



Plant Community Composition and Structure Monitoring for Devils Tower National Monument

2016 Data Report

Natural Resource Data Series NPS/NGPN/NRDS—2017/1086



ON THE COVER

Plant Community Composition and Structure Monitoring plot PCM-261 at Devils Tower National Monument, July 2016.
Photograph courtesy of the National Park Service.

Plant Community Composition and Structure Monitoring for Devils Tower National Monument

2016 Data Report

Natural Resource Data Series NPS/NGPN/NRDS—2017/1086

Stephanie L. Rockwood
Daniel J. Swanson

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

February 2017

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

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

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

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

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

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

This report is available in digital format from the [Northern Great Plains Inventory & Monitoring website](#) and the [Natural Resource Publications Management website](#). To receive this report in a format that is optimized to be accessible using screen readers for the visually or cognitively impaired, please email irma@nps.gov.

Please cite this publication as:

Rockwood, S. L., and D. J. Swanson. 2017. Plant community composition and structure monitoring for Devils Tower National Monument: 2016 data report. Natural Resource Data Series NPS/NGPN/NRDS—2017/1086. National Park Service, Fort Collins, Colorado.

Contents

	Page
Figures.....	iv
Tables.....	iv
Abstract.....	v
Acknowledgments.....	vi
Introduction.....	1
Methods.....	1
NGPN and NGPFire Monitoring Plots 2016.....	1
Plot Layout and Sampling	3
Data Management and Analysis.....	7
Results.....	8
Literature Cited	20

Figures

	Page
Figure 1. Map of Devils Tower National Monument plant community monitoring plots visited in 2016.....	2
Figure 2. Long-term monitoring plot layout used for sampling vegetation in Devils Tower National Monument.....	5
Figure 3. The Northern Great Plains Inventory & Monitoring vegetation crew used point-intercept and 1m ² quadrats to document plant diversity and abundance.	5

Tables

	Page
Table 1. Field journal for Northern Great Plains Network plant community monitoring in Devils Tower National Monument in 2016.	3
Table 2. Field journal for Northern Great Plains Fire Effects Program visits to plant community monitoring plots at Devils Tower National Monument in 2016.....	3
Table 3. 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.	6
Table 4. Definitions of state and global species conservation status ranks.....	6
Table 5. List of all plant species identified in Devils Tower National Monument long-term plant community monitoring plots in 2016.....	8
Table 6. Number of plant species per plot observed in seventeen plots at Devils Tower National Monument in 2016.	13
Table 7. Absolute and relative cover of native and exotic species in plots monitored at Devils Tower National Monument in 2016.	13
Table 8. Woody species data from seven plots visited at Devils Tower National Monument in 2016.....	14
Table 9. Surface fuels summary for 19 plots visited in 2016 at Devils Tower National Monument by NGPN and NGPFire monitoring crews.....	18
Table 10. Disturbance types and area sizes observed in seven plots visited at Devils Tower National Monument in 2016.....	19

Abstract

This report presents the results of vegetation monitoring efforts in 2016 at Devils Tower National Monument (DETO) by the Northern Great Plains Inventory and Monitoring Network (NGPN) and the Northern Great Plains Fire Effects (NGPFire) program.

During the sixth full year of field work, the NGPN field crew visited eight long-term plant community monitoring (PCM) plots and the NGPFire crew visited eleven PCM plots to collect data on the plant communities at DETO. This is part of a long-term monitoring effort to better understand the condition of the riparian and upland forests in DETO. NGPN staff captured data relating to species richness, herb-layer height, abundances of native and non-native species, ground cover, and site disturbance from each PCM plot. The NGPFire crew collected data relating to herb-layer height, abundance of native and non-native species, and ground cover at each of the eleven PCM plots. In plots where woody species were present, both crews measured tree regeneration, tall shrub and tree density, and woody fuel load.

Our 2016 findings can be summarized as follows: Monitoring crews identified 117 species in eight monitoring plots visited in 2016 at DETO, of which 18 were exotic species. Generally, the upland PCM plots had greater native species diversity than the two plots along the riparian corridor. Non-native species were abundant throughout the park, averaging about 31% relative cover. None of the exotic species identified in upland plots were on the target list for the early detection and rapid response program in the Northern Great Plains Network parks. Tree regeneration and woody fuel loads were observed at eighteen of the nineteen plots. The most common disturbances observed were prescribed fire and animal use.

Acknowledgments

We thank the authors of the NGPN Plant Community Monitoring Protocol, particularly A. Symstad, for outstanding guidance on data collection and reporting. Thank you to the staff at DETO, particularly R. Ohms and law enforcement staff for providing logistical support and safety checks. We also thank M. Whitman and J. T. Smith from DETO for assistance in the field. The 2016 NGPN vegetation field crew of C. Davis, S. Rockwood, W. Vogel, and M. Davis, with the assistance of the Northern Great Plains Fire Effects crew of D. Swanson, E. Watson, I. Muirhead, and C. Tomford, collected all the data included in this report.

Introduction

Devils Tower National Monument (DETO) was established in 1906 as America's 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. 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 this report, we provide summaries of the data collected at 19 plots in 2016. Please refer to the "Northern Great Plains Fire Ecology Annual Report: Calendar Year 2016" and the Devils Tower National Monument Graham Fire Effects Monitoring Report for park burn unit analysis and interpretation of the 2016 monitoring results accessible on the Data Store <https://irma.nps.gov/DataStore>.

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 the protocol publications cited above, and available at <http://science.nature.nps.gov/im/units/ngpn/monitor/plants.cfm>.

NGPN and NGPFire Monitoring Plots 2016

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 the GRTS design, NGPN selected 20 randomly located sites within DETO to install Plant Community Monitoring (PCM) plots. These 20 sites are split into five panels containing four sites each. The NGPN visits eight PCM plots (two panels) every year using a rotating sampling scheme where four sites were visited in the previous year and four sites were most recently visited four years previous (Figure 1). In a full five-year rotation, each plot will have been visited twice. In 2016, the NGPN crew visited PCM plots in panel 1 and panel 5 during the week of July 11-14 (Table 1). Of the eight plots, six were upland and two were along the riparian corridor (PCM_261 and PCM_263). When a PCM plot was located within an active burn unit, NGPFire added additional visits based on a preburn, 1, 2, 5, and 10 year post-burn sampling schedule using the same GRTS sampling schema. In 2016, the NGPFire crew visited eleven plant community monitoring (PCM) upland plots from various sampling panels during the week of July 11-14, 2016 (Figure 1). Some of these PCM plots, plus additional PCM plots, were visited again in November 2016 to collect post-burn severity data after the Graham prescribed burn (Table 2).

