National Park Service
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Natural Resource Stewardship and Science

Vegetation Classification and Mapping Project Report, Little Bighorn Battlefield National Monument

Natural Resource Report NPS/ROMN/NRR—2012/590

ON THE COVER
Skunkbush Sumac (*Rhus trilobata)*/Bluebunch Wheatgrass (*Pseudoroegneria spicata)* Shrub Prairie (shrub/herbaceous vegetation) being sampled by the vegetation mapping crew in 2006 at Little Bighorn Battlefield National Monument.
Photograph by: B. Schweiger, NPS ROMN

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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.

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Contents

Contents (continued)

Contents (continued)

Page

Figures

Page

Figures (continued)

Page

Tables

Page

Appendices

Page

List of Abbreviations and Acronyms

AA	Accuracy Assessment
BIA	Bureau of Indian Affairs
CBI	Center for Biological Informatics (of the USGS/BRD)
CEGL	Community Element Code
cm	Centimeter(s)
DEM	Digital Elevation Model
EPMT	Exotic Plant Management Team
ESRI	Environmental Systems Research Institute
FGDC	Federal Geographic Data Committee
ft	Foot/Feet
GIS	Geographic Information System
GPS	Global Positioning System
GRKO	Grant Kohrs Ranch National Historic Site
ha	Hectare(s)
in	Inch(es)
IPM	Integrated Pest Management
I&M	Inventory and Monitoring Program
ITIS	Integrated Taxonomic Information System
LIBI	Little Bighorn Battlefield National Monument
m	Meter(s)
MMU	Minimum mapping unit
NAD	North American Datum
NAIP	National Agricultural Imagery Program
NM	National Monument
NPS	National Park Service
NRCS	Natural Resources Conservation Service
NS	NatureServe
NVC	National Vegetation Classification
NVCS	National Vegetation Classification Standard
PI	Principal Investigator
ROMN	Rocky Mountain I&M Network
TNC	The Nature Conservancy
USDA	United States Department of Agriculture
USGS	United States Geological Survey
USNVC	United States National Vegetation Classification
UTM	Universal Transverse Mercator
VMP	Vegetation Mapping Program
WRCC	Western Region Climate Center
WSAL	Wildlife Spatial Analysis Lab, University of Montana

Executive Summary

The vegetation mapping effort at Little Bighorn Battlefield National Monument is part of the National Park Service Inventory and Monitoring program and provides core or 'baseline' information that park managers need to effectively manage and protect park resources. This vegetation inventory was conducted in accordance with specified protocols and quality assurance standards. Data obtained through this inventory are compatible with other efforts, allowing for synthesis and analysis at broader levels. These data comply with standards and protocols of the USGS-NPS Vegetation Inventory Program.

To effectively classify and map the wide range of vegetation within the mapping boundary required a multi-year approach and consisted of several linked phases: (1) vegetation classification using the U.S. National Vegetation Classification applied to field data collected by this project, (2) digital vegetation map production, (3) map accuracy assessment, and (4) revision of vegetation map and production of final products. The project was a cooperative effort between researchers from the University of Montana and National Park Service staff. Constant communication and coordinated efforts between these parties allowed for consistency in both accuracy and classification.

The Little Bighorn Battlefield National Monument lies on the northern Great Plains in southeast Montana. The terrain consists of sloping uplands dissected by narrow eroded draws opening on the floodplain of the Little Bighorn River. The project mapping area is 780 acres (316 ha) and encompasses both the larger Custer Battlefield unit on the northwest end and the smaller Reno-Benteen Battlefield unit to the southeast.

A preliminary list of potential vegetation types was developed from previous descriptive vegetation inventory work in the area. Spectral analysis of aerial imagery from the National Agricultural Imagery Program was used in combination with soils data to delineate the boundaries of polygons with apparently similar vegetation. Because of the small total area of the Monument and limited number of polygons it was decided to census every polygon as to community type rather than sample a subset of polygons and conduct a supervised classification. Polygons were censused by field crews in 2006; crew members assigned each polygon to a vegetation or landcover type from the preliminary list. Accuracy assessment field work in 2007 collected data at 154 sample points which were used to assess the validity of the initial map assignments.

The initial vegetation mapping recognized 27 community types and an additional 3 landcover types. The initial fine-scale classification and mapping scheme had a pooled accuracy rate of only 56.2%. Some of the initial types were similar or overlapping in composition and their dominant or indicator species. The initial classification also used indicator species for some types based on patch dominance rather than stand formation – leading to more detail than could be reliably documented in the accuracy assessment. The original 27 types were aggregated into 22 final map classes representing 15 USNVC plant associations, 4 park-specific vegetation types, and 3 landcover classes. This consolidation resulted in a 78.1% accuracy rate (90% confidence interval 72.1% to 84.1%). Map classes were also assigned to four Ecological Systems; this level of grouping represents the Monument vegetation with an overall map accuracy of 97.9% (90% confidence interval 95.7% to 100%).

The four Ecological Systems are distributed according to the topographic positions. The extensive upland slopes represent Northwestern Great Plains Mixedgrass Prairie. The narrow woody draws dissecting these upland slopes form an example of the Western Great Plains Wooded Draw and Ravine Ecological System. The Little Bighorn River riparian zone belongs to the Northwestern Great Plains Floodplain Ecological System. One minor upland Association of Shrub-Herbaceous Vegetation belongs to the Western Great Plains Badlands Ecological System.

The two most prevalent association level map classes are Bluebunch Wheatgrass - Threadleaf Sedge Herbaceous Vegetation with 339 acres, and Western Wheatgrass - Green Needlegrass Herbaceous Vegetation with 245 acres. These two mixed grass prairie community types occupy most of the upland slopes and comprise 78% of the natural vegetation. Eastern Cottonwood - Green Ash Forest on the floodplain is the third most prevalent community, but at 41 acres it occupies much less area than the upland grass types. The remaining map classes account for areas of a few hundred square meters up to 34 acres.

Products developed for the Little Bighorn Battlefield National Monument Vegetation Classification and Mapping Project described and presented in this report and stored on the accompanying DVD include:

- A Final Report that includes a vegetation key and accuracy assessment information
- A Geodatabase containing digital vegetation map, plots, and accuracy assessment layers
- Field key for association identification and a list of associations present in the mapping area;
- Federal Geographic Data Committee-compliant metadata for all spatial database coverages and field data.

In addition, the NPS and the USGS Center for Biological Informatics (CBI) both received copies of:

- Digital data files and hard copy data sheets of the observation points, vegetation field plots, and accuracy assessment sites;
- Hardcopy, paper vegetation maps.

The DVD accompanying this report contains nine Appendices, metadata files, keys, lists, field data, geospatial data, the vegetation map, graphics, and ground photos. The final products will be available on the USGS website: http://biology.usgs.gov/npsveg/index.html

Acknowledgments

A project of this size and complexity necessarily required the enthusiasm and energy of many people over several years. The dedication of all involved helped to produce a product that we, the authors, gratefully acknowledge. The combination of ecologists, geographers, botanists and natural resource professionals in all the cooperating agencies and organizations allowed for a successful work environment that enhanced the final set of products.

We would specifically like to thank the following people for their efforts: Melana Stichman, for her support, input and field contributions throughout the project and for her patience as we completed the final products. Karl Brown and Tammy Cook provided guidance and advice on vegetation mapping and the NPS Vegetation Inventory Program. Finally, Carl and Jane Bock shared their knowledge of the vegetation ecology of Little Bighorn Battlefield National Monument and assisted with the accuracy assessment.

The field vegetation mapping and initial data processing was conducted by Tonya Vowles and Teresa Ponikvar with students at the University of Montana. They proceeded with enthusiasm and great initiative under often inclement weather conditions and prodigious swarms of mosquitos.

Thanks to Kristin Long and Laura Atkinson for assistance with figures, GIS and editing.

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Comments and suggestions from Sarah Studd (NPS, Sonoran Desert Network), who graciously agreed to peer review this report, were very helpful and used to improve report content.

Introduction

Effective management of natural resources in our national parks depends on park managers having access to comprehensive, scientifically credible information on species and habitats found in their parks. Accurate and up-to-date vegetation maps can form the foundation for resource management activities in the national parks and are recognized by the National Park Service (NPS) Inventory & Monitoring Program as one of twelve basic data sets for every park with significant natural resources (Fancy 2009). Activities as diverse as park planning, fire management, wildlife research, habitat conservation/restoration, and visitor interpretation all can be informed by current maps of vegetation distribution. Additionally, a vegetation map attributed to a standard, nationally used classification system provides a way to assess how an individual park's biodiversity fits into the context of the entire region. Finally, the associated information provide a structure for framing and answering critical scientific questions about vegetation communities and their relationship to environmental processes across the landscape.

This report presents the final products from a five year effort to classify and map the vegetation at Little Bighorn Battlefield National Monument (LIBI) in southeast Montana. Project methods, results, and products are documented in this report. This introductory section describes the USGS-NPS Vegetation Mapping Program, as well as the LIBI mapping project area. Later sections document the methods and results for each of the major steps in the project: scoping, vegetation classification and description, vegetation mapping, and map accuracy assessment.

The project was conducted by the NPS Rocky Mountain Network (ROMN), the University of Montana, LIBI park staff, and personnel from the USGS-NPS Vegetation Characterization Program. This report includes the final map (also available separately in a larger format). A project DVD that contains all products, including a geodatabase with the final data is included in select copies of this report. All materials will be available on the USGS-NPS Vegetation Characterization Program website (http://biology.usgs.gov/npsveg/index.html) and from the Rocky Mountain Network upon request.

USGS-NPS Vegetation Characterization Program

In 1994, the U.S. Geological Survey and National Park Service formed a partnership to classify, describe, and map vegetation communities in more than 280 national park units across the United (FGDC 1997, Grossman et al. 1998). The USGS-NPS Vegetation Characterization Program (referred to herein as the Vegetation Mapping Program, or VMP) is both the first to provide national-scale descriptions of vegetation for a Federal agency and the first to create national vegetation standards for its data products using the National Vegetation Classification Standard.

National Vegetation Classification

The USGS-NPS Vegetation Mapping Program adopted the U.S. National Vegetation Classification (USNVC or NVC, TNC and ESRI 1994a, Grossman et al. 1998) as a basis for the *a priori* definition of vegetation units to be inventoried. The use of standard national vegetation classification and mapping protocols (TNC and ESRI 1994b) facilitate effective resource stewardship by ensuring compatibility and widespread use of the information throughout the NPS as well as by other federal and state agencies.

The USNVC has the following key attributes:

- It is based upon current vegetation;
- It uses a systematic approach to classify vegetation communities across environmental continuums;
- It emphasizes natural and existing vegetation;
- It uses a combined physiognomic-floristic hierarchy;
- It identifies vegetation units based on both qualitative and quantitative data;
- It is appropriate for mapping at multiple scales.

In 1997, the Federal Geographic Data Committee (FGDC) adopted a modified version of the upper (physiognomic) levels of the USNVC as a federal standard (FGDC-STD-005, FGDC 1997). This standard is hereafter termed the National Vegetation Classification Standard (NVCS)[1]. The NVCS established a federal standard for a complete taxonomic treatment of vegetation in the United States at physiognomic levels (Table 1). It also established conceptual taxonomic levels for the floristic units of alliance and association, largely following the USNVC, but did not offer a taxonomic treatment for the floristic levels because of the immense scope of establishing robust floristic units for the entire United States. The FGDC standard requires that federally funded vegetation classification efforts collect data in a manner that enables crosswalking the data to the NVCS (i.e., the physiognomic levels) and sharing between agencies, but does not require use of that standard by agencies for internal mission needs. A 2008 NVCS revision (Version 2; FGDC 2008) was adopted by the FGDC in February 2008. However, the substantial revisions to the upper levels of the USNVC hierarchy accepted by the FGDC Vegetation Subcommittee (2008) are not used in this project. This has no practical impact on the content of the map or the classification of the vegetation in the park as presented in this report. It does mean that there may be some upper levels of a more current classification system that might not perfectly cross walk to those used in this report. Any future updates should include a more current USNVC hierarchy.

NatureServe maintains a treatment of floristic units (alliances and associations), which, though not a federal standard, are used as classification and mapping units by the VMP whenever feasible. This database is available online through NatureServe Explorer which provides public access to regularly updated versions of the USNVC plant community listings and descriptions. NatureServe's documentation of alliances and associations is the most accessible national listing currently available. However, the plant communities within the USNVC are not complete. Projects such as at LIBI constantly add to the documentation and listing of USNVC types. It is important to note that NatureServe, follows Kartesz (1999) as its primary nomenclatural authority. As a result, nomenclature used in final map unit names also follows Kartesz (1999),

[1] The VMP program standards refer to the National Vegetation Classification System (also NVCS). Because of nomenclatural and acronym confusion with the federal (FGDC) National Vegetation Classification Standard, this term is no longer used by the VMP.

whereas species names in the text are those used by LIBI staff, generally according to Dorn (1984).

Table 1. The 1997 U.S. National Vegetation Classification physiognomic-floristic hierarchy for terrestrial vegetation (FGDC 1997; Grossman et al. 1998). Examples are taken from LIBI.

Level	Primary Basis for Classification	Example
Class	Growth form and structure of vegetation	Herbaceous Vegetation
Subclass	Growth form characteristics, e.g., leaf phenology	Perennial graminoid vegetation
Group	Leaf types, corresponding to climate	Temperate or subpolar grassland with a sparse shrub layer
Formation	Additional physiognomic and environmental factors	Medium-tall temperate or subpolar grassland with a sparse needle-leaved or microphyllous evergreen shrub layer
Alliance	Dominant/diagnostic species of the uppermost or dominant stratum	*Artemisia tridentata ssp. wyomingensis* shrub herbaceous
Association (Plant Association)	Additional dominant/diagnostic species from any stratum	*Artemisia tridentata ssp. wyomingensis / Pascopyrum smithii* Shrub

For purposes of this document, the federal standard (FGDC 1997) is denoted as the National Vegetation Classification Standard (NVCS); the U.S. National Vegetation Classification (USNVC or NVC) will refer exclusively to NatureServe's treatment for vegetation floristic units (alliances and associations only). Alliances and associations are based on both the dominant (greatest canopy cover) species in the upper strata of a stand as well as on diagnostic species (those consistently found in some types but not others). Associations are the most specific classification unit and are hierarchically subsumed in the alliances. Each association is included in only one alliance, while each alliance typically includes many associations. Alliance names are generally based on the dominant/diagnostic species in the uppermost stratum of the vegetation, though up to four species may be used if necessary to define the type. Associations define a distinct plant composition which repeats across the landscape and are generally named using both the dominant species in the uppermost stratum of the vegetation and one or more dominant species in lower strata, or a diagnostic species in any stratum. The species nomenclature for all alliances and associations follows that of Kartesz (1999). Documentation from NatureServe (2007) describes the naming and syntax for all USNVC names:

- A hyphen ("-") separates names of species occurring in the same stratum.
- A slash ("/") separates names of species occurring in different strata.
- Species that occur in the uppermost stratum are listed first, followed successively by those in lower strata.
- Order of species names generally reflects decreasing levels of dominance, constancy, or indicator value.

- Parentheses around a species name indicates the species is less consistently found either in all associations of an alliance, or in all occurrences of an association.
- Association names include the dominant species of the significant strata, followed by the class in which they are classified (e.g., "Forest," "Woodland," or "Herbaceous Vegetation").
- Alliance names also include the class in which they are classified (e.g., "Forest," "Woodland," "Herbaceous"), but are followed by the word "Alliance" to distinguish them from associations.

In addition to the USNVC, NatureServe has created a standardized Terrestrial Ecological Systems Classification for describing sites based on both the vegetation and the ecological processes that drive them. Ecological systems are mid-scale biological communities that occur in similar physical environments and are influenced by similar dynamic ecological processes, such as fire or flooding (Comer et al. 2003). They are not conceptually a unit within the USNVC and do not have a place in the USNVC hierarchy, although they are similar in scale to the NVCS Version 2 Group Level. Because the ecological system concept has proved useful in work done by the ROMN across all network parks, we choose to include them at LIBI. Each ecological system is directly linked to USNVC by a list of core associations that occur within it. Unlike within the structure of the hierarchical USNVC where each association occurs in only one alliance, an association may occur in more than one ecological system, limited only by the range of ecological settings in which it is found. Ecological systems are much larger in scale than the map classes used at LIBI; they are broader in concept and include specific associations that might be found in a particular setting.

Standards

The NPS I&M Program established guidance and standards for all vegetation mapping projects in a series of documents. Specific projects may vary from these standards as noted (i.e., at LIBI we use Kartesz (1999) for vegetation names but do crosswalk to ITIS). These documents are available on the USGS-NPS Vegetation Program web site (http://biology.usgs.gov/npsveg/standards.html):

Protocols

- National Vegetation Classification System (TNC and ESRI 1994, NatureServe 2003a)
- Field methods and mapping procedures (TNC and ESRI 1994)
- Statistically rigorous and consistent accuracy assessment procedures (ESRI et al. 1994)
- Guidelines for using existing vegetation data (TNC 1996)

Standards

- National Vegetation Classification Standard (FGDC 1997)
- Spatial Data Transfer Standard (FGDC 1998b)
- Content Standard for Digital Geospatial Metadata (FGDC 1998a)

- United States National Map Accuracy Standards (USGS 1999)
- Integrated Taxonomic Information System (ITIS)
- Program-defined standards for map attribute accuracy and minimum mapping unit

In addition to vegetation classification, the FGDC sets standards for map spatial accuracy and for metadata employed in NPS vegetation mapping projects. Standards for map products stipulate map scales of 1:24,000 or finer, and minimum polygon size of 0.5 ha (1.24 acres). Positional accuracy for vegetation maps must meet National Map Accuracy Standards, which specify horizontal errors of less than 10.2 m (33.5 ft) on the ground for 1:12,000-scale maps.

All digital vegetation products resulting from this project are accompanied by FGDC-compliant metadata. Metadata are "data about the data," and describe the content, quality, condition, and other characteristics of the spatial dataset. Metadata are critical elements that expedite the interpretation and exchange of information among users.

Project Area Description

Setting and Location

Little Bighorn Battlefield National Monument commemorates one of the most famous battles in American history. On this site in June 1876, the 7th Calvary forces of Lieutenant Colonel George Armstrong Custer were decimated by combined Lakota Sioux, Cheyenne, and Arapaho warriors during the Battle of the Little Bighorn. The park interprets this battle, as well as westward expansion and settlement of the U.S., and its effects on the Great Plains tribes.

The Monument is in southeast Montana approximately 55 miles southeast of Billings, the largest regional city, and approximately 13 miles southeast of Hardin the largest proximal town (Figure 1). LIBI officially encompasses 765 acres (309 ha); the mapped acreage is slightly larger (780 acres, 316 ha) due to small edge polygons resulting from the mapping procedure. The Monument has two separate units connected by four miles of a narrow two-lane tour road (Figure 2). The larger Custer Battlefield unit is on the northwest end and contains the Custer National Cemetery. The smaller Reno-Benteen Battlefield unit is to the southeast. The landscape is characterized by rolling hills covered by grasslands and shrublands interspersed with pockets of junipers. The meandering Little Bighorn River is a prominent feature of the adjacent floodplain below the western boundary of the Monument.

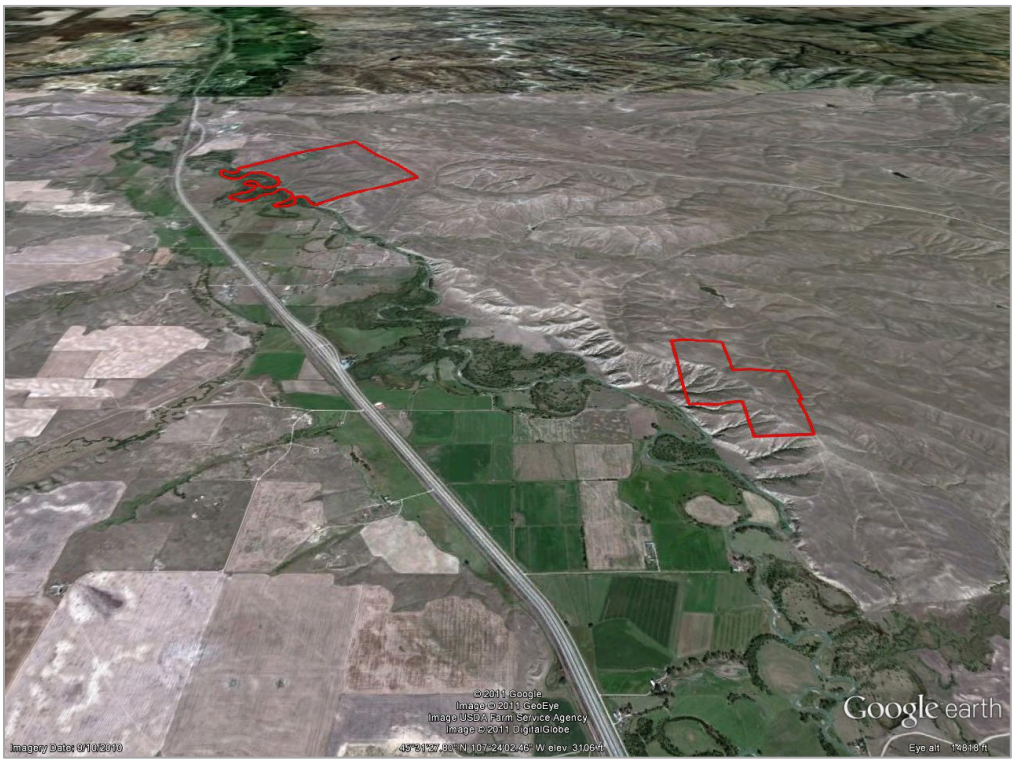
Settlement History and Land Use

The Little Bighorn area of southeastern Montana has been home to various Native American tribes since prehistoric times (Greene 2008). Archaeological evidence suggests that human activities have taken place in the region for the last 10,000 years. Throughout most of that time, people using the area practiced a highly mobile hunting and gathering subsistence. Nomadic tribes demonstrating a bison-centered lifestyle characterize the historic period beginning around 200 years ago. The Apsáalooke people entered the area by the early1800s, seeking access to rich bison hunting grounds of the Little Bighorn valley. Buffalo terraces -- parallel trails following the contours of hillsides compacted in the soil following centuries of buffalo grazing -- are still visible in the area today (NPS 2010). Although the Little Bighorn was acquired by the United States as part of the Louisiana Purchase in 1803, few whites, aside from sporadic traders and explorers, ventured into the area before the late 1800s.

The Crow Indian Reservation was established by the Treaty of 1851. Custer Battlefield National Cemetery was established in 1879 by General Orders Number 79 to protect the graves of Seventh Cavalrymen who fell in the Battle of the Little Bighorn. Later, as the frontier era came to a close, the role of the cemetery expanded. In 1886 the boundary was established, setting aside one square mile within the Crow Reservation for military purposes. In 1926 an Act was passed authorizing the acquisition of the Reno-Benteen site (Greene 2008). The War Department managed the two sites until 1940 when they became part of the National Park Service. In 1991, the name changed to Little Bighorn Battlefield National Monument and the cemetery was renamed Custer National Cemetery.

Figure 1. General location of Little Bighorn Battlefield National Monument in southeastern Montana.

