poles	Pine trees	Juniper poles
PCM-0016	-	-		-	10	
PCM-0023	796	-		53	46	
PCM-0027	2928	32	32	732	150	64
PCM-0028	255	-			30	

Summary

Understory plant community plots measured in 2014 at WICA had a high diversity of native plants, and species richness was within the range of natural variability for mixed-grass prairie. Future work is needed to develop reference conditions that are specific to the Black Hills. Exotic plant cover was higher than in past years and was greater than 10% cover at most sites. Kentucky bluegrass and Japanese brome were the most widespread and abundant exotic species. To retain ecological integrity and the high diversity of native plants in WICA, it is important to continue efforts to reduce the cover of invasive plants. Continued monitoring efforts will be critical to track changes in the condition of the vegetation communities in WICA.

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

Plant community composition monitoring in WICA was completed using two crews of three to eight people working seven 10-hour days, plus some overtime. Only one crew worked in WICA on July 16. Total NGPN person-hours were 487. WICA staff contributed approximately 13 8-hour days (104 hours), a paid contractor (Mike Bynum) provided 40 hours of assistance, and one volunteer (Beth Burkhart, retired WICA botanist) provided eight hours of assistance. Total hours were 639.

Date	Day of week	Approximate Travel Time (hrs)	Housing	Sites Completed
June 18, 2014	Wednesday	2.5	N/A	PCM-0016 PCM-0020
June 19, 2014	Thursday	2.5	N/A	PCM-0027 PCM-0028
July 7, 2014	Monday	2.5	N/A	PCM-0015 PCM-0022 PCM-0026
July 8, 2014	Tuesday	2.5	N/A	PCM-0023 PCM-0025
July 9, 2014	Wednesday	2.5	N/A	PCM-0018 PCM-0024
July 10, 2014	Thursday	2.5	N/A	PCM-0017 PCM-0021
July 16, 2014	Wednesday	2.5	N/A	PCM-0019

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

Family	Code	Scientific Name	Common Name	Exotic
Agavaceae	YUGL	<i>Yucca glauca</i>	soapweed yucca	
Amaranthaceae	AMBL	<i>Amaranthus blitoides</i>	mat amaranth	*
	AMRE	<i>Amaranthus retroflexus</i>	redroot amaranth	
Anacardiaceae	RHTR	<i>Rhus trilobata</i>	skunkbush sumac	
	TORY	<i>Toxicodendron rydbergii</i>	western poison ivy	
Apiaceae	MUTE3	<i>Musineon tenuifolium</i>	slender wildparsley	
Asclepiadaceae	ASPU	<i>Asclepias pumila</i>	plains milkweed	
	ASST	<i>Asclepias stenophylla</i>	slimleaf milkweed	
	ASVE	<i>Asclepias verticillata</i>	whorled milkweed	
	ASVI	<i>Asclepias viridiflora</i>	green comet milkweed	
Asteraceae	AMAR2	<i>Ambrosia artemisiifolia</i>	annual ragweed	
	AMPS	<i>Ambrosia psilostachya</i>	Cuman ragweed	
	ANMI3	<i>Antennaria microphylla</i>	littleleaf pussytoes	
	ANNE	<i>Antennaria neglecta</i>	field pussytoes	
	ANPA4	<i>Antennaria parvifolia</i>	small-leaf pussytoes	
	ARDR4	<i>Artemisia dracunculus</i>	tarragon	
	ARFR4	<i>Artemisia frigida</i>	prairie sagewort	
	ARLU	<i>Artemisia ludoviciana</i>	white sagebrush	
	BREU	<i>Brickellia eupatorioides</i>	false boneset	
	CIAR4	<i>Cirsium arvense</i>	Canada thistle	*
	CIUN	<i>Cirsium undulatum</i>	wavyleaf thistle	
	CIVU	<i>Cirsium vulgare</i>	bull thistle	*
	COCA5	<i>Conyza canadensis</i>	Canadian horseweed	
	CORA4	<i>Conyza ramosissima</i>	dwarf horseweed	
	CYXA	<i>Cyclachaena xanthifolia</i>	giant sumpweed	
	DYPA	<i>Dyssodia papposa</i>	fetid marigold	
	ECAN2	<i>Echinacea angustifolia</i>	blacksamson echinacea	
	ERCA4	<i>Erigeron canus</i>	hoary fleabane	
	ERFL	<i>Erigeron flagellaris</i>	trailing fleabane	
	GNPA	<i>Gnaphalium palustre</i>	western marsh cudweed	
	GRSQ	<i>Grindelia squarrosa</i>	curlycup gumweed	
	GUSA2	<i>Gutierrezia sarothrae</i>	broom snakeweed	
	HEAN3	<i>Helianthus annuus</i>	common sunflower	
	HEMA2	<i>Helianthus maximiliani</i>	Maximilian sunflower	
	HEPA19	<i>Helianthus pauciflorus</i>	stiff sunflower	
	HEVI4	<i>Heterotheca villosa</i>	hairy false goldenaster	
	LASE	<i>Lactuca serriola</i>	prickly lettuce	*
	LIPU	<i>Liatris punctate</i>	dotted blazing star	
	LOAR5	<i>Logfia arvensis</i>	field cottonrose	*
	LYJU	<i>Lygodesmia juncea</i>	rush skeletonplant	

