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Natural Resource Stewardship and Science

Plant Community Composition and Structure at Mount Rushmore National Memorial

2011–2017 Summary Report

Natural Resource Report NPS/NGPN/NRR—2019/1951

ON THIS PAGE
Field crews from the Northern Great Plains Inventory and Monitoring and Fire Effects crews are trained in field methodology at Mount Rushmore National Memorial, 2017
Image credit: NPS

ON THE COVER
The diminutive orchid *Corallorhiza maculata*, or summer coralroot, grows in the forest understory of Mount Rushmore National Memorial, 2017
Image credit: NPS

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Executive Summary

This report presents the results of vegetation monitoring efforts at Mount Rushmore National Memorial (MORU) by the Northern Great Plains Inventory and Monitoring Network (NGPN) and the Northern Great Plains Fire Ecology Group (NGPFire) from 2010-2017. Field crews collected data relating to species richness, herb-layer height, and abundance of individual native and non-native species, ground cover, seedling and tree densities, and site disturbance at 15 plots and across 57 plot visits. We compared our findings to the range of natural variability seen in the Black Hills and management targets to develop summaries of natural resource condition (Appendix C). We also explored how key metrics have changed over time from 2010 to 2017. In addition to annual monitoring, we also surveyed forest condition in 2010, 2012, and 2016 at 60 randomly located plots. We collected data on tree and seedling density, tree condition, disturbance, and the presence of exotic species of management concern, such as smooth brome and Canada thistle.

Monitoring crews identified 232 vascular plant species, most of which are native. Exotic species are present in the park, but remain in low abundance. At most sites, the understory is dominated by bare rock and pine litter with few herbaceous plants in the understory. The average absolute plant cover was 28% and an average of 3.6 native plant species occurred within any given 1 m^2 quadrat sampled. Common juniper (*Juniperus communis*), Richardson's sedge (*Carex richardsonii*), Ross's sedge (*C. rossii*), and poverty oatgrass (*Danthonia spicata*) were the most common species observed in monitoring plots. Both plant cover and native species richness in 1 m^2 quadrats has increased since 2010. This suggests the thinning project in 2010-2011 was successful in changing forest structure and increasing plant diversity. One risk of the thinning project was increasing the susceptibility of the forest to exotic plant invasions. While exotic species are present in the park, we found them in such low abundance (<1 cover %) that it was difficult to detect an increasing trend.

Forests are dominated by ponderosa pine (*Pinus ponderosa*) trees and the forest density in MORU is now similar to that of historic forest records. This was not the case during the forest survey in 2010, which was completed prior to a large scale thinning project where smaller ponderosa pine trees were removed from much of the park. There was a reduction in basal area following the thinning treatment, but was no change in forest structure between the 2012 and 2016 surveys. Chokecherry (*Prunus virginiana*), serviceberry (*Amelanchier alnifolia*), paper birch (*Betula papyrifera*), and ponderosa pine seedlings are common in MORU. There has been a significant increase in paper birch seedling densities since 2010. Future forest surveys will reveal how many of these seedlings persist and grow to become mature trees. The most frequently observed exotic species of management concern in forest plots was Canada thistle (*Cirsium arvense*), occurring in 58% of plots in 2016. Woody fuel loads in the park are high, averaging about 27 tons per acre, which exceeds the fire management program's target range of 2-12 tons per acre.

Overall, the forest condition has improved since the 2010 Hazardous Fuel Reduction thinning project. Surface fuel loads remain high, but forest density is now more consistent with historic conditions, the risk of crown fire has been reduced, understory plant cover and native plant diversity has increased, and deciduous species, such as paper birch, are successfully regenerating.

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Introduction

Mount Rushmore National Memorial (MORU) is located in the Black Hills and its purpose is to commemorate the founding, expansion, preservation and unification of the United States by preserving, protecting, and interpreting the mountain sculpture in its historic, cultural, and natural setting while providing for the education, enjoyment, and inspiration of the public (National Park Service 2015). MORU protects 517 ha (1278 ac) and contains the second-largest area of old growth ponderosa pine forest in the Black Hills (Symstad and Bynum 2007). Fire suppression over the last century has contributed to a change in forest structure from open to closed stands with a particular increase in small diameter trees (Brown et al. 2008). In recent decades, mountain pine beetle (MPB; *Dendroctonus ponderosae*) outbreaks have been of particular concern because they are increasing throughout the Black Hills and have caused 100% mortality of ponderosa pine in some areas (Allen and Long 2008, Hocking et al. 2010). Mechanical fuel reduction projects have been undertaken to reduce stand density in MORU with the hope that this will reduce the susceptibility to mountain pine beetle attacks and high severity fires and to restore old growth structural characteristics (Wienk 2010, Swanson 2013).

The Northern Great Plains Fire Ecology Program (NGPFire) began monitoring plant communities in 1998 to better understand and manage the forest in MORU (Wienk et al. 2010). In 2010 MORU was incorporated into the Northern Great Plains Inventory & Monitoring Network (NGPN). At that time, the vegetation monitoring protocols and plot locations being used at MORU were modified to better represent the entire park and to coordinate efforts between NGPN and NGPFire (Symstad et al. 2011). A total of 60 plots were established in MORU by NGPFire and NGPN, and combined sampling efforts began in 2010 with a survey of 15 plant community plots and an additional 54 forest structure plots (Ashton et al. 2012). In 2011, and thereafter, a subset of the 15 plant community plots were visited annually (Ashton et al. 2013, Ashton and Prowatzke 2014, Prowatzke and Wilson 2015, Davis 2017). The forest structure survey was repeated in 2012 and 2016. In this report, we use data collected from 2013–2017 to assess the current condition of park vegetation, and we use data from 2010–2017 to look at longer-term trends.

Using 8 years of plant community monitoring data in MORU, we explore the following questions:

1. What is the current status of understory plant community composition and structure in MORU?
2. What, if any, rare plants were identified in MORU long-term monitoring plots?
3. How has plant community composition and structure changed from 2010 to 2017?
4. What is the current status of the forest structure in MORU and how has it changed since 2012?

Methods

The NGPN monitoring protocol (Symstad et al. 2012b, a) has been used to monitor vegetation plots in MORU since 2010. Our methods are briefly described below, and more detail can be found in the full monitoring protocol (https://irma.nps.gov/DataStore/Reference/Profile/2182479).

Plant Community Monitoring Plots 2010–2017

The NGPN and NGPFire programs 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 the GRTS design, NGPN selected 15 randomly located sites within MORU (PCM plots; Figure 1).

The NGPN program is scheduled to visit six plant community monitoring (PCM) plots every year using a rotating sampling scheme where three sites were visited in the previous year and three sites are new visits. In 2010, all 15 plots were visited. Thereafter, at five year intervals (e.g., 2011–2015, 2016–2020) all of the PCM plots are visited twice between late June and July (see Appendix A for a detailed list of which plots were visited in each year, Table A-1).

Plant species cover and frequency data were collected in rectangular, 50 m × 20 m (0.1 ha), permanent plots (Figure 2). Data on ground cover and herb-layer (≤ 2 m) height and plant cover were collected along two 50 m transects (the long sides of the plot) using a point-intercept method (Figure 3). At 50 locations along each transect (every 1.0 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 top-most plant intercepted. Using this method, absolute canopy cover can be greater than 100% (particularly in wet years and at productive sites) because we record multiple layers of plants. In plots read by NGPN crews, species richness data from the point-intercept method were supplemented with species presence data collected in five sets of nested square quadrats (0.01 m^2, 0.1 m^2, 1 m^2, and 10 m^2) located systematically along each transect (Figure 3). In 2016, we discontinued the use of all but the 1 m^2 quadrats, which is the quadrat size most commonly used by vegetation ecologists. This was done to save time while continuing to collect species richness data at the 1 m^2 scale. In this report, we present only the data from the 1 m^2 quadrats.

When woody species were present anywhere within 38 m of the center of a plot, tree regeneration and tall shrub density data were collected within a 10 m radius subplot centered in the larger 50 m × 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 (live or dead), and condition (e.g., leaf-discoloration, insect-damaged, etc.) were recorded. Juniper trees (*Juniperus scopulorum*) and tall shrubs were commonly encountered and these were measured at root collar rather than DBH. Where they were present, dead and downed woody fuel load data were collected at 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).

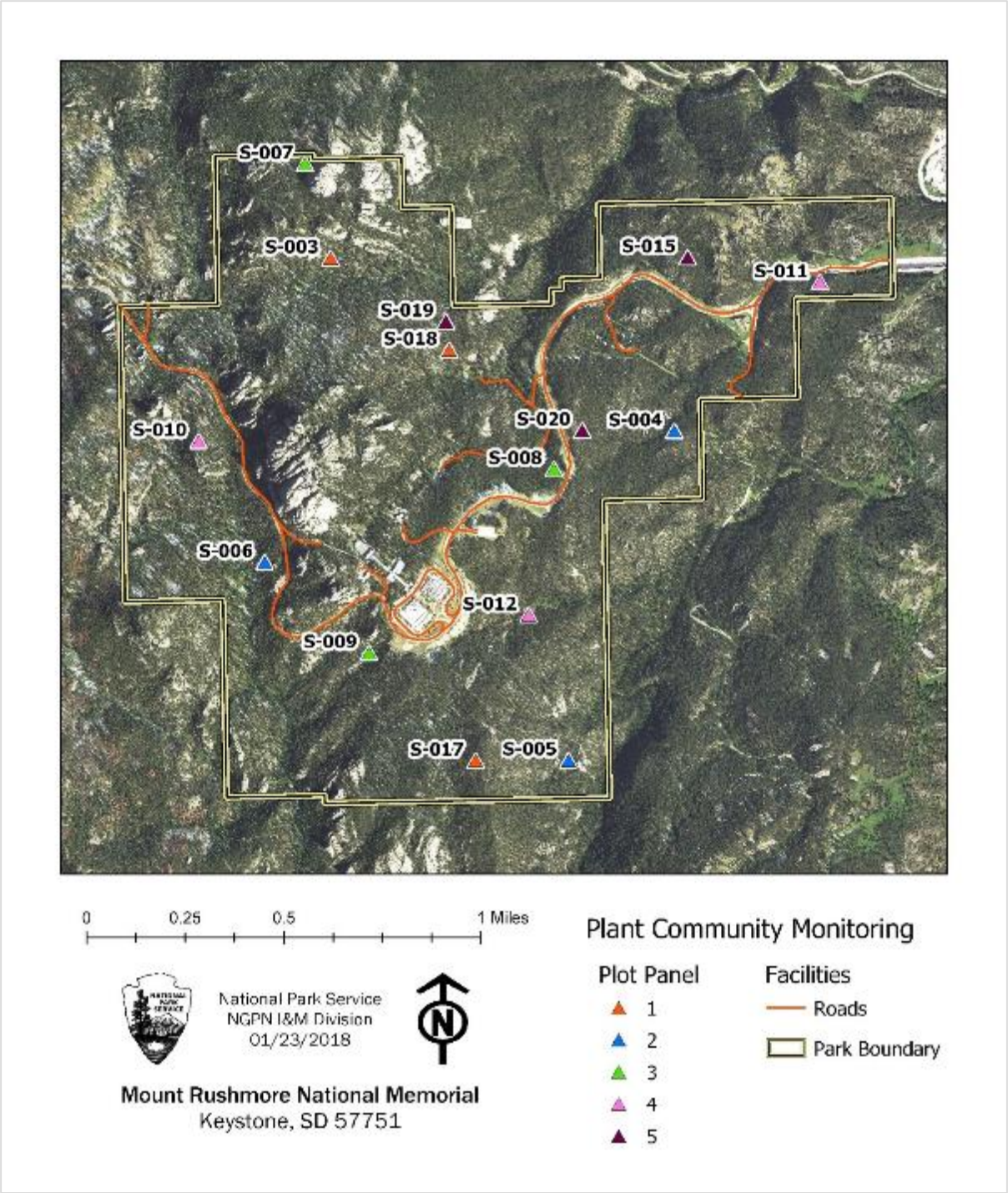

Figure 1. Map of long-term vegetation monitoring plots in Mount Rushmore National Memorial visited from 2010–2017. Each of the fifteen long-term monitoring plots has been visited 3 or more times since 2010.

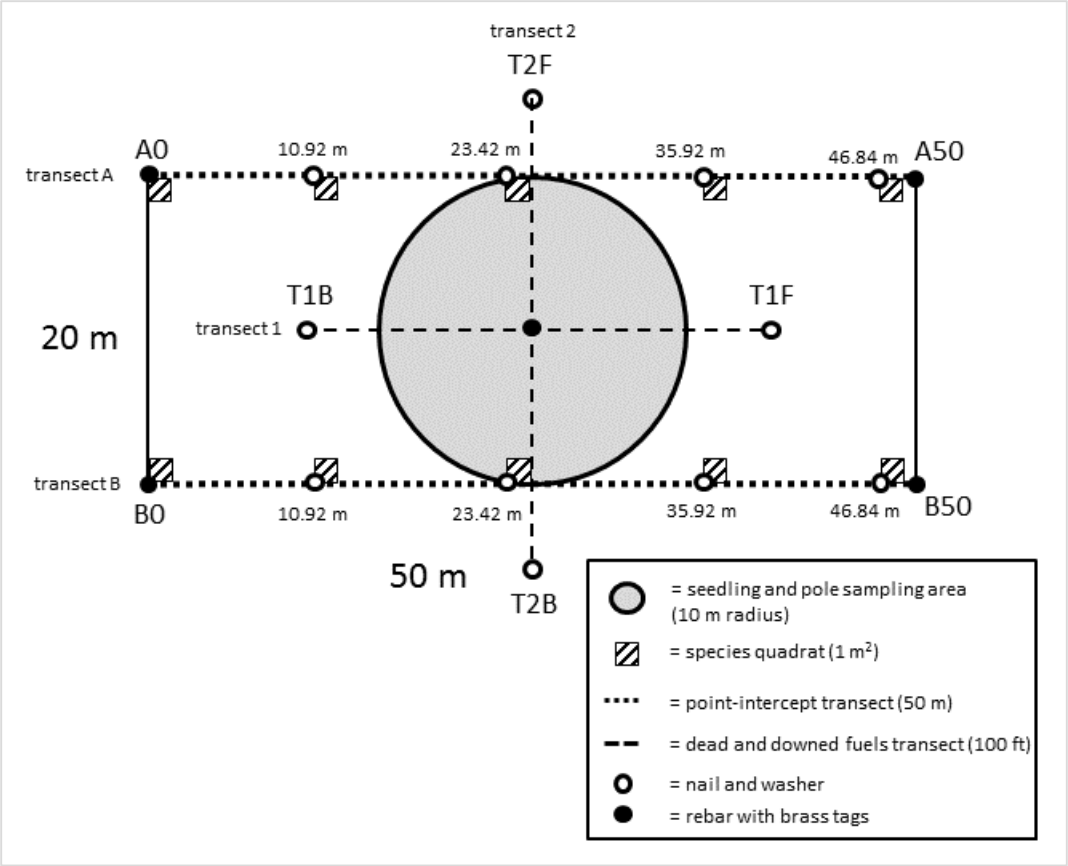

Figure 2. Long-term monitoring plot layout used for sampling vegetation in Mount Rushmore National Memorial.

Photographs were taken at the beginning and end of all transects of a plot using standard methods (e.g., height, distance, camera settings). The same set of photographs are repeated at each visit.

At all plots we surveyed the area for common disturbances and target species of interest to the park. Common disturbances included logging and selective thinning, animal trails, and fire. For all plots, the type and severity of the disturbances were recorded. We also surveyed the area for new or recent exotic species that have the potential to spread into the park and cause significant ecological impacts, otherwise known as "target species" (Table 1). These species were chosen with assistance from Midwest Invasive Plant Network staff, the Northern Great Plains Exotic Plant Management Team, park managers, and local weed experts. Each target species that was present at a site was assigned an abundance class 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. This information was not intended to allow for mapping of common exotic species in the park. Instead, the information gathered from this procedure is critical for early detection and rapid response to new or previously undocumented exotic species invasions.

Table 1. List of exotic species targeted in searches of all Mount Rushmore National Memorial monitoring plots as part of the early detection and rapid response program in the Northern Great Plains Network. An asterisk next to a species name indicates the species is on South Dakota's state list of noxious weeds (SD Department of Agriculture 2017).

