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Natural Resource Stewardship and Science

Plant Community Composition and Structure Monitoring for Jewel Cave National Monument

2016 Annual Report

Natural Resource Data Series NPS/NGPN/NRDS—2017/1100





ON THIS PAGE
View of landscape from long-term forest structure monitoring plot JECA_PCM_053 at Jewel Cave National Monument.
Photograph courtesy of the National Park Service.

ON THE COVER
Long-term monitoring plot JECA_PCM_018 at Jewel Cave National Monument.
Photograph courtesy of the National Park Service.

Plant Community Composition and Structure Monitoring at Jewel Cave National Monument

2016 Annual Report

Natural Resource Data Series NPS/NGPN/NRDS—2017/1100

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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. Data in this report were collected and analyzed using methods based on established, peer-reviewed protocols and were analyzed and interpreted within the guidelines of the protocols.

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Contents

Page

Figures....iii

Tables....iv

Abstract....v

Acknowledgments....v

Introduction....1

Methods....1

NGPN and NGPFire Monitoring Plots 2016....1

Plot Layout and Sampling....6

Data Management and Analysis....11

Results....13

Literature Cited....24

Figures

Page

Figure 1. Map of Jewel Cave National Monument (JECA) plant community monitoring (PCM) and fire plant community (FPCM) plots visited in 2016 by the Northern Great Plains Inventory & Monitoring Program (NGPN) and the Northern Great Plains Fire Effects Program (NGPFire). 5

Figure 2. Long-term monitoring plot layout used for sampling vegetation in Jewel Cave National Monument. 6

Figure 3. The Northern Great Plains Inventory & Monitoring vegetation crew used point-intercept (left and center panel), and 1m^2 quadrats (right panel) to document plant diversity and abundance. 7

Figure 4. Forest Structure monitoring plot layout used in 60 forested plots at Jewel Cave National Monument. 8

Tables

Page

Table 1. Field journal for vegetation and forest structure monitoring of plant community monitoring (PCM) and fire plant community monitoring (FPCM) plots at Jewel Cave National Monument (JECA) in 2016 2

Table 2. Exotic species surveyed for at Jewel Cave National Monument as part of the early detection and rapid response program within the Northern Great Plains Network. 8

Table 3. Exotic species surveyed for in Jewel Cave National Monument during forest structure surveys. 9

Table 4. Rare species that were surveyed for during the 2016 field season at Jewel Cave National Monument. 11

Table 5. Definitions of state and global species conservation status ranks 12

Table 6. List of all plant species identified in long-term plant community monitoring plots visited in 2016 at Jewel Cave National Monument (JECA) 13

Table 7. Number of plant species per plot, observed in nine plots at Jewel Cave National Monument in 2016 17

Table 8. Absolute and relative percent cover of exotic and native plants observed in nine plots at Jewel Cave National Monument (JECA) in 2016. (* Plot read by NGPFire.) 18

Table 9. List of exotic target species present in plots surveyed by NGPN and NGPFire at Jewel Cave National Monument in 2016 18

Table 10. Tree and tall shrub species data from 61 plots at Jewel Cave National Monument in 2016. 19

Table 11. Surface fuels summary for 61 plots at Jewel Cave National Monument in 2016. 20

Table 12. Disturbance types and occurrence in 60 plant community monitoring plots visited in 2016 at Jewel Cave National Monument. 23

Abstract

This report presents the results of vegetation and forest structure monitoring efforts in 2016 at Jewel Cave National Monument (JECA) by the Northern Great Plains Inventory and Monitoring Network (NGPN) and the Northern Great Plains Fire Effects (NGPFire) program.

During the sixth full year of field work, the NGPN field crew visited six long-term plant community monitoring (PCM) plots to collect data on the plant communities at JECA. Crews captured data relating to species richness, herb-layer height, native and non-native species abundance, ground cover, and site disturbance from each of these plots. Additionally, NGPN and NGPFire collaborated to visit an additional 54 plots, for a total of 60, to collect data relating to forest structure and health. In each of the 60 plots, crews also collected data relating to tree regeneration, tall shrub and tree density, and woody fuel load. The NGPFire crew collected additional data relating to herb-layer height, abundance of native and non-native species, ground cover, and target species data as part of their post-burn monitoring at three plots, two of which were included in the above-mentioned 60 plots. These collective efforts are part of long-term monitoring to help better understand the condition of the mixed-grass prairie and ponderosa pine woodlands within the boundaries of JECA.

Our 2016 findings can be summarized as follows: Monitoring crews identified 128 plant species in 61 monitoring plots visited at JECA. Of these species, 18 were exotic species with an average relative cover of approximately 12%. There were no targeted early-detection exotic species and no rare native species observed in any plot. Tree density, health, seedling regeneration, and woody fuel loads were observed at 61 plots. Seedlings were observed in 50 plots, and mature trees and poles were observed in 56 plots. Disturbances were observed in 60 plots, with fire (wildland and prescribed) being the most common.

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 JECA, especially Megan Bushur, Jenn White, Sam Wright. We also thank M. Bynum for assistance in the field. The 2016 NGPN vegetation field crew of C. Davis, S. Rockwood, W. Vogel, M. Davis, I. Ashton, L. Mickelson, L. LaFleur, and K. Rugg, with the assistance of the Northern Great Plains Fire Effects crew of D. Swanson, E. Watson, I. Muirhead, and C. Tomford, collected all the data included in this report.

Introduction

Jewel Cave National Monument (JECA) is located in the southwestern Black Hills of South Dakota. It was established in 1908 with the mission to preserve Jewel Cave through management of the surface and subsurface ecosystem, while providing opportunities for the pursuit of scientific interests and public enjoyment. While covering a relatively small area (516 ha, 1274 ac), JECA contains diverse native ponderosa forest and grassland communities (Marriot and Hartment 1986, Ashton et al. 2012a). In 2000 the Jasper Fire greatly impacted the park, moderately to severely burning seventy-five percent of the landscape and resulting in more than 50% of the trees in the park dying due to fire-injury (Lentile et al. 2005). Ninety-five percent of the monument was affected by this forest fire (NPS 2004), resulting in a patchwork of intact and entirely consumed ponderosa pine stands.

Long-term monitoring is essential to sound management in order to provide information on environmental quality and condition, benchmarks of ecological integrity, and early warning of declines in ecosystem health. The Northern Great Plains Inventory & Monitoring Program (NGPN) began two vegetation monitoring efforts in JECA in 2011: a program to monitor understory vegetation annually (Ashton et al. 2012a), and a large survey of forest condition that is repeated every five years (Ashton et al. 2012b). Vegetation monitoring protocols and plot locations were chosen to represent the entire park and to coordinate efforts with the Northern Great Plains Fire Ecology Program (NGPFire). This report is intended to provide a timely release of basic data sets and data summaries from sampling efforts in 61 plots at JECA in 2016.

Methods

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

NGPN and NGPFire Monitoring Plots 2016

The NGPN and NGPFire implemented a survey to monitor plant community structure and composition in JECA 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 JECA to install Plant Community Monitoring (PCM) plots. These 15 sites are organized into five panels containing three sites each. NGPN crews visit two panels (6 sites total) every year using a rotating sampling scheme, and after five years all 15 sites will have been visited twice. In 2016, NGPN crews visited six PCM sites (PCM Dual; Figure 1) in panel 1 and panel 5, during the third week of July (Table 1). Data from these randomly selected sites can be used to estimate condition of vegetation communities for the whole park and over time, can be used to discern trends in condition.

When a site was located within an active burn unit, NGPFire added additional visits based on a pre-burn, 1, 2, 5, and 10 year post-burn sampling schedule using the GRTS sampling schema, and establishing fire plant community monitoring (FPCM) plots. Post-burn monitoring by the NGPFire crew took place at three plots in early July: PCM_038, FPCM_102, and FPCM_134 (S-038, S-102, S-134; Table 1). Plot FPCM_102 was only visited for this post-burn monitoring, but FPCM_134 (S-134; Figure 1), was also visited as a forest structure plot (see description below).