(a)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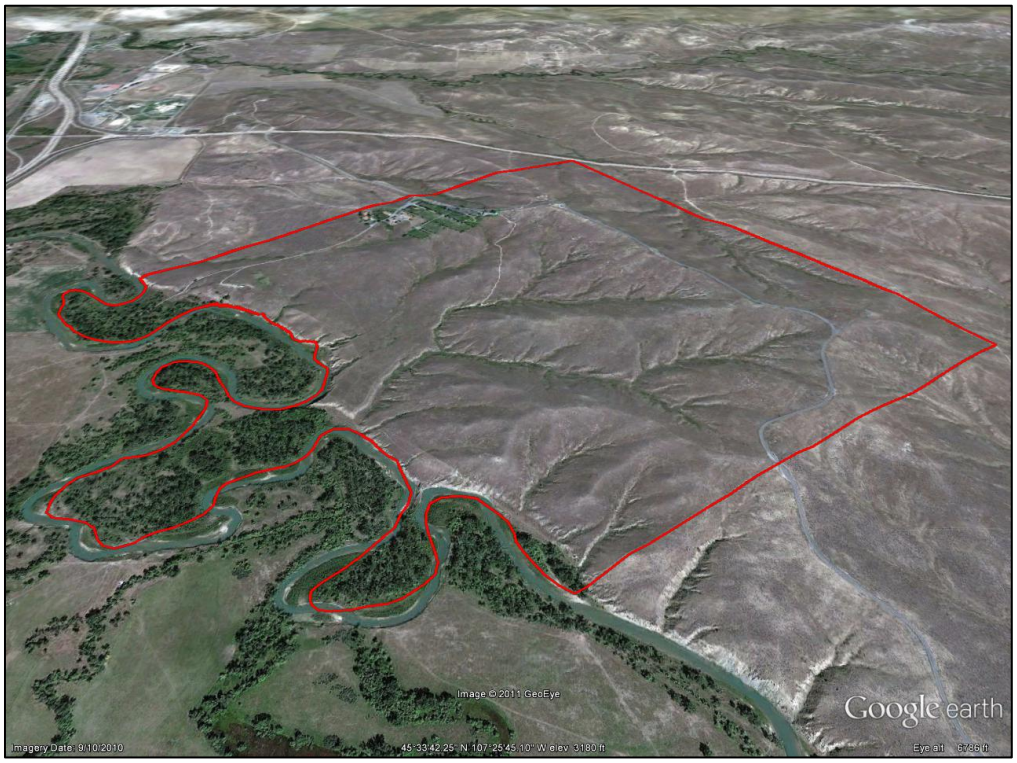
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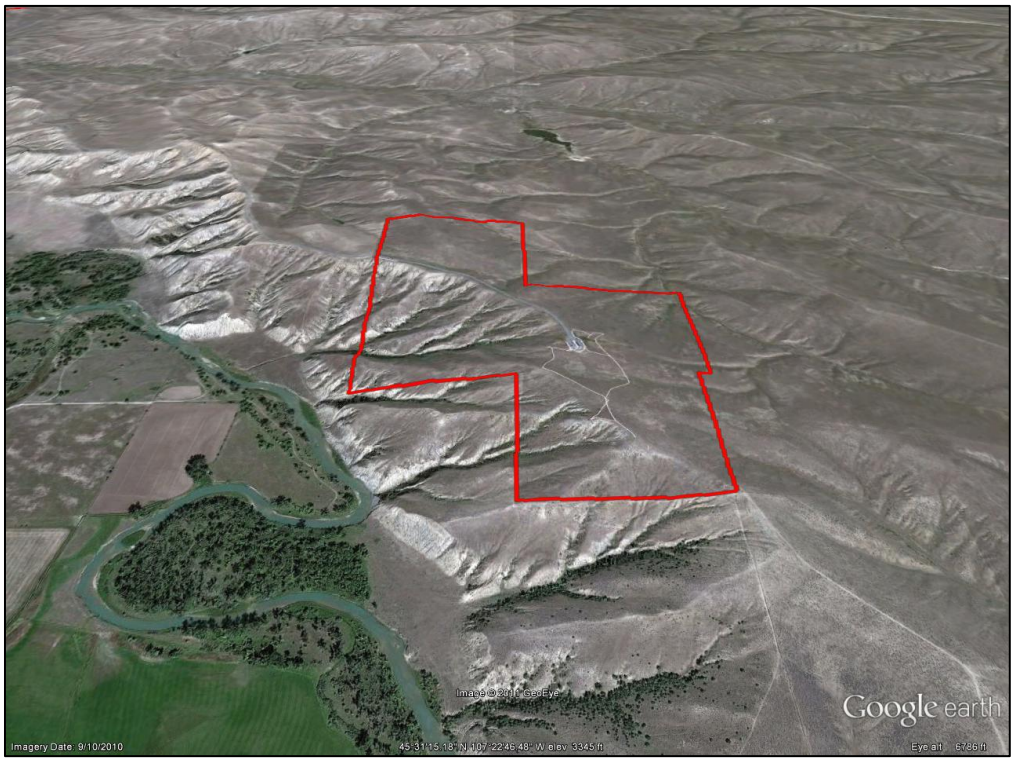


Figure 2. Little Bighorn Battlefield National Monument viewshed (oblique, looking north) (a) the Custer and Reno-Benteen Battlefield units, (b) close up of the Custer Battlefield unit, (c) close up of the Reno-Benteen Battlefield. Scenes are from Google Earth on early fall, 2010 imagery.

Current land-use activities in LIBI are related to visitation, which peaks in July and August, with an annual average of nearly 320,000 visitors during the past five years (NPS 2011). The monument has a visitor center, several administrative buildings and residences, numerous cultural features, three trails, and several kilometers of roads. Grazing has been excluded from the Custer Battlefield since 1891 and from the Reno-Benteen Battlefield since 1954. Since the Custer Battlefield boundary fence is on the bluffs, grazing occurs occasionally between the Little Bighorn River and the fence. The primary land use in the reservation surrounding LIBI is irrigated agriculture along the valley floor for cultivation of alfalfa, pasture grass, corn, and sugar beets (Tuck 2003). The higher terraces and foothill areas are primarily used as rangeland for horses and cattle.

Topography, Geology and Soils

Various geomorphic landforms dominate the landscape of Little Bighorn Battlefield National Monument. The primary form consists of ridges dissected by ravines and coulees. “Coulee” is a French term applied in the western United States to a small stream (or the bed of such a stream) that is often intermittent. During the Battle of the Little Bighorn, ridges provided views across the broad valley and defensible high ground for soldiers of the 7th Cavalry. Ravines and coulees, which cut into the ridges, allowed for the secluded advance of Indian attackers. The steep banks on the east side of the Little Bighorn River form an abrupt edge, limiting access (and escape) from the floodplain. Some of the most conspicuous topographic features are the prominent stream terraces, which primarily line the west side of the Little Bighorn River valley. Unlike the

ridges and coulees, these features did not figure significantly in the actions taken during the Battle of the Little Bighorn. However, the flat-topped terraces that sit above the Little Bighorn River served as suitable camping grounds for the warriors and their families at the time of the battle.

Elevation in the Monument ranges from approximately 915 m (3,000 ft) near the river, to 1,035 meters (3,400 ft.) at higher points of the Reno-Benteen unit. The topography of the site supports several non-perennial streams (NPS 2010). The transition between the uplands and Little Bighorn River floodplain at the Custer Battlefield unit is abrupt, with steep cliffs along most of the southwest boundary. These cliffs are maintained by natural erosion processes. Small ravines start on the upper slopes, run to the southwest, and are deeply cut by the time they reach the floodplain. The Reno-Benteen Battlefield unit is entirely in the uplands.

The uplands are formed in the Cretaceous Bearpaw and Judith River formations (Figure 3). The higher elevation Bearpaw Formation to the northeast is a marine sedimentary rock, primarily shale, while the lower uplands to the southwest are part of the sedimentary late Cretaceous Judith River Group (Vuke et al. 2000a and b, NPS 2006b). The Judith River Formation can contain fossilized dinosaurs. Along the floodplain, the Cretaceous sediments are covered by Quaternary alluvium composed of unconsolidated gravel, sand, silt, and clay (Figure 4). The alluvium, which typically is less than 9 m thick, forms the principal aquifer in the Little Bighorn River basin (Tuck, 2003). Upland soils range from deep to very shallow, and from clay to loamy fine sands. Silty clay loams are the predominant texture class. Across both units the lower slopes and shales have deep soils, which are prone to both wind and water erosion (NPS 2006a, 2007).

The bedrock that underlies LIBI represents sediments originally deposited in a seaway that inundated North America from the Arctic to the Tropics. Vuke et al. (2000a, 200b) mapped six Upper Cretaceous formations in the vicinity of the Monument. Of the six Upper Cretaceous units, only the Bearpaw and Judith River formations are exposed in the national monument. More recent units deposited during the Quaternary Period (the past 2.6 million years) are terrace and landslide deposits and alluvium; however, no landslide deposits occur within the national monument.

Biogeography

LIBI lies close to the western boundary of the Unglaciated Missouri Plateau section in the northern part of the Great Plains physiographic province, near its border with the Middle Rocky Mountains province to the west. The Great Plains province extends from Mexico to Canada east of the Rocky Mountains, and encompasses more than 137 million ha (529,000 mi^2), including a substantial portion of eastern Montana. This province can be characterized as a fairly uniform eastward-sloping surface formed by sediments that have eroded from the Rocky Mountains, beginning about 65 million years ago (Vigil et al. 2000). Within the unglaciated portion of the Missouri Plateau section, landforms are dominated by older plateau surfaces, with terraced uplands, local badlands, and isolated mountains. Native vegetation of the Great Plains is dominated by grasses and shrubs, except where river courses or favorable local conditions permit the establishment of trees (Vigil et al. 2000).

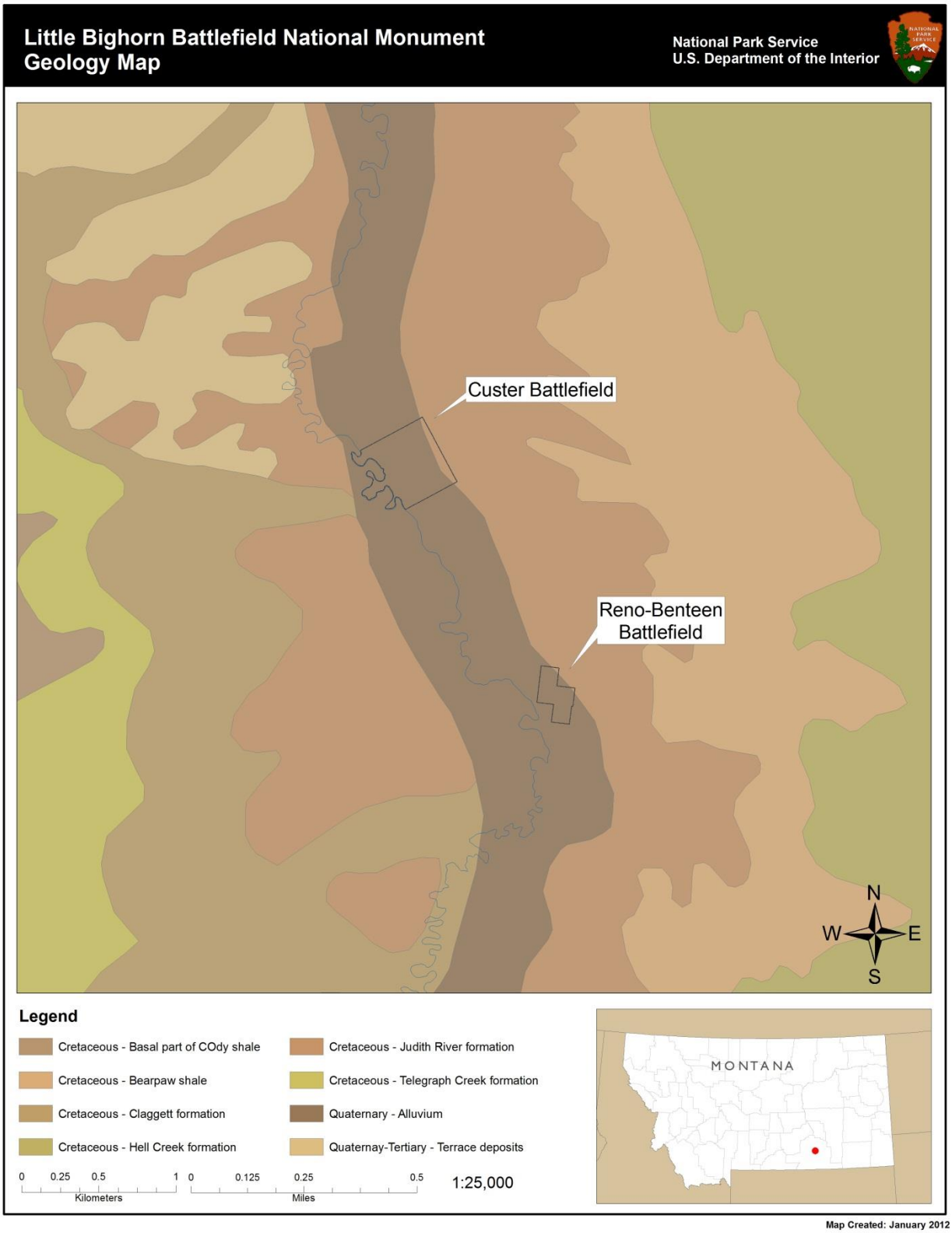


Figure 3. Surficial geology at Little Bighorn Battlefield National Monument (KellerLynn 2011).

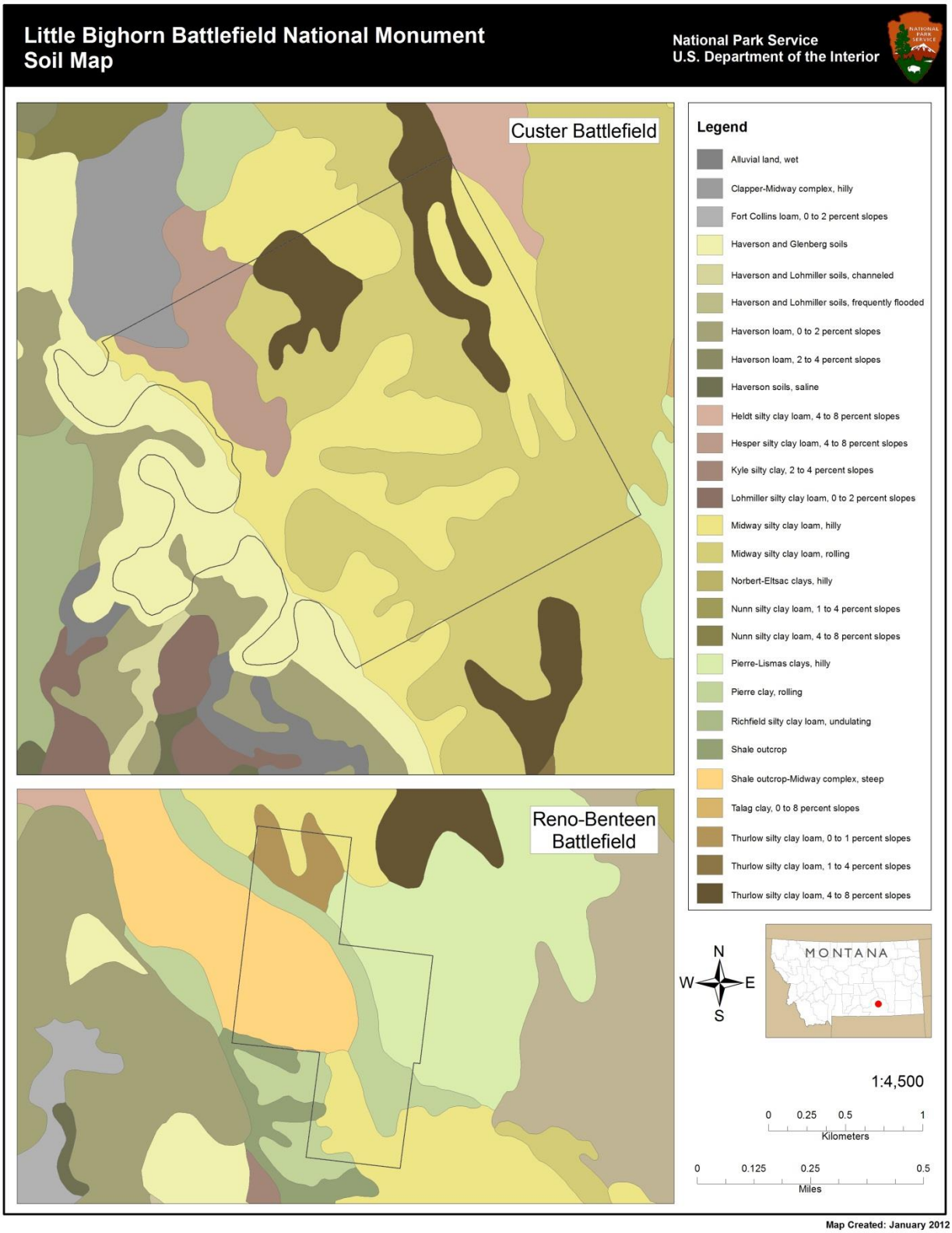


Figure 4. Soils at Little Bighorn Battlefield National Monument (NRCS 2003).

Climate

The climate of LIBI is typical of colder short-grass prairies in the Great Plains province. Climatic data were recorded at the Crow Agency station located north of LIBI between 1898 and 1991 (Western Regional Climate Center 2011). Mean monthly air temperatures for this period of record ranged from -6.8°C (19.7°F) in January to 22.2°C (71.9°F) in July. Average annual precipitation for the same period was 39 cm (15.4 in), with May and June being the wettest months. The area receives about 105 cm (41 in) of snowfall each year between October and April. Figure 5 gives average monthly temperature and precipitation for a subset of this period (1971 – 2000).

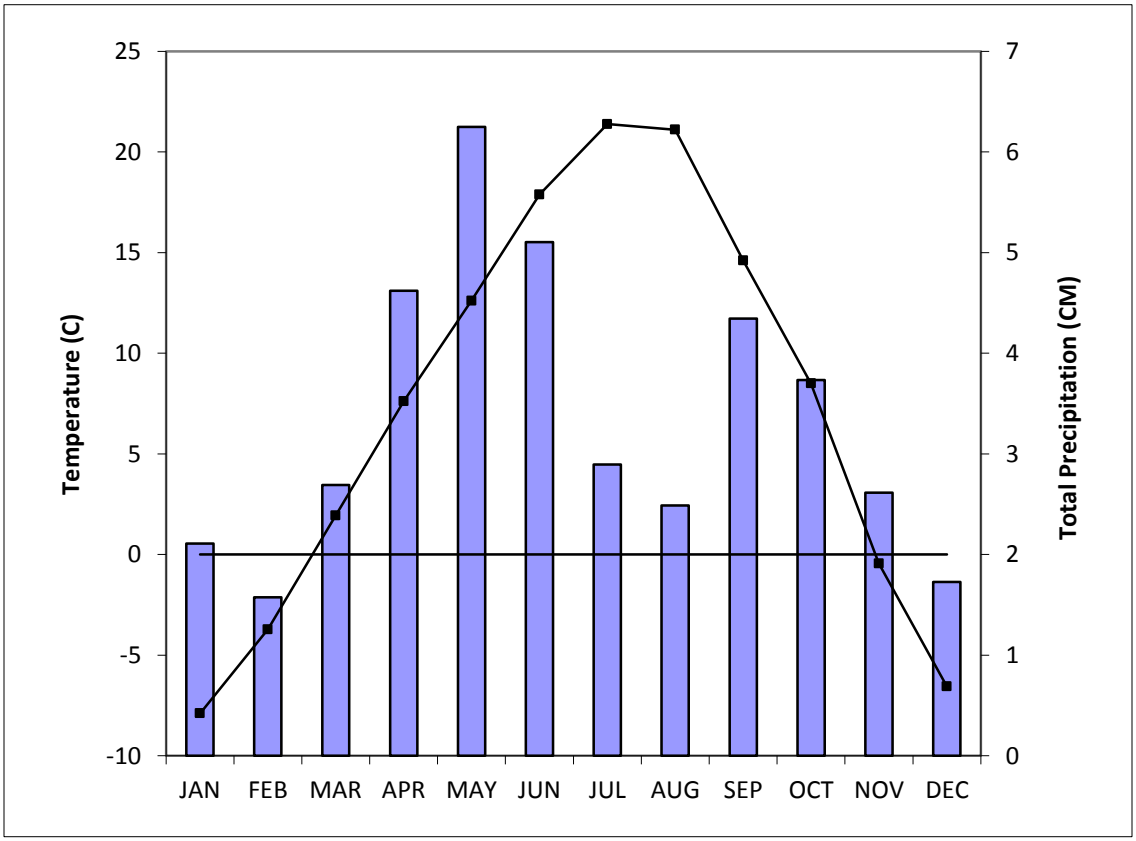


Figure 5. Monthly mean precipitation (bars) and temperature (line) over 1971-2000 at Little Bighorn. Data are from Crow Agency (WRCC 2011).

Hydrology and Water Resources

LIBI is situated along the lower reaches of the Little Bighorn River, which drains an area of about 3,370 km2 (see Figure 1). The river originates in the Bighorn Mountains in Wyoming and flows north for a distance of about 130 km (80 mi) through foothills and a broad alluvial valley. Lodge Grass and Pass creeks are the main perennial tributaries and Owl and Reno creeks are the largest ephemeral tributaries. The monument sits on terraces above the floodplain of the Little Bighorn River. A small area (approximately 0.20 km^2) along the western boundary of the monument extends onto the floodplain of the river, with the legal park boundary designated by the high water mark on the right (or east) bank of the river. There are no perennial or ephemeral streams flowing through the monument. There are several ephemeral springs and at least one alkaline seep in the Custer unit.

LIBI water rights allow the park to divert water from the river for fire suppression and for limited consumptive use via groundwater well only. LIBI obtains drinking water from an in-park, potable (chlorinated and filtered) water system (supplied from the Little Bighorn) and wastewater is handled by the septic and leach system which is located southwest of the maintenance shop. The Little Bighorn River is also a key lifeline of the Little Bighorn Valley and the Crow Reservation. It is an important source of water for irrigation in the valley and as a water supply for many towns including Lodge Grass and Crow Agency. It is also a key source of recreation, including fishing and rafting.

The USGS has operated as many as seven streamflow-gauging stations in the Little Bighorn River basin (USGS 2012); only four of these stations were active as of 2008. The NPS operated a stream-flow gauging station on the Little Bighorn River along the western edge of the monument until 2008. Discharge at the NPS station from 1999-2005 ranged from a low of about 2 m^3/second in September to around 6 m^3/second in May and June during snowmelt. Intense rainstorms and saturated or frozen soils are additional factors contributing to high runoff during the spring. Streamflow decreases rapidly through July and is lowest in August and September because of low precipitation rates and high rates of evapotranspiration. During summer months, water also is diverted from the river for irrigation.

Historic water-quality data for the Little Bighorn River adjacent to the monument are reported in Mast (2007). River water was fairly concentrated and well buffered with nutrient concentrations low and close to laboratory reporting limits, except for those sample events collected during very high flows when elevated nitrogen, phosphorous and suspended sediments levels may be caused by runoff from agricultural areas upstream from the park. The Little Bighorn River is classified as under the Administrative Rules of Montana section 17.30.624 as B-2, which is surface water suitable for domestic water supply, recreation, aquatic life (salmonid fishes), and agricultural and industrial water supply. No stream reaches in this segment are on the most recent 303(d) list for the State of Montana (Montana Department of Environmental Quality 2010). None of the samples analyzed in Mast (2007) had constituent concentrations that exceeded state water-quality standards.

Vegetation

The uplands areas of LIBI consist of relatively intact native mixed-grass prairie. The narrow ravines dissecting the uplands form a favorable microclimate for woody vegetation and are termed woody draws. The Little Bighorn River floodplain is dominated by native riparian trees and shrubs. The Monument also has urban park-like landscaped areas that encompass Custer National Cemetery and various buildings. Major factors affecting the native vegetation are wildfire and fire suppression, lack of intensive grazing on the native grass prairie, flow regulation of the Little Bighorn River, erosion, and a moderate level of exotic plant invasion (Britten et al. 2007).

The upland grassland dominants (Figure 6) include bluebunch wheatgrass (*Agropyron spicatum = Pseudoroegneria spicata*[2]) and rhizomatous western wheatgrass (*Agropyron smithii = Pascopyrum smithii*). Needle and thread grass (*Stipa comata = Hesperostipa comata*), green needlegrass (*Stipa viridula = Nassella viridula*), and prairie sand reedgrass (*Calamovilfa*

[2] We list nomenclature from Dorn (1984) followed by Kartesz (1999) where they are different. See Appendix A.

longifolia) are common in more clumped distributions. Several short graminoids are common but occur with low cover values and even more patchy distributions; these include threadleaf sedge (*Carex filifolia*), sideoats grama (*Bouteloua curtipendula*), and blue grama (*Bouteloua gracilis*). Two exotic annual bromes, cheatgrass (*Bromus tectorum*) and Japanese brome (*B. japonicus, B. arvensis)* are frequent in these uplands. Select forbs occur in the understory of the grasses, including prairie coneflower (*Ratibida columnaris*) and narrow-leaf coneflower (*Echinacea angustifolia*).

Photograph by: B. Schweiger, NPS ROMN

Figure 6. Bluebunch Wheatgrass - Threadleaf Sedge Mixed Prairie (*Pseudoroegneria spicata - Carex filifolia* Herbaceous Vegetation*).* Upright prairie coneflower *(Ratibida columnaris)* in foreground*.*

Wyoming big sagebrush (*Artemisia tridentata* ssp. *wyomingensis*) is the most abundant upland shrub. However, vegetation monitoring done over a two decade period by Bock and Bock (2006) after a 1983 wildfire in the Custer unit and a 1991 wildfire in the Reno-Benteen unit did not document any reestablishment of big sagebrush in the burn zones. Bock and Bock (2006) concluded that the current presence of big sagebrush is a Native American grazing-era disclimax. NPS crews located juvenile sagebrush in 2007 immediately adjacent to the remnant stand of mature plants in the NE portion of the Custer Unit – survival and current status is unknown. Native American horse herds made extensive use of this area in the Nineteenth Century. Black greasewood (*Sarcobatus vermiculatus*) and skunkbush sumac (*Rhus trilobata* (syn*. aromatica*)) are common as scattered individuals or in low co ver clumped distributions (Figure 7).

