



Plant Community Composition and Structure Monitoring for Devils Tower National Monument

2011-2015 Summary Report

Natural Resource Report NPS/NGPN/NRR—2016/1207



ON THE COVER

Long-term monitoring plot PCM-013 at Devils Tower National Monument, 2015
Photograph courtesy of the National Park Service

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Executive Summary

The Northern Great Plains Inventory & Monitoring Program and Fire Effects Program have been monitoring vegetation in Devils Tower National Monument (DETO) for over 18 years. While methods have changed slightly, this report summarizes data from 57 locations from 1998 to 2015. Below, we list the questions we asked and provide a summarized answer. For more details see the full report. A summary of the current condition (2011-2015) and trends (based on 1988-2015) in plant communities at DETO is found in the natural resource condition table below.

1. What is the current status of plant community composition and structure of DETO grasslands (species richness, cover, and diversity) and how has this changed from 1998 to 2015?

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. The highest plant species richness was found in the prairie dog town.

We found no significant trends in native diversity or evenness from 1998 to 2015, but both are threatened by the increasing cover of annual bromes. Annual bromes are an emerging threat in DETO, and keeping them in low abundance will help maintain native plant diversity. Other exotics, such as Kentucky bluegrass, are more prevalent, but there is no evidence of an increasing trend in their cover.

2. How do trends in grassland condition correlate with climate and fire history?

The large variability in DETO's climate makes it difficult to discern strong patterns linking temperature, precipitation, and plant community structure (e.g. exotic cover, diversity). Plant height increased in years with more total precipitation but we found no other significant relationship between climate and vegetation. A longer time series of vegetation data will make it easier to elucidate trends in the future.

DETO has been using prescribed burning as a management tool since the 1980s. We found that there was no difference in native diversity or exotic cover among plots that had burned recently and those that had not burned for longer time periods. This suggests that prescribed burning is not having a large effect on herbaceous vegetation in DETO.

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

We identified nine rare plant species in DETO between 1998 and 2015; eight of these are considered critically imperiled within Wyoming. These plants are found in such low abundance and in such few plots, it is unlikely that plant community monitoring will be able to detect any trends in rare plant abundance. We recommend more targeted surveys of rare plant species of concern be completed when funds are available.

Table E1. Natural resource condition summary table for plant communities in Devils Tower National Monument (DETO). Current values are based on data from 2011-2015 and trends are based on data from 1998-2015.

Indicator of Condition	Specific Measures	Current Value (mean $\pm$ SE)	Reference Condition and Data Source	Condition Status/Trend	Rationale for Resource Condition
Upland Plant Community Structure and Composition	Native species richness (1m ² quadrats)	6.5 $\pm$ 0.4	8-18 species		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 and average richness is below a natural range of variability (Symstad and Jonas 2014). The highest native diversity is found in the prairie dog town. The lowest diversity is found in the riparian areas. Native evenness has not changed since monitoring began in 1998.
	Evenness (point-intercept transects)	0.74 $\pm$ 0.01	To be determined		
Exotic Plant Early Detection and Management	Relative cover of exotic species	28.4 $\pm$ 2.3%	< 10 % cover		Many areas of DETO have a high cover of exotic species. Kentucky bluegrass is the most widespread and abundant invasive plant species. There is no evidence of an increasing or decreasing trend in total exotic cover or Kentucky bluegrass cover. While still in low abundance, annual brome cover has shown an increasing trend since 1998.
	Relative cover of annual bromes	2.4 $\pm$ 0.5%	< 10 % cover		
	Relative cover of Kentucky bluegrass	16.5 $\pm$ 1.5 %	< 10 % 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 for providing logistical support and safety checks. We also thank all the DETO staff that helped in the field over the years. The NGPN and NGPFire vegetation field crews collected all the data included in this report. We thank D. Swanson for providing data on fire history and A. Weaver for helping with the maps for this report. Comments from R. Ohms and J. Handley improved 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, fire, and floods, that have historically maintained ponderosa and cottonwood forests. In addition, there is the continual pressure of exotic invasive species. 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.

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). Vegetation monitoring began at DETO in 1997 by the Northern Great Plains Fire Ecology Program (NGPFire; Wienk et al. 2011). In 2011, the Northern Great Plains Inventory & Monitoring Network (NGPN) combined efforts with NGPFire to establish a coordinated vegetation monitoring protocol and plot locations were shifted to better represent the entire park (Symstad et al. 2012b). Combined sampling efforts began in 2011 (Ashton et al. 2012). In 2013, a large survey of forests within the park was completed by the two programs and results from that effort were published separately (Ashton et al. 2014). In this report, we use the data from 2011-2015 to assess the current condition of herbaceous park vegetation and the data from 1998-2015 are used to look at longer-term trends.

Using 18 years of plant community monitoring data in DETO, we explore the following questions:

1. What is the current status of plant community composition and structure of DETO herbaceous vegetation (species richness, exotic plant cover, and diversity) and how has this changed from 1998-2015?
2. How do trends in vegetation condition correlate with climate and fire history?
3. What, if any, rare plants were found in DETO long-term monitoring plots?

Methods

Two different methods and protocols have been used to monitor long-term vegetation plots at DETO since 1998: the NGPN monitoring protocol (Symstad et al. 2012b, a), and the Fire Monitoring Handbook (NPS 2003). Below, we briefly describe both methods, but focus on the NGPN monitoring protocol, which is the current standard and was used to collect most of the data in this report. For more detail on any of the methods, please see the protocol publications (cited above).

NGPN and NGPFire Monitoring Plots 2011-2015

The NGPN and NGPFire 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, NGPN selected 20 randomly located sites within DETO to become Plant Community Monitoring plots (PCM plots; Figure 1). The NGPN visits eight PCM plots every year using a rotating sampling scheme where four sites were visited in the previous year and four sites are new visits. Two of these sites each year are located in the riparian corridor. After five years (2011-2015), most of the PCM plots were visited at least twice during late June or July. When a PCM plot fell within an active burn unit, NGPFire added additional visits based on a 1, 2, 5, and 10 year sampling schedule. This happened eight times. NGPFire also established and monitored a number of new sites focused in active burn units (Fire FPCM plots) using the same GRTS sampling schema. From 2011-2015, 28 PCM plots and 6 FPCM plots were established.

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 and herb-layer (≤ 2 m) height and plant cover were collected on two 50 m transects (the long sides of the plot) using a point-intercept method (Figure 3). At 100 locations along the transects (every 0.5 m) a pole was dropped to the ground and all species that touched the pole were recorded, along with ground cover, and the height of the canopy (Figure 3). Using this method, absolute canopy cover can be greater than 100% (particularly in wet years and productive sites) because we record multiple layers of plants. Species richness data from the point-intercept method were supplemented in the 20 NGPN plots with species presence data collected in five sets of nested square quadrats (0.01 m², 0.1 m², 1 m², and 10 m²) located systematically along each transect (Figure 2).

When woody species were also present, tree regeneration and tall shrub density data were collected within a 10 m radius subplot centered in the larger 50 m x 20 m plot (Figure 2). Trees with diameter at breast height (DBH) > 15 cm, located within the entire 0.1 ha plot, were mapped and tagged. For each tree, the species, DBH, status, and condition (e.g., leaf-discoloration, insect-damaged, etc.) were recorded. Dead and downed woody fuel load data were collected at forested plots 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). These data are not reported here because they are included in past forest survey reports (Ashton et al. 2014) and will be included in subsequent reports that summarize the resurvey effort in 2018.

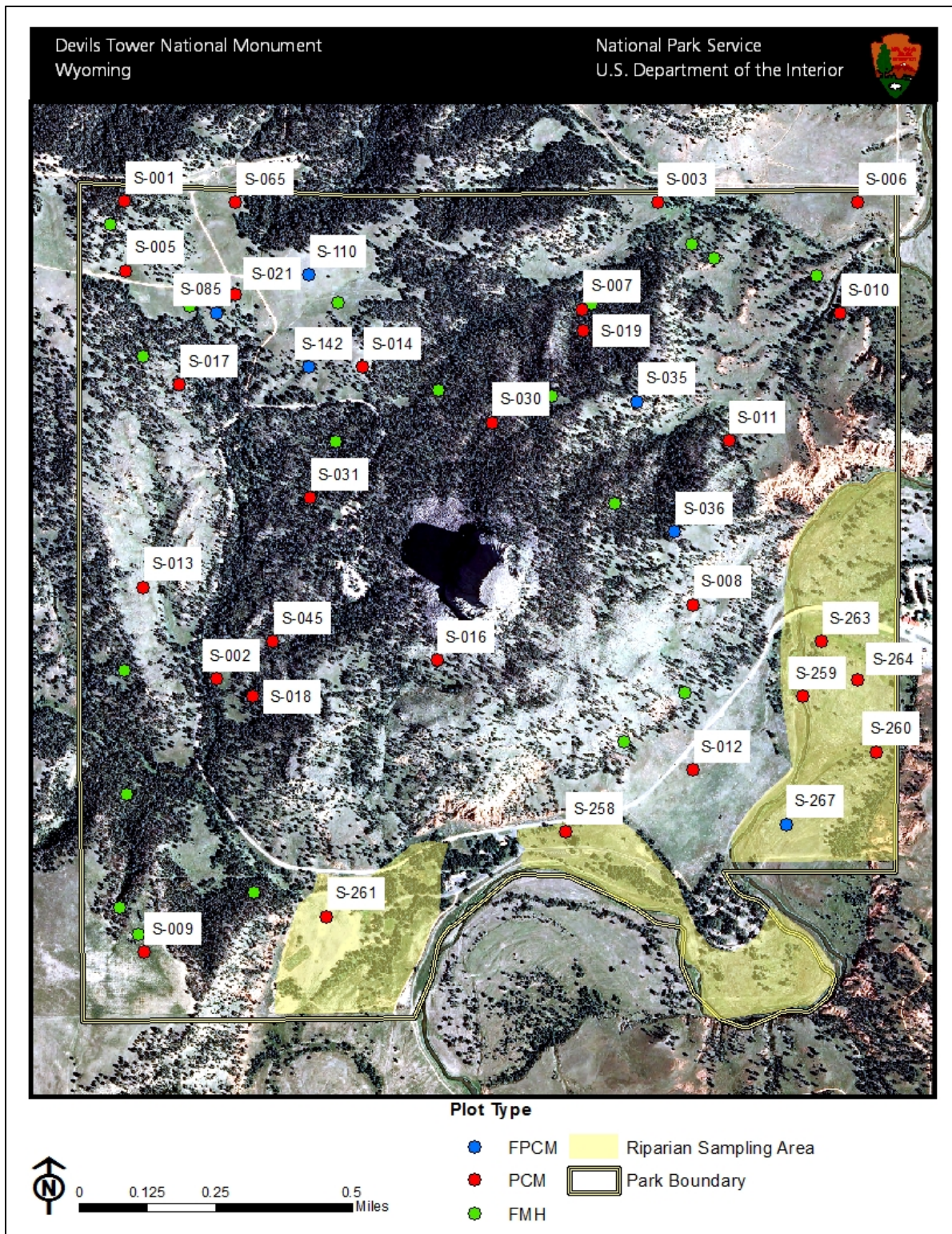


Figure 1. Map of Devils Tower National Monument (DETO) plant community monitoring plots, 1997-2015. Twenty-eight PCM plots (red) and six (blue) FPCM were established by the Northern Great Plains Inventory & Monitoring Program (NGPN) and the Fire Effects Program (NGPFire) between 2011 and 2015. An additional 23 FMH plots (green) were monitored from 1997-2011 by NGPFire. The riparian sampling area is shaded in yellow.