Asteraceae	MUOB99	<i>Mulgedium oblongifolium</i>	blue lettuce	
	PACA15	<i>Packera cana</i>	woolly groundsel	
	PAPL12	<i>Packera plattensis</i>	prairie groundsel	
	RACO3	<i>Ratibida columnifera</i>	upright prairie coneflower	
	SOMI2	<i>Solidago missouriensis</i>	Missouri goldenrod	
	SOMO	<i>Solidago mollis</i>	velvety goldenrod	
	SONE	<i>Solidago nemoralis</i>	gray goldenrod	
	SORI2	<i>Solidago rigida</i>	stiff goldenrod	
	SOSP2	<i>Solidago speciosa</i>	showy goldenrod	
	SYFA	<i>Symphyotrichum falcatum</i>	white prairie aster	
	SYMPH4	<i>Symphyotrichum</i> sp.	aster	
	SYOB	<i>Symphyotrichum oblongifolium</i>	aromatic aster	
	TAOF	<i>Taraxacum officinale</i>	common dandelion	*
	TEAC	<i>Tetraneuris acaulis</i>	stemless four-nerve daisy	
	TRDU	<i>Tragopogon dubius</i>	yellow salsify	*
	XASP99	<i>Xanthisma spinulosum</i>	lacy tansyaster	
Betulaceae	BEPA	<i>Betula papyrifera</i>	paper birch	
Boraginaceae	CRTH	<i>Cryptantha thyrsiflora</i>	calcareous cryptantha	
	CYOF	<i>Cynoglossum officinale</i>	gypsyflower	*
	LACE	<i>Lappula cenchrusoides</i>	Great Plains stickseed	
	LAOC3	<i>Lappula occidentalis</i>	flatspine stickseed	
	LASQ	<i>Lappula squarrosa</i>	European stickseed	*
	LIIN2	<i>Lithospermum incisum</i>	narrowleaf stoneseed	
	MELA3	<i>Mertensia lanceolata</i>	prairie bluebells	
	ONBE	<i>Onosmodium bejariense</i>	soft-hair marbleseed	
Brassicaceae	ALDE	<i>Alyssum desertorum</i>	desert madwort	*
	ARHI	<i>Arabis hirsute</i>	hairy rockcress	
	CABU2	<i>Capsella bursa-pastoris</i>	shepherd's purse	*
	CAMI2	<i>Camelina microcarpa</i>	littlepod false flax	*
	DEPI	<i>Descurainia pinnata</i>	western tansymustard	
	DESO2	<i>Descurainia sophia</i>	herb sophia	*
	DRRE2	<i>Draba reptans</i>	Carolina draba	
	ERAS2	<i>Erysimum asperum</i>	western wallflower	
	ERCA14	<i>Erysimum capitatum</i>	sanddune wallflower	
	ERCH9	<i>Erysimum cheiranthoides</i>	wormseed wallflower	*
	ERIN7	<i>Erysimum inconspicuum</i>	shy wallflower	
	LEDE	<i>Lepidium densiflorum</i>	common pepperweed	
	PHLU99	<i>Physaria ludoviciana</i>	foothill bladderpod	
	SIAL2	<i>Sisymbrium altissimum</i>	tall tumbledustard	*
Cactaceae	ECVI2	<i>Echinocereus viridiflorus</i>	nylon hedgehog cactus	
	ESMI3	<i>Escobaria missouriensis</i>	Missouri foxtail cactus	
	ESVI2	<i>Escobaria vivipara</i>	spiny star	
	OPFR	<i>Opuntia fragilis</i>	brittle pricklypear	

