



Plant Community Composition and Structure Monitoring for Fort Laramie National Historic Site

2014 Annual Report

Natural Resource Data Series NPS/NGPN/NRDS—2015/771



ON THE COVER

Long-term monitoring plot PCM-006 at Fort Laramie National Historic Site, 2014
Photograph courtesy of the National Park Service

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Michael Prowatzke
Stephen K. Wilson

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

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

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

All manuscripts in the series receive the appropriate level of peer review to ensure that the information is scientifically credible, technically accurate, appropriately written for the intended audience, and designed and published in a professional manner. This report received informal peer review by subject-matter experts who were not directly involved in the collection, analysis, or reporting of the data. Data in this report were collected and analyzed using methods based on established, peer-reviewed protocols and were analyzed and interpreted within the guidelines of the protocols.

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Abstract

This report presents the results of vegetation monitoring efforts in 2014 at Fort Laramie National Historic Site (FOLA) by the Northern Great Plains Inventory and Monitoring Network (NGPN).

During the fourth full year of field work, crew members from NGPN visited six plant community monitoring plots to collect data on the vegetation at FOLA. This is part of a long-term monitoring effort that will sample 6 of 15 randomly located upland plots every year, so that each plot is visited for two consecutive years and then rested for three years, on a five-year rotating basis. NGPN staff captured data relating to species richness, herb-layer height, abundance of individual native and non-native species, ground cover, and site disturbance on each of the six plots.

Our 2014 findings can be summarized as follows: The crew observed 102 vascular plant species, with an average of 4.4 native species occurring within any given 1 m² quadrat sampled. While native species diversity is still at a moderate level, non-native species represented 55.9% of cover and present extreme management challenges. Cheatgrass was a dominant species throughout the park.

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 FOLA, particularly M. Evans, for help in the field. The 2014 NGPN vegetation field crew of K. Legner, R. Manuel, L. Mickelson, and D. Pinigis, F. Sewell, and K. Paintner-Green collected all the data included in this report.

Introduction

During the last century, much of the prairie within the Northern Great Plains has been plowed for cropland, planted with non-natives to maximize livestock production, or otherwise developed, making it one of the most threatened ecosystems in the United States. The National Park Service (NPS) plays an important role in preserving and restoring some of the last pieces of intact prairies within its boundaries. The stewardship goal of the NPS is to “preserve ecological integrity and cultural and historical authenticity” (NPS 2012); however, resource managers struggle with the reality that there have been fundamental changes in the disturbance regimes, such as climate, fire, and large ungulate grazing, that have historically maintained prairies, and there is the continual pressure of exotic invasive species. Long-term monitoring in national parks is essential to sound management of prairie landscapes because it can provide information on environmental quality and condition, benchmarks of ecological integrity, and early warning of declines in ecosystem health.

Fort Laramie National Historic Site (FOLA), established in 1938 to protect and preserve the well-known military post, covers 833 acres within the northern mixed-grass prairie region (Lauenroth et al. 1999). The park is a mosaic of disturbed old-fields, riparian forests, and native prairie and is host to 376 plant species (Heidel 2004). The Northern Great Plains Inventory & Monitoring Program (NGPN) began vegetation monitoring at FOLA in 2011 (Ashton et al. 2012a). The long-term objectives of the NGPN plant community monitoring effort (Symstad et al. 2012b) in FOLA are to:

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

This report is intended to provide a timely release of basic data sets and data summaries from our sampling efforts at FOLA in 2014, our fourth year of sampling. We visited six plots, and it will take one more year to visit every plot in the park twice (Figure 1). We expect to produce reports with more in-depth data analysis and interpretation when we complete our fifth year of sampling in 2015. In the interim, reports, spatial data, and data summaries can be provided for park management and interpretation upon request.



Northern Great Plains Inventory and Monitoring Network Plant Community Monitoring