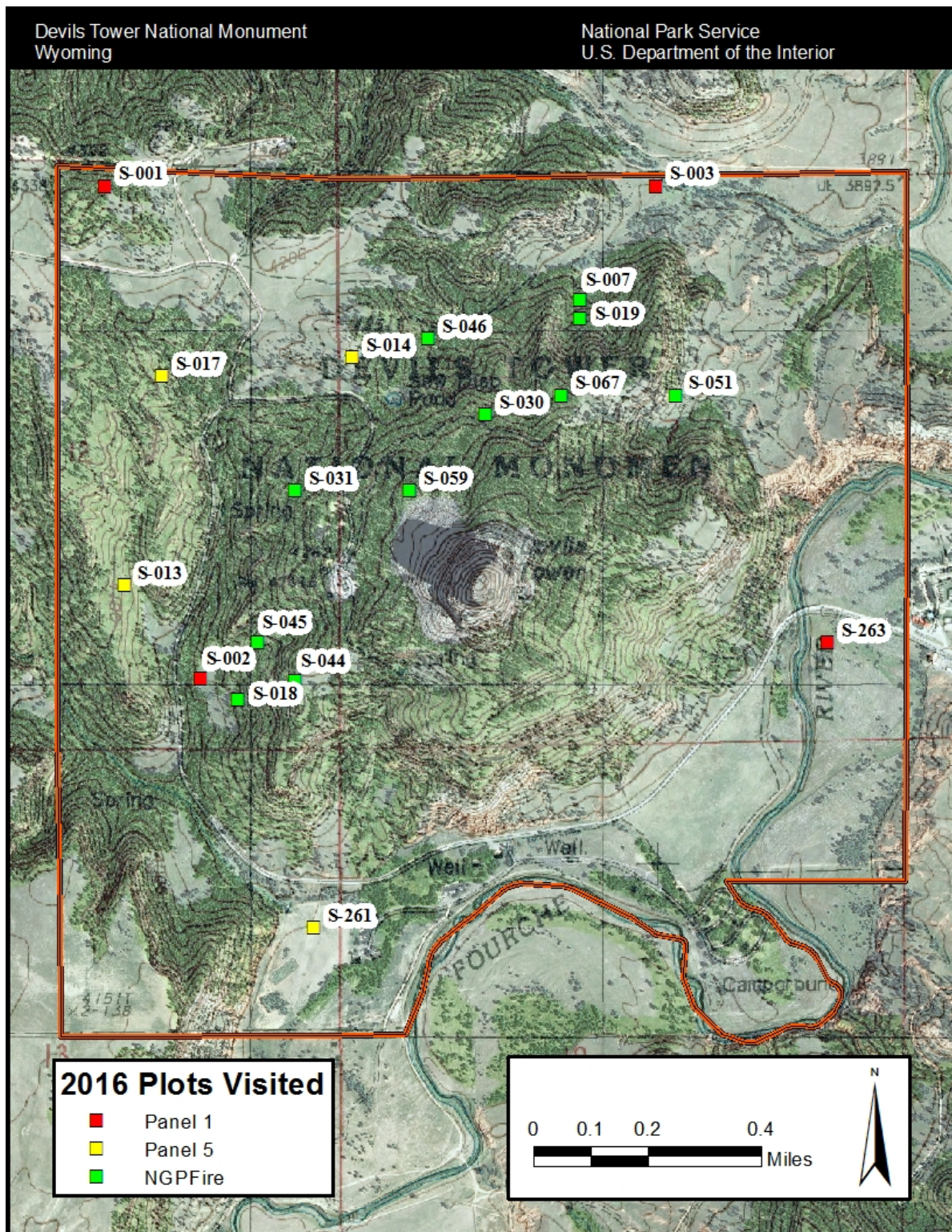


Figure 1. Map of Devils Tower National Monument (DETO) plant community monitoring (PCM) plots visited in 2016. Long-term vegetation monitoring plots were established by the Northern Great Plains Inventory and Monitoring Program (NGPN) and the Fire Effects Program (NGPFire) between 2011 and 2015. Four Panel 1 plots (in red), and four Panel 5 plots (in yellow) were monitored in 2016 by NGPN. Eleven PCM plots were visited in 2016 by NGPFire.

Table 1. Field journal for Northern Great Plains Network plant community monitoring (PCM) in Devils Tower National Monument (DETO) in 2016. A crew of four people completed 8 PCM plots, along with the assistance of DETO staff.

Date	Travel time	Housing	Plots Read	Notes
Monday July 11, 2016	3 hrs	Park campground	PCM_261 PCM_263	Megan Whitman (DETO) assisted at PCM_261 Started PCM_263
Tuesday July 12, 2016		Park campground	PCM_014 PCM_002 PCM_003	Also finished PCM_263. Plot PCM_003 moderate diversity. PCM_014 very dry.
Wednesday July 13, 2016		Park campground	PCM_001 PCM_017	Only locating and plot photos took place at PCM_001; rest of data collected 7/14.
Thursday July 14, 2016	3 hrs	NA	PCM_001 PCM_013	

Table 2. Field journal for Northern Great Plains Fire Effects Program visits to plant community monitoring (PCM) plots at Devils Tower National Monument (DETO) in 2016. Plant community monitoring was completed using a crew of four people, along with the assistance of DETO staff. The 114 acre Graham prescribed fire was completed on October 24, 2016

Date	Monitoring Status *	Burn Unit	Plots Read
Monday July 11, 2016	Preburn	Graham	PCM_031
Tuesday July 12, 2016	Preburn	Graham	PCM_018, PCM_044, PCM_045
Monday July 11, 2016	Preburn	Northside	PCM_059
Tuesday July 12, 2016	Preburn	Northside	PCM_046
Wednesday July 13, 2016	Preburn	Northside	PCM_007, PCM_019, PCM_030, PCM_067
Thursday July 14, 2016	Preburn	Northside	PCM_051
Thursday November 03, 2016	Immediate Post-burn	Graham	PCM_031, PCM_045, PCM_063
Friday November 04, 2016	Immediate Post-burn	Graham	PCM_018, PCM_044, PCM_047, PCM_002
Wednesday November 09, 2016	Immediate Post-burn	Graham	PCM_050, PCM_066

* 2016 Northern Great Plains Fire Ecology Annual Report and DETO Graham Fire Effects Monitoring Report contain detailed information on changes to vegetative composition and cover following prescribed fire as well as fire objectives, progression, weather, behavior, smoke, and plot analysis.

