



Plant Community Composition and Structure Monitoring for Mount Rushmore National Memorial

2013 Annual Report

Natural Resource Data Series NPS/NGPN/NRDS—2014/617



ON THE COVER

Long-term monitoring plot PCM_009 at Mount Rushmore National Memorial, 2013
Photograph by: NPS

Plant Community Composition and Structure Monitoring for Mount Rushmore National Memorial

2013 Annual Report

Natural Resource Data Series NPS/NGPN/NRDS—2014/617

Isabel W. Ashton
Michael Prowatzke

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

February 2014

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 (<http://science.nature.nps.gov/im/units/ngpn/monitor/plants.cfm>) and the Natural Resource Publications Management website (<http://www.nature.nps.gov/publications/nrpm/>). To receive this report in a format optimized for screen readers, please email irma@nps.gov.

Please cite this publication as:

Ashton, I. W. and M. Prowatzke. 2014. Plant community composition and structure monitoring for Mount Rushmore National Memorial: 2013 annual report. Natural Resource Data Series NPS/NGPN/NRDS—2014/617. National Park Service, Fort Collins, Colorado.

Contents

	Page
Figures.....	iv
Tables.....	iv
Acknowledgments.....	v
Introduction.....	1
Methods.....	3
Sample design.....	3
Plot layout and sampling	3
Data Management and Analysis	5
Reporting on Natural Resource Condition	6
Changing Nail Locations	7
Results and Discussion	8
Changing Nail Locations	12
Summary	13
Literature Cited	14
Appendix A: Field journal for plant community monitoring in MORU for the 2013 season.....	15
Appendix B: List of plant species found in 2013 at MORU.....	16

Figures

	Page
Figure 1. Map of Mount Rushmore National Memorial (MORU) and plant community monitoring (PCM) plots.....	2
Figure 2. Long-term monitoring plot used for sampling vegetation in Mount Rushmore National Memorial.	4
Figure 3. Drought conditions in late June 2013 in the Northern Great Plains.	8
Figure 4. Average cover by lifeform in 6 plant community monitoring plots in Mount Rushmore National Memorial in 2013.....	8
Figure 5. The average absolute cover of the 10 most common plants recorded at Mount Rushmore National Memorial in 2013.....	10
Figure 6. Long-term monitoring plot PCM_004 at Mount Rushmore National Memorial has a thick layer of pine litter, chips, and duff on the forest floor.	12

Tables

	Page
Table 1. Exotic species surveyed for at Mount Rushmore National Memorial as part of the early detection and rapid response program within the Northern Great Plains Network.....	5
Table 2. Rare species that were surveyed for during the 2013 field season at Mount Rushmore National Memorial.....	5
Table 3. Key to the symbols used in the Natural Resource Condition Table.....	7
Table 4. Natural resource condition summary table for upland plant communities in Mount Rushmore National Memorial (MORU).	9
Table 5. Average plant species richness in 6 plots at Mount Rushmore National Memorial in 2013.....	11
Table 6. Characteristics of the plant community at 6 plots in Mount Rushmore National Memorial in 2013 including native species richness, exotic plant cover, and area of disturbance.	11

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 MORU, particularly B. Weisman, S. Davis, and D. Hart and dispatch for providing logistical support and safety checks. M. Bynum helped for 4 days in the field and served as the primary botanist. The 2013 NGPN vegetation field crew of I. Ashton, M. Prowatzke, E. Moore, M. Owen, J. Moran, J. Ladd, C. Traft, and S. Rockwood collected all the data included in this report. We thank S. Wilson for invaluable support and instruction on managing data in the FFI database and for assistance with the GIS data.

Introduction

The Black Hills is a 1.5 million ha (3.7 million acres) refuge of ponderosa pine (*Pinus ponderosa*) forest surrounded by the prairies of western South Dakota and eastern Wyoming (Figure 1). 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 mosaic of open and closed canopy forests maintains a relatively high diversity of vascular plants with an estimate of 1000 species in the Black Hills (Larson and Johnson 2007).

Mount Rushmore National Memorial (MORU), located in the Black Hills, has a mission to preserve and protect the sculptured visages of George Washington, Thomas Jefferson, Theodore Roosevelt, and Abraham Lincoln, as well as the land surrounding it. While this is a relatively small area (517 ha, 1278 ac), MORU contains the second-largest area of old growth ponderosa pine forest in the Black Hills (Symstad and Bynum 2007). Ponderosa pine is the dominant plant throughout the park, but there are 459 vascular plant species listed on the park's certified species list (NRinfo: <https://irma.nps.gov/>). Plant diversity is highest in the small areas of the park that contain wetlands and deciduous canopy cover. There is a lower diversity of plants found under the closed-canopy of ponderosa pines, but the pristine condition of the older forest stands provides a valuable reference condition for Black Hills forests (Hoffman and Hansen 1986). Scientifically credible information on the current status and long-term trends of the composition and diversity of the forests in MORU is critical to increase our understanding of how changes in forest cover are impacting the understory.

The Northern Great Plains Inventory & Monitoring Program (NGPN) began vegetation monitoring at MORU in 2011 (Ashton et al. 2012b). The long-term objectives of the NGPN plant community monitoring effort (Symstad et al. 2012b) in MORU are to:

1. Determine park-wide status and long-term trends in vegetation species composition (e.g., exotic vs. native) and structure (e.g., cover, height) of herbaceous and shrub species.
2. Determine status (at 5-yr intervals) and long-term trends of tree density by species, height class, and diameter class in lowland areas near targeted perennial streams.
3. Improve our understanding of the effects of external drivers and management actions on plant community species composition and structure by correlating changes in vegetation composition and structure with changes in climate, landscape patterns, atmospheric chemical composition, fire, and invasive plant control.

This report is intended to provide a timely release of basic data sets and data summaries from the 6 sites we visited at MORU in 2013 (Figure 1). Previous reports document the recent park-wide status of the understory vegetation (Ashton et al. 2013) and forest health and fuel loads (Ashton et al. 2012a).