Photograph by: B. Schweiger, NPS ROMN

Figure 7. Skunkbush Sumac / Bluebunch Wheatgrass Shrub Prairie (*Rhus trilobata* / *Pseudoroegneria spicata* Shrub Herbaceous Vegetation) being sampled by the vegetation mapping crew in 2008.

Woody draws can support small stands of western snowberry (*Symphoricarpos occidentalis*), Rocky Mountain juniper (*Juniperus scopulorum*), common chokecherry (*Prunus virginiana*), and box elder (*Acer negundo*). The transition zone from the lowest reaches of the woody draws to the floodplain can support more dense green ash (*Fraxinus pennsylvanica*) and choke cherry (*Prunus virginiana*) (Figure 8 – taken in a partially decadent stand at the Reno-Benteen unit).

Photograph by: B. Schweiger, NPS ROMN

Figure 8. Green Ash / Choke Cherry Wooded Draw (*Fraxinus pennsylvanica / Prunus virginiana* Forest). Crews pictured are ROMN monitoring field staff. Site is at the Reno-Benteen unit.

The largest dominants on the floodplain (Figure 9) are green ash along with eastern or Great Plains cottonwood (*Populus deltoides*). Common chokecherry (*Prunus virginiana*) and box elder (*Acer negundo*) are common. Diagnostic short, woody species on the floodplain include silver sage (*Artemisia cana*), silver buffaloberry (*Shepherdia argentea*), and sandbar or coyote willow (*Salix exigua*). The exotics salt cedar (*Tamarix* sp.) and Russian olive (*Elaeagnus angustifolia*) have made a few small inclusions on the floodplain.

Photograph by: B. Schweiger, NPS ROMN

Figure 9. Cottonwood - Green Ash Floodplain Forest (*Populus deltoides - Fraxinus pennsylvanica Forest*) as viewed from the Little Bighorn River in 2011.

Exotic Plant Management

Exotics within the natural prairie at LIBI did not become a concern until the early 1990s. Since this time LIBI Facility Management staff, with BIA & Crow Tribe assistance, have managed weed species including St. Johnswort (*Hypericum perforatum*), spotted knapweed (*Centaurea biebersteinii*), and Dalmatian toadflax (*Linaria dalmatica*) along roads and within the prairie. Systematic management efforts using pesticides ceased in the mid-1990s when new state and federal documentation requirements became effective.

Under the formal guidance of the Natural Resource Challenge issued in 1999, Yellowstone National Park, Bighorn Canyon National Recreation Area and NPS Exotic Plant Management Teams (EPMTs) aided LIBI employees in sporadic treatments using chemicals, mechanical tools, and by hand pulling. Efforts focused on treatment and restoration as well as prevention. Seed (species unknown) and matting were laid at the Tour Road pullouts when curbing was established in the mid-1980s. Throughout the 1980s and 1990s unimproved trails were closed periodically at the discretion of the Superintendent, to protect the resource. Visitor access was restricted to roads and improved trails in 2000, when improved trails opened permanently. Although intended to protect the cultural resources of the Monument, access restrictions also helped to prevent the spread of exotic species. Unfortunately, when the Indian Memorial was constructed in 2003, soil brought in from outside the park carried Russian knapweed (*Acroptilon repens*), a species which had not been seen in the park previously. Although native seed was planted in the areas disturbed by the Indian Memorial construction, other sites are believed to

have been cultivated with the non-native crested wheatgrass (*Agropyron cristatum*). EPMTs continue to assist with exotic species management. A team visits once annually to monitor and treat infestations as well as provide recommendations to park management. The park continually works with EPMTs to refine control methods for greater environmental soundness, effectiveness, and efficiency.

The LIBI Natural Resources program was established in 2004 through Visitor Use Fees. Natural Resources initiated exotic species management targeting state-listed species (noxious weeds) throughout the park's road and trail system, building network, and disturbed sites. During the program's first year, Montana State University completed a baseline survey inventorying several other non-native plants including Japanese brome (*Bromus japonicus*), cheatgrass (*Bromus tectorum*), field bindweed (*Convolvulus arvensis*), houndstongue (*Cynoglossum officinale*), whitetop (*Cardaria draba*), and thistles. Bulbous bluegrass (*Poa bulbosa*) was first documented in 2003 in isolated areas in Custer Battlefield. A 2011 survey shows bulbous bluegrass is very widespread in the northeastern portion of the Custer Battlefield and there are a few occurrences along the Tour Road and in the Reno-Benteen Battlefield. Weeds, including yellow sweetclover (*Melilotus officinalis*) and smooth brome (*Bromus inermis*), most likely were present since the late 1800s, and goatsbeard (*Tragopogon dubius*) since the early 1900s. Other non-natives such as various ornamental trees have been planted in the cemetery. Tatarian honeysuckle (*Lonicera tatarica*), Canada thistle (*Cirsium arvense*), Russian olive (*Elaeagnus angustifolia*), and salt cedar (*Tamarix chinensis*) occur in the riparian area of the park. During 2007-2008 a coordinated effort with the EPMT resulted in treating over 3 acres of Russian olive and salt cedar.

In 2007, an effort began to develop an invasive plant management plan and associated environmental assessment for 10 small parks within the northern Rocky Mountains (including LIBI). Under this plan, resource managers identify high priority invasive species for treatment, determine what treatments are feasible to reduce the number of or population of plants, identify the most reasonable management strategy or strategies, and then select the most appropriate treatment option or combination of treatments to minimize potential impacts and maximize overall management success (NPS 2011). A Finding of No Significant Impact was signed in 2011 for the invasive plant management plan environmental assessment.

Methods

The basic set of tasks for the LIBI Vegetation Classification and Mapping Project included planning and scoping, collecting and analyzing existing data, photo interpretation, development of a vegetation classification, development of a sample design, field work, data input, accuracy assessment and analyses, and final map interpretation and cartography. These tasks necessarily interacted with one another throughout the entire process.

Planning and Scoping

The Rocky Mountain Network (including park representatives) decided in early 2006 to fund and administer the two remaining Vegetation Mapping projects for the network (LIBI and Grant Kohrs Ranch National Historic Site, GRKO). This decision was supported by the national Vegetation Mapping Program and included an informal agreement that staff from the national program would assist on select items within the projects. The ROMN entered into a cooperative agreement with Peter Rice from the University of Montana and Will Gustafson from the University's Wildlife Spatial Analysis Lab (WSAL) in the spring of 2006. Peter Rice served as the lead principal investigator (PI) for the project, with a primary focus on the vegetation classification effort and running the field crews. Remote sensing and most initial GIS tasks within the project were assigned to WSAL. The ROMN assumed responsibility for administration of the project, select collaboration on vegetation classification, assistance in running the field crews, some field data collection and in organizing and completing the final products. Chris Lea from the national VMP assisted in the Accuracy Assessment design, implementation and analyses, and helped integrate these results into the final classification and map. Melana Stichmann from LIBI provided project guidance, field crew assistance and overall motivation. The LIBI and GRKO mapping projects were done concurrently by the same PIs, approaches, field crews, and general methods.

Meetings

A project initiation and general planning meeting was held at LIBI in March of 2006 and included park staff, NPS staff, and the project Principal Investigators. Key decisions made during this meeting included adoptguidance for 'small parks' in use at the time (http://biology.usgs.gov/npsveg/standards.html). A common approach in large park units (greater than around 1000 acres) is to define the vegetation community of a park based on quantitative (relevé or similar) plot data. Vegetation types are defined through multivariate analyses that compare plots based on their similarity to g are then matched ("crosswalked") to the most similar USNVC units maintained by NatureServe (NatureServe 2007). In most cases, a suitable concept in the USNVC can be found. These vegetation groups are then attributed to the map units defined by imagery analysis (i.e., the segmentation discussed above). In many cases the scale of the map units differs from the scale of the vegetation groups and an additional crosswalk must be developed that nests vegetation groups within the map units. This approach to creating vegetation maps is well suited to large areas with high floristic diversity. It is, however, an expensive and time consuming effort.

The small park protocol includes the following key steps:

1. Apply existing classifications of vegetation at LIBI (versus developing a classification from novel or existing plot data),

2. Use largely automated remote sensing or mapping techniques (versus traditional photo interpretation or "heads up" digitizing) to create map unit polygons within the map,

3. Conduct a field census of all polygons identified using these automated techniques to assign a type from the existing classifications,

4. Conduct an Accuracy Assessment of these classified polygons using a sample of sites in the park,

5. Restrict the final map extent to the official park boundary of 765 acres (309 ha).

Project participants met on several occasions over the course of the project to discuss progress and develop the scope of activities that needed to be completed over the near-term. These usually informally structured meetings were held at least once per year, often more frequently. Most project communication occurred in small group phone calls, e-mails and in face-to-face meetings too numerous and informal to detail here.

Following completion of the vegetation sampling in 2007, the project focused on analyses and mapping. Important processing steps included the methodology for defining the appropriate number and distribution (spatial and thematic) of the AA plots, data to be collected at the plot locations, and logistics for sampling.

A close-out meeting was held on May 14th, 2008 at GRKO. Staff and management were present from both LIBI and GRKO and we allocated equal time to each effort. We presented our draft final results, discussed the products and how they might meet the management needs of each park, gave examples of case studies and applications of the digital products and answered process and development questions.

Preliminary Data Collection and Review of Existing Information

To minimize duplication of previous work and to aid in the overall mapping project, existing data and reports were obtained from various sources. Background GIS data was obtained from the ROMN and LIBI. This included geology, soils, digital elevation models (DEM), structures, roads, and the official park boundary. The WSAL was provided with these layers as well as 2004 True Color National Agriculture Imagery Program (NAIP) aerial photography with a 2 meter pixel size covering the park.

Development of an Initial Vegetation Classification

We used two well developed and accepted existing classifications of the expected vegetation in the park. Hansen and Hoffman (1988) developed a habitat typing classification for a western portion of the northern Great Plains by sampling upland vegetation plots from southeastern Montana to northwestern South Dakota. The Little Bighorn River drainage is approximately fifty miles west of the Hansen & Hoffman (1988) study area. Hansen et al. (1995) provides

community and habitat types for riparian vegetation across the entire state of Montana. A major subsection of their work covers riparian and wetland sites for the Northern Great Plains.

Careful review of these classifications by the project PIs allowed a subset of the most likely types to be found at LIBI to be identified and compiled into a key specific to the park. This was facilitated by the experience of the PIs and LIBI staff with the extant vegetation types in the park and by the relative small size and simplicity of the vegetation in the park. Topographic position determined which source to employ. For uplands we used Hansen & Hoffman (1988) and on the river floodplain we used Hansen et al. (1995 - although the mouths of the woody draws form short ecotones extending some floodplain vegetation into the uplands). We crosswalked each of these initial types to the best fit in the USNVC.

The initial classification included 15 Hansen and Hoffman (1988) upland and woody draw habitat types (Table 2). Two USNVC Alliance types were also assigned for natural upland vegetation that could not be directly classified using Hansen and Hoffman (1988). These were the *Prunus virginiana* Shrubland Alliance characterized by upland draw chokecherry thickets and the *Pseudoroegneria spicata* Herbaceous Alliance where the grassland community could not be typed to a finer level as described by Hansen and Hoffman (1988) because of the lack of strong indication of a second diagnostic species. Two additional non-natural vegetation types were developed for the upland: a Disturbed Area where severe disturbance of surface soil had allowed the formation of mixed species weedy communities that could not be typed and a Landscaped Areas characterized by bluegrass lawn or spruce trees (Custer National Cemetery and areas around park buildings). Ten Hansen et al. (1995) floodplain vegetation types were initially recognized. Eight were native communities. Two were small stands of invasive woody species: *Elaeagnus angustifolia* and *Tamarix chinensis* community types. Two additional, non-vegetated landcover classes were also used, for a total of 29 types (Table 2).

Table 2. Initial classification types from the original source classifications or the USNVC (marked with an asterisk). Types are cross walked to their equivalent USNVC Association or Alliance.

Type Name from Original Key	Crosswalk to USNVC Association or Alliance[§]
Upland/Woody Draw (17; from Hansen and Hoffman 1988)	
Agropyron smithii/Carex filifolia	*Pascopyrum smithii - Bouteloua gracilis - Carex filifolia* Herbaceous Vegetation
Agropyron spicatum/Bouteloua curtipendula	*Pseudoroegneria spicata - Bouteloua curtipendula* Herbaceous Vegetation
Agropyron spicatum/Carex filifolia	*Pseudoroegneria spicata - Carex filifolia* Herbaceous Vegetation
*Agropyron spicatum herbaceous Alliance**	*Pseudoroegneria spicata* Herbaceous Alliance
Artemisia cana/Agropyron smithii	*Artemisia cana / Pascopyrum smithii* Shrubland
Artemisia tridentata/Agropyron smithii	*Artemisia tridentata ssp. wyomingensis / Pascopyrum smithii* Shrub Herbaceous Vegetation
Artemisia tridentata/Agropyron spicatum	*Artemisia tridentata ssp. wyomingensis / Pseudoroegneria spicata* Shrub Herbaceous Vegetation
Calamovilfa longifolia/Carex heliophila	*Calamovilfa longifolia - Carex inops ssp. heliophila* Herbaceous Vegetation
Fraxinus pennsylvanica/Prunus virginiana	*Fraxinus pennsylvanica - Ulmus americana / Prunus virginiana* Woodland
Juniperus scopulorum/Agropyron spicatum	*Juniperus scopulorum / Pseudoroegneria spicata* Woodland
*Prunus virginiana Shrubland alliance**	*Prunus virginiana* Shrubland Alliance
Rhus trilobata/Agropyron spicatum	*Rhus trilobata / Pseudoroegneria spicata* Shrub Herbaceous Vegetation
Sarcobatus vermiculatus/Agropyron smithii	*Sarcobatus vermiculatus / Pascopyrum smithii - (Elymus lanceolatus)* Shrub Herbaceous Vegetation
Sarcobatus vermiculatus/Agropyron spicatum	*Sarcobatus vermiculatus / Pseudoroegneria spicata* Shrubland
Shepherdia argentea	*Shepherdia argentea* Shrubland
Stipa comata/Carex filifolia	*Hesperostipa comata - Bouteloua gracilis - Carex filifolia* Herbaceous Vegetation
Symphoricarpos occidentalis	*Symphoricarpos occidentalis* Shrubland
Floodplain Forest/Woodland/Shrubland (10; from Hansen et al. 1995)	
Acer negundo/Prunus virginiana	*Acer negundo / Prunus virginiana* Forest
Elaeagnus angustifolia	*Elaeagnus angustifolia* Semi-natural Woodland Alliance
Fraxinus pennsylvanica/Prunus virginiana	*Fraxinus pennsylvanica / Prunus virginiana* Forest

Type Name from Original Key	Crosswalk to USNVC Association or Alliance[§]
Populus deltoides/Recent alluvial bar	*Populus deltoides* Temporarily Flooded Woodland Alliance
Populus deltoides/Symphoricarpos occidentalis	*Populus deltoides / Symphoricarpos occidentalis* Woodland
Prunus virginiana	*Prunus virginiana - (Prunus americana)* Shrubland
Salix exigua	*Salix exigua* Temporarily Flooded Shrubland
Shepherdia argentea	*Shepherdia argentea* Shrubland
Symphoricarpos occidentalis	*Symphoricarpos occidentalis* Shrubland
Tamarix chinensis	*Tamarix spp.* Semi-natural Temporarily Flooded Shrubland Alliance
Non-natural Vegetated Types (2)	
Disturbed area	N/A
Landscaped areas	N/A
Landcover, non-vegetated (2)	
Road	N/A
Water	N/A

[§] Natural or semi-natural vegetation community name is for USNVC Association unless ending with Alliance

Photo Interpretation

Given cost considerations, the small project area, and the relative simplicity of the vegetation at LIBI, a largely automated process for defining map units (distinct areas or 'polygons') in the 2005 NAIP imagery was chosen. Known as "segmentation", the process uses a computer algorithm implemented in Definians (now Trimble) eCognition software to divide an image into regions defined by greater spectral homogeneity within each segment versus the spectral diversity found in the surrounding matrix (Figure 10). The process extracts information from images using a hierarchy of image objects (groups of pixels) examining pixels not in isolation, but in context based on color, shape, texture and size. We assumed that these polygons reflected meaningful patterns in the vegetation community at LIBI. Moreover, as discussed below, we assumed that in most cases types from the existing classifications could be applied at the same spatial scale to the map unit polygons. In other words, the scale of the vegetation classification used was almost always the same as the map units.

We intersected the LIBI boundary layer with a soils layer to guide the detail at which eCognition performed the segmentation. We created two zones, one for less diverse areas (uplands) so that they would be segmented into larger regions, and one for more complex communities (floodplain and woody draws) so they would be segmented into smaller regions. Image segmentation using eCognition was an iterative process with some manual edits made between automated runs.

Minimum Mapping Unit

Although standards for VMP map products stipulate a minimum map unit (MMU) size of 0.5 ha (1.24 acres), we felt that our imagery analysis process, field methods that and a one-to-one application of vegetation type to map unit polygon would allow a finer resolution at LIBI. We therefore set a target MMU of 0.1 ha (0.247 acres) for the final map unit polygons. **This MMU was only considered an approximate target. If the segmentation 'found' polygons smaller than this that were then confirmed in the field as a real vegetation type they would not be merged with adjacent map unit polygons.** This method choice was developed in consultation with national VMP staff. A MMU on this order represents an attempt to map vegetation in great detail at LIBI. As a comparative example, our initial classification at LIBI (less than 700 acres) had 29 map classes, whereas at Rocky Mountain National Park (~270,000 acres) there were only 46 map classes (Salas et al. 2005).

Figure 10. Example of 2005 NAIP imagery and initial segmentation by eCognition software at Little Bighorn Battlefield National Monument. The center of the image is Last Stand Hill with the main visitor facilities on the left edge of the image. Polygons or map units are shown with black linework.

Sample Design

Another common tool in large park units is to use replicated samples that represent a reasonably complete span of the floristic variability of each vegetation type across the park. Because of the small size of LIBI the use of an existing vegetation classification, and our approach to imagery analysis, we elected to census every polygon identified by the segmentation and assign each to existing community types (Table 2) developed Hansen and Hoffman (1988) and Hansen et al. (1995). Initial segmentations of the NAIP imagery indicated that approximately 1,500 polygons would be created and we felt that a census could be achieved with reasonable effort.

Field Mapping Protocol

The uplands were mapped from June 10 through June 23, 2006. The floodplain was mapped from July 10 through July 18, 2006 after the river had receded. Crew members assigned initial vegetation type to each map unit polygon. Crew members were provided with the initial list of LIBI types, standard flora references for the area (Dorn 1984, Hitchcock and Cronquist 1973), GPS (Garmin 63c) and Polygon Data Forms referencing each map unit polygon number and the UTM coordinates for the approximate center of the polygon. They also had printed map sheets with the NAIP base images, polygon boundaries, map unit polygon numbers, and the

approximate centroids for the polygons. Crew members navigated into the polygon using the GPS and reference to the printed map. Zones assigned to polygons during segmentation were confirmed or adjusted. After inspecting each vegetated polygon as a whole for dominants and indicator species the polygon was assigned a community type based on the original keys. The upland and woody draw polygons at Little Bighorn were initially classified by the field mapping team according to Hansen and Hoffman (1988). The Little Bighorn River riparian zone was initially mapped according to Hansen et al. (1995). *Importantly, crews were limited to the set of vegetation types available in these keys.* To facilitate later accuracy assessment, a reference waypoint was recorded within each polygon in a location representative of the polygon.

The cover class of up to three dominant indicator species was recorded at that representative, reference point. Cover classes for dominants were based on the traditional Braun-Blanquet cover scale: T=<1%, 1=1–5%, 2=6–25%, 3=26–50%, 4=51–75%, 5=76–95%, 6=96–100%. Data on dominants were collected to assist in later confirmation of assignment by crews of each map unit to one of the initital types.

In limited cases crews were allowed to adjust the topology of map unit polygons. This was done when it was clear that the segmentation split two or more distinct vegetation communites within the intitial set of types or when a more homogeneous polygon could be created by dissolving boundaries. Crews added new boundary lines directly to the NAIP imagery field sheets for these polygon(s). A supplemental form (Appendix A) was completed for any adjusted polygon.

Data Input and Polygon Adjustment

After the field mapping crew finished the initial map unit polygon census, data was entered into a geodatabase (Appendix G). This data was quality checked and the finl version was passed to WSAL. Polygons in the initial segmentation that were modified by crews as noted on the hardcopy maps supplied by the field crew were edited directly in the geodatabase. Any new map unit polygons created had a letter added to their original polygon-id field (i.e., 1241 became 1241a). A crosswalk table was created that linked the initial field key types to the USNVC series of hierarchical classifications and the field comments for each type. These classification attributes were then joined to the initial and final map units in the geodatabase.

Accuracy Assessment

An accuracy assessment (AA) is a statistical test of how well polygon map class attributes represent vegetation on the ground. The AA compares field observations collected through a stratified random sampling design with the map class assignment of the sampled polygon. Errors occur when map classes assigned to the polygons do not agree with observations from the field sampling. Results are presented as “producer’s accuracy” (the probability that an AA point was mapped correctly) and “user’s accuracy” (the probability that the map represents what was found on the ground). High producer’s accuracy in combination with low user’s accuracy indicates that the type is under-mapped. Low producer’s accuracy combined with high user’s accuracy indicates that a type is over-mapped. Ideally, a map has both high user’s and producer’s accuracy. Accuracy requirements for the VMP specify a 80% accuracy for both the collective map classes and for each individual map class.

In many other small park vegetation mapping projects that also employed a census an AA is not implemented (i.e., Saugus Iron Works National Historic Site (Largay and Sneddon, 2008), Buck

Island Reef National Monument (Moser et al 2010), Knife River Indian Villages National Historic Site (Salas and Pucherelli, 2002). Rather, the assumption is that because every polygon created in the map is visited and attributed in the field, map accuracy will be within the NPS 80% standard. However, we felt that given the detail at which LIBI was segmented (using a 0.1 ha MMU) and the potential for misapplication of, or an imperfect fit with the *a priori* classifications in Hansen and Hoffman (1988) and Hansen et al. (1995), an AA was necessary.

Our aim in mapping the vegetation of LIBI was to provide accurate descriptions and locations of vegetation types as described by the USNVC. We sought to create a set of products that followed VMP standard and that were useful for the park and the ROMN. For the LIBI vegetation mapping project, the AA involved an analysis of data sets measuring the probability of map accuracy (absence of error) using a field based classification acquired at randomly selected sites for each map class (a thematic accuracy assessment). Positional accuracy (of polygon boundaries) was not considered in the AA since perceptions of transitions between type classes are only occasionally well-defined and variable seasonally and across years. Therefore, polygon boundaries represent approximate location within a gradient (ecotone) which was observed during these mapping years. Future work might use permanent fixtures (i.e., buildings) visible in the imagery to establish positional accuracy.

The objectives of collecting samples for accuracy assessment are somewhat different than those for classification. For AA the sampling is aimed at drawing inferences about the nature and magnitude of discrepancies between the true properties of a point or area and its representation on the map. Specifically, the primary purpose of collecting samples to assess the accuracy of the LIBI vegetation map is to obtain a measure of the probability with which a particular location has been assigned its correct vegetation class (thematic accuracy). According to the NPS Vegetation Mapping Program's Accuracy Assessment Procedures document (ESRI et al. 1994), the AA allows users of the data to assess the data's suitability for a particular application and enables the producers of the data to learn more about the data's errors and improve the mapping process and outcome.

The AA at LIBI was conducted from June 12 to June 15, 2007 (with some sites visited in late June and early July) by staff from LIBI, ROMN, the national VMP, and well-qualified volunteers. Analyses of these data were done in the fall of 2007 and winter of 2008 by Lea and Schweiger. All field and analytical methods followed the USGS-NPS Vegetation Characterization Program standards except as noted below.

Accuracy Assessment Sample Design

For a valid AA the randomness of site selection is crucial and the number of sites within map unit classes is heavily influenced by statistical constraints. In other words, the objectives require a sufficient number of samples to permit valid statistical inferences about the data as a whole.

We used the ESRI ArcView 3.2 geoprocessing wizard to prepare the sampling frame. We began by measuring the total area of each original map unit class (summing all individual polygon areas). Individual polygons representing the same map class were dissolved to eliminate polygon boundaries between polygons of like map class. An 18 meter buffer inside the boundary of all dissolved polygons was then created. Polygons that were within the 18 meter buffer were selected and deleted from this union theme. The result of these geoprocessing steps was a

polygon theme (sampling population) that was comprised of the interiors of all polygons (all areas more than 18 meters from a boundary with a different map class).