PCM plots located within an active burn unit were visited based on a preburn, 1, 2, 5, and 10 year post-burn sampling schedule.

Plot Layout and Sampling

At each of the sites visited, the NGPN crew 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 along two 50 m transects (the long sides of the plot) using a point-intercept method. At 50 locations along each transect, once every 1 meter, a pole was dropped to the ground and all species that touched the pole were recorded, along with ground cover and canopy height (Figure 3). Species richness data from the point-intercept method were supplemented with species presence data collected in five 1 m² quadrats located systematically along each transect (Figure 2) (Figure 3). At plots visited by NGPFire, only point-intercept data were collected. Vegetation data was not collected at all from two plots visited by NGPFire in 2016: PCM_059, and PCM_067.

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). Both NGPN and NGPFire crews collected woody species data in PCM plots. 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 (live or dead), and condition (e.g., leaf-discoloration, insect-damaged, etc.) were recorded. Dead and downed woody fuel load data were also collected at these forested plots along two perpendicular, 100 foot (30.49 m) transects with midpoints at the center of the plot (Figure 2), following Brown's Line methods (Brown 1974, Brown et al. 1982).

At each of the plots visited by NGPN, common disturbances and target species of interest were also assessed and documented. Common disturbances included such things as prairie dog towns, animal trails, and fire occurrence. For each plot, the type, severity, and approximate area (m²) of the disturbances were recorded. The NGPN crew also surveyed the area for early-detection exotic species that have the potential to spread into the park and cause significant ecological impacts (Table 3). 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 present, 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. NGPFire did not collect disturbance or early-detection species data. The plants identified by NGPN staff were also cross-referenced with the list of plants designated as "noxious weeds" in Wyoming by the Wyoming Weed and Pest Council (<http://www.wyoweed.org/weeds>).

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 4 for a detailed definition of each conservation status rank.

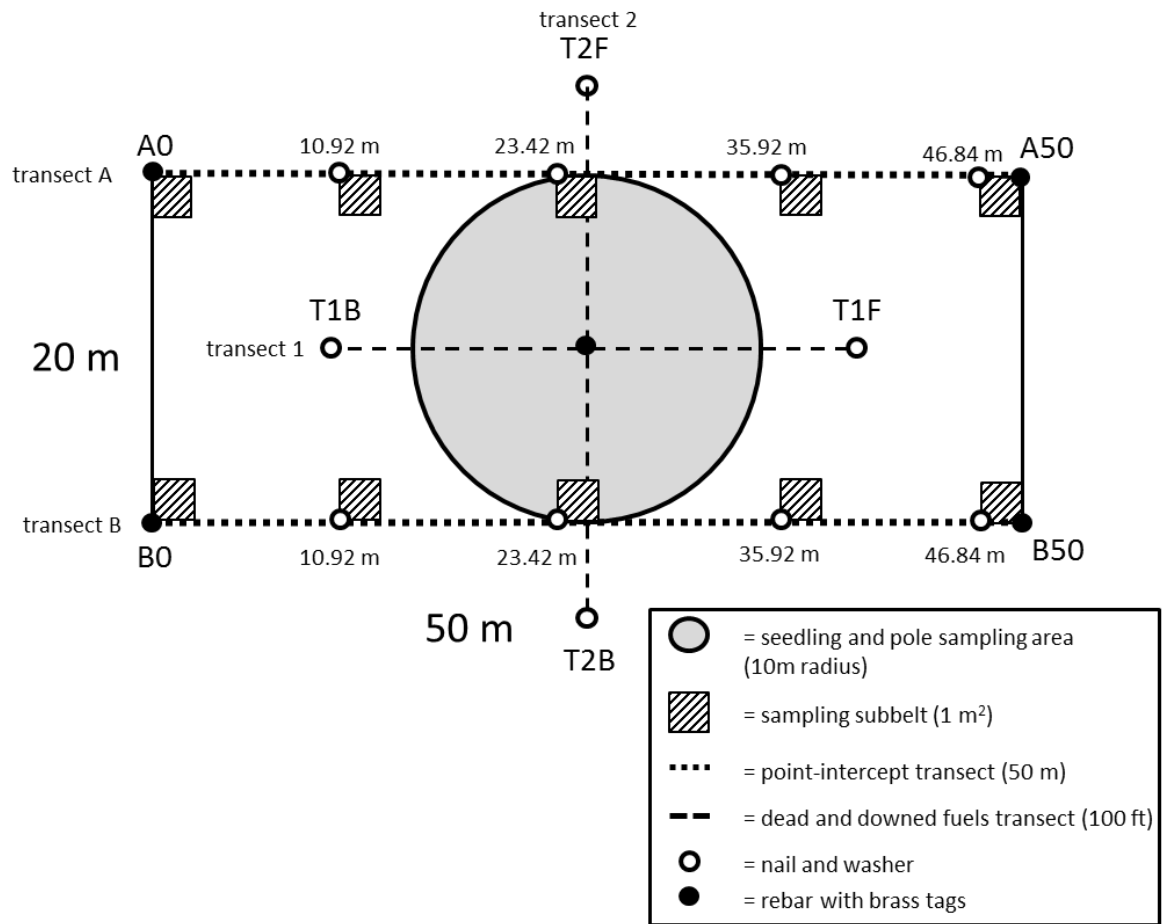


Figure 2. Long-term monitoring plot layout used for sampling vegetation in Devils Tower National Monument.

