



Vegetation Composition, Structure, and Soils Monitoring at Little Bighorn Battlefield National Monument

Data Report 2010-2014

Natural Resource Report NPS/ROMN/NRR—2016/1210



ON THE COVER

Photograph of field crew reading a cover plot at Little Bighorn Battlefield National Monument

Photograph courtesy of the National Park Service

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Executive Summary

Scientifically credible information on the current status and long-term trends of the composition, structure, and function of the forests and grasslands in Little Bighorn Battlefield National Monument (NM) is a key component for sound management. This report presents summary data and information from the Rocky Mountain Inventory and Monitoring (I&M) Network monitoring between 2010 and 2014. In 2006, the network began an effort to determine status and trends in upland vegetation structure, species composition, and soil condition in Little Bighorn Battlefield NM. After two pilot years, a set of 32 long-term sites were established in the park using a spatially-balanced probability survey design. A subset of these sites was visited each year to understand the condition of park upland vegetation and soils. This report is not an in-depth analysis of ecological condition or trend in condition. We focus on simple summaries of sample effort and a few select patterns in specific responses.

Key results include the following:

- The percent cover of grasses, forbs, and shrubs was generally at or above expected reference values compared to ecological site descriptions. High plant cover helps minimize runoff and erosion.
- Native species richness and cover was greater than richness and cover of exotic species, though there was a considerable presence of exotics. Over 20% of the plant taxa identified in Little Bighorn Battlefield NM were non-native. Common exotic species included cheatgrass (*Bromus tectorum*), Japanese/field brome (*Bromus japonicus*, *B. arvensis*), and Kentucky bluegrass (*Poa pratensis*). Network crews found very few species deemed noxious weeds by the state of Montana.
- Erosion potential was generally low because of high soil stability and low bare ground cover.
- Soil quality parameters were similar to values found by the U.S. Forest Service and the Natural Resources Conservation Service. We will continue to explore ways to determine the appropriate reference condition for soil metrics as we track soil quality over time.

Rocky Mountain Network upland vegetation and soils monitoring will help Little Bighorn Battlefield NM staff understand issues such as the impact of a changing climate on the park ecosystems, the response of soils to disturbance, and changes in native and non-native species composition. As we collect more data and conduct additional analyses, we will look for patterns and trends that might indicate a change in the ecological integrity of the park's vegetation and soils.

Introduction

Little Bighorn Battlefield National Monument (NM) is a 309.72 hectare (765.34 acre) park located within the boundaries of the Crow Indian Reservation in Montana. The site of the Battle of the Little Bighorn has been protected since 1879, three years after the battle. The Reno-Benteen Battlefield land has been protected since 1926. The land was transferred to the National Park Service in 1940 and was given its current name in 1991. The Little Bighorn River runs along the western boundary of the park. At 915-1000 m in elevation (3000-3400 ft.), the landscape is typical of a mixed-grass prairie grassland with woody and herbaceous vegetation in the ravines, riparian plants along the floodplains, and both tall and short grasses in the uplands. Changing climate, invasive species, development, and altered fire and grazing regimes influence vegetation and soils. Along with the goal of interpreting and preserving historic and cultural resources of the time surrounding the battle, Little Bighorn Battlefield NM aims to preserve and protect the natural resources of the park (NPS 2015).

Scientifically credible information on the current status and long-term trends of the composition, structure, and function of the uplands in Little Bighorn Battlefield NM is a key component for sound management. In 2006, the Rocky Mountain Inventory & Monitoring Network began an effort to determine status and trends in upland vegetation structure,

species composition, and soil condition in the park (Manier et al. 2011). This protocol directly addresses two high priority vital signs in the network's small parks -vegetation composition, structure, and soils and invasive/exotic plants - and is linked to three other vital signs: landscape dynamics, weather and climate, and wet and dry deposition (Britten et al. 2007). A set of 32 long-term sites were established in the park using a spatially-balanced probability survey design. A subset of these sites was visited each year to help understand the condition of the park's upland vegetation and soils.

This report presents a summary of results from vegetation composition, structure, and soils (VCSS) monitoring at Little Bighorn Battlefield NM from 2010-2014. We focus on simple summaries of sample effort and a few select patterns in specific responses. Future reports will include more detail and interpretation including park-scale estimates of condition, change in select responses and with sufficient samples, statistical estimates of trend. The pilot years of protocol development (2006-2008) are not included here because methods were still under development and some are not compatible with those used to collect data presented here. Data from the 2009 field season are summarized in Shorrock et al. (2010).

Methods

Manier et al. (2011) provides detailed descriptions of the field and analytical techniques used for VCSS monitoring in Little Bighorn Battlefield NM and other Rocky Mountain Network parks. The VCSS protocol used a probability (“random”) sampling design (Stevens and Olsen 2004) with 32 sample sites (Figure 1) within three ecological site and soil types that fall in areas loosely called “gullies” (19 sites) and “uplands” (13 sites). Though the Gulley2 site type has more shale in its soil than Gulley1, they are associated with the same ecological site description (USDA et al. 2013) and so, for this report, we have combined them to better compare with expected reference conditions. Note that the study was not designed to group the data in this way, and by combining groups we may be masking variability between Gulley1 and Gulley2.

The target resource sampled by the design was all terrestrial vegetation and soil, excluding areas in park-identified sensitive areas (e.g., cultural resources) or developed infrastructure. Ten sites were visited each year following a paneled structure that repeats every five years. A subset of two sites was re-visited every year to help estimate inter-annual variation. The design also included a large oversample to replace sites determined to be not sampleable or to validly expand the survey in the future. The study design was developed and field methods refined during three pilot years (2006-2008). During this time, plants were identified by their lifeform category, not to the species level, and data on woody stand composition were not collected. Field methods have been consistent from 2009 to present.

Field methods

Vegetation composition and structure

VCSS sites were sampled during peak vegetation phenology. Crew availability and consistency of timing from one year to the next caused some variation in the date of some sample events (Table 1).

Field crews measured vegetation composition using both transect and plot-based methods. Along three 36-meter transects radiating out from site center (Figure 2), crews used a point-intercept method to gather

cover information on canopy and surface features. At 0.5-m intervals, the data collector dropped a pin and recorded the presence of all species and surface types that touched the pin. These “hits” were later converted into percent cover. Transect sampling is a fairly objective method for estimating cover (Barbour et al. 1987) and can be used for larger areas. In addition to transect-based measures, crews collected data in ten 1-m² plots (Figure 2). At each plot, crews used ocular estimates to record absolute percent cover of each species’ canopy and surface feature (e.g., coarse gravel, litter). Estimating cover in small quadrats complements transect measurements by detecting lower cover species (Elzinga et al. 1998). At these same plots, crew members also documented frequency of each species in nested 0.01-m², 0.1-m², and 1-m² quadrats. During the first pilot years, vascular plants were not identified to the species level. Rather, they were identified by their lifeform group, such as forb, perennial graminoid, annual graminoid, etc. Beginning in 2009, all vascular plants were identified to the species level. Nomenclature for all vegetation data followed the Integrated Species Taxonomic Information System (www.itis.gov), which can be crosswalked to multiple other nomenclature schemata used in Montana. We assigned life and natural history attributes to each taxon (i.e., nativity and lifeform using the USDA Plants database (USDA, NRCS 2014) and the Colorado Natural Heritage Program provided an attribute table (Lemly and Gilligan 2013).

When trees were present, crews set up 3 woody plots, one at the end of each transect (Figure 2). Crews measured tree diameter, canopy position, crown condition, and presence of any pests or diseases on mature trees > 12.7 cm in diameter at breast height (DBH) and saplings between 2.5 and 12.6 cm DBH. Crews tallied the number of seedlings present by species in smaller subplots.

Table 1. Dates of vegetation composition, structure, and soils monitoring from 2010-2014.