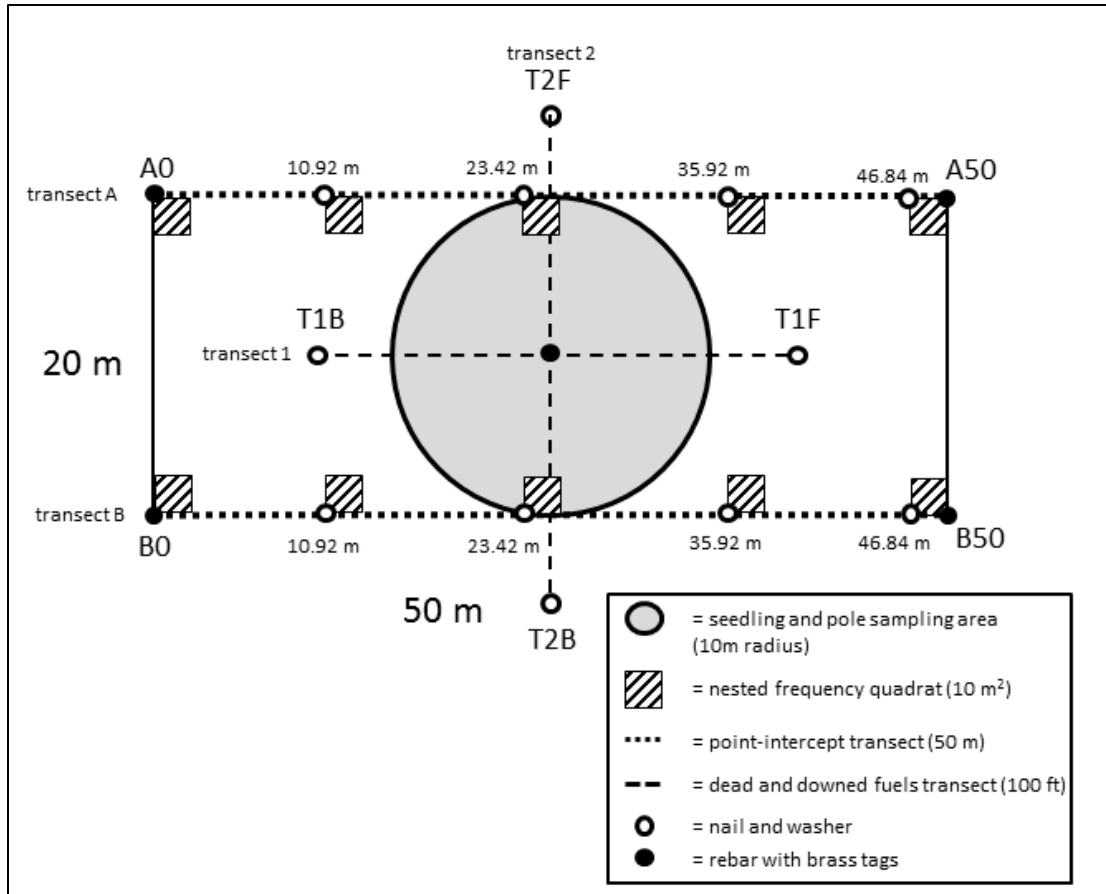


Figure 2. Long-term monitoring plot layout used for sampling vegetation in Devils Tower National Monument.

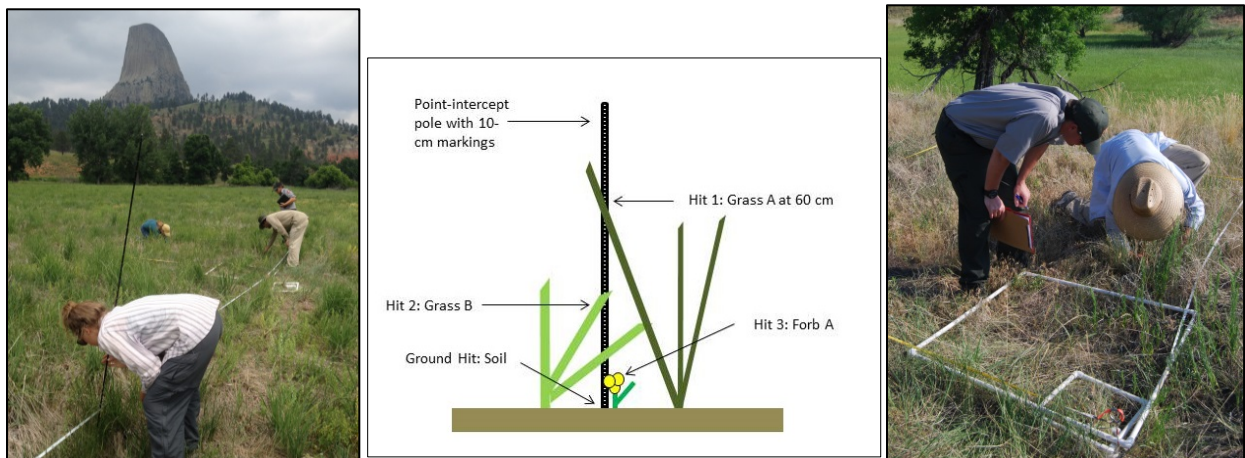


Figure 3. The Northern Great Plains Inventory & Monitoring vegetation crew used point-intercept (left and center panel) and quadrats (right panel) to document plant diversity and abundance.

At the 20 PCM plots visited by NGPN we also surveyed the area for common disturbances and target species of interest to the park. Common disturbances included such things as prairie dog towns, rodent mounds, animal trails, and fire. For all plots, the type and severity of the disturbances were recorded. We also surveyed the area for exotic species that have the potential to spread into the park and cause significant ecological impacts (Table 1). These species were chosen in collaboration with the Midwest Invasive Plant Network, the Exotic Plant Management Team, park managers, and local weed experts. For each target species that was present at a site, an abundance class was given on a scale from 1-5 where 1 = one individual, 2 = few individuals, 3 = cover of 1-5%, 4 = cover of 5-25%, and 5 = cover > 25% of the plot. The information gathered from this procedure is critical for early detection and rapid response to such threats.

Table 1. Exotic species surveyed for at 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 aethiopsis</i>	Mediterranean sage	Upland
<i>Ventenata dubia</i>	African wiregrass	Upland

Other Monitoring Plots (1998-2015)

In 1998, NGPFire began monitoring plots within DETO to evaluate the effectiveness of prescribed burns. Starting in 1998, data collection followed the NPS National Fire Ecology Program protocols

(NPS 2003): in grassland plots vegetation cover and height data were collected using a point-intercept method, with 100 points evenly distributed along a single 30 m transect. In forested sites, plots are 0.1 ha (20 x 50 m) in size and point-intercept data were collected along the two 50 m sides. For each live tree with a DBH > 15 cm located within the 0.1 ha plot, the species and DBH were recorded. The densities of smaller trees ($2.54 \text{ cm} \leq \text{DBH} \leq 15 \text{ cm}$) were measured within a subset of the plot area. NGPFire plot locations were located randomly within major vegetation types within areas planned for prescribed burning (burn units) in the near future. The plots were then sampled prior to a burn and 1, 2, 5, and 10 years after a prescribed burn. Hereafter, we refer to these plots as Fire Monitoring Handbook (FMH) plots. These FMH plots are being retired after the 10 year visit (e.g. the rebar will be removed) and replaced with the FPCM plots described above.

Data Management and Analysis

We used FFI (FEAT/FIREMON Integrated; <http://frames.gov/ffi/>) as the primary software environment for managing our sampling data. FFI is used by a variety of agencies (e.g., NPS, USDA Forest Service, U.S. Fish and Wildlife Service), has a national-level support system, and generally conforms to the Natural Resource Database Template standards established by the Inventory and Monitoring Program. Species scientific names, codes, and common names are from the USDA Plants Database (USDA-NRCS 2015). However, nomenclature follows the Integrated Taxonomic Information System (ITIS) (<http://www.itis.gov>). In the few cases where ITIS recognizes a new name that was not in the USDA PLANTS database, the new name was used, and a unique plant code was assigned. This report uses common names after the first occurrence in the text, but scientific names can be found in Appendix A.

After data for the sites were entered, 100% of records were verified to the original data sheet to minimize transcription errors. A further 10% of records were reviewed a second time. After all data were entered and verified, automated queries were used to check for errors in the data. When errors were caught by the crew or the automated queries, changes were made to the original datasheets and/or the FFI database as needed. Summaries were produced using the FFI reporting and query tools and statistical summaries, and graphics were generated using R software (version 3.2.2).

Plant life forms (e.g., shrub, forb) were based on definitions from the USDA Plants Database (USDA-NRCS 2015). The conservation status ranks of plant species in Wyoming is determined by the Wyoming Natural Diversity Database (WYNDD). For the purpose of this report, a species was considered rare if its conservation status rank was S1, S2, or S3. See Table 2 for a detailed definition of each conservation status rank.

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

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

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

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

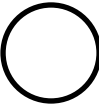
Climate data from the Hulett, Wyoming weather station (GHCND:USC00494760) were downloaded from NOAA's online database (NOAA 2015). Fire history maps were compiled for the park and cross-referenced with plot locations. For each time data were collected at a plot (i.e., plot visit), we determined the number of years since the plot had burned and the number of fires recorded for that plot.

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", or TBD, and estimate condition based on our professional judgment.

Table 3. Key to the symbols used in the Natural Resource Condition Table. The background color represents the current status, the arrow summarizes the trend, and the thickness of the outside line represents the degree of confidence in the assessment. A symbol that does not contain an arrow indicates that there is insufficient information to assess a trend. Based on the State of the Park reports (<http://www.nps.gov/stateoftheparks/>).

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

Results and Discussion

Status & Trends in Community Composition and Structure of DETO Prairies

There are 471 plant species on the DETO species list and we found 355 species in monitoring plots from 1998-2015 at DETO (Appendix A). Graminoids, which includes grasses, sedges, and rushes, accounted for most of the vegetative cover at DETO, but forbs, shrubs, and subshrubs (defined as low-growing shrubs usually shorter than 0.5m) were also present (Figure 4). We found 66 exotic plant species at DETO, all of which were forbs or graminoids. Exotic graminoids were particularly abundant (Figure 4). The shrubs and subshrubs were all native species.

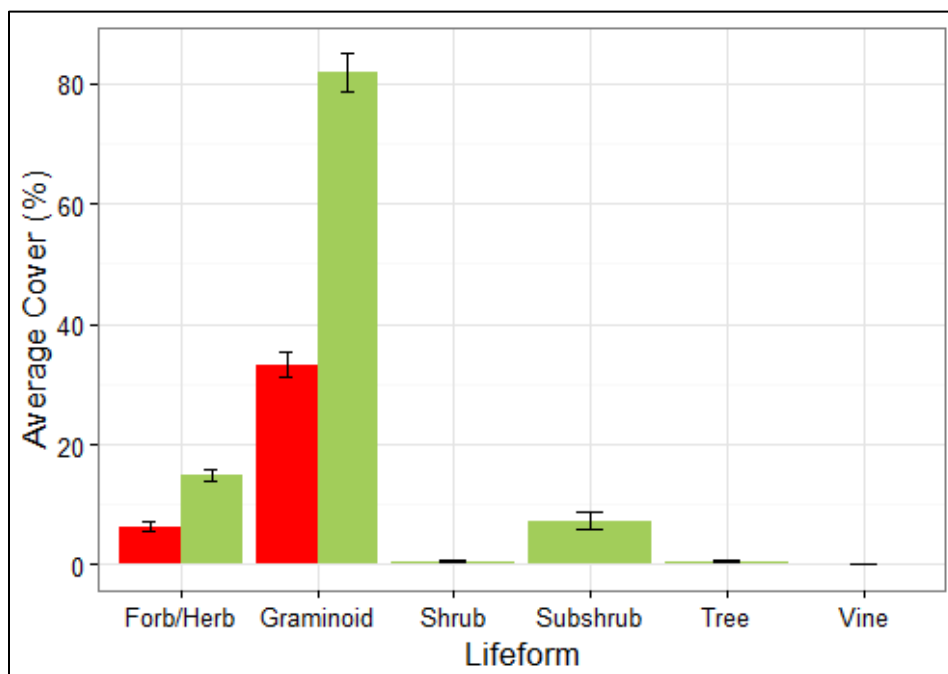


Figure 4. Average cover by lifeform of native (green) and exotic (red) plants recorded in monitoring plots in Devils Tower National Monument (1998-2015). Absolute cover can be greater than 100% because the point-intercept methods records layers of overlapping vegetation.