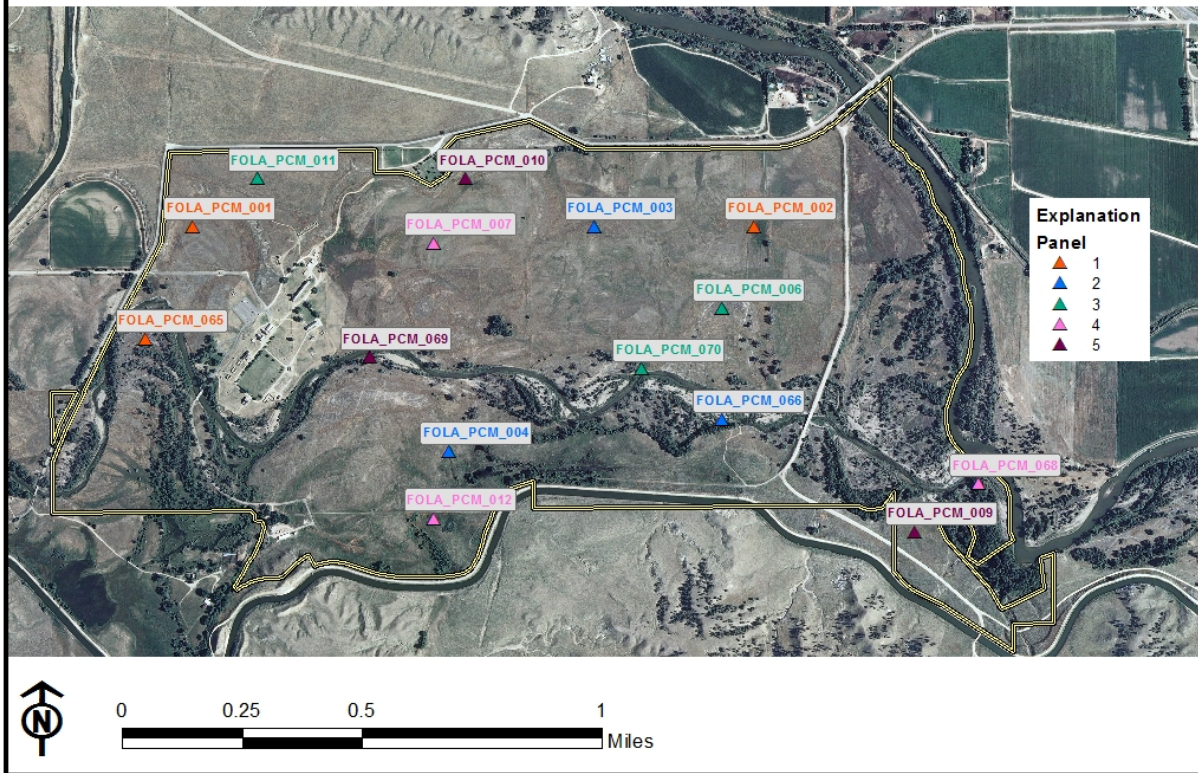


Figure 1. Map of Fort Laramie National Historic Site and plant community monitoring plots. Plots in panel 3 (green) and panel 4 (pink) were visited in 2014.

Methods

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

Sample Design

We implemented a survey to monitor plant community structure and composition in FOLA using a spatially balanced probability design (Generalized Random Tessellation Stratified [GRTS]; Stevens and Olsen 2003, 2004). Using a GRTS design, we selected 15 randomly located sites within FOLA (Figure 1). We split these 15 sites into five panels with three sites each. We visit two panels (six sites) every year, and after five years (2015) we will have visited all 15 sites twice. In 2011, we visited sites in panel 1 and panel 5. In 2012, we visited sites in panel 1 and panel 2. In 2013, we visited sites in panel 2 and panel 3, and in 2014, we visited sites in panel 3 and 4 during the first week of June (Figure 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.

Plot Layout and Sampling

At each of the sites we visited, we recorded plant species cover and frequency in a rectangular, 50 m x 20 m (0.1 ha), permanent plot (Figure 2). Data on ground cover, herb-layer height ≤ 2 m, and plant cover were collected on two 50 m transects (the long sides of the plot) using a point-intercept method. Species richness data from the point-intercept method were supplemented with species presence data collected in five sets of nested square quadrats (0.01 m², 0.1 m², 1 m², and 10 m²) located systematically along each transect (Figure 2). In 2014, sampling at FOLA took a 4-person crew approximately 169.5 crew hours with travel time (see Appendix A for a detail of activities each day).

