



Plant Community Composition and Structure Monitoring for Devils Tower National Monument

2014 Annual Report

Natural Resource Data Series NPS/NGPN/NRDS—2015/772



ON THE COVER

Long-term monitoring plot PCM-260 at Devils Tower National Monument, 2014
Photograph courtesy of the National Park Service

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The National Park Service, Natural Resource Stewardship and Science office in Fort Collins, Colorado, publishes a range of reports that address natural resource topics. These reports are of interest and applicability to a broad audience in the National Park Service and others in natural resource management, including scientists, conservation and environmental constituencies, and the public.

The Natural Resource 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.

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Abstract

This report presents the results of vegetation monitoring efforts in 2014 at Devils Tower National Monument (DETO) 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 DETO. 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. NGPN staff captured data relating to species richness, herb-layer height, abundance of individual native and non-native species, ground cover, and site disturbance on each of the eight plots.

Our 2014 findings can be summarized as follows: The crew observed 171 vascular plant species in upland plots, with an average of 7.1 native species occurring within any given 1 m² quadrat sampled. Grasses and forbs made up the bulk of the plant cover. Non-native species were abundant, averaging about 28.6% of cover. Generally, the upland areas seem to be in better condition than riparian areas, with greater native species diversity and lower exotic cover.

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 DETO, particularly R. Ohms and law enforcement staff for providing logistical support, safety checks, and secure shelter during a tornado warning. Thank you to T. Mayes, J. Balmagia, M. Chapman, and A. Hammesfahr from DETO for help in the field. Thanks to the Northern Great Plains Fire Effects crew of D. Swanson, E. Watson, and W. Watson for collecting tree, seedling, and fuel data at one plot. With the assistance of the aforementioned, the 2014 NGPN vegetation field crew of M. Prowatzke, S. Rockwood, D. Pinigis, and L. Mickelson collected all the data included in this report.

Introduction

The Black Hills is a 1.5 million hectare refuge of ponderosa pine (*Pinus ponderosa*) forest surrounded by the prairies of western South Dakota and eastern Wyoming. The ponderosa pine forest of 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 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 and fire, that have historically maintained ponderosa woodlands, 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 of ponderosa woodlands because it can provide information on environmental quality and condition, benchmarks of ecological integrity, and early warning of declines in ecosystem health.

Devils Tower National Monument (DETO) was established in 1906 as the first National Monument with a mission to protect and preserve the impressive rock tower and the lands around it. It is located in northeastern Wyoming on the edge of the Black Hills. The vegetation is a mosaic of ponderosa pine woodlands and mixed-grass prairie with a narrow riparian corridor of cottonwoods. The prevalence of exotic species in the park, changes in ponderosa pine density due to historic fire suppression, and the lack of cottonwood regeneration are of concern to park management and result in a fairly poor overall condition of native plant communities in the park (Komp et al. 2011). The Northern Great Plains Inventory & Monitoring Program (NGPN) began vegetation monitoring at DETO in 2011 (Ashton et al. 2012). Vegetation monitoring protocols and plot locations were chosen to represent the entire park and to coordinate efforts with the Northern Great Plains Fire Ecology Program (FireEP). The long-term objectives of the NGPN and FireEP plant community monitoring effort (Symstad et al. 2012b) in DETO 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 and long-term trends of tree density by species, height class, and diameter class, and of fuel loads by fuel classes.
3. Determine status (at 5-year intervals) and long-term trends of tree density by species, height class, and diameter class in lowland areas near targeted perennial streams.
4. 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 fourth year of sampling efforts at DETO, in 2014. NGPN visited eight plots (Figure 1). Not all plots are visited every year, and it will take one more year to visit every plot in the park twice. 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.