Western wheatgrass (*Pascopyrum smithii*), big bluestem (*Andropogon gerardii*), green needlegrass (*Nassella viridula*), and upland sedges (*Carex* sp.) were the most abundant native graminoids and averaged between 5 and 15% absolute cover (Figure 5). Kentucky bluegrass (*Poa pratensis*) was the most pervasive exotic at DETO. The average percent cover of exotic plant species in DETO has stayed fairly consistent over time (Figure 6), with the exception of very high cover in 1998, which may have been due to wet conditions. Currently (2011-2015), the relative cover of exotic species at long-term plots in DETO averages 28.4 ± 2.3 % (mean $\pm$ one standard error). Most of this cover is Kentucky bluegrass, which averaged 16.5 ± 1.5 % from 2011-2015 and there is no evidence that it has decreased or increased since 1998. Kentucky bluegrass is a cool-season perennial grass that has recently been increasing in abundance in and around the Northern Great Plains (DeKeyser et al. 2013) and its presence is often correlated with declines in native species richness (Miles and Knops 2009). This pattern is also seen from our data in DETO where there is a significant decline in native

richness with increasing Kentucky bluegrass abundance (Figure 7; $F_{1,151}=8.8$, $P=0.003$). The U.S. Fish and Wildlife Service has begun an adaptive management program to control Kentucky bluegrass in South Dakota and North Dakota refuges (Grant et al. 2009). Their work suggests that Kentucky bluegrass can often spread and become a dominant component in mixed-grass prairie that is rested for long periods (e.g. neither burned nor grazed) (Grant et al. 2009).

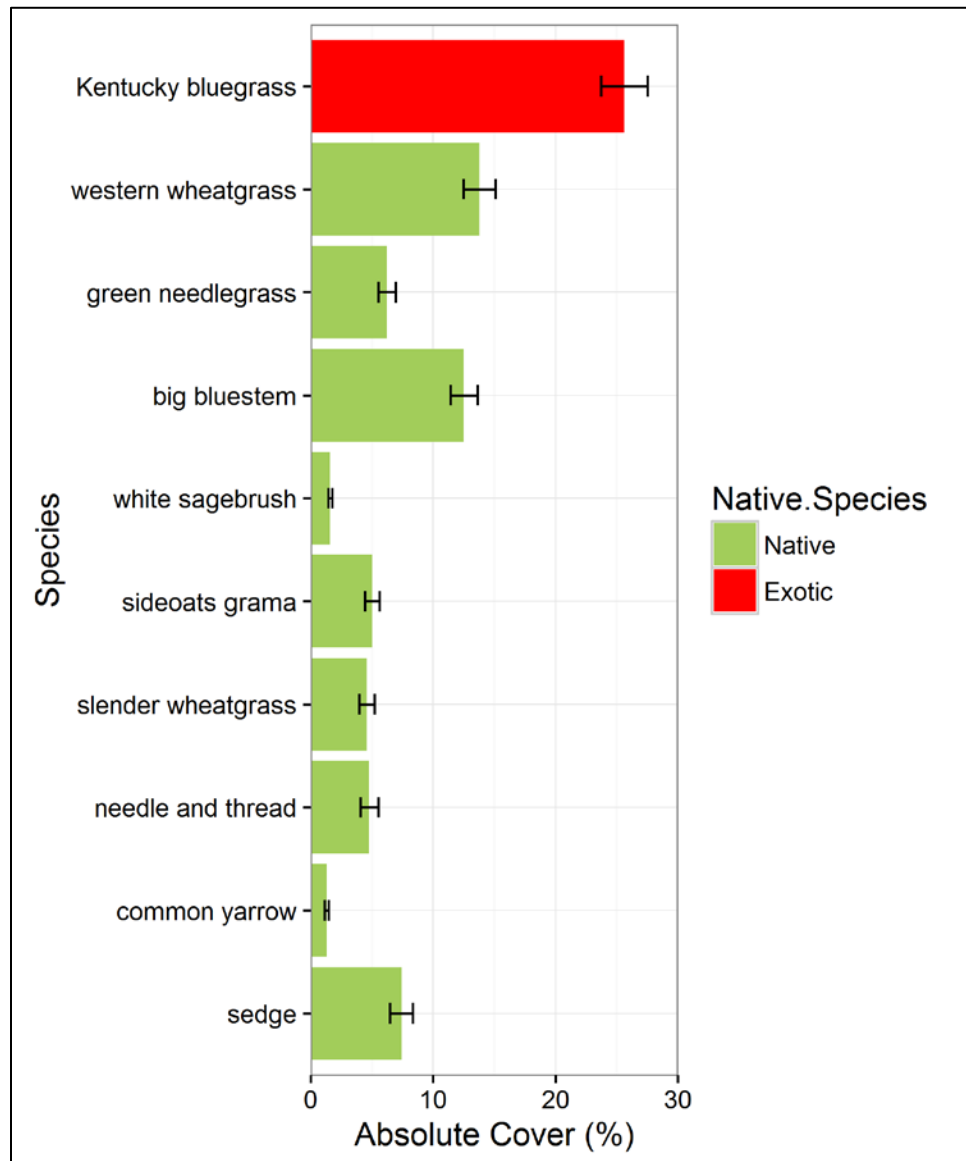


Figure 5. The average absolute cover of the 10 most common native (green) and exotic (red) plants recorded at Devils Tower National Monument in 1998-2015. Bars represent means $\pm$ one standard error.

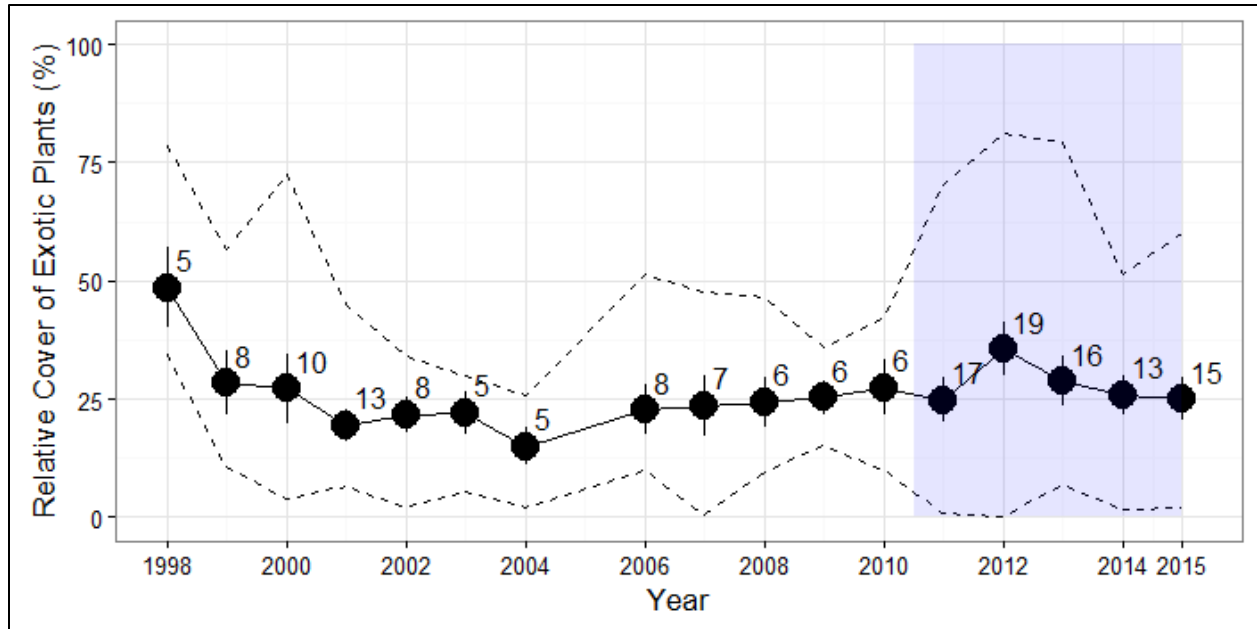


Figure 6. Trends in the relative cover of exotic species in Devils Tower National Monument from 1998-2015. Points represent mean $\pm$ one standard errors and sample size is to the right of the point. Years with fewer than three monitoring plots were excluded from the graph. The shaded area highlights the period from 2011-2015 when sampling methods were consistent and distribution of plots was more even and consistent across years. The dashed line represents the maximum and minimum cover values for each year.

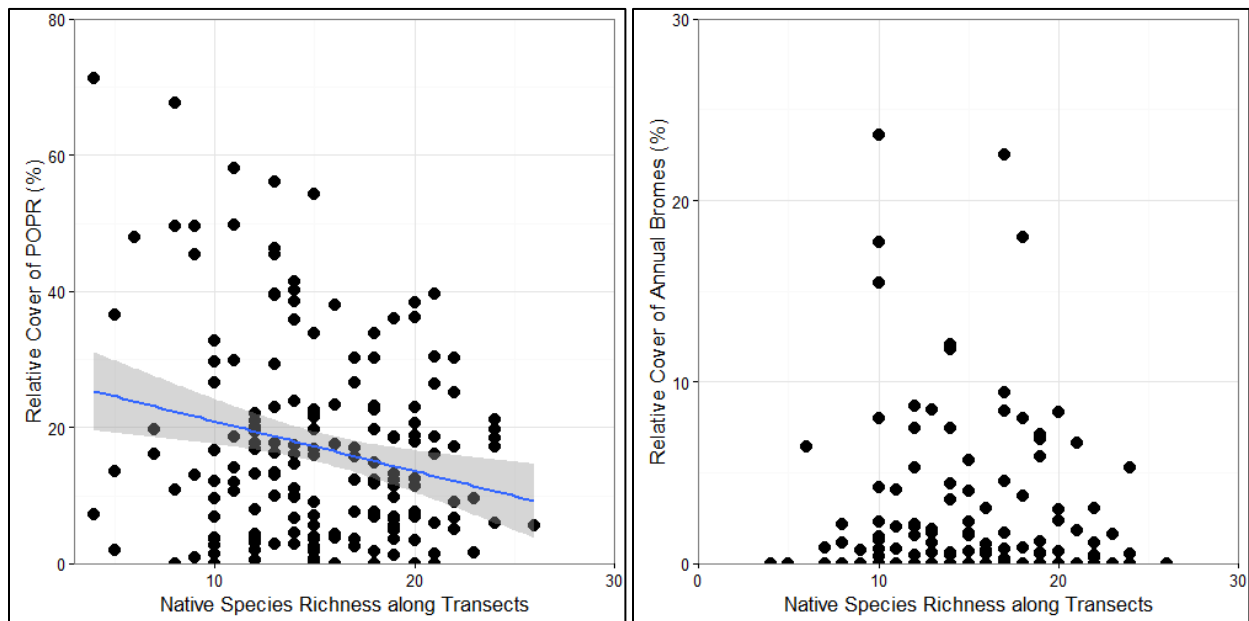


Figure 7. The relationship between native species richness and the relative cover of Kentucky bluegrass (POPR, left) and annual bromes (right) in long-term monitoring plots in Devils Tower National Monument, 1998-2015.