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

Forest Structure Plots 2010, 2012, & 2016

In 2010, 2012, and 2016, a survey was completed by NGPN and NGPFire using a set of 60 forested sites in MORU (Figure 3). The goal of this survey was to assess status and trends in forest condition. The forest survey will be repeated every five years (e.g., 2016, 2021, 2026, and so on). The site locations were selected from within MORU using the same GRTS sampling scheme described above for plant community monitoring plots and 15 of the plots were used for plant community monitoring and the forest survey.

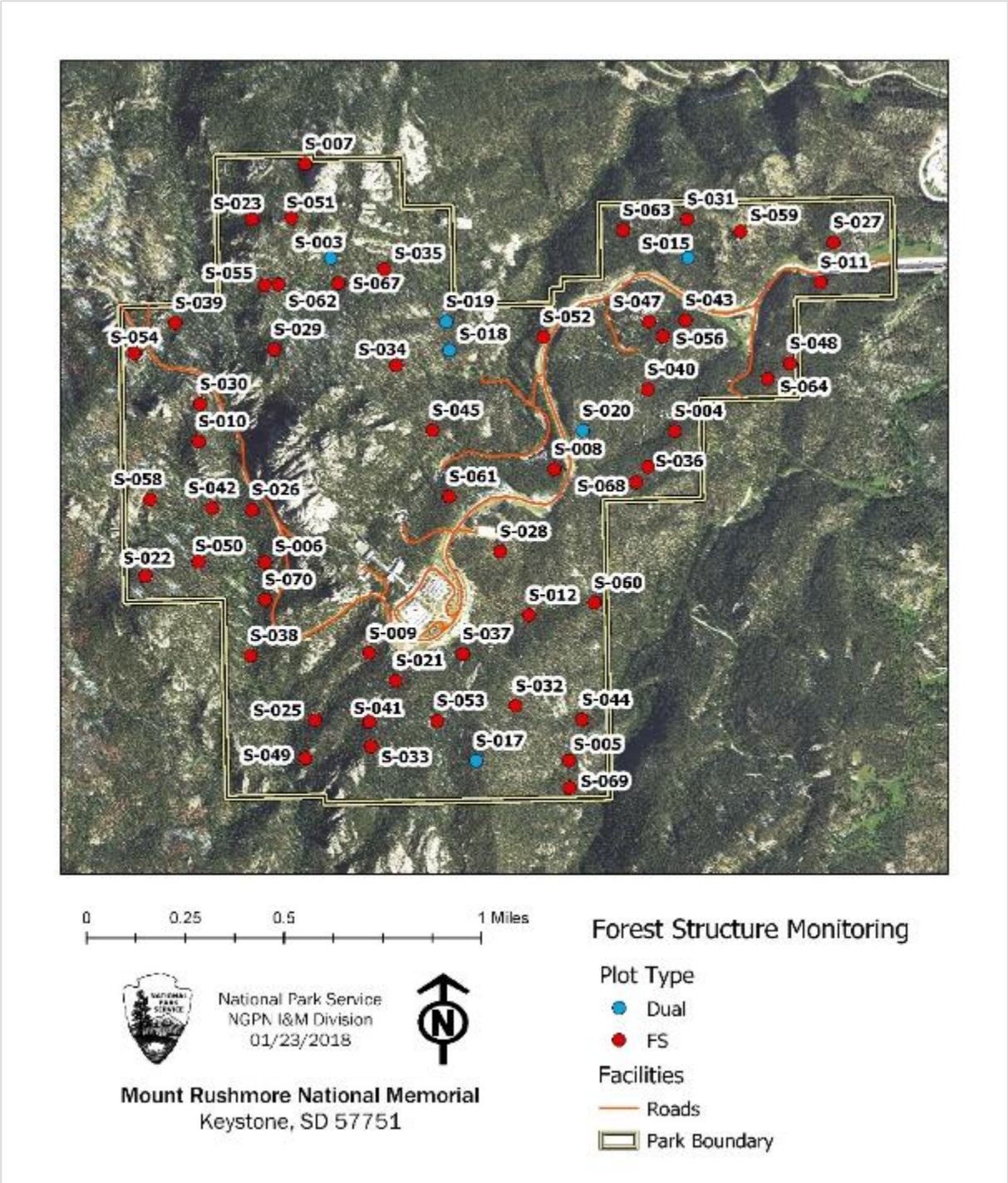

Figure 3. Map of long-term forest structure monitoring plots in Mount Rushmore National Memorial visited in 2012 and 2016. There are 54 forest structure plots (red) and 6 dual plots (blue). The dual plots are larger (0.1 ha) and both the herbaceous community and forest structure are monitored.

The methods used for forest structure surveys were similar to those previously described for plant community monitoring plots. Data was collected for tree density and condition, seedling density, disturbance type and extent, and target species cover. There were some important differences

between plant community and forest structure protocols. In forest structure plots (1) the plot size was smaller and data on trees were only collected within a 10 m radius around plot center (Figure 2; only the seedling and pole sampling area). If there were fewer than 5 trees or poles, the plot radius was extended to 20 m and all trees (but not poles or seedlings) within the larger area were measured; (2) trees were not tagged; (3) neither point-intercept nor 1 m^2 quadrat data were collected; (4) disturbances and target species were measured when they were located within a 50 ft radius of the center (Figure 2; Transect 1 and 2 are the diameters of the circle); and (5) target species included additional early detection species (Table 1) and more widespread exotic species that were identified as management concerns (Table 2).

Table 2. List of exotic species targeted in searches of Mount Rushmore National Memorial forest structure plots as part of the early detection and rapid response program in the Northern Great Plains Network. In the SD Status column "Noxious" indicates the species is on South Dakota's state list of noxious weeds (SD Department of Agriculture 2017), and "Noxious-Pennington" indicates species classified as noxious only in Pennington County, SD.

Scientific Name	Common Name	SD Status
Heracleum mantegazzianum	giant hogweed	–
Arctium minus	common burdock	–
Artemisia absinthium	absinth wormwood	–
Carduus nutans	musk thistle	–
Cirsium arvense	Canada thistle	Noxious
Cirsium vulgare	bull thistle	–
Onopordum acanthium	Scotch thistle	–
Rhaponticum repens	Russian knapweed/hardheads	–
Tanacetum vulgare	common tansy	Noxious–Pennington
Cynoglossum officinale	houndstongue	Noxious–Pennington
Hypericum perforatum	common St Johnswort	–
Elaeagnus angustifolia	Russian olive	–
Euphorbia esula	leafy spurge	Noxious
Bromus inermis	smooth brome	–
Bromus japonicus	Japanese brome	–
Bromus tectorum	cheatgrass	–
Verbascum thapsus	common mullein	–
Hyoscyamus niger	black henbane	–
Tamarix ssp.	salt cedar	Noxious

To mitigate the impacts of the potential spread of MPB into MORU, a large hazardous fuel reduction project was undertaken in 2010 where forest stands were thinned across much of the park. In designated project areas that were to be "thin & piled", trees with a diameter at breast height of 6

inches or less were cut and the slash was hand-piled to specifications (Swanson 2013). In designated project areas that were to be “thin & chipped", trees with a diameter at breast height of 10 inches or less were chipped with resulting wood chips less than 4 inches along any plane. Appendix A includes a list of each plot and whether it was thinned as part of that project, thinned prior to 2010, or if it has not been thinned in the last few decades (Table A-2).

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., National Park Service (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 NPS Inventory and Monitoring Program.

Species scientific names, codes, and common names were taken from the USDA Plants Database (USDA-NRCS 2018). To ensure the most current nomenclature was being used, scientific names were cross-referenced with the Integrated Taxonomic Information System (ITIS;http://www.itis.gov) database. In the few cases where ITIS recognized a new scientific name that was not in the USDA PLANTS database, the new name was used and a unique plant code was assigned for that species. This report uses common names after the first occurrence in the text, but scientific names can be found in Appendix B.

After data 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. When errors were identified by the crew or automated queries, changes were made to the original datasheets and/or the FFI database as needed. Data summaries were produced using the FFI reporting and query tools. Through this process, we were also able to find and correct errors in our historic monitoring data. The data in this report are the most accurate to date. Where there are discrepancies in this report with older data reports (e.g. Ashton et al. 2012, Ashton et al. 2013, Ashton and Prowatzke 2014, Prowatzke and Wilson 2015, Davis 2017) it should be assumed that the data presented in this report are correct. The data are available to the public at: https://irma.nps.gov/DataStore/Reference/Profile/2238103.

The complete list of species that NGPN observed in MORU was cross-referenced with the certified list of plant species known to occur in MORU (https://irma.nps.gov/NPSpecies/Search/SpeciesList/MORU). In the field, when a species identified by NGPN was not on the certified park list and specimen collection was possible, a voucher specimen was sent to botanists for independent verification. In some cases, a mismatch between the certified list and the field data was not found until after the data were collected. In these cases, professional judgement was used to determine whether the species is likely to be a new addition to the park flora or simply a misidentification. In the case of misidentification, the species entry was changed in the database to an unknown or to a genus-level record. In 2017, a botanical survey of MORU was conducted with a goal of obtaining a better documented park flora (Heidel *in preparation*). Specimens that had been identified by NGPN in the past but did not have vouchered

evidence (e.g. a plant specimen on record) were searched for and collected where possible. In some cases, it was determined that species were unlikely to be present in the park.

Plant life forms (e.g., tree, shrub, forb, graminoid) were based on definitions from the USDA Plants Database (USDA-NRCS 2018). The conservation status rank of plant species in South Dakota was determined by cross-referencing the list of species observed by NGPN with conservation status lists for South Dakota (https://gfp.sd.gov/rare-plants/), Wyoming (https://www.uwyo.edu/ wyndd/species-of-concern/plants/), and a list of rare species of the Black Hills compiled by the US Forest Service. For the purpose of this report, a species was considered rare if its conservation status rank was critically imperiled (S1/G1), imperiled (S2/G2), or vulnerable (S3/G3) (Table 3). Noxious weed designations are maintained by the South Dakota Department of Agriculture (https://sdda.sd.gov/ag-services/weed-and-pest-control/weed-pest-control/sd-state-noxious-weed-declared-pest-list-and-distribution-maps/) and are identified in Appendix B species list.

Table 3. Definitions of state and global species conservation status ranks. * Adapted from NatureServe status assessment table (http://www.natureserve.org/conservation- tools/conservation-status-assessment).

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.
SNR/SUR	Rank undetermined	Species either not ranked in this state (SNR) or under review (SUR) for status classification.
SNT	Not tracked	Species occurrence is not currently being tracked in the state.

A number of vegetation metrics were calculated from our data including: species richness, absolute herbaceous cover, relative cover, and an index of beta-diversity. Absolute cover was calculated using point-intercept data and was the total number of vegetation intercepts out of 100 possible intercepts. This value can be greater than 100% because more than one species can be intercepted per point due to overlapping vegetation. Relative cover was calculated by dividing the absolute cover of the species or grouping of interest (e.g., native forbs) by the total absolute cover. Relative cover is therefore constrained between 0 and 100%. Species richness is simply a count of the species recorded in an area, and is reported as the number of species (or grouping of interest) intercepted along two 50 m transects or the average number of species observed in ten 1 m^2 quadrats within a plot. Beta-diversity was calculated as the total number of species observed in ten 1 m^2 quadrats divided by the average

number of species observed within the quadrats. Larger beta-diversity index values indicate that there is greater heterogeneity among the $1m^2$ quadrats.

Forest structure metrics include measures of density and basal area. Plot sizes varied across the dataset and were dependent upon visit type and tree size classes being measures as described in the field methods above. Prior to analysis, we standardized plot size by including only trees and poles measured within a 10 m radius of center for all plots (0.0314 ha). Seedlings were typically counted in a 0.0314 ha area, but when densities were very high (>100 individuals) a smaller area was searched (0.0079 ha, 0.0157 ha, or 0.02355 ha). Basal area is the area that is occupied by the cross-section of tree trunks and reported as square meter per hectare. For our calculations of basal area, we included all live trees greater than 2.4 cm DBH. Densities were calculated separately for each tree size class (pole, tree, and seedling). Seedlings were only counted when they were at least one season old (indicated by hardened off stems), and small stump resprouts were included in the seedling category. Snag density was calculated as the number of standing dead trees per unit area (poles are not included). Target exotic species cover values were calculated using midpoint values of each cover class (e.g., 1-5% = 3%, 5-25% = 15%, etc.), and the smallest cover class of a single plant was calculated using 0.1%.

Metric calculations, statistical summaries, and graphics were generated using the R statistics software package (R Core Team 2017, version 3.4.3). Trends in plant community plots were tested using generalized or linear mixed model with plots and years as random factors using R software. Models were compared with and without factors to compare likelihood, and effects were considered significant P value was <0.05. When initial likelihood tests were significant, models were compared using parametric bootstrap methods to improve the accuracy of the p value estimate. See Supplementary Material for R code. For most forest density metrics (e.g. basal area, tree density), there was a significant change after the thinning project in 2010. Therefore, to look at recent trends over time the data were compared between the 2012 and 2016 survey using simple linear models.

Results and Discussion

Status of plant community composition and structure

There are 465 plant species on the MORU species list, and we identified 232 species (42 of these were exotic) in monitoring plots from 2010–2017 (Appendix B). The most commonly observed species in the monitoring plots at MORU was a small shrub, common juniper (*Juniperus communis*). Graminoids, or grasses and grass-like species, were the next most commonly encountered species. Richardson's sedge (*Carex richardsonii*), Ross's sedge (*C. rossii*), and poverty oatgrass (*Danthonia spicata*) were recorded at more than 15 site visits between 2013 and 2017; however, their absolute cover was fairly low (less than 15 %; Figure 4). Ponderosa pine (*Pinus ponderosa*) and the low-growing shrub kinnikinnick (*Arctostaphylos uva-ursi*) were also very common. All of the most commonly encountered plants were native species.

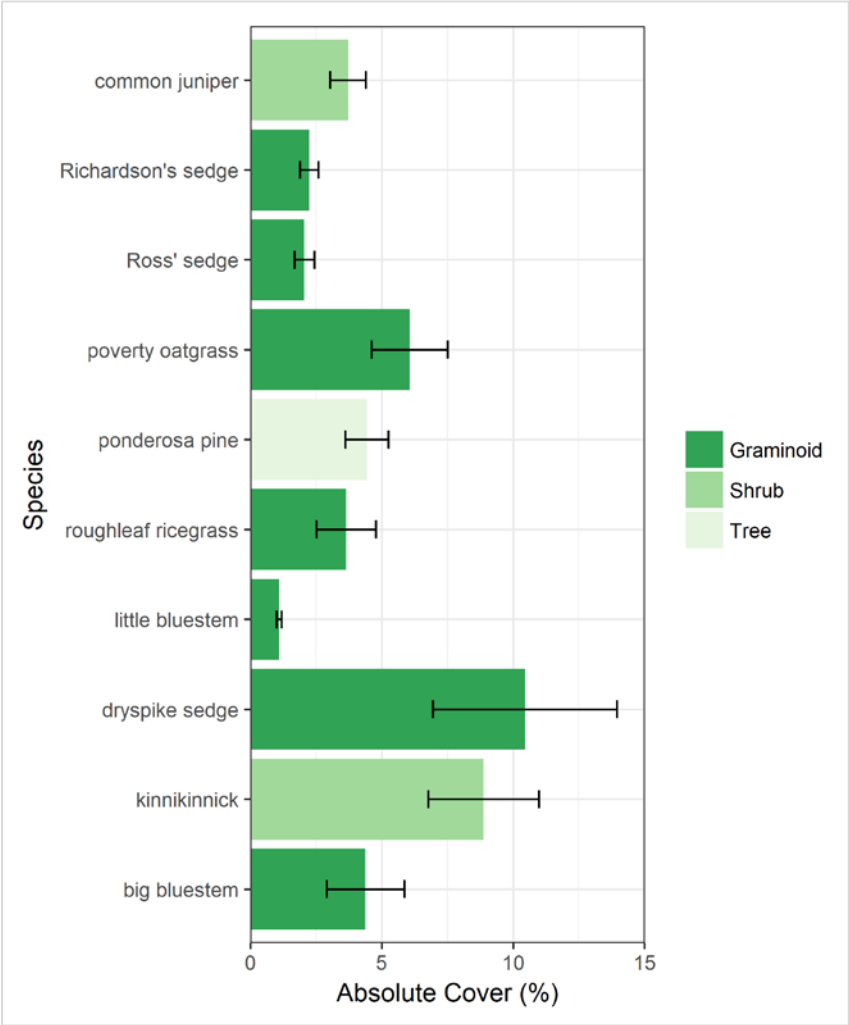

Figure 4. The average absolute cover of the 10 most common species of plants recorded in Mount Rushmore National Memorial from 2013–2017. The species are in rank order with the most commonly encountered species at the top of the graph. Bars represent means ± one standard error. Dark green are graminoid species, medium green are shrub species, and the lightest green is a tree.