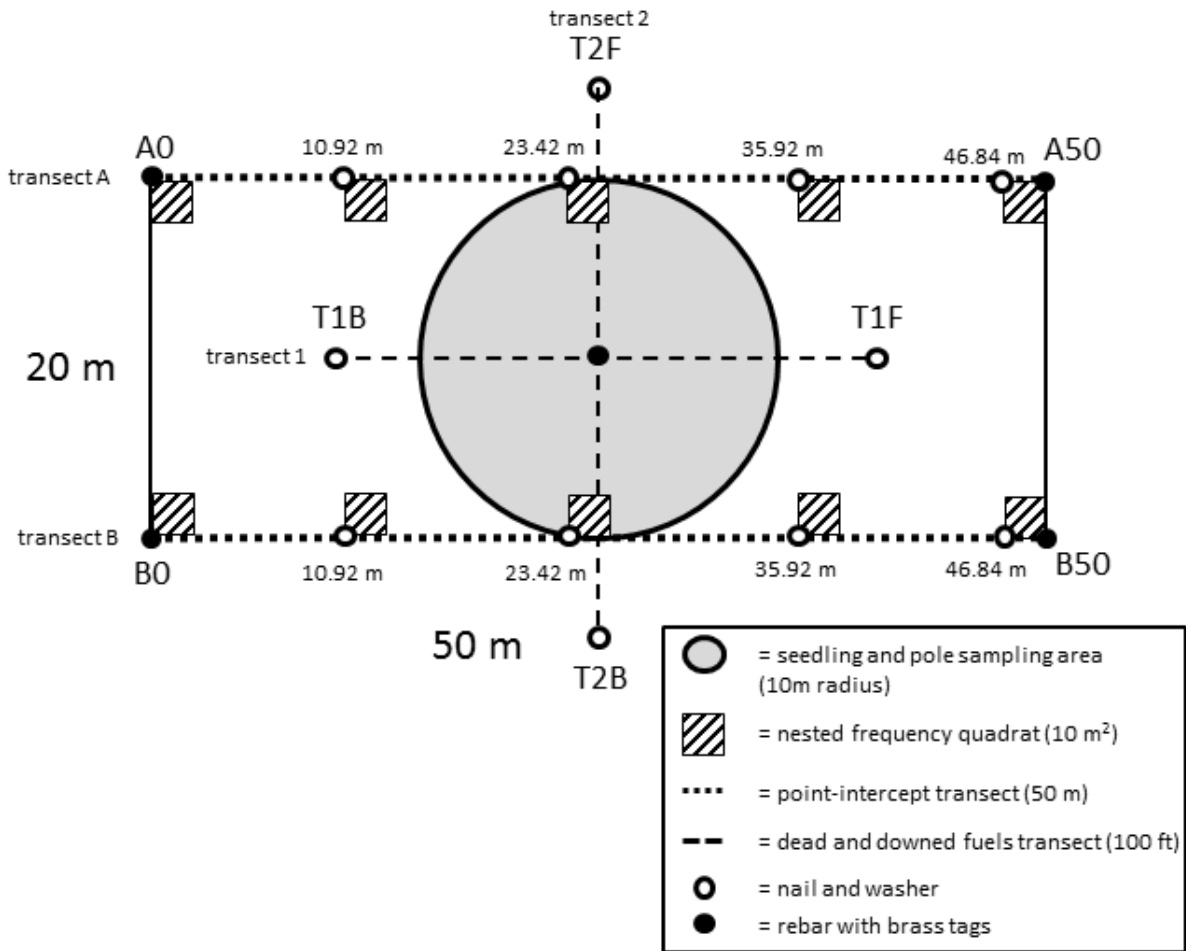


Figure 2. Long-term monitoring plot layout used for sampling vegetation in Fort Laramie National Historic Site.

When woody species were present, tree regeneration and tall shrub density data were collected within a 10 m radius subplot centered in the larger 50 m x 20 m plot (Figure 2). Trees with diameter at breast height (DBH) > 15 cm, located within the entire 0.1 ha plot, are mapped and tagged. For each tree, the species, DBH, status, and condition (e.g., leaf-discoloration, insect-damaged, etc.) are recorded. An assessment of parkwide forest structure and health will be conducted after five years, when more data are available. In addition to upland plant community sampling, NGPN completed a survey of riparian forests in FOLA in the last week of September 2014. Results of this effort will be published separately, and the riparian forest survey is to be repeated every five years thereafter.

At all plots, we also surveyed the area for common disturbances and target species of interest to the park. Common disturbances included such things as roads, rodent mounds, animal trails, and fire. For all plots, the type and severity of the disturbances were recorded. We also surveyed the area for exotic species that have the potential to spread into the park and cause significant ecological impacts (Table 1). For each target species that was present at a site, an abundance class was given on a scale from 1-5 where 1 = one individual, 2 = few individuals, 3 = cover of 1-5%, 4 = cover of 5-25%, and

5 = cover > 25% of the plot. The information gathered from this procedure is critical for early detection and rapid response to such threats. In addition, we noted the presence of plant species that are considered rare or vulnerable to loss in Wyoming and which may potentially occur in FOLA (Table 2).

Table 1. Exotic species surveyed for at Fort Laramie National Historic Site as part of the early detection and rapid response program within the Northern Great Plains Network.

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

Table 2. Rare species that were surveyed for during the 2014 field season at Fort Laramie National Historic Site.

Scientific Name	Common Name
<i>Agalinis tenuifolia</i>	slender false foxglove
<i>Cyperus acuminatus</i>	short point flat sedge
<i>Cyperus bipartitus</i>	shining flatsedge
<i>Dalea aurea</i>	golden prairie clover
<i>Dalea cylindriceps</i>	Andean prairie clover
<i>Euphorbia hexagona</i>	six-angle spurge
<i>Eustoma exaltatum</i> ssp. <i>russellianum</i> / <i>E. russellianum</i> / <i>E. grandiflorum</i>	showy prairie gentian
<i>Gaura neomexicana</i> ssp. <i>coloradensis</i>	Colorado butterfly plant
<i>Lipocarpa drummondii</i>	dwarf bulrush
<i>Lithospermum multiflorum</i>	many flowered puccoon
<i>Lobelia siphilitica</i>	great blue lobelia
<i>Paronychia jamesii</i>	James's nailwort
<i>Shinnersoseris rostrata</i>	beaked skeletonweed
<i>Sorghastrum nutans</i>	Indiangrass
<i>Spiranthes diluvialis</i>	Ute lady's tresses

Data Management and Analysis

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

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

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

Plant life forms (e.g., shrub, forb) were based on definitions from the USDA Plants Database (USDA-NRCS 2012). Warm-season grasses were identified primarily using a guide by Skinner (2010). Summaries were produced using the FFI reporting and query tools and statistical summaries and graphics were generated using R software (version 3.1.2).

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

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

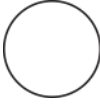
Reporting on Natural Resource Condition

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

We chose a set of indicators and specific measures that can describe the condition of vegetation in the Northern Great Plains and the status of exotic plant invasions. The measures include: absolute

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

Table 3. Key to the symbols used in the Natural Resource Condition Table. The background color represents the current status, the arrow summarizes the trend, and the thickness of the outside line represents the degree of confidence in the assessment. A symbol that does not contain an arrow indicates that there is insufficient information to assess a trend. Based on the State of the Park reports (<http://www.nps.gov/stateoftheparks/>).