Year	Date visited	Field crew	Sites visited
2010	June 7-12	Asebrook, Hintz, Shorrock, Driver	22, 23, 24, 25, 26, 27, 28, 32, 33, 34
2011	June 6-12	Asebrook, Hintz	33, 34, 36, 37, 38, 40, 43, 50, 1, 4
2012	June 4-8	Asebrook, Hintz	1, 4, 5, 6, 7, 8, 9, 10, 11, 12
2013	June 3-7	Asebrook, Hintz, Brunn, Miles	11, 12, 15, 16, 17, 18, 20, 21, 22, 23
2014	June 2-6	Asebrook, Hintz, Borgman	22, 23, 24, 25, 26, 27, 28, 32, 33, 34

Little Bighorn Battlefield National Monument

Vegetation and soil monitoring sites 2010-2014

National Park Service
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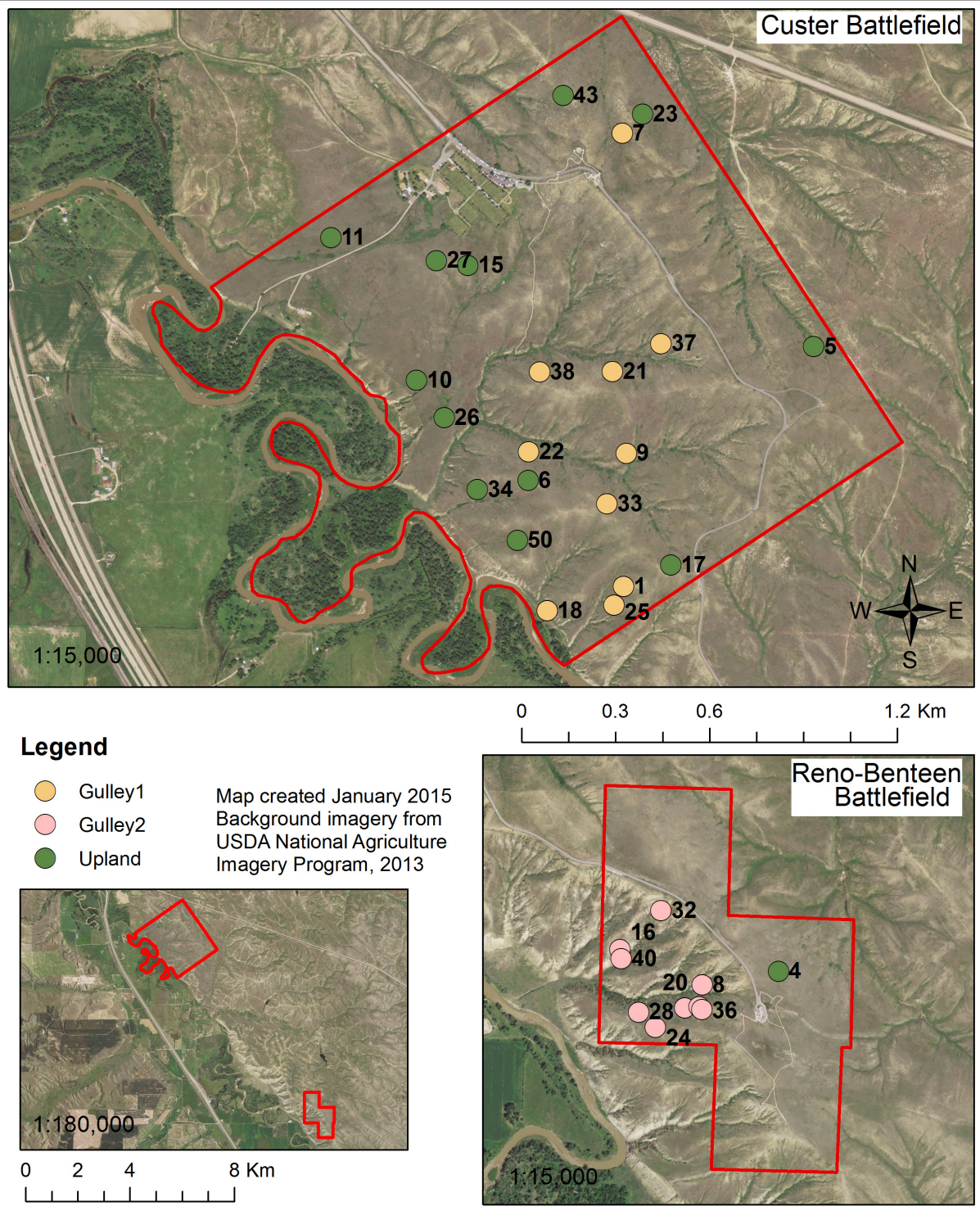


Figure 1. 32 Rocky Mountain Network vegetation composition, structure, and soils sites visited from 2010-2014 at Little Bighorn Battlefield National Monument in each design category. Gulley1 and 2 are combined for the purposes of this report, as they are both associated with the same ecological site type.

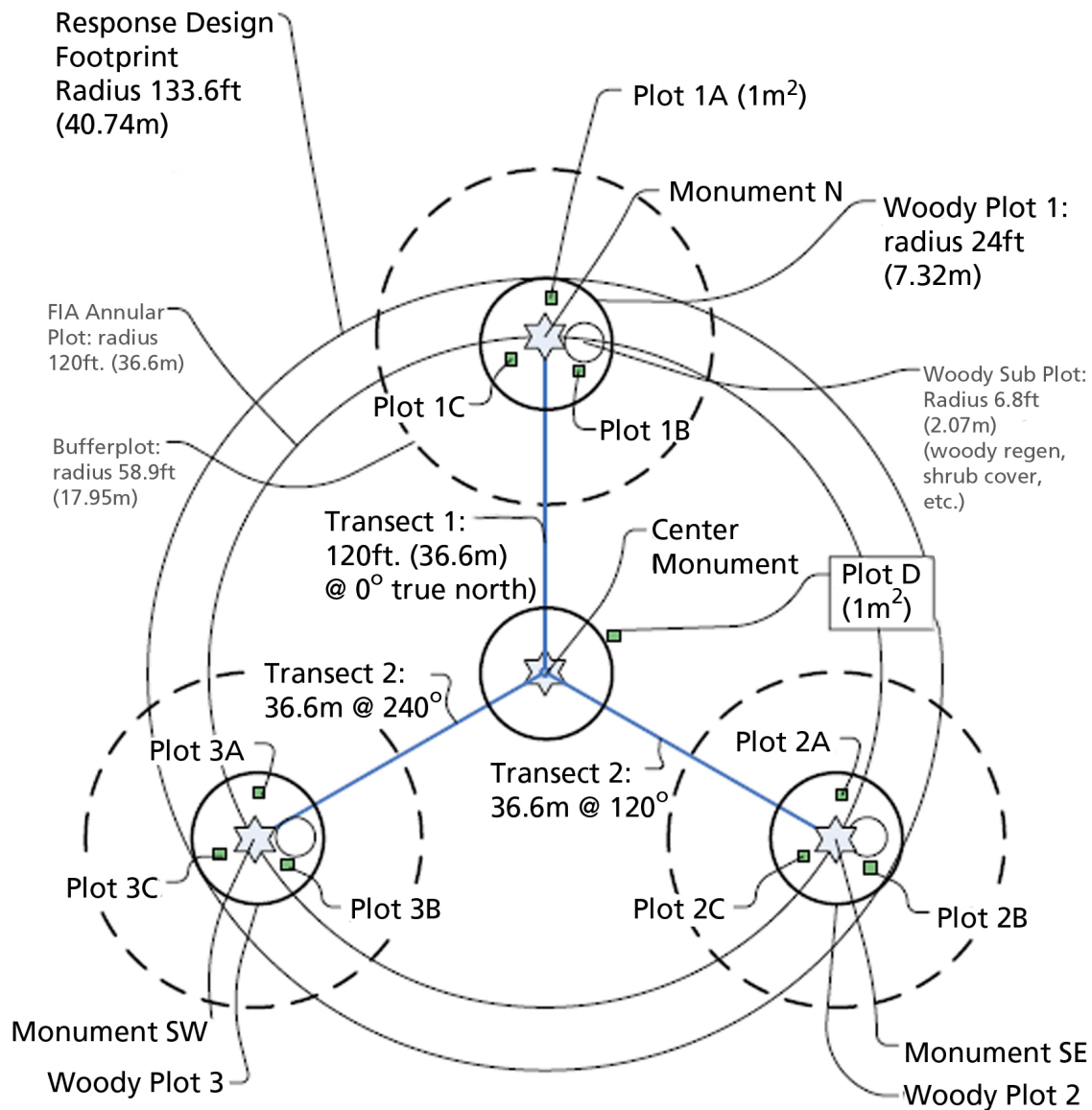


Figure 2. Rocky Mountain Network vegetation composition, structure, and soils (VCSS) site layout.

Soils

Collection of samples to estimate soil stability and susceptibility to erosion followed Herrick et al. (2005). Crews collected six surface and six subsurface soil samples from each of the three transects (36 total samples) and submerged each in water in a field soil kit. Samples were assigned a stability class score based upon the length of time the group of soil particles cohered to one another after immersion. At the site level, crews assessed rills and gullies, pedestals, and evidence of surface flow using ratings ranging from none to extreme.