In general, understory plant cover was quite low, averaging only 27.9% absolute cover. Native graminoids accounted for most of the plant cover at MORU, but shrubs were also abundant (Table 4). There are a number of factors contributing to low herbaceous cover at MORU including large boulders in the plots, dense forest stands that shade out understory plants, and a thick layer of pine litter, duff, and chips. Average relative cover of exotic species at MORU was less than 1 % from 2013–2017 (Table 4), which is well below the exotic species management target level of 10% or less (Appendix C).

Table 4. Average plant cover by growth form and nativity in long-term monitoring plots at Mount Rushmore National Memorial 2013–2017. Averages are across 15 plots.

Variable	Mean	SE	Min	Max
Absolute herbaceous cover	27.9	6.6	5.5	106.5
Native graminoid relative cover (%)	49.3	6.8	8.1	84.9
Native forb and subshrub relative cover (%)	11.2	2.5	0.0	26.7
Native shrub relative cover (%)	22.9	5.1	0.0	51.3
Total exotic species relative cover (%)	0.8	0.3	0.0	3.4
Exotic perennial graminoid relative cover (%)	0.4	0.3	0.0	3.4
Exotic annual graminoid relative cover (%)	0.0	0.0	0.0	0.0
Other exotics relative cover (%)	0.3	0.2	0.0	2.0

Examining the status and trends of a park's native plant diversity and species evenness is one of the ways the NPS measures the effectiveness of management actions directed at achieving the Park Service mission of preserving ecological integrity. Average native species richness in the forest understory has been measured at monitoring plots throughout MORU using species presence observations in 1 m^2 quadrats and point-intercept measurements. In the last 5 years of monitoring, average native species richness was 3.6 species m^{-2} and on average we found 9.6 native species along 2 50 m transects (Table 5). One of the plots with the most native species in the park (PCM_003; is located in the northwest portion of the park, Figure 5). In 2017, we identified an average of 8 native species m^{-2} at this site.

Understory plant species richness and cover values at MORU are low compared to neighboring park units with a larger grassland component. For instance, Wind Cave National Park had an average 11 native species per square meter (Ashton and Davis 2016). The low plant cover and diversity within the dense forest stands at MORU compared to more open woodland areas is consistent with patterns seen in other parts of the Black Hills. For instance, Uresk and Severson (1998) found that understory production and species richness declines as basal area increases, but there were unique species that were only found in the dense forest. 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 and Hansen 1986).

Table 5. Average species richness in long-term monitoring plots at Mount Rushmore National Memorial (2013–2017). Richness values are the number of unique species observed along two 50 m transects (Transect Richness) or in ten 1 m^2 quads (Quadrat [1 m^2] Richness) averaged across the number of plots visited ± 1 standard error of the mean.

Unit	Plots	Total Richness	Native Richness	Native Graminoid Richness	Native Forb & Subshrub Richness	All Quads Native Richness	Beta-Richness
Transect Richness	15	9.9 ± 1.8	9.6 ± 1.7	4.2 ± 0.5	2.3 ± 0.8	na	na
Quadrat (1 m^2) Richness	15	3.9 ± 0.6	3.6 ± 0.5	1.3 ± 0.2	1.5 ± 0.3	18.4 ± 2.3	5.1 ± 0.3

Figure 5. A photograph of the long-term monitoring plot, PCM_003, with the highest average native species diversity in Mount Rushmore National Memorial. In 2017, we found an average of 8 native species in each 1m^2 quadrat.

Disturbance from natural disturbances and management actions can affect plant community structure and composition. For this reason, we measured the approximate area affected by natural and human disturbances at each site we visited. From 2010-2017, the most common disturbances noted in MORU was thinning treatments and pile burns, but there was also evidence of erosion, mountain pine beetles, wind and storm damage to trees, and small mammals (e.g. squirrel midden). We found that field observers had difficulty accurately identifying all the management treatments over time (e.g. thinning, pile burns, chipping). The evidence of these treatments also become obscured over time. Therefore, we are revisiting the disturbance protocol and have not used the disturbance data for analyses in this report.

Rare Plants

While our monitoring protocol was not specifically designed to survey rare plants or to detect changes in their populations over time, we occasionally identify rare species in our plots. We observed nine plant species of conservation concern in long-term monitoring plots in MORU (Table 6). Several of these species are rare in the Black Hills of Wyoming, but not in South Dakota where MORU is located. Because MORU is located within 50 km of the Wyoming border and many of these rare Wyoming species are also under review for status classification in South Dakota, they are included in this discussion. Definitions of conservation ranks can be found in Table 3.

Table 6. Rare plant species observed in long-term monitoring plots in Mount Rushmore National Memorial. Species with an asterisk are on the verified MORU species list, however, there is no vouchered specimen in an herbarium to confirm that these species are in the park, so specimens need to be collected for these species.

Scientific Name	Common Name	Status	Number of Unique Plot Observations
Carex richardsonii	Richardson's sedge	SDS4, WYS2	50
Selaginella rupestris	northern selaginella	SDUR, WYS1	12
*Dichanthelium linearifolium**	slimleaf panicgrass	SDUR, WYS1	10
Lactuca canadensis	Canada lettuce	SDUR, WYS1NT	9
*Physalis virginiana**	Virginia groundcherry	SDUR, WYS1	4
Mimulus floribundus	manyflowered monkeyflower	SDS4NT, WYS2S3NT	3
*Sporobolus heterolepis**	prairie dropseed	SDUR, WYS1	3
Carex intumescens	greater bladder sedge	SDS2, WYS1	1
Viola pedatifida	prairie violet	SDNR, WYS1	1

Richardson's sedge (*Carex richardsonii*) is an imperiled species in Wyoming and was observed in 14 plots with 50 unique plot observations between 2010 and 2017. This low-growing perennial sedge is widespread and common in Canadian territories along the US border, and is rare in the US (NatureServe 2018, USDA-NRCS 2018), with the exception of populations in the Black Hills where it is relatively common (Larson and Johnson 2007, NatureServe 2018). This species is of conservation concern largely due to the geographic isolation of these Black Hills populations.

Northern selaginella (*Selaginalla rupestris*) is another rare species that is relatively common in eastern Canadian territories and several eastern US states including Georgia and Virginia, with several isolated populations in the Black Hills of South Dakota and Wyoming (Dorn 2001, NatureServe 2018). This small plant can easily be mistaken for a moss, and is critically imperiled in Wyoming and under review in South Dakota. This species was observed in five plots with 12 unique plot observations between 2010 and 2016.

Generally, the remaining rare species we observed followed a similar pattern of distribution across North America, being common in some Canadian territories, a few eastern states, and reaching the end of their southern and western extent in South Dakota and Wyoming (Table 6). The exception to this pattern was manyflowered monkeyflower (*Mimulus floribundus*) which is mainly located in western territories and states, and reaches its easternmost extent in western South Dakota (NatureServe 2018, USDA-NRCS 2018) .

Trends in vegetation community composition and structure

Using the 2013–2017 dataset as a baseline for plant community conditions, we found that MORU has low plant cover in the forest understory (Table 5, Appendix C). We were interested in determining whether there have been changes to this and other key metrics since 2010. We found that absolute plant cover changed over time (χ^2 =5.7, $P < 0.0339$), increasing from a low of 11.4 ± 3.7% in 2011 to a high of 34.8 ± 18.0 % in 2017. It is likely that the increasing trend is due in part to increased light in the forest understory and a corresponding decrease in basal area after the thinning project in 2010 (Figure 6).

While there was varibility from year to year in native species richness along transects and the relative cover of native graminoids (Figure 7), there has been no significant change over time (P=0.666 and, P=0.4353, respectively). In contrast to the transect data, we found an increase in native species richness in the 1 m^2 quadrats since 2010 (Figure 7; (χ^2 =10.2, $P < 0.0099$). Again, this is likley due to increasing light in the understory. There are few exotic species in MORU and they make up such a low percent of cover (<1 %), that it is difficult to test for ecologically meaningful changes over time. The mean cover of exotic species has stayed similar from the low in 2012 (0.3 ± 0.4 %) to 2017 (1.4 ± 0.9 %).

The diversity and productivity of plant communities in the Northern Great Plains is affected by the dramatically shifting weather patterns of the Great Plains (Jonas et al. 2015). Fluctuations in species abundances due to changes in weather can make detecting long-term trends difficult. For instance, late spring snow in 2015 likely contributed to the reduction in herbaceous cover and native species

richness in that year (Figure 7). Continued long-term collection of monitoring data will be needed to better understand the complex relationships between climate and vegetation in MORU.

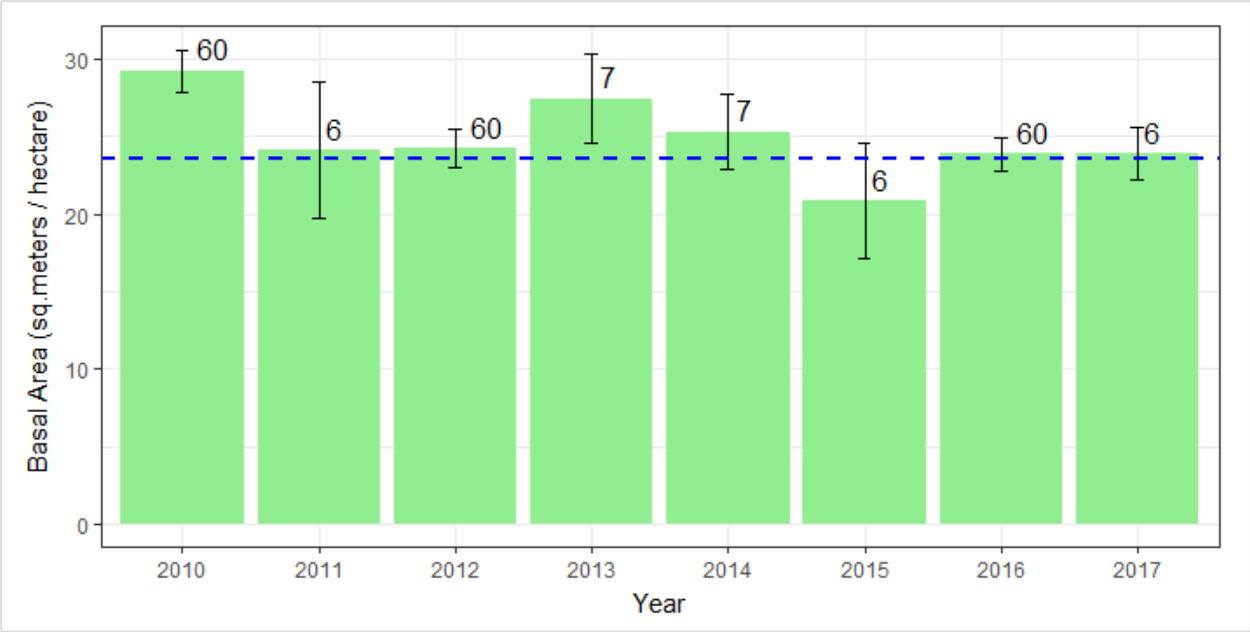

Figure 6. Bar graph of basal area at Mount Rushmore National Memorial from 2010–2017. Bars represent means and lines represent one standard error of the mean. The number of plots monitored each year is shown at the top of the bar. The blue dashed line is the reconstructed historic basal area from ~ 1870 (Brown et al. 2008).

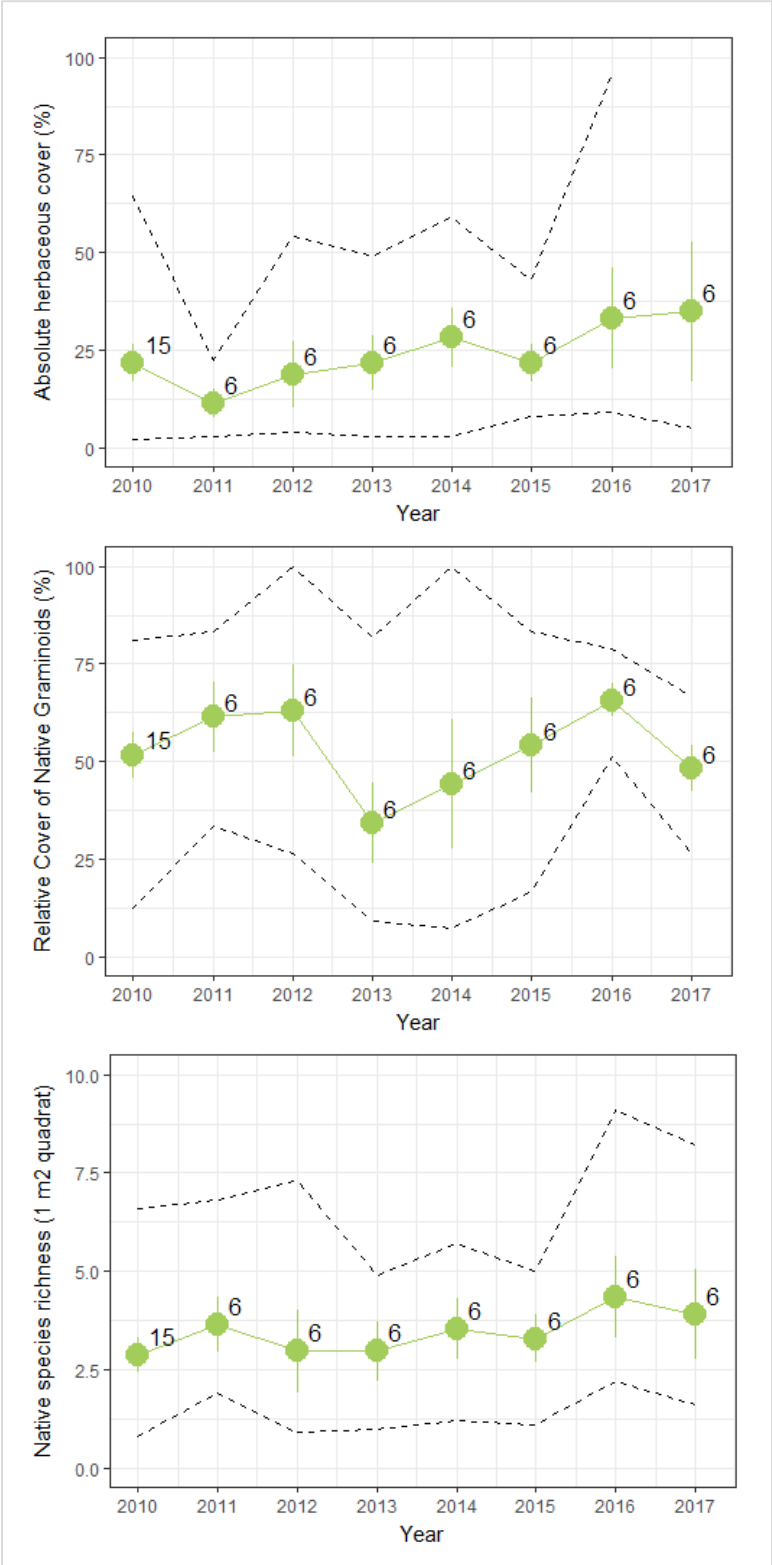

Figure 7. Line graphs showing the changes from 2010 to 2017 at Mount Rushmore National Memorial in absolute cover of herbaceous plants (top), relative cover of native graminoids (middle) and native species richness (bottom). Points represent mean ± one standard error and sample size is to the right of the point. The dashed line represents the maximum and minimum cover values for each year.

Upland Forest Condition

Trees & Seedlings in Forest Survey

We measured tree and seedling densities in 60 monitoring plots that had a tree or tall shrub within 38 m of the plot center (Figure 8) in 2010, 2012, and 2016. In other years, we visited just a subset of 6 plots. Ponderosa pine was the most common tree we encountered in MORU, and in 2016 an adult ponderosa tree, pole or seedling was observed in all of the monitoring plots. A number of other species of mature trees were observed in plots including paper birch (*Betula papyrifera*), bur oak (*Quercus macrocarpa*) and Black Hills spruce (*Picea glauca*) (Table 7). In the smaller size classes (poles and seedlings), we found a greater diversity of species in monitoring plots (Table 7). Ponderosa seedlings were present in all plots, but chokecherry, serviceberry, and paper birch seedlings were also common (Table 7). The most diverse forest plots were those areas in MORU with a lower canopy layer of deciduous trees and shrubs (Figure 8).