Unlike many park units in the Northern Great Plains region, DETO has a low abundance of cheatgrass (*Bromus tectorum*) and Japanese brome (*Bromus japonicus*). Together, they only accounted for an average of $2.4 \pm 0.5\%$ cover from 2011 to 2015. Cheatgrass and Japanese brome are Eurasian annual grasses that have been a part of the NGP landscape for more than a century, but their invasion in the region has accelerated since 1950 (Schachner et al. 2008). Our data suggest that the cover of annual bromes has been increasing over time at DETO (Ashton et al. in review). This is a concern because the presence of bromes is associated with a decrease in native species richness in the Northern Great Plains (data not shown), but there is not a significant relationship between annual brome abundance and native species richness in DETO (Figure 7). This is likely due to the relatively low abundances of annual bromes. An adaptive management program for annual bromes in the NGPN starting in 2017 should help guide management actions in the future so that abundances of annual bromes remain low in DETO.

Species Richness, Diversity, and Evenness

One of the ways for the NPS to measure effectiveness of actions to achieve its mission of ‘preserving ecological integrity’ is to examine trends in native plant diversity and evenness within park boundaries. Average species richness has been measured by point-intercept since 1998 and in 1 m² and 10 m² quadrats since 2011 (Table 4).

Table 4. Average plant species richness in monitoring plots at Devils Tower National Monument from 1998 to 2015. Values represent means $\pm$ one standard error.

Species Richness Type	Point-intercept (1998-2015; n=57)	1 m² quadrats (2011-2015, n=38)	10 m² quadrats (2011-2015, n=38)
Species richness	19.1 $\pm$ 0.6	8.7 $\pm$ 0.4	15.3 $\pm$ 0.7
Native species richness	15.0 $\pm$ 0.5	6.5 $\pm$ 0.4	11.3 $\pm$ 0.7
Exotic species richness	4.0 $\pm$ 0.3	2.2 $\pm$ 0.2	3.9 $\pm$ 0.3
Graminoid species richness	10.2 $\pm$ 0.3	4.1 $\pm$ 0.2	5.9 $\pm$ 0.2
Forb species richness	8.0 $\pm$ 0.4	4.3 $\pm$ 0.2	8.6 $\pm$ 0.5

While there was some variation across the park, the plots we visited in DETO tended to have a low to moderate number 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 DETO, there is also a mixed history of past land-use practices that have affected current species richness. While it is difficult to define a reference condition for species richness, which naturally varies considerably across both space and time, the natural range of variation over long-time periods may be a good starting point (Symstad and Jonas 2014). Long-term records of species diversity in mixed-grass prairie in a moderately grazed site in Montana ranged between 8 and 18 species per square meter (10-90th percentile range) between 1933-1945 (Symstad and Jonas 2014). 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). The riparian plots PCM_263 and PCM_259 had fewer than 3 native species per square meter. The most species-rich site is PCM_012 which averages 11.5 species native species per square meter. This plot is located within a prairie dog town, and in this region prairie dogs have been shown to increase native species richness, particularly of forbs, by decreasing the dominance of grass species (Fahnestock and Detling 2002).



Figure 8. A photograph of long-term monitoring plot DETO_PCM_012 which lies within a prairie dog town and has a large diversity of native plant species.

We did not find any trends in species richness or evenness (Figure 9). Native species richness in 1m^2 quadrats was consistent from 2011 to 2015 and ranged from a low in 2012 of 5.2 ± 0.6 (a drought year) to a high of 7.6 ± 1.0 in 2011 (a wet year). In the longer record from point-intercept data (1998-2015; Figure 9: top) annual average native richness ranged between 11.0 and 19.2 species. Annual average evenness ranged from 0.63 to 0.79 during this time period, indicating the plots were not strongly dominated by a single species (Figure 9: bottom). There is a great deal of variation in species richness and evenness among sites within the park (dashed lines in Figure 9 represent the maximum and minimum values) which makes long-term trends in these metrics difficult to detect.

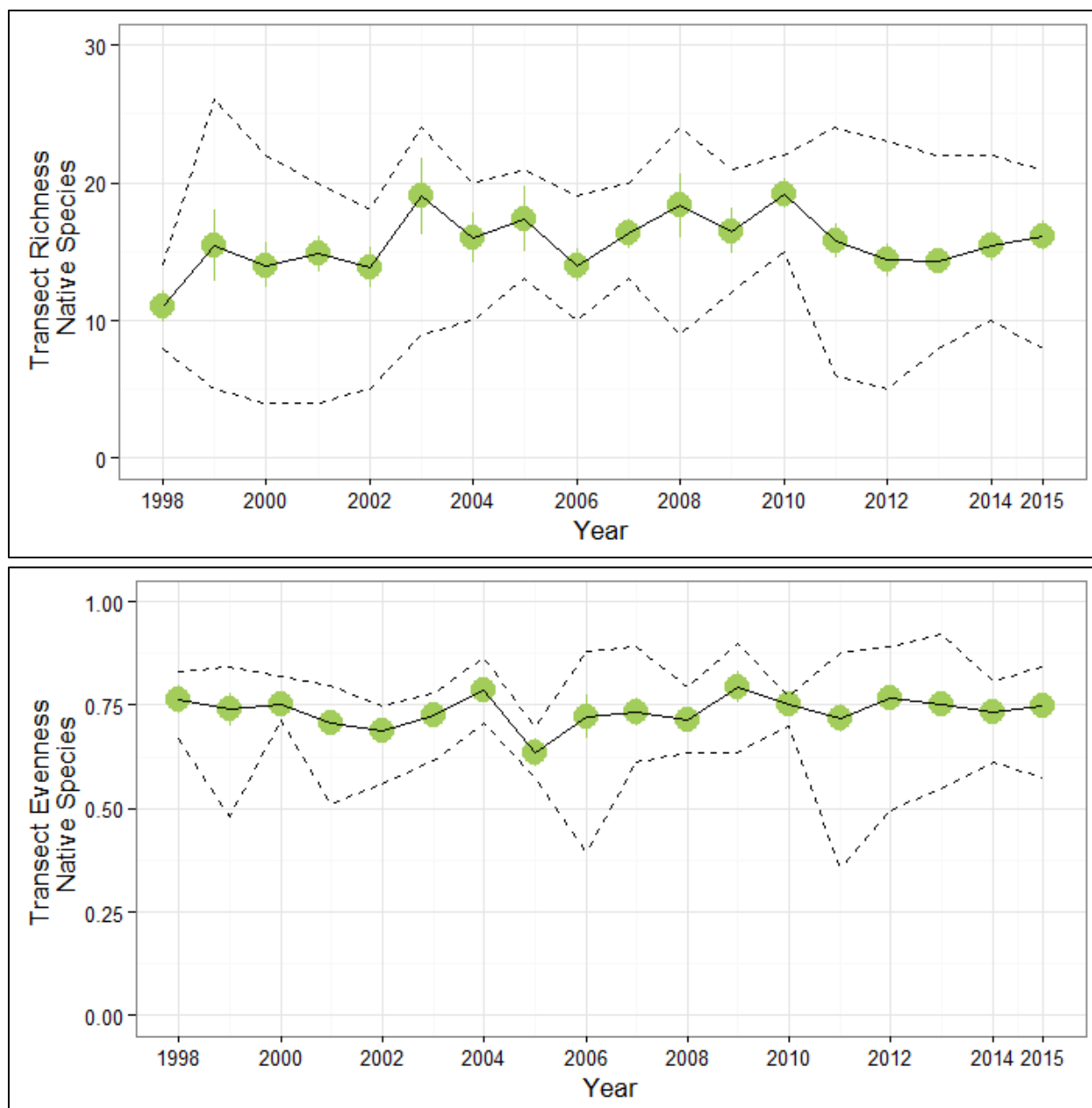


Figure 9. Trends in native species richness and evenness in Devils Tower National Monument, 1998-2015. Data are means $\pm$ one standard error. The dashed line indicates the maximum and minimum values for each year.

Disturbance from grazing, prairie dogs, fire, and humans affects plant community structure and composition in mixed-grass prairie. We estimated the approximate area affected by natural and human disturbances at each site we visited in 2011-2015 by surveying the area for ~ 5 minutes at the end of the plot visit. The most common disturbance was from fire and deer trails, but there was also evidence of flooding, herbicide treatments, and off-road use. Because disturbances were relatively rare and monitoring began recently, more monitoring data will be needed before we can test for the effects of disturbance on vegetation. The exception is fire, which we discuss later in this report.

Species richness and exotic cover in riparian and upland plots

The original fire monitoring sample design focused on upland areas, and as a result, monitoring in riparian plots did not begin until 2011. In the sections above, the condition of the park was derived using data from all monitoring plots including those in the riparian and upland areas (Figure 1). In Table 5, we provide averages of species richness and relative exotic cover for riparian and upland plots. Riparian plots have significantly fewer native species along transects ($F_{1,74}=16.6$, $P<0.001$) and fewer within 1m² quadrats ($F_{1,32}=41.2$, $P<0.001$) than upland plots (Table 5). The average native species richness in upland plots (7.5 species m⁻²) is still less than the natural range of variability for comparable areas (between 8 and 18 species m⁻²; Symstad and Jonas 2014). The relative cover of exotic species ($F_{1,74}=12.4$, $P<0.001$) and the relative cover of annual bromes ($F_{1,74}=11.5$, $P=0.001$) is higher in riparian plots, but there is no difference in the relative cover of Kentucky bluegrass between upland and riparian plots ($F_{1,74}=0.4$, $P=0.54$). These data suggest that concentrated restoration and exotic control efforts in the riparian zones of DETO could significantly improve the condition of the park.

Table 5. Native species richness and the relative cover of exotic species in upland and riparian plots in Devils Tower National Monument. Data are averages $\pm$ standard error from 2011 to 2015. For most metrics, averages are from 14 riparian plot visits and 66 upland plot visits. For native species richness in 1m² quadrats, riparian plot visits=10 and upland plots visits=28.

Metric	Upland plot average	Riparian plot average
Native Species Richness (transect)	16.0 $\pm$ 0.5	11.1 $\pm$ 0.7
Native Species Richness (1m ²)	7.5 $\pm$ 0.4	3.7 $\pm$ 0.5
Average relative cover of exotic species (%)	25.1 $\pm$ 2.3 %	43.8 $\pm$ 5.6 %
Average relative cover of Kentucky bluegrass (%)	17.0 $\pm$ 1.8 %	14.0 $\pm$ 2.2 %
Average relative cover of annual bromes (%)	1.6 $\pm$ 0.4 %	6.1 $\pm$ 2.1 %

The Influence of Climate and Fire on Plant Community Structure and Diversity

Climate

The Northern Great Plains has a continental climate, with hot summers and very cold winters. The 30-year normal temperatures at a nearby weather station in Hulett, WY ranged from average minimum monthly temperatures in December of 11.6° F to maximum monthly July temperatures of 85.6° F (based on 1981-2010). The 30-year normal annual precipitation totals 17.6 inches. Annual precipitation at DETO in 1998-2015 was variable and ranged between 8.1 and 27.5 inches, in 2012 and 2013, respectively. There were dry years in 2000 to 2006 and again in 2012 (Figure 10). The native vegetation is adapted to this variation, and productivity responds strongly to decreases in spring and summer precipitation (Yang et al. 1998, Smart et al. 2007). Species richness and diversity in regional grasslands are also sensitive to temperature and precipitation fluctuation, but the response is complex and less predictable (Jonas et al. 2015).