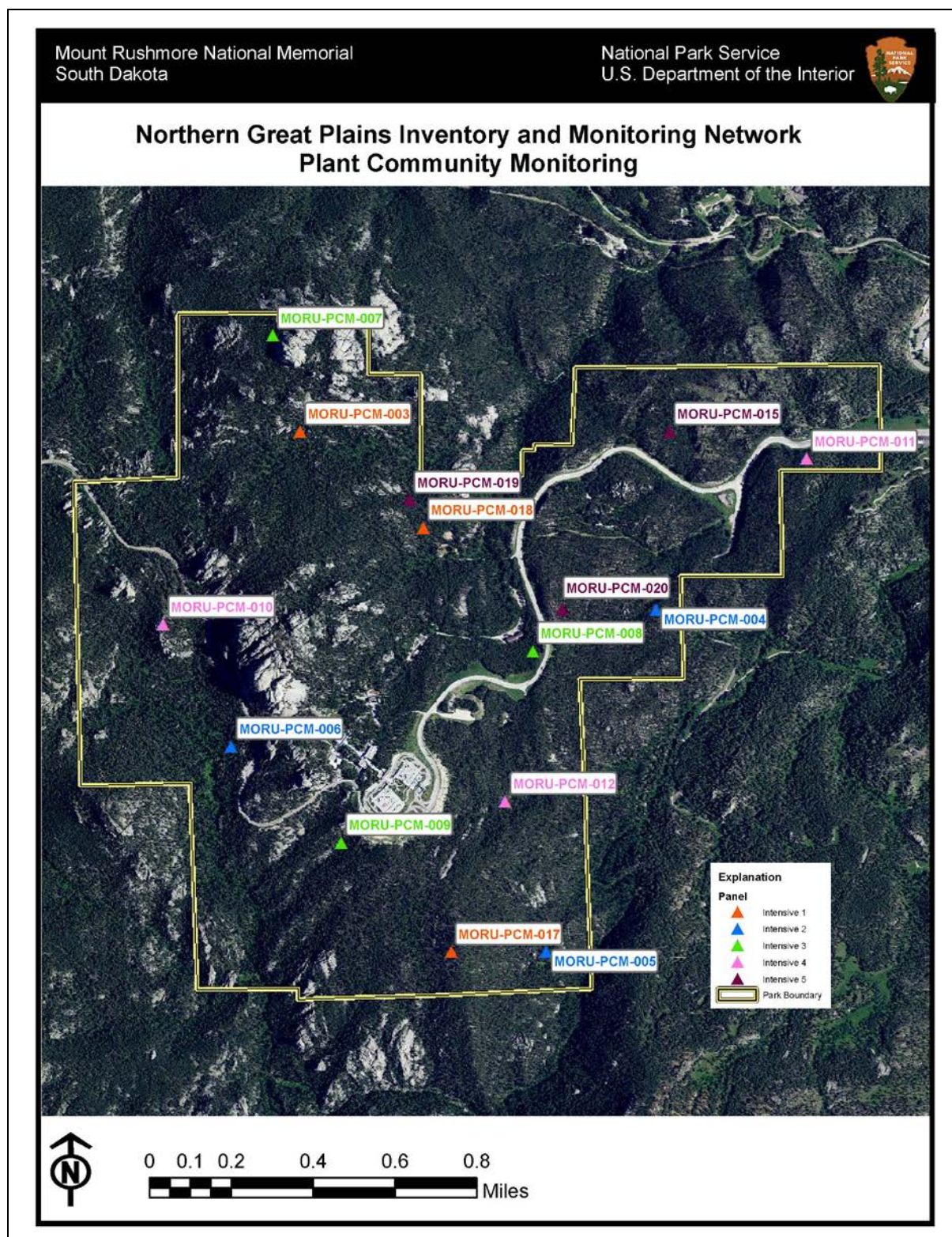


Figure 1. Map of Mount Rushmore National Memorial (MORU) and plant community monitoring (PCM) plots. Plots in panel 2 (blue) and panel 3 (green) were visited in 2013.

Methods

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

Sample design

We implemented a survey to monitor plant community structure and composition in MORU using a spatially balanced probability design (Generalized Random Tessellation Stratified [GRTS]; Stevens and Olsen 2003, 2004). Using a GRTS design, we selected 15 randomly located sites within MORU (Figure 1). We split these 15 sites into 5 panels with 3 sites each. As part of our pilot monitoring efforts we visited all 15 plots in 2010 during the second half of July. Since then, we visited 2 panels (6 sites) every year. In 2011, we visited sites in panel 1 and panel 5, and in 2012 we visited sites in panel 1 and panel 2 (Figure 1). In 2013, we visited sites in panel 2 and panel 3 during the last week of June. Data from these randomly selected sites can be used to estimate condition of vegetation communities for the whole park and over time, can be used to discern trends in condition.

Plot layout and sampling

At each of the sites we visited, we recorded plant species cover and frequency in a rectangular, 50 m x 20 m (0.1 ha), permanent plot (Figure 2). Data on ground cover, herb-layer height ≤ 2 m, and plant cover were collected on two 50 m transects (the long sides of the plot) using a point-intercept method. Species richness data from the point-intercept method were supplemented with species presence data collected in 5 sets of nested square quadrats (0.01 m², 0.1 m², 1 m², and 10 m²) located systematically along each transect (Figure 2). In 2013, sampling at MORU took a 5-person crew approximately 6 days to complete and an additional few days were used to replace nails in trees (see Appendix A for a detail of activities each day).