Figure 8. Photograph of monitoring plot PCM_039 at Mount Rushmore National. Ponderosa pine and many deciduous tree species were present at this site.

Table 7. Tree and tall shrub frequency in Mount Rushmore National Memorial in 2016 at 60 monitoring plots. Seedlings have a DBH <2.54 cm, poles are > 2.54 cm and <15.0 cm DBH. Snags are dead mature trees >15 cm DBH.

Species	Common Name	Number of plots with mature trees	Number of plots with poles	Number of plots with seedlings	Number of plots with snags
Pinus ponderosa	ponderosa pine	59	24	60	30
Betula papyrifera	paper birch	3	9	17	-
Prunus virginana	chokecherry	-	1	21	-
Amelanchier alnifolia	Saskatoon serviceberry	-	1	18	-
Populus tremuloides	aspen	-	7	13	3
Quercus macrocarpa	bur oak	1	4	13	-
Prunus pensylvanica	pin cherry	-	1	10	-
Picea glauca	Black Hills spruce	1	1	2	-
Salix bebbiana	Bebb willow	-	1	-	1
Juniperus scopulorum	Rocky Mountain juniper	-	-	1	-
All species		**60**	**34**	**60**	**32**

Reconstructed estimates of forest stand density and tree basal area from Black Hills forests in 1870s were 23.6 m^2 ha^{-1} and 280 stems ha^{-1}, respectively (Brown et al. 2008). Compared to this reference condition, MORU forests in 2016 have a similar density (331 stems ha^{-1}) and basal area (23.9 m^2 ha^{-1}) (Appendix C). This is in contrast to forest condition prior to the 2010 thinning project at MORU. In 2005, basal area was 30.7 m^2 ha^{-1} (Brown et al. 2008) and 2010 basal areas were 29.3 m^2 ha^{-1} (Table 8). In 2016, the largest basal areas were found at plots PCM_052 (43. m^2 ha^{-1}) and PCM_023 (41.0 m^2 ha^{-1}). Poles were less common than mature trees in 2016, presumably because of the thinning treatment work in 2010. Snags (large standing dead trees) provide important habitat for many native wildlife species and the Black Hills National Forest management guidelines recommends maintaining 5 to 10 snags per hectare (Shepperd and Battaglia 2002). MORU is well above this recommendation with an average of 36 snags per hectare (or about 1 per plot) in 2016 (Table 8).

Table 8. Tree basal area and density by size class for ponderosa pine in Mount Rushmore National Memorial in 2010, 2012, and 2016. Values are the mean across 60 forest monitoring sites ± standard error of the mean. Note a large thinning project focused on removing ponderosa poles was conducted between the 2010 and 2012 survey.

Metric	2010	2012	2016
Basal Area (m^2/ha)	29.3 ± 1.4	24.2 ± 1.2	23.9 ± 1.1
Ponderosa pine Tree Density (stems/ha)	385 ± 24	334 ± 24	325 ± 25
Ponderosa pine Pole Density (stems/ha)	666 ± 114	166 ± 47	148 ± 43
Ponderosa pine Snag Density (stems/ha)	26.5 ± 5.0	29.7 ± 5.5	35.6 ± 6.2

There was a marginally significant change in basal area after 2010 due to the large scale thinning project (Table 8; χ^2=4.2, P=0.0938). The mean density of ponderosa pine poles was reduced from 666 to 166 stems ha^{-1} (Table 8). The effectiveness of the thinning project was examined in depth elsewhere (Swanson 2013). Here, we were most interested in determining whether there has been change between the 2012 and 2016 survey. We found that there has been no significant change in the forests of MORU between 2012 and 2016 (Table 8). Basal area ($F_{1,118}$=0.04, P=0.8393), ponderosa pine tree density ($F_{1,118}$=0.08, P=0.7845), pole density ($F_{1,118}$=0.08, P=0.7767), and snag density ($F_{1,118}$=0.5, P=0.4808) were similar across the two years (Table 8). When other tree species were included in the measurements, we still found no difference across the two sampling periods.

There were 6 species of seedlings that were found in a large enough set of plots to test whether there has been a change in seedling counts over time (Table 8). This includes ponderosa pine, paper birch, serviceberry, chokecherry, aspen, and bur oak. Plots where the species were found were compared in 2010, 2012 and 2016 (this ignores all the plots where that species of seedling was never found). We found in most cases that there has not been a significant change in the number of seedlings over time.

The exception is paper birch. We found that paper birch increased significantly over time (Figure 9, χ^2=4.2, *P*=0.0022). It is unclear why this increase occurred, but it could be due increased light availability following the thinning treatment, a series of wet years, or reduced understory competition in the first couple of years following the thinning (lower absolute cover in Figure 7).

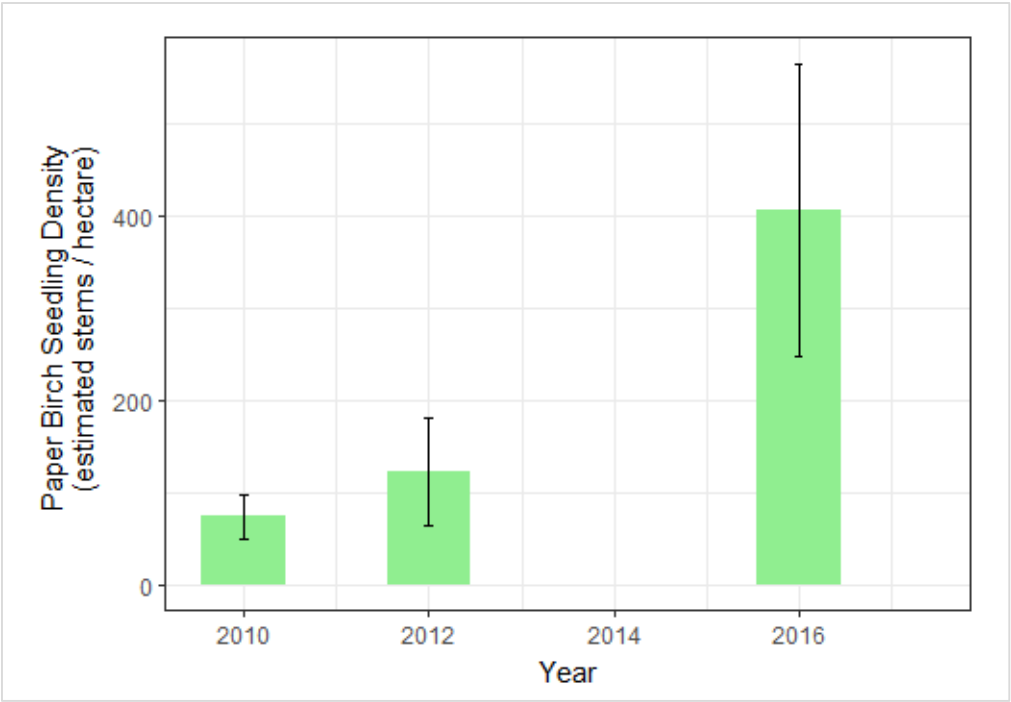

Figure 9. Bar graph of paper birch densities (*Betula papyrifera*) at Mount Rushmore National Memorial from 2010, 2012, and 2016. Bars represent means and lines represent one standard error of the mean. Sixty plots were monitored each year, but this figure includes only the 19 plots where paper birch was found.

Surface Fuels in Forest Survey

Woody fuels are abundant in Mount Rushmore National Memorial (Table 9). Some plots had chips present after the thinning treatment (Table A-1) which can complicate estimates of fuel loads. Because most plots did not have chips or burn piles and there was significant variation from year to year and plot to plot, we have not included chips or burn piles in the fuel load estimates. This allows for better comparison of fuels over time but likely underestimates the true fuel load. Despite their omission, the current fuel loads of 26 ton acre^{-1} is higher than the management target of the fire program (2-12 tons acre^{-1}) in all years of monitoring (Appendix C). The duff layer is particularly high, averaging 15.3 tons acre^{-1} in 2017 (Table 9). There has been no significant change in total fuel loads, woody fuels, fine fuel, duff or litter over time.

Table 9. Surface fuels loads in Mount Rushmore National Memorial Surface by size class from 2011 to 2017. Values represent means ± one standard error. Notes these values underestimate the true fuel load because do not include burn piles or chips.

Year	Number of Plots	Total Fuel Loads (tons acre^{-1})	Total Fine Woody Fuels (tons acre^{-1})	Rotten Coarse Woody Fuels (tons acre^{-1})*	Sound Coarse Woody Fuels (tons acre^{-1})*	Duff (tons acre^{-1})	Litter (tons acre^{-1})
2010	39	23.9 ± 2.1	1.9 ± 0.3	3.9 ± 0. 9	5.0± 1.1	9. 7± 0.9	3.5 ± 0.15
2011	3	25.7 ± 5.9	2.6 ± 0. 3	1.8 ± 1.4	5.7± 2.0	12.0 ± 3.8	3.6 ± 0.4
2012	60	21.0 ± 1.7	1.3 ± 0.2	4.2 ± 0.8	3.2± 0.8	9.7± 0.8	2.5 ± 0.2
2013	8	34.1 ± 7.1	1.4 ± 0.4	4.9 ± 1.8	4.8 ± 1.5	19.1 ± 4.9	3.9 ± 0.8
2014	7	28.3 ± 5.7	2.7 ± 0.6	3.7 ± 1.9	4.9 ± 2.2	14.1 ± 4.8	2.9 ± 0.5
2015	6	21.9 ± 4.4	1.4 ± 0.4	4.9 ± 1.9	2.0 ± 0.7	11.0 ± 3.0	2.7 ± 0.6
2016	60	25.6 ± 1.9	1.7 ± 0.2	5.0 ± 0.9	4.1 ± 1.1	12.4 ± 0.8	2.4 ± 0.2
2017	6	30.1 ± 3.3	3.0 ± 0.9	6.4 ± 3.1	2.8 ± 1.2	15.3 ± 1.5	2.5 ± 0.3

Target Exotic Species in Forest Survey

Seven target exotic species were identified during forest structure monitoring in 2016. The most commonly observed target species was Canada thistle (*Cirsium arvense*), a noxious species in South Dakota, which was identified in 58% of the plots visited (Table 10). Canada thistle cover was approximately 0.6% in plots where it was observed. Smooth brome (*Bromus inermis*) was only observed in 9 plots but occupied the most plot area in the plots where it was observed with 1.6% average cover. Wooly mullein was also the second most-commonly observed target species, being identified in 48% of plots, but with relatively low cover of 0.8% in plots where it was observed. Houndstongue (*Cynoglossum officinale*) was the third most-commonly observed target species, and was identified in 34% of plots with an average cover of 0.5% in invaded plots. Houndstongue is also included on Pennington County's list of noxious exotic species. These baseline data will be compared to data that will be collected in 2021 and every five years thereafter to determine how these target species populations are changing over time. See appendix D for maps of target species observation locations and cover values in the park.

Repeat Photography

The last mountain pine beetle epidemic began in the northern Black Hills in 1997 and progressively expanded throughout the Black Hills over the following one to two decades. As a way to photo-document the ingress of mountain pine beetles and resultant ponderosa pine mortality at Mount Rushmore NMem, NGPFire established two photopoint locations in August 2009 to assess long-term changes to forest structure. In addition, these photopoints would be a way to visually document the effectiveness at a landscape level the 2010 Hazardous Fuel Reduction project had in reducing potential ponderosa pine mortality in MORU from the mountain pine beetle epidemic. The park staff was most concerned about the potential advancement of the mountain pine beetles located in the Black Elk Wilderness of the Black Hills National Forest (BHNF) situated to the southwest of MORU. Ponderosa pine mortality in the Black Elk Wilderness had reached levels exceeding 90% by 2008 (Allen and Long 2008). Every year in August or September repeat photos are taken by NGPFire from the same location, with each site having shots with multiple bearings. Figure 10 shows a series of photos taken from near Mt. Baldy in the northwest portion of the park between 2009 and 2017. Note the large extant of red ponderosa pine trees in the far background in Figure 10 (b) which lies within the Black Elk Wilderness. Ponderosa pine trees are typically attacked in August from the mountain pine beetle, yet don't show the red needles until the following May/June. The large-scale Hazardous Fuels Reduction project took place in the Memorial in 2010 soon after the photo was taken in Figure 10 (b). Lower forest stand densities are evident from Figure 10 (c) through Figure 10 (f). You can also see the advancement of the red mountain pine beetle hit trees in Figure 10 (c) and (d) photos in the mid to background areas.

Table 10. Target exotic species identified in 60 forest structure plots in Mount Rushmore National Memorial in 2016. Species marked with (*) are also on South Dakota's noxious exotic species list and those with (**) are noxious only in Pennington County. "Mean cover across all forest plots" is the average cover across all 60 plots, while "mean cover in invaded forest plots" is the average cover across only the plots where that species was observed. Mean values are percent cover ± one standard error of the mean.

Species	Common Name	Mean Cover Across All Forest Plots (%)	Number of Invaded Plots	Mean Cover in Invaded Forest Plots (%)
Verbascum thapsis	Woolly mullein	0.4 ± 0.1	29	0.8 ± 0.2
*Cirsium arvense**	Canada thistle	0.3 ± 0.1	35	0.6 ± 0.1
Bromus inermis	Smooth brome	0.2 ± 0.1	9	1.6 ± 0.3
*Cynoglossum officinale***	Houndstongue	0.2 ± 0.1	20	0.5 ± 0.1
Cirsium vulgare	Bull thistle	0.1 ± <0.1	16	0.3 ± <0.1
Bromus japonicus	Japanese brome	<0.1 ± <0.1	1	0.5 ± 0.1
Bromus tectorum	Cheatgrass	<0.1 ± <0.1	1	0.5 ± 0.1

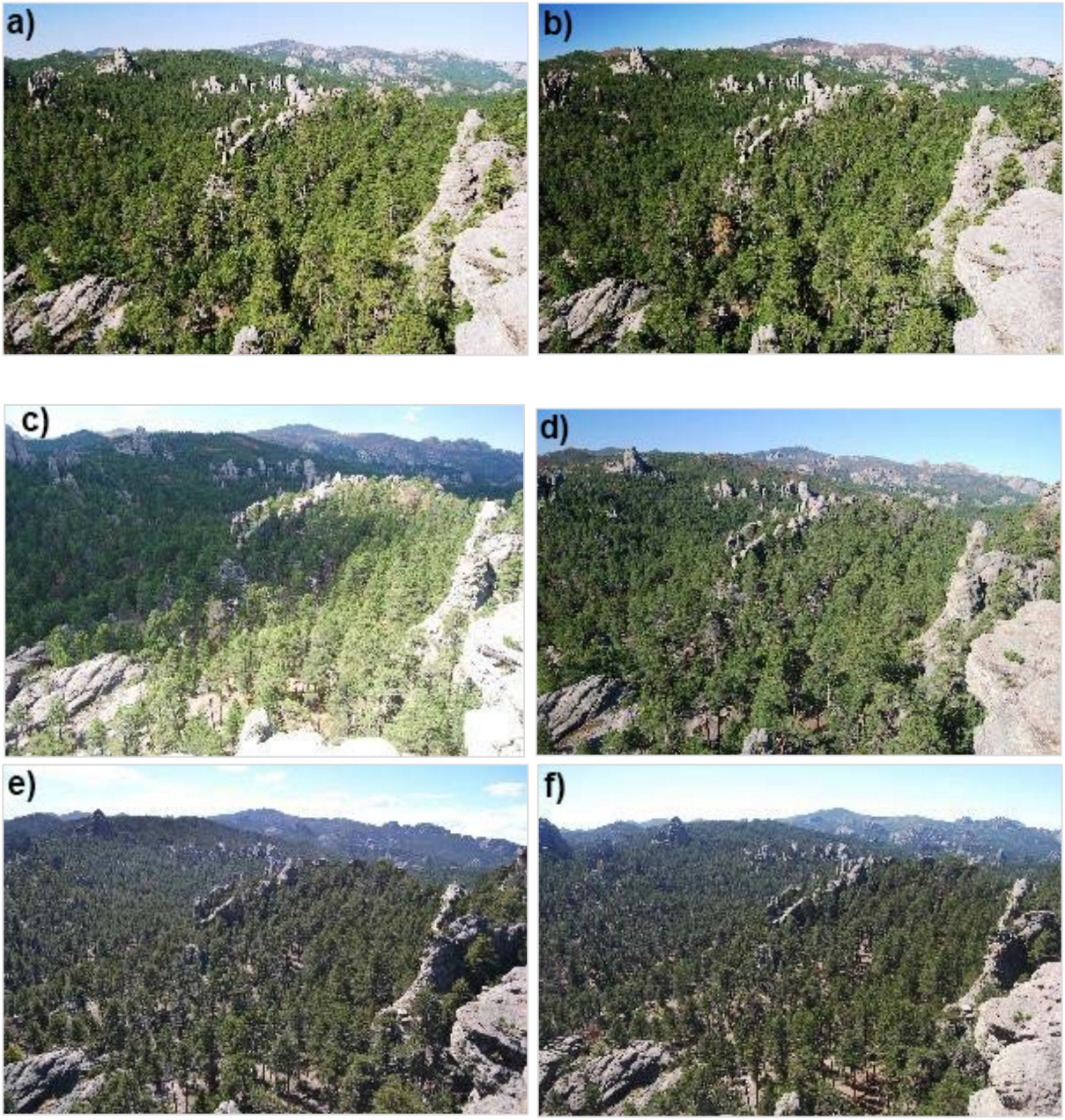

Figure 10. Photo series from near Mount Baldy in Mount Rushmore National Memorial. (a) 2009, (b) 2010, (c) 2011, (d) 2013, (e) 2015, (f) 2017 Photos taken towards the west south-west (244°).