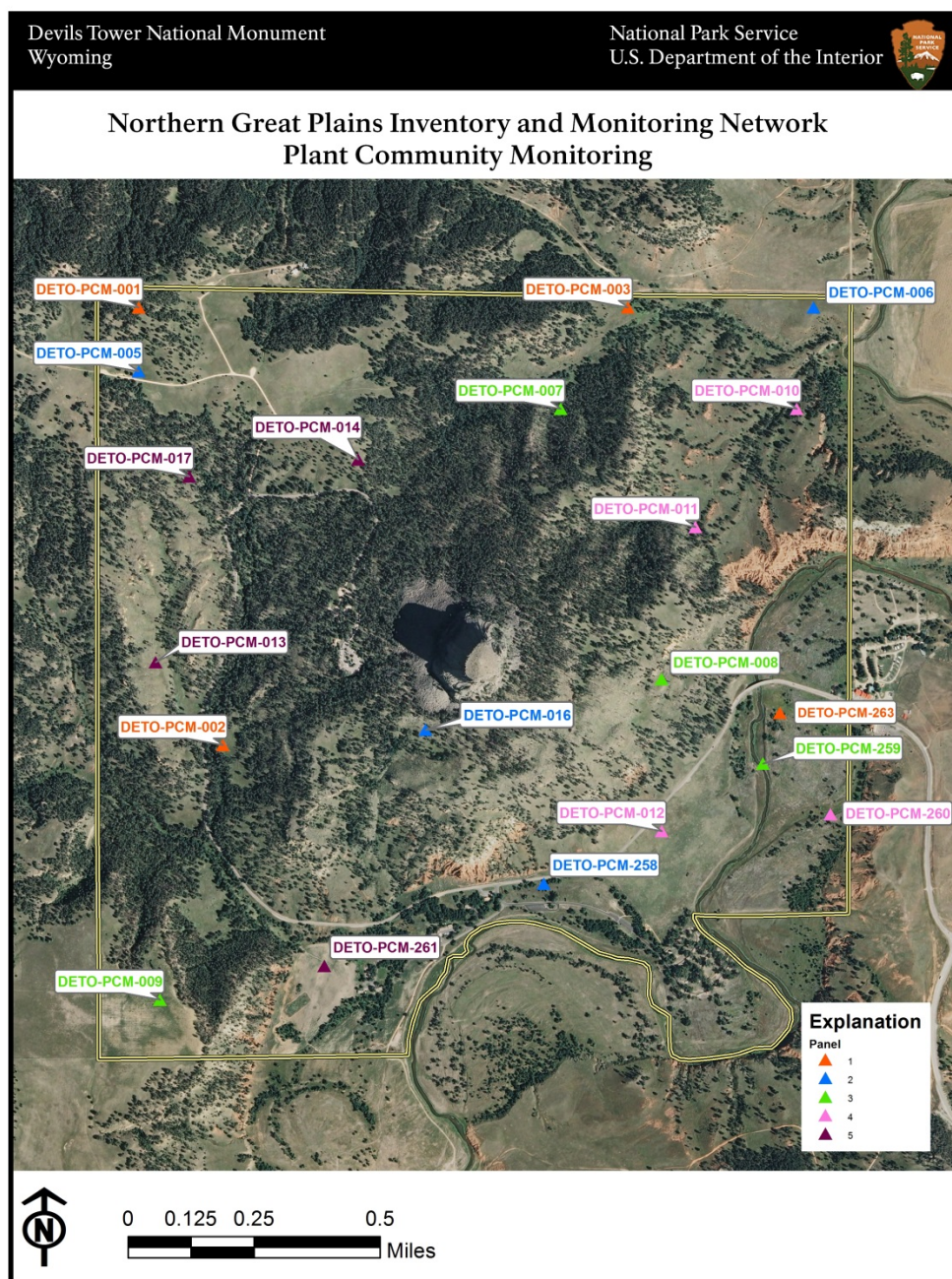


Figure 1. Map of Devils Tower National Monument (DETO) and plant community monitoring (PCM) plots. Plots in panel 3 (green) and panel 4 (pink) were visited in 2014.

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 DETO 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 DETO (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. This year, we visited sites in panel 3 and panel 4 during the last week of June (Figure 1). 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.

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 DETO took a 4-person crew approximately 168.25 hours with travel time, plus 3.75 hours from the fire effects crew, and 37.5 hours of assistance from DETO staff, for a total of 209.5 hours (see Appendix A for a detail of activities each day).