Using the same GRTS sampling design, NGPN implemented a survey to monitor forest structure and fuel loads in JECA, with a final design including 60 randomly located sites (PCM Forest Structure; Figure 1). These sites are visited every five years, with the goal to report on the change in the condition of JECA forests over time. NGPN and NGPFire crews worked together in early fall to complete these 60 plots (Table 1). This was a replacement plot after the rejection of S-026, a site that was removed from the sample design after major highway construction project destroyed most of the plot.

Table 1. Field journal for vegetation and forest structure monitoring of plant community monitoring (PCM) and fire plant community monitoring (FPCM) plots at Jewel Cave National Monument (JECA) in 2016. A total of 61 plots were completed by Northern Great Plains Network Inventory & Monitoring (NGPN) and Northern Great Plains Fire (NGPFire) Ecology Program crews.

Plot Name	Date(s) Visited	Monitoring Type	Crew Notes
PCM_004	September 9	Forest Structure	NGPFire, 2 person crew
PCM_007	August 18	Forest Structure	NGPFire, 3 person crew
PCM_011	August 12	Forest Structure	NGPFire, 3 person crew
PCM_012	September 12	Forest Structure	NGPN and NGPFire, 3 person crew
PCM_013	July 19	Dual (Panel 5)	NGPN, 4 person crew
PCM_014	July 19	Dual (Panel 5)	NGPN, 4 person crew + M. Bynum and M. Bushur
PCM_015	July 18	Dual (Panel 5)	NGPN, 4 person crew
PCM_016	July 19	Dual (Panel 1)	NGPN, 4 person crew + M. Bynum and J. White
PCM_017	July 20	Dual (Panel 1)	NGPN, 4 person crew + S. Wright
PCM_018	July 18	Dual (Panel 1)	NGPN, 4 person crew
PCM_019	August 10	Forest Structure	NGPFire, 4 person crew
PCM_021	September 14	Forest Structure	NGPN, 3 person crew
PCM_023	August 18	Forest Structure	NGPFire, 3 person crew
PCM_024	September 12	Forest Structure	NGPN, 2 person crew
PCM_025	September 13	Forest Structure	NGPN, 3 person crew
PCM_027	August 16	Forest Structure	NGPFire, 3 person crew
PCM_028	September 12	Forest Structure	NGPN, 2 person crew
PCM_029	September 12	Forest Structure	NGPN and NGPFire, 3 person crew
PCM_030	August 4	Forest Structure	NGPFire, 4 person crew
PCM_031	September 14	Forest Structure	NGPN, 3 person crew
PCM_032	September 9	Forest Structure	NGPFire, 2 person crew

Table 1 (continued). Field journal for vegetation and forest structure monitoring of plant community monitoring (PCM) and fire plant community monitoring (FPCM) plots at Jewel Cave National Monument (JECA) in 2016. A total of 61 plots were completed by Northern Great Plains Network Inventory & Monitoring (NGPN) and Northern Great Plains Fire (NGPFire) Ecology Program crews.

Plot Name	Date(s) Visited	Monitoring Type	Crew Notes
PCM_033	August 10	Forest Structure	NGPFire, 4 person crew
PCM_035	August 4	Forest Structure	NGPFire, 4 person crew
PCM_036	August 3	Forest Structure	NGPFire, 3 person crew
PCM_037	September 12	Forest Structure	NGPN and NGPFire, 3 person crew
PCM_038	July 5	Post-Burn	NGPFire, 3 person crew
	September 14	Forest Structure	NGPN, 3 person crew
PCM_039	July 24	Forest Structure	NGPFire, 3 person crew
PCM_040	September 13	Forest Structure	NGPN, 3 person crew
PCM_041	September 12	Forest Structure	NGPN and NGPFire, 3 person crew
PCM_042	August 11	Forest Structure	NGPFire, 3 person crew
PCM_043	August 11	Forest Structure	NGPFire, 3 person crew
PCM_044	September 15	Forest Structure	NGPN, 3 person crew
PCM_045	September 13	Forest Structure	NGPN, 3 person crew
PCM_046	August 4	Forest Structure	NGPFire, 4 person crew
PCM_047	August 10	Forest Structure	NGPFire, 4 person crew
PCM_048	September 15	Forest Structure	NGPN, 3 person crew
PCM_049	September 14	Forest Structure	NGPN, 3 person crew
PCM_050	August 8	Forest Structure	NGPFire, 4 person crew
PCM_051	August 4	Forest Structure	NGPFire, 4 person crew
PCM_052	August 3	Forest Structure	NGPFire, 3 person crew
PCM_053	September 14	Forest Structure	NGPN, 3 person crew
PCM_054	September 13	Forest Structure	NGPN, 3 person crew
PCM_055	August 12	Forest Structure	NGPFire, 3 person crew
PCM_056	September 12	Forest Structure	NGPN and NGPFire, 3 person crew
PCM_057	September 12	Forest Structure	NGPN and NGPFire, 3 person crew
PCM_058	August 12	Forest Structure	NGPFire, 3 person crew
PCM_059	August 16	Forest Structure	NGPFire, 3 person crew
PCM_060	September 15	Forest Structure	NGPN, 3 person crew
PCM_061	September 20	Forest Structure	NGPN, 4 person crew
PCM_062	July 24	Forest Structure	NGPFire, 3 person crew
PCM_063	August 31	Forest Structure	NGPFire, 2 person crew
PCM_064	September 13	Forest Structure	NGPN, 3 person crew
PCM_065	August 8	Forest Structure	NGPFire, 4 person crew
PCM_066	September 13	Forest Structure	NGPN, 3 person crew
PCM_067	July 24	Forest Structure	NGPFire, 3 person crew

Table 1 (continued). Field journal for vegetation and forest structure monitoring of plant community monitoring (PCM) and fire plant community monitoring (FPCM) plots at Jewel Cave National Monument (JECA) in 2016. A total of 61 plots were completed by Northern Great Plains Network Inventory & Monitoring (NGPN) and Northern Great Plains Fire (NGPFire) Ecology Program crews.

Plot Name	Date(s) Visited	Monitoring Type	Crew Notes
PCM_068	August 3	Forest Structure	NGPFire, 3 person crew
PCM_069	September 14	Forest Structure	NGPN, 3 person crew
PCM_070	September 13	Forest Structure	NGPN, 3 person crew
PCM_071	August 4	Forest Structure	NGPFire, 4 person crew
FPCM_102	July 5	Post-Burn	NGPFire, 3 person crew
FPCM_134	July 5	Post-Burn	NGPFire, 3 person crew
	September 13	Forest Structure	NGPN, 3 person crew