The Black Hills NF mapped the newly infested red Mountain pine beetle trees throughout the epidemic and with 2013 the peak at approximately 34,000 infested acres. Approximately half as many acres were affected in 2014 as the previous year, and in 2016 the mountain pine beetle epidemic was over and went back to endemic levels (Black Hills National Forest 2017).

Conclusions

Overall, the forest condition at MORU has improved since the Hazardous Fuels Reduction project in 2010. At most sites, the understory is dominated by bare rock and pine litter with few herbaceous plants. Common juniper (*Juniperus communis*), Richardson's sedge (*Carex richardsonii*), Ross's sedge (*C. rossii*), and poverty oatgrass (*Danthonia spicata*) were the most common species observed. The average absolute plant cover was 28% and an average of 3.6 native plant species occurred within any given 1 m^2 quadrat sampled. Both plant cover and native species richness in 1 m^2 quadrats has increased since 2010 suggesting the Hazardous Fuels Reduction in 2010 was successful in changing forest structure and increasing plant diversity. One risk of the thinning project was increasing the susceptibility of the forest to exotic plant invasions. While exotic species are present in the park, we found them in such low abundance (<1 cover %) that it was difficult to detect an increasing trend.

Forests are dominated by ponderosa pine (*Pinus ponderosa*) trees and the forest density in MORU is now similar to that of historic records. There was a reduction in basal area following the Hazardous Fuels Reduction, but was no change in forest structure between the more recent 2012 and 2016 surveys. The mountain pine beetle epidemic in the Black Hills which peaked in 2013 and was over in 2016, caused only pockets of tree mortality. Chokecherry, serviceberry, paper birch, and ponderosa pine seedlings are common in MORU. There has been a significant increase in paper birch seedling densities since 2010. Future forest surveys will reveal how many of these seedlings persist and grow to become mature trees. The most frequently observed exotic species of management concern in forest plots was Canada thistle (*Cirsium arvense*), occurring in 58% of plots in 2016. Woody fuel loads in the park are high, averaging about 27 tons per acre, which exceeds the fire management program's target range of 2-12 tons per acre and can lead to increased risk of high intensity fires.

Forest density is now more consistent with historic conditions, the risk of crown fire has been reduced, understory plant cover and native plant diversity has increased, and deciduous species, such as paper birch, are successfully regenerating.

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Appendix A: Plot visits and treatments at Mount Rushmore National Memorial

Table A-1. Monitoring activities in Mount Rushmore National Memorial at Plant Community Monitoring Plots from 2010 – 2017. UTM X and Y coordinates are given for plot center and are in Zone 13N of the NAD 83 datum. Reads are designated as FS= Forest Structure, PC= Plant Community, FX= Fire Effects, T= Tree data only collected, Dual= plant community and forest structure data were collected from that plot in same year.

Plot	UTM X	UTM Y	2010	2011	2012	2013	2014	2015	2016	2017
MORU_PCM_003	623874.6	4860591.8	DUAL	PC	DUAL	T	–	–	DUAL	PC
MORU_PCM_004	625276.9	4859887.3	DUAL	–	DUAL	PC	–	–	FS	PC
MORU_PCM_005	624845.8	4858545.0	DUAL	–	DUAL	PC	–	–	FS	PC
MORU_PCM_006	623606.6	4859352.5	DUAL	–	DUAL	PC	–	–	FS	PC
MORU_PCM_007	623771.2	4860976.4	DUAL	–	FS	PC	PC	–	FS	–
MORU_PCM_008	624786.4	4859732.3	DUAL	–	FS	PC	PC	–	FS	–
MORU_PCM_009	624031.8	4858982.8	DUAL	–	FS	PC	PC	–	FS	–
MORU_PCM_010	623336.6	4859845.5	DUAL	–	FS	T	PC	PC	FS	–
MORU_PCM_011	625871.6	4860493.3	DUAL	–	FS	T	PC	PC	FS	–
MORU_PCM_012	624682.9	4859138.0	DUAL	–	FS	T	PC	PC	FS	–
MORU_PCM_015	625331.3	4860594.5	DUAL	PC	FS	T	–	PC	DUAL	–
MORU_PCM_017	624466.8	4858544.0	DUAL	PC	DUAL	T	–	–	DUAL	PC
MORU_PCM_018	624358.8	4860217.5	DUAL	PC	DUAL	T	–	–	DUAL	PC
MORU_PCM_019	624345.8	4860333.7	DUAL	PC	FS	T	–	PC	DUAL	–
MORU_PCM_020	624902.0	4859889.9	DUAL	PC	FS	T	–	PC	DUAL	–
MORU_PCM_021	624139.7	4858870.1	FS	–	FS	–	–	–	FS	–
MORU_PCM_022	623119.7	4859297.5	FS	–	FS	–	–	–	FS	–
MORU_PCM_023	623555.0	4860751.1	FS	–	FS	–	–	–	FS	–
MORU_PCM_025	623811.2	4858710.0	FS	–	FS	–	–	–	FS	–
MORU_PCM_026	623554.6	4859566.2	FS	–	FS	–	–	–	FS	–
MORU_PCM_027	625923.6	4860656.1	FS	–	FS	–	–	–	FS	–
MORU_PCM_028	624565.0	4859397.0	FS	–	FS	FX	FX	–	FS	–
MORU_PCM_029	623644.6	4860219.8	FS	–	FS	–	–	–	FS	–
MORU_PCM_030	623342.2	4859997.7	FS	–	FS	–	–	–	FS	–
MORU_PCM_031	625327.5	4860750.9	FS	–	FS	–	–	–	FS	–
MORU_PCM_032	624627.5	4858767.7	FS	–	FS	–	–	–	FS	–
MORU_PCM_033	624039.1	4858602.3	FS	–	FS	–	–	–	FS	–
MORU_PCM_034	624141.4	4860155.5	FS	–	FS	–	–	–	FS	–
MORU_PCM_035	624093.2	4860546.3	FS	–	FS	–	–	–	FS	–

Table A-1 (continued). Monitoring activities in Mount Rushmore National Memorial at Plant Community Monitoring Plots from 2010 – 2017. UTM X and Y coordinates are given for plot center and are in Zone 13N of the NAD 83 datum. Reads are designated as FS= Forest Structure, PC= Plant Community, FX= Fire Effects, T= Tree data only collected, Dual= plant community and forest structure data were collected from that plot in same year.

Plot	UTM X	UTM Y	2010	2011	2012	2013	2014	2015	2016	2017
MORU_PCM_036	625119.2	4859678.9	FS	–	FS	–	–	–	FS	–
MORU_PCM_037	624413.5	4858979.2	FS	–	FS	–	–	–	FS	–
MORU_PCM_038	623547.9	4858972.6	FS	–	FS	–	–	–	FS	–
MORU_PCM_039	623241.1	4860328.2	FS	–	FS	–	–	–	FS	–
MORU_PCM_040	625166.8	4860057.3	FS	–	FS	–	–	–	FS	–
MORU_PCM_041	624032.0	4858702.4	FS	–	FS	–	–	–	FS	–
MORU_PCM_042	623391.2	4859573.4	FS	–	FS	–	–	–	FS	–
MORU_PCM_043	625320.4	4860338.9	FS	–	FS	–	–	–	FS	–
MORU_PCM_044	624899.3	4858711.7	FS	–	FS	–	–	–	FS	–
MORU_PCM_045	624289.3	4859890.5	FS	–	FS	–	–	–	FS	–
MORU_PCM_047	625171.9	4860332.2	FS	–	FS	–	–	–	FS	–
MORU_PCM_048	625746.2	4860163.1	FS	–	FS	–	–	–	FS	–
MORU_PCM_049	623772.1	4858554.7	FS	–	FS	–	–	–	FS	–
MORU_PCM_050	623336.7	4859354.8	FS	–	FS	–	–	–	FS	–
MORU_PCM_051	623714.8	4860754.8	FS	–	FS	–	–	–	FS	–
MORU_PCM_052	624741.5	4860270.7	FS	–	FS	–	–	–	FS	–
MORU_PCM_053	624308.0	4858706.2	FS	–	FS	–	–	–	FS	–
MORU_PCM_054	623073.5	4860204.4	FS	–	FS	–	–	–	FS	–
MORU_PCM_055	623605.6	4860481.4	FS	–	FS	–	–	–	FS	–
MORU_PCM_056	625228.3	4860273.5	FS	–	FS	–	–	–	FS	–
MORU_PCM_058	623138.7	4859609.2	FS	–	FS	–	–	–	FS	–
MORU_PCM_059	625544.2	4860701.0	FS	–	FS	–	–	–	FS	–
MORU_PCM_060	624950.2	4859188.1	FS	–	FS	–	–	–	FS	–
MORU_PCM_061	624358.0	4859620.5	FS	–	FS	–	–	–	FS	–
MORU_PCM_062	623661.8	4860484.9	FS	–	FS	–	–	–	FS	–
MORU_PCM_063	625066.4	4860706.0	FS	–	FS	–	–	–	FS	–
MORU_PCM_064	625655.7	4860100.0	FS	–	FS	–	–	–	FS	–
MORU_PCM_067	623906.2	4860490.3	FS	–	FS	–	–	–	FS	–
MORU_PCM_068	625167.8	4859741.6	FS	–	FS	–	–	–	FS	–
MORU_PCM_069	624847.8	4858434.0	FS	–	FS	–	–	–	FS	–
MORU_PCM_070	623607.0	4859200.2	FS	–	FS	–	–	–	FS	–

Table A-2. Management actions in Mount Rushmore National Memorial at Plant Community Monitoring Plots from 2010 – 2017.

Plot	Year thinning Treatment was detected	Chipped	Average depth of Chips in inches (max year)
MORU_PCM_003	2011	Yes	Not measured
MORU_PCM_004	2010	Yes (2009)	–
MORU_PCM_005	2011	–	–
MORU_PCM_006	No treatment	–	–
MORU_PCM_007	No treatment	–	–
MORU_PCM_008	2010	–	–
MORU_PCM_009	2011	–	–
MORU_PCM_010	No treatment	–	–
MORU_PCM_011	2011	Yes	1.0 ± 0.2
MORU_PCM_012	2011	–	–
MORU_PCM_015	No treatment	–	–
MORU_PCM_017	2010	–	–
MORU_PCM_018	2011	Yes	Not measured
MORU_PCM_019	2011	Yes	2.8 ± 0.5
MORU_PCM_020	2010	–	–
MORU_PCM_021	2010	–	–
MORU_PCM_022	2011	–	–
MORU_PCM_023	No treatment	–	–
MORU_PCM_025	2011	–	–
MORU_PCM_026	No treatment	–	–
MORU_PCM_027	2010	–	–
MORU_PCM_028	2011	–	–
MORU_PCM_029	2011	–	–
MORU_PCM_030	2011	Yes	0.6 ± 0.2
MORU_PCM_031	No treatment	–	–
MORU_PCM_032	2011	–	–
MORU_PCM_033	2010	–	–
MORU_PCM_034	2011	Yes	2.5 ± 0.3
MORU_PCM_035	2011	Yes	1.1 ± 0.2

Table A-2 (continued). Management actions in Mount Rushmore National Memorial at Plant Community Monitoring Plots from 2010 – 2017.

Plot	Year thinning Treatment was detected	Chipped	Average depth of Chips in inches (max year)
MORU_PCM_036	2010	–	–
MORU_PCM_037	No treatment	–	–
MORU_PCM_038	2011	Yes	0.4 ± 0.2
MORU_PCM_039	2011	Yes	–
MORU_PCM_040	2010	–	–
MORU_PCM_041	2010	–	–
MORU_PCM_042	2011	Yes	1.7 ± 0.2
MORU_PCM_043	2010	–	–
MORU_PCM_044	2011	–	–
MORU_PCM_045	2011	Yes	1.3 ± 0.3
MORU_PCM_047	2010	–	–
MORU_PCM_048	No treatment	–	–
MORU_PCM_049	2011	–	–
MORU_PCM_050	2011	–	–
MORU_PCM_051	No treatment	–	–
MORU_PCM_052	No treatment	–	–
MORU_PCM_053	No treatment	–	–
MORU_PCM_054	2011	–	–
MORU_PCM_055	2011	Yes	1.9 ± 0.3
MORU_PCM_056	2010	–	–
MORU_PCM_058	2011	Yes	1.0 ± 0.3
MORU_PCM_059	No treatment	–	–
MORU_PCM_060	2010	–	–
MORU_PCM_061	No treatment	–	–
MORU_PCM_062	2011	Yes	1.9 ± 0.3
MORU_PCM_063	No treatment	–	–
MORU_PCM_064	No treatment	–	–
MORU_PCM_067	2010	Yes	0.7 ± 0.3
MORU_PCM_068	2010	–	–

Table A-2 (continued). Management actions in Mount Rushmore National Memorial at Plant Community Monitoring Plots from 2010 – 2017.

Plot	Year thinning Treatment was detected	Chipped	Average depth of Chips in inches (max year)
MORU_PCM_069	2010	–	–
MORU_PCM_070	2011	Yes	–

Appendix B: List of vascular plant species found at Mount Rushmore National Memorial 2010–2017

Table B-1. This table lists all species identified by NGPN staff during monitoring activities in Mount Rushmore National Memorial. In the *Notes* column: “Exotic” indicates non-native species; “Target” indicates an exotic species identified as having the potential to cause negative ecological impacts; “Noxious” indicates an exotic species declared a noxious pest by the state of South Dakota; “WY-S#” and “SD-S#” indicate the state conservation status for a species of conservation concern due to rarity, habitat alteration, or distribution in that respective state. “New” indicates a species that was identified by NGPN staff but is not on the verified species list maintained by the park.

Family	Scientific Name	Common Name	Notes
Amaranthaceae	*Dysphania botrys*	Jerusalem oak goosefoot	Exotic
Anacardiaceae	*Toxicodendron rydbergii*	western poison ivy	–
Apiaceae	*Sanicula marilandica*	Maryland sanicle	–
Apiaceae	*Zizia aptera*	meadow zizia	–
Apocynaceae	*Apocynum androsaemifolium*	spreading dogbane	–
Araliaceae	*Aralia nudicaulis*	wild sarsaparilla	–
Aspleniaceae	*Asplenium septentrionale*	forked spleenwort	–
Asteraceae	*Achillea millefolium*	common yarrow	–
Asteraceae	*Agoseris glauca*	pale agoseris	–
Asteraceae	*Ambrosia artemisiifolia*	annual ragweed	–
Asteraceae	*Ambrosia psilostachya*	Cuman ragweed	–
Asteraceae	*Anaphalis margaritacea*	western pearly everlasting	–
Asteraceae	*Antennaria*	pussytoes	–
Asteraceae	*Antennaria microphylla*	littleleaf pussytoes	–
Asteraceae	*Antennaria neglecta*	field pussytoes	–
Asteraceae	*Antennaria parvifolia*	small-leaf pussytoes	–
Asteraceae	*Artemisia ludoviciana*	white sagebrush	–
Asteraceae	*Carduus nutans*	musk thistle	Exotic, Noxious, Target

Table B-1 (continued). This table lists all species identified by NGPN staff during monitoring activities in Mount Rushmore National Memorial. In the *Notes* column: “Exotic” indicates non-native species; “Target” indicates an exotic species identified as having the potential to cause negative ecological impacts; “Noxious” indicates an exotic species declared a noxious pest by the state of South Dakota; “WY-S#” and “SD-S#” indicate the state conservation status for a species of conservation concern due to rarity, habitat alteration, or distribution in that respective state. “New” indicates a species that was identified by NGPN staff but is not on the verified species list maintained by the park.