We allocated 30 AA sites to each map class that occupied more than 50 ha total area within LIBI. Map classes representing water, roads, and developed areas were omitted (these are assumed to be close to 100% accurate). For map classes with 50 ha or less of total area, we allocated AA plots equal to the total map class area (in hectares) divided by 1.67 (same ratio as the 30 points per 50 hectares). The map class area was calculated prior to buffering for field positioning error, although the buffered areas of a map class were not considered for site placement. In the cases of very small map classes, the total size of the buffered area available combined with the requirement of sampling without replacement limited the map class allocation to the total area available for multiple AA plots of minimum mapping unit size. We did not allocate additional points for map classes merely because they were more fragmented (e.g., less than 50 hectares total area, but more than 30 polygons). Our sample sizes per map unit class vary slightly from the guidance in Table 6 of Section 8.2.1.2 of ESRI et al. (1994).

To select individual AA sites from the sampling frame we used the Select Random Features function in the National Park Service Alaskapak tools package (NPS 2002). This uses simple random sampling within each map class, which is appropriate for the statistical analyses of the LIBI AA data (ESRI et al. 1994). When two or more AA plot sites were near enough to one another to produce overlapping observation areas (i.e., within 36 meters of one another, see below), one site at a time was selected randomly (using the random numbers function in Microsoft Excel) and deleted. A replacement site was generated for each site so deleted, using the "Select Random Features" function (as above). If the replacement site overlapped a previously determined site, it was rejected, and the process repeated, until either (1) the full complement of sites for the map class was assigned or (2) it was determined that the map class was saturated (could accommodate no more sites without observation area overlap between one or more AA plots). Figure 11 shows the 177 AA sample sites in LIBI.

Accuracy Assessment Field Methods

Four teams (of one to two persons each) were employed to conduct the accuracy assessment. At least one person on each team was familiar with all plant species mentioned in the field key and similar species (potential "look-alikes" that might cause erroneous key decisions). The total number of plots to be visited for each map class was stratified by observation team (i.e., each team was assigned to visit an equal or near equal number of plots for each individual map class as the other teams) in order to minimize effects of observer bias. Such methodological stratification is desirable, but precludes each site being visited sequentially by location, and is usually practical only in small projects such as LIBI where travel time is a minor consideration. Immediately prior to the accuracy assessment, teams were trained in the field at LIBI to calibrate the individual team interpretation of the field keys, cover estimates, species identification, and field observation methods. The site locations and unique identifiers were loaded into Garmin 76CSX or Garmin 76S GPS units. Teams navigated to each assigned site (plot center), usually in a sequence of proximity.

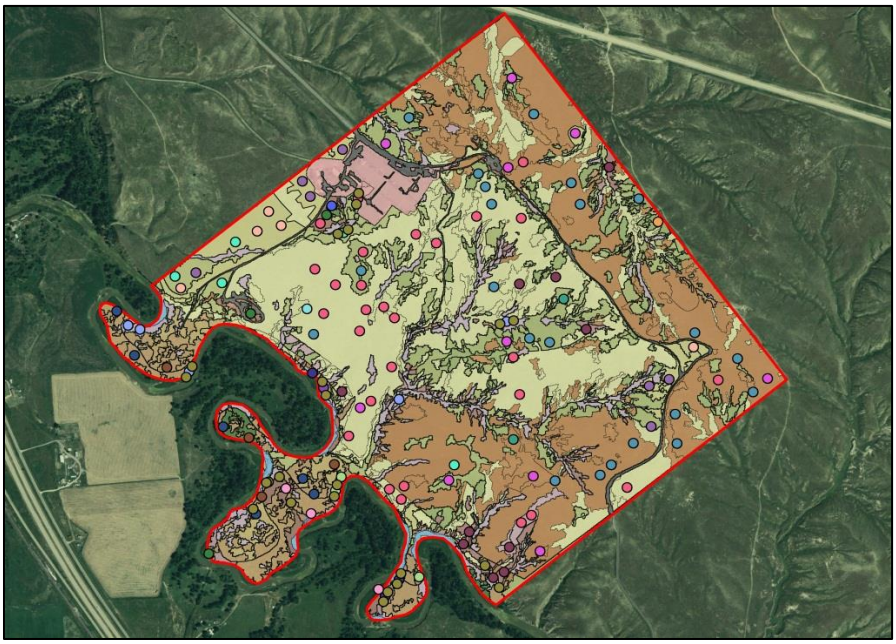
The teams were not informed as to location of the map boundaries. Revealing map class boundaries creates a bias in the field calls that is especially problematic in small area projects, where a larger proportion of each map class (compared to large area projects) is likely to have

polygons populated with multiple sites and where adjoining polygons may also often have sites. It is unreasonable to expect a ground observer to make independent assessments of adjacent sites, when it has been revealed that the mapper has declared them to be the same (if it is revealed that two sites are in the same polygon/map class) or if the mapper has declared them to be different (if two sites are separated by a single polygon/map class boundary). The bias can be especially problematic where field calls are not entirely clear cut, which is very often the case. There is also some inherent bias in using polygons where the lines have been determined based on spectral information that may or may not be visible on the ground.

A 0.1 hectare observation area (usually a circular plot, 18 meters in radius) was centered on each AA site. The area reduction from the normative 0.5 hectare observation area was necessary because of the small mean polygon area at LIBI (~ 0.15 hectares). Moreover, the vegetation at LIBI is primarily shrubland and herbaceous vegetation, in which smaller observation areas can capture an adequate number of attributes to establish class (vegetation type).

A dichotomous vegetation community classification key was prepared from the list of the 27 initial types for the accuracy assessment teams. The key was designed to work in observation areas of relatively homogeneous (ecologically and floristically) stands of vegetation. While gradual transition zones within the observed area are acceptable (to test the key across the full gradient of described types), sharp boundaries with two or more very different vegetation types (e.g., wetlands and uplands) occurring in the observation area often will yield spurious key results and were avoided. However, it is possible for such sharp transitions to occur within an area mapped as a single class (an error of omission). To mitigate this situation, field crews were instructed to assess whether one of more such boundaries occurred within the circular 18 meter radius (0.1 hectare) observation area. The general criteria for recognizing a boundary was a transition at the Formation level (i.e, shrubland versus woodland) of the USNVC (FGDC 1997); transitions between different alliances or associations within same Formation are generally too subtle for an observer to reliably and precisely locate on the ground; such boundaries are usually best ignored and the vegetation keyed in place. If a sharp (Formation or higher) vegetation boundary was detected in the observation area from the waypoint, the observer decided what vegetation type occupied the majority of the observation area (if two types are detected in the observation area) or plurality (if more than two types). The plot center was moved the minimal distance into the majority/plurality type along a path perpendicular to an imaginary line tangent to the ecological boundary between the majority/plurality type and all other types until only one association was detected within the plot. At this point, the observer stopped and evaluated a circular observation area of 18 meters radius from this new position.

(a)



(b)

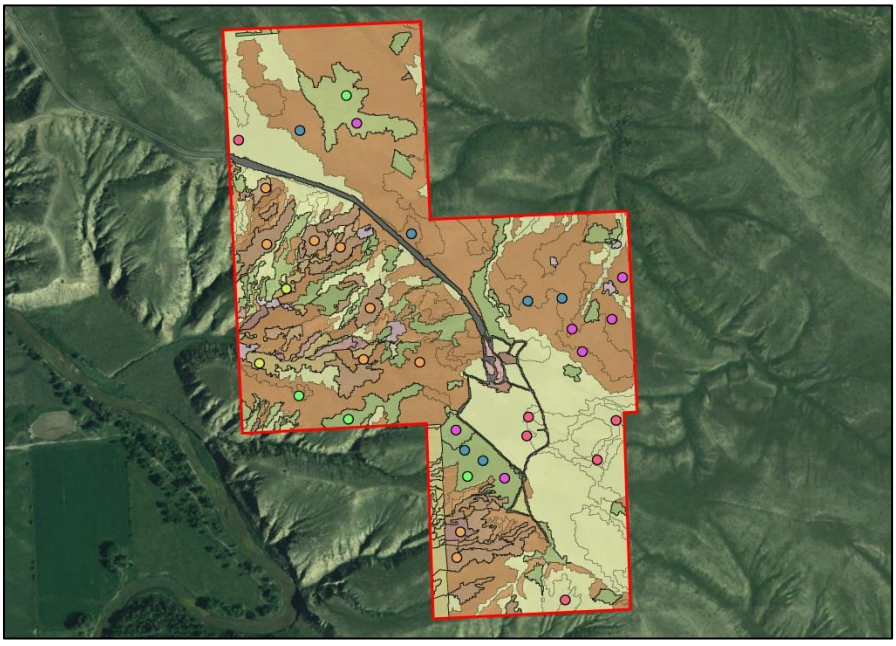


Figure 11. Accuracy assessment sample points at Little Bighorn Battlefield National Monument; (a) Custer Battlefield unit, (b) Reno-Benteen Battlefield. Initial map unit polygons and 2005 NAIP imagery are included as background. Point symbology is based on the field designation of the vegetation type at each site. Note that the scales are different in the two panels.

If, while moving the plot center, a new ecological boundary appeared on another side of the circular plot, the observer stopped and attempted to implement a rectangular observation plot. To implement a rectangular plot, the observer located the point in the majority vegetation type along the path attempted above that is equidistant between the original boundary detected and the second boundary encountered when trying to move the circular plot. From this position, a 25 meter x 40 meter rectangular plot, with its short axis along the perpendicular path described above and centered on this point, was attempted. If the plot were more than 90% homogeneous as to vegetation type, the field call was made from this 25 meter x 40 meter plot. If a sharp vegetation boundary, as described above, existed in the rectangular plot, so that the area was less than 90% homogeneous to type, a 20 meter x 50 meter plot was attempted. If the 20 meter x 50 meter plot failed to produce 90% internal homogeneity, a 10 meter x 100 meter plot was attempted. If the 10 meter x 100 meter plot failed to produce 90% homogeneity, data from the site were not recorded.

Data collected within the final plot size and shape included location and plot type, the dominant vegetation type, secondary vegetation types, the proportional coverage of the plot of the dominant and secondary types (and any minor tertiary type). Crews also recorded the 1st to 5th most dominant species in the tree/shrub/ herbaceous layers (where these layers existed). An example AA form is given in Appendix A.

Accuracy Assessment Analytical Methods

All data was entered into a series of spreadsheets and quality checked. A misclassification matrix (contingency table) was created using the map unit assignment and the AA data. The field position (GPS) data were converted to a point theme and each point attributed with the vegetation type field call and the positioning (GPS) error recorded on the forms. Each field point was buffered by the field positioning (GPS) error recorded on the field forms to create a polygon theme of circular polygons with radius of each polygon equal to the recorded GPS error. The individual polygons represented the area where true position likely occurred. For rectangular observation areas, the dimensions of the observation area and the bearing of the long axis were taken from the field forms to create rectangular polygons. These polygons were spatially joined to the original LIBI vegetation type to determine whether any polygons had multiple original map class memberships (i.e., uncertainty about the map class that should be assigned to each point due to positioning error) and should therefore be discarded from the analysis.

The table derived from the spatially joined AA point data and original polygon map class layer was exported to Excel. A pivot table representing a misclassification matrix (contingency table) was created with the table columns representing the field AA calls, the table rows representing map classes (in the same order for rows and columns), and the cell totals representing the total number of plots for each possible combination of map class assignment and field class assignment.

User's accuracy (1 – commission error rate) was calculated as:

$$\frac{n_{ii}}{n_{i+}}$$

where i is the map class type, nii is the number of matches between map and reference data and ni+ is the total number of samples of i in the map. This formula is the number of "correct" observations divided by the sum of the column.

Producer's accuracy (1 – omission error rate) was calculated as:

$$\frac{n_{ii}}{n_{+i}}$$

where n+i = total number of sample of i in the reference data. This formula is the number of "correct" observations divided by the sum of the row.

Overall accuracy for the map was calculated as:

$$\frac{\sum_{i=1}^{k} n_{ii}}{n}$$

where k is the number of map class types and n is the total number of reference points. This formula is simply the sum of the diagonal entries divided by the total number of AA points.

A 90% confidence interval for a binomial distribution was obtained from the following equation:

$$\hat{p} \pm \left\{ z_{\alpha} \sqrt{\frac{\hat{p}(1 - \hat{p})}{n} + \frac{1}{(2n)}} \right\}$$

where zα = 1.645 (from a z-distribution at the significance level for a two-sided limit with a 90% confidence interval), $\hat{p}$ is the sample accuracy (0 to 1.0) and n is the number of sites sampled. The term 1/(2n) is the correction for continuity. The correction should be applied to account for the fact the binomial distribution describes discrete populations.

A kappa statistic was calculated for the overall accuracy. The Kappa statistic is a measure of agreement between model predictions and reality (Foody, 1992; Congalton 1991) that makes use of both the overall accuracy and the accuracies within each vegetation type category to correct for chance agreement between categories. Kappa can be used to determine if the values contained in an error matrix represent a result significantly better than random (Jensen 1996). Kappa is computed as:

$$\kappa = \frac{N \sum_{i=1}^{r} x_{ii} - \sum_{i=1}^{r} (x_{i+} \times x_{+i})}{N^2 - \sum_{i=1}^{r} (x_{i+} \times x_{+i})}$$

where N is the total number of sites in the matrix, r is the number of rows in the matrix, xii is the number in row i and column i, x+i is the total for row i, and xi+ is the total for column i (Jensen1996). An ArcView script made this process easy and repeatable (Jenness and Wynne 2005).

Final Data Interpretation and Map Production

Patterns in User's and Producer's error were used to guide possible changes in the map classes to be used in a final map. Collapsed map classes were also considered based on input from the park as to the utility of a particular class that while perhaps mapped with a lower accuracy, might still be desirable to retain given management applications.

The final map classes were summarized using standard queries in ArcGIS. A high quality map was generated following cartographic standards specified by the USGS-NPS Vegetation Characterization Program.

Results and Discussion

Image Segmentation

Processing of the NAIP imagery with eCognition produced 1,675 polygons within the park boundary. We went through several iterations of the segmentation as we explored the balance of the settings for discriminating polygons based on color, shape, texture and size. The soils layer used to guide the detail at which eCognition segmented imagery allowed us to create larger polygons in the upland than in the floodplain or wooded draws, reflecting the additional complexity of vegetation structure in these areas. However, in general, many polygons were below the target MMU of 0.1 ha. These were not dissolved in the GIS as the expectation was that there were mappable to a vegetation type.

Pre-AA Vegetation Map Classes

Map unit polygons were initially assigned to 27 vegetated and four land use types (Table 2, Appendix B) based on field observations. The following discussion summarizes these types. In many cases these are also the final, post AA types (Appendices E and F). However, given results of the AA as detailed below, the reader should carefully review the results and discussion below on the final post-AA map classes and classification.

Associations dominated by *Agropyron spicatum* (*Pseudoroegneria spicata*) and *Agropyron smithii* (*Pascopyrum smithii*) account for two-thirds of the Park acreage. These two grasses are often codominants or at least sympatric, but *Agropyron spicatum* is typically more abundant on steeper slopes and coarser soils while *Agropyron smithii* tends to dominate more level sites and clay textured soils. These upland native grass types also form the largest continuous polygons. Anecdotally, sagebrush communities (*Artemisia*) are much less prevalent than they were before the 1983 and 1991 wildfires (there are dead charred bases of sagebrush occasionally evident throughout the uplands). Although the sagebrush types are similar in abundance the patch size for *Artemisia cana/Agropyron smithii* is much smaller than *Artemisia tridentata/Agropyron smithii* or *Artemisia tridentata/Agropyron spicatum. Artemisia cana/Agropyron smithii* is generally associated with deeper soils.

Table 3. Summary of extent and spatial characteristics of pre-Accuracy Assessment vegetation types at Little Bighorn Battlefield National Monument. All units are acres.

Initial Type	Count	Smallest Polygon	Largest Polygon	Total	% of Total
UPLANDS					
Agropyron cristatum - (Pascopyrum smithii, Hesperostipa comata) Semi-natural Herbaceous Vegetation	1	0.41	0.41	0.41	
Agropyron smithii/Carex filifolia	349	0.00*	54.75	238.84	
Agropyron spicatum Herbaceous Alliance	255	0.01	39.04	239.23	
Agropyron spicatum/Bouteloua curtipendula	144	0.01	3.12	43.68	
Agropyron spicatum/Carex filifolia	145	0.01	5.40	54.55	
Artemisia cana/Agropyron smithii	70	0.01	3.46	18.55	
Artemisia tridentata/Agropyron smithii	7	0.04	12.37	15.32	
Artemisia tridentata/Agropyron spicatum	12	0.03	2.59	7.19	
Calamovilfa longifolia/Carex heliophila	8	0.03	0.71	1.43	
Rhus trilobata/Agropyron spicatum	47	0.01	1.31	13.26	
Sarcobatus vermiculatus/Agropyron smithii	83	0.01	1.01	11.71	
Sarcobatus vermiculatus/Agropyron spicatum	7	0.01	0.74	1.59	
Stipa comata/Carex filifolia	19	0.02	2.57	5.93	
UPLANDS TOTAL	1147			651.69	83.45
RIPARIAN FLOODPLAIN					
Acer negundo/Prunus virginiana	4	0.04	2.07	2.73	
Elaeagnus angustifolia	1	0.05	0.05	0.05	
Populus deltoides/Recent alluvial bar	1	0.12	0.12	0.12	
Populus deltoides/Symphoricarpos occidentalis	50	0.03	3.58	29.49	
Riverbank herbs	22	0.01	0.44	2.26	
Salix exigua	7	0.03	2.83	3.93	
Shepherdia argentea	15	0.01	1.05	3.06	
Tamarix chinensis	4	0.02	0.46	0.57	
RIPARIAN FLOODPLAIN TOTAL	104			42.20	5.40
WOODY DRAWS					
Fraxinus pennsylvanica/Prunus virginiana	15	0.01	2.62	9.94	

Initial Type	Count	Smallest Polygon	Largest Polygon	Total	% of Total
Juniperus scopulorum/Agropyron spicatum	4	0.09	0.34	0.86	
Prunus virginiana	27	0.02	1.03	4.61	
Symphoricarpos occidentalis	162	0.01	1.35	34.26	
WOODY DRAWS TOTAL	208			49.66	6.36
NON-VEGETATED OTHER LANDCOVER					
Developed	18	0.01	10.84	15.39	
Road	9	0.01	10.65	14.12	
Ruderal	14	0.02	1.50	3.32	
Water	21	0.01	0.79	4.51	
NON-VEGETATED OTHER LANDCOVER	62			37.34	4.78
GRAND TOTAL	1521			780.89	

*small polygons below the precision of this table

Populus deltoides/Symphoricarpos occidentalis in the floodplain and *Symphoricarpos occidentalis* in the upland woody draws and the floodplain are the predominant woody vegetation types but the total acreage and the patch sizes are an order of magnitude smaller than the two most prevalent upland grass types. *Populus deltoides* regeneration (*Populus deltoides*/Recent alluvial bar) is very limited. *Salix exigua* is the principle initial colonizing type of the river edges but occupies less than 7 acres. *Fraxinus pennsylvanica/Prunus virginiana* floodplain is the second most prevalent large tree type but only totals 8 acres. There are also two small clumps of *Fraxinus pennsylvanica/Prunus virginiana* upland type in the lower reaches of the woody draws where greater seepage allows an ecotone transition to floodplain

There are a number of other low prevalence shrub and small tree types in upland, woody draw, and floodplain habitats. Numerous small low-density patches of *Rhus trilobata/Agropyron spicatum*, *Sarcobatus vermiculatus/Agropyron smithii* and few patches of *Sarcobatus vermiculatus/Agropyron spicatum* are scattered throughout the uplands. The upland woody draw *Prunus virginiana* shrubland Alliance and the *Prunus virginiana* floodplain community type form small but very dense thicket stands. Three stands of *Acer negundo/Prunus virginiana* habitat type were found in the floodplain. The *Shepherdia argentea* community type is a small component of the floodplain vegetation and the *Shepherdia argentea* type is a very minor part of the upland. *Juniperus scopulorum/Agropyron spicatum* occupies less than one acre in the woody draws but numerous dead trunks indicate juniper was more prevalent before the wildfires.

Dominant Species

Dominant taxa (Table 4) generally mirrored the patterns seen in the vegetation community types. The five most frequent dominants (*Pascopyrum smithii*, *Pseudoroegneria spicata*, *Bromus japonicus*, *Symphoricarpos occidentalis* and *Bouteloua curtipendula*) account for almost 60% of the occurrences in the list. There were also several taxa with restricted distributions across the park, including *Salix exigua*, *Populus tremuloides*, *Tamarix chinensis*, *Vitis spp.* and *Bromus tectorum* but that were locally abundant. Although the list of dominant species does not represent a complete species list for LIBI, given the comprehensive coverage of the LIBI vegetation mapping project census at over 1,200 locations in the park, the list is a useful characterization of patterns in characteristic species across LIBI and will be an important reference in a long-term monitoring context.

Table 4. Summary of dominant taxa as recorded in censused map unit polygons in Little Bighorn Battlefield National Monument. Count is of the total number of occurrences. Mean cover is across all occurrences of a taxa using the mid-point of the Braun-Blanquet cover class assigned to each observation. *The list is sorted by frequency with the most common taxa first.*

Species Name	Count	Mean cover	SD of cover
Pascopyrum smithii	678	8.3	7.48
Pseudoroegneria spicata	619	11.6	6.94
Bromus japonicus	318	7.0	8.40
Symphoricarpos occidentalis	256	28.1	23.98
Bouteloua curtipendula	153	1.4	1.88
Sarcobatus vermiculatus	148	9.4	8.87
Artemisia cana ssp. viscidula	134	9.8	13.43
Prunus virginiana	119	19.5	21.97
Rhus trilobata	117	8.7	13.68

Species Name	Count	Mean cover	SD of cover
Carex filifolia	101	1.1	0.92
Yucca glauca	78	3.8	6.71
Koeleria macrantha	77	1.7	1.87
Poa pratensis	70	4.9	7.45
Melilotus officinalis	56	6.1	7.46
Hesperostipa comata	56	7.2	10.74
Populus deltoides	51	40.5	19.89
Fraxinus pennsylvanica	48	15.5	15.20
Artemisia tridentata	43	8.3	9.45
Bromus inermis	43	7.9	9.23
Artemisia ludoviciana	37	2.6	4.57
Shepherdia argentea	30	13.1	11.62
Calamovilfa longifolia	28	8.9	14.76
Toxicodendron rydbergii	25	9.5	10.63
Achillea millefolium	24	1.5	1.00
Bouteloua gracilis	24	1.1	0.91
Tragopogon dubius	21	1.2	0.94
Alyssum alyssoides	18	1.1	0.90
Nassella viridula	16	1.6	0.99
Phlox hoodii	15	2.4	3.62
Glycyrrhiza lepidota	14	18.3	20.76
Ericameria nauseosa	13	0.7	0.53
Psoralidium tenuiflorum	13	2.4	3.89
Juniperus scopulorum	9	20.4	27.31
Rosa woodsii	8	9.9	12.04
Lactuca serriola	6	0.8	0.75
Convolvulus arvensis	5	11.4	14.43
Acer negundo	4	29.1	15.37
Cirsium undulatum	4	0.5	0.00
Salix exigua	4	63.0	0.00
Agropyron cristatum	3	1.2	0.94
Echinacea angustifolia	3	1.8	0.94
Antennaria luzuloides	2	1.5	1.00
Bromus tectorum	2	50.5	12.50
Elaeagnus angustifolia	2	9.0	6.50
Hordeum jubatum	2	26.8	11.25
Opuntia polyacantha	2	1.5	1.00
Poa compressa	2	15.5	0.00
Antennaria microphylla	1	0.5	0.00
Artemisia frigida	1	15.5	0.00
Cornus stolonifera	1	15.5	0.00
Poa secunda	1	0.5	0.00
Populus tremuloides	1	63.0	0.00
Sisymbrium altissimum	1	2.5	0.00
Tamarix chinensis	1	63.0	0.00

Species Name	Count	Mean cover	SD of cover
Vitis spp.	1	63.0	0.00
Grand Mean		13.3	6.81

Accuracy Assessment

A total of 154 AA plots were collected by four teams of observers. Seventeen plots from the original AA design were not assessed due to access issues or because they could not meet the requirements for fitting within a community type (see Methods). The overall map accuracies for the initial and final post AA vegetation classes and for the assignment of post-AA classes to Ecological Systems are given in Table 5. We include 90% confidence intervals and a Kappa statistic for the final post AA classifications. A set of full contingency tables are given in Appendix C.

Table 5. Overall map accuracies for pre and post accuracy assessment classifications at Little Bighorn Battlefield National Monument.