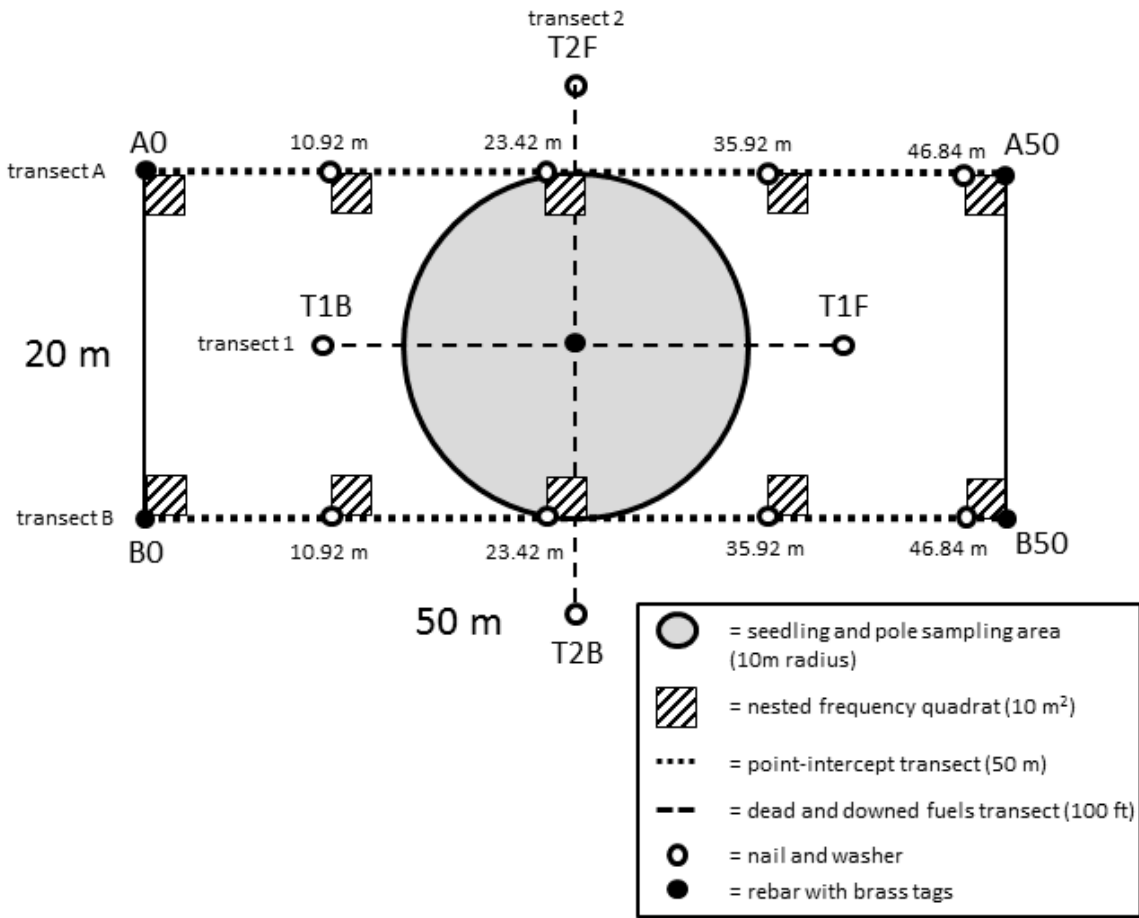


Figure 2. Long-term monitoring plot used for sampling vegetation in Mount Rushmore National Memorial.

When woody species were present, tree regeneration and tall shrub density data were collected within a 10 m radius subplot centered in the larger 50 m x 20 m plot (Figure 2). Trees with diameter at breast height (DBH) > 15 cm, located within the entire 0.1 ha plot, were mapped and tagged. For each tree, the species, DBH, status, and condition (e.g., leaf-discoloration, insect-damaged, etc.) were recorded. Dead and downed woody fuel load data were collected on two perpendicular, 100 ft (30.49 m) transects with midpoints at the center of the plot (Figure 2), following Brown's Line methods (Brown 1974, Brown et al. 1982).

At all plots, we also surveyed the area for common disturbances and target species of interest to the park. Common disturbances included such things as roads, rodent mounds, animal trails, and fire. For all plots, the type and severity of the disturbances were recorded. We also surveyed the area for exotic species that have the potential to spread into the park and cause significant ecological impacts (Table 1). For each target species that was present at a site, an abundance class was given on a scale from 1-5 where 1 = one individual, 2 = few individuals, 3 = cover of 1-5%, 4 = cover of 5-25%, and 5 = cover > 25% of the plot. The information gathered from this procedure is critical for early detection and rapid response to such threats. In addition, we noted the presence of plant species that are considered rare or vulnerable to loss in South Dakota, and may occur in MORU (Table 2).

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

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

Table 2. Rare species that were surveyed for during the 2013 field season at Mount Rushmore National Memorial.

Scientific Name	Common Name
<i>Boechera divaricarpa</i>	limestone rockcress
<i>Boechera holboellii</i>	limestone rockcress
<i>Botrychium multifidum</i>	leathery grapefern
<i>Carex bella</i>	elegant sedge
<i>Collinsia parviflora</i>	maiden blue eyed Mary
<i>Cypripedium parviflorum</i>	lesser yellow lady's slipper
<i>Helianthemum bicknellii</i>	hoary frostweed
<i>Oxyria digyna</i>	alpine mountain sorrel
<i>Platanthera orbiculata</i>	lesser round-leaved orchid
<i>Viola selkirkii</i>	Selkirk's violet

Data Management and Analysis

We used FFI (FEAT/FIREMON Integrated; <http://frames.gov/ffi/>) as the primary software environment for managing our sampling data. FFI is used by a variety of agencies (e.g., NPS, USDA Forest Service, U.S. Fish and Wildlife Service), has a national-level support system, and generally conforms to the Natural Resource Database Template standards established by the Inventory and Monitoring Program.

Species scientific names, codes, and common names are from the USDA Plants Database (USDA-NRCS 2012). However, nomenclature follows the Integrated Taxonomic Information System (ITIS) (<http://www.itis.gov>). In the few cases where ITIS recognizes a new name that was not in the USDA PLANTS database, the new name was used and a unique plant code was assigned.

After data for the sites were entered, 100% of records were verified to the original data sheet to minimize transcription errors. A further 10% of records were reviewed a second time. After all data were entered and verified, automated queries were developed to check for errors in the data. When errors were caught by the crew or the automated queries, changes were made to the original datasheets and the FFI database as needed.

Plant life forms (e.g., shrub, forb) were based on definitions from the USDA Plants Database (USDA-NRCS 2012). Warm-season grasses were identified primarily using a guide by Skinner (2010). Summaries were produced using the FFI reporting and query tools, and statistical summaries and graphics were generated using R software (version 2.15.1).

We measured diversity at the plots in 3 ways: species richness, the Shannon Index, and Pielou's Index of Evenness. Species richness is simply a count of the species recorded in an area. The Shannon Index, H' , is a measure of the number of species in an area and how even abundances are across the community. It typically ranges between 0 (low richness and evenness) to 3.5 (high species richness and evenness). Pielou's Index of Evenness, J' , measures how even abundances are across taxa. It ranges between 0 and 1; values near 0 indicate dominance by a single species, and values near 1 indicate nearly equal abundance of all species present.

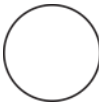
Disturbances were recorded in square meters and ranged from 0 (not present) to 2290 (the whole plot area) for each type of disturbance. We report the sum of all individual disturbances, so the value can be greater than 2290 m².