Family	Scientific Name	Common Name	Notes
Asteraceae	*Cirsium*	thistle	Exotic
Asteraceae	*Cirsium arvense*	Canada thistle	Target
Asteraceae	*Cirsium drummondii*	dwarf thistle	–
Asteraceae	*Cirsium vulgare*	bull thistle	Exotic, Noxious, Target
Asteraceae	*Conyza canadensis*	horseweed	–
Asteraceae	*Crepis occidentalis*	largeflower hawksbeard	–
Asteraceae	*Crepis runcinata*	fiddleleaf hawksbeard	–
Asteraceae	*Erigeron formosissimus*	beautiful fleabane	–
Asteraceae	*Erigeron subtrinervis*	threenerve fleabane	–
Asteraceae	*Grindelia squarrosa*	curlycup gumweed	–
Asteraceae	*Heterotheca villosa*	hairy false goldenaster	–
Asteraceae	*Hieracium aurantiacum*	orange hawkweed	Target
Asteraceae	*Hieracium canadense*	Canadian hawkweed	–
Asteraceae	*Hieracium umbellatum*	narrowleaf hawkweed	–
Asteraceae	*Lactuca canadensis*	Canada lettuce	SDUR, WYS1NT
Asteraceae	*Lactuca serriola*	prickly lettuce	Exotic
Asteraceae	*Logfia arvensis*	field cottonrose	Exotic, New
Asteraceae	*Packera cana*	woolly groundsel	–
Asteraceae	*Pseudognaphalium macounii*	Macoun's cudweed	–
Asteraceae	*Rudbeckia hirta*	blackeyed Susan	–
Asteraceae	*Senecio rapifolius*	openwoods ragwort	–
Asteraceae	*Solidago*	goldenrod	–

Table B-1 (continued). This table lists all species identified by NGPN staff during monitoring activities in Mount Rushmore National Memorial. In the *Notes* column: “Exotic” indicates non-native species; “Target” indicates an exotic species identified as having the potential to cause negative ecological impacts; “Noxious” indicates an exotic species declared a noxious pest by the state of South Dakota; “WY-S#” and “SD-S#” indicate the state conservation status for a species of conservation concern due to rarity, habitat alteration, or distribution in that respective state. “New” indicates a species that was identified by NGPN staff but is not on the verified species list maintained by the park.

Family	Scientific Name	Common Name	Notes
Asteraceae	*Solidago canadensis*	Canada goldenrod	–
Asteraceae	*Solidago gigantea*	giant goldenrod	–
Asteraceae	*Solidago missouriensis*	Missouri goldenrod	–
Asteraceae	*Solidago nemoralis*	gray goldenrod	–
Asteraceae	*Solidago ptarmicoides*	prairie goldenrod	–
Asteraceae	*Solidago speciosa*	showy goldenrod	–
Asteraceae	*Sonchus asper*	spiny sowthistle	–
Asteraceae	*Symphyotrichum ciliolatum*	Lindley's aster	–
Asteraceae	*Symphyotrichum falcatum*	white prairie aster	–
Asteraceae	*Symphyotrichum laeve*	smooth blue aster	–
Asteraceae	*Symphyotrichum oblongifolium*	aromatic aster	–
Asteraceae	*Taraxacum officinale*	common dandelion	–
Asteraceae	*Tragopogon dubius*	yellow salsify	–
Betulaceae	*Betula papyrifera*	paper birch	–
Betulaceae	*Corylus cornuta*	beaked hazelnut	–
Boraginaceae	*Cryptantha fendleri*	sanddune cryptantha	–
Boraginaceae	*Cryptantha torreyana*	Torrey's cryptantha	–
Boraginaceae	*Cynoglossum officinale*	houndstongue	Noxious, Target
Boraginaceae	*Lappula squarrosa*	European stickseed	–
Brassicaceae	*Arabis pycnocarpa*	creamflower rockcress	New
Brassicaceae	*Boechera*	rockcress	Exotic
Brassicaceae	*Turritis glabra*	tower rockcress	–

Table B-1 (continued). This table lists all species identified by NGPN staff during monitoring activities in Mount Rushmore National Memorial. In the *Notes* column: “Exotic” indicates non-native species; “Target” indicates an exotic species identified as having the potential to cause negative ecological impacts; “Noxious” indicates an exotic species declared a noxious pest by the state of South Dakota; “WY-S#” and “SD-S#” indicate the state conservation status for a species of conservation concern due to rarity, habitat alteration, or distribution in that respective state. “New” indicates a species that was identified by NGPN staff but is not on the verified species list maintained by the park.

Family	Scientific Name	Common Name	Notes
Campanulaceae	*Campanula rotundifolia*	bluebell bellflower	–
Campanulaceae	*Triodanis perfoliata*	clasping Venus' looking-glass	–
Caprifoliaceae	*Lonicera dioica*	limber honeysuckle	–
Caprifoliaceae	*Sambucus racemosa*	red elderberry	–
Caprifoliaceae	*Symphoricarpos*	snowberry	–
Caprifoliaceae	*Symphoricarpos albus*	common snowberry	–
Caprifoliaceae	*Symphoricarpos occidentalis*	western snowberry	–
Caryophyllaceae	*Cerastium fontanum*	mouse-ear chickweed	Exotic
Caryophyllaceae	*Silene antirrhina*	sleepy silene	–
Caryophyllaceae	*Silene drummondii*	Drummond's campion	–
Chenopodiaceae	*Chenopodium*	goosefoot	Exotic
Chenopodiaceae	*Chenopodium album*	lambsquarters	Exotic
Chenopodiaceae	*Chenopodium pratericola*	desert goosefoot	–
Chenopodiaceae	*Chenopodium fremontii*	Fremont's goosefoot	–
Chenopodiaceae	*Chenopodium leptophyllum*	narrowleaf goosefoot	–
Chenopodiaceae	*Chenopodium simplex*	mapleleaf goosefoot	–
Commelinaceae	*Tradescantia occidentalis*	prairie spiderwort	–
Convolvulaceae	*Convolvulus arvensis*	field bindweed	Exotic, Noxious
Crassulaceae	*Sedum lanceolatum*	spearleaf stonecrop	–
Cupressaceae	*Juniperus communis*	common juniper	–
Cupressaceae	*Juniperus scopulorum*	Rocky Mountain juniper	–
Cyperaceae	*Carex*	sedge	Exotic

Table B-1 (continued). This table lists all species identified by NGPN staff during monitoring activities in Mount Rushmore National Memorial. In the *Notes* column: “Exotic” indicates non-native species; “Target” indicates an exotic species identified as having the potential to cause negative ecological impacts; “Noxious” indicates an exotic species declared a noxious pest by the state of South Dakota; “WY-S#” and “SD-S#” indicate the state conservation status for a species of conservation concern due to rarity, habitat alteration, or distribution in that respective state. “New” indicates a species that was identified by NGPN staff but is not on the verified species list maintained by the park.

Family	Scientific Name	Common Name	Notes
Cyperaceae	*Carex brevior*	shortbeak sedge	–
Cyperaceae	*Carex filifolia*	threadleaf sedge	–
Cyperaceae	*Carex foenea*	dryspike sedge	–
Cyperaceae	*Carex inops*	sun sedge	–
Cyperaceae	*Carex intumescens*	greater bladder sedge	SDS2, WYS1
Cyperaceae	*Carex richardsonii*	Richardson's sedge	SDS4, WYS2
Cyperaceae	*Carex rossii*	Ross' sedge	–
Dryopteridaceae	*Cystopteris fragilis*	brittle bladderfern	–
Dryopteridaceae	*Woodsia scopulina*	Rocky Mountain cliff fern	–
Elaeagnaceae	*Shepherdia canadensis*	russet buffaloberry	–
Ericaceae	*Arctostaphylos uva-ursi*	kinnikinnick	–
Fabaceae	*Amorpha canescens*	leadplant	–
Fabaceae	*Astragalus laxmannii*	Laxmann's milkvetch	–
Fabaceae	*Glycyrrhiza lepidota*	American licorice	–
Fabaceae	*Lathyrus ochroleucus*	cream pea	–
Fabaceae	*Medicago lupulina*	black medick	Exotic
Fabaceae	*Melilotus officinalis*	yellow sweetclover	Exotic
Fabaceae	*Pediomelum argophyllum*	silverleaf Indian breadroot	–
Fabaceae	*Pediomelum esculentum*	large Indian breadroot	–
Fabaceae	*Thermopsis rhombifolia*	golden pea	–
Fabaceae	*Trifolium hybridum*	alsike clover	Exotic
Fabaceae	*Trifolium pratense*	red clover	–

Table B-1 (continued). This table lists all species identified by NGPN staff during monitoring activities in Mount Rushmore National Memorial. In the *Notes* column: “Exotic” indicates non-native species; “Target” indicates an exotic species identified as having the potential to cause negative ecological impacts; “Noxious” indicates an exotic species declared a noxious pest by the state of South Dakota; “WY-S#” and “SD-S#” indicate the state conservation status for a species of conservation concern due to rarity, habitat alteration, or distribution in that respective state. “New” indicates a species that was identified by NGPN staff but is not on the verified species list maintained by the park.

Family	Scientific Name	Common Name	Notes
Fabaceae	*Trifolium repens*	white clover	Exotic
Fabaceae	*Vicia americana*	American vetch	–
Fagaceae	*Quercus macrocarpa*	bur oak	–
Gentianaceae	*Halenia deflexa*	American spurred gentian	–
Geraniaceae	*Geranium*	geranium	Exotic
Geraniaceae	*Geranium carolinianum*	Carolina geranium	New
Geraniaceae	*Geranium richardsonii*	Richardson's geranium	–
Grossulariaceae	*Ribes*	currant	Exotic
Grossulariaceae	*Ribes cereum*	wax currant	–
Grossulariaceae	*Ribes hirtellum*	hairystem gooseberry	–
Grossulariaceae	*Ribes oxyacanthoides*	Canadian gooseberry	–
Iridaceae	*Sisyrinchium montanum*	strict blue-eyed grass	–
Juncaceae	*Juncus interior*	inland rush	–
Lamiaceae	*Galeopsis tetrahit*	brittlestem hempnettle	Exotic
Lamiaceae	*Hedeoma*	pennyroyal	Exotic
Lamiaceae	*Monarda fistulosa*	wild bergamot	–
Lamiaceae	*Nepeta cataria*	catnip	Exotic
Liliaceae	*Allium cernuum*	nodding onion	–
Liliaceae	*Anticlea elegans*	mountain deathcamas	–
Liliaceae	*Lilium philadelphicum*	wood lily	–
Liliaceae	*Maianthemum canadense*	Canada mayflower	–
Liliaceae	*Maianthemum stellatum*	starry false lily of the valley	–

Table B-1 (continued). This table lists all species identified by NGPN staff during monitoring activities in Mount Rushmore National Memorial. In the *Notes* column: “Exotic” indicates non-native species; “Target” indicates an exotic species identified as having the potential to cause negative ecological impacts; “Noxious” indicates an exotic species declared a noxious pest by the state of South Dakota; “WY-S#” and “SD-S#” indicate the state conservation status for a species of conservation concern due to rarity, habitat alteration, or distribution in that respective state. “New” indicates a species that was identified by NGPN staff but is not on the verified species list maintained by the park.

Family	Scientific Name	Common Name	Notes
Monotropaceae	*Pterospora andromedea*	woodland pinedrops	–
Onagraceae	*Chamerion angustifolium*	fireweed	–
Onagraceae	*Epilobium brachycarpum*	tall annual willowherb	–
Onagraceae	*Epilobium ciliatum*	fringed willowherb	–
Onagraceae	*Epilobium halleanum*	glandular willowherb	–
Onagraceae	*Oenothera*	evening-primrose	Exotic
Onagraceae	*Oenothera biennis*	common evening primrose	–
Onagraceae	*Oenothera villosa*	hairy evening primrose	–
Orchidaceae	*Corallorhiza*	coralroot	–
Orchidaceae	*Corallorhiza wisteriana*	spring coralroot	–
Orchidaceae	*Goodyera repens*	lesser rattlesnake plantain	–
Pinaceae	*Picea glauca*	Black Hills spruce	–
Pinaceae	*Pinus ponderosa*	ponderosa pine	–
Plantaginaceae	*Plantago rugelii*	blackseed plantain	–
Poaceae	*Achnatherum hymenoides*	Indian ricegrass	–
Poaceae	*Achnatherum nelsonii*	Columbia needlegrass	–
Poaceae	*Agrostis hyemalis*	winter bentgrass	–
Poaceae	*Agrostis scabra*	rough bentgrass	–
Poaceae	*Agrostis stolonifera*	creeping bentgrass	–
Poaceae	*Andropogon gerardii*	big bluestem	–
Poaceae	*Bouteloua gracilis*	blue grama	–
Poaceae	*Bromus ciliatus*	fringed brome	–

Table B-1 (continued). This table lists all species identified by NGPN staff during monitoring activities in Mount Rushmore National Memorial. In the *Notes* column: “Exotic” indicates non-native species; “Target” indicates an exotic species identified as having the potential to cause negative ecological impacts; “Noxious” indicates an exotic species declared a noxious pest by the state of South Dakota; “WY-S#” and “SD-S#” indicate the state conservation status for a species of conservation concern due to rarity, habitat alteration, or distribution in that respective state. “New” indicates a species that was identified by NGPN staff but is not on the verified species list maintained by the park.

Family	Scientific Name	Common Name	Notes
Poaceae	*Bromus inermis*	smooth brome	Exotic, Target
Poaceae	*Bromus japonicus*	Japanese brome	Exotic, Target
Poaceae	*Bromus kalmii*	arctic brome	–
Poaceae	*Bromus porteri*	Porter brome	–
Poaceae	*Bromus tectorum*	cheatgrass	Exotic, Target
Poaceae	*Danthonia spicata*	poverty oatgrass	–
Poaceae	*Dichanthelium*	rosette grass	Exotic
Poaceae	*Dichanthelium leibergii*	Leiberg's panicum	–
Poaceae	*Dichanthelium linearifolium*	slimleaf panicgrass	SDUR, WYS1
Poaceae	*Dichanthelium oligosanthes*	Heller's rosette grass	–
Poaceae	*Elymus canadensis*	Canada wildrye	–
Poaceae	*Elymus trachycaulus*	slender wheatgrass	–
Poaceae	*Elymus virginicus*	Virginia wildrye	–
Poaceae	*Festuca*	fescue	Exotic
Poaceae	*Festuca ovina*	sheep fescue	Exotic
Poaceae	*Festuca saximontana*	Rocky Mountain fescue	–
Poaceae	*Hesperostipa spartea*	porcupinegrass	–
Poaceae	*Koeleria macrantha*	prairie Junegrass	–
Poaceae	*Muhlenbergia cuspidata*	plains muhly	–
Poaceae	*Muhlenbergia racemosa*	marsh muhly	–
Poaceae	*Nassella viridula*	green needlegrass	–
Poaceae	*Oryzopsis asperifolia*	roughleaf ricegrass	–

Table B-1 (continued). This table lists all species identified by NGPN staff during monitoring activities in Mount Rushmore National Memorial. In the *Notes* column: “Exotic” indicates non-native species; “Target” indicates an exotic species identified as having the potential to cause negative ecological impacts; “Noxious” indicates an exotic species declared a noxious pest by the state of South Dakota; “WY-S#” and “SD-S#” indicate the state conservation status for a species of conservation concern due to rarity, habitat alteration, or distribution in that respective state. “New” indicates a species that was identified by NGPN staff but is not on the verified species list maintained by the park.