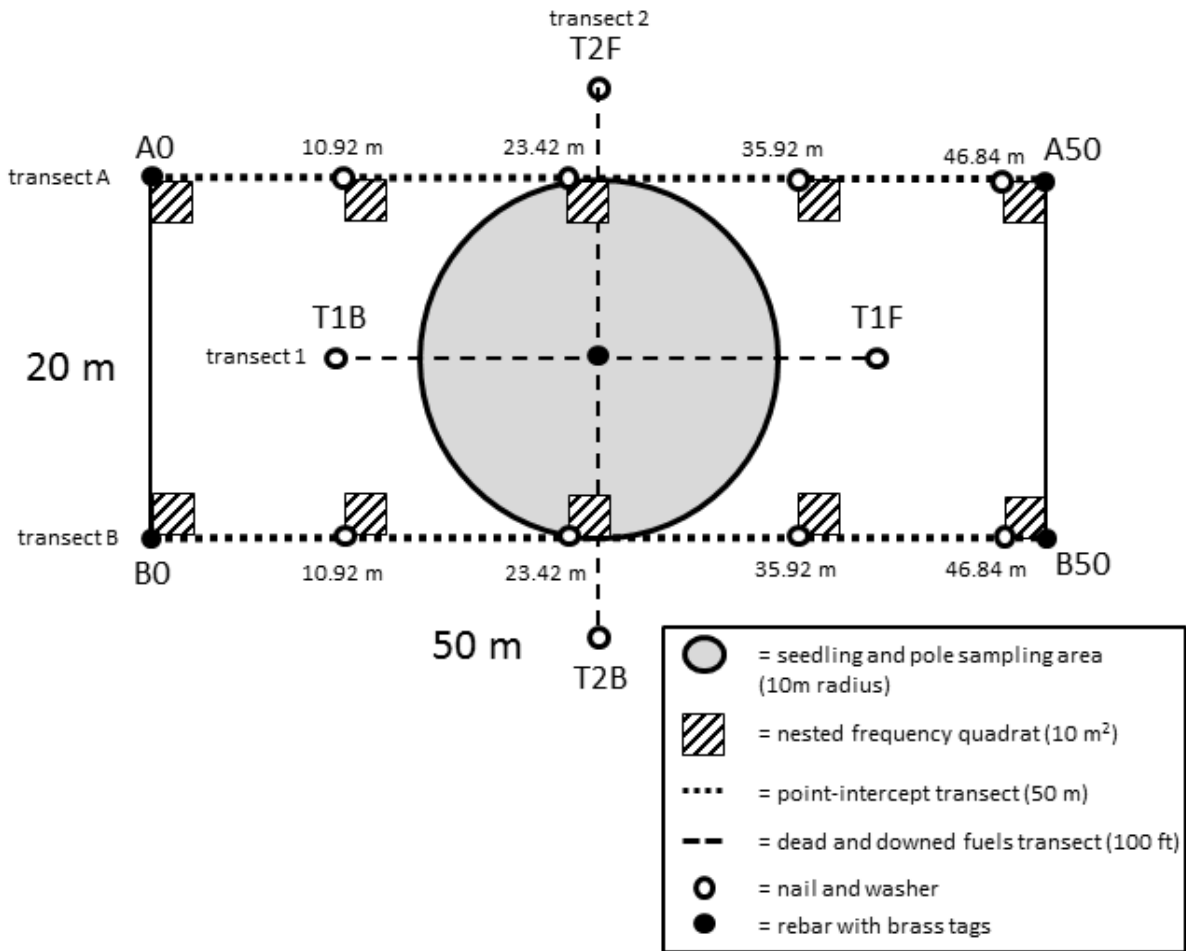


Figure 2. Long-term monitoring plot layout used for sampling vegetation in Devils Tower National Monument.

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, are mapped and tagged. For each tree, the species, DBH, status, and condition (e.g., leaf-discoloration, insect-damaged, etc.) are recorded. In ponderosa pine woodlands, dead and downed woody fuel load data were collected on two perpendicular 100 ft (30.48 m) transects centered at the center of the plot (Figure 2).

Common disturbances and target species of interest were also assessed and documented in all plots visited. Common disturbances included such things as roads, rodent mounds, animal trails, and fire. In all plots, the type, severity, and approximate area (m²) 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 Wyoming, and which may potentially occur in DETO (Table 2).

Table 1. Exotic species surveyed for at Devils Tower National Monument 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 Devils Tower National Monument.

Scientific Name	Common Name
<i>Asclepias verticillata</i>	whorled milkweed
<i>Carex alopecoidea</i>	foxtail sedge
<i>Carex emoryi</i>	Emory's sedge
<i>Diaperia prolifera</i>	bighead pygmy cudweed
<i>Dichanthelium wilcoxianum</i>	fall rosette grass
<i>Elymus villosus</i>	hairy wildrye
<i>Glandularia bipinnatifida</i>	Dakota (mock) vervain
<i>Helianthemum bicknellii</i>	hoary frostweed
<i>Oenothera laciniata</i>	cutleaf evening primrose
<i>Polystichum lonchitis</i>	holly fern
<i>Verbesina encelioides</i>	cowpen crownbeard

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.

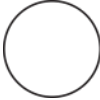
Reporting on Natural Resource Condition

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 case, 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

Devils Tower National Monument experienced slightly above average precipitation levels in 2014

(<http://www.ncdc.noaa.gov/cdo-web/datasets/GHCND/stations/GHCND:USC00484760/detail>; Figure 3).

At the time of NGPN's visit, precipitation for the year was very close to average, though severe storms dropped several inches of rain during our visit.

Average canopy cover was 161% (Table 4) in 2014, which was an relative increase of 19% over the previous year (Ashton and Prowatzke 2014). There was a large amount of litter on the ground with ground cover at the sites averaging 81% plant litter.

We found 171 plant species in 2014 at DETO (Appendix B). Graminoids, which includes grasses, sedges, and rushes, accounted for most of the vegetative cover at DETO, but forbs were also abundant. Only a few shrubs, trees, and vines were found in the plots this year (Figure 4). We found 32 exotic species at the park, all of which were either forbs or graminoids. No exotic target species were found at any sites in 2014. The shrubs, subshrubs, trees, and vines were all native species. Oregon grape (*Berberis repens*) was the only subshrub we recorded in the park. It was found at only one site (PCM-007) where it accounted for a large proportion of the plant cover.

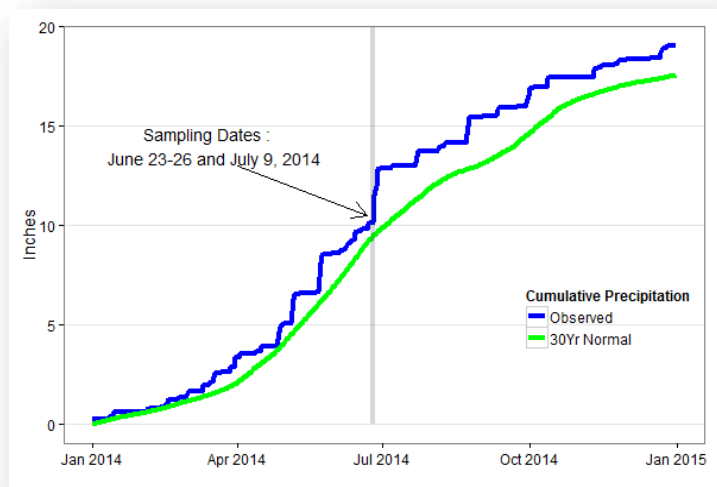


Figure 3. Observed and 30-year (1981-2010) normal precipitation near Devils Tower National Monument. Timing of NGPN visit is shown by vertical gray bar.