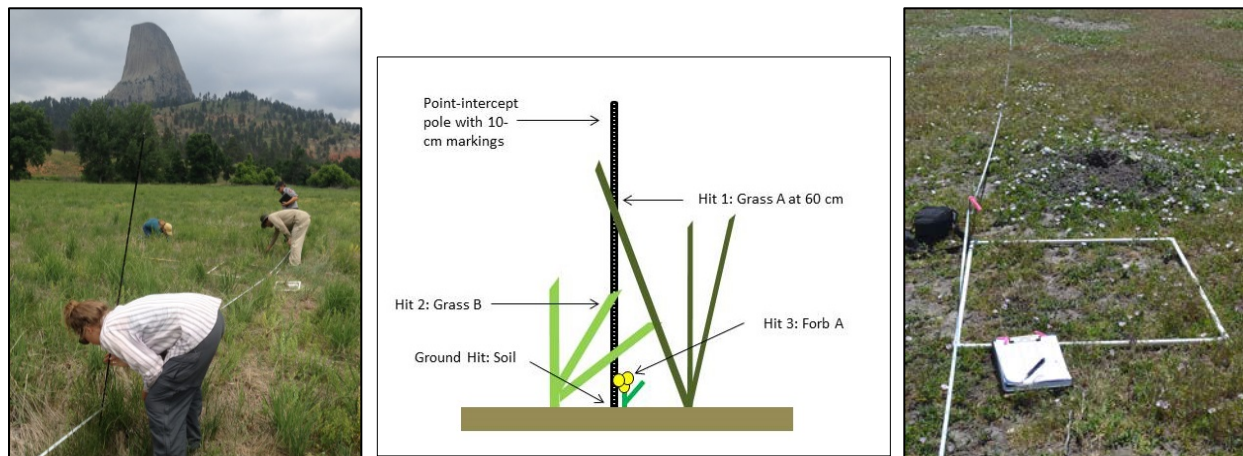


Figure 3. The Northern Great Plains Inventory & Monitoring vegetation crew used point-intercept (left and center panel) and 1m² quadrats (right panel) to document plant diversity and abundance.

Table 3. 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 aethiopis</i>	Mediterranean sage	Upland
<i>Ventenata dubia</i>	African wiregrass	Upland

Table 4. 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>)

Data Management and Analysis

FFI (FEAT/FIREMON Integrated; <http://frames.gov/ffi/>) was used as the primary software environment for managing the sampling data. This database 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 2016). However, nomenclature follows the Integrated Taxonomic Information System (ITIS) (<http://www.itis.gov>). In the few cases where ITIS recognizes a new name that was not in the USDA Plants database, the new name was used and a unique plant code was assigned. After data for the sites were entered, 100% of records were verified to the original data sheet to minimize transcription errors. A further 10% of records were reviewed a second time. After all data were entered and verified, automated queries were used to check for errors in the data. When errors were identified by the crew or the automated queries, changes were made to the original datasheets and the FFI database as needed.

Results

There are 471 vascular plant species on the DETO species list, and the NGPN and NGPFire monitoring crews identified 117 of these species in nineteen monitoring plots visited in 2016 at DETO (Table 5). Of these plant species, 18 are exotic species at DETO. All exotics identified were either forbs or graminoids (grasses, sedges, and rushes). After review of the 2016 plant species list, we determined that two species were misidentified: prairie phlox (*Phlox andicola*) and slimflower scurfpea (*Psoralea tenuiflora*). Neither of these species are known to occur in DETO or within Crook County, WY, and all data sheets and database entries were changed to indicate the correct species: prickly phlox (*Phlox hoodii*) and lemon scurfpea (*Psoralea lanceolata*), respectively.

Table 5. List of all plant species identified in DETO long-term plant community monitoring plots in 2016. 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. A “WY” in the Exotic column indicates that a species is on Wyoming’s list of designated noxious weeds. Species that are rare in Wyoming are marked in the final column and the state conservation ranks are provided. Conservation rank definitions are in Table 4 of the report.

Family	Code	Scientific Name	Common Name	Exotic	Rare
Aceraceae	ACNE2	<i>Acer negundo</i>	boxelder		
Anacardiaceae	RHTR	<i>Rhus trilobata</i>	skunkbush sumac		
	TORY	<i>Toxicodendron rydbergii</i>	western poison ivy		
Apocynaceae	APAN2	<i>Apocynum androsaemifolium</i>	spreading dogbane		
Asclepiadaceae	ASPU	<i>Asclepias pumila</i>	plains milkweed		
	ASVI	<i>Asclepias viridiflora</i>	green comet milkweed		
Asteraceae	ACMI2	<i>Achillea millefolium</i>	common yarrow		
	AMPS	<i>Ambrosia psilostachya</i>	Cuman ragweed		
	ANPA4	<i>Antennaria parvifolia</i>	small-leaf pussytoes		
	ARFR4	<i>Artemisia frigida</i>	prairie sagewort		
	ARLU	<i>Artemisia ludoviciana</i>	white sagebrush		
	ARTR2	<i>Artemisia tridentata</i>	big sagebrush		
	BASA3	<i>Balsamorhiza sagittata</i>	arrowleaf balsamroot		
	CANU4	<i>Carduus nutans</i>	nodding plumeless thistle	WY	
	CIAR4	<i>Cirsium arvense</i>	Canada thistle	WY	
	CIUN	<i>Cirsium undulatum</i>	wavyleaf thistle		
	COCA5	<i>Conyza canadensis</i>	Canadian horseweed		
	ECAN2	<i>Echinacea angustifolia</i>	blacksamson echinacea		
	ERST3	<i>Erigeron strigosus</i>	prairie fleabane		
	ERSU2	<i>Erigeron subtrinnervis</i>	threenerve fleabane		

Table 5 (continued). List of all plant species identified in DETO long-term plant community monitoring plots in 2016. 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. A “WY” in the Exotic column indicates that a species is on Wyoming’s list of designated noxious weeds. Species that are rare in Wyoming are marked in the final column and the state conservation ranks are provided. Conservation rank definitions are in Table 4 of the report.