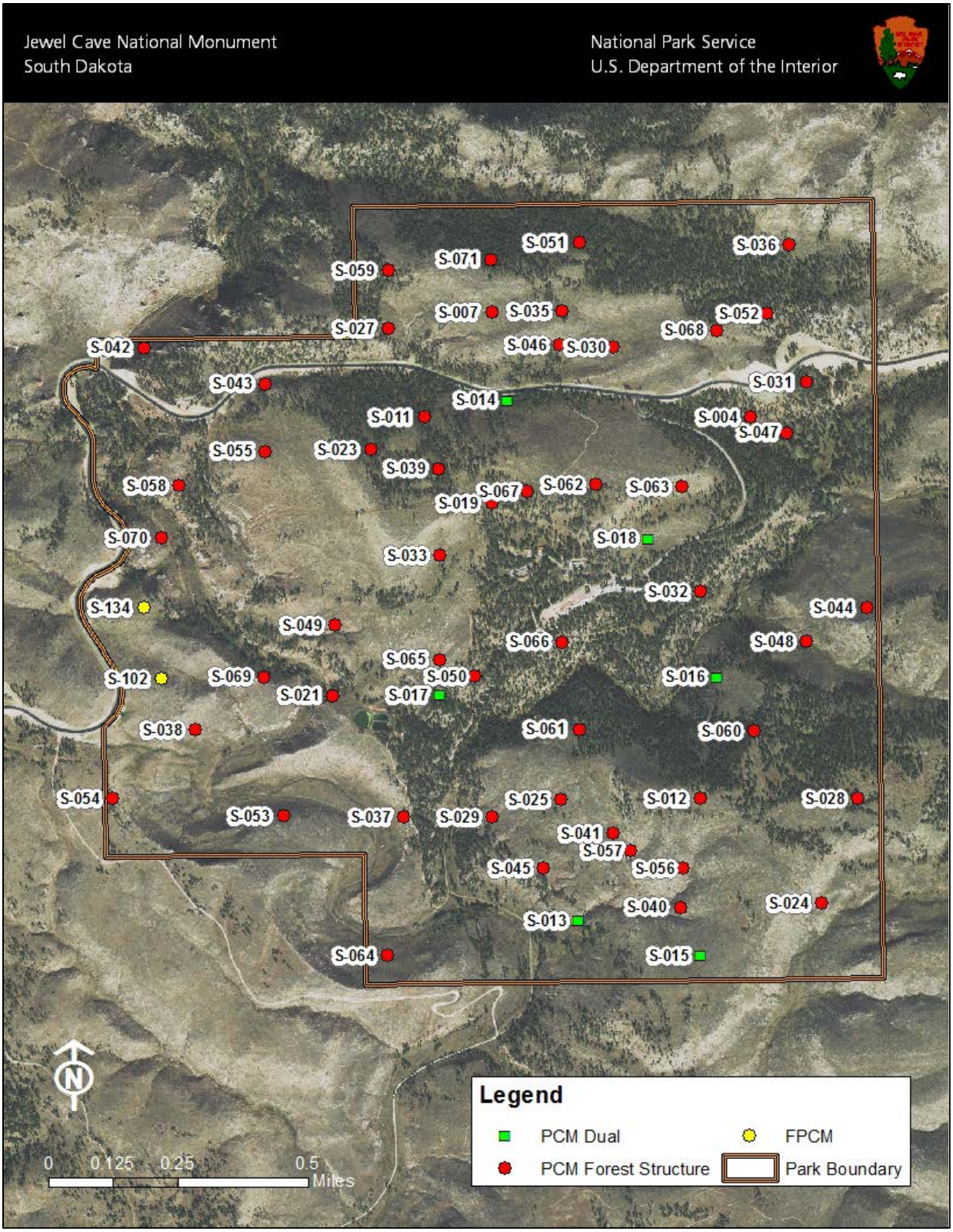


Figure 1. Map of Jewel Cave National Monument (JECA) plant community monitoring (PCM) and fire plant community (FPCM) plots visited in 2016 by the Northern Great Plains Inventory & Monitoring Program (NGPN) and the Northern Great Plains Fire Effects Program (NGPFire).

Plot Layout and Sampling

At each of the six vegetation composition monitoring sites, NGPN teams recorded plant species cover and frequency in a rectangular, 50 m x 20 m (0.1 ha), permanent plot (Figure 2). Data on ground cover, herb-layer height (≤ 2 m), and plant cover were collected along two 50 m transects (the long sides of the plot) using a point-intercept method (Figure 3). At 50 locations along each transect, once every meter, 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 tallest/first plant intercepted (Figure 3). Species richness data from the point-intercept method were supplemented with species presence data collected from five (1 m^2) quadrats located systematically along each transect (Figure 2). At the three vegetation monitoring plots visited by NGPFire, only point-intercept data were collected when plant species cover data was necessary.

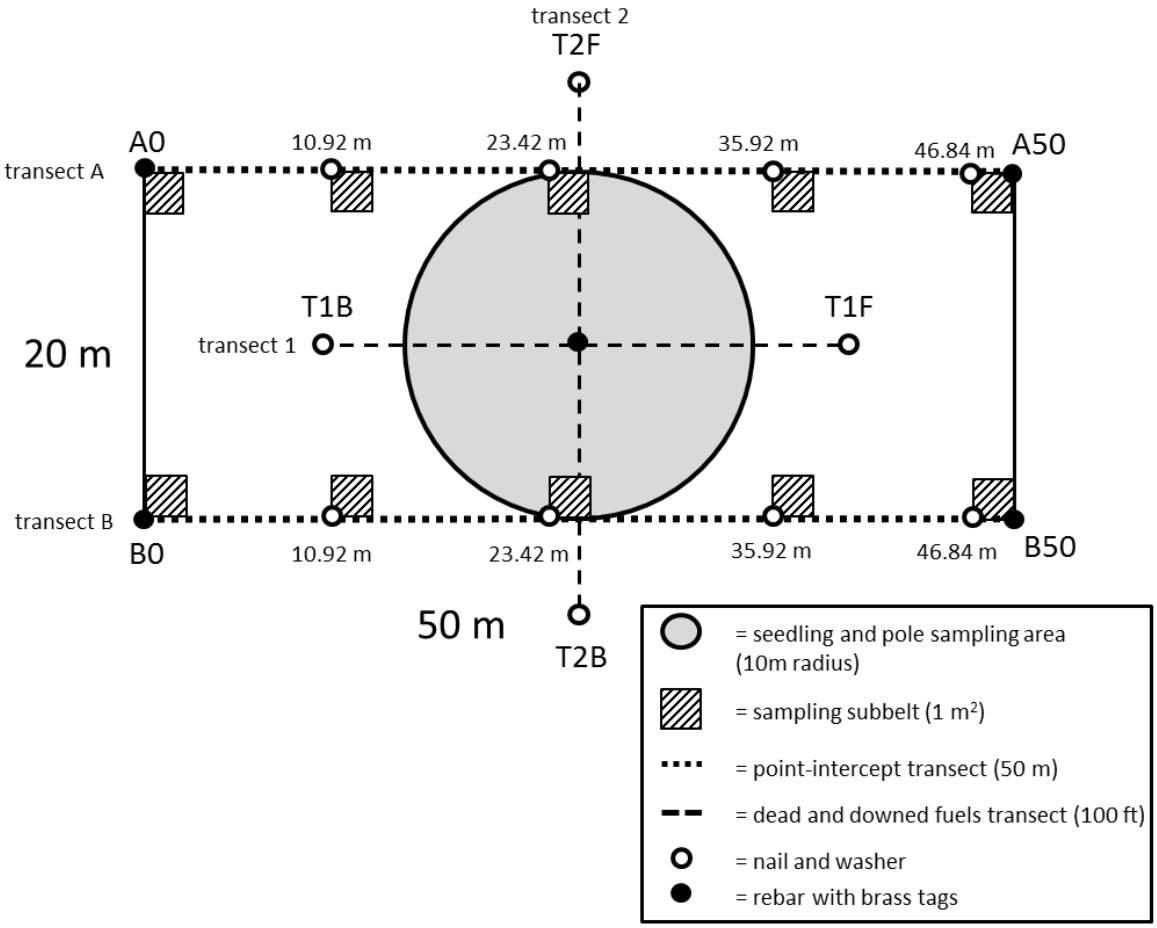


Figure 2. Long-term monitoring plot layout used for sampling vegetation in Jewel Cave National Monument.

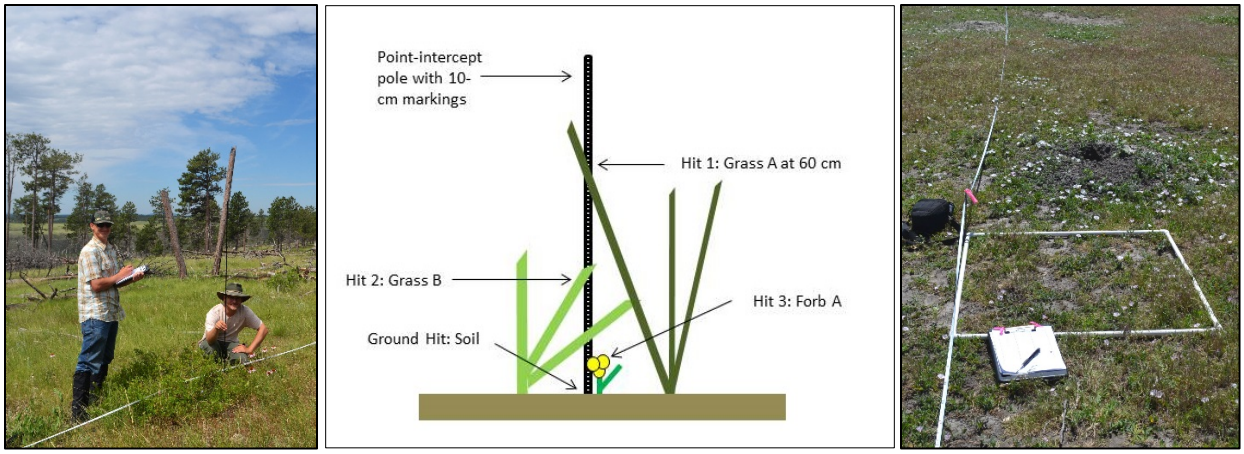


Figure 3. The Northern Great Plains Inventory & Monitoring vegetation crew used point-intercept (left and center panel), and 1m^2 quadrats (right panel) to document plant diversity and abundance.