Family	Scientific Name	Common Name	Notes
Poaceae	*Panicum virgatum*	switchgrass	–
Poaceae	*Pascopyrum smithii*	western wheatgrass	–
Poaceae	*Phleum pratense*	timothy	Exotic
Poaceae	*Piptatherum micranthum*	littleseed ricegrass	–
Poaceae	*Piptatherum pungens*	mountain ricegrass	New
Poaceae	*Poa interior*	inland bluegrass	–
Poaceae	*Poa pratensis*	Kentucky bluegrass	–
Poaceae	*Schedonorus arundinaceus*	tall fescue	Exotic
Poaceae	*Schizachne purpurascens*	false melic	–
Poaceae	*Schizachyrium scoparium*	little bluestem	–
Poaceae	*Sporobolus heterolepis*	prairie dropseed	SDUR, WYS1
Poaceae	*Thinopyrum intermedium*	intermediate wheatgrass	Exotic
Polygonaceae	*Fallopia convolvulus*	black bindweed	Exotic
Polypodiaceae	*Polypodium saximontanum*	Rocky Mountain polypody	–
Primulaceae	*Androsace septentrionalis*	pygmyflower rockjasmine	–
Primulaceae	*Primula pauciflora*	darkthroat shootingstar	–
Pyrolaceae	*Pyrola chlorantha*	greenflowered wintergreen	–
Ranunculaceae	*Anemone cylindrica*	candle anemone	–
Ranunculaceae	*Anemone patens*	eastern pasqueflower	–
Ranunculaceae	*Thalictrum dasycarpum*	purple meadow-rue	–
Ranunculaceae	*Thalictrum venulosum*	veiny meadow-rue	–
Rosaceae	*Amelanchier alnifolia*	Saskatoon serviceberry	–

Table B-1 (continued). This table lists all species identified by NGPN staff during monitoring activities in Mount Rushmore National Memorial. In the *Notes* column: “Exotic” indicates non-native species; “Target” indicates an exotic species identified as having the potential to cause negative ecological impacts; “Noxious” indicates an exotic species declared a noxious pest by the state of South Dakota; “WY-S#” and “SD-S#” indicate the state conservation status for a species of conservation concern due to rarity, habitat alteration, or distribution in that respective state. “New” indicates a species that was identified by NGPN staff but is not on the verified species list maintained by the park.

Family	Scientific Name	Common Name	Notes
Rosaceae	*Drymocallis arguta*	tall cinquefoil	New
Rosaceae	*Drymocallis fissa*	bigflower cinquefoil	–
Rosaceae	*Fragaria virginiana*	Virginia strawberry	–
Rosaceae	*Physocarpus monogynus*	mountain ninebark	–
Rosaceae	*Potentilla*	cinquefoil	Exotic
Rosaceae	*Prunus pensylvanica*	pin cherry	–
Rosaceae	*Prunus virginiana*	chokecherry	–
Rosaceae	*Rosa acicularis*	prickly rose	–
Rosaceae	*Rosa woodsii*	Woods' rose	–
Rosaceae	*Rubus idaeus*	American red raspberry	–
Rosaceae	*Spiraea betulifolia*	white spirea	–
Rubiaceae	*Galium*	bedstraw	Exotic
Rubiaceae	*Galium aparine*	stickywilly	–
Rubiaceae	*Galium boreale*	northern bedstraw	–
Rubiaceae	*Galium triflorum*	fragrant bedstraw	–
Salicaceae	*Populus deltoides*	eastern cottonwood	–
Salicaceae	*Populus tremuloides*	quaking aspen	–
Salicaceae	*Salix*	willow	Exotic
Salicaceae	*Salix bebbiana*	Bebb willow	–
Saxifragaceae	*Heuchera richardsonii*	Richardson's alumroot	–
Scrophulariaceae	*Castilleja sulphurea*	sulphur Indian paintbrush	–
Scrophulariaceae	*Collinsia parviflora*	maiden blue eyed Mary	–

Table B-1 (continued). This table lists all species identified by NGPN staff during monitoring activities in Mount Rushmore National Memorial. In the *Notes* column: “Exotic” indicates non-native species; “Target” indicates an exotic species identified as having the potential to cause negative ecological impacts; “Noxious” indicates an exotic species declared a noxious pest by the state of South Dakota; “WY-S#” and “SD-S#” indicate the state conservation status for a species of conservation concern due to rarity, habitat alteration, or distribution in that respective state. “New” indicates a species that was identified by NGPN staff but is not on the verified species list maintained by the park.

Family	Scientific Name	Common Name	Notes
Scrophulariaceae	*Mimulus floribundus*	manyflowered monkeyflower	SDS4NT, WYS2S3NT
Scrophulariaceae	*Penstemon gracilis*	lilac penstemon	–
Scrophulariaceae	*Verbascum thapsus*	common mullein	Noxious, Target
Scrophulariaceae	*Veronica*	speedwell	Exotic
Scrophulariaceae	*Veronica americana*	American speedwell	–
Scrophulariaceae	*Veronica officinalis*	common gypsyweed	–
Selaginellaceae	*Selaginella rupestris*	northern selaginella	SDUR, WYS1
Solanaceae	*Physalis virginiana*	Virginia groundcherry	SDUR, WYS1
Urticaceae	*Parietaria pensylvanica*	Pennsylvania pellitory	New
Urticaceae	*Urtica dioica*	stinging nettle	–
Violaceae	*Viola*	violet	Exotic
Violaceae	*Viola adunca*	hookedspur violet	–
Violaceae	*Viola canadensis*	Canadian white violet	–
Violaceae	*Viola pedatifida*	prairie violet	SDNR, WYS1
Violaceae	*Viola pubescens*	downy yellow violet	–
Vitaceae	*Parthenocissus vitacea*	woodbine	–

Appendix C: Natural Resource Condition Summary

Results were summarized in a Natural Resource Condition Table based on the templates from the State of the Park report series (Appendix C). 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 C.1.

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. Reference values were based on descriptions of historic condition and variation, past studies, and/or management targets. Current park condition was compared to the reference value, and status was scored as “good condition”, “warrants moderate concern”, or “warrants significant concern” (Table 5). “Good condition” was applied to values that fell within the range of the reference value, and “warrants significant concern” was applied to conditions that fell outside the bounds of the reference value. Indicators were classified as “warrants moderate concern” when the average value was near the threshold of significant concern but the variation associated with that value (e.g., 1 standard error) fell within both good condition and significant concern. In some cases, reference conditions can only be determined after we have accumulated more years of data. When this is the case, we refer to these conditions as “To be determined”, or TBD, and estimate condition based on our professional judgment.

Table C-1. Key to the symbols used in the Natural Resource Condition Table. The symbol 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.

Condition Status		Trend in Condition		Confidence in Assessment	
Condition Icon	**Condition Icon Definition**	**Trend Icon**	**Trend Icon Definition**	**Confidence Icon**	**Confidence Icon Definition**
	Resource is in Good Condition		Condition is Improving		High
	Resource warrants Moderate Concern		Condition is Unchanging		Medium
	Resource warrants Significant Concern		Condition is Deteriorating		Low

Table C-2. Natural resource condition summary table for upland plant communities in Mount Rushmore National Memorial (MORU). Trends are based on 2010–2017, current condition is 2013–2017 or 2016 (forest metrics).

Indicator of Condition	Specific Measures	Current Value (mean ± SE)	Reference Condition and Data Source	Condition Status/Trend	Rationale for Resource Condition
Upland Plant Community Structure and Composition	Native species richness (based on average of 10 1m^2 quadrats per plot)	3.6 ± 0.5	2.9 ± 1.0 (2010 value)		MORU has a low diversity of native plants in the understory but this is consistent with the older ponderosa forests in the Black Hills. Since 2010, there has been an increase in understory native plant richness.
Upland Plant Community Structure and Composition	Absolute cover of herbaceous plants (%)	27.9 ± 6.6	21.7 + 4.8 (2010 value)		MORU has a forest floor with low herbaceous plant canopy cover. Plant canopy cover has increased following the thinning project in 2010-2011.
Upland Plant Community Structure and Composition	Ponderosa pine seedling densities (stems / ha)	2023 ± 377	2177 ± 290 (2010 value)		Ponderosa pine seedlings were found in all 60 plots visited in the 2016 Forest Survey. The densities are extremely variable and there has been no change since 2010. In contrast, paper birch seedlings have become more abundant during this time period.
Upland Plant Community Structure and Composition	Forest basal area (m^2/ha)	23.9 ± 1.1	23.6 ± 2.2 [1]		Forest densities are similar to historic conditions. The thinning projects in the last decade reduced forest density to be more characteristic of the past.
Exotic Plant Early Detection and Management	Relative cover of exotic plant species (%)	0.8 ± 0.3	≤ 10 % cover [2]		MORU has a very low cover of exotic species.

[1] Historical condition Brown et al. 2008 .

[2] Management target based on professional judgment.

Table C-2 (continued). Natural resource condition summary table for upland plant communities in Mount Rushmore National Memorial (MORU). Trends are based on 2010–2017, current condition is 2013–2017 or 2016 (forest metrics).

Indicator of Condition	Specific Measures	Current Value (mean ± SE)	Reference Condition and Data Source	Condition Status/Trend	Rationale for Resource Condition
Exotic Plant Early Detection and Management	Relative cover of exotic perennial graminoids (%)	0.4 ± 0.3	≤ 10 % cover [2]		Exotic perennial grasses are present in MORU but remain in low abundance.
Fire and Fuel Dynamics	Total downed fuel loads (tons/acre)	26.7 ± 1.6	Between 2 and 10 [2]		The current fire ecology program aims to maintain fuel loads of less than 10 tons/acre. MORU is well above this management target, primarily due to a thick duff and litter layer, which can lead to increased risk of high intensity fires.

[1] Historical condition Brown et al. 2008 .

[2] Management target based on professional judgment.

Appendix D: Maps of 2016 Target Exotic Species Observations and Cover in Mount Rushmore National Memorial

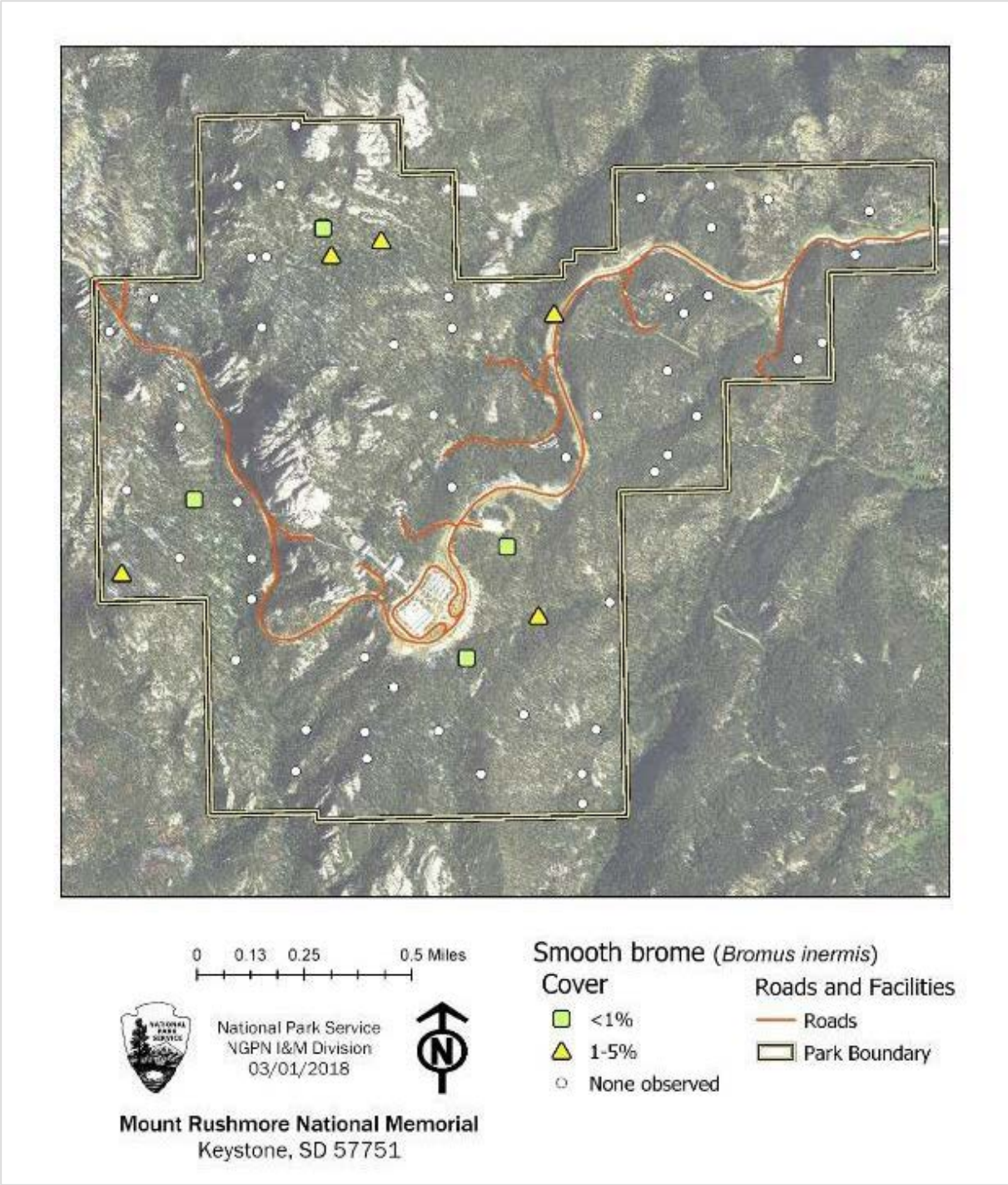

Figure D-1. Map showing the 2016 targeted observations of smooth brome at Mount Rushmore National Monument.

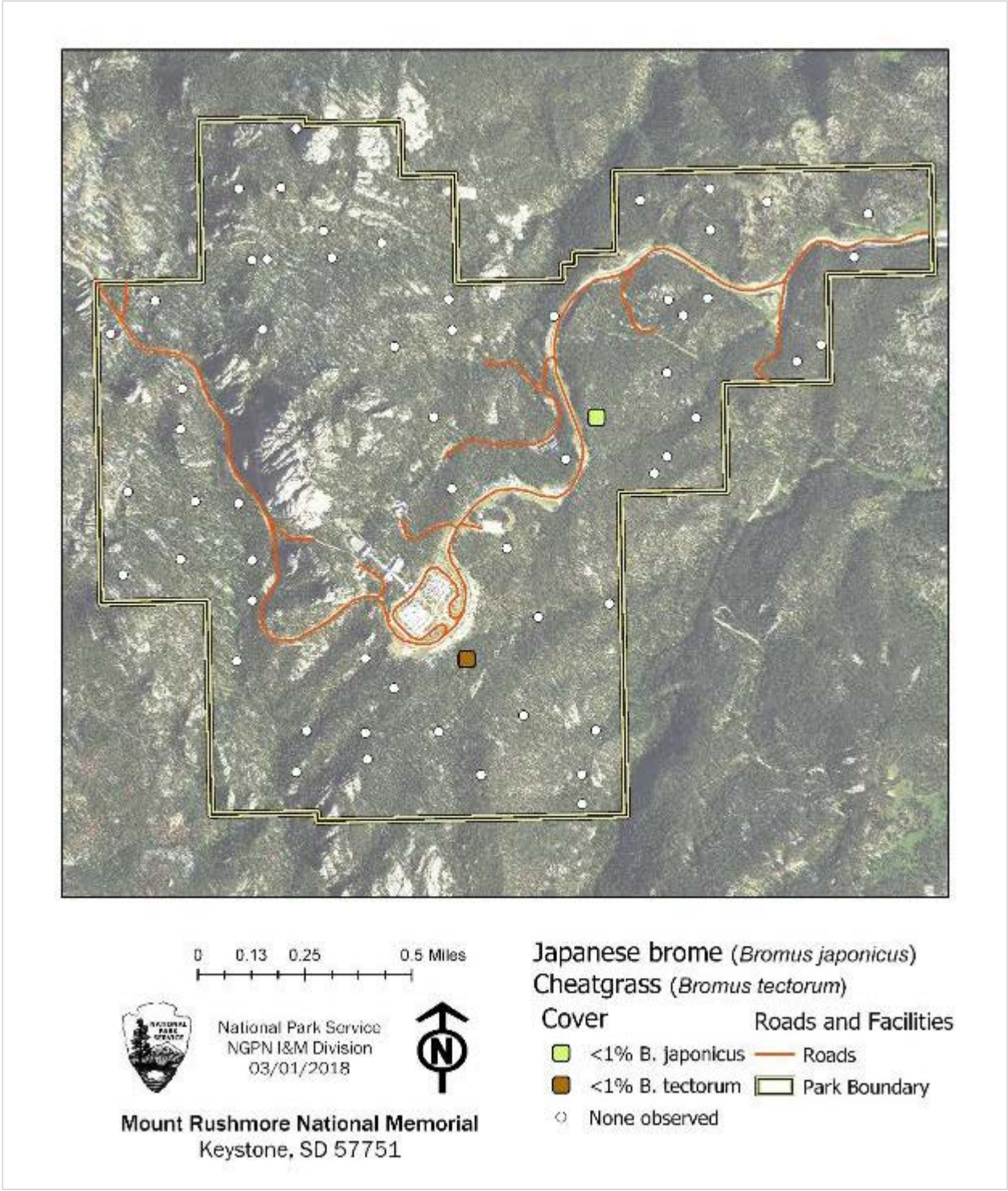

Figure D-2. Map showing the 2016 targeted observations of Japanese brome at Mount Rushmore National Monument.