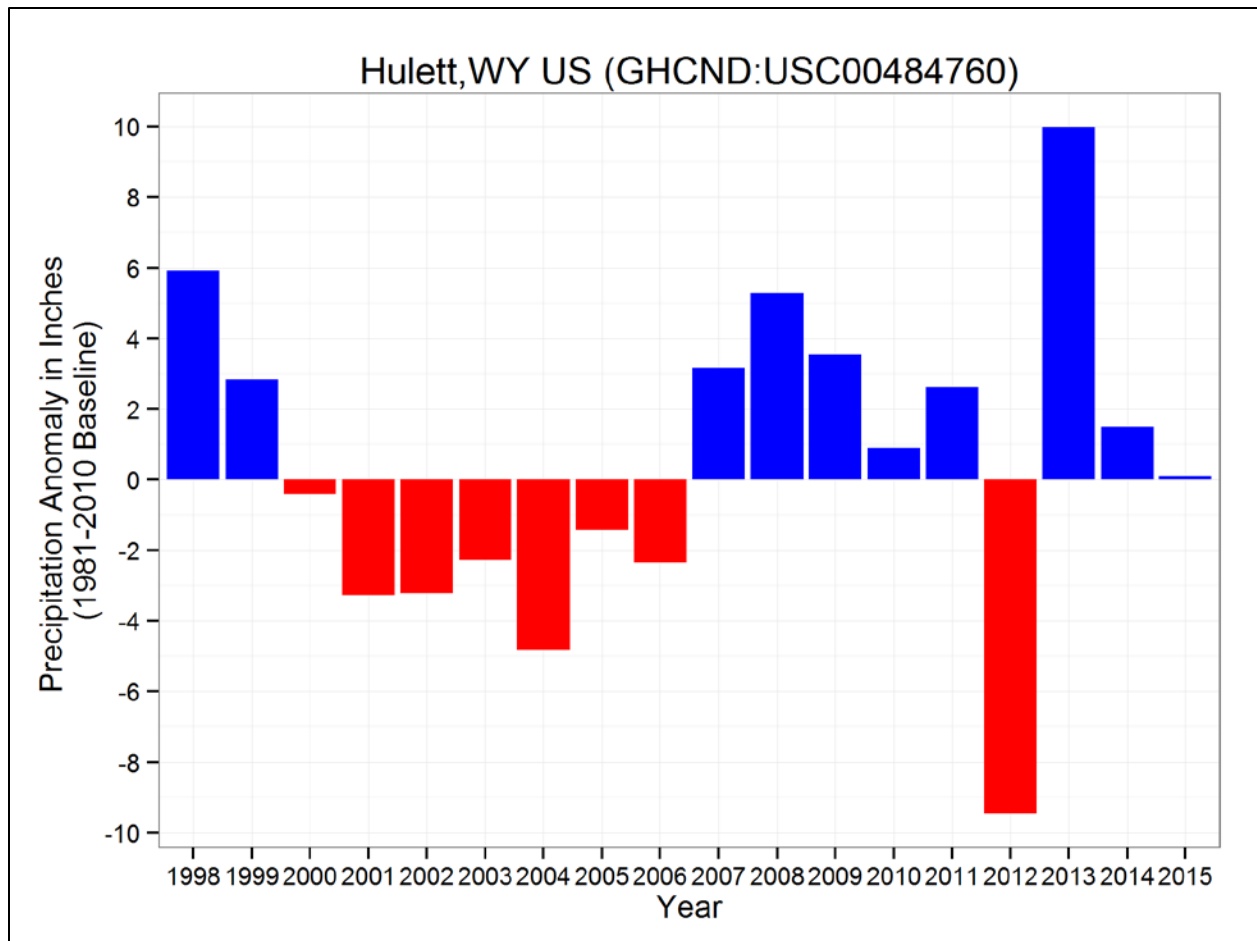


Figure 10. The total annual precipitation anomaly from 1998-2015 for Devils Tower National Monument. Positive values (blue) represent years wetter than and negative values (red) years drier than the 1981-2010 average. The anomaly is measured in inches and based on data from a nearby weather station.

At DETO, the average height of plants increased with increasing precipitation ($F_{1,109}=6.4$, $P=0.013$), but did not respond to temperature. Native species richness and the cover of exotic species did not correlate with total annual precipitation or temperature. Because of the large variation in annual temperature and precipitation patterns at DETO, a longer time series of vegetation data is needed to elucidate trends and correlations with climate.

Fire History

Historically, fires occurred at an interval of 11-32 years at DETO, which helped maintain a mosaic of open ponderosa woodlands and grassland (Fisher et al. 1987, Stambaugh et al. 2008). Natural fires have been suppressed for most of the last century, but the use of prescribed burning in Northern Great Plains parks to mitigate the effects of the absence of natural fires has increased over time since its start at Wind Cave NP in 1973 (Wienk et al. 2011). Since 1993, 75% of the park has been within the boundary of at least one prescribed burn (Figure 11).

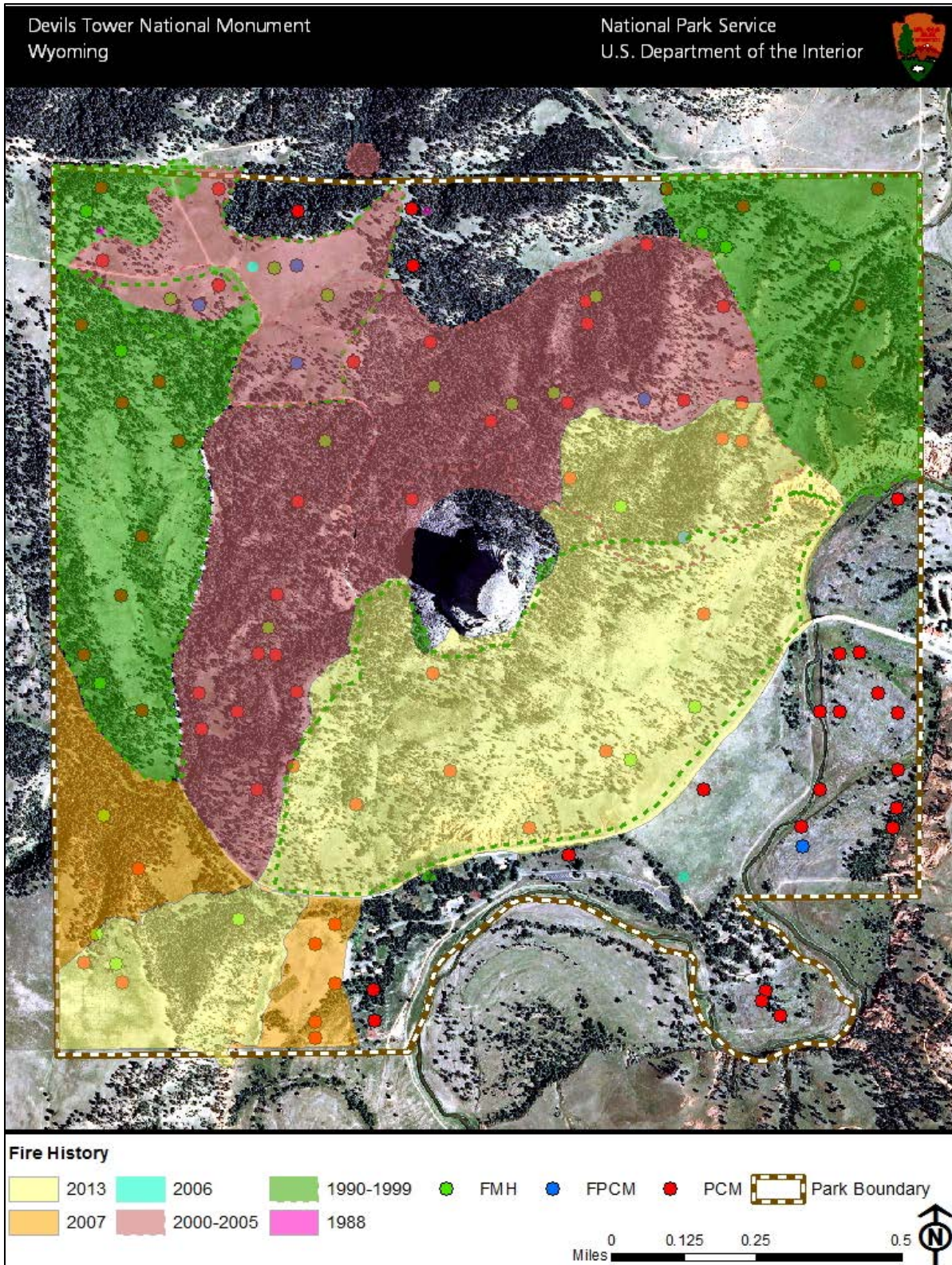


Figure 11. Map of recent fire history (polygons) and long-term monitoring plots at Devils Tower National Monument.

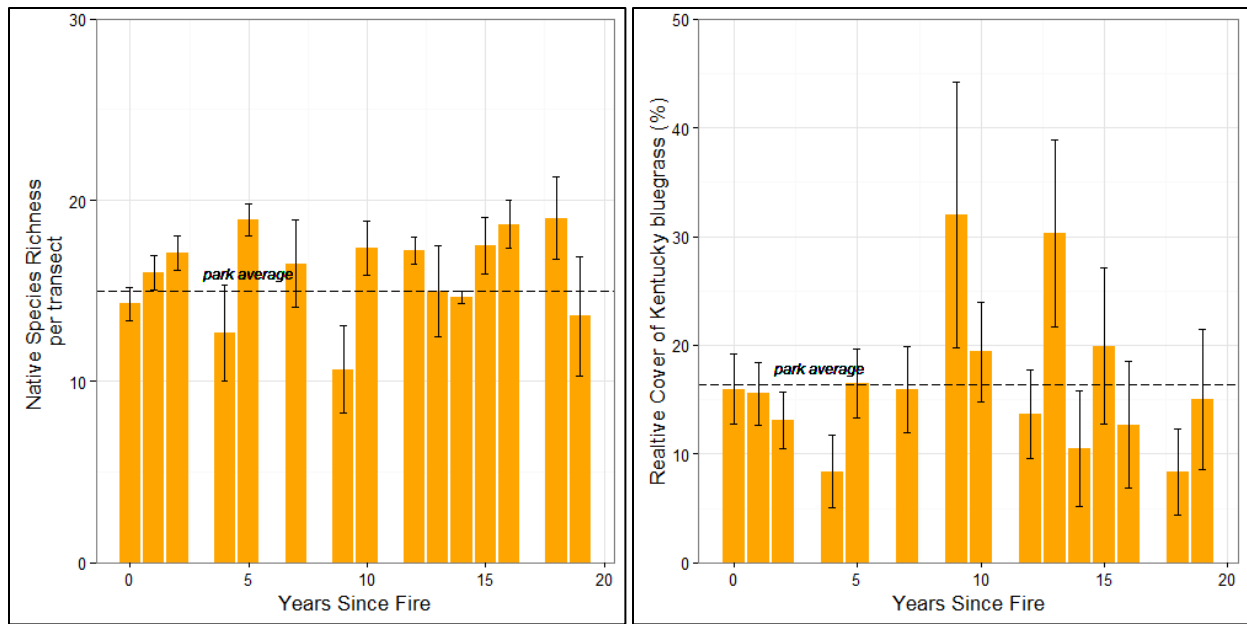


Figure 12. Native species richness and percent cover of Kentucky bluegrass across plots with different fire histories.

The effects of specific prescribed burns on vegetation and fuel loads and more details about fires at DETO can be found in past NGPFire annual reports (see <http://www.nps.gov/ngpfire/docs.htm>). Here, we were interested in determining the relationship between fire history and vegetation. We compared two vegetation metrics with the length of time between the data collection at a plot and the most recent fire at that plot (years since fire). For example, a site that burned in the spring and was visited in the summer would be zero years since fire. We found no relationship between native richness and years since fire or the cover of Kentucky bluegrass and years since fire (Figure 12). Nor was there a significant relationship between litter cover, total exotic cover, or annual brome cover and fire history. These results suggest that prescribed fires have had little effect on the herbaceous vegetation in DETO.