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

Results and Discussion

Fort Laramie National Historic Site obtained some relief from an ongoing drought in 2014, and precipitation was slightly above average for the year

(<http://www.ncdc.noaa.gov/cdo-web/datasets/GHCND/stations/GHCND:USC00486852/detail>;

Figure 3). When NGPN visited the park in June, precipitation was near normal, but the park was noticeably greener than it had been in recent memory.

Average canopy cover was 167% (Table 4) in 2014, more than double that of the previous year (Ashton and Prowatzke 2013) and almost four times that of 2012 (Ashton et al. 2012b). There was a large amount of litter on the ground with ground cover at the sites averaging 84% plant litter.

We found 102 plant species in 2014 at FOLA (Appendix B). Graminoids, which includes grasses, sedges, and rushes, accounted for most of the vegetative cover at FOLA, but trees, forbs, shrubs, subshrubs (defined as a low-growing shrub usually under 0.5m), and vines were also present (Figure 4). We found 30 exotic species at the park. The shrubs, subshrubs, and trees were all native species. No exotic target species were found at any sites in 2014.

The most common species in the sites we visited were a mixture of graminoids and forbs, both native and exotic (Figure 5). Cheatgrass (*Bromus tectorum*), western wheatgrass (*Pascopyrum smithii*), prickly Russian thistle (*Salsola tragus*), sand dropseed (*Sporobolus cryptandrus*), and Canadian horseweed (*Conyza canadensis*) were found at all six sites.

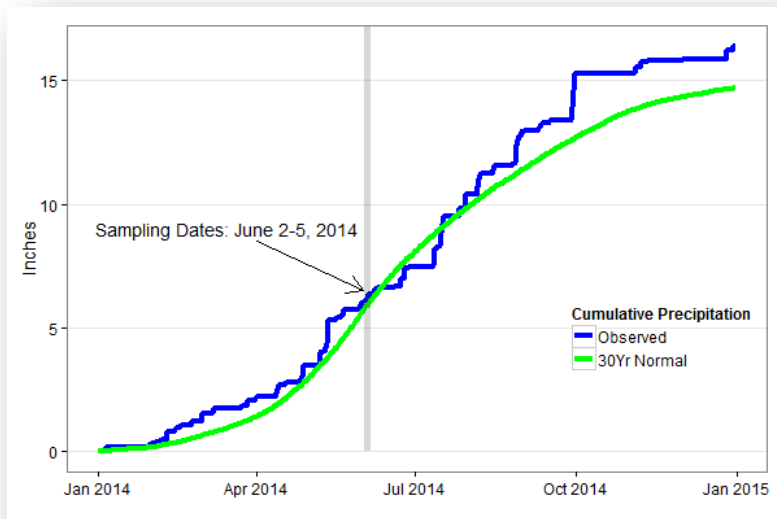


Figure 3. Observed and 30-year (1981-2010) normal precipitation at Fort Laramie National Historic Site. Timing of NGPN visit is shown by vertical gray bar.

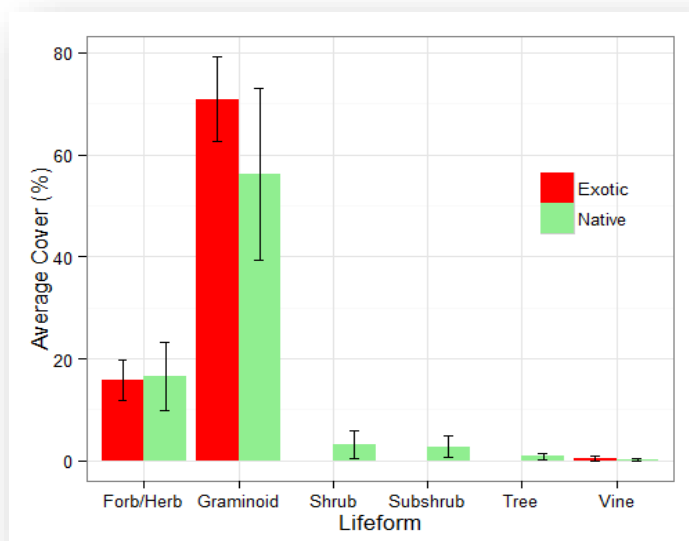
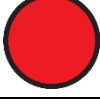


Figure 4. Average cover by lifeform and nativity in six plant community monitoring plots in Fort Laramie National Historic Site in 2014. Native (green) and exotic (red) graminoids were the most abundant lifeform across the plots. Bars represent means $\pm$ standard errors.

Table 4. Natural resource condition summary table for upland plant communities in Fort Laramie National Historic Site (FOLA).