Reporting on Natural Resource Condition

Results were summarized in a Natural Resource Condition Table based on the templates from the State of the Park report series (<http://www.nps.gov/stateoftheparks/>). The goal is to improve park priority setting and to synthesize and communicate complex park condition information to the public in a clear and simple way. By focusing on specific indicators, such as exotic species cover, it will also be possible and straightforward to revisit the metric in subsequent years. The status and trend of each indicator is scored and assigned a corresponding symbol based on the key found in Table 3.

We chose a set of indicators and specific measures that can describe the condition of vegetation in the Northern Great Plains and the status of exotic plant invasions. The measures include: absolute herb-layer canopy cover, native species richness, evenness, relative cover of exotic species, and annual brome cover. Reference values were based on descriptions of historic condition and variation, past studies, and/or management targets. Current park condition was compared to a reference value, and status was scored as good condition, warrants moderate caution, or warrants significant concern based on this comparison (Table 3). Good condition was applied to values that fell within the range of the reference value, and significant concern was applied to conditions that fell outside the bounds of the reference value. In some cases, reference conditions can be determined only after we have accumulated more years of data. When this is the case, we refer to these as "To be determined" and estimate condition based on our professional judgment.

Table 3. Key to the symbols used in the Natural Resource Condition Table. The background color represents the current status, the arrow summarizes the trend, and the thickness of the outside line represents the degree of confidence in the assessment. A symbol that does not contain an arrow indicates that there is insufficient information to assess a trend.

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

Changing Nail Locations

In the winter of 2012-2013, the Fire Ecology Program and NGPN determined that the nails used to mark trees in MORU needed to be moved for three reasons: (1) During pilot monitoring in 2010, when the nails were originally placed, the draft protocol advised them to be placed at breast height (1.37 m) as measured from the base of the tree at a mid-slope location. However, after review, the published protocol stated that nails should be placed 1.37 m from the base as measured on the uphill side of the tree (Symstad et al. 2012), which is more consistent with generally accepted forestry practices and consistent with fire ecology; (2) After three years, many of the nails were being engulfed by tree growth; and (3) replacing aluminum nails with brass nails would increase fire resistance.

In the summer of 2013, nails were moved at all 15 sites in panels 1 through 5. To do this, DBH was measured at the original location (i.e., breast height as measured from a mid-slope location). Nails and tags were removed and repositioned at 1.37 m height from the base of the uphill side of the tree. DBH was measured again at the new nail location. In the few flat areas, the mid-slope and uphill location were within 5 cm of each other; when this happened, we did not move the nail. We replaced nails and measured DBH on 575 trees. In FFI, the new location was recorded in the “DBH”, and the old location was recorded within the column indicated for “DRC”. This double measurement was done to allow investigators to compare growth from 2010-2013 consistently, but in the future the new height will be used.

DBH was measured at MORU in 2010-2013 in the following manner:

- 2010- DBH was measured at the mid-slope for all 60 plots (Ashton et al. 2012a)
- 2011- DBH was measured at the mid-slope for 6 plots in Panels 1 and 5 (Ashton et al. 2012a)
- 2012- DBH was measured at the mid-slope for 15 plots in Panels 1 to 5 and on the uphill side for 45 plots.
- 2013- DBH was measured at the mid-slope and uphill side for 15 plots in Panels 1 to 5.

Results and Discussion

Mount Rushmore NMem experienced drought conditions throughout the winter and into the spring of 2013 (Figure 3). When the NGPN visited the park in June, recent wet weather allowed for some green-up, but overall the park was still experiencing drought conditions. Average herbaceous canopy cover was 22% (Table 4) in 2013, which was similar to the previous year (Ashton et al. 2013). There was a large amount of standing litter on the ground with ground cover at the sites averaging 74% plant litter and about 25% of the ground cover was bedrock or rock.

We found 99 plant species in 2013 at MORU (Appendix B). Graminoids, which includes grasses, sedges, and rushes, and shrubs accounted for most of the vegetative cover at MORU, but trees, forbs, ferns and subshrubs (defined as a low-growing shrub usually under 0.5m) were also abundant (Figure 4). We found 17 exotic species at the park, all of which were either forbs or graminoids.

There was some variation in species composition across the 6 sites. The most common species encountered on the transect lines were common juniper (*Juniperus communis*) and poverty oatgrass (*Danthonia spicata*). Of the 10 most common species, all were native (Figure 5). We found one rare target species, blue-eyed Mary (*Collinsia parviflora*) at site PMC_009.

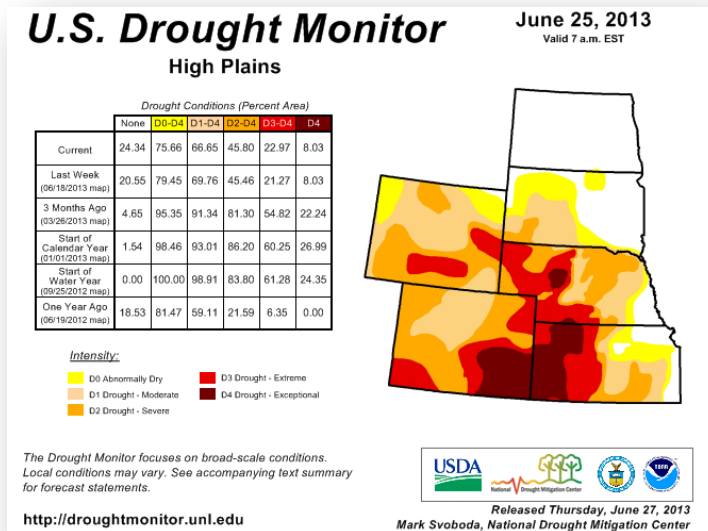


Figure 3. Drought conditions in late June 2013 in the Northern Great Plains. Mount Rushmore National Memorial experienced abnormally dry conditions at that time.