Rare Plants

While repeating rare plant surveys and locating rare species is not the focus of NGPN plant community monitoring, we identified nine rare plant species in DETO monitoring plots from 1998 to 2015. Of these species, the critically imperiled species greater bladder sedge (*Carex intumescens* S1; Figure 13) was the most abundant and was found in six plots with an average cover of 0.06%. All of the remaining rare species we observed also occurred in low frequencies and abundances (Table 5). Additionally, all these species are classified as secure (G5) at the global scale, but are rare in Wyoming as a result of these species existing on the edge of their global range in the state.



Figure 13. Photographs of two critically imperiled species found in plant community monitoring plots at Devils Tower National Monument. *Left:* greater bladder sedge (*Carex intumescens* S1). *Right:* longbract spiderwort (*Tradescantia bracteata* S1).

Table 6. Rare species occurrence in Devils Tower National Monument from 1998-2015. Status ranks are based on Wyoming Natural Diversity Database designations. Plot count is the number of unique plots a species was recorded in across all years. Mean cover is the average cover of that species across all years in plots where cover measurements were recorded.

Species	Common Name	State Rank	Global Rank	Plot Count	Mean Cover (%)
<i>Aristida oligantha</i>	prairie threeawn	S1	G5	1	0.03
<i>Asclepias verticillata</i>	whorled milkweed	S1	G5	4	0.01
<i>Carex emoryi</i>	Emory's sedge	S1	G5	1	0.04
<i>Viola pedatifida</i>	prairie violet	S1	G5	1	0.00
<i>Physalis virginiana</i>	Virginia groundcherry	S1	G5	1	0.00
<i>Tradescantia bracteata</i>	longbract spiderwort	S1	G5	1	0.00
<i>Carex intumescens</i>	greater bladder sedge	S1	G5	6	0.06
<i>Elymus villosus</i>	hairy wildrye	S1S2	G5	2	0.01
<i>Gymnocarpium dryopteris</i>	western oakfern	S2	G5	1	0.00

A rare plant species survey was conducted in 2008 and found six rare species (Heidel 2008). Of the rare species observed in that survey, only three matched those we observed in our plots, and our observations included five species the Heidel survey did not list as being previously observed in DETO. We recommend that a new rare species survey that includes the locations of our species observations and any other new observations be completed when funds are available. Any future construction efforts that could disturb native vegetation (e.g. trail building), should avoid damaging species considered rare in Wyoming.

Conclusion

The Northern Great Plains Inventory & Monitoring Program and Fire Effects Program have been monitoring vegetation in Devils Tower National Monument for over 18 years. While methods have changed slightly, this report summarizes data from 57 locations from 1998-2015. Below, we list the questions we asked and provide a summarized answer, for more details see the Results and Discussion section. We conclude with a Natural Resource Condition Table (Table 10) that summarizes the current status and trends in a few key vegetation metrics.

1. What is the current status of plant community composition and structure of DETO grasslands (species richness, cover, and diversity) and how has this changed from 1998 to 2015?

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. The highest plant species richness was found in the prairie dog town.

We found no significant trends in native diversity or evenness from 1998 to 2015, but both are threatened by the increasing cover of annual bromes. Annual bromes are an emerging threat in DETO, and keeping them in low abundance will help maintain native plant diversity. Other exotics, such as Kentucky bluegrass are more prevalent, but there is no evidence of an increasing trend in their cover.

2. How do trends in grassland condition correlate with climate and fire history?

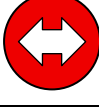
The large variability in DETO's climate makes it difficult to discern strong patterns linking temperature, precipitation, and plant community structure (e.g. exotic cover, diversity). Plant height increased in years with more total precipitation, but we found no other significant relationship between climate and vegetation. A longer time series of vegetation data will make it easier to elucidate trends in the future.

DETO has been using prescribed burning as a management tool since the 1980s. We found that there was no difference in native diversity or exotic cover among plots that had burned recently and those that had not burned for longer time periods. This suggests that prescribed burning is not having a large effect on herbaceous vegetation in DETO.

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

We identified nine rare plant species in DETO between 1998 and 2015, and eight of these are considered critically imperiled within Wyoming. These plants are found in such low abundance and in such few plots, it is unlikely that plant community monitoring will be able to detect any trends in rare plant abundance. We recommend more targeted surveys of rare plant species of concern be completed when funds are available.

Table 7. Natural resource condition summary table for plant communities in Devils Tower National Monument (DETO). Current values are based on data from 2011-2015 and trends are based on data from 1998-2015.

Indicator of Condition	Specific Measures	Current Value (mean $\pm$ SE)	Reference Condition and Data Source	Condition Status/Trend	Rationale for Resource Condition
Upland Plant Community Structure and Composition	Native species richness (1m ² quadrats)	6.5 $\pm$ 0.4	8-18 species		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 and average richness is below a natural range of variability (Symstad and Jonas 2014). The highest native diversity is found in the prairie dog town. The lowest diversity is found in the riparian areas. Native evenness has not changed since monitoring began in 1998.
	Evenness (point-intercept transects)	0.74 $\pm$ 0.01	To be determined		
Exotic Plant Early Detection and Management	Relative cover of exotic species	28.4 $\pm$ 2.3%	< 10 % cover		Many areas of DETO have a high cover of exotic species. Kentucky bluegrass is the most widespread and abundant invasive plant species. There is no evidence of an increasing or decreasing trend in total exotic cover or Kentucky bluegrass cover. While still in low abundance, annual brome cover has shown an increasing trend since 1998.
	Relative cover of annual bromes	2.4 $\pm$ 0.5%	< 10 % cover		
	Relative cover of Kentucky bluegrass	16.5 $\pm$ 1.5 %	< 10 % cover		

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Appendix A: List of plant species found at DETO 1998-2015

Below is a list of all the plant species found in DETO long-term plant community monitoring plots. The species are grouped by plant family. An “X” in the exotic column means that species is not native to the park or, in the case where only the genus was identified, there are some species within that genus that are exotic. Species considered to be rare in Wyoming are marked in the final column and the state conservation ranks are provided. Conservation rank definitions are in Table 2 of the report.

Family	Code	Scientific Name	Common Name	Exotic	Rare
Aceraceae	ACNE2	<i>Acer negundo</i>	boxelder		
Agavaceae	YUGL	<i>Yucca glauca</i>	soapweed yucca		
Amaranthaceae	AMAL	<i>Amaranthus albus</i>	prostrate pigweed	X	
	AMARA	<i>Amaranthus</i>	pigweed	X	
	AMBL	<i>Amaranthus blitoides</i>	mat amaranth	X	
Anacardiaceae	RHAR4	<i>Rhus aromatica</i>	fragrant sumac		
	RHTR	<i>Rhus trilobata</i>	skunkbush sumac		
	TORY	<i>Toxicodendron rydbergii</i>	western poison ivy		
Apiaceae	ERIGE	<i>Erigenia</i>	erigenia		
	LOFO	<i>Lomatium foeniculaceum</i>	desert biscuitroot		
	LOOR	<i>Lomatium orientale</i>	N. Idaho biscuitroot		
	OSLO	<i>Osmorhiza longistylis</i>	longstyle sweetroot		
	PEGA3	<i>Perideridia gairdneri</i>	Gardner's yampah		
Apocynaceae	APAN2	<i>Apocynum androsaemifolium</i>	spreading dogbane		
	APCA	<i>Apocynum cannabinum</i>	common dogbane		
Asclepiadaceae	ASCLE	<i>Asclepias</i>	milkweed		
	ASPU	<i>Asclepias pumila</i>	plains milkweed		
	ASSP	<i>Asclepias speciosa</i>	showy milkweed		
	ASST	<i>Asclepias stenophylla</i>	slimleaf milkweed		
	ASVE	<i>Asclepias verticillata</i>	whorled milkweed		S1/G5
	ASVI	<i>Asclepias viridiflora</i>	green comet milkweed		
Asteraceae	ACMI2	<i>Achillea millefolium</i>	common yarrow		

Family	Code	Scientific Name	Common Name	Exotic	Rare
	AGGL	<i>Agoseris glauca</i>	pale agoseris		
	AGPA14	<i>Agoseris parviflora</i>	false agoseris		
	AMAR2	<i>Ambrosia artemisiifolia</i>	common ragweed		
	AMPS	<i>Ambrosia psilostachya</i>	Cuman ragweed		
	AMTR	<i>Ambrosia trifida</i>	great ragweed		
	ANHO	<i>Antennaria howellii</i>	Howell's pussytoes		
	ANMI3	<i>Antennaria microphylla</i>	littleleaf pussytoes		
	ANNE	<i>Antennaria neglecta</i>	field pussytoes		
	ANPA4	<i>Antennaria parvifolia</i>	small-leaf pussytoes		
	ANTEN	<i>Antennaria</i>	pussytoes		
	ARCA12	<i>Artemisia campestris</i>	field sagewort		
	ARCA13	<i>Artemisia cana</i>	silver sagebrush		
	ARCO9	<i>Arnica cordifolia</i>	heartleaf arnica		
	ARDR4	<i>Artemisia dracunculus</i>	tarragon		
	ARFR4	<i>Artemisia frigida</i>	fringed sagewort		
	ARFU3	<i>Arnica fulgens</i>	foothill arnica		
	ARLU	<i>Artemisia ludoviciana</i>	white sagebrush		
	ASTER	<i>Aster</i>	aster		
	BASA3	<i>Balsamorhiza sagittata</i>	arrowleaf balsamroot		
	BREU	<i>Brickellia eupatorioides</i>	false boneset		
	CANU4	<i>Carduus nutans</i>	musk thistle	X	
	CIAR4	<i>Cirsium arvense</i>	Canada thistle	X	
	CIFL	<i>Cirsium flodmanii</i>	Flodman's thistle		
	CIRSI	<i>Cirsium</i>	thistle	X	
	CIUN	<i>Cirsium undulatum</i>	wavyleaf thistle		
	CIVU	<i>Cirsium vulgare</i>	bull thistle	X	
	COCA5	<i>Conyza canadensis</i>	horseweed		
	CORA4	<i>Conyza ramosissima</i>	dwarf horseweed		
	CRAC2	<i>Crepis acuminata</i>	tapertip hawksbeard		

Family	Code	Scientific Name	Common Name	Exotic	Rare
	CRRU3	<i>Crepis runcinata</i>	fiddleleaf hawksbeard		
	ECAN2	<i>Echinacea angustifolia</i>	blacksamson echinacea		
	ERCA4	<i>Erigeron canus</i>	hoary fleabane		
	ERFO3	<i>Erigeron formosissimus</i>	beautiful fleabane		
	ERIGE2	<i>Erigeron</i>	fleabane		
	ERNA99	<i>Ericameria nauseosa</i>	rubber rabbitbrush		
	ERST3	<i>Erigeron strigosus</i>	prairie fleabane		
	ERSU2	<i>Erigeron subtrinervis</i>	threenerve 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		
	HEPE	<i>Helianthus petiolaris</i>	prairie sunflower		
	HEVI4	<i>Heterotheca villosa</i>	hairy false goldenaster		
	HIAL2	<i>Hieracium albiflorum</i>	white hawkweed		
	HIERA	<i>Hieracium</i>	hawkweed		
	HIFE	<i>Hieracium fendleri</i>	yellow hawkweed		
	HYFI	<i>Hymenopappus filifolius</i>	fineleaf hymenopappus		
	LACA	<i>Lactuca canadensis</i>	Canada lettuce		
	LASE	<i>Lactuca serriola</i>	prickly lettuce	X	
	LIPU	<i>Liatris punctata</i>	dotted blazing star		
	LOAR5	<i>Logfia arvensis</i>	field cottonrose		
	LYJU	<i>Lygodesmia juncea</i>	rush skeletonplant		
	MINU	<i>Microseris nutans</i>	nodding microseris		
	MUOB99	<i>Mulgedium oblongifolium</i>	blue lettuce		