Crews collected four soil samples along each transect (12 samples/site) for laboratory analyses during the first visit to a new site. Three samples were combined for chemistry analysis while the fourth sample was kept intact and used to measure bulk density. Soil characteristics measured included texture, pH, cation exchange capacity, soil organic matter content, total nitrogen and carbon content, and the concentration of mineral nutrients.

Soil samples were sent to the Soil, Water and Plant Testing Laboratory at Colorado State University at the close of each field season. The laboratory used

internal quality control standards that meet or exceed all standards required by Rocky Mountain Network for sample analyses.

Disturbance and Context

Crews observed and documented disturbance within and surrounding each site. Crew members rated the level of human-caused disturbance by observing features like distance to nearest road, presence of buildings, quality of vegetation cover in the buffer area surrounding the site, hydrological alterations, and physical disturbance. Crews also evaluated natural disturbance by observing signs of use and/or disturbance from natural processes (e.g., fire or disturbance from rodents). All metrics were later combined into a Human Disturbance Index (HDI) or Natural Disturbance Index (NDI) following a standardized set of algorithms using weighted values (modified from Rocchio 2007).

Finally, crews recorded features such as location (UTM coordinates), site description, dominant aspect, slope, topographic position, and hydrologic environment. Crews also photographed each site following set photo point procedures for future comparison of changes in vegetation structure and land use.

Data management

The goal of Rocky Mountain Network information management is to develop high-quality VCSS datasets according to standards established in the network Data and Information Management Plan and Standard Operation Procedures (NPS 2007). The data management system that supports the VCSS protocol ensured that all data collected and used in analysis and reporting were subject to quality control verification and validation processes to establish data integrity.

After all monitoring data were digitally compiled and reviewed, multiple quality assurance tools were used to verify the logical consistency of the data. The VCSS database was equipped with a user interface to execute error reports designed to identify missing data and data that are outside conditional ranges of variability. The protocol lead and the data management team collaborated to address each data issue.

All digital data acquired and derived were archived annually according to the procedures and standards in NPS National Data Management Plan and the network Data Management Plan, Rocky Mountain Network SOP: Archive Format Standards for Network

Data (NPS 2008; NPS 2007). These archives included monitoring data, data processed in the laboratory, field sheet scans, and photographs. During the spring of each year, the annual archive of these products was made available through the Integrated Resource Management Applications (IRMA) Portal (<https://irma.nps.gov/App/Reference/Profile/2204154>).

Analysis

The sample unit for most analyses was the site (i.e., all subsamples within a site were composited) with data summarized as a mean and its standard deviation across upland and gully sites (Figure 1). Plots were used to estimate species richness (the mean number of species per site) and the cover of exotic species. Transects were used to estimate lifeform abundance (e.g., relative cover of forbs), species level abundance (e.g., relative cover of *Bromus japonicus*), and frequency. For soil aggregate stability, the 18 surface and 18 sub-surface samples from each site were averaged to produce one estimate of stability per site.

A soil quality index (SQI; Amacher et al. 2007; Equation 1) from the U.S. Forest Service (USFS) was used to interpret Little Bighorn Battlefield NM soil chemistry data. The SQI combines index values for soil chemistry parameters into an overall indicator of soil quality. The original SQI included 19 parameters while the Rocky Mountain Network treatment only included 14. The index accounts for the fact that not all 19 parameters may be measured, so missing properties do not contribute to the index. Though it is not recommended to use this index if only a few measured properties are included (Amacher et al. 2007), this index was developed to account for several missing parameters, as is the case here. Each soil parameter was assigned an index value based on whether the level of each parameter was at, above, or below what was deemed ideal by expert opinion. For example, an optimal soil pH level between 5.51 and 7.2 would receive the highest possible index value while levels above or below that threshold would receive a lower index value. See Amacher et al. (2007) for a more detailed rationale for soil property threshold levels.

$$SQI = \frac{\sum \text{individual soil index values}}{\text{maximum index values possible for properties measured}} \times 100$$

Equation 1. The USFS soil quality index (SQI; Amacher et al. 2007).

Crews did not take soil samples in 2013 or 2014 and not all sites have been sampled. Given this missing data, the SQI was summarized across all sites (not by year and gulley or upland).

Assessment

While we minimize involved interpretation in this simple data report, where possible we qualitatively compare results to reference conditions within ecological site descriptions (ESD) developed by the Natural Resources Conservation Service. Little Bighorn Battlefield NM upland sites correspond to [ESD R058AE002MT](#), Clayey; park gulley sites correspond to [ESD R058AE199MT](#), Shallow Clay.

Finally, all results and their assessments in this report apply only to the specific sites sampled (or the mean of these sites). Future reports will include design-based methods that statistically infer responses at a site to the entirety of sampleable upland vegetation and soils at Little Bighorn Battlefield NM. Future reports will also include other metrics and more involved interpretation in the context of expected ecological reference conditions and resource management needs of the park.

Results

Vegetation composition and structure

Between 2010 and 2014, 183 vascular plant species (41 of which were non-native) were identified in all sites. Of these, 118 were herbaceous broad-leafed forbs, 30 were graminoids (grasses, sedges, and rushes), 7 were shrubs, 23 were woody subshrubs, 4 were trees/shrubs, and one was a vine (Appendix A).

Graminoids were on average the lifeform with the highest percent relative cover in both gullies and uplands with a mean relative cover across all years of 75.7% (standard deviation of 7.1) in gullies and 72.9% (7.9) in uplands. Shrubs and forbs were also present but usually with less than 25 percent cover (Table 2). Based on ecological site descriptions, the percent cover of forbs was above the expected range at both site types, cover of graminoids was within the expected range in uplands and above expected in gullies, and shrub cover was within the expected range for uplands and lower than expected for gullies (Table 2).

The most abundant species found at gulley sites across all years were *Pseudoroegneria spicata* (blue-bunch wheatgrass) with a mean cover of 24.8%

(11.7), *Pascopyrum smithii* (western wheatgrass) at 10.2% (6.2), and *Poa pratensis* (Kentucky bluegrass) at 9.5%(9.6). The most abundant species found in upland sites were *Pascopyrum smithii* at 16.9% (9.8), *Bromus japonicus* at 15.7% (13.6), and *Bromus tectorum* at 13.2% (11.7; Table 3).

Community composition between 2010 and 2014 included a mixture of native and exotic plants. Native species richness in gullies was 32.7 (9.6) and in uplands was 29.3 (4.7) across all years. Exotic species richness in gullies was 11.0 (2.4) and in uplands was 12.4 (2.5) across all years (Figure 3). Most sites contained more native than exotic plant species. The exotic species with the highest relative cover across all sites were *Bromus tectorum* (cheatgrass) with a mean cover of 9.74% (11.76), *Bromus japonicus* (Japanese/field brome) with a mean of 8.87% (7.94), and *Poa pratensis* (Kentucky bluegrass) with a mean of 6.73% (6.62; Figure 4). There were few exotics deemed noxious weeds by the state of Montana, including trace amounts of *Hypericum perforatum* (St. Johnswort) at site 27 and small amounts of *Convolvulus arvensis* (field bindweed) at sites 15 and 21.

Table 2. Mean relative cover (with standard deviation) of forbs, graminoids, and shrubs across all sites in uplands or gullies by year. Ecological site description (ESD) reference values are given for qualitative comparisons. Green indicates values are above expected, brown are values below expected, and black are values within expected range. There is no ESD reference condition for tree cover. Annual sample size is ~5. Each year has a set of unique sites.

Site	Expected or Actual (Year)	Percent cover by lifeform		
		Forb	Graminoid	Shrub
Uplands(Clayey) ESD# R058AE002MT	Expected based on ecological site description	5-10	55-85	1-5
	Actual (2010)	30.0 (5.9)	66.6 (3.7)	4.5 (3.4)
	Actual (2011)	34.4 (5.6)	64.9 (5.8)	0.7 (0.3)
	Actual (2012)	12.9 (1.4)	83.4 (3.5)	3.7 (3.6)
	Actual (2013)	20.6 (3.6)	75.5 (2.9)	3.9 (3.4)
	Actual (2014)	25.5 (4.2)	71.5 (3.7)	3.0 (3.0)
Gullies (Shallow Clay) ESD# R058AE199MT	Expected based on ecological site description	1-5	20-40	10-15
	Actual (2010)	19.9 (8.2)	73.9 (7.0)	6.3 (6.0)
	Actual (2011)	25.2 (8.4)	69.3 (7.7)	5.4 (7.6)
	Actual (2012)	13.2 (6.1)	80.8 (7.7)	5.9 (4.4)
	Actual (2013)	13.6 (4.3)	77.0 (3.6)	8.9 (3.9)
	Actual (2014)	16.4 (6.0)	78.4 (4.6)	5.2 (5.4)

Table 3. The five species with the highest mean relative cover found in transects for each site type and each year, 2010-2014. The mean frequency of each species is also shown. A standard deviation (SD) of "NA" indicates that species was found only at one site. Annual sample size is ~5. Each year has a set of unique sites.