Indicator of Condition	Specific Measures	2014 Value (mean $\pm$ SE)	Reference Condition and Data Source	Condition Status/Trend	Rationale for Resource Condition
Upland Plant Community Structure and Composition	Absolute herb-layer canopy cover	167 $\pm$ 16.8%	TBD ⁽¹⁾		FOLA plays a vital role in protecting and managing some of the last remnants of native mixed-grass prairie and riparian forests in the region. The park is characterized by low native species richness, but average richness is within a natural range of variability. One plot in the riparian area (PCM-068) fell well below the range.
	Native species richness (based on average of 10 1m ² quadrats per plot)	4.4 $\pm$ 1.1 species	3-15 species ⁽²⁾		
	Evenness (based on point-intercept of 2-50m transects per plot)	0.71 $\pm$ 0.04	TBD ⁽¹⁾		
Exotic Plant Early Detection and Management	Relative cover of exotic species	55.9 $\pm$ 8.6%	< 10% cover		The sites in FOLA had a high cover of exotic species. None of the sites had <25% cover. Cheatgrass was the most abundant exotic species, and more research on effective management strategies in the mixed-grass prairie is greatly needed.
	Annual brome cover	27.8 $\pm$ 8.8%	< 10% cover		
Riparian Plant Community Structure and Composition	Cottonwood seedling density	785 $\pm$ 545 stems/hectare ⁽³⁾	TBD		Some areas of the riparian forest in FOLA are healthy and contain numerous trees of all size classes, while others are more typical of old cottonwood forests where only large old trees are present and there is no significant regeneration. Exotic species such as Russian olive and tamarisk are currently in low abundance in the riparian corridor, but active management will be needed to maintain this condition.

References, Notes, and Data Sources:

1. To be determined when more data are available 2. Symstad, A. J. and J. L. Jonas. 2014. Using natural range of variation to set decision thresholds: a case study for Great Plains grasslands. in G. R. Gultenspergen, editor. Application of threshold concepts in natural resource decision making. Springer Verlag. 3. Ashton, I.W. and M. Prowatzke. *in press*. Forest condition at Fort Laramie National Historic Site: 2014 status report. Natural Resource Technical Report NPS/NGPN/NRTR—2015/XXX. National Park Service, Fort Collins, CO.

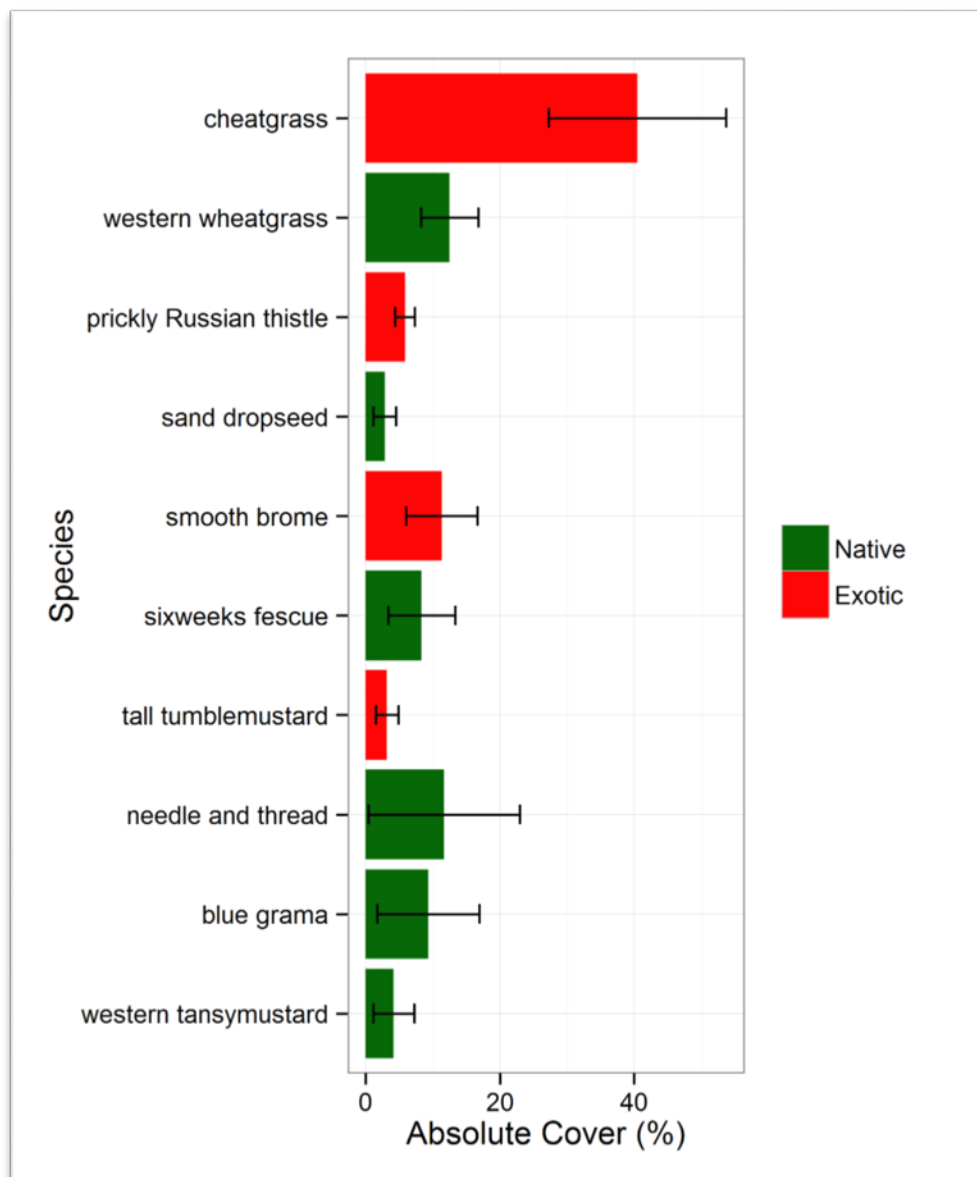


Figure 5. The average absolute cover of the 10 most common native (green) and exotic (red) plants recorded at Fort Laramie National Historic Site in 2014. Bars represent means $\pm$ standard errors.