Family	Code	Scientific Name	Common Name	Exotic	Rare
	ONAC	<i>Onopordum acanthium</i>	Scotch cottonthistle	X	
	PIOP	<i>Picradeniopsis oppositifolia</i>	oppositeleaf bahia		
	RACO3	<i>Ratibida columnifera</i>	upright prairie coneflower		
	SEIN2	<i>Senecio integerrimus</i>	lambstongue ragwort		
	SENEC	<i>Senecio</i>	ragwort		
	SESP4	<i>Senecio sphaerocephalus</i>	ballhead ragwort		
	SOLID	<i>Solidago</i>	goldenrod		
	SOMI2	<i>Solidago missouriensis</i>	Missouri goldenrod		
	SOMO	<i>Solidago mollis</i>	velvety goldenrod		
	SONE	<i>Solidago nemoralis</i>	gray goldenrod		
	SYER	<i>Symphyotrichum ericoides</i>	white heath aster		
	SYFA	<i>Symphyotrichum falcatum</i>	white prairie aster		
	SYLA3	<i>Symphyotrichum laeve</i>	smooth blue aster		
	SYNO2	<i>Symphyotrichum novae-angliae</i>	New England aster		
	SYOB	<i>Symphyotrichum oblongifolium</i>	aromatic aster		
	TAOF	<i>Taraxacum officinale</i>	common dandelion	X	
	TEAC	<i>Tetraneuris acaulis</i>	stemless 4-nerve daisy		
	TRDU	<i>Tragopogon dubius</i>	yellow salsify	X	
	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>	houndstongue	X	
	HADE	<i>Hackelia deflexa</i>	nodding stickseed		
	LAOC3	<i>Lappula occidentalis</i>	flatspine stickseed		
	LIIN2	<i>Lithospermum incisum</i>	narrowleaf stoneseed		
	MELA3	<i>Mertensia lanceolata</i>	prairie bluebells		
	ONBE	<i>Onosmodium bejariense</i>	soft-hair marbleseed		
Brassicaceae	ALAL3	<i>Alyssum alyssoides</i>	pale madwort	X	

Family	Code	Scientific Name	Common Name	Exotic	Rare
	ALDE	<i>Alyssum desertorum</i>	desert madwort	X	
	ARAB12	<i>Arabis</i>	rockcress	X	
	ARHI	<i>Arabis hirsuta</i>	hairy rockcress		
	ARPY4	<i>Arabis pycnocarpa</i>	creamflower rockcress		
	BOCO4	<i>Boechera collinsii</i>	Collins' rockcress		
	BOH099	<i>Boechera holboellii</i>	Holboell's rockcress		
	BRASS2	<i>Brassica</i>	mustard	X	
	CABU2	<i>Capsella bursa-pastoris</i>	shepherd's purse	X	
	CAMI2	<i>Camelina microcarpa</i>	littlepod false flax	X	
	CHTE2	<i>Chorispora tenella</i>	blue mustard	X	
	DEPI	<i>Descurainia pinnata</i>	western tansymustard		
	DESO2	<i>Descurainia sophia</i>	herb sophia	X	
	DRRE2	<i>Draba reptans</i>	Carolina draba		
	ERCA14	<i>Erysimum capitatum</i>	sanddune wallflower		
	HEMA3	<i>Hesperis matronalis</i>	dames rocket	X	
	LEDE	<i>Lepidium densiflorum</i>	common pepperweed		
	PHLU99	<i>Physaria ludoviciana</i>	foothill bladderpod		
	SIAL2	<i>Sisymbrium altissimum</i>	tall tumbledmustard	X	
	THAR5	<i>Thlaspi arvense</i>	field pennycress	X	
	TUGL	<i>Turritis glabra</i>	tower rockcress		
Cactaceae	ESMI3	<i>Escobaria missouriensis</i>	Missouri foxtail cactus		
	ESVI2	<i>Escobaria vivipara</i>	spinystar		
	OPFR	<i>Opuntia fragilis</i>	brittle pricklypear		
	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		

Family	Code	Scientific Name	Common Name	Exotic	Rare
	SYMPH	<i>Symphoricarpos</i>	snowberry		
	SYOC	<i>Symphoricarpos occidentalis</i>	western snowberry		
Caryophyllaceae	CEAR4	<i>Cerastium arvense</i>	field chickweed		
	SIAN2	<i>Silene antirrhina</i>	sleepy silene		
	SILEN	<i>Silene</i>	catchfly	X	
	SINO	<i>Silene noctiflora</i>	nightflowering silene	X	
	SIVU	<i>Silene vulgaris</i>	maidenstears	X	
Chenopodiaceae	CHAL7	<i>Chenopodium album</i>	lambsquarters	X	
	CHBE4	<i>Chenopodium berlandieri</i>	pitseed goosefoot		
	CHDE	<i>Chenopodium desiccatum</i>	aridland goosefoot		
	CHENO	<i>Chenopodium</i>	goosefoot	X	
	CHSI2	<i>Chenopodium simplex</i>	mapleleaf goosefoot		
	SATR12	<i>Salsola tragus</i>	prickly Russian thistle	X	
Commelinaceae	TRBR	<i>Tradescantia bracteata</i>	longbract spiderwort		S1/G5
	TROC	<i>Tradescantia occidentalis</i>	prairie spiderwort		
Convolvulaceae	COAR4	<i>Convolvulus arvensis</i>	field bindweed	X	
Cucurbitaceae	ECLO	<i>Echinocystis lobata</i>	wild cucumber		
Cupressaceae	JUCO6	<i>Juniperus communis</i>	common juniper		
	JUSC2	<i>Juniperus scopulorum</i>	Rocky Mountain juniper		
Cyperaceae	CAAQ	<i>Carex aquatilis</i>	water sedge		
	CABA3	<i>Carex backii</i>	Back's sedge		
	CABR10	<i>Carex brevior</i>	shortbeak sedge		
	CADU6	<i>Carex duriuscula</i>	needleleaf sedge		
	CAEM2	<i>Carex emoryi</i>	Emory's sedge		S1/G5
	CAFI	<i>Carex filifolia</i>	threadleaf sedge		
	CAFO3	<i>Carex foenea</i>	dryspike sedge		
	CAHO5	<i>Carex hoodii</i>	Hood's sedge		
	CAIN11	<i>Carex interior</i>	inland sedge		

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	CAIN12	<i>Carex intumescens</i>	greater bladder sedge		S1/G5
	CAIN9	<i>Carex inops</i>	sun sedge		
	CAPE42	<i>Carex pellita</i>	woolly sedge		
	CAREX	<i>Carex</i>	sedge		
	CARO5	<i>Carex rossii</i>	Ross' sedge		
	CASP7	<i>Carex sprengelii</i>	Sprengel's sedge		
	CATO3	<i>Carex torreyi</i>	Torrey's sedge		
	CAUT	<i>Carex utriculata</i>	NW Territory sedge		
	CAXE	<i>Carex xerantica</i>	whitescale sedge		
	ELAC	<i>Eleocharis acicularis</i>	needle spikerush		
	ELPA3	<i>Eleocharis palustris</i>	common spikerush		
Dryopteridaceae	CYFR2	<i>Cystopteris fragilis</i>	brittle bladderfern		
	DRYOP	<i>Dryopteris</i>	woodfern		
	GYDR	<i>Gymnocarpium dryopteris</i>	western oakfern		S2/G5
Equisetaceae	EQAR	<i>Equisetum arvense</i>	field horsetail		
	EQHY	<i>Equisetum hyemale</i>	scouringrush horsetail		
	EQLA	<i>Equisetum laevigatum</i>	smooth horsetail		
Euphorbiaceae	EUES	<i>Euphorbia esula</i>	leafy spurge	X	
	EUGL3	<i>Euphorbia glyptosperma</i>	ribseed sandmat		
	EUSP	<i>Euphorbia spathulata</i>	warty spurge		
Fabaceae	ACAM99	<i>Acemispion americanus</i>	American bird's-foot trefoil		
	ASAG2	<i>Astragalus agrestis</i>	purple milkvetch		
	ASCR2	<i>Astragalus crassicaupus</i>	groundplum milkvetch		
	ASDR3	<i>Astragalus drummondii</i>	Drummond's milkvetch		
	ASFL2	<i>Astragalus flexuosus</i>	flexile milkvetch		
	ASGI5	<i>Astragalus gilviflorus</i>	plains milkvetch		
	ASLA27	<i>Astragalus laxmannii</i>	Laxmann's milkvetch		

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	ASMI10	<i>Astragalus missouriensis</i>	Missouri milkvetch		
	ASPL2	<i>Astragalus plattensis</i>	Platte River milkvetch		
	ASTRA	<i>Astragalus</i>	milkvetch		
	DACA7	<i>Dalea candida</i>	white prairie clover		
	DALEA	<i>Dalea</i>	prairie clover		
	DAPU5	<i>Dalea purpurea</i>	purple prairie clover		
	FABAC	<i>Fabaceae</i>		X	
	GLLE3	<i>Glycyrrhiza lepidota</i>	American licorice		
	HEAL	<i>Hedysarum alpinum</i>	alpine sweetvetch		
	LAOC2	<i>Lathyrus ochroleucus</i>	cream pea		
	LAPO2	<i>Lathyrus polymorphus</i>	manystem pea		
	LATHY	<i>Lathyrus</i>	Pea	X	
	LUAR3	<i>Lupinus argenteus</i>	silvery lupine		
	MELIL	<i>Melilotus</i>	sweetclover	X	
	MELU	<i>Medicago lupulina</i>	black medick	X	
	MEOF	<i>Melilotus officinalis</i>	yellow sweetclover	X	
	MESA	<i>Medicago sativa</i>	alfalfa	X	
	OXBE2	<i>Oxytropis besseyi</i>	Bessey's locoweed		
	OXCA4	<i>Oxytropis campestris</i>	field locoweed		
	OXLA3	<i>Oxytropis lambertii</i>	purple locoweed		
	OXSE	<i>Oxytropis sericea</i>	white locoweed		
	OXYTR	<i>Oxytropis</i>	locoweed		
	PEAR6	<i>Pedimelum argophyllum</i>	silverleaf Indian breadroot		
	PECU3	<i>Pedimelum cuspidatum</i>	largebract Indian breadroot		
	PEES	<i>Pedimelum esculentum</i>	large Indian breadroot		
	PSES	<i>Psoralea esculenta</i>	large Indian breadroot	X	
	PSLA3	<i>Psoralidium lanceolatum</i>	lemon scurfpea		
	PSTE5	<i>Psoralidium tenuiflorum</i>	slimflower scurfpea		

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	THRH	<i>Thermopsis rhombifolia</i>	golden pea		
	VIAM	<i>Vicia americana</i>	American vetch		
	QUMA2	<i>Quercus macrocarpa</i>	bur oak		
Geraniaceae	GEBI2	<i>Geranium bicknellii</i>	Bicknell's cranesbill		
	GECA5	<i>Geranium carolinianum</i>	Carolina geranium		
	GERAN	<i>Geranium</i>	geranium	X	
	GERI	<i>Geranium richardsonii</i>	Richardson's geranium		
Grossulariaceae	RIAU	<i>Ribes aureum</i>	golden currant		
	RIBES	<i>Ribes</i>	currant		
	RICE	<i>Ribes cereum</i>	wax currant		
	RIHI	<i>Ribes hirtellum</i>	hairystem gooseberry		
	RIOX	<i>Ribes oxycanthoides</i>	Canadian gooseberry		
Hydrophyllaceae	ELNY	<i>Ellisia nyctelea</i>	Aunt Lucy		
	PHLI	<i>Phacelia linearis</i>	threadleaf phacelia		
Iridaceae	SIMO2	<i>Sisyrinchium montanum</i>	strict blue-eyed grass		
Juncaceae	JUIN2	<i>Juncus interior</i>	inland rush		
	LUMU2	<i>Luzula multiflora</i>	common woodrush		
	LUZUL	<i>Luzula</i>	woodrush		
Lamiaceae	DRPA2	<i>Dracocephalum parviflorum</i>	American dragonhead		
	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	X	
Liliaceae	ALTE	<i>Allium textile</i>	textile onion		
	CAGU	<i>Calochortus gunnisonii</i>	Gunnison's mariposa lily		
	CANU3	<i>Calochortus nuttallii</i>	sego lily		