Classification	Overall Accuracy	Lower 90% CI	Lower 90% CI	Kappa Index
Original Vegetation Types	**56.2**	49.1	63.2	--
Post AA Vegetation Types	**78.1**	72.1	84.1	72.8
Post AA Ecological Systems	97.9	95.7	100	93.9

The original classification and mapping scheme was assessed to have a pooled (all sites totaled) accuracy rate of **56.2%**. This was unexpectedly low, considering that all polygons had been individually attributed on the ground. The inherent limitations of remote sensing methods in attributing vegetation stands are usually a large potential source of errors in most mapping projects. However, because map unit polygons at LIBI were attributed on the ground by field crews, this source was probably a relatively minor cause for error. As we crosswalked the original types to USNVC Associations recognized by NatureServe (2007) it became clear that the original vegetation types were sometimes at a finer scale than most corresponding USNVC Associations. As a result, the taxonomic (thematic) resolution of the initial classification was likely too specific, leading to one set of qualified field observers (the accuracy assessment team) not being able to consistently repeat the observations of the original team of qualified field observers (the original field crew). In a strict sense, this might be termed a lack of correspondence, rather than a deficit of accuracy, but this is not a meaningful distinction for a potential map user (such as staff from LIBI) who wishes to know the frequency of match or mismatch between the map class and what is found at a given site. The very small polygons enabled by the mapping methodology may also have played a role in the resulting low accuracy rate. By constraining the observation areas used by the AA team, highly local patterns in vegetation composition may have been evaluated instead of the community level structure more typical of NPS vegetation maps (i.e., the polygon scale at which the map was delineated and attributed). Note that some types were rare and were never ‘found’ at an AA point. While this suggests that the accuracy on these types is not high, there may also be artifacts from the design (i.e., not enough points were allocated to the type) and so we describe these as ‘not evaluated’.

Final Little Bighorn Battlefield National Monument Classification

Several patterns of type confusion (e.g. two types frequently reciprocally misidentified as the other) are evident in the accuracy assessment contingency table (Appendix C). These patterns

suggested several new (or post-AA) combinations of types that would both retain ecological meaning and result in higher individual class and total map accuracy. In addition, many of the aggregated types were very sparsely represented in the original map (several by a single tiny polygon). While the aggregations represent a loss in detail of 14% of the map area we felt it would be difficult to recognize the some of the rare or inaccurate types in the field, or to use them in any meaningful management application. The following sections present brief summaries of the changes adopted given the accuracy assessment and a summary of the final map and vegetation classification at LIBI.

Changes to Create Final Vegetation Types

Based on the AA, the 29 original types were collapsed into 22 vegetation and landcover types (Table 6). These include three forest and woodland types, six shrubland types, ten herbaceous and herbaceous-shrubland types, and three landcover or cultural vegetation types. Detailed descriptions of each (excluding landcover) are found in Appendix E.

Key changes from the initial types include the following:

- The three tree-dominated floodplain types *Populus deltoides / Symphoricarpos occidentalis, Acer negundo/ Prunus virginiana* and all floodplain stands of *Fraxinus pennsylvanica / Prunus virginiana* were merged into the USNVC Association of *Populus deltoides - Fraxinus pennsylvanica* Forest. This final type has a user's accuracy of 82%.

- Two small upland/wooded draw stands of *Fraxinus pennsylvanica / Prunus virginiana* were retained in the final map using the USNVC Association of *Fraxinus pennsylvanica / Prunus virginiana* Forest. This final type was too rare to evaluate in the AA.

- The *Salix exigua* type and small stands of *Populus deltoides* saplings in swales (similar habitat) were merged to create the *Salix exigua* Shrubland. This aggregation was due to the fact that the *Populus deltoides* saplings in swales type was originally a spatial subset that was resolved in the final types. This final type has a user's accuracy of 100%.

- The original *Sarcobatus vermiculatus / Agropyron smithii* and *Sarcobatus vermiculatus / Agropyron spicatum* types were merged in the classification and map to the USNVC plant association of *Sarcobatus vermiculatus / Pascopyrum smithii - (Elymus lanceolatus)* Shrub Herbaceous Vegetation. This final type has a user's accuracy of 83%.

- The *Agropyron spicatum / Carex filifolia*, *Agropyron spicatum / Bouteloua curtipendula,* and the *Calamovilfa longifolia / Carex heliophila* types and the *Agropyron spicatum* Herbaceous Alliance (undefined to association) were merged into the USNVC Association of *Pseudoroegneria spicata - Carex filifolia* Herbaceous Vegetation. This final type has a user's accuracy of 100%.

- The *Agropyron smithii / Carex filifolia* and *Stipa comata / Carex filifolia* types were merged into the USNVC Association of *Pascopyrum smithii - Nassella viridula* Herbaceous Vegetation. This final type has a user's accuracy of 70%.

- The *Shepherdia argentea*, *Tamarix chinensis*, and *Elaeagnus angustifolia* types were originally merged into the USNVC Association of *Shepherdia argentea* Shrubland. This final type has a user's accuracy of 100%. However, because park staff wanted to be able to distinguish between the three types, the final classification includes three *Shepherdia argentea* Shrubland types, two of which are designated as invaded. The *Shepherdia argentea* Shrubland *Tamarix* spp. Invaded, and the *Shepherdia argentea* Shrubland *Elaeagnus angustifolia* Invaded types were too rare to evaluate in the AA.

The primary effect of aggregated map classes is the reduction of forests/woodland types from three types to one and the combination of four of the drier grass types (mostly bluebunch) into a single class. We reasoned that, since errors were clustered within relatively small sets of similar vegetation types, these types could be lumped into a broader treatment of USNVC associations in order to increase accuracy, with a minimal loss in taxonomic (thematic) resolution. All decisions to collapse or combine types were made by the lead ecologists on the project, with input from park management in cases where we felt that the park might want to accept lower accuracy to retain a useful designation. The final map is still a very "busy" treatment, with an impressive amount of detail remaining. Details of the post-hoc aggregations of ecologically similar or operationally indistinguishable types are described below.

Additional Accuracy Assessment Results

An additional result of the AA process was a field check of polygons that were mapped as "Unclassified" or otherwise unattributed. Such polygons may have been missed in the original field work, or lost in the various updates to the database. Unclassified polygons were all field checked and assigned to appropriate classes (using the final set developed by the AA). Most were placed in the *Agropyron cristatum - (Pascopyrum smithii, Stipa comata)* Semi-natural Herbaceous Vegetation, the Great Plains Floodplain Herbaceous Vegetation, or the Weedy Annual Great Plains Herbaceous Vegetation, as the setting suggested.

Final Accuracy

The final map classes generated a total accuracy rate of 78.1% (90% confidence interval 72.1% to 84.1%), with a kappa of 72.8%. The post-AA Kappa value suggests that final set of vegetation types at LIBI was better than random (Jensen 1996). When associations were aggregated to the thematically coarser classification scheme of Ecological Systems (Comer et al. 2003; NatureServe 2007), the overall map accuracy was very high (97.9% with a 90% confidence interval 95.7% to 100% and a Kappa of 93.9%). Table 6 presents estimated User's Accuracy for the final (aggregated) vegetation types at LIBI. Detailed descriptions of each type are in Appendix E. Appendix F provides descriptions of ecological systems occurring at LIBI.

Table 6. Final vegetation and landcover types in the Little Bighorn Battlefield National Monument Vegetation Map. Vegetation types not currently recognized within the USNVC are indicated by an asterisk.

Final Types	Common Name	User's Accuracy[†]
Forest & Woodland (3):		
Populus deltoides - Fraxinus pennsylvanica Forest	Eastern Cottonwood - Green Ash Forest	81.8%
Fraxinus pennsylvanica / Prunus virginiana Forest	Green Ash / Choke Cherry Forest	Not evaluated
Juniperus scopulorum / Pseudoroegneria spicata Woodland	Rocky Mountain Juniper / Bluebunch Wheatgrass Woodland	50%
Shrubland (6):		
Prunus virginiana – (Prunus americana) Shrubland	Chokecherry - (American Plum) Shrubland	60%
Salix exigua Temporarily Flooded Shrubland	Coyote Willow Temporarily Flooded Shrubland	100%
Shepherdia argentea Shrubland	Silver Buffalo-berry Shrubland	100%
**Shepherdia argentea Shrubland - Elaeagnus angustifolia Invaded [Park-specific]*	*Silver Buffaloberry Floodplain Shrubland - Russian Olive Invaded	Not evaluated
**Shepherdia argentea Floodplain Shrubland - Tamarix ssp. Invaded [Park-specific]*	*Silver Buffaloberry Floodplain Shrubland - Tamarisk Invaded	Not evaluated
Symphoricarpos occidentalis Shrubland	Western Snowberry Shrubland	80%
Herbaceous and Shrub-Herbaceous Vegetation (10):		
Pascopyrum smithii - Nassella viridula Herbaceous Vegetation	Western Wheatgrass - Green Needlegrass Mixedgrass Prairie	70.3%
Agropyron cristatum - (Pascopyrum smithii, Stipa comata) Semi-natural Herbaceous Vegetation [Provisional]	Crested Wheatgrass - (Western Wheatgrass, Needle-and-Thread Grass) Semi-natural Herbaceous Vegetation	Not evaluated
Pseudoroegneria spicata - Carex filifolia Herbaceous Vegetation	Bluebunch Wheatgrass – Threadleaf Sedge Mixed Prairie	79.6%
Artemisia cana ssp. cana / Pascopyrum smithii Shrub-Herbaceous Vegetation	Plains Silver Sagebrush / Western Wheatgrass Shrub Prairie	60%
Artemisia tridentata ssp. wyomingensis / Pascopyrum smithii Shrub-Herbaceous Vegetation	Wyoming Big Sagebrush / Western Wheatgrass Shrub Prairie	80%
Artemisia tridentata ssp. wyomingensis / Pseudoroegneria spicata Shrub-Herbaceous Vegetation	Wyoming Big Sagebrush / Bluebunch Wheatgrass Shrub Prairie	100%
Rhus trilobata / Pseudoroegneria spicata Shrub-Herbaceous Vegetation	Skunkbush Sumac / Bluebunch Wheatgrass Shrub Prairie	100%
Sarcobatus vermiculatus / Pascopyrum smithii - (Elymus lanceolatus) Shrub-Herbaceous Vegetation	Greasewood / Western Wheatgrass Shrub Prairie	83.3%
**Great Plains Floodplain and Riverbank Tall Herbaceous Vegetation [Park-specific]*	*Great Plains Floodplain and Riverbank Tall Herbaceous Vegetation	Not evaluated

Final Types	Common Name	User's Accuracy†
**Weedy Annual Great Plains Herbaceous Vegetation [Park-specific]*	*Weedy Annual Great Plains Herbaceous Vegetation	Not evaluated
Landcover (3)		
**Road*	*Road	NA
**Water*	*Water	NA
**Cultural Vegetation (Developed)*	*Cultural Vegetation (Developed)	NA

† User's accuracy was not calculated for landcover types or for more uncommon types (provisional or park-specific).

Final Little Bighorn Battlefield National Monument Map

Figure 12 presents the final Vegetation Map for LIBI. Table 7 presents summary statistics for the spatial extent of each type. Map unit polygons with a common final type and shared contiguous boundaries with a neighbor(s) were dissolved (or spatially combined) in the geodatabase. This reduced the total number of unique map unit polygons in the final map to 541. However, even after the type aggregations described above and the dissolves in the GIS across common type boundaries, many polygons were still below the target MMU of 0.1 ha (0.247 acres).

Overall, Little Bighorn Battlefield National Monument has an interesting array of relatively intact natural vegetation communities. At the Association scale, the two most prevalent types are *Pseudoroegneria spicata - Carex filifolia* Herbaceous Vegetation and *Pascopyrum smithii - Nassella viridula* Herbaceous Vegetation. These two mixed grass prairie community types occupy most of the upland slopes and comprise 78% of the natural vegetation. *Populus deltoides - Fraxinus pennsylvanica* Forest on the floodplain is the third most prevalent community but at 41 acres it occupies an order of magnitude less area than the upland grass types. The low stature *Symphoricarpos occidentalis* Shrubland is the second most prevalent woody vegetation type. It is found in woody draws and on the floodplain. Three sagebrush types have a current total acreage (41) similar to *Symphoricarpos occidentalis* Shrubland. Sagebrush communities were more prevalent before the 1983 and 1991 wildfires. There is limited recruitment of sagebrush downwind of the remnant sagebrush patch near the eastern corner of the Custer Unit. *Rhus trilobata / Pseudoroegneria* spicata Shrub-Herbaceous Vegetation and *Sarcobatus vermiculatus / Pascopyrum smithii - (Elymus lanceolatus)* Shrub-Herbaceous Vegetation each cover thirteen acres. The two shrubs types are situated on the upland slopes and the upper edges of the woody draws but *Sarcobatus vermiculatus / Pascopyrum smithii - (Elymus lanceolatus)* Shrub-Herbaceous also develops along the upland to floodplain cliffs where there is active erosion.

The remaining eight plant associations each occupy less than ten acres. The dense thicket forming *Prunus virginiana* – (*Prunus americana*) Shrubland is present in the deep bottoms of woody draws and on the floodplain. *Salix exigua* Temporarily Flooded Shrubland is the principal longer term colonizer of the edges of the Little Bighorn River and presumably more transient and less structured Great Plains Floodplain Herbaceous Vegetation also currently occupies some of the recent river edges. There is no recent regeneration of *Populus deltoides. Shepherdia argentea* Shrubland is also present on the floodplain, within which there have been small invasions of a *Tamarix sp.* and *Elaeagnus angustifolia*. *Fraxinus pennsylvanica / Prunus virginiana* Forest is found at two transition points where woody draws open on to the floodplain. *Juniperus scopulorum / Pseudoroegneria spicata* Woodland occupies less than one acre and is most prominent in the draws of the Reno-Benteen Unit. Numerous dead trunks indicate juniper was more prevalent before the wildfires. A small disturbed upland area was planted with *Agropyron cristatum* (crested wheatgrass) and this was classified as *Agropyron cristatum* - (*Pascopyrum smithii, Stipa comata*) Semi-natural Herbaceous Vegetation.

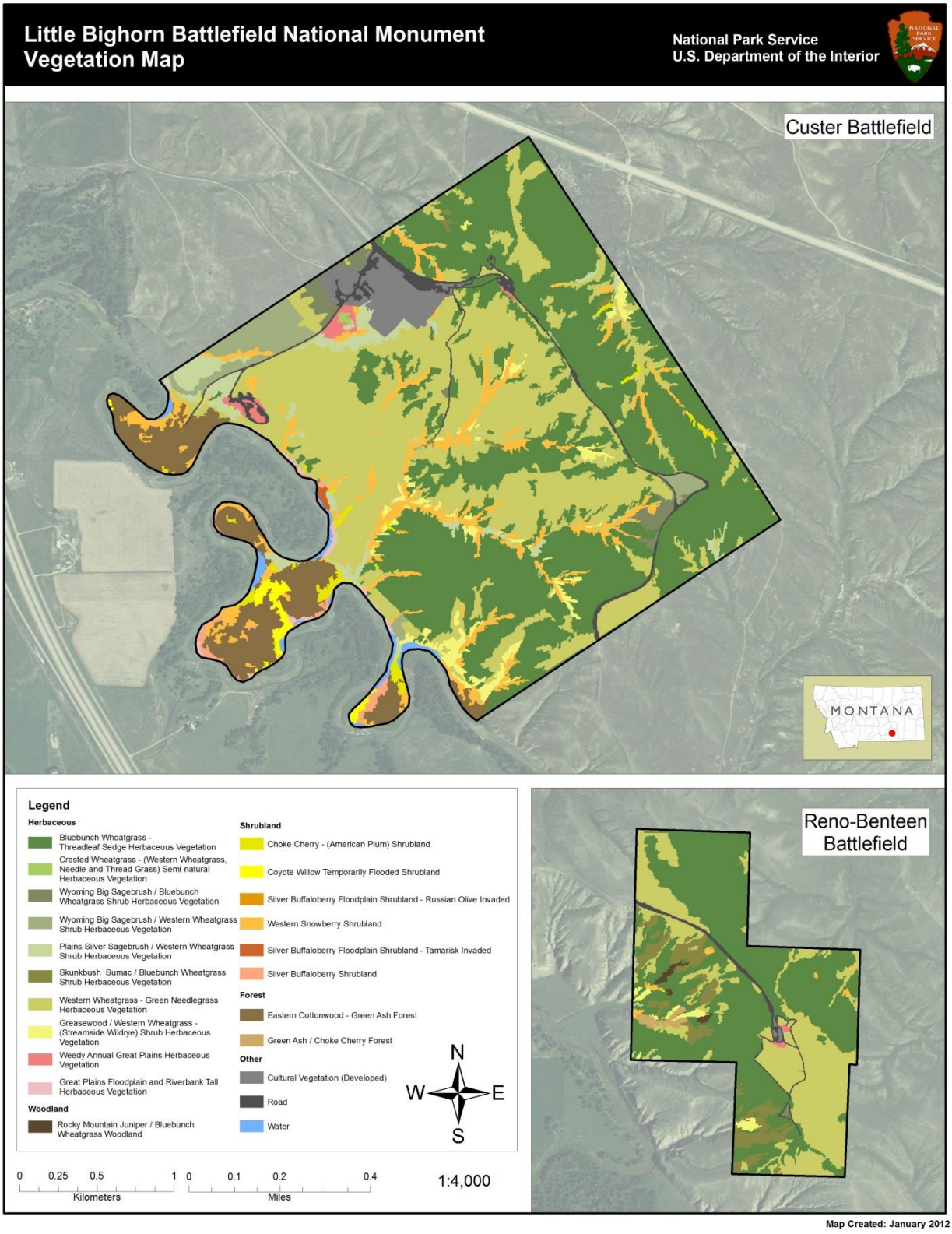


Figure 12. Final Vegetation Map for Little Bighorn Battlefield National Monument.

Table 7. Summary of extent and spatial characteristics of final vegetation types at Little Bighorn Battlefield National Monument. All sizes are acres.

Initial Type	Count	Smallest Polygon	Largest Polygon	Total	% of Total
UPLANDS					
Agropyron cristatum - (Pascopyrum smithii, Hesperostipa comata) Semi-natural Herbaceous Vegetation	1	0.41	0.41	0.41	
Artemisia cana ssp. cana / Pascopyrum smithii Shrub Herbaceous	37	0.01	4.34	18.54	
Artemisia tridentata ssp. wyomingensis / Pascopyrum smithii Shrub Herbaceous Vegetation	5	0.04	12.37	15.32	
Artemisia tridentata ssp. wyomingensis / Pseudoroegneria spicata Shrub Herbaceous Vegetation	7	0.04	2.82	7.19	
Pascopyrum smithii - Nassella viridula Herbaceous Vegetation	122	0.00*	74.91	244.78	
Pseudoroegneria spicata - Carex filifolia Herbaceous Vegetation	75	0.03	79.55	338.96	
Rhus trilobata / Pseudoroegneria spicata Shrub Herbaceous Vegetation	27	0.01	3.76	13.19	
Sarcobatus vermiculatus / Pascopyrum smithii - (Elymus lanceolatus) Shrub Herbaceous Vegetation	54	0.01	2.61	13.30	
Weedy Annual Great Plains Herbaceous Vegetation [Provisional]	7	0.13	1.60	3.32	
UPLANDS TOTAL	335			655.01	83.88
RIPARIAN FLOODPLAIN					
Great Plains Floodplain and Riverbank Tall Herbaceous Vegetation	16	0.01	0.44	2.27	
Populus deltoides - Fraxinus pennsylvanica Forest	10	0.04	13.24	40.70	
Salix exigua Temporarily Flooded Shrubland	4	0.03	3.11	4.05	
Shepherdia argentea Floodplain Shrubland - *Tamarix ssp.* Invaded	1	0.57	0.57	0.57	
Shepherdia argentea Shrubland	11	0.03	1.05	3.06	
Shepherdia argentea Shrubland - *Elaeagnus angustifolia* Invaded	1	0.05	0.05	0.05	
RIPARIAN FLOODPLAIN TOTAL	43			50.70	6.49
WOODY DRAWS					
Fraxinus pennsylvanica / Prunus virginiana Forest	2	0.01	1.43	1.44	
Juniperus scopulorum / Pseudoroegneria spicata Woodland	3	0.09	0.52	0.86	
Prunus virginiana - (Prunus americana) Shrubland	21	0.02	1.03	4.61	
Symphoricarpos occidentalis Shrubland	94	0.01	4.12	34.27	
WOODY DRAWS TOTAL	120			41.18	5.27
NON-VEGETATED OTHER LANDCOVER					
Cultural Vegetation (Developed)	9	0.01	11.92	15.72	
Road	3	0.15	10.78	13.78	
Water	14	0.01	0.90	4.51	

Initial Type	Count	Smallest Polygon	Largest Polygon	Total	% of Total
NON-VEGETATED OTHER LANDCOVER TOTAL	26			34.01	4.36
GRAND TOTAL	524			780.89	

*small polygons below the precision of this table

Ecological Systems

The final vegetation associations constitute three large and one much less abundant USNVC Ecological Systems within the Monument (Table 8). These Ecological Systems are distributed according to the topographic positions. Northwestern Great Plains Mixedgrass Prairie constitutes the extensive upland slopes. The narrow woody draws dissecting these upland slopes form a Western Great Plains Wooded Draw and Ravine Ecological System. A minor upland Association *Sarcobatus vermiculatus / Pascopyrum smithii - (Elymus lanceolatus)* Shrub-Herbaceous Vegetation belongs to the Western Great Plains Badlands. The Little Bighorn River riparian zone belongs to the Northwestern Great Plains Floodplain Ecological System.

Table 8. Summary statistics for final vegetation types at Little Bighorn Battlefield National Monument within ecological system.

Ecological System and component final type	Total Area	% of Total
Northwestern Great Plains Mixedgrass Prairie		
Agropyron cristatum - (Pascopyrum smithii, Hesperostipa comata) Semi-natural Herbaceous Vegetation	0.41	
Artemisia tridentata ssp. wyomingensis / Pascopyrum smithii Shrub Herbaceous Vegetation	15.32	
Artemisia tridentata ssp. wyomingensis / Pseudoroegneria spicata Shrub Herbaceous Vegetation	7.19	
Pascopyrum smithii - Nassella viridula Herbaceous Vegetation	244.78	
Pseudoroegneria spicata - Carex filifolia Herbaceous Vegetation	338.96	
Rhus trilobata / Pseudoroegneria spicata Shrub Herbaceous Vegetation	13.19	
Northwestern Great Plains Mixedgrass Prairie Total	619.85	79.38%
Western Great Plains Badlands		
Artemisia cana ssp. cana / Pascopyrum smithii Shrub Herbaceous	18.54	
Sarcobatus vermiculatus / Pascopyrum smithii - (Elymus lanceolatus) Shrub Herbaceous Vegetation	13.30	
Western Great Plains Badlands Total	31.84	4.08%
Western Great Plains Wooded Draw and Ravine		
Fraxinus pennsylvanica / Prunus virginiana Forest	1.44	
Juniperus scopulorum / Pseudoroegneria spicata Woodland	0.86	
Prunus virginiana - (Prunus americana) Shrubland	4.61	
Symphoricarpos occidentalis Shrubland	34.27	
Western Great Plains Wooded Draw and Ravine Total	41.18	5.27%
Northwestern Great Plains Floodplain		
Great Plains Floodplain and Riverbank Tall Herbaceous Vegetation	2.27	
Populus deltoides - Fraxinus pennsylvanica Forest	40.70	
Salix exigua Temporarily Flooded Shrubland	4.05	
Shepherdia argentea Floodplain Shrubland - *Tamarix ssp.* Invaded	0.57	
Shepherdia argentea Shrubland	3.06	
Shepherdia argentea Shrubland - *Elaeagnus angustifolia* Invaded	0.05	
Northwestern Great Plains Floodplain Total	50.70	6.49%

Ecological System and component final type	Total Area	% of Total
Other vegetation type and component association(s) – No or unknown Ecological System		
Weedy Annual Great Plains Herbaceous Vegetation [Provisional]	3.32	
Cultural Vegetation (Developed)	15.72	
Road	13.78	
Water	4.51	
Land Use Classes Total	37.33	4.78%
Grand Total	780.89	

Verification Plots

Several types previously undocumented within the NVC, emerged as a result of the mapping effort at LIBI. Consequently, it was decided to establish verification plots in these new types. As of 2010, 14 verification plots had been sampled at LIBI in 12 types (two types had two plots). Methodology used followed the Vegetation Mapping Program protocol for classification plots in large parks. Verification data include a full floristic treatment (i.e. species level cover) and select environmental attributes. These data are available in the public domain (via the NPS/USGS Vegetation Mapping Program web site and/or VegBank) so that future development of the USNVC will include these types and enable LIBI and other users to see how types recorded as of 2010 are treated as the USNVC matures. The ROMN geospatial database developed for the LIBI project also includes the verification data. Note that some verification plots have a different final vegetation type name than the larger polygon they are nested within due to differences in how vegetation structure was interpreted across scale (e.g., the verification plot may be a small inclusion in a larger polygon).