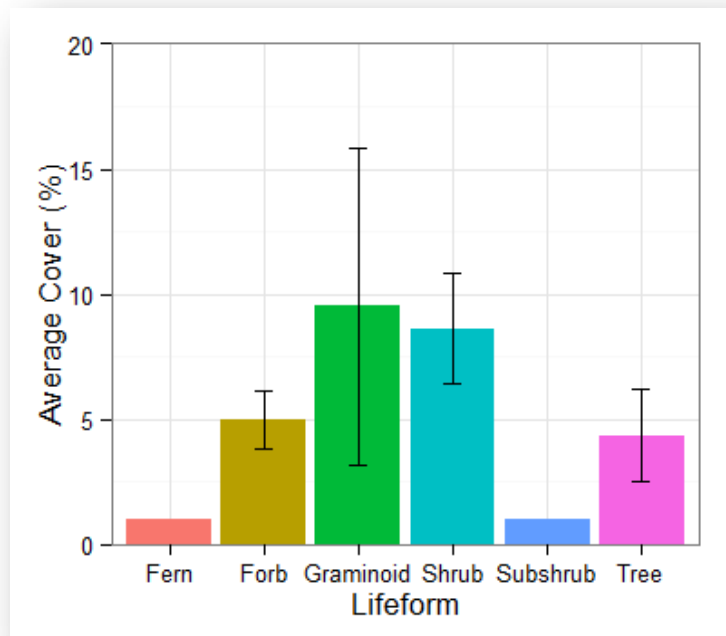


Figure 4. Average cover by lifeform in 6 plant community monitoring plots in Mount Rushmore National Memorial in 2013. Graminoids and shrubs were the most abundant lifeform found in the understory across the plots. Bars represent means $\pm$ standard errors.

Table 4. Natural resource condition summary table for upland plant communities in Mount Rushmore National Memorial (MORU).

Indicator of Condition	Specific Measures	2013 Value (mean $\pm$ SE)	Reference Condition and Data Source	Condition Status/Trend	Rationale for Resource Condition
Upland Plant Community Structure and Composition	Absolute herb-layer canopy cover	22 $\pm$ 6.9%	TBD ⁽¹⁾		The mission of many NPS park units is to maintain native plant diversity. MORU has a low diversity of native plants and a low cover of understory plants, which is consistent with older ponderosa forests with high conservation value and closed canopies. Current forest basal area is similar to the historic range in 1870 (2). A recent thinning action (2010-2011) reduced forest basal area and the risk of high intensity fires. At this time, our condition assessments for understory vegetation are based on professional judgment, but as we collect more data and understand the natural range of variability our confidence in these assessments will increase.
	Native species richness (based on average of 10 1m ² quadrats per plot)	4 $\pm$ 0.8 species	TBD ⁽¹⁾		
	Evenness (based on point-intercept of 2-50m transects per plot)	0.83 $\pm$ 0.05	TBD ⁽¹⁾		
	Forest basal area (m ² /ha)	27.2 $\pm$ 3.8	23.6 $\pm$ 2.2 ⁽²⁾		
Exotic Plant Early Detection and Management	Relative cover of exotic species	0.3 $\pm$ 0.3 %	$\leq$ 5 % cover		In general, the sites in MORU had a low cover of exotic species. Only one site had >1% exotic cover.
Fire and Fuel Dynamics	Total downed fuel loads (tons/acre)	41 $\pm$ 7.1	Between 2 and 15		The current fire ecology program aims to maintain fuel loads of less than 10 tons/acre, but in thick forests of MORU there is expected to be a range of conditions. The high values are driven by a thick layer of litter and duff on the forest floor.

References, Notes, and Data Sources:

1. To be determined when more data are available 2. Brown, P. M., C. L. Wienk, and A. J. Symstad. 2008. Fire and forest history at Mount Rushmore. Ecological Applications 18:1984-1999.

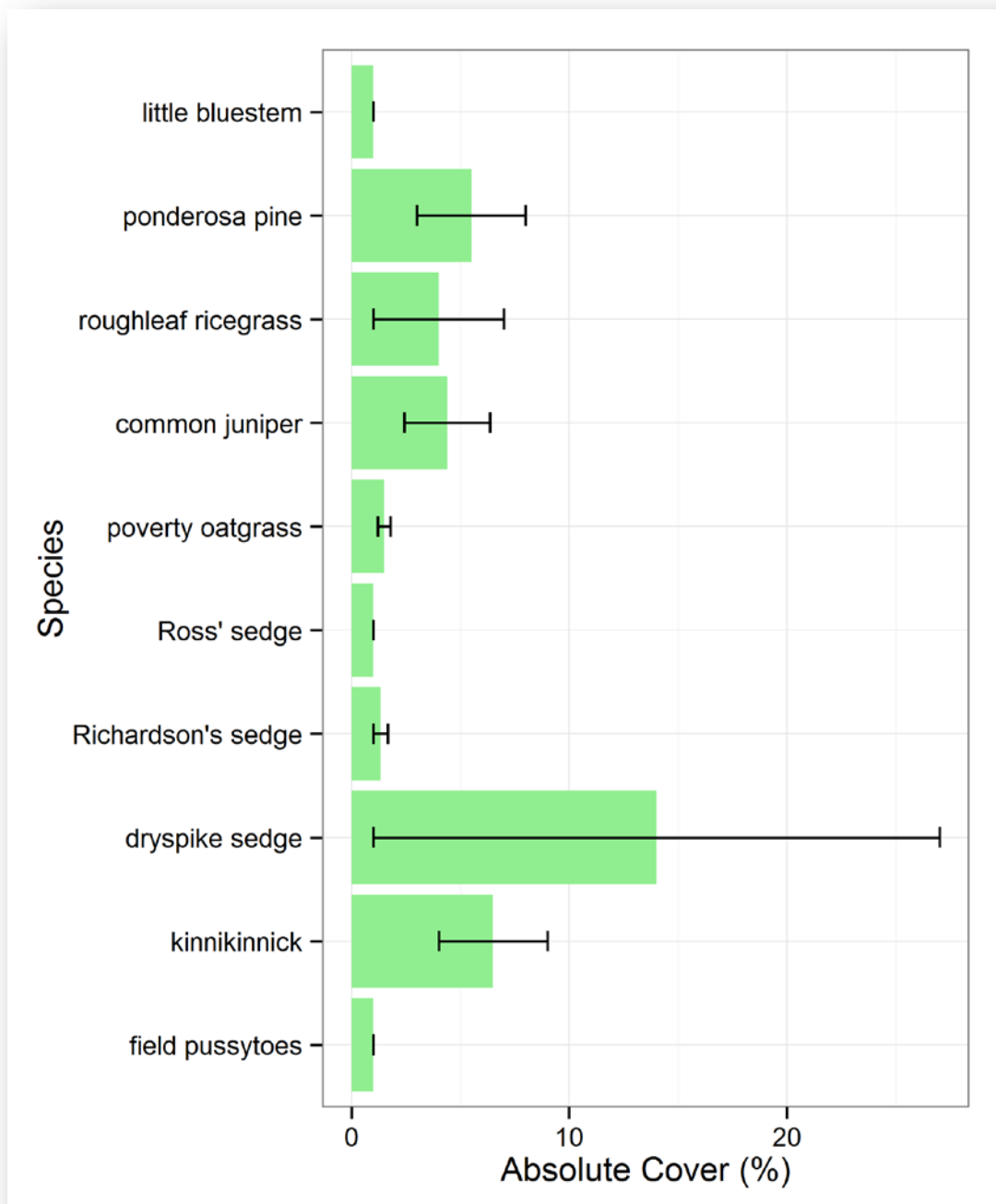


Figure 5. The average absolute cover of the 10 most common plants recorded at Mount Rushmore National Memorial in 2013. All were native species. Bars represent means $\pm$ standard errors.