Family	Code	Scientific Name	Common Name	Exotic	Rare
Asteraceae, cont.	GRSQ	<i>Grindelia squarrosa</i>	curlycup gumweed		
	GUSA2	<i>Gutierrezia sarothrae</i>	broom snakeweed		
	HEPA19	<i>Helianthus pauciflorus</i>	stiff sunflower		
	LIPU	<i>Liatris punctata</i>	dotted blazing star		
	LYJU	<i>Lygodesmia juncea</i>	rush skeletonplant		
	MUOB99	<i>Mulgedium oblongifolium</i>	blue lettuce		
	RACO3	<i>Ratibida columnifera</i>	upright prairie coneflower		
	SOMI2	<i>Solidago missouriensis</i>	Missouri goldenrod		
	SONE	<i>Solidago nemoralis</i>	gray goldenrod		
	SYFA	<i>Symphyotrichum falcatum</i>	white prairie aster		
	SYOB	<i>Symphyotrichum oblongifolium</i>	aromatic aster		
	TAOF	<i>Taraxacum officinale</i>	common dandelion	X	
	TEAC	<i>Tetrameuris acaulis</i>	stemless four-nerve daisy		
	TRDU	<i>Tragopogon dubius</i>	yellow salsify	X	
Berberidaceae	BERE	<i>Berberis repens</i>	Oregon grape		
Boraginaceae	CYOF	<i>Cynoglossum officinale</i>	gypsyflower	WY	
	LIIN2	<i>Lithospermum incisum</i>	narrowleaf stoneseed		
Brassicaceae	ALDE	<i>Alyssum desertorum</i>	desert madwort	X	
	ARPY4	<i>Arabis pycnocarpa</i>	creamflower rockcress		
	CABU2	<i>Capsella bursa-pastoris</i>	shepherd's purse	X	
	THAR5	<i>Thlaspi arvense</i>	field pennycress	X	
Cactaceae	OPPO	<i>Opuntia polyacantha</i>	plains 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		
Cupressaceae	JUSC2	<i>Juniperus scopulorum</i>	Rocky Mountain juniper		
Cyperaceae	CADU6	<i>Carex duriuscula</i>	needleleaf sedge		
	CAEM2	<i>Carex emoryi</i>	Emory's sedge		S1
	CAFI	<i>Carex filifolia</i>	threadleaf sedge		

Table 5 (continued). List of all plant species identified in DETO long-term plant community monitoring plots in 2016. 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. A “WY” in the Exotic column indicates that a species is on Wyoming’s list of designated noxious weeds. Species that are rare in Wyoming are marked in the final column and the state conservation ranks are provided. Conservation rank definitions are in Table 4 of the report.

Family	Code	Scientific Name	Common Name	Exotic	Rare
Cyperaceae, cont.	CAIN9	<i>Carex inops</i>	long-stolon sedge		
	CAREX	<i>Carex</i>	sedge		
	CASP7	<i>Carex sprengelii</i>	Sprengel's sedge		
Equisetaceae	EQLA	<i>Equisetum laevigatum</i>	smooth horsetail		
Euphorbiaceae	EUES	<i>Euphorbia esula</i>	leafy spurge	WY	
	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		
	ASFL2	<i>Astragalus flexuosus</i>	flexile milkvetch		
	ASLA27	<i>Astragalus laxmannii</i>	Laxmann's milkvetch		
	DACA7	<i>Dalea candida</i>	white prairie clover		
	DAPU5	<i>Dalea purpurea</i>	purple prairie clover		
	GLLE3	<i>Glycyrrhiza lepidota</i>	American licorice		
	MEOF	<i>Melilotus officinalis</i>	yellow sweetclover	X	
	OXSE	<i>Oxytropis sericea</i>	white locoweed		
	PEAR6	<i>Pedimelum argophyllum</i>	silverleaf Indian breadroot		
	PSLA3	<i>Psoralidium lanceolatum</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		
Iridaceae	SIMO2	<i>Sisyrinchium montanum</i>	strict blue-eyed grass		
Linaceae	LINUM	<i>Linum</i>	flax		
Onagraceae	OESU99	<i>Oenothera suffrutescens</i>	scarlet beeblossom		
Pinaceae	PIPO	<i>Pinus ponderosa</i>	ponderosa pine		
Poaceae	ANGE	<i>Andropogon gerardii</i>	big bluestem		
	ARPU9	<i>Aristida purpurea</i>	purple threeawn		
	BOCU	<i>Bouteloua curtipendula</i>	sideoats grama		
	BOGR2	<i>Bouteloua gracilis</i>	blue grama		
	BRAN	<i>Bromus anomalus</i>	nodding brome		

Table 5 (continued). List of all plant species identified in DETO long-term plant community monitoring plots in 2016. 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. A “WY” in the Exotic column indicates that a species is on Wyoming’s list of designated noxious weeds. Species that are rare in Wyoming are marked in the final column and the state conservation ranks are provided. Conservation rank definitions are in Table 4 of the report.

Family	Code	Scientific Name	Common Name	Exotic	Rare
Poaceae, cont.	BRIN2	<i>Bromus inermis</i>	smooth brome	X	
	BRJA	<i>Bromus japonicus</i>	Japanese brome	X	
	BRTE	<i>Bromus tectorum</i>	cheatgrass	X	
	CALO	<i>Calamovilfa longifolia</i>	prairie sandreed		
	DASP2	<i>Danthonia spicata</i>	poverty oatgrass		
	DIOL	<i>Dichanthelium oligosanthos</i>	Heller's rosette grass		
	DIWI5	<i>Dichanthelium wilcoxianum</i>	fall rosette grass		S2
	ELCA4	<i>Elymus canadensis</i>	Canada wildrye		
	ELRE4	<i>Elymus repens</i>	quackgrass	X	
	ELTR7	<i>Elymus trachycaulus</i>	slender wheatgrass		
	FEID	<i>Festuca idahoensis</i>	Idaho fescue		
	FESTU	<i>Festuca</i>	fescue	X	
	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		
	NAVI4	<i>Nassella viridula</i>	green needlegrass		
	PASM	<i>Pascopyrum smithii</i>	western wheatgrass		
	POA	<i>Poa</i>	bluegrass	X	
	POBU	<i>Poa bulbosa</i>	bulbous bluegrass	X	
	POPR	<i>Poa pratensis</i>	Kentucky bluegrass	X	
	POSE	<i>Poa secunda</i>	Sandberg bluegrass		
	PSSP6	<i>Pseudoroegneria spicata</i>	bluebunch wheatgrass		
	SCPU	<i>Schizachne purpurascens</i>	false melic		
	SCSC	<i>Schizachyrium scoparium</i>	little bluestem		
	SPCR	<i>Sporobolus cryptandrus</i>	sand dropseed		

Table 5 (continued). List of all plant species identified in DETO long-term plant community monitoring plots in 2016. 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. A “WY” in the Exotic column indicates that a species is on Wyoming’s list of designated noxious weeds. Species that are rare in Wyoming are marked in the final column and the state conservation ranks are provided. Conservation rank definitions are in Table 4 of the report.