Year	SiteType	Scientific name	Common name	Cover mean (%)	Cover SD (%)	Frequency mean (%)	Frequency SD (%)
2010	gully	<i>Pseudoroegneria spicata</i>	bluebunch wheatgrass	25.12	11.22	49.33	23.37
2010	gully	<i>Bromus japonicus</i> *	Japanese/field brome*	10.96	8.08	63.33	30.16
2010	gully	<i>Bromus tectorum</i> *	cheatgrass*	10.92	12.46	28.17	33.78
2010	gully	<i>Poa pratensis</i> *	Kentucky bluegrass*	10.25	9.53	28.33	25.22
2010	gully	<i>Pascopyrum smithii</i>	western wheatgrass	6.03	3.15	64.33	13.88
2010	upland	<i>Bromus japonicus</i> *	Japanese/field brome*	31.93	21.56	69.25	36.54
2010	upland	<i>Bromus tectorum</i> *	cheatgrass*	18.19	15.72	46.00	33.24
2010	upland	<i>Symphoricarpos occidentalis</i>	western snowberry	8.92	NA	23.00	NA
2010	upland	<i>Pseudoroegneria spicata</i>	bluebunch wheatgrass	8.34	8.14	44.00	21.69
2010	upland	<i>Pascopyrum smithii</i>	western wheatgrass	7.75	2.25	64.67	13.65
2011	gully	<i>Pseudoroegneria spicata</i>	bluebunch wheatgrass	25.98	16.65	53.33	21.95
2011	gully	<i>Symphoricarpos occidentalis</i>	western snowberry	15.02	NA	10.00	NA
2011	gully	<i>Poa pratensis</i> *	Kentucky bluegrass*	10.33	10.33	21.00	13.21
2011	gully	<i>Pascopyrum smithii</i>	western wheatgrass	10.25	6.52	61.50	14.10
2011	gully	<i>Bromus japonicus</i> *	Japanese/field brome*	8.22	5.83	79.50	12.36
2011	upland	<i>Pascopyrum smithii</i>	western wheatgrass	19.13	6.54	90.00	8.87
2011	upland	<i>Poa pratensis</i> *	Kentucky bluegrass*	15.50	3.98	33.50	19.09
2011	upland	<i>Pseudoroegneria spicata</i>	bluebunch wheatgrass	14.20	13.28	44.00	22.00
2011	upland	<i>Bromus tectorum</i> *	cheatgrass*	9.70	8.99	33.00	17.32
2011	upland	<i>Bromus japonicus</i> *	Japanese/field brome*	9.51	6.85	89.00	11.46
2012	gully	<i>Pseudoroegneria spicata</i>	bluebunch wheatgrass	17.75	14.58	42.80	23.34
2012	gully	<i>Bromus tectorum</i> *	cheatgrass*	13.05	7.53	45.00	24.21
2012	gully	<i>Pascopyrum smithii</i>	western wheatgrass	12.49	6.60	73.40	17.52
2012	gully	<i>Bromus japonicus</i> *	Japanese/field brome*	7.42	4.63	74.00	25.18
2012	gully	<i>Symphoricarpos occidentalis</i>	western snowberry	6.41	0.27	17.00	NA
2012	upland	<i>Poa pratensis</i> *	Kentucky bluegrass*	17.96	7.44	30.60	17.21
2012	upland	<i>Pascopyrum smithii</i>	western wheatgrass	17.75	8.85	73.20	17.37
2012	upland	<i>Pseudoroegneria spicata</i>	bluebunch wheatgrass	14.32	13.96	36.80	33.48
2012	upland	<i>Bromus japonicus</i> *	Japanese/field brome*	10.05	6.21	91.80	2.68
2012	upland	<i>Bromus tectorum</i> *	cheatgrass*	7.16	4.38	40.00	28.15

* Exotic species

Table 3. The five species with the highest mean relative cover found in transects for each site type and each year, 2010-2014. The mean frequency of each species is also shown. A standard deviation (SD) of "NA" indicates that species was found only at one site. Annual sample size is ~5. Each year has a set of unique sites, cont.

Year	SiteType	Scientific name	Common name	Cover mean (%)	Cover SD (%)	Frequency mean (%)	Frequency SD (%)
2013	gully	<i>Pseudoroegneria spicata</i>	bluebunch wheatgrass	24.57	8.71	49.00	13.80
2013	gully	<i>Poa pratensis</i> *	Kentucky bluegrass*	12.30	11.93	37.83	27.41
2013	gully	<i>Pascopyrum smithii</i>	western wheatgrass	11.66	8.98	57.33	14.79
2013	gully	<i>Symphoricarpos occidentalis</i>	western snowberry	6.57	2.20	12.67	9.07
2013	gully	<i>Sarcobatus vermiculatus</i>	greasewood	4.70	2.65	6.33	5.77
2013	upland	<i>Pascopyrum smithii</i>	western wheatgrass	17.96	12.10	76.75	11.03
2013	upland	<i>Pseudoroegneria spicata</i>	bluebunch wheatgrass	16.59	11.08	25.75	18.03
2013	upland	<i>Bromus tectorum</i> *	cheatgrass*	16.28	17.72	41.00	37.66
2013	upland	<i>Bromus japonicus</i> *	Japanese/field brome*	8.80	2.35	70.00	14.35
2013	upland	<i>Carex douglasii</i>	Douglas' sedge	8.69	4.99	46.50	9.19
2014	gully	<i>Pseudoroegneria spicata</i>	bluebunch wheatgrass	29.19	7.01	52.83	19.06
2014	gully	<i>Bromus tectorum</i> *	cheatgrass*	14.20	12.78	44.00	40.61
2014	gully	<i>Pascopyrum smithii</i>	western wheatgrass	10.72	4.10	75.00	21.00
2014	gully	<i>Poa pratensis</i> *	Kentucky bluegrass*	10.49	11.63	32.00	24.46
2014	gully	<i>Bromus japonicus</i> *	Japanese/field brome*	7.98	6.14	73.50	18.17
2014	upland	<i>Pascopyrum smithii</i>	western wheatgrass	21.83	13.67	82.50	11.15
2014	upland	<i>Bromus japonicus</i> *	Japanese/field brome*	19.84	10.68	85.75	12.84
2014	upland	<i>Bromus tectorum</i> *	cheatgrass*	14.67	11.81	60.33	15.28
2014	upland	<i>Pseudoroegneria spicata</i>	bluebunch wheatgrass	13.30	5.06	32.25	23.71
2014	upland	<i>Symphoricarpos occidentalis</i>	western snowberry	9.86	NA	20.00	NA