Average species richness at each of the 6 plots was measured by point-intercept and in 1 m² and 10 m² quadrats (Table 5). From the point-intersect data, we found average plot diversity, H', to be 1.5 ± 0.26, and evenness, J', averaged 0.83 ± 0.05 across the plots (Table 4). These values were the same when only native species were included.

Table 5. Average plant species richness in 6 plots at Mount Rushmore National Memorial in 2013. Values represent means ± standard errors, n=6.

	Point-intercept	1 m ² quadrats	10 m ² quadrats
Species richness	8 ± 2.0	4 ± 0.9	10 ± 2.1
Native species richness	7 ± 1.9	4 ± 0.8	9 ± 1.9
Exotic species richness	0.2 ± 0.2	1 ± 0.2	2 ± 0.3
Graminoid species richness	3 ± 1.0	2 ± 0.3	3 ± 0.5
Forb species richness	2 ± 0.8	2 ± 0.3	5 ± 1.2

While there was some variation across sites (Table 6), the plots we visited in MORU tended to have a low diversity of native plants when compared to neighboring park units with a larger grassland component. For instance, Wind Cave National Park had an average diversity (H') of 2.4 and averaged 12 native species per square meter (Ashton et al. 2012c). Despite a low diversity of plant species, the forest stands in MORU are prime examples of late-stage ponderosa forest that are of high conservation value (Hoffman 1986). MORU also maintains a very low cover of exotic plants (Table 6). While we do not yet have defined reference conditions for upland plant communities in MORU, we choose to interpret the 2013 values as representative of a forest in good condition (Table 4). They are very similar to the values seen in past years (Ashton et al. 2013).

Table 6. Characteristics of the plant community at 6 plots in Mount Rushmore National Memorial in 2013 including native species richness, exotic plant cover, and area of disturbance.

Plot	Native species richness in 1 m ²	Exotic cover (%)	Cumulative area of disturbance (m ²)
MORU_PCM_004	2	0	9170
MORU_PCM_005	1	0	2390
MORU_PCM_006	5	0	0
MORU_PCM_007	3	0	4690
MORU_PCM_008	6	2	2555
MORU_PCM_009	6	0	4070
<i>Park Average</i>	4 ± 0.6	0.3 ± 0.3	-

Disturbance from grazing, fire, and humans affects plant community structure and composition. For this reason, we measured the approximate area affected by natural and human disturbances at each site we visited. In 2013, the most common disturbance was from fire and thinning treatments, but there was also evidence of trail use, grazing, mountain pine beetles, and garbage.

In 2010, we visited 60 sites in MORU and reported on overall forest health and fuel loads (Ashton et al. 2012a). In 2013, we visited only a small subset of these plots. From these 6 plots, we found that average basal area was reduced since 2010 from 30 to 27 m²/ha (Table 4). Average total downed fuel loads were much higher than in previous years (Ashton et al. 2012a) and higher than the

reference condition (Table 4). This increase was driven by the duff and litter layer which averaged 2.5 inches in 2013 as compared to 1.4 inches in 2010. The mechanical thinning treatments removed smaller trees, but chipping has left a thick layer of duff, chips, and litter (Figure 6).



Figure 6. Long-term monitoring plot PCM_004 at Mount Rushmore National Memorial has a thick layer of pine litter, chips, and duff on the forest floor.

Changing Nail Locations

In 2013, the location of tree tags was moved in 15 plots from breast height as measured from a mid-slope position to breast height as measured on the uphill side of the trees. We conducted analyses to determine the average difference in diameter as measured at the two locations (mid-slope diameter averaged 0.26 cm larger than uphill diameter with a standard deviation of 0.63) and how it changes basal area of trees at each site (a 2.2% decrease). The average change in diameter is within published error rates for the measurement of DBH using tapes (Elzinga et al. 2005). It is also within the range of annual growth rates for ponderosa pine which in managed areas of the Black Hills can average 0.26 to 0.58 cm diameter growth per year over the course of 80 to 120 years (Alexander and Edminster 1981). In the plots in MORU, trees grew on average 0.20 cm between 2010 and 2013. We recommend that future analyses of forest growth are cautious in their interpretation of growth data if the absolute values remain within this measurement error rate ($\sim < 1.0$ cm).

Summary

In conclusion, MORU understory plant communities are in good condition. The mission of many NPS park units includes maintaining native plant diversity. MORU has a low diversity of native plants and a low cover of understory plants, but this is consistent with older ponderosa forests with high conservation value. The recent mechanical thinning project has increased the depth of litter and duff on the forest floor. In 2016, when we conduct another comprehensive survey of forest health, we will attempt to determine whether this has long-term implications.