Average species richness at each of the six plots was measured by point-intercept and in 1 m² and 10 m² quadrats (Table 5). Native species per 1m² increased from 6.35 to 7.83 from 2013 to 2014. On average, there are about three exotic species within the 1 m² quadrat (Table 5). From the point-intersect data, we found average plot diversity, H' , to be 2.02 ± 0.19 . Evenness, J' , averaged 0.71 ± 0.04 across the plots (Table 4). When including only native species, average diversity and evenness were 1.64 ± 0.12 and 0.73 ± 0.02 , respectively.

Table 5. Average plant species richness in six plots at Fort Laramie National Historic Site in 2014. Values represent means $\pm$ standard errors, $n=6$.

	Point-intercept	1 m ² quadrats	10 m ² quadrats
Species richness	17 $\pm$ 2.1	8 $\pm$ 1.1	13 $\pm$ 1.6
Native species richness	10 $\pm$ 1.5	4 $\pm$ 1.1	8 $\pm$ 1.5
Exotic species richness	7 $\pm$ 1.3	3 $\pm$ 0.5	6 $\pm$ 0.6
Graminoid species richness	8 $\pm$ 1.3	3 $\pm$ 0.4	4 $\pm$ 0.3
Forb species richness	7 $\pm$ 1.3	4 $\pm$ 0.6	7 $\pm$ 1.0

While there was some variation across sites, the plots we visited in FOLA tended to have a low diversity of native plants compared to other mixed-grass prairies. Species richness in the mixed-grass prairie is determined by numerous factors including fire regime, grazing, prairie dog disturbance, and weather fluctuations (Symstad and Jonas 2011). While it is difficult to define a reference condition for species richness that can vary so much spatially and temporally, the natural range of variation over long-time periods may be a good starting point (Symstad and Jonas 2014). Long-term records of species diversity in mixed-grass prairie from a relatively undisturbed site in Kansas vary between 3 and 15 species per square meter over the course of 30 years (Symstad and Jonas 2014). Compared to this, FOLA is within the natural range (Table 4). The highest diversity was seen in site PCM-011 (Figure 6), in the northwest portion of the park (Table 1). This site actually increased from 5.1 native species to 9.1 native species per 1 m² quadrat between 2013 and 2014. At the other end of the spectrum, PCM-068, which struggles with a thick layer of exotic quackgrass (*Elymus repens*) and smooth brome (*B. inermis*), averaged only 1.6 species per 1 m² quadrat.

Table 6. Characteristics of the plant community at six plots in Fort Laramie National Historic Site in 2014 including native species richness, average cover of annual bromes, exotic plant cover, and area of disturbance.

Plot	Native species richness in 1 m ²	Exotic cover (%)	Annual brome cover (%)	Disturbance within site (m ²)
PCM-006	4	82	65	5
PCM-007	5	38	29	10
PCM-011	9	25	19	2
PCM-012	4	58	20	15
PCM-068	2	71	0	40
PCM-070	3	62	32	0
Park Average	4.4 $\pm$ 1.1	55.9 $\pm$ 8.6	27.8 $\pm$ 8.8	-

The average relative cover of exotic species at sites in FOLA was high (56 $\pm$ 8.6%; Table 4). However, like species richness, cover of exotic species varied considerably among sites. Site PCM-011 had the lowest cover of exotic species at 25%. The highest cover of exotic species was 82%, found at PCM-006. Cheatgrass accounted for a majority of the exotic cover in upland plots (Table 6), but the riparian plots had other exotic grasses as well. Weedy annual forbs such as prickly Russian thistle and tall tumbled mustard (*Sisymbrium altissimum*) were common throughout the park. The presence of annual bromes in mixed grass prairie is associated with decreased productivity and altered nutrient cycling (Ogle et al. 2003), and there is strong evidence from regions further west that cheatgrass alters fire regimes and the persistence of native species (D'Antonio and Vitousek 2003). Reducing the cover of annual bromes remains a major challenge for the park.

Disturbance from grazing, prairie dogs, fire, and humans affects plant community structure and composition in mixed-grass prairie. For this reason, we measured the approximate area affected by natural and human disturbances at each site we visited. In 2014, the most common disturbance was from small rodents, but there was also evidence of grazing, old fences, and storm damage. With this small sample size, we found no correlation with disturbance and native richness or exotic cover. However, the site with the highest exotic cover (PCM-006) lies in the footprint of a former campground. When sampling across the park is complete in 2015 and we have a larger data set, we hope to compare diversity in pastures with and without horses.