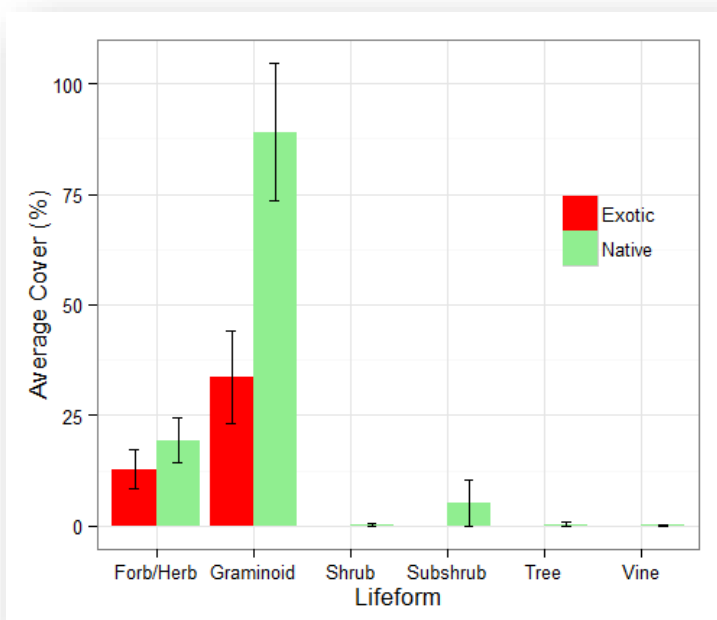


Figure 4. Average cover by lifeform and nativity in eight plant community monitoring plots in Devils Tower National Monument in 2014. Native (green) and exotic (red) graminoids were the most abundant lifeform across the plots. Bars represent means $\pm$ standard errors.

There was considerable variation in species composition across the eight sites. Most of the plots were in grasslands, though two (PCM-010 and PCM-011) fell in a young pine “savannah”, and PCM-007 was in a mature pine forest. PCM-012 was in a prairie dog town. The most common species on the transect lines were graminoids (Figure 5). The native Western wheatgrass (*Pascopyrum smithii*) was found in every plot, while non-native Kentucky bluegrass (*Poa pratensis*) was found in all plots except the one in the prairie dog town.

We did not find any rare species in the park, despite revisiting two sites at which rare species were reported in 2013. However, this may be a case of mistaken identity rather than a loss of rare species. Specifically, whorled milkweed (*Asclepias verticillata*) had been reported in 2013 at PCM-007 and PCM-008. In 2014, the similar slimleaf milkweed (*A. stenophylla*) was identified at PCM-008 in its place, and plains milkweed (*A. pumila*) was identified at PCM-007. The differences between *A. verticillata* and *A. pumila* are usually quite subtle, and they have been documented to be especially similar within DETO (Heidel and Marriott 2014). The other rare species reported in 2013 was Emory’s sedge (*Carex emoryi*), found along the riverbanks at site PCM-259; this year, the superficially similar and common woolly sedge (*C. pellita*) was identified in this location. Definitive voucher collections should be made in the future when the plants are in full flowering and/or fruiting stages to determine which of these species is actually present.

Table 4. Natural resource condition summary table for plant communities in Devils Tower National Monument (DETO).

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	161 $\pm$ 14.4%	TBD ⁽¹⁾		The park is characterized by moderate native species richness. Half of the sites had a native diversity within the natural range of variability. Upland plots average at the low end of the range, while riparian areas lag far below. 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.
	Native species richness (based on average of 10 1m ² quadrats per plot)	7.1 $\pm$ 1.0 species	8-18 species ⁽²⁾		
	Evenness (based on point-intercept of 2-50m transects per plot)	0.73 $\pm$ 0.03	TBD ⁽¹⁾		
Exotic Plant Early Detection and Management	Relative cover of exotic species	28.6 $\pm$ 7.1%	$\leq$ 10 % cover		In general, the sites in DETO had a high cover of exotic species. Two of the eight sites had $\leq$ 10% cover. Kentucky bluegrass was the most widespread and abundant exotic species. Leafy spurge was also common, but it was found in low abundance.
	Annual brome cover	1.5 $\pm$ 0.9%	$\leq$ 10 % cover		

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.