Literature Cited

- Alexander, R. R. and C. B. Edminster. 1981. Management of ponderosa pine in even-aged stands in the Black Hills. *in* USDA, editor. USDA Forest Service Research Paper RM-228.
- Ashton, I., M. Prowatzke, M. Bynum, T. Shepherd, S. K. Wilson, K. Paintner-Green, and D. Swanson. 2012a. Status of forest structure and fuel loads at Mount Rushmore National Memorial: 2010-2011 report. Natural Resource Technical Report NPS/NGPN/NRTR—2012/590. National Park Service, Fort Collins, Colorado.
- Ashton, I., M. Prowatzke, M. Bynum, T. Shepherd, S. K. Wilson, and K. Paintner-Green. 2013. Plant community composition and structure monitoring at Mount Rushmore National Memorial: 2010-2012 status report. Natural Resource Technical Report NPS/NGPN/NRTR—2013/677. National Park Service, Fort Collins, Colorado.
- Ashton, I., M. Prowatzke, M. Bynum, T. Shepherd, S. K. Wilson, and K. Paintner-Green. 2012b. Fort Laramie National Historic Site plant community composition and structure monitoring: 2011 annual report. Natural Resource Technical Report NPS/NGPN/NRTR—2012/536. National Park Service, Fort Collins, Colorado.
- Ashton, I., M. Prowatzke, M. Bynum, T. Shepherd, S. K. Wilson, and K. Paintner-Green. 2012c. Wind Cave National Park plant community composition and structure monitoring: 2011 annual report. Natural Resource Technical Report NPS/NGPN/NRTR—2012/534. 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.
- Elzinga, C., R. C. Shearer, and G. Elzinga. 2005. Observer Variation in Tree Diameter Measurements. *Western Journal of Applied Forestry* 20:134-137.
- Hoffman, G. R. and P. L. Hansen. 1986. Vegetation baseline study of Mount Rushmore National Monument. University of South Dakota.
- Larson, G. E. and J. R. Johnson. 2007. Plants of the Black Hills and Bear Lodge Mountains, 2nd edition. South Dakota State University, Brookings, SD.
- Skinner, Q. D. 2010. Field guide to Wyoming grasses. Education Resources Publishing, Cumming, GA.
- Stevens, D. L. and A. R. Olsen. 2003. Variance estimation for spatially balanced samples of environmental resources. *Environmetrics* 14:593-610.
- Stevens, D. L. and A. R. Olsen. 2004. Spatially balanced sampling of natural resources. *Journal Of The American Statistical Association* 99:262-278.
- Symstad, A. J. and M. Bynum. 2007. Conservation Value of Mount Rushmore National Memorial's Forest. *Natural Areas Journal* 27:293-301.
- Symstad, A. J., R.A. Gitzen, C. L. Wienk, M. R. Bynum, D. J. Swanson, A. D. Thorstenson, and K. J. Paintner. 2012a. Plant community composition and structure monitoring protocol for the Northern Great Plains I&M Network-Standard Operating Procedures: version 1.01. Natural Resource Report NPS/NGPN/ NRR-2012/489.1.
- Symstad, A. J., R.A. Gitzen, C. L. Wienk, M. R. Bynum, D. J. Swanson, A. D. Thorstenson, and K. J. Paintner. 2012b. Plant community composition and structure monitoring protocol for the Northern Great Plains I&M Network: version 1.01. Natural Resource Report NPS/NGPN/ NRR-2012/489.
- USDA-NRCS. 2012. The PLANTS Database (<http://plants.usda.gov>, 24 January 2012). National Plant Data Team, Greensboro, NC 27401-4901 USA.

Appendix A: Field journal for plant community monitoring in MORU for the 2013 season

The majority of the plant community composition monitoring in Mount Rushmore National Monument was completed using a crew of 5 people working 4, 10-hour days. M. Bynum served as the fifth crew member and botanist. It took 2 additional days (3- or 4-person crew days) to complete trees at the 6 sites, the first day was used as a field training exercise in the spring. In late August, we visited the intensive sites in Panel 1, 4, and 5 to remove nails and move them to a level consistent with breast height as measured from the uphill side of the trees.

Date	Day of week	Approximate Travel Time (hrs)	Housing	Sites Completed
May 9, 2013	Thursday	1.25	N/A	PCM-004 (trees/moved nails) PCM-008 (trees/moved nails)
June 24, 2013	Monday	1.25	N/A	PCM-005 (full plot read/moved nails)
June 25, 2013	Tuesday	1.25	N/A	PCM-007 (understory) PCM-008 (understory)
June 26, 2013	Wednesday	1.25	N/A	PCM-006 (full plot read/moved nails) PCM-004 (understory)
June 27, 2013	Thursday	1.25	N/A	PCM-009 (full plot read/moved nails) PCM-008 (trees/moved nails)
August 14, 2013	Wednesday	1.25	N/A	PCM-007 (trees/moved nails)
August 15, 2013	Thursday	1.25	N/A	PCM-018 (trees/moved nails) PCM-019 (trees/moved nails)
August 19, 2013	Monday	1.25	N/A	PCM-003 (trees/moved nails) PCM-010 (trees/moved nails) PCM-012 (trees/moved nails) PCM-020 (trees/moved nails)
August 21, 2013	Tuesday	1.25	N/A	PCM-011 (trees/moved nails) PCM-015 (trees/moved nails) PCM-017 (trees/moved nails)

Appendix B: List of plant species found in 2013 at MORU

Family	Code	Scientific Name	Common Name	Exotic
Amaranthaceae	AMRE	<i>Amaranthus retroflexus</i>	redroot amaranth	
Anacardiaceae	TORY	<i>Toxicodendron rydbergii</i>	western poison ivy	
Apocynaceae	APAN2	<i>Apocynum androsaemifolium</i>	spreading dogbane	
Araliaceae	ARNU2	<i>Aralia nudicaulis</i>	wild sarsaparilla	
Aspleniaceae	ASSE	<i>Asplenium septentrionale</i>	forked spleenwort	
Asteraceae	ACMI2	<i>Achillea millefolium</i>	common yarrow	
	ANMI3	<i>Antennaria microphylla</i>	littleleaf pussytoes	
	ANNE	<i>Antennaria neglecta</i>	field pussytoes	
	ANPA4	<i>Antennaria parvifolia</i>	small-leaf pussytoes	
	ARLU	<i>Artemisia ludoviciana</i>	white sagebrush	
	CIRSI	<i>Cirsium</i> species	thistle	*
	CIAR4	<i>Cirsium arvense</i>	Canada thistle	*
	COCA5	<i>Conyza canadensis</i>	Canadian horseweed	
	HICA3	<i>Hieracium canadense</i>	Canadian hawkweed	
	LASE	<i>Lactuca serriola</i>	prickly lettuce	*
	SERA	<i>Senecio rapifolius</i>	openwoods ragwort	
	SOMI2	<i>Solidago missouriensis</i>	Missouri goldenrod	
	SONE	<i>Solidago nemoralis</i>	gray goldenrod	
	SOSP2	<i>Solidago speciosa</i>	showy goldenrod	
	SYFA	<i>Symphyotrichum falcatum</i>	white prairie aster	
	SYLA3	<i>Symphyotrichum laeve</i>	smooth blue aster	
	SYOB	<i>Symphyotrichum oblongifolium</i>	aromatic aster	
	TAOF	<i>Taraxacum officinale</i>	common dandelion	*
Betulaceae	BEPA	<i>Betula papyrifera</i>	paper birch	
Boraginaceae	CRFE3	<i>Cryptantha fendleri</i>	sanddune cryptantha	
	CYOF	<i>Cynoglossum officinale</i>	houndstongue	*
Campanulaceae	CARO2	<i>Campanula rotundifolia</i>	bluebell bellflower	
	TRPE4	<i>Triodanis perfoliata</i>	clasping Venus' looking-glass	
Caprifoliaceae	SYMPH	<i>Symphoricarpos</i>	snowberry	
	SYAL	<i>Symphoricarpos albus</i>	common snowberry	
	SYOC	<i>Symphoricarpos occidentalis</i>	western snowberry	
Caryophyllaceae	SIAN2	<i>Silene antirrhina</i>	sleepy silene	