Family	Code	Scientific Name	Common Name	Exotic	Rare
Polemoniaceae	PHAL3	<i>Phlox alyssifolia</i>	alyssumleaf phlox		
	PHHO	<i>Phlox hoodii</i>	spiny phlox		
Ranunculaceae	ANCY	<i>Anemone cylindrica</i>	candle anemone		
Rosaceae	PRVI	<i>Prunus virginiana</i>	chokecherry		
	ROAR3	<i>Rosa arkansana</i>	prairie rose		
Rubiaceae	GABO2	<i>Galium boreale</i>	northern bedstraw		
Salicaceae	PODE3	<i>Populus deltoides</i>	eastern cottonwood		
	POTR5	<i>Populus tremuloides</i>	quaking aspen		
	SAAM2	<i>Salix amygdaloides</i>	peachleaf willow		
Scrophulariaceae	PEGR7	<i>Penstemon grandiflorus</i>	large beardtongue		
Selaginellaceae	SEDE2	<i>Selaginella densa</i>	lesser spikemoss		

The total number of plant species observed by plot was compiled using both point-intercept and quadrat data collected (Table 6). The plot with the greatest species diversity, with a total of 48 species identified, was DETO_PCM_014, a plot located on the northwest side of the park in a transition zone between forest and grassland. DETO_PCM_001, an open ponderosa pine and grassland species-mix plot located in the northwest corner of the park, had the fewest invasive species observed. Absolute and relative cover were calculated using point-intercept data (Table 7). Plots DETO_PCM_003 and DETO_PCM_007 both had the greatest exotic species relative cover, with 75% and 72%, respectively. Plot DETO_PCM_003 also had the greatest absolute cover of exotic species. Plot DETO_PCM_261, located along the riparian corridor, is the most native by both absolute percent cover and plot DETO_PCM_017 has highest relative cover of native species.

Two plant species identified in the plots are rare in Wyoming: the critically imperiled Emory’s sedge (*Carex emoryi*), and imperiled (not critically) fall rosette grass (*Dichanthelium wilcoxianum*). In a previous visit, Emory’s sedge had been identified as water sedge (*Carex aquatilis*), a superficially similar species. Definitive voucher specimens should be collected during the next plot visit to verify identification. All trees, shrubs and subshrubs were native species. No target early detection exotic species were identified (Table 3).

Table 6. Number of plant species per plot observed in seventeen plots at Devils Tower National Monument in 2016.

MacroPlot Name	Native (number of plant species)	Invasive (number of plant species)	Total (number of species)
DETO_PCM_001	25	1	26
DETO_PCM_002	26	7	33
DETO_PCM_003	25	5	30
DETO_PCM_007*	6	9	15
DETO_PCM_013	25	3	28
DETO_PCM_014	42	6	48
DETO_PCM_017	39	5	44
DETO_PCM_018*	1	14	15
DETO_PCM_019*	5	12	17
DETO_PCM_030*	3	11	14
DETO_PCM_031*	1	13	14
DETO_PCM_044*	2	14	16
DETO_PCM_045*	2	10	12
DETO_PCM_046*	5	12	17
DETO_PCM_051*	2	15	17
DETO_PCM_261	10	6	16
DETO_PCM_263	16	10	26

*Plot read by NGPFire. Data only include point-intercept data, and, as a result, fewer species were observed.

Table 7. Absolute and relative cover of native and exotic species in plots monitored at Devils Tower National Monument in 2016. Absolute cover includes overlapping species canopies and can be greater than 100%.

Plot Name	Absolute Cover (%)		Relative Cover (%)	
	Exotic	Native	Exotic	Native
DETO_PCM_001	20	97	17	83
DETO_PCM_002	39	99	28	72
DETO_PCM_003	121	41	75	25
DETO_PCM_007*	103	40	72	28
DETO_PCM_013	61	117	34	66
DETO_PCM_014	23	130	15	85
DETO_PCM_017	9	118	7	93
DETO_PCM_018*	9	67	12	88
DETO_PCM_019*	53	60	47	53
DETO_PCM_030*	33	43	43	57
DETO_PCM_031*	13	69	16	84

* NGPFire plot visits

Table 7 (continued). Absolute and relative cover of native and exotic species in plots monitored at Devils Tower National Monument in 2016. Absolute cover includes overlapping species canopies and can be greater than 100%. (* NGPFire plot visits)

Plot Name	Absolute Cover (%)		Relative Cover (%)	
	Exotic	Native	Exotic	Native
DETO_PCM_044*	6	62	9	91
DETO_PCM_045*	5	42	11	89
DETO_PCM_046*	46	49	48	52
DETO_PCM_051*	6	66	8	92
DETO_PCM_261	41	163	20	80
DETO_PCM_263	110	64	63	37

* NGPFire plot visits

Live trees and seedlings were present in eighteen of nineteen sites visited in 2016 (Table 8). Data collected included species name, size class based on diameter at breast height (DBH), status, total number of individuals, and density per hectare. DBH categories are tree (DBH>15 cm), pole (2.54 cm<DBH>15 cm), and seedling (DBH<2.54 cm). Tree regeneration was greatest in DETO_PCM_030, an upland plot located north of the tower (Table 8).

Table 8. Woody species data from seven plots visited at Devils Tower National Monument in 2016. DBH categories are tree (DBH>15 cm), pole (2.54 cm<DBH>15 cm), and seedling (DBH<2.54 cm).

Plot Name	Common Name	DBH	Status	Density/ha.
DETO_PCM_001	Ponderosa Pine	Tree	Dead	10
DETO_PCM_001	Ponderosa Pine	Tree	Alive	180
DETO_PCM_001	Ponderosa Pine	Pole	Alive	31.85
DETO_PCM_001	Chokecherry	Seedling	Alive	31.83
DETO_PCM_001	Ponderosa Pine	Seedling	Alive	190.96
DETO_PCM_002	Ponderosa Pine	Tree	Alive	100
DETO_PCM_002	Bur Oak	Seedling	Alive	95.48
DETO_PCM_002	Ponderosa Pine	Seedling	Alive	381.92
DETO_PCM_003	Bur Oak	Tree	Dead	10
DETO_PCM_003	Bur Oak	Tree	Alive	80
DETO_PCM_003	Bur Oak	Seedling	Alive	604.71
DETO_PCM_007	Bur Oak	Tree	Alive	31.85
DETO_PCM_007	Ponderosa Pine	Tree	Dead	254.78
DETO_PCM_007	Ponderosa Pine	Tree	Alive	509.55
DETO_PCM_007	Ponderosa Pine	Seedling	Alive	1241.25
DETO_PCM_013	Ponderosa Pine	Seedling	Alive	159.13
DETO_PCM_014	Ponderosa Pine	Seedling	Alive	254.61

Table 8 (continued). Woody species data from seven plots visited at Devils Tower National Monument in 2016. DBH categories are tree (DBH>15 cm), pole (2.54 cm<DBH>15 cm), and seedling (DBH<2.54 cm).