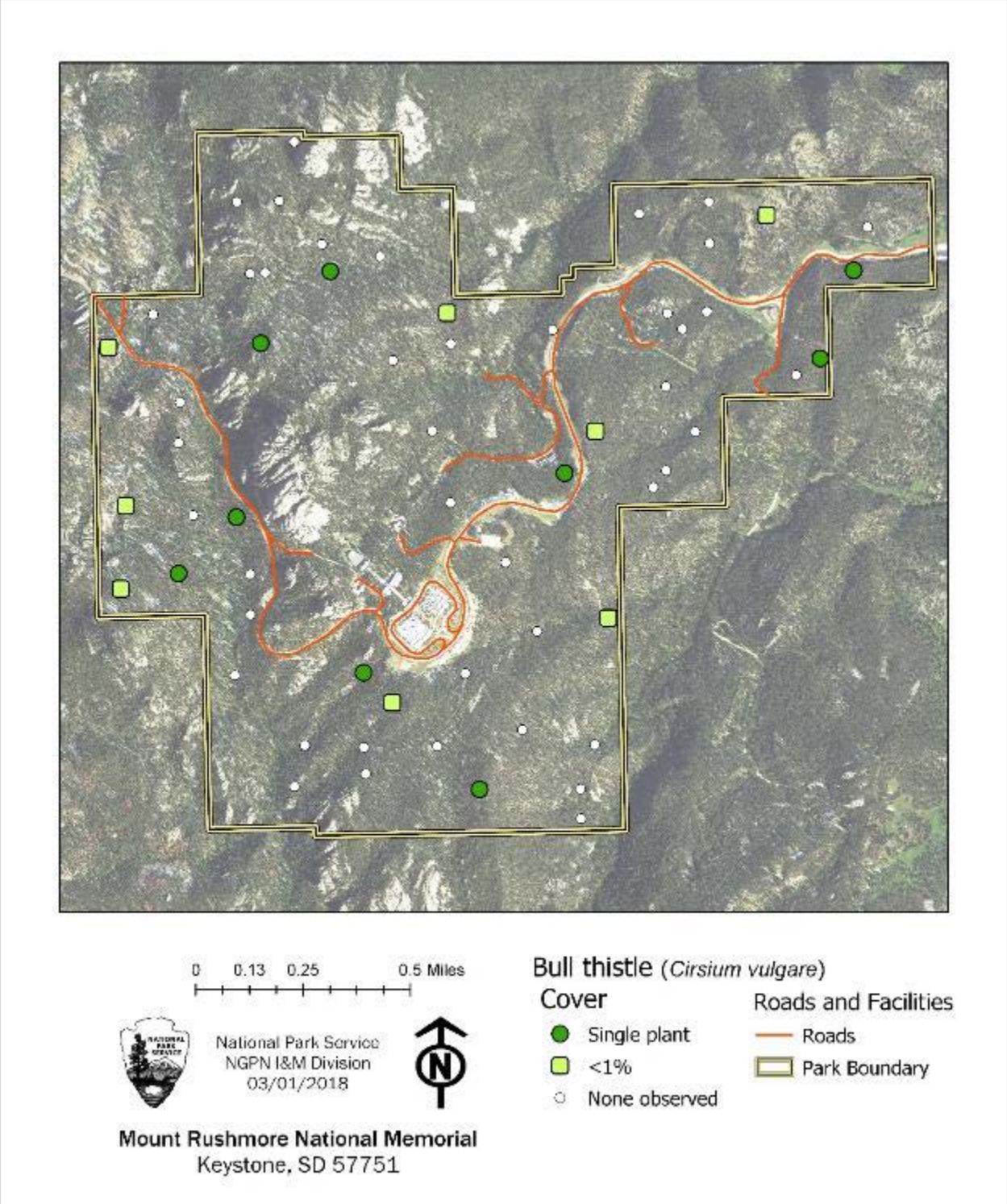

Figure D-3. Map showing the 2016 targeted observations of bull thistle at Mount Rushmore National Monument.

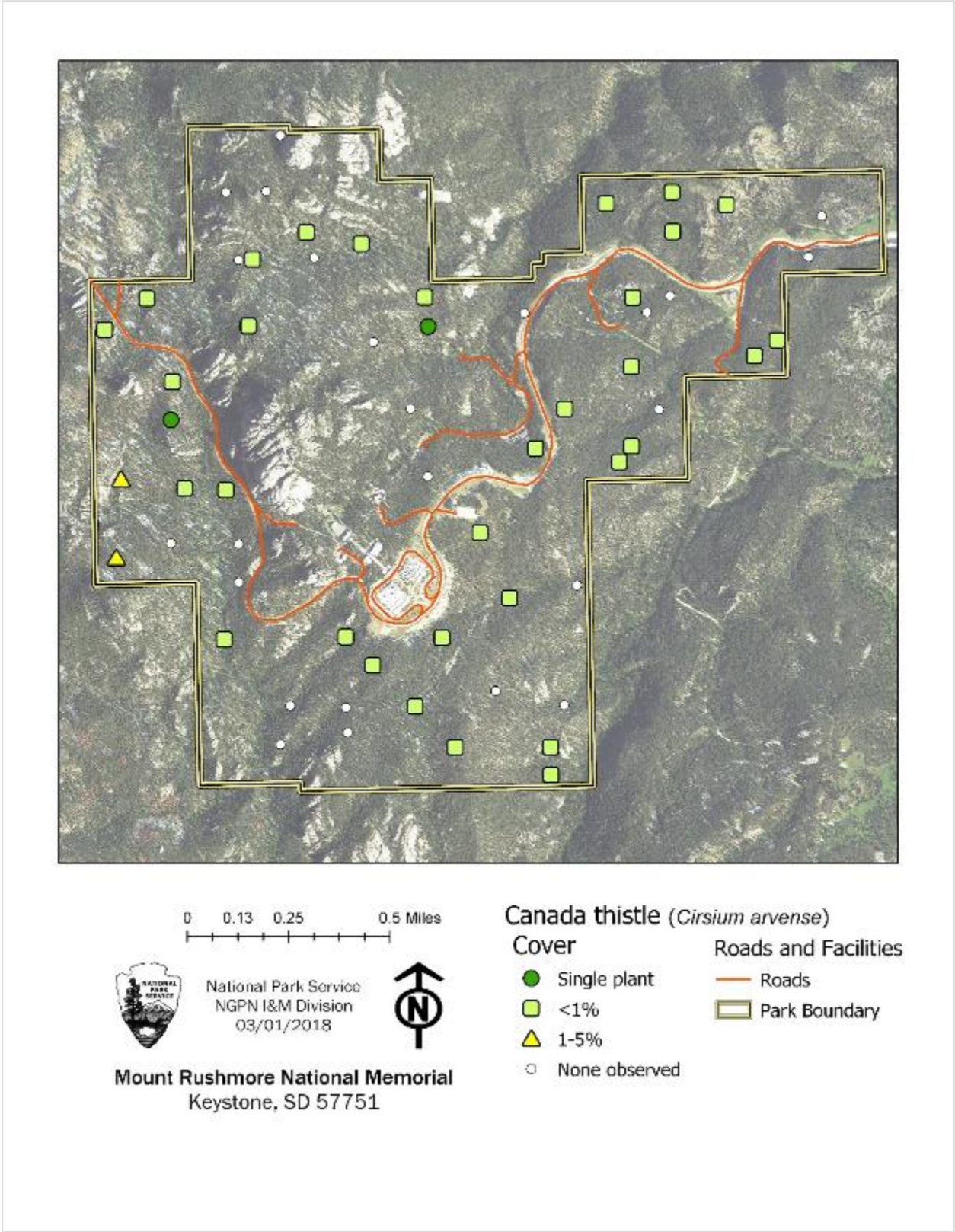

Figure D-4. Map showing the 2016 targeted observations of Canada thistle at Mount Rushmore National Monument.

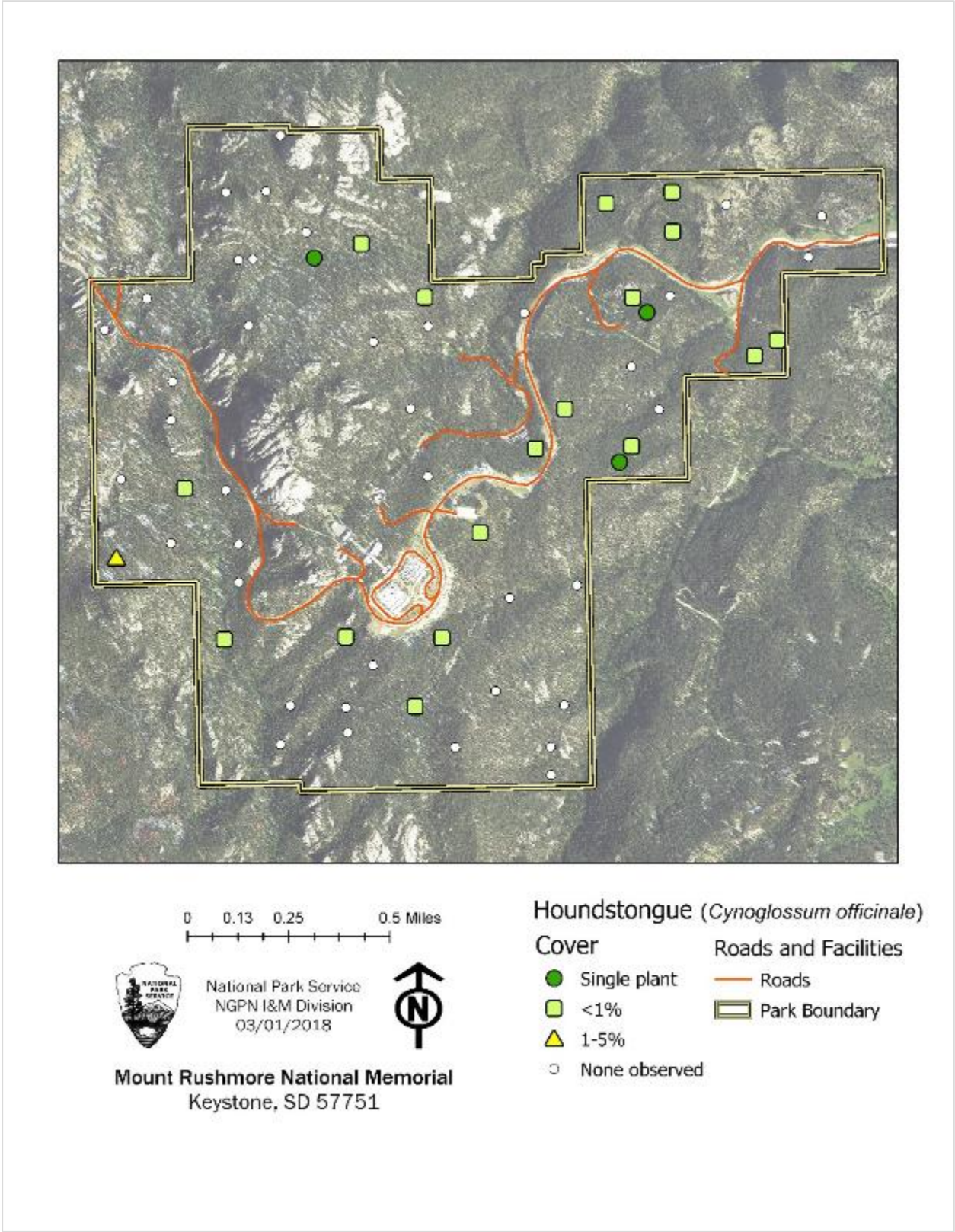

Figure D-5. Map showing the 2016 targeted observations of houndstoungue at Mount Rushmore National Monument.

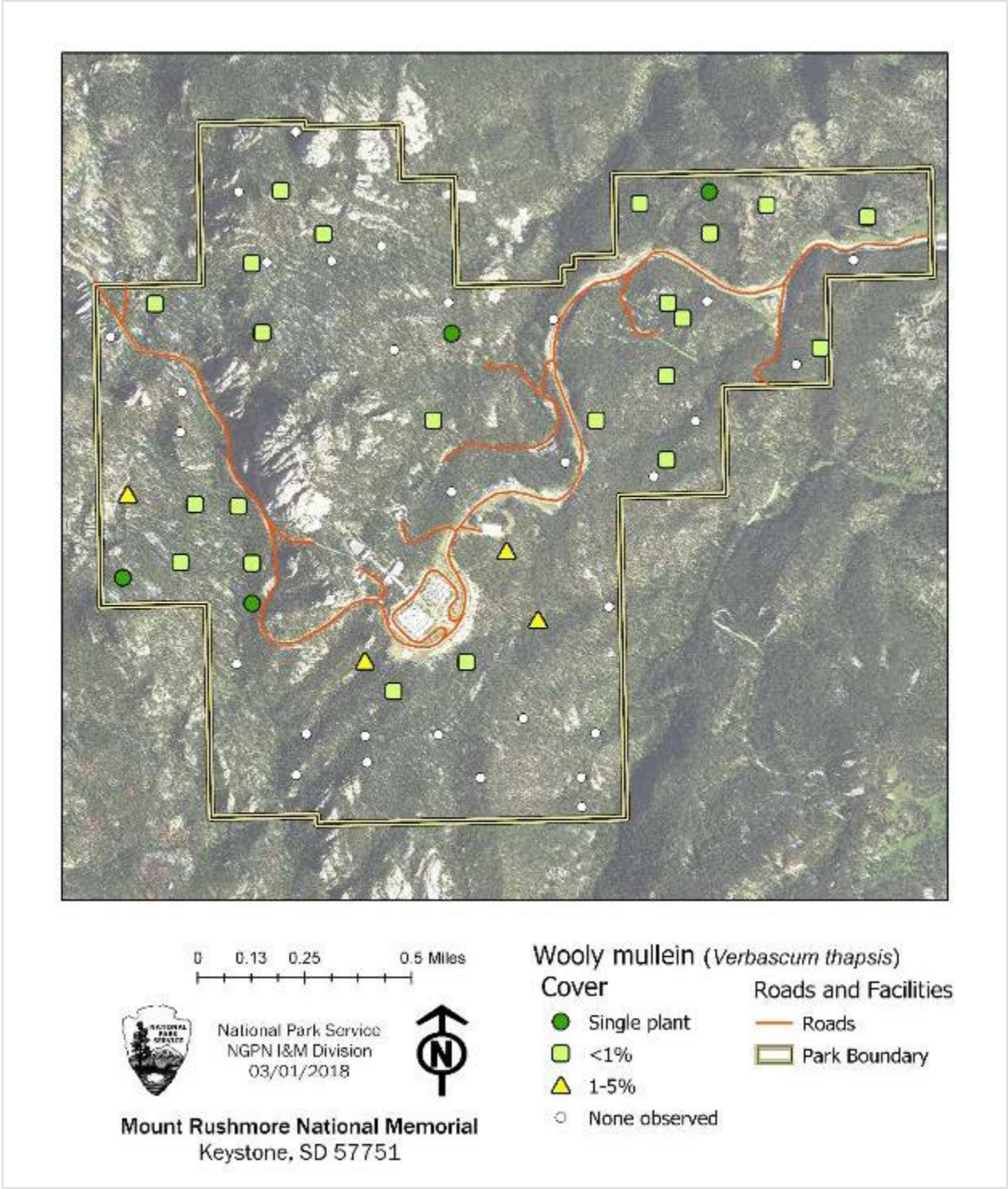

Figure D-6. Map showing the 2016 targeted observations of wooly mullein at Mount Rushmore National Monument.

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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