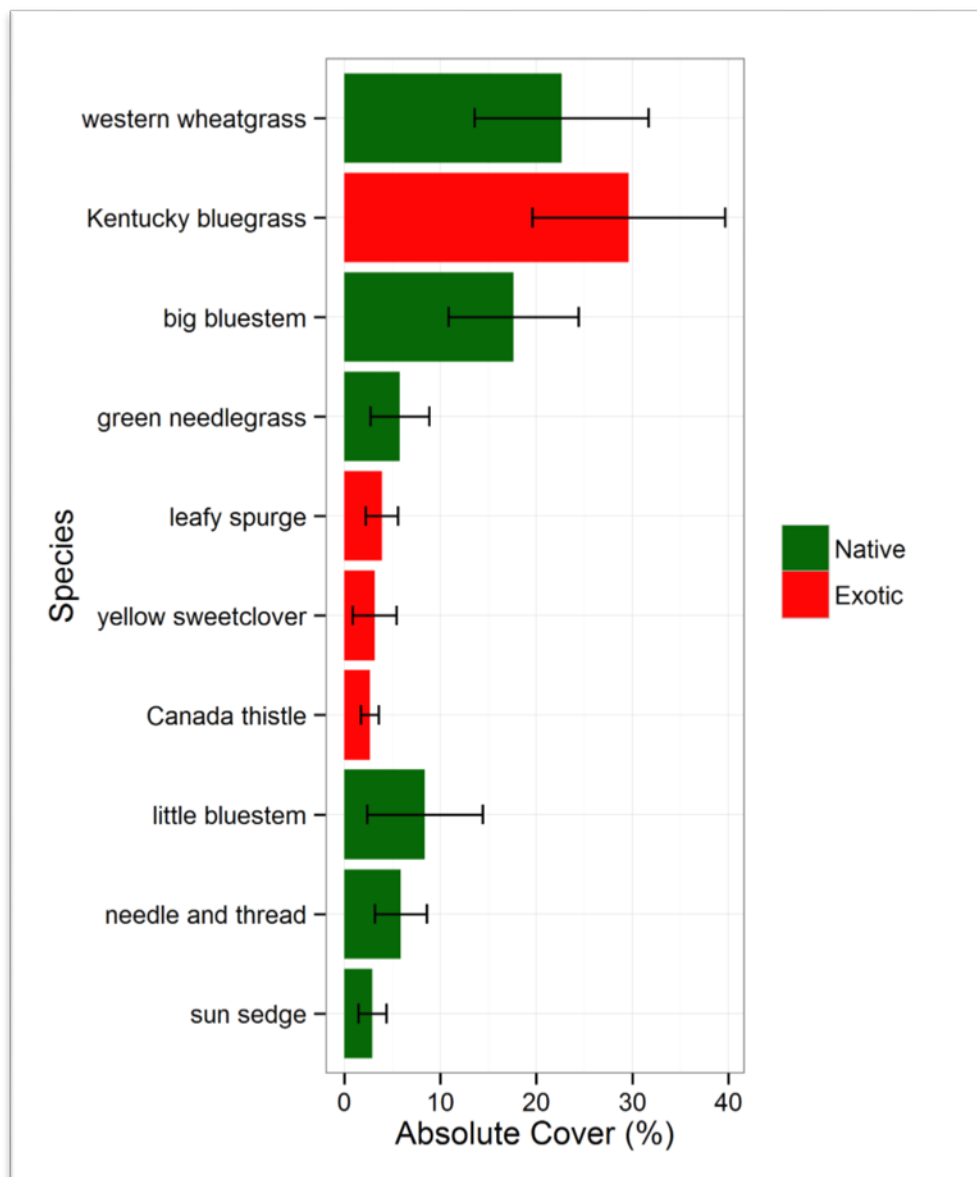


Figure 5. The average absolute cover of the 10 most common native (green) and exotic (red) plants recorded at Devils Tower National Monument in 2014. Bars represent means $\pm$ standard errors.

Average species richness at each of the eight plots was measured by point-intercept and in 1 m² and 10 m² quadrats (Table 5). On average, there are about three exotic species within the 1 m² quadrat (Table 5). From the point-intersect data, we found average plot diversity, H' , to be 2.2 ± 0.13 . Evenness, J' , averaged 0.73 ± 0.03 across the plots (Table 4). When including only native species, average diversity and evenness were 1.9 ± 0.1 and 0.72 ± 0.02 , respectively.

Table 5. Average plant species richness in eight plots at Devils Tower National Monument in 2014. Values represent means $\pm$ standard errors, $n=8$.

	Point-intercept	1 m ² quadrats	10 m ² quadrats
Species richness	21 $\pm$ 1.6	10 $\pm$ 0.8	17 $\pm$ 1.2
Native species richness	15 $\pm$ 1.0	7 $\pm$ 1.0	12 $\pm$ 1.5
Exotic species richness	6 $\pm$ 1.0	3 $\pm$ 0.4	5 $\pm$ 0.7
Graminoid species richness	9 $\pm$ 0.7	4 $\pm$ 0.4	6 $\pm$ 0.4
Forb species richness	11 $\pm$ 1.6	5 $\pm$ 0.6	10 $\pm$ 1.0

While there was some variation across sites, the upland plots we visited in DETO tended to have a moderate diversity of native plants and the riparian plots 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). 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 in a moderately grazed site in Montana ranged between 8 and 18 species per square meter (10-90th percentile range) between 1933-1945 (Symstad and Jonas 2014). 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, DETO is slightly below the natural range (Table 4).

However, when examined separately, the upland plots' average lies within the natural range. The highest diversity was seen in site PCM-012, which lies within a prairie dog town. Native diversity lagged in the riparian plots which averaged four native species per square meter (Table 6).

The average relative cover of exotic species at sites in DETO was high ($29 \pm 7\%$; Table 4).

However, like species richness, cover of exotic species varied considerably among sites (Table

6). PCM-010 and PCM-012 had exotic cover below 5%, whereas PCM-007 had exotic cover of 62%. In most cases, the ubiquitous Kentucky bluegrass formed the majority of the exotic cover, but other exotics such as leafy spurge, yellow sweetclover, and Canada thistle were also abundant (Figure 5). We did not find any of the exotic early detection species (Table 1) in the park.



Figure 6. Yellow sweetclover and leafy spurge were abundant at PCM-008. Yellow sweetclover flourished throughout the entire Northern Great Plains region in 2014.

Table 6. Characteristics of the plant community at eight plots in Devils Tower National Monument in 2014 including average cover of annual bromes and Kentucky bluegrass, exotic plant cover, and area of disturbance.