* Exotic species

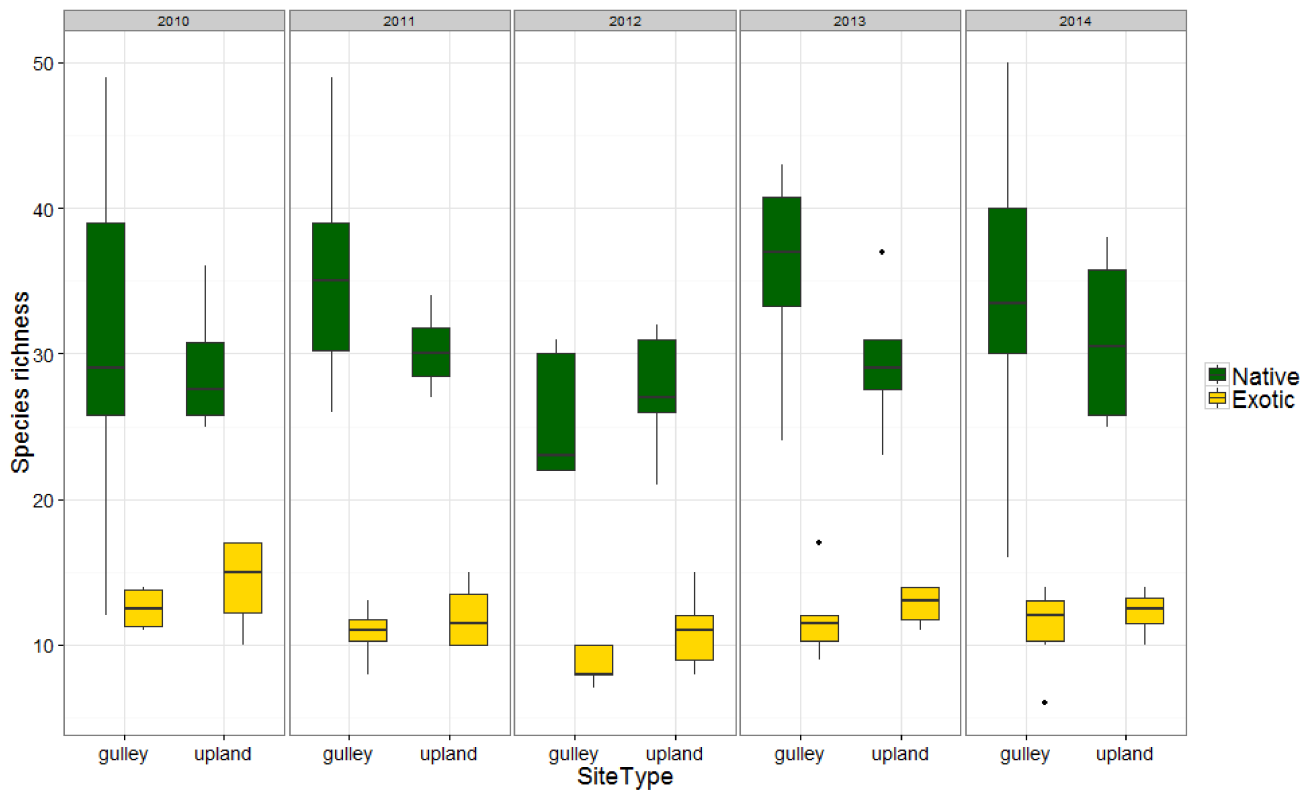


Figure 3. Native (green) and exotic (yellow) plant species richness by site type for each year, 2010-2014. Horizontal lines within each box represent the median; boxes extend to the upper 75th and lower 25th quartile. Vertical lines extend to the maximum and minimum observed values. Dots represent outliers. Annual sample size is ~5. Each year has a set of unique sites.

Little Bighorn Battlefield National Monument

Native and exotic plant cover, 2010-2014

National Park Service
U.S. Department of the Interior

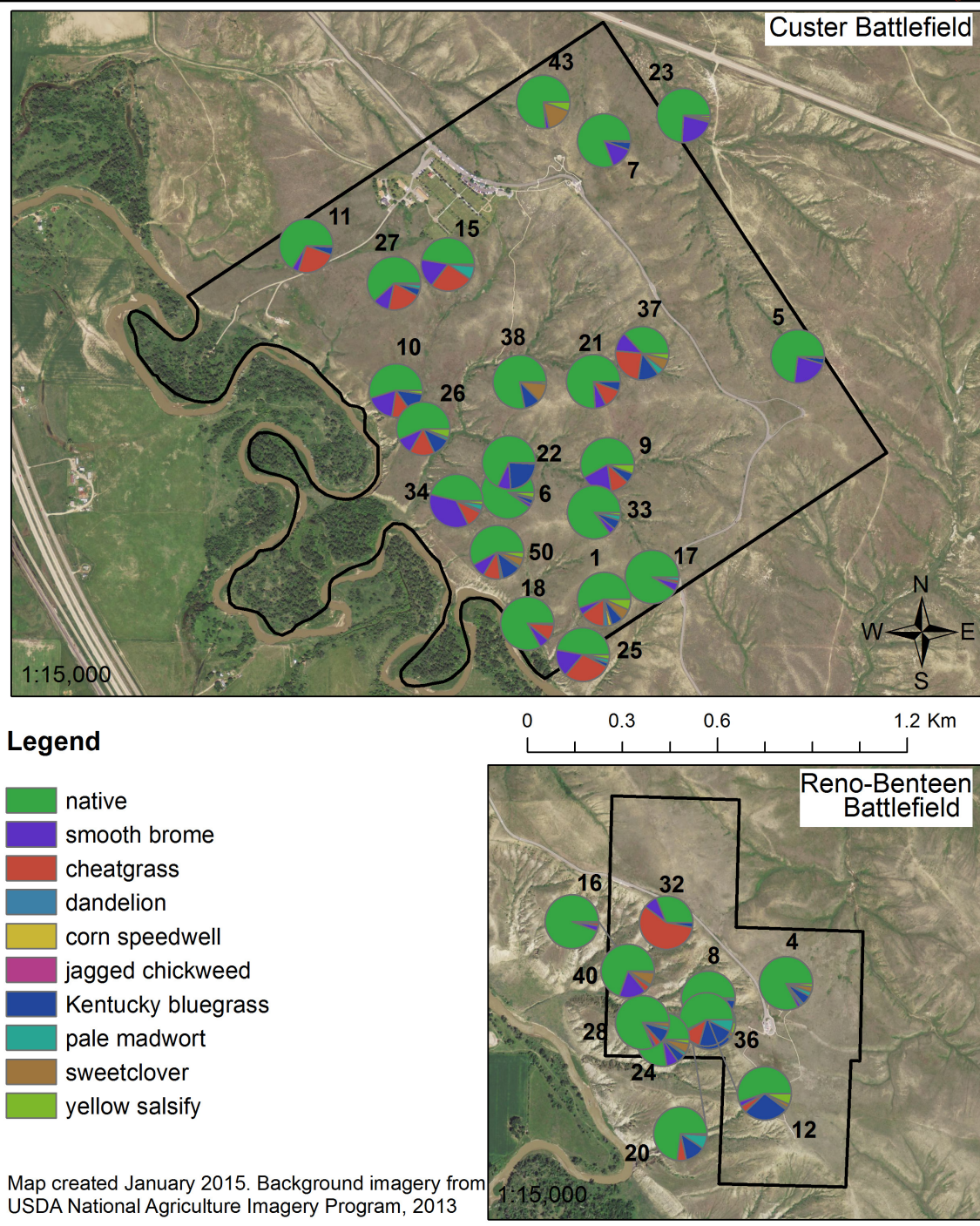


Figure 4. Relative cover of native species (green) and exotic species with relative covers over 1% (all other colors) at sampled sites 2010-2014. Site names appear above each circle in black text.

Woody species

A small number of *Juniperus scopulorum* (Rocky Mountain Juniper) were found in at least one site each field season (Table 4). All individuals were mature, with no seedlings or saplings found.

Anthropogenic and natural disturbance

Crews collected both natural and anthropogenic disturbance data each year. Each index produces one disturbance score for every site. Scores for both indices range from 0 to 100; lower scores signify less disturbance. Both HDI and NDI scores were low (Table 5).

Erosion potential and soil chemistry

Erosion potential is, in part, a function of soil aggregate stability (the ability of particles of soil to adhere to each other) and the percent cover of bare ground. We used modified methods from Herrick et al. (2005) to create a soil aggregate stability metric. The metric ranges from 1 to 6, with lower values indicating lower stability. Mean surface soil aggregate stability in gullies across all years was 4.84 (0.87) and in upland sites was 5.22 (0.61). Mean subsurface soil aggregate stability in gullies was 4.57 (0.81) and in upland sites was 4.55 (0.69; Table 6). The average cover of litter across all

Table 5. Values for the human disturbance index (HDI) and natural disturbance index (NDI) averaged across all sites for each year. Annual sample size is ~10. Each year has a set of unique sites.

Year	HDI		NDI	
	Mean	SD	Mean	SD
2010	14.0	3.2	3.9	3.4
2011	15.2	2.8	5.6	5.9
2012	22.5	10.5	5.7	4.3
2013	25.2	16.0	7.4	5.3
2014	14.5	3.2	8.2	6.0

years was higher than expected for uplands (83.7%) and gullies (72.5%; Table 7), based on ecological site descriptions. The mean cover of bare soil was in the expected range at upland sites (9.1%) while it was below expected at gulley sites (17.3%; Table 7).

Using the soil quality index developed by the USFS, the mean soil quality index at Little Bighorn Battlefield NM from 2010 and 2012 was 12 out of 21 possible points, or 57% (Table 8; Amacher et al. 2007). This index is a percentage, with lower values indicating lower soil quality.