Plot Name	Common Name	DBH	Status	Density/ha.
DETO_PCM_017	Ponderosa Pine	Tree	Dead	10
DETO_PCM_017	Ponderosa Pine	Tree	Alive	190
DETO_PCM_017	Bur Oak	Seedling	Alive	63.65
DETO_PCM_017	Ponderosa Pine	Seedling	Alive	2387.01
DETO_PCM_018	Ponderosa Pine	Tree	Alive	254.78
DETO_PCM_018	Ponderosa Pine	Pole	Alive	159.24
DETO_PCM_018	Rocky Mountain Juniper	Pole	Dead	95.54
DETO_PCM_018	Ponderosa Pine	Seedling	Alive	1495.86
DETO_PCM_019	Ponderosa Pine	Tree	Dead	127.39
DETO_PCM_019	Ponderosa Pine	Tree	Alive	95.54
DETO_PCM_019	Bur Oak	Pole	Dead	63.69
DETO_PCM_019	Ponderosa Pine	Pole	Dead	31.85
DETO_PCM_019	Ponderosa Pine	Pole	Alive	31.85
DETO_PCM_019	Ponderosa Pine	Seedling	Alive	7542.97
DETO_PCM_019	Rocky Mountain Juniper	Seedling	Alive	31.83
DETO_PCM_030	Bur Oak	Tree	Alive	31.85
DETO_PCM_030	Ponderosa Pine	Tree	Dead	127.39
DETO_PCM_030	Ponderosa Pine	Tree	Alive	254.78
DETO_PCM_030	Bur Oak	Pole	Dead	159.24
DETO_PCM_030	Bur Oak	Pole	Alive	31.85
DETO_PCM_030	Ponderosa Pine	Pole	Dead	31.85
DETO_PCM_030	Ponderosa Pine	Seedling	Alive	60343.73
DETO_PCM_031	Ponderosa Pine	Tree	Alive	318.47
DETO_PCM_031	Ponderosa Pine	Pole	Dead	63.69
DETO_PCM_031	Ponderosa Pine	Pole	Alive	31.85
DETO_PCM_031	Ponderosa Pine	Seedling	Alive	1018.46
DETO_PCM_044	Ponderosa Pine	Tree	Dead	31.85
DETO_PCM_044	Ponderosa Pine	Tree	Alive	286.62
DETO_PCM_044	Ponderosa Pine	Pole	Dead	31.85
DETO_PCM_044	Ponderosa Pine	Pole	Alive	63.69
DETO_PCM_044	Ponderosa Pine	Seedling	Alive	2227.88
DETO_PCM_044	Rocky Mountain Juniper	Seedling	Alive	31.83

Table 8 (continued). Woody species data from seven plots visited at Devils Tower National Monument in 2016. DBH categories are tree (DBH>15 cm), pole (2.54 cm<DBH>15 cm), and seedling (DBH<2.54 cm).

Plot Name	Common Name	DBH	Status	Density/ha.
DETO_PCM_045	Ponderosa Pine	Tree	Dead	63.69
DETO_PCM_045	Ponderosa Pine	Tree	Alive	222.93
DETO_PCM_045	Ponderosa Pine	Pole	Dead	31.85
DETO_PCM_045	Ponderosa Pine	Pole	Alive	95.54
DETO_PCM_045	Ponderosa Pine	Seedling	Alive	286.44
DETO_PCM_046	Bur Oak	Tree	Alive	159.24
DETO_PCM_046	Ponderosa Pine	Tree	Alive	159.24
DETO_PCM_046	Bur Oak	Seedling	Alive	127.31
DETO_PCM_046	Ponderosa Pine	Seedling	Alive	22533.42
DETO_PCM_051	Ponderosa Pine	Tree	Alive	87.58
DETO_PCM_051	Ponderosa Pine	Seedling	Alive	127.31
DETO_PCM_059	Ponderosa Pine	Tree	Dead	31.85
DETO_PCM_059	Ponderosa Pine	Tree	Alive	127.39
DETO_PCM_059	Ponderosa Pine	Pole	Dead	31.85
DETO_PCM_059	Ponderosa Pine	Pole	Alive	254.78
DETO_PCM_059	Bur Oak	Seedling	Alive	31.83
DETO_PCM_059	Ponderosa Pine	Seedling	Alive	413.75
DETO_PCM_059	Quaking Aspen	Seedling	Alive	159.13
DETO_PCM_067	Ponderosa Pine	Tree	Alive	828.03
DETO_PCM_067	Rocky Mountain Juniper	Tree	Dead	31.85
DETO_PCM_067	Rocky Mountain Juniper	Pole	Dead	31.85
DETO_PCM_067	Rocky Mountain Juniper	Pole	Alive	31.85
DETO_PCM_067	Ponderosa Pine	Seedling	Alive	2227.88
DETO_PCM_067	Rocky Mountain Juniper	Seedling	Alive	63.65
DETO_PCM_263	Boxelder	Tree	Alive	30
DETO_PCM_263	Boxelder	Seedling	Alive	1782.3
DETO_PCM_263	Eastern Cottonwood	Seedling	Alive	572.88
DETO_PCM_263	Peachleaf Willow	Seedling	Alive	222.79

Dead and downed wood, and surface fuels, provide foraging habitat and refugia for small wildlife species, as well as substrate for mosses and fungi. Downed wood sometimes also provides “nursery” logs for vascular plant establishment. However, when surface fuels are too abundant in a forest they can increase the risk of high intensity fires. The NGP Fire Effects Program has developed a management target for surface fuels: the goal is to keep a range between 2 and 10 tons per acre within the Black Hills parks. NGPN and NGPFire surveyed for and measured surface fuels in 19 plots (Table 9). In DETO_PCM_261, all fuels are zeros because this plot was a grassland plot and contained no measureable woody fuels.

Table 5. Surface fuels summary for 19 plots visited in 2016 at Devils Tower National Monument by NGPN and NGPFire monitoring crews.