When woody species were also present, tree regeneration and tall shrub density data were collected within a 10 m radius subplot centered in the larger 50 m x 20 m plot (Figure 2). Trees with diameter at breast height (DBH, 137 cm from ground level) > 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-damage, etc.) were recorded. Tree and targeted tall shrub species with DBH< 2.54 cm (seedlings) were tallied by species. For all poles species (2.54 cm ≤ DBH ≤ 15 cm), DBH, and status were recorded. Dead and downed woody fuel load data were also collected at these forested plots along two perpendicular, 100 foot (30.49 m) transects with midpoints at the center of the plot (Figure 2), following Brown's Line methods (Brown 1974, Brown et al. 1982). Both NGPN and NGPFire crews collected woody species data in six PCM plots and one FPCM plot.

To increase the number of forested plots and our understanding of the forest condition at JECA, NGPN and NGPFire completed a forest structure monitoring survey 60 sites, which includes the six vegetation monitoring plots (Figure 1). For the 54 sites not included in regular monitoring, seedlings and poles were measured as described above, but trees (DBH >15cm) were not tagged and only measured within the 10 m radius subplot. If there were fewer than 5 trees and poles observed of all species combined within the 10 m radius plot, the plot size was extended to 20 m radius (Figure 4) and all trees (DBH > 15 cm) within the larger area were measured. Dead and downed woody fuel load data were also collected at these forested plots.

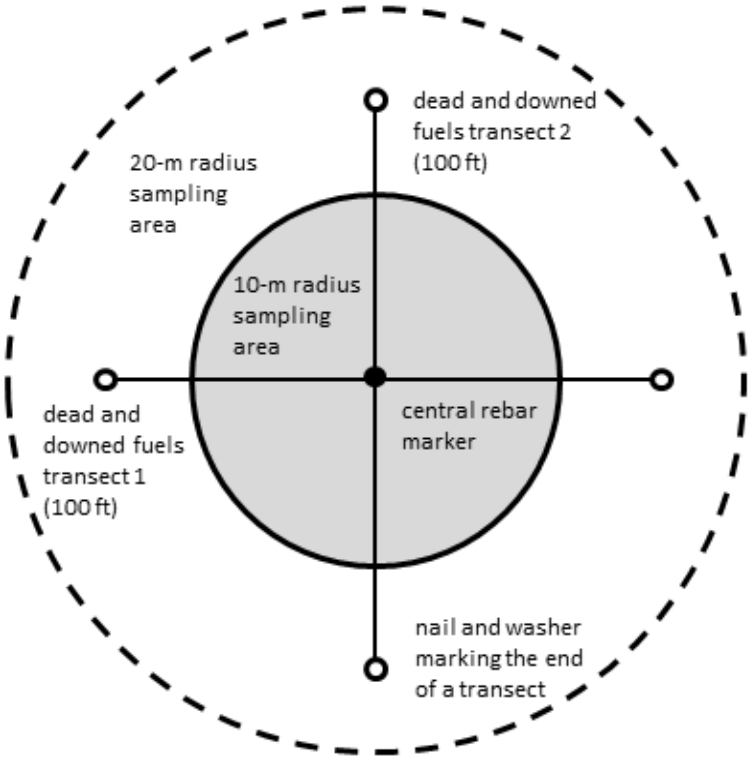


Figure 4. Forest Structure monitoring plot layout used in 60 forested plots at Jewel Cave National Monument.

At each PCM plot visited by NGPN, common disturbances and target species of interest were also assessed and documented. Common disturbances included such things as animal trails, rodent mounds, and fire occurrence. For each disturbance type, the severity and approximate area (m^2) was recorded. Monitoring crews also surveyed the area for early-detection exotic species that have the potential to spread into the park and cause significant ecological impacts (Table 2). These species were chosen in collaboration with the Midwest Invasive Plant Network, the Exotic Plant Management Team, park managers, and local weed experts. In addition, all plots were thoroughly surveyed for more common exotic species of management concern in JECA (Table 3). Crews also surveyed for plant species considered rare or vulnerable to loss in South Dakota, and may potentially occur in JECA (Table 4). 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.

Table 2. Exotic species surveyed for at Jewel Cave National Monument as part of the early detection and rapid response program within the Northern Great Plains Network.

Scientific Name	Common Name	Habitat
Alliaria petiolata	garlic mustard	Riparian
Polygonum cuspidatum; P. sachalinense; P. x bohemicum	knotweeds	Riparian
Pueraria montana var. *lobata*	kudzu	Riparian
Iris pseudacorus	yellow iris	Riparian

Table 2 (continued). Exotic species surveyed for at Jewel Cave National Monument as part of the early detection and rapid response program within the Northern Great Plains Network.

Scientific Name	Common Name	Habitat
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

Table 3. Exotic species surveyed for in Jewel Cave National Monument during forest structure surveys.

Family	Scientific Name	Common Name
Apiaceae	*Heracleum mantegazzianum*	giant hogweed
Asteraceae	*Arctium minus*	common burdock
	Artemisia absinthium	absinth wormwood
	Carduus nutans	musk thistle
	Centaurea diffusa	diffuse knapweed
	Centaurea solstitialis	yellow star thistle
	Centaurea stoebe	spotted knapweed
	Centaurea virgata	squarrose knapweed
	Chondrilla juncea	rush skeletonweed
	Cirsium arvense	Canada thistle
	Cirsium vulgare	bull thistle
	Hieracium aurantiacum	orange hawkweed
	Hieracium caespitosum	meadow hawkweed
	Onopordum acanthium	Scotch thistle
	Rhaponticum repens	Russian knapweed/hardheads
	Tanacetum vulgare	common tansy
Boraginaceae	*Cynoglossum officinale*	houndstongue

Table 3 (continued). Exotic species surveyed for in Jewel Cave National Monument during forest structure surveys.

Family	Scientific Name	Common Name
Brassicaceae	*Alliaria petiolata*	garlic mustard
	Isatis tinctoria	Dyer's woad
	Lepidium latifolium	perennial pepperweed
Caryophyllaceae	*Gypsophila paniculata*	baby's breath
Clusiaceae	*Hypericum perforatum*	common St Johnswort
Dipsacaceae	*Dipsacus fullonum*	Fuller's teasel
	Dipsacus laciniatus	common teasel
Eleagnaceae	*Elaeagnus angustifolia*	Russian olive
Euphorbiaceae	*Euphorbia cyparissias*	cypress spurge
	Euphorbia esula	leafy spurge
	Euphorbia myrsinites	myrtle spurge
Fabaceae	*Pueraria montana var. lobata*	kudzu
Iridaceae	*Iris pseudacorus*	yellow iris
Lamiaceae	*Salvia aethiopis*	Mediterranean sage
Poaceae	*Arundo donax*	giant reed
	Bromus inermis	smooth brome
	Bromus japonicus	Japanese brome
	Bromus tectorum	cheatgrass
	Taeniatherum caput-medusae	medusahead
	Ventenata dubia	African wiregrass
Polygonaceae	*Polygonum cuspidatum*	Japanese knotweed
	Polygonum sachalinense	giant knotweed
	Polygonum x bohemicum	Bohemian knotweed
Rhamnaceae	*Rhamnus cathartica*	common buckthorn
Scrophulariaceae	*Linaria dalmatica*	Dalmatian toadflax
	Linaria vulgaris	yellow toadflax
	Verbascum thapsus	common mullein
Simaroubaceae	*Ailanthus altissima*	tree of heaven
Solanaceae	*Hyoscyamus niger*	black henbane
Tamariaceae	*Tamarix ssp.*	salt cedar

Table 4. Rare species that were surveyed for during the 2016 field season at Jewel Cave National Monument.