Trees and seedlings were present in only two of the six sites we visited in June 2014 (PCM-068 and PCM-070). Eastern cottonwood (*Populus deltoides*), peachleaf willow (*Salix amygdaloides*), and green ash (*Fraxinus pennsylvanica*) were the only tree species we found. Since we completed a more thorough assessment of riparian forest structure and health in FOLA in late September, we will forego further discussion on the condition of the park's forests. Rather, we will present the results of that assessment, involving 20 sites, in a separate report. However, one summary statistic from that forthcoming report is used in Table 4 of this report.



Figure 6. PCM-011, site of highest native diversity in 2014. This site jumped from five native species in 2013 to nine native species per m² quadrat in 2014.

Summary

FOLA plays a vital role in protecting and managing some of the last remnants of native mixed-grass prairie in the area. Almost all areas seem to be struggling with exotic species, particularly cheatgrass. Native plant diversity is currently at a moderate level, but to retain ecological integrity it is important to continue efforts to reduce the cover of invasive plants. Annual bromes present the largest challenge to FOLA, and more research on effective management strategies in the mixed-grass prairie is greatly needed. Continued monitoring efforts will be critical to track changes in the condition of the vegetation communities in FOLA.

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Appendix A: Field journal for plant community monitoring in FOLA for the 2014 season

Plant community composition monitoring in Fort Laramie National Historic Site was completed using a crew of four people working four 10-hour days. We spent 169.5 total crew hours. We also had assistance from park employees for approximately 10 hours.

Date	Day of week	Approximate Travel Time (hrs)	Housing	Sites Completed
June 2, 2014	Monday	5	Holiday Inn, Torrington	PCM-006
June 3, 2014	Tuesday	1	Holiday Inn, Torrington	PCM-011 PCM-070
June 4, 2014	Wednesday	1	Holiday Inn, Torrington	PCM-007 PCM-012
June 5, 2014	Thursday	5	N/A	PCM-068

Appendix B: List of plant species found in 2014 at FOLA

Family	Code	Scientific Name	Common Name	Exotic
Asclepiadaceae	ASSP	<i>Asclepias speciosa</i>	showy milkweed	
	ASVI	<i>Asclepias viridiflora</i>	green comet milkweed	
Asteraceae	AMPS	<i>Ambrosia psilostachya</i>	Cuman ragweed	
	ARCA12	<i>Artemisia campestris</i>	field sagewort	
	ARFI2	<i>Artemisia filifolia</i>	sand sagebrush	
	ARFR4	<i>Artemisia frigida</i>	prairie sagewort	
	ARLU	<i>Artemisia ludoviciana</i>	white sagebrush	
	CIAR4	<i>Cirsium arvense</i>	Canada thistle	*
	COCA5	<i>Conyza canadensis</i>	Canadian horseweed	
	GRSQ	<i>Grindelia squarrosa</i>	curlycup gumweed	
	HEAN3	<i>Helianthus annuus</i>	common sunflower	
	HEPE	<i>Helianthus petiolaris</i>	prairie sunflower	
	HEVI4	<i>Heterotheca villosa</i>	hairy false goldenaster	
	LASE	<i>Lactuca serriola</i>	prickly lettuce	*
	LYJU	<i>Lygodesmia juncea</i>	rush skeletonplant	
	MATA2	<i>Machaeranthera tanacetifolia</i>	tanseyleaf tansyaster	
	MUOB99	<i>Mulgedium oblongifolium</i>	blue lettuce	
	ONAC	<i>Onopordum acanthium</i>	Scotch cottonthistle	*
	SYER	<i>Symphyotrichum ericoides</i>	white heath aster	
	SYLA6	<i>Symphyotrichum lanceolatum</i>	white panicle aster	
	TRDU	<i>Tragopogon dubius</i>	yellow salsify	*
	LAOC3	<i>Lappula occidentalis</i>	flatspine stickseed	
	LIIN2	<i>Lithospermum incisum</i>	narrowleaf stoneseed	
Brassicaceae	ALDE	<i>Alyssum desertorum</i>	desert madwort	*
	CAMI2	<i>Camelina microcarpa</i>	littlepod false flax	*
	DEPI	<i>Descurainia pinnata</i>	western tansymustard	
	DESO2	<i>Descurainia sophia</i>	herb sophia	*
	LEDE	<i>Lepidium densiflorum</i>	common pepperweed	
	SIAL2	<i>Sisymbrium altissimum</i>	tall tumbled mustard	*
	THAR5	<i>Thlaspi arvense</i>	field pennycress	*
Cactaceae	ESVI2	<i>Escobaria vivipara</i>	spiny star	
	OPMA2	<i>Opuntia macrorhiza</i>	twistspine pricklypear	
	OPPO	<i>Opuntia polyacantha</i>	plains pricklypear	
Caprifoliaceae	SYOC	<i>Symphoricarpos occidentalis</i>	western snowberry	
Chenopodiaceae	CHBE4	<i>Chenopodium berlandieri</i>	pitseed goosefoot	
	CHENO	<i>Chenopodium</i> sp.	goosefoot	*
	KOSC	<i>Kochia scoparia</i>	burningbush, kochia	*
	SATR12	<i>Salsola tragus</i>	prickly Russian thistle	*
Commelinaceae	TROC	<i>Tradescantia occidentalis</i>	prairie spiderwort	