Macroplot	Average Tons per Acre										Avg. Depth (in.)		
	1-hr	10-hr	100-hr	1-100-hr	1000-hr sound	1000-hr rotten	1-1000-hr	Duff	Litter	Total	Duff	Litt	Total
DETO_PCM_001	0.00	0.27	0.00	0.27	1.05	0.00	1.32	4.49	3.23	9.04	0.3	0.8	1.1
DETO_PCM_002	0.06	0.00	0.73	0.79	0.00	0.00	0.79	3.79	2.56	7.13	0.2	0.6	0.9
DETO_PCM_003	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.96	1.01	2.97	0.2	0.6	0.8
DETO_PCM_007	0.08	0.00	0.73	0.81	9.03	5.33	15.16	3.26	0.68	19.09	0.2	0.2	0.4
DETO_PCM_013	0.00	0.00	0.73	0.73	0.00	2.06	2.79	2.82	1.30	6.90	0.2	0.3	0.5
DETO_PCM_014	0.00	0.14	0.00	0.14	0.00	0.00	0.14	1.14	1.22	2.50	0.1	0.3	0.4
DETO_PCM_017	0.02	0.55	2.20	2.77	6.11	0.45	9.34	5.63	2.20	17.17	0.3	0.6	0.9
DETO_PCM_018	0.08	1.78	0.75	2.61	2.52	11.23	16.36	5.02	1.26	22.64	0.3	0.3	0.6
DETO_PCM_019	0.02	1.09	4.36	5.47	11.63	9.41	26.51	6.07	1.12	33.70	0.3	0.3	0.6
DETO_PCM_030	0.04	0.27	0.74	1.05	35.71	2.42	39.19	5.37	0.96	45.52	0.3	0.2	0.5
DETO_PCM_031	0.04	0.41	2.90	3.35	4.19	2.01	9.55	2.11	0.60	12.27	0.1	0.2	0.3
DETO_PCM_044	0.00	0.83	1.48	2.31	1.28	8.56	12.14	3.79	1.24	17.17	0.2	0.3	0.5
DETO_PCM_045	0.02	1.64	4.40	6.06	13.75	12.67	32.48	7.48	0.62	40.58	0.4	0.2	0.6
DETO_PCM_046	0.06	0.28	1.49	1.83	9.96	4.65	16.44	7.57	1.98	25.99	0.4	0.5	0.9
DETO_PCM_051	0.02	0.00	1.45	1.47	0.00	0.00	1.47	1.32	0.56	3.35	0.1	0.1	0.2
DETO_PCM_059	0.00	0.54	0.00	0.54	1.08	7.80	9.41	11.44	2.80	23.65	0.7	0.7	1.4
DETO_PCM_067	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.38	0.78	3.16	0.1	0.2	0.3
DETO_PCM_261	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0	0.0	0.0
DETO_PCM_263	0.00	0.00	1.27	1.27	0.93	0.74	2.94	0.93	0.90	4.76	0.1	0.6	0.6

Disturbances occurred in seven out of eight plant community monitoring plots at DETO visited by the NGPN monitoring crew in 2016 (Table 10). The most common disturbance types observed were: animal use, which includes trails and trampled or missing vegetation, and prescribed fire signs, which was often most noticeable as char and scars on trees. No disturbance data were collected at PCM plots visited by NGPFire.

Table 6. Disturbance types and area sizes observed in seven plots visited at Devils Tower National Monument in 2016. The size was approximated, and out of a total area of 1000 m².

MacroPlot Name	Disturbance Type	Size (m ²)
DETO_PCM_001	Animal Trail	15
	Rx Fire	1000
DETO_PCM_002	Animal Trail	20
	Rx Fire	1000
DETO_PCM_003	Animal Trail	20
	Rx Fire	1000
DETO_PCM_013	Animal Trail	10
	Rx Fire	1000
	Small Mammal	5
DETO_PCM_014	Animal Trail	10
	Rx Fire	1000
DETO_PCM_017	Rx Fire	500
DETO_PCM_263	Animal Trail	20
	Fence	100

Literature Cited

- Ashton, I., M. Prowatzke, M. Bynum, T. Shepherd, S. K. Wilson, and K. Paintner-Green. 2012. Devils Tower National Monument plant community composition and structure monitoring: 2011 annual report. Natural Resource Technical Report NPS/NGPN/NRTR—2012/532. National Park Service, Fort Collins, Colorado.
- Brown, J. K. 1974. Handbook for inventorying downed material. General Technical Report INT-16. USDA Forest Service, Intermountain Forest and Range Experiment Station, Ogden, UT.
- Brown, J. K., R. D. Oberhue, and C. M. Johnston. 1982. Inventorying surface fuels and biomass in the Interior West. General Technical Report INT-129. USDA Forest Service, Intermountain Forest and Range Experiment Station, Ogden, UT.
- Stevens, D. L. and A. R. Olsen. 2003. Variance estimation for spatially balanced samples of environmental resources. *Environmetrics* 14:593-610.
- Stevens, D. L. and A. R. Olsen. 2004. Spatially balanced sampling of natural resources. *Journal Of The American Statistical Association* 99:262-278.
- Symstad, A. J., R.A. Gitzen, C. L. Wienk, M. R. Bynum, D. J. Swanson, A. D. Thorstenson, and K. J. Paintner. 2012a. Plant community composition and structure monitoring protocol for the Northern Great Plains I&M Network-Standard Operating Procedures: version 1.01. Natural Resource Report NPS/NGPN/ NRR-2012/489.1.
- Symstad, A. J., R.A. Gitzen, C. L. Wienk, M. R. Bynum, D. J. Swanson, A. D. Thorstenson, and K. J. Paintner. 2012b. Plant community composition and structure monitoring protocol for the Northern Great Plains I&M Network: version 1.01. Natural Resource Report NPS/NGPN/ NRR-2012/489.
- USDA-NRCS. 2016. The PLANTS Database (<http://plants.usda.gov>, 02 December 2016). National Plant Data Team, Greensboro, NC 27401-4901 USA.
- Wienk, C., A. Thorstenson, J. Freeman, and D. Swanson. 2011. Northern Great Plains Fire Ecology Program review: 1997-2007. Natural Resource Report NPS/NRDS/NRDS—2010/112. National Park Service, Fort Collins, Colorado.

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

NPS 109/136442, February 2017

National Park Service
U.S. Department of the Interior



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

www.nature.nps.gov