Updating the Vegetation Map and Classification

Vegetation maps and classifications are (by design) static products. Imagery and field data are based on samples of conditions that existed over a span of only one to two years. However, vegetation community structure is dynamic across many scales, with changes due to both natural and anthropogenic causes. Even in the absence of any large scale disturbance event, map products will gradually become less accurate and useful as succession, erosion, sedimentation, and other natural processes change the composition and distribution of vegetation across the Park. In the event of any large scale disturbances, the map will immediately become inaccurate for some or all areas of the park. At the more coarse levels in the LIBI classification the data presented in this report are likely correct for some time to come. However, at the patch scale the data presented here will not be accurate (to varying degrees) over time. As of 2012, LIBI has already removed a service road on the western corner of Custer unit and this area would now probably be classified as the Weedy Annual Great Plains Herbaceous Vegetation type. Eventually, this area will likely become the Western Wheatgrass - Green Needlegrass Mixedgrass Prairie type due to natural succession or active restoration by the park.

The National Vegetation Mapping Program has no official position on the process for updating maps and classifications but recognizes the importance of the issue. Until the program can complete all natural resource parks in the country (target date is 2018) there will not be funds allocated to updates. However, there are many opportunities for individual Parks and networks to

do so. Taking the perspective that the map products are an integral part of the park infrastructure to be used and maintained will allow the Park to capitalize on the investment the NPS has made in creating the map and allow the map to function more dynamically than would otherwise be possible.

In response to changes that occur in vegetation, or any differences that are observed between the map and the landscape, it is important to transfer those changes to the map products using the same mapping and classification standards with which the map was created. This will allow the map to be the best possible representation of the real world conditions that exist now and through the future. A record of the changes made to the map should be maintained in a log that documents what the change was, the justification for making it, and the party making the change. Imagery products are produced on a fairly regular basis that might be used in this effort. These include Landsat satellite imagery as well as the more inexpensive NAIP imagery used in LIBI. A focused ground-based sampling effort may be the best means to understand the diverse changes due to disturbances and other, more subtle, changes. However, even simple efforts such as LIBI and ROMN recording GPS locations of unique vegetation not already on the map or where obvious change has occurred are useful.

The LIBI Vegetation Mapping database (Appendix G) contains the point, map, AA and verification plot data collected during the project. The database is structured to allow sample locations to be resampled and the data entered using the same plot code with a new date. Together these constitute an "event" and allow the database to track the vegetation sampled at the same location repeatedly through time. This will be valuable for various long-term monitoring efforts such as planned by the Rocky Mountain Network. To formalize the update process, the following steps could be followed by LIBI and the ROMN:

- Develop a protocol for updating data that includes the update cycle,
- Integrate this process with monitoring efforts, especially to detect more subtle change,
- Adhere to Vegetation Mapping Program standards,
- Define exhaustively the range of disturbance conditions to consider (especially fire and flooding).

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Appendix A: Field Data Collection Forms

This Appendix presents examples of the forms used in collecting field data for the LIBI Vegetation Mapping Project.

Figure A-1. Field form for polygon attribution

Crew: Year: GPS Unit #:

Poly ID	13 North - NAD83 UTM E	UTM N	Super class	Date mm/dd	13 North - NAD83 UTM E	UTM N	WP #	# pts	err	New Super Class	Association	D1	D1-CC	D2	D2-CC	D3	D3-CC	See Notes
LIBI.VM-395	310633	5049612	libi-l															☐
LIBI.VM-646	310370	5049463	libi-l															☐
LIBI.VM-647	310373	5049420	libi-h															☐
LIBI.VM-653	310387	5049437	libi-h															☐
LIBI.VM-655	310410	5049420	libi-h															☐
LIBI.VM-656	310394	5049408	libi-h															☐
LIBI.VM-658	310372	5049407	libi-h															☐
LIBI.VM-659	310416	5049344	libi-h															☐
LIBI.VM-665	310510	5049542	libi-l															☐
LIBI.VM-666	310470	5049506	libi-l															☐
LIBI.VM-667	310468	5049495	libi-l															☐
LIBI.VM-668	310439	5049509	libi-l															☐
LIBI.VM-669	310483	5049510	libi-l															☐
LIBI.VM-670	310579	5049507	libi-l															☐
LIBI.VM-671	310484	5049496	libi-l															☐
LIBI.VM-672	310519	5049470	libi-l															☐
LIBI.VM-673	310449	5049484	libi-l															☐
LIBI.VM-674	310526	5049449	libi-l															☐
LIBI.VM-675	310596	5049437	libi-l															☐
LIBI.VM-676	310514	5049462	libi-l															☐
LIBI.VM-677	310468	5049477	libi-l															☐
LIBI.VM-678	310523	5049422	libi-l															☐
LIBI.VM-679	310534	5049428	libi-l															☐
LIBI.VM-680	310549	5049415	libi-l															☐

Little Bighorn Battelfield National Monument Vegetation Mapping - Rocky Mountain Network I&M *Version: June 9, 2006* Page 1 of 57

Figure A-2. Field form for polygon notes/changes

Polygon ID	Date	Dominant	Cover Class	Notes

Figure A-3. Example of a completed AA field form for LIBI AA

Revised January 2007

Accuracy Assessment Form
USGS-NPS Vegetation Mapping Program

Use one separate form for each waypoint collected. For each waypoint, fields marked marked in black capital letters are mandatory; those marked in orange italics are filled out only as are needed or applicable.

1. **PLOT (WAYPOINT) #:** 302 **2. DATE:** 07/31/2007
3. **OBSERVER (DETERMINING ASSOCIATION)** Daniel Robison
4. *Other Staff (assisting)* Makeda Trujillo
5. **PLOT CONFIGURATION (circle applicable shape and dimension used):**

   Circular, 18 meters radius (1st choice) **Rectangular, 25 m x 40 m (2nd choice)**

   Rectangular, 20 m x 50 m (3rd choice) **Rectangular, 10 m x 100 m (4th choice)**
6. **PLOT CENTER UTM NORTHING** 5142551
7. **PLOT CENTER UTM EASTING** 0366013
8. **POSITION ACCURACY (in meters) of above (from GPS)** 4.3

   Offset of above (if applicable; give reason in #22 "Comments"):
9. *Offset Distance (m):* _____ *10. Offset Azimuth (degrees):* _____
11. *Plot end1 UTM Easting (if rectangular plot used)* _____
12. *Plot end1 UTM Northing (if rectangular plot used)* _____
13. *Position Accuracy (in meters) of above (from GPS) (if applicable)* _____
14. *Plot end2 UTM Easting (if rectangular plot used)* _____
15. *Plot end2 UTM Northing (if rectangular plot used)* _____
16. *Position Accuracy (in meters) of above (from GPS) (if applicable)* _____
17. **UTM Zone** 12 **18. Datum** NAD83

19. **DOMINANT VEGETATION ASSOCIATION in plot (from key):**
JUBA
20. *Other possibilities for dominant association in plot (if applicable):*

21. *If, even after reconfiguring, plot has multiple associations, list additional associations and percentage of plot covered by each (Pages for all should total 100%):*

Dominant Association (#19 or #20): **Page:** _____

Association 2 (list): _____ **Page:** _____

Association 3 (list): _____ **Page:** _____

22. *Other possibilities for dominant association in plot (if applicable):*

19. **DOMINANT/CHARACTERISTIC SPECIES IN TREE LAYER (~ 1 – 5 species, where layer is present)**

20. **DOMINANT/CHARACTERISTIC SPECIES IN TREE LAYER (~ 1 – 5 species, where layer is present):**

21. **DOMINANT/CHARACTERISTIC SPECIES IN HERB LAYER (~ 1 – 5 species, where layer is present):**
*JUBA, *ARSM, CALA, CIAR

22. *Other comments / explanations (if needed)* _____

Appendix B: Key to Initial Vegetation Types at Little Bighorn Battlefield National Monument

This dichotomous key is specific to the **initial vegetation types** delineated during the summer 2006 mapping of the vegetation at the Little Bighorn Battlefield. A key to the final types is provided below.

Choices are made from paired couplets with the same number. After a choice is made from the couplet, the user either goes to the next higher numbered couplet, or if the selected choice is ended with a "go to #" statement the user skips to that even higher number. The key uses topographic position, vegetation height, and life form before considering specific indicator species.

The vegetation community type names used in this Little Bighorn National Battlefield specific key are the community names present in the original source documents that were used to classify the vegetation at Little Bighorn Battlefield. Most of the community types are described in either of the two Hansen documents, but several type names (followed by Association or Alliance) are taken directly from the National Vegetation Classification System as represented by the Nature Serve Explorer Ecological Communities & Systems website.

- Hansen, Paul L.; Hoffman, George R. 1987. The vegetation of the Grand River/Cedar River, Sioux, and Ashland Districts of the Custer National Forest: a habitat type classification. Fort Collins, Colorado, USA.: USDA Forest Service Rocky Mountain Forest and Range Experiment Station. General Technical Report RM GTR-157. 68pp.

- Hansen, Paul L.; Pfister, Robert D.; Boggs, Keith; Cook, Bradley J.; Joy, John; Hinckley, Dan K. 1995. Classification and management of Montana's riparian and wetland sites. School of Forestry, University of Montana, Missoula, MT 59812: Montana Forest and Conservation Experiment Station: Miscellaneous Publication No. 54. xvi + 646 pp.

- National Vegetation Classification System http://www.natureserve.org/explorer/

The original source documents have detailed descriptions of the various community types. The source documents also contain ecological and management information, and the species plot data that was used to develop each classification system. If the key leads to a community type described in one of the two Hansen source documents the page number is given for that community description in its source document. If the community name in the key ends with the word Alliance that community is a National Vegetation Classification System type described in the Nature Serve Explorer Ecological Communities & Systems website.

To effectively use this key you should be able to identify the following 21 indicator species based on their growth form and vegetative characteristics.

Binomial in Regional Flora	Local Common Name
Acer negundo	box elder
Agropyron smithii	western wheatgrass
Agropyron spicatum	bluebunch wheatgrass
Artemisia cana	silver sagebrush
Artemisia tridentata	Wyoming big sagebrush
Bouteloua curtipendula	side oats grama
Calamovilfa longifolia	prairie sand reed grass
Carex filifolia	threadleaf sedge
Carex heliophila† (syn. *inops*)	sun sedge
Elaeagnus angustifolia	Russian olive
Fraxinus pennsylvanica	green ash
Juniperus scopulorum	Rocky Mountain juniper
Populus deltoides	Great Plains cottonwood
Prunus virginiana	common chokecherry
Rhus aromatica (syn. *trilobata*)	skunkbush
Salix exigua	sandbar willow
Sarcobatus vermiculatus	black greasewood
Shepherdia argentea	silver buffaloberry
Stipa comata	needle and thread grass
Symphoricarpos occidentalis	western snowberry
Tamarix sp.	salt cedar

† *Carex heliophila* was not observed in 2006 on Little Bighorn Battlefield.

The indicator species list nomenclature is that used by the two Hansen source documents. This nomenclature is in concurrence with that used by the two standard floras covering Montana.

- Dorn, Robert D. 1984. Vascular plants of Montana. Cheyenne, Wyoming: Mountain West Publishing. 276pp.

- Hitchcock, C. L.; Cronquist, Arthur. 1973. Flora of the Pacific Northwest an illustrated manual. Seattle WA: University of Washington Press. 730pp.

1. Managed areas where human actions preclude natural or semi-natural vegetation communities

2. Landscaped areas
Developed Area-Landscaped

2'. Disturbed areas that can't be typed to a natural or semi-natural vegetation community
Disturbed Area – Management

1. Natural or semi-natural vegetation areas

3. Floodplain of Little Bighorn River (page references to Hansen et al 1995)

4. Trees greater than 20 ft tall when mature

5. *Fraxinus pennsylvanica* (green ash) with at least 5% canopy cover
Fraxinus pennsylvanica/Prunus virginiana
(Green ash/common chokecherry)

5'. *Fraxinus pennsylvanica* (green ash) less than 5% canopy cover

6. *Acer negundo* (box elder) with at least 5% canopy cover
Acer negundo/Prunus virginiana
(Box-elder/common chokecherry)

6'. *Acer negundo* (box elder) less than 5% canopy cover

7. *Populus deltoides* (Great Plains cottonwood) seedlings or saplings age classes (dbh <5 in.) dominate a recently deposited alluvial bar
***Populus deltoides*/Recent Alluvial Bar**
(Great Plains cottonwood/recent alluvial bar)

7'. Mature *Populus deltoides* with understory that may be dominated by *Symphoricarpos occidentalis* (western snowberry)
Populus deltoides/ *Symphoricarpos occidentalis*
(Great Plains cottonwood/western snowberry)

4'. Short tree (< 20 ft) or shrub (< 10 ft) go to 8.

8. Short tree less than 20 ft tall when mature

9. **Elaeagnus angustifolia** (Russian olive) dominates overstory
Elaeagnus angustifolia
(Russian olive)

9'. **Elaeagnus angustifolia** (Russian olive) a minor component

10. *Tamarix sp.* (salt cedar) with at least 15% canopy cover and with the greatest canopy cover in the tallest layer
Tamarix chinensis
(Salt cedar)

10'. *Prunus virginiana* (common chokecherry) with at least 15% canopy cover and with the greatest canopy cover in the tallest layer
Prunus virginiana
(Common chokecherry)

8'. Shrubs (less than 10 ft tall) go to 11.

11. *Salix exigua* (sandbar willow) (6 to 9 ft tall and typically close to river or slough) dominates tallest layer
Salix exigua
(Sandbar willow)

11'. Short (less than 6 ft tall) shrubs

12. *Shepherdia argentea* (silver buffaloberry) with at least 15% canopy cover and with the greatest canopy cover in the tallest layer
Shepherdia argentea
(Silver buffaloberry)

12'. *Symphorocarpus occidentalis* (western snowberry) with at least 15% canopy cover and with the greatest canopy cover in the tallest layer
Symphoricarpos occidentalis
(Western snowberry)

3'. Uplands including ravines or woody draws (page references to Hansen & Hoffman 1988) go to 13.

13. Herbaceous aspect, trees absent, may have an occasional shrub but shrubs not distributed throughout the polygon

14. Rhizomatous grasses *Agropyron smithii* (western wheatgrass) dominant or *Calamovilfa longifolia* (prairie sand reed grass) abundant

15. *Calamovilfa longifolia* (prairie sand reed grass) abundant
***Calamovilfa longifolia/Carex heliophila*†**
(Prairie sand reed grass/sun sedge†)

15'. *Agropyron smithii* (western wheatgrass) dominant
***Agropyron smithii/Carex filifolia*†**
Western wheatgrass/threadleaf sedge†

14'. Bunchgrasses *Agropyron spicatum* (bluebunch wheatgrass) or *Stipa comata* (needle and thread grass) dominant; or *Agropyron spicatum* (bluebunch wheatgrass) approximately co-dominant with *Agropyron smithii* (western wheatgrass) go to 16.

16. *Agropyron spicatum* (bluebunch wheatgrass) dominant

17. *Bouteloua curtipendula* (side oats grama) present and abundant
Agropyron spicatum/Bouteloua curtipendula
(Bluebunch wheatgrass/side oats grama)

17. *Bouteloua curtipendula* (side oats grama) absent

18. *Agropyron spicatum* (bluebunch wheatgrass) dominant
***Agropyron spicatum/Carex filifolia*†**
(Bluebunch wheatgrass/threadleaf sedge†)

18'. *Agropyron spicatum* (bluebunch wheatgrass) and Agropyron smithii (western wheatgrass) approximately co-dominant, other indicator species not apparent
Agropyron spicatum Herbaceous Alliance
Bluebunch wheatgrass Herbaceous Alliance

16'. *Stipa comata* (needle and thread grass) dominant
***Stipa comata/Carex filifolia*†**
(Needle and thread grass/threadleaf sedge†)

13'. Woody species present and distributed throughout the polygon go to 19

19. Short trees (10 to ~20 ft tall when mature) usually in a ravine

20. Evergreen *Juniperus scopulorum* (Rocky Mountain juniper) dominates the upper layer
Juniperus scopulorum/Agropyron spicatum
(Rocky Mountain juniper/bluebunch wheatgrass)

20'. Deciduous trees dominate the upper layer

21. *Fraxinus pennsylvanica* (green ash) dominates upper layer
Fraxinus pennsylvanica/Prunus virginiana
Green ash/common chokecherry

21'. *Prunus virginiana* (common chokecherry) thicket dominates
***Prunus virginiana* Shrubland Alliance**
Choke Cherry Shrubland Alliance

19'. Shrubs (less than 10 ft tall) dominate the upper layer, tree species absent go to 22

22. Sagebrush species form the shrub layer, other shrubs absent or rare

23. *Artemisia tridentata* (Wyoming big sagebrush) dominates, *Artemisia cana* (silver sagebrush) absent or inconspicuous

24. *Agropyron spicatum* (bluebunch wheatgrass) dominant in the herbaceous layer, *Agropyron smithii* (western wheatgrass) inconspicuous or absent
Artemisia tridentata/Agropyron spicatum
(Wyoming big sagebrush/bluebunch wheatgrass)

24. *Agropyron smithii* (western wheatgrass) dominant in the herbaceous layer, *Agropyron spicatum* (bluebunch wheatgrass) inconspicuous or absent
Artemisia tridentata/Agropyron smithii
(Wyoming big sagebrush/western wheatgrass)

23'. *Artemisia cana* (silver sagebrush) dominates, *Artemisia tridentata* (Wyoming big sagebrush) absent or very sparse
Artemisia cana/Agropyron smithii
Silver sagebrush/western wheatgrass

22'. Sagebrush species absent or inconspicuous go to 25

25. *Rhus aromatica* (*syn. trilobata*) (skunkbush) dominates the shrub layer
Rhus aromatica/Agropyron spicatum
(Skunkbush/bluebunch wheatgrass)

25'. *Rhus aromatica* (*syn. trilobata*) (skunkbush) absent or inconspicuous

26. *Sarcobatus vermiculatus* (black greasewood) or *Shepherdia argentea* (silver buffaloberry) abundant; *Symphoricarpos occidentalis* (western snowberry) absent or not dominant

27. *Sarcobatus vermiculatus* (black greasewood) dominant in the shrub layer; *Shepherdia argentea* (silver buffaloberry) absent

28. *Agropyron smithii* (western wheatgrass) abundant; *Agropyron spicatum* (bluebunch wheatgrass) absent
Sarcobatus vermiculatus/Agropyron smithii
(Black greasewood/western wheatgrass)

28. *Agropyron spicatum* (bluebunch wheatgrass) abundant; *Agropyron smithii* (western wheatgrass) absent or inconspicuous
Sarcobatus vermiculatus/Agropyron spicatum
(Black greasewood/bluebunch wheatgrass)

27'. *Shepherdia argentea* (silver buffaloberry) present; *Sarcobatus vermiculatus* (black greasewood) absent
Shepherdia argentea
Silver buffaloberry

26'. *Symphoricarpos occidentalis* (western snowberry) abundant and often forming a dense thicket; *Sarcobatus vermiculatus* (black greasewood) or *Shepherdia argentea* (silver buffaloberry) absent
Symphoricarpos occidentalis
Western snowberry

† In 2006 *Carex filifolia* (threadleaf sedge) was absent or often inconspicuous in the communities at LIBI, and *Carex heliophila* was not observed.

Appendix C: Accuracy Assessment Results

This appendix presents the initial and final contingency tables for the map classes used at LIBI, and for ecological systems represented at the monument. Tables C-1 and C-2 show the data metrics for each map class, a mean value for each type of error, and a mean value for the confidence interval for each type of error for pre- and post-AA types. As expected, the overall accuracy of the map and individual accuracies increase as requirements are relaxed. Table C-3 evaluates the final four ecological systems to which map classes were assigned.

Contingency tables are read as follows. The rows represent the assigned map class value for each of the polygons (the map) and the columns represent the reference or accuracy assessment point observed in the field. Shaded cells on the principal diagonal represent map values confirmed as correct. The sum of the principal diagonal divided by the total number of sample points provides the overall map accuracy. Additionally, each map class has two accuracy results, the "producers accuracy" showing errors of omission, and the "users" map accuracy reflecting errors of commission. The total number of samples (n) and a confidence interval with a 90% two-sided limit for each class are also shown. Refer to Environmental Systems Research Institute et al. (1994) for guidance on interpretation.

Table C-1. LIBI pre-AA vegetation types contingency table

This table evaluates 24 initial vegetated map classes assigned prior to the accuracy assessment and revision process. Map Classes listed in rows; field calls listed in columns. Cells representing "correct" sites (absolute agreement between map class and field call) are shaded light gray on the diagonal. Groupings of map classes/field calls that were merged in the final (USNVC association) classification and contingency table are denoted by heavy dashed lines.

	ACNE/PRVI	FRPE/PRVI (all floodplain si	PODE/SYOC	JUSC/AGSP	PRVI	PODE (saplings)	SAEX	SHAR	TACH	ELAN	SYOC	STCO/CAFI	AGSM/CAFI	CALO/CAHE	AGSP/BOCU	AGSP/CAFI	AGSP	ARCA/AGSM	ARTR/AGSP	ARTR/AGSM	RHTR/AGSP	SAVE/AGSP	SAVE/AGSM	Unclassified	*Agropyron cristatum*	GRAND TOTALS	POINT ESTIMATE OF MAP CLASS USER'S ACCURACY	LOWER LIMIT, 90% CONFIDENCE INTERVAL (two-sided)**	UPPER LIMIT, 90% CONFIDENCE INTERVAL (two-sided)**
ACNE/PRVI		1	1																							2	0.0%	0.0%	25.0%
FRPE/PRVI (all floodplain sites)		1	2	1																						4	25.0%	0.0%	73.1%
PODE/SYOC		1	3				1																			5	60.0%	14.0%	100.0%
JUSC/AGSP				1																	1					2	50.0%	0.0%	100.0%
PRVI		1	1		3																					5	60.0%	14.0%	100.0%
PODE (saplings)																										0	not evaluated		
SAEX							3																			3	0.0%	0.0%	16.7%
SHAR								2																		2	0.0%	0.0%	25.0%
TACH									1																	1	0.0%	0.0%	50.0%
ELAN																										0	not evaluated		
SYOC											4												1			5	80.0%	40.6%	100.0%
STCO/CAFI								1					3										2			6	0.0%	0.0%	8.3%
AGSM/CAFI											1	1	22			1	4						2			31	71.0%	55.9%	86.0%
CALO/CAHE																1										1	0.0%	0.0%	50.0%
AGSP/BOCU															2	3	5				1					11	18.2%	-5.5%	41.9%
AGSP/CAFI													2		1	4	3		1			1				12	33.3%	6.8%	59.9%
AGSP													3		1	8	15	1			1	1				30	50.0%	33.3%	66.7%
ARCA/AGSM																		3	1	1						5	60.0%	14.0%	100.0%
ARTR/AGSP																			5							5	100.0%	90.0%	100.0%
ARTR/AGSM																		1		4						5	80.0%	40.6%	100.0%
RHTR/AGSP																					5					5	100.0%	90.0%	100.0%
SAVE/AGSP																							1			1	0.0%	0.0%	50.0%
SAVE/AGSM																					1		4			5	80.0%	40.6%	100.0%
Unclassified													4				1				1			3	1	10	0.0%	0.0%	5.0%
GRAND TOTALS	0	4	7	2	3	0	4	3	1	0	5	1	34	0	4	17	28	5	7	5	10	2	10	3	1	146			
CLASS PRODUCER'S ACCURACY	not found	25.0%	42.9%	50.0%	100.0%	not found	75.0%	66.7%	100.0%	not found	80.0%	0.0%	64.7%	not found	50.0%	23.5%	53.6%	60.0%	71.4%	80.0%	50.0%	0.0%	40.0%	not defined	not defined	OVERALL ACCURACY*:			
LOWER LIMIT, 90% CONFIDENCE INTERVAL (two-sided)**		0.0%	4.9%	0.0%	83.3%		26.9%	5.2%	50.0%		40.6%	0.0%	49.8%		0.0%	3.7%	36.3%	14.0%	36.2%	40.6%	19.0%	0.0%	9.5%				56.16%	49.07%	63.26%
UPPER LIMIT, 90% CONFIDENCE INTERVAL (two-sided)**		73.1%	80.8%	100.0%	100.0%		100.0%	100.0%	100.0%		100.0%	50.0%	79.7%		100.0%	43.4%	70.9%	100.0%	100.0%	100.0%	81.0%	25.0%	70.5%						
** - reported as 100%, if calculated value > 100%, or as 0%, if calculated value <0%																										*-Does not include map classes and ecological classes not evaluated			

Table C-2. LIBI final vegetation types contingency table

This table presents 15 of the vegetated map classes retained following the accuracy assessment and revision process. Map Classes listed in rows; field calls listed in columns. Cells representing "correct" sites (absolute agreement between map class and field call) are shaded light gray on the diagonal. Map class totals for NVC map classes that are a result of mergings from original habitat type classification are denoted by bold borders.