Plot	Native species richness per m ²	Exotic cover (%)	Annual brome cover (%)	Kentucky blue-grass cover (%)	Disturbance within site (m ²)
Upland					
PCM-007	5	62	1	49	1005
PCM-008	10	33	1	12	2290
PCM-009	7	20	0	16	0
PCM-010	8	4	0	4	40
PCM-011	8	29	0	19	2290
PCM-012	12	2	0	0	2290
<i>Upland Average</i>	8 ± 1.0	25 ± 9.1	0 ± 0.1	17 ± 7.0	-
Riparian					
PCM-259	4	43	5	22	2290
PCM-260	4	34	6	22	2330
<i>Riparian Average</i>	4 ± 0.1	39 ± 4.7	5 ± 0.2	22 ± 0.1	-
<i>Park Average</i>	7 ± 1.0	29 ± 7.1	1.5 ± 0.9	18 ± 5.2	-

Disturbance from grazing, prairie dogs, fire, insects, and humans affects plant community structure and composition in mixed-grass prairie and ponderosa pine forests. 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 fire, but there was also evidence of herbicide spraying and associated ATV tracks, prairie dogs, animal trails, and mountain pine beetles. With this small sample size, we found no correlation with disturbance and native richness or exotic cover.

Live trees and seedlings were present in three of the eight sites we visited in 2014. A more thorough assessment of forest structure was completed in 2013 (Ashton et al. 2014); however, the 2014 data provide a snapshot of condition at a subset of the plots. Two tree species and one tall shrub species were found in upland plots (Table 7). The highest density of pine seedlings was found at PCM-007, a plot located in mature woods. The highest density of pine trees was found at PCM-011; however, this plot had no live pine seedlings in their second year or greater. (NGPN only counts seedlings in second year and above due to high mortality in first year seedlings.) This lack of seedlings is likely a residual effect of the Belle Fourche prescribed fire in 2013, and it is extremely likely that pine seedlings will return to this site soon. In 2018, NGPN is scheduled to repeat the thorough assessment of forest structure, fuel loads, and health.

Table 7. Seedling, pole, and tree densities at three plots in Devils Tower National Monument in 2014.

Plot	Seedling Density (seedlings/hectare)			Tree Density (trees/hectare)		
	Pine	Bur oak	Chokecherry	Pine poles	Pine trees	Bur oak trees
PCM_0007	3024				130	10
PCM_0010	159	32			100	
PCM_0011			95	127	380	

Summary

The ponderosa pine woodlands, mixed-grass prairie, and riparian plant communities within the boundaries of DETO are characterized by low to moderate native species richness. The riparian areas generally maintain a lower species richness and higher exotic cover than the upland areas. To retain ecological integrity it is important to continue efforts to reduce the cover of invasive plants.

Kentucky bluegrass presents a potential challenge to DETO management because it is so abundant, and more research on the consequences of the invasion is needed. Annual bromes are an emerging threat in DETO, and keeping them in low abundance will help maintain native plant diversity.

Continued monitoring efforts will be critical to track changes in the condition of the vegetation communities in DETO.

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

Plant community composition monitoring in Devil's Tower National Monument was completed using a crew of four people working four 10-hour days. Additionally, 8.25 hours of overtime were incurred. The fire effects crew finished one of the plots at a later date, spending 1.25 hours for a crew of three. Four DETO employees supplemented the crews for a 1-1.5 days, totaling 37.5 hours. Total hours worked were 209.5.

Date	Day of week	Approximate Travel Time (hrs)	Housing	Sites Completed
June 23, 2014	Monday	2	DETO Belle Fourche Campground	PCM-008
June 24, 2014	Tuesday	N/A	DETO Belle Fourche Campground	PCM-009 PCM-259 PCM-260
June 25, 2014	Wednesday	N/A	DETO Belle Fourche Campground	PCM-010 PCM-011
June 26, 2014	Thursday	2	N/A	PCM-012 PCM-007 (except trees, seedlings, fuels)
July 9, 2014	Wednesday	N/A	N/A	PCM-007 (tree, seedling, fuel data collected by Fire Effects crew)

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

Family	Code	Scientific Name	Common Name	Exotic
Apiaceae	LOOR	<i>Lomatium orientale</i>	Northern Idaho biscuitroot	
Asclepiadaceae	ASPU	<i>Asclepias pumila</i>	plains milkweed	
	ASSP	<i>Asclepias speciosa</i>	showy milkweed	
	ASST	<i>Asclepias stenophylla</i>	slimleaf milkweed	
	ASVI	<i>Asclepias viridiflora</i>	green comet milkweed	
Asteraceae	ACMI2	<i>Achillea millefolium</i>	common yarrow	
	AGPA14	<i>Agoseris parviflora</i>	false agoseris	
	AMPS	<i>Ambrosia psilostachya</i>	Cuman ragweed	
	ANPA4	<i>Antennaria parvifolia</i>	small-leaf pussytoes	
	ARCA13	<i>Artemisia cana</i>	silver sagebrush	
	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	*
	CIFL	<i>Cirsium flodmanii</i>	Flodman's thistle	
	CIRSI	<i>Cirsium</i> sp.	thistle	*
	CIVU	<i>Cirsium vulgare</i>	bull thistle	*
	COCA5	<i>Conyza canadensis</i>	Canadian horseweed	
	ECAN2	<i>Echinacea angustifolia</i>	blacksamson echinacea	
	ERCA4	<i>Erigeron canus</i>	hoary fleabane	
	ERST3	<i>Erigeron strigosus</i>	prairie fleabane	
	GRSQ	<i>Grindelia squarrosa</i>	curlycup gumweed	
	HEAN3	<i>Helianthus annuus</i>	common sunflower	
	HEVI4	<i>Heterotheca villosa</i>	hairy false goldenaster	
	LASE	<i>Lactuca serriola</i>	prickly lettuce	*
	LIPU	<i>Liatris punctata</i>	dotted blazing star	
	LYJU	<i>Lygodesmia juncea</i>	rush skeletonplant	
	ONAC	<i>Onopordum acanthium</i>	Scotch cottonthistle	*
	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	
	SYFA	<i>Symphotrichum falcatum</i>	white prairie aster	