Convolvulaceae	COAR4	<i>Convolvulus arvensis</i>	field bindweed	*
Cyperaceae	CADU6	<i>Carex duriuscula</i>	needleleaf sedge	
	CAHY4	<i>Carex hystericina</i>	bottlebrush sedge	
	CAIN9	<i>Carex inops</i>	long-stolon sedge	
	CANE2	<i>Carex nebrascensis</i>	Nebraska sedge	
	CAPR5	<i>Carex praegracilis</i>	clustered field sedge	
	CAREX	<i>Carex</i> sp.	sedge	
	ELPA3	<i>Eleocharis palustris</i>	common spikerush	
	SCPU10	<i>Schoenoplectus pungens</i>	common threesquare	
Equisetaceae	EQLA	<i>Equisetum laevigatum</i>	smooth horsetail	
Fabaceae	DACA7	<i>Dalea candida</i>	white prairie clover	
	MELU	<i>Medicago lupulina</i>	black medick	*
	MEOF	<i>Melilotus officinalis</i>	yellow sweetclover	*
	PSTE5	<i>Psoralegium tenuiflorum</i>	slimflower scurfpea	
	TRFR2	<i>Trifolium fragiferum</i>	strawberry clover	*
Fumariaceae	COCU2	<i>Corydalis curvisiliqua</i>	curvepod fumewort	
Grossulariaceae	RIAU	<i>Ribes aureum</i>	golden currant	
	RICE	<i>Ribes cereum</i>	wax currant	
Hydrophyllaceae	ELNY	<i>Ellisia nyctelea</i>	Aunt Lucy	
Juncaceae	JUCO	<i>Juncus compressus</i>	roundfruit rush	*
Lamiaceae	LYAM	<i>Lycopus americanus</i>	American water horehound	
	LYAS	<i>Lycopus asper</i>	rough bugleweed	
	MEAR4	<i>Mentha arvensis</i>	wild mint	
Liliaceae	ALTE	<i>Allium textile</i>	textile onion	
Malvaceae	SPCO	<i>Sphaeralcea coccinea</i>	scarlet globemallow	
Nyctaginaceae	MIHI	<i>Mirabilis hirsuta</i>	hairy four o'clock	
Oleaceae	FRPE	<i>Fraxinus pennsylvanica</i>	green ash	
Onagraceae	OEAL	<i>Oenothera albicaulis</i>	whitest evening-primrose	
	OECU2	<i>Oenothera curtiflora</i>	velvetweed	
	OESU99	<i>Oenothera suffrutescens</i>	scarlet beeblossom	
Plantaginaceae	PLMA2	<i>Plantago major</i>	common plantain	
	PLPA2	<i>Plantago patagonica</i>	woolly plantain	
Poaceae	AGCR	<i>Agropyron cristatum</i>	crested wheatgrass	*
	ARPU9	<i>Aristida purpurea</i>	purple threeawn	
	BOGR2	<i>Bouteloua gracilis</i>	blue grama	
	BRIN2	<i>Bromus inermis</i>	smooth brome	*
	BRJA	<i>Bromus japonicus</i>	Japanese brome	*
	BRTE	<i>Bromus tectorum</i>	cheatgrass	*
	CALO	<i>Calamovilfa longifolia</i>	prairie sandreed	
	ELRE4	<i>Elymus repens</i>	quackgrass	*
	HECO26	<i>Hesperostipa comata</i>	needle and thread	
	NAVI4	<i>Nassella viridula</i>	green needlegrass	

Poaceae	PASM	<i>Pascopyrum smithii</i>	western wheatgrass	
	PHAR3	<i>Phalaris arundinacea</i>	reed canarygrass	*
	PHPR3	<i>Phleum pratense</i>	timothy	*
	POPR	<i>Poa pratensis</i>	Kentucky bluegrass	*
	SPCR	<i>Sporobolus cryptandrus</i>	sand dropseed	
	VUOC	<i>Vulpia octoflora</i>	sixweeks fescue	
Polygonaceae	ERAN4	<i>Eriogonum annuum</i>	annual buckwheat	
	PERSI99	<i>Persicaria</i> sp.	smartweed	*
Rosaceae	PRAM	<i>Prunus americana</i>	American plum	
	ROAR3	<i>Rosa arkansana</i>	prairie rose	
Salicaceae	PODE3	<i>Populus deltoides</i>	eastern cottonwood	
	SAAM2	<i>Salix amygdaloides</i>	peachleaf willow	
	SAEX	<i>Salix exigua</i>	narrowleaf willow	
Scrophulariaceae	VETH	<i>Verbascum thapsus</i>	common mullein	*
Solanaceae	PHLO4	<i>Physalis longifolia</i>	longleaf groundcherry	
Unknown Family	UNKFORB	Unknown forb	unknown forb	*
	UNKGRAM	Unknown graminoid	unknown graminoid	*
	UNKGRAMPER	Unknown perennial graminoid	unknown perennial graminoid	*
Urticaceae	PAPE5	<i>Parietaria pensylvanica</i>	Pennsylvania pellitory	
Verbenaceae	VEBR	<i>Verbena bracteata</i>	bigbract verbena	
Vitaceae	PAVI5	<i>Parthenocissus vitacea</i>	woodbine	

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

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