Table 4. Mean (with standard deviation) number of living, number of dead, and live tree diameter of *Juniperus scopulorum* (Rocky Mountain Juniper), found at sites 2010-2014. Annual sample size is ~3 sites per year; a standard deviation of NA indicates only one site had trees. Each year has a set of unique sites.

Year	Tree species	# sites with living trees	# living	# sites with dead trees	# dead	Living diameter (cm)
2010	<i>Juniperus scopulorum</i>	1	8 (NA)	3	2 (1.7)	25.9 (NA)
2011	<i>Juniperus scopulorum</i>	1	6 (NA)	1	14 (NA)	67.7 (NA)
2012	<i>Juniperus scopulorum</i>	1	1 (NA)	1	6 (NA)	21.5 (NA)
2013	<i>Juniperus scopulorum</i>	3	2 (1.7)	1	6 (NA)	38.7 (21.3)
2014	<i>Juniperus scopulorum</i>	1	8 (NA)	3	2 (1.7)	25.1 (NA)

Table 6. Mean with standard deviation soil aggregate stability for surface and sub-surface soil samples for each year, 2010-2014. The index ranges from 1 to 6, with lower values indicating lower stability. Annual sample size is ~5. Each year has a set of unique sites.

Year	Site type	Surface stability		Sub-surface stability	
		Mean	SD	Mean	SD
2010	Gullies	4.66	1.16	4.94	0.47
	Uplands	5.11	0.44	4.65	1.20
2011	Gullies	5.53	0.31	4.59	0.89
	Uplands	5.49	0.41	4.61	0.59
2012	Gullies	4.96	0.64	4.72	0.33
	Uplands	5.39	0.79	4.54	0.58
2013	Gullies	3.99	0.37	3.61	0.21
	Uplands	4.56	0.59	4.11	0.47
2014	Gullies	5.10	0.90	5.04	1.01
	Uplands	5.54	0.28	4.85	0.60

Table 7. Mean percent cover (with standard deviation) of bare ground and litter each year compared to ecological site description (ESD) expected values. Green means the values are over the expected, brown are values under the expected, and black are values within the expected range. Annual sample size is ~5. Each year has a set of unique sites.

Site	Expected or Actual (Year)	Percent cover by lifeform	
		Bare ground	Litter
Uplands(Clayey) ESD# R058AE002MT	Expected based on ecological site description	5-15	35-60
	Actual (2010)	6.5 (5.7)	73.2 (20.0)
	Actual (2011)	9.9 (9.0)	86.6 (8.7)
	Actual (2012)	6.9 (6.0)	91.2 (7.3)
	Actual (2013)	14.3 (12.1)	80.6 (13.5)
	Actual (2014)	8.5 (9.2)	85.2 (8.8)
Gullies (Shallow Clay) ESD# R058AE199MT	Expected based on ecological site description	25-40	20-30
	Actual (2010)	20.4 (18.8)	56.9 (12.3)
	Actual (2011)	17.1 (11.8)	78.3 (11.5)
	Actual (2012)	13.7 (10.2)	80.6 (10.3)
	Actual (2013)	19.0 (11.7)	75.2 (11.0)
	Actual (2014)	15.8 (13.4)	72.8 (11.8)

Table 8. Mean soil parameters with standard deviation across all sites and years 2010-2012 (not summarized by year or site type, see text). Index value was assigned based on whether the level of each parameter was at, above, or below what was deemed ideal by expert opinion. For a full list of potential index values and interpretation, see Amacher et al. 2007. Sample size is ~9.

Parameter	Mean	Standard deviation	Level	Interpretation	Index value	Maximum index value
Aluminum (mg/kg)	2.99	3.53	1 to 10	Low - adverse effects unlikely	2	2
Bulk Density (g/cm ³)	1.26	0.05	≤ 1.5	Adverse effects unlikely	1	1
Calcium (mg/kg)	3889.08	1518.08	>1000	High - excellent reserve, probably calcareous soil	2	2
Cation Exchange Capacity (meq/100g)	24.64	7.91	> 15	High – sodic soil with associated problems	0	1
Copper (mg/kg)	1.54	0.25	>1	High – possible toxicity to Cu sensitive plants, may indicate mining areas or industrial sources of Cu	0	1
Iron (mg/kg)	4.12	0.76	0.1 to 10	Moderate – effects unknown	1	1
Potassium (mg/kg)	236.06	57.96	100 to 500	Moderate - adequate levels for most plants	1	2
Magnesium (mg/kg)	392.43	201.22	50 to 500	Moderate - adequate levels for most plants	1	2
Manganese (mg/kg)	0.83	0.10	<1	Very low – deficiencies more likely	0	1
pH	7.38	0.41	7.21 to 7.5	Slightly alkaline – optimum for many plant species except those that prefer acid soils, possible deficiencies of available P and some metals	1	2
Soil sulfur (mg/kg)	70.61	156.93	1 to 100	Moderate - adverse effects unlikely	1	1
Zinc (mg/kg)	0.39	0.22	<1	Low – possible deficiencies in calcareous or sandy soils	0	1
Total Carbon (%)	1.77	0.44	1 to 5	Moderate - adequate levels	1	2
Total Nitrogen (%)	0.16	0.03	0.1 to 0.5	Moderate - adequate levels	1	2
Sum of index values					12	21
SQI (%)					57	

Discussion

The results presented here comprise a data summary report of monitoring data for Rocky Mountain Network VCSS at Little Bighorn Battlefield NM. We present some simple comparisons of a few vegetation and soils indicators with other published information for the region to provide context. This is not, however, a thorough analysis of the condition of park vegetation and soils, and these results and interpretation are provisional. Additional, more in-depth analyses including condition assessments will follow in summary status and trend reports.

Shrub and herbaceous vegetation

Though native species richness and cover was greater than richness and cover of exotic species (Figure 3), there was a considerable presence of exotics. Twenty-three of the 107 vascular plant species found in 2014 were exotic (21.5%) and six sites had greater than 50% cover by exotics (sites 15, 20, 25, 32, 34, and 37; Figure 4). Though none of these exotic species are considered noxious by the state of Montana, continued or focused management at known sites (VCSS locations and others) can prevent further spread. One of the most widespread of these exotic invasives is *Bromus tectorum*. Cheatgrass is an annual grass that grows quickly early in the growing season, outcompeting native species and forming invasive monocultures (Harris 1967; Vasquez et al 2008). Because it dries out early in the summer and is often continuously distributed, cheatgrass can alter fire regimes, creating conditions where fire is more frequent (D'Antonio and Vitousek 1992). It can also shift plant community composition from a perennial to an annual grass driven system (Vasquez et al. 2008). There was a very low presence of noxious weeds found at sites, including small amounts of St. Johnswort (*Hypericum perforatum*) and field bindweed (*Convolvulus arvensis*). Our findings are consistent with Struthers et al. (2014) in the Natural Resource Condition Assessment (NRCA) for Little Bighorn Battlefield NM; they concluded that exotic invasive species were of moderate concern due to the pervasiveness of *Bromus tectorum* and its capacity to shift grasslands away from a native-dominated system.

At upland sites, there was up to two times the expected number of forbs present compared to the ecological site description. At gulley sites, there was up to 3 times the expected number of forbs (Table 2). This pattern

was also found in the Little Bighorn Battlefield NM NRCA (Struthers et al. 2014). The high cover of forbs is not currently a concern. An abundance of forbs contributes to high plant cover, minimizing runoff and erosion and creating a good hydrologic condition (USDA, NRCS 2015). The cover of graminoids in gulley sites was over 1.5 times higher than expected based on ecological site descriptions; this pattern may be associated with the relatively low shrub cover in these site types. Though trees were not a dominant species at the park, the presence of juniper provides bird habitat and limits erosion in gullies (USDA, NRCS 2015).

Disturbance

Both HDI and NDI scores were low and within a narrow range; possible scores range from 0-100 (Table 5). There are at least a few potential reasons to explain this cluster of lower scores. One explanation for the clustering is the small size of Little Bighorn Battlefield NM; multiple sites are subjected to the same disturbance (most commonly land use in surrounding area). Scores might be fairly low because the majority of the park is inaccessible to the public. The park is a site that preserves and commemorates a significant battle in US history and is largely left undisturbed as a place of cultural significance. Visitors are restricted to the road, a few trails, and to the visitor center area. The most common sources of natural disturbance were rodents and evidence of old (> 10 years) fire. Human disturbance was mainly due to the presence of fencing, roads, or grazing in areas near the sites.