Asteraceae	SYLA3	<i>Symphotrichum laeve</i>	smooth blue 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	
	XAST	<i>Xanthium strumarium</i>	rough cocklebur	
Berberidaceae	BERE	<i>Berberis repens</i>	Oregon grape	
Boraginaceae	CYOF	<i>Cynoglossum officinale</i>	gypsyflower	*
	LAOC3	<i>Lappula occidentalis</i>	flatspine stickseed	
	LIIN2	<i>Lithospermum incisum</i>	narrowleaf stoneseed	
	MELA3	<i>Mertensia lanceolata</i>	prairie bluebells	
Brassicaceae	ALDE	<i>Alyssum desertorum</i>	desert madwort	*
	ARPY4	<i>Arabis pycnocarpa</i>	creamflower rockcress	
	DEPI	<i>Descurainia pinnata</i>	western tansymustard	
	DESO2	<i>Descurainia sophia</i>	herb sophia	*
	DRRE2	<i>Draba reptans</i>	Carolina draba	
	SIAL2	<i>Sisymbrium altissimum</i>	tall tumbledmustard	*
	THAR5	<i>Thlaspi arvense</i>	field pennycress	*
Cactaceae	OPFR	<i>Opuntia fragilis</i>	brittle pricklypear	
	OPMA2	<i>Opuntia macrorhiza</i>	twistspine pricklypear	
Campanulaceae	CARO2	<i>Campanula rotundifolia</i>	bluebell bellflower	
Caprifoliaceae	SYOC	<i>Symphoricarpos occidentalis</i>	western snowberry	
Caryophyllaceae	CEAR4	<i>Cerastium arvense</i>	field chickweed	
	SIAN2	<i>Silene antirrhina</i>	sleepy silene	
Chenopodiaceae	CHDE	<i>Chenopodium desiccatum</i>	aridland goosefoot	
	SATR12	<i>Salsola tragus</i>	prickly Russian thistle	*
Commelinaceae	TROC	<i>Tradescantia occidentalis</i>	prairie spiderwort	
Convolvulaceae	COAR4	<i>Convolvulus arvensis</i>	field bindweed	*
Cucurbitaceae	ECLO	<i>Echinocystis lobata</i>	wild cucumber	
Cyperaceae	CABA3	<i>Carex backii</i>	Back's sedge	
	CADU6	<i>Carex duriuscula</i>	needleleaf sedge	
	CAFI	<i>Carex filifolia</i>	threadleaf sedge	
	CAHO5	<i>Carex hoodii</i>	Hood's sedge	
	CAIN9	<i>Carex inops</i>	long-stolon sedge	
	CAPE42	<i>Carex pellita</i>	woolly sedge	
	CAREX	<i>Carex</i> sp.	sedge	

Cyperaceae	CARO5	<i>Carex rossii</i>	Ross' sedge	
	CASP7	<i>Carex sprengelii</i>	Sprengel's sedge	
	CAUT	<i>Carex utriculata</i>	Northwest Territory sedge	
	ELPA3	<i>Eleocharis palustris</i>	common spikerush	
Equisetaceae	EQLA	<i>Equisetum laevigatum</i>	smooth horsetail	
Euphorbiaceae	EUES	<i>Euphorbia esula</i>	leafy spurge	*
	EUSP	<i>Euphorbia spathulata</i>	warty spurge	
Fabaceae	ACAM99	<i>Acmispon americanus</i>	American bird's-foot trefoil	
	ASAG2	<i>Astragalus agrestis</i>	purple milkvetch	
	ASCR2	<i>Astragalus crassicaulus</i>	groundplum milkvetch	
	ASFL2	<i>Astragalus flexuosus</i>	flexile milkvetch	
	ASLA27	<i>Astragalus laxmannii</i>	Laxmann's milkvetch	
	ASMI10	<i>Astragalus missouriensis</i>	Missouri milkvetch	
	DACA7	<i>Dalea candida</i>	white prairie clover	
	DAPU5	<i>Dalea purpurea</i>	purple prairie clover	
	LAPO2	<i>Lathyrus polymorphus</i>	manystem pea	
	MELU	<i>Medicago lupulina</i>	black medick	*
	MEOF	<i>Melilotus officinalis</i>	yellow sweetclover	*
	OXLA3	<i>Oxytropis lambertii</i>	purple locoweed	
	OXSE	<i>Oxytropis sericea</i>	white locoweed	
	PEAR6	<i>Pedimelum argophyllum</i>	silverleaf Indian breadroot	
	PEES	<i>Pedimelum esculentum</i>	large Indian breadroot	
	PSLA3	<i>Psoralea lanceolata</i>	lemon scurfpea	
	THRH	<i>Thermopsis rhombifolia</i>	prairie thermopsis	
	VIAM	<i>Vicia americana</i>	American vetch	
Fagaceae	QUMA2	<i>Quercus macrocarpa</i>	bur oak	
Grossulariaceae	RIOX	<i>Ribes oxycanthoides</i>	Canadian gooseberry	
Hydrophyllaceae	PHLI	<i>Phacelia linearis</i>	threadleaf phacelia	
Iridaceae	SIMO2	<i>Sisyrinchium montanum</i>	strict blue-eyed grass	
Lamiaceae	HEDR	<i>Hedeoma drummondii</i>	Drummond's false pennyroyal	
	HEHI	<i>Hedeoma hispida</i>	rough false pennyroyal	
	MEAR4	<i>Mentha arvensis</i>	wild mint	
	MOFI	<i>Monarda fistulosa</i>	wild bergamot	
	NECA2	<i>Nepeta cataria</i>	catnip	*
Liliaceae	ALTE	<i>Allium textile</i>	textile onion	
	CANU3	<i>Calochortus nuttallii</i>	sego lily	