Family	Code	Scientific Name	Common Name	Exotic
Chenopodiaceae	CHDE	<i>Chenopodium desiccatum</i>	aridland goosefoot	
	CHFR3	<i>Chenopodium fremontii</i>	Fremont's goosefoot	
	CHSI2	<i>Chenopodium simplex</i>	mapleleaf goosefoot	
Convolvulaceae	COAR4	<i>Convolvulus arvensis</i>	field bindweed	*
Cupressaceae	JUCO6	<i>Juniperus communis</i>	common juniper	
Cyperaceae	CAFO3	<i>Carex foenea</i>	dryspike sedge	
	CAIN9	<i>Carex inops</i>	long-stolon sedge	
	CARI	<i>Carex richardsonii</i>	Richardson's sedge	
	CARO5	<i>Carex rossii</i>	Ross' sedge	
Dryopteridaceae	WOSC	<i>Woodsia scopulina</i>	Rocky Mountain woodsia	
Ericaceae	ARUV	<i>Arctostaphylos uva-ursi</i>	kinnikinnick	
Fabaceae	ASLA27	<i>Astragalus laxmannii</i>	Laxmann's milkvetch	
	LAOC2	<i>Lathyrus ochroleucus</i>	cream pea	
	MELU	<i>Medicago lupulina</i>	black medick	*
	MEOF	<i>Melilotus officinalis</i>	yellow sweetclover	*
	PEAR6	<i>Pedimelum argophyllum</i>	silverleaf Indian breadroot	
	PEES	<i>Pedimelum esculentum</i>	large Indian breadroot	
	THRH	<i>Thermopsis rhombifolia</i>	prairie thermopsis	
	VIAM	<i>Vicia americana</i>	American vetch	
Fagaceae	QUMA2	<i>Quercus macrocarpa</i>	bur oak	
Geraniaceae	GECA5	<i>Geranium carolinianum</i>	Carolina geranium	
Grossulariaceae	RICE	<i>Ribes cereum</i>	wax currant	
	RIOX	<i>Ribes oxyacanthoides</i>	Canadian gooseberry	
Lamiaceae	MOFI	<i>Monarda fistulosa</i>	wild bergamot	
	NECA2	<i>Nepeta cataria</i>	catnip	*
Liliaceae	ALCE2	<i>Allium cernuum</i>	nodding onion	
	MAST4	<i>Maianthemum stellatum</i>	starry false lily of the valley	
Onagraceae	CHAN9	<i>Chamerion angustifolium</i>	fireweed	
	EPBR3	<i>Epilobium brachycarpum</i>	tall annual willowherb	
	OEBI	<i>Oenothera biennis</i>	common evening-primrose	
Pinaceae	PIPO	<i>Pinus ponderosa</i>	ponderosa pine	
Poaceae	ANGE	<i>Andropogon gerardii</i>	big bluestem	
	BRIN2	<i>Bromus inermis</i>	smooth brome	*

Family	Code	Scientific Name	Common Name	Exotic
	DASP2	<i>Danthonia spicata</i>	poverty oatgrass	
Poaceae	DILI2	<i>Dichanthelium linearifolium</i>	slimleaf panicgrass	
	ELCA4	<i>Elymus canadensis</i>	Canada wildrye	
	ELTR7	<i>Elymus trachycaulus</i>	slender wheatgrass	
	FESTU	<i>Festuca</i> species	fescue	*
	MURA	<i>Muhlenbergia racemosa</i>	marsh muhly	
	NAVI4	<i>Nassella viridula</i>	green needlegrass	
	ORAS	<i>Oryzopsis asperifolia</i>	roughleaf ricegrass	
	PIMI7	<i>Piptatherum micranthum</i>	littleseed ricegrass	
	PIPU7	<i>Piptatherum pungens</i>	mountain ricegrass	
	POPR	<i>Poa pratensis</i>	Kentucky bluegrass	*
	SCSC	<i>Schizachyrium scoparium</i>	little bluestem	
	THIN6	<i>Thinopyrum intermedium</i>	intermediate wheatgrass	*
Polygonaceae	FACO	<i>Fallopia convolvulus</i>	black bindweed	*
Ranunculaceae	ANPA19	<i>Anemone patens</i>	pasqueflower	
	THDA	<i>Thalictrum dasycarpum</i>	purple meadow-rue	
Rosaceae	AMAL2	<i>Amelanchier alnifolia</i>	Saskatoon serviceberry	
	FRVI	<i>Fragaria virginiana</i>	Virginia strawberry	
	PRVI	<i>Prunus virginiana</i>	chokecherry	
	ROAC	<i>Rosa acicularis</i>	prickly rose	
Rosaceae	SPBE2	<i>Spiraea betulifolia</i>	white spirea	
Rubiaceae	GAAP2	<i>Galium aparine</i>	stickywilly	
	GABO2	<i>Galium boreale</i>	northern bedstraw	
Salicaceae	POTR5	<i>Populus tremuloides</i>	quaking aspen	
Saxifragaceae	HERI	<i>Heuchera richardsonii</i>	Richardson's alumroot	
Scrophulariaceae	COPA3	<i>Collinsia parviflora</i>	maiden blue eyed Mary	
	PEGR5	<i>Penstemon gracilis</i>	lilac penstemon	
	VETH	<i>Verbascum thapsus</i>	common mullein	*
Selaginellaceae	SERU	<i>Selaginella rupestris</i>	northern selaginella	
Solanaceae	PHVI5	<i>Physalis virginiana</i>	Virginia groundcherry	
Violaceae	VIOLA	<i>Viola</i>	violet	*
	VIAD	<i>Viola adunca</i>	hookedspur violet	
Vitaceae	PAVI5	<i>Parthenocissus vitacea</i>	woodbine	