One caveat to interpreting disturbance data is that the data were collected by crews unfamiliar with history of land use at LIBI. We are working on improving ways to reduce variability through improvements to the datasheets themselves (e.g., clarify exactly what is being asked), calibrating scoring across crew members and park staff, and applying institutional knowledge from the park that will better inform the interpretation process.

Soil and erosion potential

The low cover of bare soil, high litter cover, and high soil aggregate stability suggest low erosion potential. The relatively high soil aggregate stability (see comparisons in Bird et al. 2007 and Bestelmeyer et

al. 2006) could be associated with the high cover of litter at monitoring sites (Table 6; Table 7). Field crews reported that the majority of litter was due to the dieback of annual bromes. The presence of litter provides material for soil building and moisture retention and can lower the level of soil compaction (O'Neill et al. 2005). These results are consistent with the NRCA, which concluded that soil and site stability and hydrologic functioning were high (Struthers et al. 2014).

Soil quality parameters varied compared to other published sources; we currently have no definitive reference with which to compare Little Bighorn Battlefield NM soils data. For instance, using the USFS soil quality index, the soil quality index at the park was 57%, compared to a mean of 66% in forest inventory and analysis (FIA) plots in the Interior West between 2000 and 2004 (Amacher et al. 2007). The scale of that particular study was much larger than the area surrounding this park and may not be strictly comparable. A handful of soil metrics contributed to the low index value. Rocky Mountain Network crews measured a higher cation exchange capacity (CEC), higher copper, and lower manganese and zinc than found in the USFS study. CEC is the total capacity of a soil to hold exchangeable cations and has a strong

effect on a soil's ability to hold onto essential nutrients. It also provides a buffer against soil acidification. A high CEC could indicate high levels of sodium in soil, which could affect plant growth (Amacher et al. 2007). High copper could lead to possible toxicity to copper sensitive plants (Fernandes and Henriques 1991), while low levels of micronutrients like manganese and zinc could lead to changes in plant growth such as delayed development and smaller above-ground growth (Marschner 1995). In contrast to FIA data, zinc levels found by network crews were consistent with USFS DataMart raw soil data from southeastern Montana (<http://apps.fs.fed.us/fiadb-downloads/datamart.html>), though manganese remained low. Additionally, cation exchange capacity sampled by ROMN crews was comparable to levels measured by the Natural Resources Conservation Service (USDA et al. 2013). Since plant biomass does not seem to be compromised, levels of CEC, copper, and micronutrients are likely acceptable. We will continue to explore ways to determine the appropriate reference condition for soil metrics as we track soil quality over time.

Conclusion

In general, Rocky Mountain Network data reported here support findings in the NRCA that the grasslands at Little Bighorn Battlefield NM are dominated by native bunchgrass species and are in good condition, though exotic invasive species warrant moderate concern (Struthers et al. 2014). Further monitoring of upland vegetation and soils will help park staff understand park-wide vegetation and soils relative to issues

such as climate change, herbivory by deer and other ungulates, disturbances such as fire or beetles, and change in cover or abundance of invasive species. As more data are collected over the next several years, it may be possible to recognize patterns and trends that could indicate a change in the ecological integrity of Little Bighorn Battlefield vegetation and soil.

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Appendix A

Species List

Table A1. List of vascular plant species found in sites between 2010 and 2014 samplings seasons. Only plants identified to the species level are included. Lifeform categorization follows USDA Plants.

Scientific name	Common name
Forbs	
<i>Achillea millefolium</i> var. <i>occidentalis</i>	western yarrow
<i>Allium cernuum</i>	nodding onion
<i>Allium textile</i>	textile onion
<i>Alyssum alyssoides</i> *	pale madwort*
<i>Anaphalis margaritacea</i>	western pearly everlasting
<i>Androsace occidentalis</i>	western rockjasmine
<i>Androsace septentrionalis</i>	pygmyflower rockjasmine
<i>Antennaria corymbosa</i>	flat-top pussytoes
<i>Antennaria parvifolia</i>	small-leaf pussytoes
<i>Antennaria rosea</i>	rosy pussytoes
<i>Arabis glabra</i>	tower rockcress
<i>Arenaria serpyllifolia</i> *	thymeleaf sandwort*
<i>Arnica sororia</i>	twin arnica
<i>Artemisia campestris</i>	field sagewort
<i>Astragalus agrestis</i>	purple milkvetch
<i>Astragalus atropubescens</i>	hangingpod milkvetch
<i>Astragalus australis</i>	Indian milkvetch
<i>Astragalus crassicaulis</i>	groundplum milkvetch
<i>Astragalus drummondii</i>	Drummond's milkvetch
<i>Astragalus falcatus</i> *	Russian milkvetch*
<i>Besseyia wyomingensis</i>	Wyoming besseyia
<i>Calochortus nuttallii</i>	sego lily
<i>Camelina microcarpa</i> *	littlepod false flax*
<i>Cerastium arvense</i> *	field chickweed
<i>Cerastium fontanum</i> *	common mouse-ear chickweed*
<i>Cerastium nutans</i>	nodding chickweed
<i>Chaenactis douglasii</i>	Douglas' dustymaiden
<i>Chenopodium album</i> *	lambsquarters*
<i>Cirsium arvense</i> *	Canada thistle*
<i>Cirsium undulatum</i>	wavyleaf thistle
<i>Collomia linearis</i>	tiny trumpet
<i>Convolvulus arvensis</i> *	field bindweed*
<i>Crepis acuminata</i>	tapertip hawksbeard
<i>Crepis atriobarba</i>	slender hawksbeard
<i>Crepis occidentalis</i>	largeflower hawksbeard
<i>Cryptantha torreyana</i>	Torrey's cryptantha
<i>Descurainia incana</i>	mountain tansymustard

* Exotic species

Table A1. List of vascular plant species found in sites between 2010 and 2014 samplings seasons. Only plants identified to the species level are included. Lifeform categorization follows USDA Plants, cont.

Scientific name	Common name
Forbs cont.	
<i>Descurainia sophia</i> *	herb sophia*
<i>Dianthus armeria</i> *	Deptford pink*
<i>Draba brachycarpa</i>	shortpod draba
<i>Draba nemorosa</i>	woodland draba
<i>Draba reptans</i>	Carolina draba
<i>Echinacea angustifolia</i>	blacksamson echinacea
<i>Epilobium brachycarpum</i>	tall annual willowherb
<i>Erigeron caespitosus</i>	tufted fleabane
<i>Erigeron ochroleucus</i>	buff fleabane
<i>Erigeron pumilus</i>	shaggy fleabane
<i>Erysimum capitatum</i>	sanddune wallflower
<i>Euphorbia spathulata</i>	warty spurge
<i>Galium aparine</i>	stickywilly
<i>Gayophytum humile</i>	dwarf groundsmoke
<i>Geum triflorum</i>	old man's whiskers
<i>Glycyrrhiza lepidota</i>	American licorice
<i>Hedeoma hispida</i>	rough false pennyroyal
<i>Helianthella quinquenervis</i>	fivenerve helianthella
<i>Holosteum umbellatum</i> *	jagged chickweed*
<i>Hypericum perforatum</i> *	common St. Johnswort*
<i>Lactuca serriola</i> *	prickly lettuce*
<i>Lactuca tatarica</i>	blue lettuce
<i>Lappula occidentalis</i>	flatspine stickseed
<i>Lappula squarrosa</i> *	European stickseed*
<i>Lepidium densiflorum</i> *	common pepperweed*
<i>Lepidium perfoliatum</i> *	clasping pepperweed*
<i>Lesquerella alpina</i>	alpine bladderpod
<i>Lesquerella montana</i>	mountain bladderpod
<i>Leucocrinum montanum</i>	common starlily
<i>Liatris punctata</i>	dotted blazing star
<i>Linum rigidum</i>	stiffstem flax
<i>Lithospermum incisum</i>	narrowleaf stoneseed
<i>Lithospermum ruderales</i>	western stoneseed
<i>Logfia arvensis</i> *	field cottonrose*
<i>Lomatium dissectum</i>	fernleaf biscuitroot
<i>Lomatium nuttallii</i>	Nuttall's biscuitroot
<i>Lygodesmia juncea</i>	rush skeletonplant
<i>Maianthemum stellatum</i>	starry false lily of the valley
<i>Medicago lupulina</i> *	black medick*
<i>Medicago sativa</i> *	alfalfa*
<i>Melilotus officinalis</i> *	sweetclover*

* Exotic species

Table A1. List of vascular plant species found in sites between 2010 and 2014 samplings seasons. Only plants identified to the species level are included. Lifeform categorization follows USDA Plants, cont.