Scientific Name	Common Name
Achnatherum robustum	sleepy grass
Boechara divaricarpa/ Boechara holboelli	limestone rockcress
Botrychium campestre	prairie moonwort
Botrychium lineare	narrowleaf grapefern
Botrychium lunaria	common moonwort
Erigeron ochroleucus	buff fleabane
Fritillaria atropurpurea	spotted mission bells
Lobelia spicata	palespike Lobelia
Oenothera flava	yellow evening primrose
Oenothera laciniata	cutleaf evening primrose
Physaria montana	mountain bladderpod
Platanthera stricta	slender bog orchid
Thelesperma megapotamicum	Hopi tea
Townsendia exscapa	Easter daisy
Townsendia hookeri	Hooker's Townsend daisy

Data Management and Analysis

FFI (FEAT/FIREMON Integrated; http://frames.gov/ffi/) was used as the primary software environment for managing the sampling data. This database is used by a variety of agencies (e.g., NPS, USDA Forest Service, U.S. Fish and Wildlife Service), has a national-level support system, and generally conforms to the Natural Resource Database Template standards established by the Inventory and Monitoring Program. Species scientific names, codes, and common names are from the USDA Plants Database (USDA-NRCS 2017). However, nomenclature follows the Integrated Taxonomic Information System (ITIS). 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. The conservation status ranks of plant species in South Dakota is determined by the South Dakota Natural Heritage Program (SDNHP). For the purpose of this report, a species was considered rare if its conservation status rank was S1, S2, or S3. See Table 5 for a detailed definition of each conservation status rank.

After data for the sites were entered, 100% of records were verified with the original data sheets to minimize transcription errors. A further 10% of records were reviewed a second time. After all data were entered and verified, automated queries were used to check for errors in the data. When errors were identified by the crew or the automated queries, changes were made to the original datasheets and the FFI database as needed. Data summaries were produced using the FFI reporting and query tools. Species diversity was measured by looking at species richness, which is simply a count of the species recorded in an area. Absolute cover was calculated from the point-intercept method, and is the total number of vegetation intercepts. This is often greater than 100% because more than one

species can be intercepted per point due to overlapping vegetation. Relative cover is then calculated by dividing the absolute cover by the total absolute cover of the grouping of interest (native and exotic species in this report), and is therefore constrained between 0 and 100%.

Table 5. Definitions of state and global species conservation status ranks.*

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

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

Results

There are 460 vascular plant species on the JECA species list, and monitoring crews identified 128 of these species in 2016 (Table 6). There were 18 exotic plant species observed, all of which were either forbs or graminoids (grasses, sedges, and rushes). All shrubs, subshrubs, and trees were native species. The 2016 species list was cross-checked with the South Dakota rare plant list, with no matches made, meaning there were no rare plants observed in any plot visited.

There were three species observed at JECA that aren't on the park species list: needleleaf sedge (*Carex duriuscula*), which has been confirmed by a botanist from the Wyoming Natural Diversity Database and is in the process of being added to the park list; lotus milkvetch (*Astragalus lotiflorus*), which is also not known to be in Custer County and will need to be vouchered for verification at the next plot visit; and rough false pennyroyal (*Hedeoma hispida*), which was the most likely to have been confused with the Drummond's false pennyroyal (*Hedeoma drummondii*) and misidentified, and will also need to be verified.

Table 6. List of all plant species identified in long-term plant community monitoring plots visited in 2016 at Jewel Cave National Monument (JECA). An "X" in the exotic column means that the species is not native to the park, or, in the case where only the genus was identified, there are some species within that genus that are exotic. No species that are rare in South Dakota were found in 2016.

Family	Symbol	Scientific Name	Common Name	Exotic	Rare
Anacardiaceae	RHTR	*Rhus trilobata*	skunkbush sumac		
	TORY	*Toxicodendron rydbergii*	western poison ivy		
Apiaceae	MUTE3	*Musineon tenuifolium*	slender wildparsley		
Apocynaceae	APAN2	*Apocynum androsaemifolium*	spreading dogbane		
Asclepiadaceae	ASPU	*Asclepias pumila*	plains milkweed		
Asteraceae	ACMI2	*Achillea millefolium*	common yarrow		
	AMPS	*Ambrosia psilostachya*	Cuman ragweed		
	ANTEN	*Antennaria spp.*	pussytoes		
	ANPA4	*Antennaria parvifolia*	small-leaf pussytoes		
	ARFR4	*Artemisia frigida*	prairie sagewort		
	ARLU	*Artemisia ludoviciana*	white sagebrush		
	CIAR4	*Cirsium arvense*	Canada thistle	X	
	CIUN	*Cirsium undulatum*	wavyleaf thistle		
	CIVU	*Cirsium vulgare*	bull thistle	X	
	DICA18	*Dieteria canescens*	hoary tansyaster		
	ECAN2	*Echinacea angustifolia*	blacksamson echinacea		
	ERSU2	*Erigeron subtrinervis*	threenerve fleabane		
	GRSQ	*Grindelia squarrosa*	curlycup gumweed		
	HEPA19	*Helianthus pauciflorus*	stiff sunflower		

* Species not on the certified species list.

Table 6 (continued). List of all plant species identified in long-term plant community monitoring plots visited in 2016 at Jewel Cave National Monument (JECA). An "X" in the exotic column means that the species is not native to the park, or, in the case where only the genus was identified, there are some species within that genus that are exotic. No species that are rare in South Dakota were found in 2016.

Family	Symbol	Scientific Name	Common Name	Exotic	Rare
Asteraceae (continued)	LASE	*Lactuca serriola*	prickly lettuce	X	
	LIPU	*Liatris punctata*	dotted blazing star		
	LYJU	*Lygodesmia juncea*	rush skeletonplant		
	MUOB99	*Mulgedium oblongifolium*	blue lettuce		
	RUHI2	*Rudbeckia hirta*	blackeyed Susan		
	SOLID	*Solidago spp.*	goldenrod		
	SOCA6	*Solidago canadensis*	Canada goldenrod		
	SOMI2	*Solidago missouriensis*	Missouri goldenrod		
	SOMO	*Solidago mollis*	velvety goldenrod		
	SONE	*Solidago nemoralis*	gray goldenrod		
	SORI2	*Solidago rigida*	stiff goldenrod		
	SYMPH4	*Symphyotrichum spp.*	aster		
	SYLA3	*Symphyotrichum laeve*	smooth blue aster		
	SYOB	*Symphyotrichum oblongifolium*	aromatic aster		
	TAOF	*Taraxacum officinale*	common dandelion	X	
	TRDU	*Tragopogon dubius*	yellow salsify	X	
Boraginaceae	CYOF	*Cynoglossum officinale*	gypsyflower	X	
	LIIN2	*Lithospermum incisum*	narrowleaf stoneseed		
	MELA3	*Mertensia lanceolata*	prairie bluebells		
	ONBE	*Onosmodium bejariense*	soft-hair marbleseed		
Brassicaceae	ARPY4	*Arabis pycnocarpa*	creamflower rockcress		
	THAR5	*Thlaspi arvense*	field pennycress	X	
Campanulaceae	CARO2	*Campanula rotundifolia*	bluebell bellflower		
Caprifoliaceae	SYOC	*Symphoricarpos occidentalis*	western snowberry		
Cupressaceae	JUSC2	*Juniperus scopulorum*	Rocky Mountain juniper		
Cyperaceae	CAREX	*Carex spp.*	sedge		
	CADU6*	*Carex duriuscula*	needleleaf sedge		
	CAFI	*Carex filifolia*	threadleaf sedge		
	CAIN9	*Carex inops*	long-stolon sedge		
	CARI	*Carex richardsonii*	Richardson's sedge		
	CARO5	*Carex rossii*	Ross' sedge		
Elaeagnaceae	SHCA	*Shepherdia canadensis*	russet buffaloberry		
Ericaceae	ARUV	*Arctostaphylos uva-ursi*	kinnikinnick		
Euphorbiaceae	EUES	*Euphorbia esula*	leafy spurge	X	

* Species not on the certified species list.