Cactaceae	OPMA2	<i>Opuntia macrorhiza</i>	twistspine pricklypear	
	OPPO	<i>Opuntia polyacantha</i>	plains pricklypear	
Campanulaceae	CARO2	<i>Campanula rotundifolia</i>	bluebell bellflower	
	TRPE4	<i>Triodanis perfoliata</i>	clasping Venus' looking-glass	
Caprifoliaceae	SYAL	<i>Symphoricarpos albus</i>	common snowberry	
	SYOC	<i>Symphoricarpos occidentalis</i>	western snowberry	
Caryophyllaceae	CEAR4	<i>Cerastium arvense</i>	field chickweed	
	PADE4	<i>Paronychia depressa</i>	spreading nailwort	
	SIAN2	<i>Silene antirrhina</i>	sleepy silene	
	SIDR	<i>Silene drummondii</i>	Drummond's campion	
Chenopodiaceae	CHBE4	<i>Chenopodium berlandieri</i>	pitseed goosefoot	
	CHENO	<i>Chenopodium</i> sp.	goosefoot	*
	CHLE4	<i>Chenopodium leptophyllum</i>	narrowleaf goosefoot	
	CHPR5	<i>Chenopodium pratericola</i>	desert goosefoot	
	MONU	<i>Monolepis nuttalliana</i>	Nuttall's povertyweed	
	SATR12	<i>Salsola tragus</i>	prickly Russian thistle	*
Commelinaceae	TRBR	<i>Tradescantia bracteata</i>	longbract spiderwort	
	TROC	<i>Tradescantia occidentalis</i>	prairie spiderwort	
Convolvulaceae	COAR4	<i>Convolvulus arvensis</i>	field bindweed	*
	IPLE	<i>Ipomoea leptophylla</i>	bush morning-glory	
Cupressaceae	JUCO6	<i>Juniperus communis</i>	common juniper	
	JUSC2	<i>Juniperus scopulorum</i>	Rocky Mountain juniper	
Cyperaceae	CABR10	<i>Carex brevior</i>	shortbeak sedge	
	CADU6	<i>Carex duriuscula</i>	needleleaf sedge	
	CAFI	<i>Carex filifolia</i>	threadleaf sedge	
	CAIN9	<i>Carex inops</i>	long-stolon sedge	
	CANE2	<i>Carex nebrascensis</i>	Nebraska sedge	
	CAREX	<i>Carex</i> sp.	sedge	
	CARO5	<i>Carex rossii</i>	Ross' sedge	
Euphorbiaceae	EUBR	<i>Euphorbia brachycera</i>	horned spurge	
	EUGL3	<i>Euphorbia glyptosperma</i>	ribseed sandmat	
	EUMA8	<i>Euphorbia marginata</i>	snow on the mountain	
	EUPR3	<i>Euphorbia prostrata</i>	prostrate sandmat	
	EUSP	<i>Euphorbia spathulata</i>	warty spurge	
Fabaceae	AMCA6	<i>Amorpha canescens</i>	leadplant	
	ASAG2	<i>Astragalus agrestis</i>	purple milkvetch	
	ASCR2	<i>Astragalus crassicaarpus</i>	groundplum milkvetch	
	ASFL2	<i>Astragalus flexuosus</i>	flexile milkvetch	
	ASGI5	<i>Astragalus gilviflorus</i>	plains milkvetch	
	ASGR3	<i>Astragalus gracilis</i>	slender milkvetch	
	ASLA27	<i>Astragalus laxmannii</i>	Laxmann's milkvetch	
	ASLO4	<i>Astragalus lotiflorus</i>	lotus milkvetch	
	ASMI10	<i>Astragalus missouriensis</i>	Missouri milkvetch	