Scientific name	Common name
Forbs cont.	
<i>Mertensia longiflora</i>	small bluebells
<i>Mertensia oblongifolia</i>	oblongleaf bluebells
<i>Microseris nutans</i>	nodding microseris
<i>Monolepis nuttalliana</i>	Nuttall's povertyweed
<i>Musineon divaricatum</i>	leafy wildparsley
<i>Myosotis stricta</i> *	strict forget-me-not*
<i>Parietaria pensylvanica</i>	Pennsylvania pellitory
<i>Pedimelum argophyllum</i>	silverleaf Indian breadroot
<i>Pedimelum esculentum</i>	large Indian breadroot
<i>Phacelia linearis</i>	threadleaf phacelia
<i>Phlox hoodii</i>	spiny phlox
<i>Plantago elongata</i>	prairie plantain
<i>Plantago patagonica</i>	woolly plantain
<i>Polygonum douglasii</i>	Douglas' knotweed
<i>Prunella vulgaris</i>	common selfheal
<i>Psoraleidum tenuiflorum</i>	slimflower scurfpea
<i>Silene antirrhina</i>	sleepy silene
<i>Silene conoidea</i> *	weed silene*
<i>Silene latifolia</i> *	bladder campion*
<i>Silene menziesii</i>	Menzies' campion
<i>Silene oregana</i>	Oregon silene
<i>Sisymbrium altissimum</i> *	tall tumbledmustard*
<i>Stellaria longipes</i>	longstalk starwort
<i>Symphotrichum ericoides</i>	white heath aster
<i>Symphotrichum falcatum</i>	white prairie aster
<i>Symphotrichum subspicatum</i>	Douglas aster
<i>Tanacetum vulgare</i> *	common tansy*
<i>Taraxacum officinale</i> *	common dandelion*
<i>Thermopsis rhombifolia</i>	prairie thermopsis
<i>Thlaspi arvense</i> *	field pennycress*
<i>Tradescantia bracteata</i>	longbract spiderwort
<i>Tragopogon dubius</i> *	yellow salsify*
<i>Trifolium aureum</i> *	golden clover*
<i>Veronica americana</i>	American speedwell
<i>Veronica arvensis</i> *	corn speedwell*
<i>Veronica peregrina</i>	neckweed
<i>Vicia americana</i>	American vetch
<i>Viola nuttallii</i>	Nuttall's violet
<i>Zigadenus elegans</i>	mountain deathcamas
<i>Zigadenus elegans</i>	mountain deathcamas
<i>Zigadenus venenosus</i>	meadow deathcamas

* Exotic species

Table A1. List of vascular plant species found in sites between 2010 and 2014 samplings seasons. Only plants identified to the species level are included. Lifeform categorization follows USDA Plants, cont.

Scientific name	Common name
Graminoids	
<i>Achnatherum hymenoides</i>	Indian ricegrass
<i>Agropyron cristatum</i> *	crested wheatgrass*
<i>Aristida purpurea</i>	purple threeawn
<i>Bouteloua curtipendula</i>	sideoats grama
<i>Bouteloua gracilis</i>	blue grama
<i>Bromus hordeaceus</i> *	soft brome*
<i>Bromus inermis</i> *	smooth brome*
<i>Bromus japonicas (B. arvensis)</i> *	Japanese brome*
<i>Bromus tectorum</i> *	cheatgrass*
<i>Calamovilfa longifolia</i>	prairie sandreed
<i>Carex douglasii</i>	Douglas' sedge
<i>Carex filifolia</i>	threadleaf sedge
<i>Carex inops ssp. heliophila</i>	sun sedge
<i>Eleocharis macrostachya</i>	pale spikerush
<i>Elymus lanceolatus</i>	thickspike wheatgrass
<i>Festuca idahoensis</i>	Idaho fescue
<i>Hesperostipa comata</i>	needle and thread
<i>Koeleria macrantha</i>	prairie Junegrass
<i>Muhlenbergia montana</i>	mountain muhly
<i>Nassella viridula</i>	green needlegrass
<i>Pascopyrum smithii</i>	western wheatgrass
<i>Poa arida</i>	plains bluegrass
<i>Poa bulbosa</i> *	bulbous bluegrass*
<i>Poa compressa</i> *	Canada bluegrass*
<i>Poa palustris</i>	fowl bluegrass
<i>Poa pratensis</i> *	Kentucky bluegrass*
<i>Poa secunda</i>	Sandberg bluegrass
<i>Pseudoroegneria spicata</i>	bluebunch wheatgrass
<i>Sporobolus airoides</i>	alkali sacaton
<i>Thinopyrum intermedium</i> *	intermediate wheatgrass*
Shrubs	
<i>Echinocereus viridiflorus</i>	nylon hedgehog cactus
<i>Escobaria missouriensis</i>	Missouri foxtail cactus
<i>Opuntia fragilis</i>	brittle pricklypear
<i>Opuntia polyacantha</i>	plains pricklypear
<i>Rhus trilobata</i>	skunkbush sumac
<i>Sarcobatus vermiculatus</i>	greasewood
<i>Symphoricarpos occidentalis</i>	western snowberry

* Exotic species

Table A1. List of vascular plant species found in sites between 2010 and 2014 samplings seasons. Only plants identified to the species level are included. Lifeform categorization follows USDA Plants, cont.

Scientific name	Common name
Subshrub	
<i>Arenaria capillaris</i>	slender mountain sandwort
<i>Artemisia cana</i>	silver sagebrush
<i>Artemisia frigida</i>	prairie sagewort
<i>Artemisia ludoviciana</i>	white sagebrush
<i>Castilleja sessiliflora</i>	downy paintedcup
<i>Comandra umbellata</i>	bastard toadflax
<i>Dalea candida</i>	white prairie clover
<i>Dalea purpurea</i>	purple prairie clover
<i>Ericameria nauseosa</i>	rubber rabbitbrush
<i>Eriogonum pauciflorum</i>	fewflower buckwheat
<i>Gaura coccinea</i>	scarlet beeblossom
<i>Gutierrezia sarothrae</i>	broom snakeweed
<i>Heterotheca villosa</i>	hairy false goldenaster
<i>Iva axillaris</i>	povertyweed
<i>Linum lewisii</i>	Lewis flax
<i>Linum perenne</i> *	blue flax*
<i>Lupinus argenteus</i>	silvery lupine
<i>Penstemon nitidus</i>	waxleaf penstemon
<i>Rosa arkansana</i>	prairie rose
<i>Rosa woodsii</i>	Woods' rose
<i>Sphaeralcea coccinea</i>	scarlet globemallow
<i>Toxicodendron rydbergii</i>	western poison ivy
<i>Yucca glauca</i>	soapweed yucca
Tree/shrub	
<i>Amelanchier alnifolia</i>	Saskatoon serviceberry
<i>Artemisia tridentata</i>	big sagebrush
<i>Juniperus scopulorum</i>	Rocky Mountain juniper
<i>Prunus virginiana</i>	chokecherry
Vine	
<i>Clematis ligusticifolia</i>	western white clematis

* Exotic species

Appendix B

Table B1. List of exotic plant taxa targeted at Little Bighorn Battlefield NM. These are species that crews searched for but did not necessarily find.

Scientific Name	Common Name
<i>Acroptilon repens</i>	Russian knapweed /hardhead
<i>Centaurea diffusa</i>	diffuse knapweed
<i>Centaurea stoebe</i>	spotted knapweed
<i>Chondrilla juncea</i>	rush skeletonweed
<i>Cirsium arvense</i>	Canada thistle
<i>Cirsium vulgare</i>	bull thistle
<i>Tragopogon dubius</i>	common salsify
<i>Cynoglossum officinale</i>	common houndstongue
<i>Salsola kali</i>	Russian thistle
<i>Salsola tragus</i>	prickly Russian thistle
<i>Hypericum perforatum</i>	St.Johnswort
<i>Euphorbia esula</i>	leafy spurge
<i>Melilotus officinalis</i>	yellow sweet-clover
<i>Bromus inermis</i>	smooth brome
<i>Bromus tectorum</i>	cheatgrass
<i>Rumex crispus</i>	curly dock
<i>Linaria dalmatica</i>	dalmation toadflax

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