Table 6 (continued). List of all plant species identified in long-term plant community monitoring plots visited in 2016 at Jewel Cave National Monument (JECA). An “X” in the exotic column means that the species is not native to the park, or, in the case where only the genus was identified, there are some species within that genus that are exotic. No species that are rare in South Dakota were found in 2016.

Family	Symbol	Scientific Name	Common Name	Exotic	Rare
Fabaceae	ASAG2	*Astragalus agrestis*	purple milkvetch		
	ASFL2	*Astragalus flexuosus*	flexile milkvetch		
	ASGR3	*Astragalus gracilis*	slender milkvetch		
	ASLA27	*Astragalus laxmannii*	Laxmann's milkvetch		
	ASLO4*	*Astragalus lotiflorus*	lotus milkvetch		
	ASSP6	*Astragalus spatulatus*	tufted milkvetch		
	GLLE3	*Glycyrrhiza lepidota*	American licorice		
	LUAR3	*Lupinus argenteus*	silvery lupine		
	MELU	*Medicago lupulina*	black medick	X	
	OXCA4	*Oxytropis campestris*	field locoweed		
	OXSE	*Oxytropis sericea*	white locoweed		
	PEAR6	*Pediomelum argophyllum*	silverleaf Indian breadroot		
	PEES	*Pediomelum esculentum*	large Indian breadroot		
	VIAM	*Vicia americana*	American vetch		
Grossulariaceae	RIOX	*Ribes oxyacanthoides*	Canadian gooseberry		
Iridaceae	IRMI	*Iris missouriensis*	Rocky Mountain iris		
	SIMO2	*Sisyrinchium montanum*	strict blue-eyed grass		
Lamiaceae	HEHI*	*Hedeoma hispida*	rough false pennyroyal		
	MOFI	*Monarda fistulosa*	wild bergamot		
Liliaceae	ALCE2	*Allium cernuum*	nodding onion		
	MAST4	*Maianthemum stellatum*	starry false lily of the valley		
	TOVE2	*Toxicoscordion venenosum*	meadow deathcamas		
Linaceae	LICO3	*Linum compactum*	Wyoming flax		
	LILE3	*Linum lewisii*	Lewis flax		
Malvaceae	SPCO	*Sphaeralcea coccinea*	scarlet globemallow		
Onagraceae	OESU99	*Oenothera suffrutescens*	scarlet beeblossom		
Pinaceae	PIPO	*Pinus ponderosa*	ponderosa pine		
Poaceae	ACHY	*Achnatherum hymenoides*	Indian ricegrass		
	ACRI8	*Achnatherum richardsonii*	Richardson's needlegrass		
	ANGE	*Andropogon gerardii*	big bluestem		
	BOCU	*Bouteloua curtipendula*	sideoats grama		
	BRAN	*Bromus anomalus*	nodding brome		
	BRIN2	*Bromus inermis*	smooth brome	X	
	BRJA	*Bromus japonicus*	Japanese brome	X	
	BRTE	*Bromus tectorum*	cheatgrass	X	

* Species not on the certified species list.

Table 6 (continued). List of all plant species identified in long-term plant community monitoring plots visited in 2016 at Jewel Cave National Monument (JECA). An “X” in the exotic column means that the species is not native to the park, or, in the case where only the genus was identified, there are some species within that genus that are exotic. No species that are rare in South Dakota were found in 2016.

Family	Symbol	Scientific Name	Common Name	Exotic	Rare
Poaceae (continued)	DASP2	*Danthonia spicata*	poverty oatgrass		
	ELCA4	*Elymus canadensis*	Canada wildrye		
	ELEL5	*Elymus elymoides*	squirreltail		
	ELRE4	*Elymus repens*	quackgrass	X	
	ELTR7	*Elymus trachycaulus*	slender wheatgrass		
	HECO26	*Hesperostipa comata*	needle and thread		
	KOMA	*Koeleria macrantha*	prairie Junegrass		
	MUCU3	*Muhlenbergia cuspidata*	plains muhly		
	MURA	*Muhlenbergia racemosa*	marsh muhly		
	NAVI4	*Nassella viridula*	green needlegrass		
	PASM	*Pascopyrum smithii*	western wheatgrass		
	PIMI7	*Piptatherum micranthum*	littleseed ricegrass		
	POA	*Poa spp.*	bluegrass	X	
	POCO	*Poa compressa*	Canada bluegrass	X	
	POPR	*Poa pratensis*	Kentucky bluegrass	X	
	PSSP6	*Pseudoroegneria spicata*	bluebunch wheatgrass		
	SCSC	*Schizachyrium scoparium*	little bluestem		
	SPHE	*Sporobolus heterolepis*	prairie dropseed		
Polemoniaceae	PHAL3	*Phlox alyssifolia*	alyssumleaf phlox		
	PHHO	*Phlox hoodii*	spiny phlox		
Ranunculaceae	ANCY	*Anemone cylindrica*	candle anemone		
	ANPA19	*Anemone patens*	eastern pasqueflower		
Rosaceae	AMAL2	*Amelanchier alnifolia*	Saskatoon serviceberry		
	FRVI	*Fragaria virginiana*	Virginia strawberry		
	PHMO4	*Physocarpus monogynus*	mountain ninebark		
	POPE8	*Potentilla pensylvanica*	Pennsylvania cinquefoil		
	PRVI	*Prunus virginiana*	chokecherry		
	ROAC	*Rosa acicularis*	prickly rose		
	ROAR3	*Rosa arkansana*	prairie rose		
	ROWO	*Rosa woodsii*	Woods' rose		
Rubiaceae	GABO2	*Galium boreale*	northern bedstraw		
	GATR3	*Galium triflorum*	fragrant bedstraw		
Salicaceae	POTR5	*Populus tremuloides*	quaking aspen		
Santalaceae	COUM	*Comandra umbellata*	bastard toadflax		
Saxifragaceae	HERI	*Heuchera richardsonii*	Richardson's alumroot		

* Species not on the certified species list.

Table 6 (continued). List of all plant species identified in long-term plant community monitoring plots visited in 2016 at Jewel Cave National Monument (JECA). An "X" in the exotic column means that the species is not native to the park, or, in the case where only the genus was identified, there are some species within that genus that are exotic. No species that are rare in South Dakota were found in 2016.

Family	Symbol	Scientific Name	Common Name	Exotic	Rare
Scrophulariaceae	VETH	*Verbascum thapsus*	common mullein	X	
Solanaceae	HYNI	*Hyoscyamus niger*	black henbane	X	
Unknown family	UNKFORB	*Unknown forb*	unknown forb		
Violaceae	VIOLA	*Viola spp.*	violet		
	VIAD	*Viola adunca*	hookedspur violet		

* Species not on the certified species list.

The total number of plant species observed in each plot was compiled using point-intercept, quadrat, woody species, and targets species data (Table 7). The plot with the greatest species diversity, with a total of 61 species identified, was PCM_014. This plot, located on the south side of the highway and just west of the visitor center entrance, tied with PCM_013 for the highest number of native species, with 50 species observed. In contrast, PCM_014 was also the plot with the greatest number of exotic species. Absolute and relative covers were calculated using point-intercept data in nine plots at (Table 8). Overall, the nine plots have a high relative cover of native plants, ranging from 69% to 95%. The two plots with the highest relative native cover were PCM_013 and PCM_015, with 95%. Plot PCM_013 also had the highest absolute native cover. The plot with both the highest absolute and relative cover of exotic plant species was FPCM_134.

Monitoring crews found a total of ten different common exotic species in the 61 forest structure plots surveyed (Table 9). The most commonly observed exotic target species were common mullein and Canada thistle, however the average cover was rarely more than one percent. Smooth brome had the highest average cover of 1-5%, the most coming from plots PCM_013 and PCM_070, with covers of 25-50% and greater than 50% respectively. Crews did not find any target exotic species in six of the visited plots.