Linaceae	LILE3	<i>Linum lewisii</i>	Lewis flax	
	LIRI	<i>Linum rigidum</i>	stiffstem flax	
Malvaceae	SPCO	<i>Sphaeralcea coccinea</i>	scarlet globemallow	
Melanthiaceae	TOVE2	<i>Toxicoscordion venenosum</i>	meadow deathcamas	
Nyctaginaceae	MILI3	<i>Mirabilis linearis</i>	narrowleaf four o'clock	
Oleaceae	FRPE	<i>Fraxinus pennsylvanica</i>	green ash	
Onagraceae	OESU99	<i>Oenothera suffrutescens</i>	scarlet beeblossom	
Oxalidaceae	OXST	<i>Oxalis stricta</i>	common yellow oxalis	
Pinaceae	PIPO	<i>Pinus ponderosa</i>	ponderosa pine	
Plantaginaceae	PLPA2	<i>Plantago patagonica</i>	woolly plantain	
Poaceae	AGCR	<i>Agropyron cristatum</i>	crested wheatgrass	*
	AGSC5	<i>Agrostis scabra</i>	rough bentgrass	
	ANGE	<i>Andropogon gerardii</i>	big bluestem	
	ARPU9	<i>Aristida purpurea</i>	purple threeawn	
	BOCU	<i>Bouteloua curtipendula</i>	sideoats grama	
	BODA2	<i>Bouteloua dactyloides</i>	buffalograss	
	BOGR2	<i>Bouteloua gracilis</i>	blue 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	
	ELCA4	<i>Elymus canadensis</i>	Canada wildrye	
	ELRE4	<i>Elymus repens</i>	quackgrass	*
	ELTR7	<i>Elymus trachycaulus</i>	slender wheatgrass	
	FEID	<i>Festuca idahoensis</i>	Idaho fescue	
	HECO26	<i>Hesperostipa comata</i>	needle and thread	
	HESP11	<i>Hesperostipa spartea</i>	porcupinegrass	
	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	
	NAVI4	<i>Nassella viridula</i>	green needlegrass	
	PASM	<i>Pascopyrum smithii</i>	western wheatgrass	
	PHAR3	<i>Phalaris arundinacea</i>	reed canarygrass	
	PIMI7	<i>Piptatherum micranthum</i>	littleseed ricegrass	
	POBU	<i>Poa bulbosa</i>	bulbous bluegrass	*

Poaceae	POPR	<i>Poa pratensis</i>	Kentucky bluegrass	*
	SCSC	<i>Schizachyrium scoparium</i>	little bluestem	
	SPCR	<i>Sporobolus cryptandrus</i>	sand dropseed	
	THIN6	<i>Thinopyrum intermedium</i>	intermediate wheatgrass	*
	VUOC	<i>Vulpia octoflora</i>	sixweeks fescue	
Polemoniaceae	COLI2	<i>Collomia linearis</i>	tiny trumpet	
	PHHO	<i>Phlox hoodii</i>	spiny phlox	
Polygalaceae	POAL4	<i>Polygala alba</i>	white milkwort	
Polygonaceae	POAV	<i>Polygonum aviculare</i>	prostrate knotweed	*
	RUCR	<i>Rumex crispus</i>	curly dock	*
Primulaceae	ANOC2	<i>Androsace occidentalis</i>	western rockjasmine	
Ranunculaceae	ANCY	<i>Anemone cylindrica</i>	candle anemone	
	ANPA19	<i>Anemone patens</i>	eastern pasqueflower	
Rosaceae	PRVI	<i>Prunus virginiana</i>	chokecherry	
Rubiaceae	GAAP2	<i>Galium aparine</i>	stickywilly	
	GABO2	<i>Galium boreale</i>	northern bedstraw	
Salicaceae	PODE3	<i>Populus deltoides</i>	eastern cottonwood	
Scrophulariaceae	PEAL2	<i>Penstemon albidus</i>	white penstemon	
	PEGR5	<i>Penstemon gracilis</i>	lilac penstemon	
	PEGR7	<i>Penstemon grandiflorus</i>	large beardtongue	
	SYWY99	<i>Synthyris wyomingensis</i>	Wyoming kittentails	
	VEPE2	<i>Veronica peregrina</i>	neckweed	
	VETH	<i>Verbascum thapsus</i>	common mullein	*
Solanaceae	PHHE5	<i>Physalis heterophylla</i>	clammy groundcherry	
	SOTR	<i>Solanum triflorum</i>	cutleaf nightshade	
Unknown family	UNKFORB	Unknown forb	unknown forb	*
	UNKFORBANN	Unknown annual forb	unknown annual forb	*
	UNKGRAMPER	Unknown perennial graminoid	unknown perennial graminoid	*
Verbenaceae	VEBR	<i>Verbena bracteata</i>	bigbract verbena	
Violaceae	VIAD	<i>Viola adunca</i>	hookedspur 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.

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