	PODE/FRPE	FRPE/PRVI	JUSC/AGSP	PRVI	SAEX	SHAR	SYOC	SGSM/STVI	AGSP/CAFI	ARCA/AGSM	ARTR/AGSM	ARTR/AGSP	RHTR/AGSP	SAVE/AGSM	AGCR	RUDERAL	GRAND TOTALS	POINT ESTIMATE OF MAP CLASS USER'S ACCURACY	LOWER LIMIT, 90% CONFIDENCE INTERVAL (two sided)	UPPER LIMIT,90% CONFIDENCE INTERVAL (two sided)**
PODE/FRPE	9		1		1												11	81.8%	58.1%	100.0%
FRPE/PRVI																	0	Not evaluated		
JUSC/AGSP			1										1				2	50.0%	0.0%	100.0%
PRVI	2			3													5	60.0%	14.0%	100.0%
SAEX					3												3	100.0%	83.3%	100.0%
SHAR						3											3	100.0%	83.3%	100.0%
SYOC							4							1			5	80.0%	40.6%	100.0%
SGSM/STVI						1	1	26	5					4			37	70.3%	56.6%	84.0%
AGSP/CAFI								5	43	1		1	2	2			54	79.6%	69.7%	89.6%
ARCA/AGSM										3	1	1					5	60.0%	14.0%	100.0%
ARTR/AGSM										1	4						5	80.0%	40.6%	100.0%
ARTR/AGSP												5					5	100.0%	90.0%	100.0%
RHTR/AGSP													5				5	100.0%	90.0%	100.0%
SAVE/AGSM													1	5			6	83.3%	50.0%	100.0%
Unclassified								4	1				1		1	3	10	Not evaluated		
GRAND TOTALS	11	0	2	3	4	4	5	31	48	5	5	7	9	12	0	0	146			
POINT ESTIMATE OF MAP CLASS PRODUCER'S ACCURACY	81.8%		50.0%	100.0%	75.0%	75.0%	80.0%	83.9%	89.6%	60.0%	80.0%	71.4%	55.6%	41.7%			OVERALL ACCURACY*:			
LOWER LIMIT, 90% CONFIDENCE INTERVAL (two-sided)	58.1%	Not evaluated	0.0%	83.3%	26.9%	26.9%	40.6%	71.4%	81.3%	14.0%	40.6%	36.2%	22.8%	14.1%	Not evaluated	Not evaluated		78.1%	72.1%	84.1%
UPPER LIMIT, 90% CONFIDENCE INTERVAL (two-sided)**	100.0%		100.0%	100.0%	100.0%	100.0%	100.0%	96.4%	97.9%	100.0%	100.0%	100.0%	88.4%	69.2%			KAPPA INDEX*:		72.8%	
** reported as 100%, if calculated value > 100%, or as 0%, if calculated value <0%																				
																	* Does not include Unclassified map class			

Table C-3. LIBI final ecological system contingency table

This table represents the final four ecological systems to which map classes were assigned. Assigned Map Classes listed in rows; field calls listed in columns. Cells representing "correct" sites (absolute agreement between map class and field call) are shaded light gray on the diagonal.

	Northwestern Great Plains Mixedgrass Prairie	Western Great Plains Wooded Draw and Ravine	Northwestern Great Plains Floodplain	Western Great Plains Badlands	GRAND TOTALS	POINT ESTIMATE OF MAP CLASS USER'S ACCURACY (two-sided)**	LOWER LIMIT, 90% CONFIDENCE INTERVAL (two-sided)**	UPPER LIMIT, 90% CONFIDENCE INTERVAL (two-sided)**
Northwestern Great Plains Mixedgrass Prairie	115	1	1		117	98.3%	95.9%	100.0%
Western Great Plains Wooded Draw and Ravine	1	6			7	85.7%	56.8%	100.0%
Northwestern Great Plains Floodplain		1	20		21	95.2%	85.2%	100.0%
Western Great Plains Badlands				1	1	0.0%	0.0%	100.0%
GRAND TOTALS	116	8	21	1	146			
POINT ESTIMATE OF MAP CLASS PRODUCER'S ACCURACY	99.1%	75.0%	95.2%	100.0%		OVERALL ACCURACY:		
LOWER LIMIT, 90% CONFIDENCE INTERVAL (two-sided)**	97.3%	43.6%	85.2%	0.0%		97.9%	95.7%	100.0%
UPPER LIMIT, 90% CONFIDENCE INTERVAL (two-sided)**	100.0%	100.0%	100.0%	100.0%		KAPPA INDEX:		93.9%
** - reported as 100% or 0%, if calculated value > 100% or <0%, respectively								

Appendix D: Key to Final Vegetation Types at Little Bighorn National Battlefield

The following key is for the **final vegetation types** at Little Bighorn National Battlefield. The keys is "dichotomous", which means the user follows the order of the 'couplets' and makes a choice between the 2 options represented in the couplet. The ordering of the couplets in each key does matter, and the user should choose the option in each couplet that best fits the data or field situation. A choice leads the user to the next couplet to be utilized in the keying process, via a number at the far right, or else leads to a final result (map class).

If the choices the user makes leads to a "result", then a vegetation type is named and represents a NVC association, alliance or group of alliances, or a landcover type. These NVC-based map classes are recognizable because "alliance" or "association" is in the name, although some of the landcover types may be described using NVC alliances. Keys are generally based on dominance within vegetation strata, with tree cover generally considered first, then shrubs, and finally the herbaceous component. Co-dominant species within a given strata may be important as well, in some cases an association or alliances will have 2 or more codominant species, which may or may not be present in all stands.

To effectively use this key you should be able to identify the primary dominant species in Table 4 in the main text based on their growth form and vegetative characteristics.

The regional flora useful for identifying these indicator species are:

- Dorn, Robert D. 1984. Vascular plants of Montana. Cheyenne, Wyoming: Mountain West Publishing. 276pp.

- Hitchcock, C. L.; Cronquist, Arthur. 1973. Flora of the Pacific Northwest an illustrated manual. Seattle WA: University of Washington Press. 730pp.

Key to Final Plant Communities at Little Bighorn National Battlefield

The key assumes that the type of interest is a vegetated type (i.e., not water, road or other developed areas).

1. Managed areas where human actions preclude natural or semi-natural vegetation communities

2. Landscaped areas
Cultural Vegetation (Developed)

2'. Disturbed areas that can't be typed to a natural or semi-natural vegetation community

The perennial grass *Agropyron cristatum* is important or dominant
Agropyron cristatum - (Pascopyrum smithii, Hesperostipa comata) **Semi-natural Herbaceous**
The perennial grass *Agropyron cristatum* absent or unimportant; ruderal weeds predominate.
Weedy Annual Great Plains Herbaceous Vegetation

1'. Natural or semi-natural vegetation areas

3. Floodplain of Little Bighorn River

4. Trees greater than 20 ft tall when mature $\geq$ 25% absolute cover

7. *Populus deltoides* (Great Plains cottonwood) seedlings or saplings age classes (dbh <5 in.) dominate a recently deposited alluvial bar
Salix exigua **Temporarily Flooded Shrubland (in part)**

7'. Mature *Populus deltoides* with understory that may be dominated by
Verification Plots*Symphoricarpos occidentalis* (western snowberry)
Populus deltoides – Fraxinus pennsylvanica **Forest**

4'. Short tree (< 20 ft) or shrub (< 10 ft) go to 8 (tall trees < 25 % absolute cover).

8. Short tree less than 20 ft tall when mature

9. *Elaeagnus angustifolia* (Russian olive) dominates overstory
Shepherdia argentea **Shrubland (in part)**

9'. *Elaeagnus angustifolia* (Russian olive) a minor component

10. *Tamarix sp.* (salt cedar) with at least 15% canopy cover and with the greatest canopy cover in the tallest layer
Shepherdia argentea **Shrubland (in part)**

10'. *Prunus virginiana* (common chokecherry) with at least 15%

canopy cover and with the greatest canopy cover in the tallest layer
Prunus virginiana – (Prunus americana) **Shrubland (in part)**

8'. Shrubs (less than 10 ft tall) go to 11.

11. *Salix exigua* (sandbar willow) (6 to 9 ft tall and typically close to river or slough) dominates tallest layer
Salix exigua **Temporarily Flooded Shrubland (in part)**

11'. Short (less than 6 ft tall) shrubs

12. *Shepherdia argentea* (silver buffaloberry) with at least 15% canopy cover and with the greatest canopy cover in the tallest layer
Shepherdia argentea **Shrubland (in part)**

12'. *Symphoricarpos occidentalis* (western snowberry) with at least 15% canopy cover and with the greatest canopy cover in the tallest layer
Symphoricarpos occidentalis **Shrubland (in part)**

3'. Uplands including ravines or woody draws go to 13.

13. Herbaceous aspect, trees absent, may have an occasional shrub but shrubs not distributed throughout the polygon

14. Rhizomatous grasses *Agropyron smithii* (western wheatgrass) dominant or *Calamovilfa longifolia* (prairie sand reed grass) abundant

15. *Calamovilfa longifolia* (prairie sand reed grass) abundant
Pseudoroegneria spicata – Carex filifolia **Herbaceous Vegetation (in part)**

15'. *Pascopyrum smithii* (western wheatgrass) dominant
Pascopyrum smithii - Nassella viridula **Herbaceous Vegetation (in part)**

14'. Bunchgrasses *Pseudoroegneria spicata* (bluebunch wheatgrass) or *Hesperostipa comata* (needle and thread grass) dominant; or *Pseudoroegneria spicata* (bluebunch wheatgrass) approximately co-dominant with *Pascopyrum smithii* (western wheatgrass) go to 16.

16. *Pseudoroegneria spicata* (bluebunch wheatgrass) dominant
Pseudoroegneria spicata – Carex filifolia **Herbaceous Vegetation (in part)**

16'. *Hesperostipa comata* (needle and thread grass) dominant
Pascopyrum smithii - Nassella viridula **Herbaceous Vegetation (in part)**

13. Woody species present and distributed throughout the polygon go to 19

19. Short trees (10 to ~20 ft tall when mature) usually in a ravine

20. Evergreen *Juniperus scopulorum* (Rocky Mountain juniper) dominates the upper layer
Juniperus scopulorum / Pseudoroegneria spicata Woodland

20'. Deciduous trees dominate the upper layer

21. *Fraxinus pennsylvanica* (green ash) dominates upper layer
Fraxinus pennsylvanica / Prunus virginiana **Forest**

21. *Prunus virginiana* (common chokecherry) thicket dominates
Prunus virginiana – (Prunus americana) **Shrubland (in part)**

19'. Shrubs (less than 10 ft tall) dominate the upper layer, tree species absent go to 22

22. Sagebrush species form the shrub layer, other shrubs absent or rare

23. *Artemisia tridentata* (Wyoming big sagebrush) dominates, *Artemisia cana* (silver sagebrush) absent or inconspicuous

24. *Agropyron spicatum* (bluebunch wheatgrass) dominant in the herbaceous layer, *Agropyron smithii* (western wheatgrass) inconspicuous or absent
Artemisia tridentata ssp. wyomingensis / Pseudoroegneria spicata Shrub Herbaceous Vegetation

24'. *Pascopyrum smithii* (western wheatgrass) dominant in the herbaceous layer, *Pseudoroegneria spicata* (bluebunch wheatgrass) inconspicuous or absent ***Artemisia tridentata ssp. wyomingensis / Pascopyrum smithii*** Shrub Herbaceous Vegetation

23'. *Artemisia cana* (silver sagebrush) dominates, *Artemisia tridentata* (Wyoming big sagebrush) absent or very sparse
Artemisia cana ssp. cana / Pascopyrum smithii Shrub Herbaceous Vegetation

22'. Sagebrush species absent or inconspicuous go to 25

25. *Rhus trilobata* (*syn aromatica*) (skunkbush) dominates the shrub layer
Rhus trilobata / Pseudoroegneria spicata Shrub Herbaceous Vegetation

25'. *Rhus trilobata* (*syn aromatica*) (skunkbush) absent or inconspicuous

26. *Sarcobatus vermiculatus* (black greasewood) or *Shepherdia argentea* (silver buffaloberry) abundant; *Symphoricarpos occidentalis* (western snowberry) absent or not dominant

27. *Sarcobatus vermiculatus* (black greasewood) dominant in the shrub layer; *Shepherdia argentea* (silver buffaloberry) absent
Sarcobatus vermiculatus / Pascopyrum smithii - (Elymus lanceolatus) Shrub Herbaceous Vegetation

27'. *Shepherdia argentea* (silver buffaloberry) present; *Sarcobatus vermiculatus* (black greasewood) absent
Shepherdia argentea Shrubland (in part)

26'. *Symphoricarpos occidentalis* (western snowberry) abundant and often forming a dense thicket; *Sarcobatus vermiculatus* (black greasewood) or *Shepherdia argentea* (silver buffaloberry) absent
Symphoricarpos occidentalis Shrubland (in part)

Appendix E: Final Vegetation Type Descriptions

The Little Bighorn Battlefield National Monument vegetation mapping project identified 14 vegetation types, one provisional type, and four Park-specific types described from this project. The detailed vegetation descriptions in this appendix are essential for recognizing vegetation types in the field. In this appendix, vegetation types are arranged by physiognomic class (e.g. Woodland, Shrubland, etc.). An explanation of the field names used in the following descriptions is presented below (Table E-1). A bibliography of sources used in these descriptions is included in this appendix.

Table E-1. Explanation of field names used in vegetation association descriptions

FIELD	DESCRIPTION
MAP NAME	The name used to describe the vegetation type. At LIBI this was usually at the Association level. When this is the case we use Latin names of nominal taxa as conferred by NatureServe (2007).
COMMON NAME	The map name in common usage. When the map name is an association we use common (English) names of nominal taxa as conferred by NatureServe (2007).
LOCAL NAME	Additional descriptive name for the association is listed, if available.
CLASS	1997 National Vegetation Classification Standard (NVCS) Class assignment of association.
SUBCLASS	1997 NVCS Subclass assignment of association.
GROUP	1997 NVCS Group assignment of association.
SUBGROUP	1997 NVCS Subgroup assignment of association.
FORMATION	1997 NVCS Formation assignment of association.
ALLIANCE	The alliance assignment of the association, as conferred by NatureServe (2007).
ASSOCIATION IDENTIFIER	The unique alphanumeric identifier of the association, as conferred by NatureServe (2007)
USFWS WETLAND SYSTEM	The Cowardin et al. assignment of the association, including National Wetlands Inventory (NWI) mapping code, if applicable.
NS ECOLOGICAL SYSTEM	Most likely NatureServe Ecological System assignment for association at Little Bighorn Battlefield National Monument (Comer et al. 2003) (NatureServe 2007).
RANGE	The geographic range of the association, both at Little Bighorn Battlefield National Monument (as defined by this study) and global (NatureServe 2007).
ENVIRONMENTAL DESCRIPTION	The environmental setting of the association, both at Little Bighorn Battlefield National Monument, as defined by this study, including National Park Service (2006a, 2006b) and global, as defined by NatureServe (2007).
MOST ABUNDANT SPECIES	The most abundant species in each vegetation stratum for the association at Little Bighorn Battlefield National Monument (as defined by this study).
CHARACTERISTIC SPECIES	Characteristic species for the association at Little Bighorn Battlefield National Monument (as defined by this study).

FIELD	DESCRIPTION
VEGETATION DESCRIPTION	A qualitative description of the vegetation (floristic) composition of the association, both at Little Bighorn Battlefield National Monument (as defined by this study) and globally (NatureServe 2007)
GLOBAL CLASSFICATION CONFIDENCE	A relative ranking of the confidence in the robustness of the association concept on a global scale (1=”Strong”; 2=”Moderate”; 3=”Weak” (NatureServe 2007).
CONSERVATION RANK	A ranking of the global abundance of the association (see Grossman et al. 1998 for symbol explanations) (NatureServe 2007).
SIMILAR ASSOCIATIONS	Distinguishing characters between the association and similar and/or intergrading associations that also occur at Little Bighorn Battlefield National Monument (if applicable).
CLASSIFICATION COMMENTS	Discussion of association assignments as derived at Little Bighorn Battlefield National Monument (if applicable). Also, discussion of distinguishing characters between the association and similar and/or intergrading associations that also occur at Little Bighorn Battlefield National Monument (if applicable).

Table of Contents

Forest

Populus deltoides - Fraxinus pennsylvanica Forest

COMMON NAME	Eastern Cottonwood - Green Ash Forest
LOCAL NAME	Cottonwood - Green Ash Floodplain Forest
CLASS	Forest (I)
SUBCLASS	Deciduous forest (I.B)
GROUP	Cold-deciduous forest (I.B.2)
SUBGROUP	Natural/Semi-natural cold-deciduous forest (I.B.2.N)
FORMATION	Temporarily flooded cold-deciduous forest (I.B.2.N.d)
ALLIANCE	*POPULUS DELTOIDES* TEMPORARILY FLOODED FOREST
ASSOCIATION IDENTIFIER	CEGL000658
USFWS WETLAND SYSTEM	Upland
NS ECOLOGICAL SYSTEM	Northwestern Great Plains Floodplain (CES303.676)

RANGE

Little Bighorn Battlefield National Monument

At Little Bighorn Battlefield National Monument, this forest is limited to the floodplain of the Little Bighorn River in the Main Unit, where it occurs extensively.

Global

This association is reported from throughout the northern and central Great Plains of the United States and adjacent Canada, ranging from the Dakotas northwest to Montana and Saskatchewan, and south to Nebraska.

ENVIRONMENTAL DESCRIPTION

Little Bighorn Battlefield National Monument

Stands are found on the floodplain of the Little Bighorn River on Quaternary alluvium. Soils are mapped as Haverson and Glenberg soils.

Global

This association occurs along rivers and streams and around ponds and lakes. The soils are developed from alluvium. In southwest North Dakota, Girard et al. (1989) found this type on silty clay loam, clay loam, clay, and loam. The soils were alkaline. Johnson (1971) found sandy loams, loamy sands, and silty clays along the Missouri River.

MOST ABUNDANT SPECIES

STRATUM	SPECIES
Tree	*Populus deltoides, Fraxinus pennsylvanica*
Shrub	*Prunus virginiana, Symphoricarpos occidentalis, Rosa woodsii, Fraxinus pennsylvanica*
Herbaceous	*Bromus inermis, Poa pratensis, Cynoglossum officinale, Thalictrum* sp. *Galium aparine*

CHARACTERISTIC SPECIES

Populus deltoides, Fraxinus pennsylvanica, Acer negundo, Galium aparine, Bromus inermis, Thalictrum sp., *Cynoglossum officinale, Vitis riparia*

VEGETATION DESCRIPTION

Little Bighorn Battlefield National Monument

(from 10 accuracy assessment observations)

This type ranges in physiognomic expression from a woodland to a closed canopy forest. *Populus deltoides* is important to the sole dominant in the tree canopy, with large specimens contributing from 20-90%. It is generally absent from the subcanopy and lower strata. *Fraxinus pennsylvanica* is often present in the tree canopy and occasionally exceeds *P. deltoides* in cover; it is almost always present at considerable cover (5-50%) in the tree subcanopy and/or tall shrub (sapling) layers, suggesting a gradual replacement of *P. deltoides* by more shade-tolerant *F. pennsylvanica* with floodplain accretion and stability. *Acer negundo* and/or *Salix amygdaloides* may

contribute minor amounts of cover, usually in more open (woodland) stands. *Prunus virginiana* and *Symphoricarpos occidentalis* are the most abundant shrubs and can be frequent but scattered to densely patch-dominant. *Rosa woodsii* and *Shepherdia argentea* may be present at low cover. The vines *Vitis riparia, Clematis ligusticifolia,* and *Toxicodendron radicans* are often present, especially in more open stands. The herbaceous layer may be moderately dense to dense, depending on canopy closure of the upper strata. The non-native *Bromus inermis* and/or *Poa pratensis* are often dominant. *Thalictrum* sp., *Solidago canadensis, Galium aparine,* and *Cynoglossum officinale* are frequent forbs.

Global

This association is a riparian forest with open to closed canopy dominated by deciduous trees. Girard et al. (1989) sampled two stands in southwestern North Dakota that had an average of 293 trees/ha. Hansen et al. (1984) sampled four stands that had an average basal area of 41 m2/ha and 427 trees/ha. They found that the average cover by strata was shrubs 76.8%, graminoids 64.2%, and forbs 43.5%. *Populus deltoides* and *Fraxinus pennsylvanica* are the most abundant mature trees. *Acer negundo, Salix amygdaloides*, and *Juniperus scopulorum* may also be present in the tree layer. This association is seral and in younger stands. *Populus deltoides* is the dominant, but as stands age *Fraxinus pennsylvanica* becomes more prominent until the stand becomes a different type. The closed canopy leads to poor reproduction by *Populus deltoides* in stands of all ages. The shrub layer is often vigorous. Species such as *Rosa woodsii, Symphoricarpos occidentalis, Juniperus scopulorum, Juniperus communis*, and *Cornus sericea ssp. sericea* can be abundant. The composition of the herbaceous layer is variable. Along the Missouri River, Keammerer (1972) found *Poa pratensis* to be the most prevalent species, with *Amphicarpaea bracteata, Bromus inermis,* and *Elymus virginicus* common. *Carex* spp., *Juncus* spp., *Leymus cinereus, Lysimachia ciliata, Thalictrum venulosum*, and *Elymus canadensis* are common. Weedy species are almost ubiquitous, among them *Poa* spp., *Bromus inermis, Melilotus officinalis, Ambrosia* spp., and *Urtica* spp.

CONSERVATION RANK G2G3

GLOBAL CLASSFICATION CONFIDENCE 3

CLASSIFICATION COMMENTS

This type was originally mapped as *Populus deltoides / Symphoricarpos occidentalis* Habitat Type, *Fraxinus pennsylvanica / Prunus virginiana* Habitat Type, and the *Acer negundo / Prunus virginiana* Habitat Type. Confusion in recognizing these as three NVCS associations stemmed from (1) occurrence of *Acer negundo* more as isolated trees than pure stands, (2) the treatment of Girad et al. (1989) and the NVCS equivalent to the *Fraxinus pennsylvanica / Prunus virginiana* Habitat Type as a forest of upland ravines (see *Fraxinus pennsylvanica / Prunus virginiana* Forest), rather than floodplains, and (3) more-or-less continuous variation between the dominance or importance of *Populus deltoides* and of *Fraxinus pennsylvanica* in the tree layer and, similarly between that of *Prunus virginiana* and of *Symphoricarpos occidentalis* in the shrub layer, for most parts of the Little Bighorn floodplain. Girard et al. (1989) observe that a *Populus deltoides – Fraxinus pennsylvanica* Community Type in southwestern North Dakota is seral to a *Fraxinus pennsylvanica* / *Symphoricarpos occidentalis* Habitat Type, a situation that seems to occur at Little Bighorn Battlefield National Monument. In general, an overstory of *P. deltoides*, usually in a relatively monospecific layer, but sometimes with *F. pennsylvanica* co-dominant, occurs above strongly regenerating *F. pennsylvanica* cohorts in the subcanopy and sapling (tall shrub) layers, making it difficult to assign many individual stands with confidence to multiple types. A single NVCS concept (*Populus deltoides-Fraxinus pennsylvanica* Forest) seemed the best fit for this continuum and the limited amount of vegetation at this site.

Fraxinus pennsylvanica / Prunus virginiana Forest

COMMON NAME	Green Ash / Choke Cherry Forest
LOCAL NAME	Green Ash / Choke Cherry Wooded Draw
CLASS	Forest (I)
SUBCLASS	Deciduous forest (I.B)
GROUP	Cold-deciduous forest (I.B.2)
SUBGROUP	Natural/Semi-natural cold-deciduous forest (I.B.2.N)
FORMATION	Temporarily flooded cold-deciduous forest (I.B.2.N.d)
ALLIANCE	*FRAXINUS PENNSYLVANICA - (ULMUS AMERICANA)* TEMPORAILY FLOODED FOREST
ASSOCIATION IDENTIFIER	CEGL000642
USFWS WETLAND SYSTEM	Upland
NS ECOLOGICAL SYSTEM	Western Great Plains Wooded Draw and Ravine (CES303.680)

RANGE

Little Bighorn Battlefield National Monument

At Little Bighorn Battlefield National Monument, this forest was observed in two very small patches – one in each unit.

Global

This association is reported from Montana and Wyoming.

ENVIRONMENTAL DESCRIPTION

Little Bighorn Battlefield National Monument

These forests occupy bottoms of steep, narrow upland draws. One stand is below a *Juniperus scopulorum / Pseudoroegneria spicata* Woodland that occupies a higher, steep north-facing slope. These are mapped as Midway silty clay loams on the Judith River and Bearpaw Formations.