Table 7. Number of plant species per plot, observed in nine plots at Jewel Cave National Monument in 2016. Data collected using point-intercept, quadrats, target species surveys, and woody species surveys. (* Plot read by NGPFire; quadrat method was not used to collect data.)

Plot Name	Number of Exotic Species	Number of Native Species	Total number of species
JECA_FPCM_102*	4	17	21
JECA_FPCM_134*	7	14	21
JECA_PCM_013	8	50	58
JECA_PCM_014	11	50	61
JECA_PCM_015	6	31	37
JECA_PCM_016	9	47	56

Table 7 (continued). Number of plant species per plot, observed in nine plots at Jewel Cave National Monument in 2016. Data collected using point-intercept, quadrats, target species surveys, and woody species surveys. (* Plot read by NGPFire; quadrat method was not used to collect data.)

Plot Name	Number of Exotic Species	Number of Native Species	Total number of species
JECA_PCM_017	5	36	41
JECA_PCM_018	5	28	33
JECA_PCM_038*	6	14	20

Table 8. Absolute and relative percent cover of exotic and native plants observed in nine plots at Jewel Cave National Monument (JECA) in 2016. (* Plot read by NGPFire.)

Plot Name	Exotic Absolute Cover	Native Absolute Cover	Total Absolute Cover	Exotic Relative % Cover	Native Relative % Cover
JECA_FPCM_102	2	16	18	11	89
JECA_FPCM_134	5	11	16	31	69
JECA_PCM_013	2	35	37	5	95
JECA_PCM_014	5	33	38	13	87
JECA_PCM_015	1	19	20	5	95
JECA_PCM_016	2	21	23	9	91
JECA_PCM_017	2	19	21	10	90
JECA_PCM_018	2	19	21	10	90
JECA_PCM_038	2	13	15	13	87

Table 9. List of exotic target species present in plots surveyed by NGPN and NGPFire at Jewel Cave National Monument in 2016. 61 plots were surveyed, and 6 plots contained no exotics species on the list. 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.

Scientific Name	Common Name	Number of Plots	Average Abundance Class
Bromus inermis	smooth brome	22	3
Bromus japonicus	Japanese brome	10	2
Bromus tectorum	cheatgrass	2	2
Cirsium arvense	Canada thistle	46	2
Cirsium vulgare	bull thistle	3	2
Cynoglossum officinale	houndstongue	14	2
Euphorbia esula	leafy spurge	5	2
Hyoscyamus niger	black henbane	3	2
Thlaspi arvense	field pennycress	1	2
Verbascum thapsus	common mullein	40	2

Tree and tall shrub species were surveyed in 61 plots at JECA. Two of the plots visited, PCM_038 and PCM_134, were visited twice. The first visit was made by NGPFire for post-burn data collection, and the crew did not use the full forest structure monitoring protocol. Therefore, only the woody data from the second visit was used for this report. In summary, five species of tree and tall shrubs were observed (Table 10). A total of 525 mature trees and 166 poles were measured. The largest tree was a live ponderosa pine measured at 57.6 cm DBH, located in PCM_016. Seedlings were observed in 50 of 61 plots, and in five of those plots no mature trees or poles were observed. Plot PCM_014 had the greatest seedling recruitment. Mature trees and poles were observed in 56 of 61 plots, ten of which had no seedling recruitment of any species. Five of the 61 plots surveyed had no trees or poles, even after the plot radius was extended from 10 m to 20 m. One plot, PCM_056, had no trees, poles, or seedlings. Twenty of the plots with trees had only dead standing trees and no live trees or poles, with live trees found in only 36 plots. The plot with the most trees, live or dead, was PCM_060, with 65 total individuals.

Surface fuels and dead and downed wood provide foraging habitat and refugia for small wildlife species, as well as substrate for mosses and fungi. Downed wood can also provide “nursery” logs for vascular plant establishment. However, when surface fuels are too abundant in a forest they can increase the risk of high intensity fires. NGPFire has developed a management target for surface fuels with a goal to maintain fuel loads between 2 and 10 tons per acre within the Black Hills parks. NGPN and NGPFire surveyed and measured surface fuels in 61 plots visited in JECA (Table 11).

Disturbances occurred in all 60 surveyed plant community monitoring plots at JECA visited by the NGPN and NGPFire monitoring crews in 2016 (Table 12). Disturbance data was not collected by NGPFire, for post-burn plot data collection, in plot PCM_102. The most common disturbance types observed were fire, due to the prevalence of wildfire and prescribed fire, and animal use. There was one plot, PCM_060, with signs of mountain pine beetle infestation on five dead ponderosa pine trees, though not observed on any living trees.

Table 10. Tree and tall shrub species data from 61 plots at Jewel Cave National Monument in 2016.

Species Name	Common Name	Number of plots with trees	Number of plots with poles	Number of plots with seedlings
Pinus ponderosa	ponderosa pine	56	21	36
Juniperus scopulorum	Rocky Mountain juniper	3	1	2
Amelanchier alnifolia	western serviceberry	-	-	39
Prunus virginiana	chokecherry	-	-	21
Populus tremuloides	quaking aspen	-	-	4
Total of All Species		56	22	50

Table 11. Surface fuels summary for 61 plots at Jewel Cave National Monument in 2016.

	Average Tons per Acre										Avg. Depth (in.)		
Macroplot	1-hr	10-hr	100-hr	1-100-hr	1000-hr sound	1000-hr rotten	1-1000-hr	Duff	Litter	Total	Duff	Litt	Total
JECA_FPCM_102	0.06	0.57	1.50	2.13	3.72	6.48	12.34	0.97	0.44	13.75	0.1	0.1	0.2
JECA_FPCM_134	0.00	0.14	3.63	3.77	0.34	2.25	6.36	7.66	0.88	14.90	0.4	0.2	0.7
JECA_PCM_004	0.04	1.25	0.00	1.29	7.20	0.00	8.49	1.32	0.46	10.27	0.1	0.1	0.2
JECA_PCM_007	0.00	0.14	3.64	3.78	4.05	18.80	26.63	3.87	0.52	31.02	0.2	0.1	0.4
JECA_PCM_011	0.10	1.93	2.93	4.96	12.70	18.38	36.05	4.75	0.62	41.42	0.3	0.2	0.4
JECA_PCM_012	0.00	0.00	0.73	0.73	1.72	1.36	3.80	5.81	1.00	10.61	0.3	0.3	0.6
JECA_PCM_013	0.00	0.82	4.39	5.20	4.36	1.08	10.65	4.23	2.00	16.87	0.2	0.5	0.7
JECA_PCM_014	0.04	0.82	2.19	3.04	13.53	2.40	18.97	9.15	2.38	30.50	0.5	0.6	1.1
JECA_PCM_015	0.16	1.63	2.92	4.72	11.03	9.63	25.38	1.14	1.18	27.70	0.1	0.3	0.4
JECA_PCM_016	0.12	1.69	10.52	12.34	2.78	24.00	39.12	5.99	2.42	47.52	0.3	0.6	0.9
JECA_PCM_017	0.08	0.69	2.18	2.95	11.06	0.00	14.00	6.95	4.11	25.07	0.4	1.0	1.4
JECA_PCM_018	0.00	0.98	5.20	6.18	15.05	1.16	22.39	0.00	0.92	23.31	0.0	0.2	0.2
JECA_PCM_019	0.08	0.82	2.18	3.08	1.45	1.78	6.30	1.76	0.54	8.60	0.1	0.1	0.2
JECA_PCM_021	0.02	1.19	0.00	1.21	0.38	2.67	4.27	6.34	1.92	12.52	0.4	0.5	0.8
JECA_PCM_023	0.06	1.49	0.73	2.28	12.20	17.01	31.49	4.58	0.70	36.77	0.3	0.2	0.4
JECA_PCM_024	0.10	1.90	10.22	12.22	4.44	12.26	28.92	0.79	1.54	31.25	0.0	0.4	0.4
JECA_PCM_025	0.00	0.54	4.40	4.94	7.37	12.34	24.66	3.79	1.52	29.96	0.2	0.4	0.6
JECA_PCM_027	0.24	3.34	12.00	15.58	0.59	8.86	25.02	7.04	0.52	32.58	0.4	0.1	0.5
JECA_PCM_028	0.00	0.81	2.18	3.00	0.43	0.00	3.43	6.51	3.11	13.06	0.4	0.8	1.2
JECA_PCM_029	0.00	0.68	2.19	2.87	3.00	10.08	15.95	2.38	1.40	19.73	0.1	0.4	0.5
JECA_PCM_030	0.06	1.49	5.82	7.37	20.20	11.33	38.90	0.88	0.36	40.14	0.1	0.1	0.1
JECA_PCM_031	0.06	0.28	1.48	1.82	1.17	0.00	3.00	14.08	2.08	19.16	0.8	0.5	1.3
JECA_PCM_032	0.02	0.14	0.00	0.16	8.29	0.93	9.38	1.58	0.72	11.68	0.1	0.2	0.3
JECA_PCM_033	0.00	0.27	2.19	2.46	25.10	8.39	35.95	0.53	0.04	36.52	0.0	0.0	0.0