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	LEMO4	<i>Leucocrinum montanum</i>	common starlily		
	LILIU	<i>Lilium</i>	lily		
	PRTR4	<i>Prosartes trachycarpa</i>	roughfruit fairybells		
	MAST4	<i>Maianthemum stellatum</i>	starry false lily of the valley		
Linaceae	LILE3	<i>Linum lewisii</i>	Lewis flax		
Linaceae	LIRI	<i>Linum rigidum</i>	stiffstem flax		
Malvaceae	SPCO	<i>Sphaeralcea coccinea</i>	scarlet globemallow		
Melanthiaceae	TOVE2	<i>Toxicoscordion venenosum</i>	meadow deathcamas		
Monotropaceae	PTAN2	<i>Pterospora andromedea</i>	woodland pinedrops		
Nyctaginaceae	MILI3	<i>Mirabilis linearis</i>	narrowleaf four o'clock		
Oleaceae	FRPE	<i>Fraxinus pennsylvanica</i>	green ash		
Onagraceae	CHAN9	<i>Chamerion angustifolium</i>	fireweed		
	EPCI	<i>Epilobium ciliatum</i>	fringed willowherb		
	GADI2	<i>Gayophytum diffusum</i>	spreading groundsmoke		
	OESU99	<i>Oenothera suffrutescens</i>	scarlet beeblossom		
Orchidaceae	COMA4	<i>Corallorhiza maculata</i>	summer coralroot		
Oxalidaceae	OXST	<i>Oxalis stricta</i>	common yellow woodsorrel		
Pinaceae	PIPO	<i>Pinus ponderosa</i>	ponderosa pine		
Plantaginaceae	PLPA2	<i>Plantago patagonica</i>	woolly plantain		
Poaceae	ACHY	<i>Achnatherum hymenoides</i>	Indian ricegrass		
	ACNE9	<i>Achnatherum nelsonii</i>	Columbia needlegrass		
	ACRI8	<i>Achnatherum richardsonii</i>	Richardson's needlegrass		
	AGCR	<i>Agropyron cristatum</i>	crested wheatgrass	X	
	AGEX	<i>Agrostis exarata</i>	spike bentgrass		
	AGHY	<i>Agrostis hyemalis</i>	winter bentgrass		
	AGROP2	<i>Agropyron</i>	wheatgrass		

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	AGSC5	<i>Agrostis scabra</i>	rough bentgrass		
	ANGE	<i>Andropogon gerardii</i>	big bluestem		
	AROL	<i>Aristida oligantha</i>	prairie threeawn		S1/G5
	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		
	BOHI2	<i>Bouteloua hirsuta</i>	hairy grama		
	BRAN	<i>Bromus anomalus</i>	nodding brome		
	BRIN2	<i>Bromus inermis</i>	smooth brome	X	
	BRJA	<i>Bromus japonicus</i>	Japanese brome	X	
	BROMU	<i>Bromus</i>	brome	X	
	BRPO2	<i>Bromus porteri</i>	Porter brome		
	BRTE	<i>Bromus tectorum</i>	cheatgrass	X	
	BUDA	<i>Buchloe dactyloides</i>	buffalograss		
	CALO	<i>Calamovilfa longifolia</i>	prairie sandreed		
	DAGL	<i>Dactylis glomerata</i>	orchardgrass	X	
	DASP2	<i>Danthonia spicata</i>	poverty oatgrass		
	DIOL	<i>Dichanthelium oligosanthos</i>	Heller's rosette grass		
	DISP	<i>Distichlis spicata</i>	saltgrass		
	DIWI5	<i>Dichanthelium wilcoxianum</i>	fall rosette grass		
	ECCR	<i>Echinochloa crus-galli</i>	barnyardgrass	X	
	ELCA11	<i>Elymus caninus</i>	bearded wheatgrass		
	ELCA4	<i>Elymus canadensis</i>	Canada wildrye		
	ELEL5	<i>Elymus elymoides</i>	squirreltail		
	ELGL	<i>Elymus glaucus</i>	blue wildrye		
	ELRE4	<i>Elymus repens</i>	quackgrass	X	
	ELTR7	<i>Elymus trachycaulus</i>	slender wheatgrass		
	ELVI	<i>Elymus villosus</i>	hairy wildrye		S1S2/ G5

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	ELVI3	<i>Elymus virginicus</i>	Virginia wildrye		
	ELYMU	<i>Elymus</i>	wildrye	X	
	FEID	<i>Festuca idahoensis</i>	Idaho fescue		
	FEOV	<i>Festuca ovina</i>	sheep fescue	X	
	FESA	<i>Festuca saximontana</i>	Rocky Mountain fescue		
	FESTU	<i>Festuca</i>	fescue	X	
	HECO26	<i>Hesperostipa comata</i>	needle and thread		
	HESP11	<i>Hesperostipa spartea</i>	porcupinegrass		
	HOJU	<i>Hordeum jubatum</i>	foxtail 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		
	NAVI4	<i>Nassella viridula</i>	green needlegrass		
	ORAS	<i>Oryzopsis asperifolia</i>	roughleaf ricegrass		
	PACA6	<i>Panicum capillare</i>	witchgrass		
	PASM	<i>Pascopyrum smithii</i>	western wheatgrass		
	PHAR3	<i>Phalaris arundinacea</i>	reed canarygrass		
	PIMI7	<i>Piptatherum micranthum</i>	littleseed ricegrass		
	POA	<i>Poa</i>	bluegrass	X	
	POBU	<i>Poa bulbosa</i>	bulbous bluegrass	X	
	POCO	<i>Poa compressa</i>	Canada bluegrass	X	
	POIN	<i>Poa interior</i>	inland bluegrass	X	
	POPA2	<i>Poa palustris</i>	fowl bluegrass		
	POPR	<i>Poa pratensis</i>	Kentucky bluegrass	X	
	POSE	<i>Poa secunda</i>	Sandberg bluegrass		
	PSJU3	<i>Psathyrostachys juncea</i>	Russian wildrye	X	
	PSSP6	<i>Pseudoroegneria spicata</i>	bluebunch wheatgrass		
	SCPU	<i>Schizachne purpurascens</i>	false melic		

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	SCSC	<i>Schizachyrium scoparium</i>	little bluestem		
	SPCR	<i>Sporobolus cryptandrus</i>	sand dropseed		
	STIPA	<i>Stipa</i>	needlegrass		
	THIN6	<i>Thinopyrum intermedium</i>	intermediate wheatgrass	X	
	THPO7	<i>Thinopyrum ponticum</i>	tall wheatgrass	X	
	VUOC	<i>Vulpia octoflora</i>	sixweeks fescue		
Polemoniaceae	COLI2	<i>Collomia linearis</i>	tiny trumpet		
	IPCO5	<i>Ipomopsis congesta</i>	ballhead ipomopsis		
	PHAL3	<i>Phlox allysifolia</i>	alyssumleaf phlox		
	PHAN4	<i>Phlox andicola</i>	prairie phlox		
	PHDI5	<i>Phlox divaricata</i>	wild blue phlox		
	PHHO	<i>Phlox hoodii</i>	spiny phlox		
	PHLOX	<i>Phlox</i>	phlox		
Polygalaceae	POAL4	<i>Polygala alba</i>	white milkwort		
Polygonaceae	FACO	<i>Fallopia convolvulus</i>	black bindweed	X	
	POAV	<i>Polygonum aviculare</i>	prostrate knotweed	X	
	PODO4	<i>Polygonum douglasii</i>	Douglas' knotweed		
	PORA3	<i>Polygonum ramosissimum</i>	bushy knotweed		
	RUCR	<i>Rumex crispus</i>	curly dock	X	
	ANOC2	<i>Androsace occidentalis</i>	western rockjasmine		
Primulaceae	PRPA99	<i>Primula pauciflora</i>	darkthroat shootingstar		
	ANCY	<i>Anemone cylindrica</i>	candle anemone		
Ranunculaceae	ANPA	<i>Anemone parviflora</i>	smallflowered anemone		
	ANPA19	<i>Anemone patens</i>	eastern pasqueflower		
	AMAL2	<i>Amelanchier alnifolia</i>	Saskatoon serviceberry		
Rosaceae	CRCH	<i>Crataegus chrysocarpa</i>	fireberry hawthorn		
	GETR	<i>Geum triflorum</i>	prairie smoke		
	POTEN	<i>Potentilla</i>	cinquefoil		

Family	Code	Scientific Name	Common Name	Exotic	Rare
	PRAM	<i>Prunus americana</i>	American plum		
	PRPE2	<i>Prunus pensylvanica</i>	pin cherry		
	PRVI	<i>Prunus virginiana</i>	chokecherry		
	ROAR3	<i>Rosa arkansana</i>	prairie rose		
	ROWO	<i>Rosa woodsii</i>	Woods' rose		
	GAAP2	<i>Galium aparine</i>	stickywilly		
Rubiaceae	GABO2	<i>Galium boreale</i>	northern bedstraw		
	GALIU	<i>Galium</i>	bedstraw		
	GATR3	<i>Galium triflorum</i>	fragrant bedstraw		
	PODE3	<i>Populus deltoides</i>	eastern cottonwood		
Salicaceae	POTR5	<i>Populus tremuloides</i>	quaking aspen		
	SAAM2	<i>Salix amygdaloides</i>	peachleaf willow		
	HERI	<i>Heuchera richardsonii</i>	Richardson's alumroot		
Saxifragaceae	LIPA5	<i>Lithophragma parviflorum</i>	smallflower woodland-star		
	COPA3	<i>Collinsia parviflora</i>	maiden blue eyed Mary		
Scrophulariaceae	ORLU2	<i>Orthocarpus luteus</i>	yellow owl's-clover		
	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		
	VEAR	<i>Veronica arvensis</i>	corn speedwell	X	
	VEPE2	<i>Veronica peregrina</i>	neckweed		
	VETH	<i>Verbascum thapsus</i>	common mullein	X	
	SEDE2	<i>Selaginella densa</i>	lesser spikemoss		
Selaginellaceae	SMILA2	<i>Smilax</i>	greenbrier		
Smilacaceae	SMLA3	<i>Smilax lasioneura</i>	Blue Ridge carrionflower		
	PHHE4	<i>Physalis hederifolia</i>	ivyleaf groundcherry		
Solanaceae	PHHE5	<i>Physalis heterophylla</i>	clammy groundcherry		

Family	Code	Scientific Name	Common Name	Exotic	Rare
	PHVI5	<i>Physalis virginiana</i>	Virginia groundcherry		S1/G5
	SOLAN	<i>Solanum</i>	nightshade	X	
	SOTR	<i>Solanum triflorum</i>	cutleaf nightshade		
	PAPE5	<i>Parietaria pensylvanica</i>	Pennsylvania pellitory		
Urticaceae	VEBR	<i>Verbena bracteata</i>	bigbract verbena		
Verbenaceae	VIAD	<i>Viola adunca</i>	hookedspur violet		
Violaceae	VICA4	<i>Viola canadensis</i>	Canadian white violet		
	VINU2	<i>Viola nuttallii</i>	Nuttall's violet, yellow prairie violet		
	VIOLA	<i>Viola</i>	violet	X	
	VIPE2	<i>Viola pedatifida</i>	prairie violet		S1/G5
	VISO	<i>Viola sororia</i>	common blue 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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