Fabaceae	ASPL2	<i>Astragalus plattensis</i>	Platte River milkvetch	
	ASSP6	<i>Astragalus spatulatus</i>	tufted milkvetch	
	ASTRA	<i>Astragalus</i> sp.	milkvetch	
	DAPU5	<i>Dalea purpurea</i>	purple prairie clover	
	GLLE3	<i>Glycyrrhiza lepidota</i>	American licorice	
	LAPO2	<i>Lathyrus polymorphus</i>	manystem pea	
	MELU	<i>Medicago lupulina</i>	black medick	*
	MEOF	<i>Melilotus officinalis</i>	yellow sweetclover	*
	OXSE	<i>Oxytropis sericea</i>	white locoweed	
	PEAR6	<i>Pedimelum argophyllum</i>	silverleaf Indian breadroot	
	PEES	<i>Pedimelum esculentum</i>	large Indian breadroot	
	PSTE5	<i>Psoraleidum tenuiflorum</i>	slimflower scurfpea	
Grossulariaceae	RIAU	<i>Ribes aureum</i>	golden currant	
Iridaceae	SIMO2	<i>Sisyrinchium montanum</i>	strict blue-eyed grass	
Juncaceae	JUIN2	<i>Juncus interior</i>	inland rush	
Lamiaceae	HEDR	<i>Hedeoma drummondii</i>	Drummond's false pennyroyal	
	HEHI	<i>Hedeoma hispida</i>	rough false pennyroyal	
	MAVU	<i>Marrubium vulgare</i>	horehound	*
	MOFI	<i>Monarda fistulosa</i>	wild bergamot	
	SARE3	<i>Salvia reflexa</i>	lanceleaf sage	
Liliaceae	ALTE	<i>Allium textile</i>	textile onion	
	LEMO4	<i>Leucocrinum montanum</i>	common starlily	
Linaceae	LIRI	<i>Linum rigidum</i>	stiffstem flax	
Malvaceae	SPCO	<i>Sphaeralcea coccinea</i>	scarlet globemallow	
Melanthiaceae	TOVE2	<i>Toxicoscordion venenosum</i>	meadow deathcamas	
Montiaceae	PHPA29	<i>Phemeranthus parviflorus</i>	sunbright	
Nyctaginaceae	MILI3	<i>Mirabilis linearis</i>	narrowleaf four o'clock	
Onagraceae	EPBR3	<i>Epilobium brachycarpum</i>	tall annual willowherb	
	OECO2	<i>Oenothera coronopifolia</i>	crownleaf evening-primrose	
	OECU99	<i>Oenothera curtiflora</i>	velvetweed	
	OELA	<i>Oenothera laciniata</i>	cutleaf evening-primrose	
	OESE3	<i>Oenothera serrulata</i>	yellow sundrops	
	OESU99	<i>Oenothera suffrutescens</i>	scarlet beeblossom	
	OEVI	<i>Oenothera villosa</i>	hairy evening-primrose	
Orobanchaceae	ORFA	<i>Orobanche fasciculata</i>	clustered broomrape	
Oxalidaceae	OXST	<i>Oxalis stricta</i>	common yellow oxalis	
Papaveraceae	ARPO2	<i>Argemone polyanthemus</i>	crested pricklypoppy	
Pinaceae	PIPO	<i>Pinus ponderosa</i>	ponderosa pine	
Plantaginaceae	PLPA2	<i>Plantago patagonica</i>	woolly plantain	
	SYWY99	<i>Synthyris wyomingensis</i>	Wyoming kittentails	
Poaceae	AGSC5	<i>Agrostis scabra</i>	rough bentgrass	
	ANGE	<i>Andropogon gerardii</i>	big bluestem	
	ARPU9	<i>Aristida purpurea</i>	purple threeawn	