Table 11 (continued). Surface fuels summary for 61 plots at Jewel Cave National Monument in 2016.

	Average Tons per Acre										Avg. Depth (in.)		
Macroplot	1-hr	10-hr	100-hr	1-100-hr	1000-hr sound	1000-hr rotten	1-1000-hr	Duff	Litter	Total	Duff	Litt	Total
JECA_PCM_035	0.00	0.54	1.45	1.99	12.54	50.33	64.86	3.87	1.26	69.99	0.2	0.3	0.5
JECA_PCM_036	0.02	1.66	2.97	4.66	6.92	2.95	14.52	3.35	0.68	18.55	0.2	0.2	0.4
JECA_PCM_037	0.00	0.00	1.45	1.45	7.91	2.37	11.73	0.00	0.16	11.89	0.0	0.0	0.0
JECA_PCM_038	0.00	0.00	0.73	0.73	0.74	0.64	2.11	4.14	0.42	6.66	0.2	0.1	0.3
JECA_PCM_039	0.08	0.68	0.00	0.76	3.37	0.00	4.13	3.52	0.86	8.51	0.2	0.2	0.4
JECA_PCM_040	0.06	1.69	5.92	7.67	5.50	11.57	24.74	2.90	1.80	29.44	0.2	0.5	0.6
JECA_PCM_041	0.00	1.10	2.96	4.05	6.15	11.96	22.16	15.05	2.62	39.83	0.9	0.7	1.5
JECA_PCM_042	0.04	0.77	3.19	4.01	10.66	16.82	31.49	2.29	0.12	33.90	0.1	0.0	0.2
JECA_PCM_043	0.00	0.55	4.49	5.04	15.86	25.33	46.23	2.82	0.46	49.50	0.2	0.1	0.3
JECA_PCM_044	0.18	2.54	8.94	11.67	7.43	11.36	30.46	8.98	0.64	40.07	0.5	0.2	0.7
JECA_PCM_045	0.08	0.81	4.36	5.26	3.01	33.49	41.76	11.80	1.32	54.87	0.7	0.3	1.0
JECA_PCM_046	0.00	0.68	3.70	4.38	10.45	18.15	32.98	6.60	1.08	40.66	0.4	0.3	0.6
JECA_PCM_047	0.04	0.41	0.73	1.17	12.80	0.00	13.97	1.67	0.82	16.46	0.1	0.2	0.3
JECA_PCM_048	0.16	0.68	8.92	9.76	1.12	5.10	15.99	8.01	0.82	24.82	0.5	0.2	0.7
JECA_PCM_049	0.04	0.96	4.48	5.48	2.37	12.40	20.24	1.06	1.86	23.16	0.1	0.5	0.5
JECA_PCM_050	0.00	0.57	0.00	0.57	1.74	0.45	2.76	0.26	0.76	3.78	0.0	0.2	0.2
JECA_PCM_051	0.26	3.41	4.38	8.05	84.50	8.92	101.47	11.80	0.64	113.90	0.7	0.2	0.8
JECA_PCM_052	0.08	1.09	1.49	2.66	2.46	4.02	9.13	8.01	1.66	18.80	0.5	0.4	0.9
JECA_PCM_053	0.02	0.82	6.57	7.41	9.51	1.29	18.20	5.81	0.26	24.27	0.3	0.1	0.4
JECA_PCM_054	0.00	0.41	1.47	1.88	1.13	0.00	3.01	0.00	0.40	3.41	0.0	0.1	0.1
JECA_PCM_055	0.08	1.09	2.18	3.34	13.24	26.63	43.22	1.94	0.50	45.65	0.1	0.1	0.2
JECA_PCM_056	0.06	1.94	7.44	9.44	2.42	9.96	21.82	0.70	0.24	22.77	0.0	0.1	0.1
JECA_PCM_057	0.00	0.00	0.00	0.00	0.47	0.00	0.47	0.00	0.22	0.69	0.0	0.1	0.1
JECA_PCM_058	0.24	1.23	6.55	8.02	7.02	13.43	28.47	1.41	0.14	30.02	0.1	0.0	0.1

Table 11 (continued). Surface fuels summary for 61 plots at Jewel Cave National Monument in 2016.

	Average Tons per Acre										Avg. Depth (in.)		
Macroplot	1-hr	10-hr	100-hr	1-100-hr	1000-hr sound	1000-hr rotten	1-1000-hr	Duff	Litter	Total	Duff	Litt	Total
JECA_PCM_059	0.14	1.08	4.36	5.58	4.96	36.90	47.43	3.61	0.40	51.44	0.2	0.1	0.3
JECA_PCM_060	0.00	1.64	1.45	3.09	1.48	0.66	5.23	7.48	2.84	15.54	0.4	0.7	1.1
JECA_PCM_061	0.18	1.22	3.65	5.06	5.95	3.39	14.39	11.27	3.09	28.75	0.6	0.8	1.4
JECA_PCM_062	0.00	0.14	0.00	0.14	3.37	10.80	14.30	1.32	0.44	16.06	0.1	0.1	0.2
JECA_PCM_063	0.00	0.43	1.53	1.96	8.75	0.00	10.71	0.79	0.32	11.82	0.0	0.1	0.1
JECA_PCM_064	0.00	0.41	5.86	6.27	0.94	9.24	16.45	6.34	2.56	25.35	0.4	0.6	1.0
JECA_PCM_065	0.00	0.81	5.12	5.94	5.90	13.92	25.76	0.18	0.46	26.39	0.0	0.1	0.1
JECA_PCM_066	0.06	0.46	1.63	2.15	0.27	0.00	2.41	0.62	1.48	4.51	0.0	0.4	0.4
JECA_PCM_067	0.28	0.55	2.19	3.02	17.49	4.26	24.76	2.20	0.70	27.66	0.1	0.2	0.3
JECA_PCM_068	0.12	0.69	2.24	3.05	1.83	3.68	8.56	1.06	0.58	10.19	0.1	0.1	0.2
JECA_PCM_069	0.10	2.07	5.11	7.28	3.23	9.84	20.35	5.11	1.72	27.17	0.3	0.4	0.7
JECA_PCM_070	0.04	0.14	5.08	5.26	16.87	6.48	28.61	2.64	1.04	32.29	0.2	0.3	0.4
JECA_PCM_071	0.12	1.76	0.00	1.88	2.18	1.78	5.84	8.80	2.06	16.70	0.5	0.5	1.0

Table 12. Disturbance types and occurrence in 60 plant community monitoring plots visited in 2016 at Jewel Cave National Monument.

Disturbance Category	Number of Plots
Fire	59
Wildfire	*56*
Prescribed Fire	*16*
Animal	17
Game Trail	*5*
Small Mammal (mounds)	*11*
Grazing	*4*
Wallow	*1*
Other	7
Road/ Trail	*3*
Human (trash, etc.)	*2*
Herbicide	*2*
Storm/ Wind Damage	*1*
Tree Removal	6
Logging	*3*
Thinning	*5*
Mountain Pine Beetle	1

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