Poaceae	BOCU	<i>Bouteloua curtipendula</i>	sideoats grama	
	BODA2	<i>Bouteloua dactyloides</i>	buffalograss	
	BOGR2	<i>Bouteloua gracilis</i>	blue grama	
	BOHI2	<i>Bouteloua hirsuta</i>	hairy grama	
	BRIN2	<i>Bromus inermis</i>	smooth brome	*
	BRJA	<i>Bromus japonicus</i>	Japanese brome	*
	BRTE	<i>Bromus tectorum</i>	cheatgrass	*
	CALO	<i>Calamovilfa longifolia</i>	prairie sandreed	
	DILI2	<i>Dichanthelium linearifolium</i>	slimleaf panicgrass	
	DIOL	<i>Dichanthelium oligosanthos</i>	Heller's rosette grass	
	DIWI5	<i>Dichanthelium wilcoxianum</i>	fall rosette grass	
	ELCA4	<i>Elymus canadensis</i>	Canada wildrye	
	ELEL5	<i>Elymus elymoides</i>	squirreltail	
	ELRE4	<i>Elymus repens</i>	quackgrass	*
	ELTR7	<i>Elymus trachycaulus</i>	slender wheatgrass	
	HECO26	<i>Hesperostipa comata</i>	needle and thread	
	HOJU	<i>Hordeum jubatum</i>	foxtail barley	
	HOPU	<i>Hordeum pusillum</i>	little barley	
	KOMA	<i>Koeleria macrantha</i>	prairie Junegrass	
	MUCU3	<i>Muhlenbergia cuspidata</i>	plains muhly	
	MUPA99	<i>Muhlenbergia paniculata</i>	tumblegrass	
	MURA	<i>Muhlenbergia racemosa</i>	marsh muhly	
	MUSQ3	<i>Munroa squarrosa</i>	false buffalograss	
	NAVI4	<i>Nassella viridula</i>	green needlegrass	
	PASM	<i>Pascopyrum smithii</i>	western wheatgrass	
	PAVI2	<i>Panicum virgatum</i>	switchgrass	
	PIMI7	<i>Piptatherum micranthum</i>	littleseed ricegrass	
	POCO	<i>Poa compressa</i>	Canada bluegrass	*
	POPR	<i>Poa pratensis</i>	Kentucky bluegrass	*
	SCSC	<i>Schizachyrium scoparium</i>	little bluestem	
	SPCR	<i>Sporobolus cryptandrus</i>	sand dropseed	
	SPHE	<i>Sporobolus heterolepis</i>	prairie dropseed	
	THIN6	<i>Thinopyrum intermedium</i>	intermediate wheatgrass	*
	VUOC	<i>Vulpia octoflora</i>	sixweeks fescue	
Polemoniaceae	COLI2	<i>Collomia linearis</i>	tiny trumpet	
	PHAL3	<i>Phlox alyssifolia</i>	alyssumleaf phlox	
	PHAN4	<i>Phlox andicola</i>	prairie phlox	
	PHHO	<i>Phlox hoodii</i>	spiny phlox	
Polygalaceae	POAL4	<i>Polygala alba</i>	white milkwort	
	POVE	<i>Polygala verticillata</i>	whorled milkwort	
Polygonaceae	ERAN4	<i>Eriogonum annuum</i>	annual buckwheat	
	ERFL4	<i>Eriogonum flavum</i>	alpine golden buckwheat	
	FACO	<i>Fallopia convolvulus</i>	black bindweed	*

Polygonaceae	PORA3	<i>Polygonum ramosissimum</i>	bushy knotweed	
Portulacaceae	POOL	<i>Portulaca oleracea</i>	little hogweed	*
Primulaceae	ANAR	<i>Anagallis arvensis</i>	scarlet pimpernel	*
	ANOC2	<i>Androsace occidentalis</i>	western rockjasmine	
	ANSE4	<i>Androsace septentrionalis</i>	pygmyflower rockjasmine	
Ranunculaceae	MYMI2	<i>Myosurus minimus</i>	tiny mousetail	
Rosaceae	DRFI3	<i>Drymocallis fissa</i>	bigflower cinquefoil	
	POCO13	<i>Potentilla concinna</i>	elegant cinquefoil	
	POHI6	<i>Potentilla hippiana</i>	woolly cinquefoil	
	POPE8	<i>Potentilla pensylvanica</i>	Pennsylvania cinquefoil	
	PRPU3	<i>Prunus pumila</i>	sandcherry	
	ROAC	<i>Rosa acicularis</i>	prickly rose	
	ROAR3	<i>Rosa arkansana</i>	prairie rose	
Scrophulariaceae	CASE5	<i>Castilleja sessiliflora</i>	downy paintedcup	
	PEAN4	<i>Penstemon angustifolius</i>	broadbeard beardtongue	
	PEGR5	<i>Penstemon gracilis</i>	lilac penstemon	
	VEPE2	<i>Veronica peregrina</i>	neckweed	
	VETH	<i>Verbascum thapsus</i>	common mullein	*
Selaginellaceae	SEDE2	<i>Selaginella densa</i>	lesser spikemoss	
Solanaceae	PHLO4	<i>Physalis longifolia</i>	longleaf groundcherry	
	PHVI5	<i>Physalis virginiana</i>	Virginia groundcherry	
	SOTR	<i>Solanum triflorum</i>	cutleaf nightshade	
Unknown family	UNKFORB	Unknown forb	unknown forb	*
	UNKFORBANN	Unknown annual forb	unknown annual forb	*
	UNKFORBPER	Unknown perennial forb	unknown perennial forb	*
Verbenaceae	VEBR	<i>Verbena bracteata</i>	bigbract verbena	
	VEST	<i>Verbena stricta</i>	hoary verbena	
Violaceae	VIAD	<i>Viola adunca</i>	hookedspur violet	
	VINU2	<i>Viola nuttallii</i>	Nuttall's violet	
	VIOLA	<i>Viola</i> sp.	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 108/128104, March 2015

National Park Service
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