Global

In western South Dakota and North Dakota, this association occurs in upland ravines and broad valleys or on moderately steep slopes. It also occurs along small permanent or ephemeral streams. In central North Dakota, this association is also found along the north slopes of end moraines or kames and along lakeshores (Williams 1979 and Godfread 1976). On these sites, soil and topography permit greater than normal moisture conditions. In south-central South Dakota this association occurs on steep north-facing escarpments, and around boulder outcrops. In the western Dakotas soils are clay loams, sandy clay loam, silty clay, and sandy loam. Soil pH ranges from 6.3 to 7.5 in South Dakota, while soils in North Dakota have pH of 6.0-8.1. Slopes range from 0 to 40 percent. In south-central South Dakota soils are dry to moist, and moderately drained (Hansen and Hoffman 1988, Girard *et al*. 1989).

MOST ABUNDANT SPECIES

STRATUM	SPECIES
Tree	*Fraxinus pennsylvanica*
Shrub	*Prunus virginiana, Symphoricarpos occidentalis*
Herbaceous	Unknown

CHARACTERISTIC SPECIES

Fraxinus pennsylvanica, Prunus virginiana, Symphoricarpos occidentalis

VEGETATION DESCRIPTION

Little Bighorn Battlefield National Monument

Fraxinus pennsylvanica is the dominant tree species, with *Prunus virginiana* is the most common shrub. *Symphoricarpos occidentalis* is usually present. The herbaceous layer was not recorded, but is assumed to be comprised of mesic species.

Global
This association is an open to closed canopy woodland dominated by *Fraxinus pennsylvanica*. *Ulmus americana* sometimes achieves codominance. The largest trees are 50 to 60 cm dbh, but most trees are 20 to 30 cm dbh. In sharply cut, V-shaped upland ravines, the largest trees are near the center or bottom of the ravine where there is greater soil moisture. The average tree age is 70 to 80 years. In undisturbed stands, the understory is composed of two layers. The taller and more conspicuous layer is a shrub layer 2 to 3 m tall. This layer is dominated by *Prunus virginiana* with smaller amounts of *Symphoricarpos occidentalis*. The lower layer is dominated by grasses and sedges such as *Elymus virginicus* and *Carex sprengelii*. Common herbaceous species include *Galium boreale*, *G. aparine*, and *Maianthemum stellatum*. In central South Dakota this association is a woodland with an open canopy of ash trees and an extremely dense shrubby understory. The average tree height is 6.7 m and the shrub understory is 1.6 m high. There are few herbaceous species (U.S. Army Corp of Engineers 1979). The continuation of the status of *Ulmus americana* as a prominent part of this association is uncertain due to the effects of Dutch Elm disease (Hansen et al. 1984, Hansen and Hoffman 1988, Girard et al. 1989, Hansen et al. 1990).

GLOBAL CLASSFICATION CONFIDENCE 2

CONSERVATION RANK G3?

CLASSIFICATION COMMENTS
This type was originally applied more widely at Little Bighorn Battlefield National Monument., including to some floodplain forests (see discussion under *Populus deltoides – Fraxinus pennsylvanica* Forest). Following the accuracy assessment, the concept was applied in a more limited manner, so that its occurrence was reduced to a few small patches in upland draws or ravines, in accordance with the concept attributed by Hansen and Hoffman (1988), Girard et al. (1989), and NatureServe.

The *Fraxinus pennsylvanica – Ulmus americana* / *Prunus virginiana* Woodland (CEGL000643) (NatureServe 2007) (apparently equivalent to the *Ulmus americana* phase of the *Fraxinus pennsylvanica* / *Prunus virginiana* Habitat Type (Girard et al. 1989)) seems nearly identical to this association, except for the presence of *Ulmus americana* in the former. Since *Ulmus americana* was not seen at Little Bighorn Battlefield National Monument, the *Fraxinus pennsylvanica* / *Prunus virginiana* Forest is recognized here.

Woodland

Juniperus scopulorum / Pseudoroegneria spicata Woodland

COMMON NAME	Rocky Mountain Juniper / Bluebunch Wheatgrass Woodland
LOCAL NAME	Rocky Mountain Juniper / Bluebunch Wheatgrass Woodland
CLASS	Woodland (II)
SUBCLASS	Evergreen Woodland (II.A)
GROUP	Temperate or subpolar needle-leaved evergreen woodland (II.A.4)
SUBGROUP	Natural/Semi-natural temperate or subpolar needle-leaved evergreen woodland (II.A.4.N)
FORMATION	Round-crowned temperate or subpolar needle-leaved evergreen woodland (II.A.4.N.a)
ALLIANCE	*JUNIPERUS SCOPULORUM* WOODLAND ALLIANCE
ASSOCIATION IDENTIFIER	CEGL000748
USFWS WETLAND SYSTEM	Upland
NS ECOLOGICAL SYSTEM	Western Great Plains Wooded Draw and Ravine (CES303.680)

RANGE

Little Bighorn Battlefield National Monument

At Little Bighorn Battlefield National Monument, this woodland is known only from a single small stand in the Reno-Benteen Unit.

Global

This association is reported from Colorado, Montana and Wyoming.

ENVIRONMENTAL DESCRIPTION

Little Bighorn Battlefield National Monument

The stand is on a steep, north-facing slope on the lower slope of a ravine. Slope and aspect appear to be the most important factors for the occurrence of this vegetation. The area is mapped as a shale outcrop on the Midway soil complex at the interface of the Judith River and Bearpaw Formations.

Global

This association typically occurs on moderate to steep (16-70%) north-facing slopes, but can occur on a variety of aspects (Johnston 1988, Von Loh et al. 1999). The soils are poorly developed, shallow, loamy sands, sandy loams, and clay loams, sometimes with high gravel content. These woodlands are frequently associated with outcrops of sandstone (DeVelice et al. 1995) or scoria and clay slopes (Girard et al. 1989).

MOST ABUNDANT SPECIES

STRATUM	SPECIES
Tree	*Juniperus scopulorum*
Short	*Symphoricarpos albus*
Herbaceous	*Pseudoroegneria spicata, Muhlenbergia cuspidata, Geum triflorum*

CHARACTERISTIC SPECIES

Juniperus scopulorum, Pseudoroegneria spicata, Symhoricarpos albus, Geum triflorum, Muhlenbergia cuspidata, Maianthemum stellatum, Campanula rotundifolia,Cerastium arvense, Silene menziesii, Antennaria parvifolia, Cystopteris fragilis

VEGETATION DESCRIPTION

Little Bighorn Battlefield National Monument

(from 1 classification plot and 2 accuracy assessment observations)

This association is densely wooded for a *Juniperus scopulorum*-dominated type, with short (mostly < 5 meters tall) *J. scopulorum* strongly dominant in the tree canopy, accompanied by minor amounts of *Fraxinus pennsylvanica.* The shrub layer is dominated by *Symphoricarpos albus*, with small amounts of *Prunus virginiana*, *Symphoricarpos*

occidentalis, Amelanchier alnifolia, *Fraxinus pennsylvanica, Rhus trilobata*, *Ericameria nauseosa*, *Artemisia frigida*, *Rosa arkansana*, *Ribes oxyacanthoides* ssp. *setosum,* and *Juniperus scopulorum*. The herb layer is dominated by *Pseudoroegneria spicata,* with a large number of lower cover species of both dry prairie and more mesic/higher elevation forest affinities. *Geum triflorum, Muhlenbergia cuspidata, Maianthemum stellatum, Campanula rotundifolia, Cerastium arvense, Silene menziesii, Antennaria parvifolia, Cystopteris fragilis, Parietaria pensylvanica, Achillea millefolium, Carex filifolia, Helianthella quinquenervis, Allium textile, Zigadenus venenosus, Koeleria macrantha, Galium aparine, Vicia americana, Phacelia linearis, Phlox hoodii, Crepis acuminata, Elymus trachycaulus,* and *Oxytropis sericea* were observed in the single classification plot. This type may be the most species-rich non-alluvial association at Little Bighorn Battlefield National Monument, with a number of species not observed in other habitats.

Global
No information available.

GLOBAL CLASSFICATION CONFIDENCE 1

CONSERVATION RANK G4

CLASSIFICATION COMMENTS
Although *Oryzopsis micrantha* was not seen and *Pseudoroegneria spicata* was dominant in the herbaceous layer, the stand at Little Bighorn Battlefield has floristic and environmental similarities with the *Juniperus scopulorum* / *Oryzopsis micrantha* Woodland, as described from Theodore Roosevelt National Park.

Shrubland

Prunus virginiana – (Prunus americana) Shrubland

COMMON NAME	Choke Cherry – (American Plum) Shrubland
LOCAL NAME	Choke Cherry Shrubland
CLASS	Shrubland (III)
SUBCLASS	Deciduous shrubland (III.B)
GROUP	Cold-deciduous shrubland (III.B.2)
SUBGROUP	Natural/Semi-natural cold-deciduous shrubland (III.B.2.N)
FORMATION	Temperate cold-deciduous shrubland (III.B.2.N.a)
ALLIANCE	*PRUNUS VIRGINIANA* SHRUBLAND ALLIANCE
ASSOCIATION IDENTIFIER	CEGL001108
USFWS WETLAND SYSTEM	Upland
NS ECOLOGICAL SYSTEM	Western Great Plains Wooded Draw and Ravine (CES303.680), Northwestern Great Plains Floodplain (CES303.676)

RANGE

Little Bighorn Battlefield National Monument

At Little Bighorn Battlefield National Monument, this shrubland is known only from the Main Unit, where it is found in small patches, primarily on the floodplain of the Little Bighorn River, and also in upland draws.

Global

This association is a widespread, if small-patch, shrubland that is known from the Columbia Plateau of eastern Washington, eastern Oregon, eastern Nevada, southeastern Idaho, throughout Wyoming, Montana, Colorado and western South Dakota.

ENVIRONMENTAL DESCRIPTION

Little Bighorn Battlefield National Monument

Stands are found on the floodplain of the Little Bighorn River on Quaternary alluvium (Haverson and Glenberg soils) and in wooded draws in upland settings (mapped mostly as Midway silty clay loams on the Judith River Formation).

Global

This is a widespread small-patch shrubland that is known from the Columbia Plateau of eastern Washington, eastern Oregon, eastern Nevada, southeastern Idaho, throughout Wyoming, Montana, Colorado and western South Dakota. It occurs in the foothills and lower slopes of mountains, along higher creeks, and in draws and ravines of plateaus and the Great Plains. The elevation range is 716 to 2652 m (2234-8700 feet). This association grows at the interface between larger riparian areas and the adjacent upland, as well as on high ridges where snow collects, and occurs as small dense thickets, narrow bands, or irregular patches. It often occupies draws, ephemeral creeks in steep narrow-bottomed canyons, and shallow ravines. It can occur on slopes below seeps and springs. Stands can also occur as small pockets on higher terraces or as narrow bands along the high-water mark of steep banks and incised channels. It also grows at the base of cliffs adjacent to rivers. Slope varies from flat to very steep, with variable aspects, and can be associated with rock outcrops and talus. Stands are typically on very well-drained, rocky soils but occasionally have finer soils. Soil texture ranges from sandy loam to clay loam.

MOST ABUNDANT SPECIES

STRATUM	SPECIES
Tree	*Fraxinus pennsylvanica*
Shrub	*Prunus virginiana, Symphoricarpos occidentalis*
Herbaceous	*Poa pratensis*

CHARACTERISTIC SPECIES

Prunus virginiana

VEGETATION DESCRIPTION

Little Bighorn Battlefield National Monument
(from 3 accuracy assessment observations)
Prunus virginiana is the dominant species, ranging from fairly open to dense cover. In the upland (draw) "phase," *Symphoricarpos occidentalis* may be associated with *P. virginiana*. The herbaceous cover is variable, and may be very high when *P. virginiana* cover is patchy to very low. *Pascopyrum smithii* and *Poa pratensis* are the highest cover species. In the floodplain phase, scattered short trees of *Fraxinus pennsylvanica*, *Acer negundo*, and/or *Salix amygdaloides* may occur, and *Symphoricarpos occidentalis*, *Shepherdia argentea*, *Rosa woodsii*, and the non-native *Eleagnus angustifolia* may be associated shrubs. The herbaceous layer in the floodplain "phase" is similarly variable to the "upland" phase, but floristically quite different, with the non-native grasses *Bromus inermis* and *Poa pratensis* and the native *Solidago canadensis* and *Galium aparine* characteristic. Vines (*Vitis riparia*, *Toxicodendron radicans*, and *Clematis ligusticifolia* often contribute substantial cover.

Global
Shrub cover ranges from 100% to more open stands of 30%, with the higher values tending to occur in sites located in drainage bottoms and on lowermost slopes, and the lower values on higher slopes. *Prunus virginiana* is usually the dominant shrub species, but *Prunus americana* may be solely present to codominant. Stands can be dominated by one species but are often a mix of three to six other shrub species, which can be as abundant and sometimes more abundant than the *Prunus*. Other shrubs include *Rhus trilobata, Ribes aureum, Ribes lacustre, Ribes inerme, Salix exigua, Sambucus* spp., *Amelanchier* spp., *Amorpha canescens, Artemisia tridentata, Symphoricarpos oreophilus, Symphoricarpos occidentalis, Juniperus scopulorum, Rosa woodsii, Mahonia repens*, and *Toxicodendron* spp. In drainage bottom situations, herbaceous cover is usually sparse, less than 10%. On slopes, the shrubs typically occur in a matrix of other shrubland or grassland types, and graminoid cover can be greater than 75%. Herbaceous species include *Bromus carinatus, Maianthemum stellatum (= Smilacina stellata), Poa pratensis, Poa fendleriana, Muhlenbergia montana, Leymus cinereus, Agastache urticifolia, Balsamorhiza sagittata*, and *Eriogonum umbellatum*. Exotic herbaceous species may be present, including *Cirsium arvense, Bromus inermis*, and *Bromus tectorum*.

GLOBAL CLASSFICATION CONFIDENCE 2

CONSERVATION RANK G4Q

CLASSIFICATION COMMENTS
The distinction between mesic shrublands (*Prunus virginiana - (Prunus americana* Shrubland and the *Symphoricarpos occidentalis* Shrubland) is somewhat "artificial" at Little Bighorn Battlefield National Monument. *Prunus virginiana* and *Symphoricarpos occidentalis* show a considerable amount of ecological overlap with each other and exhibit considerable small-scale patch (clonal) dominance in both upland draws and on the Little Bighorn floodplain. In matching stands by dominant species to the best NVC fit, this treatment finds both types split somewhat artificially, with each type exhibiting variable associates, especially in the herbaceous layer, depending on its environmental setting. The dominance of one species over the other, especially on the Little Bighorn floodplain, where grazing by cattle occurs, may relate to selective grazing pressure, as well as ecological site effects. Both NVC analogs describe both types as an upland draw or floodplain edge vegetation. A more ecologically meaningful treatment might recognize an (1) upland draw type characterized by variable dominance of the two shrub species (with *S. occidentalis* usually at higher cover) and mesic grassland associates (eg., *Pascopyrum smithii*) and (2) a floodplain type characterized by variable dominance of the two shrub species (with *P. virginiana* usually at higher cover) and more floodplain associates (*Solidago canadensis*, etc.). In the absence of plot data, the NVC treatment, and the reasonably high accuracy in mapping solely by the dominant shrub species in the stand, we retain this artificial distinction between the two types at Little Bighorn Battlefield National Monument.

Salix exigua Temporarily Flooded Shrubland

COMMON NAME	Coyote Willow Temporarily Flooded Shrubland
LOCAL NAME	Sandbar Willow Shrubland
CLASS	Shrubland (III)
SUBCLASS	Deciduous shrubland (III.B)
GROUP	Cold-deciduous shrubland (III.B.2)
SUBGROUP	Natural/Semi-natural cold-deciduous shrubland (III.B.2.N)
FORMATION	Temporarily flooded cold-deciduous shrubland (III.B.2.N.d)
ALLIANCE	*SALIX (EXIGUA, INTERIOR)* TEMPORARILY FLOODED SHRUBLAND ALLIANCE
ASSOCIATION IDENTIFIER	CEGL001197
USFWS WETLAND SYSTEM	Palustrine Scrub-Shrub broad-leaved deciduous, temporarily flooded (PSS1A)
NS ECOLOGICAL SYSTEM	Northwestern Great Plains Floodplain (CES303.676)

RANGE

Little Bighorn Battlefield National Monument

At Little Bighorn Battlefield National Monument, this shrubland is known only from the Main Unit, where it is found in small patches along the Little Bighorn River.

Global

This willow shrubland association is found along rivers and streams at lower elevations throughout the western United States and Great Plains, ranging sporadically from Oklahoma northwest to the Dakotas and Manitoba, west to Washington, and south to the Rio Grande, San Juan and Canadian River watersheds in northern New Mexico. In California, this association has been sampled along the Sacramento River, in the Central Coast Ranges, northern and central Sierra Nevada foothills, and Cascade Range foothills. Part of this type's former range in the Great Plains and eastward is actually occupied, at least in part, by *Salix interior* [see *Salix interior* Temporarily Flooded Shrubland (CEGL008562)].

ENVIRONMENTAL DESCRIPTION

Little Bighorn Battlefield National Monument

Stands are found on the banks and active channels of the Little Bighorn River on Quaternary alluvium (Haverson and Glenberg soils). They are lower in relative elevation (more frequently flooded) than other floodplain types, including the *Populus deltoides – Fraxinus pennsylvanica* Forest, the *Symphoricarpos occidentalis* Shrubland, the *Prunus virginiana – (Prunus americana)* Shrubland and the *Shepherdia argentea* Shrubland.

Global

This association is found on recently deposited or disturbed alluvial material. The parent material is alluvial sand, although silt, clay, or gravel may be present. Soil development is poor to absent. In New Mexico, this association occurs along wide, low-gradient streams and rivers in foothill regions and in lowland valleys and canyons at low to mid elevations of 1430 to 1910 m (4700-6250 feet). The type is common on low alluvial bars that are subject to repeated flooding (1- to 5-year recurrence intervals). Soils are poorly stratified and generally consist of a thin layer of sandy loam at the surface overlying deep deposits of sand, gravel, or cobble. Rock fragments comprise upwards of 80% of the soil profile. These well-drained soils provide good aeration and rapid movement of water through the profile. Sites composed mostly of riverwash are moist at the surface for much of the season, while high bars may be dry on the surface, but tend to be moist at depths of 15 to 30 cm (6-12 inches) during most years.

MOST ABUNDANT SPECIES

STRATUM	SPECIES
Shrub	*Salix exigua, Fraxinus pennsylvanica, Populus deltoides*
Herbaceous	Unknown

CHARACTERISTIC SPECIES

Salix exigua

VEGETATION DESCRIPTION

Little Bighorn Battlefield National Monument

(from 4 accuracy assessment observations)

Salix exigua is the dominant species, usually forming moderately dense to dense cover in the tall shrub layer. *Fraxinus pennsylvanica* and/or *Populus deltoides* saplings often also occur, and P. deltoids may be locally dominant and exceed *S. exigua* cover. *Cornus sericea* was important in one stand. Because the herbaceous layers of most stands were under water during the accuracy assessment, their composition at Little Bighorn Battlefield National Monument is largely unknown.

Global

This association is dominated by shrubs, generally between 2 and 4 m tall. The most common of these is *Salix exigua* (*Salix interior* or intermediates of the two willow species may be present in the eastern part of the range). *Salix irrorata*, *Salix lutea*, and saplings of *Populus deltoides* or *Salix amygdaloides* are also frequently found in the shrub layer in lower elevation stands. *Populus balsamifera* seedlings become more common in northern and western stands. This stratum can have moderate to high stem density in the association as a whole. The species in the shrub layer do not form a closed canopy, allowing significant light to reach the ground layer. There are often patches where the shrub layer is absent. The herbaceous cover is sparse to moderate but rarely exceeds 30%. Older stands and places with less competition from the shrubs have greater herbaceous cover. The composition of the herbaceous layer can vary greatly. Species that are often found in this association are *Cenchrus longispinus, Polygonum lapathifolium, Schoenoplectus americanus (= Scirpus americanus), Triglochin maritima*, *Xanthium strumarium, Juncus balticus, Eleocharis palustris, Elymus repens (= Elytrigia repens), Poa pratensis, Phleum pratense, Agrostis scabra, Bromus inermis, Heracleum maximum, Achillea millefolium, Solidago* sp., *Equisetum arvense*, and *Linaria vulgaris*.

GLOBAL CLASSFICATION CONFIDENCE 1

CONSERVATION RANK G5

COMMENTS

A tiny stand of shrub-sized *Populus deltoides* observed during the mapping within a river channel was adjacent to and environmentally similar to a stand of this type. It was re-interpreted as patch dominance by rapidly colonizing *P. deltoides* within the *Salix exigua* Shrubland.

Shepherdia argentea Shrubland

COMMON NAME	Silver Buffaloberry Shrubland
LOCAL NAME	Silver Buffaloberry Floodplain Shrubland
CLASS	Shrubland (III)
SUBCLASS	Deciduous shrubland (III.B)
GROUP	Cold-deciduous shrubland (III.B.2)
SUBGROUP	Natural/Semi-natural cold-deciduous shrubland (III.B.2.N)
FORMATION	Temporarily flooded cold-deciduous shrubland (III.B.2.N.d)
ALLIANCE	*SHEPHERDIA ARGENTEA* TEMPORARILY FLOODED SHRUBLAND ALLIANCE
ASSOCIATION IDENTIFIER	CEGL001128
USFWS WETLAND SYSTEM	Upland
NS ECOLOGICAL SYSTEM	Northwestern Great Plains Floodplain (CES303.676), Western Great Plains Wooded Draw and Ravine (CES303.680)

RANGE

Little Bighorn Battlefield National Monument

At Little Bighorn Battlefield National Monument, this shrubland is known only from the Main Unit, where it is found in small patches along the Little Bighorn River.

Global

This association is found in the northern Great Plains of the United States and Canada, extending from Colorado northward to the Dakotas and to Alberta and Saskatchewan. It is found in the northern Great Plains on stream terraces, rolling uplands, and badlands. Although restricted in distribution in Alberta, it is a dominant type in many areas within its range.

ENVIRONMENTAL DESCRIPTION

Little Bighorn Battlefield National Monument

Stands are found on the floodplain and banks of the Little Bighorn River on Quaternary alluvium (Haverson and Glenberg soils). They are evidently slightly lower in relative elevation (more frequently flooded) than the *Populus deltoids – Fraxinus pennsylvanica* Forest, the *Symphoricarpos occidentalis* Shrubland, and the *Prunus virginiana – (Prunus americana)* Shrubland. They are higher in relative elevation (less frequently flooded) than the *Salix exigua* Temporarily Flooded Shrubland.

Global

This association is found on stream terraces, rolling uplands, and badlands. It occurs where moisture is more plentiful than on the surrounding landscape, such as in swales, ravines, near streams, and on northwest- to east-facing slopes (Hansen and Hoffman 1988, DeVelice et al. 1995). This trend is more pronounced in Wyoming where Jones and Walford (1995) only found this association near streams, and it may be less pronounced in Saskatchewan and northern Montana. Soils are loamy sand, sandy loam, silty loam, or loam and are derived from glacial drift, siltstone, or sandstone (U.S. Forest Service 1992, DeVelice et al. 1995). This environment of this association does not flood often, but some sites show evidence of a high water table (DeVelice et al. 1995).

MOST ABUNDANT SPECIES

STRATUM	SPECIES
Tree	*Fraxinus pennsylvanica*
Shrub	*Shepherdia argentea, Fraxinus pennsylvanica*
Herbaceous	*Poa pratensis, Bromus inermis, Solidago canadensis*

CHARACTERISTIC SPECIES

Shepherdia argentea, Vitis riparia, Clematis ligusticifolia, Salix amygdaloides, Acer negundo, Bromus inermis, Solidago canadensis, Apocynum cannabinum

VEGETATION DESCRIPTION

Little Bighorn Battlefield National Monument

(from 4 accuracy assessment observations)

Shepherdia argentea is the dominant or a co-dominant shrub, and occurs in sparse to dense patches (10-60% cover). A number of other species are usually present, including *Fraxinus pennsylvanica*, *Prunus virginiana*, *Symphoricarpos occidentalis*, Ribes sp., and Rosa woodsii. Occasionally, the invasive non-native *Tamarix chinensis* or *Eleagnus angustifolia* may be present and can exceed the native species in cover. In some cases, scattered young trees (*Fraxinus pennsylvanica, Salix amygdaloides*, *Acer negundo*, and/or *Populus deltoides* may be present and emergent from the shrub layer. Vines (*Vitis riparia, Toxicodendron radicans*, *Clematis ligusticifolia*) are often present. The herbaceous layer is often dominated by the non-native grasses *Bromus inermis* and/or *Poa pratensis*. Characteristic native species include *Solidago canadensis*, *Carex* sp., *Apocynum cannabinum*, and *Cirsium* sp.

Global

The vegetation is dominated by a moderate to dense canopy of medium-tall shrubs. The most abundant of these, *Shepherdia argentea*, is typically 1.5-3 m tall. Other species commonly found in the shrub layer are *Juniperus horizontalis, Prunus virginiana, Ribes* spp., *Rhus aromatica, Rosa woodsii*, and *Symphoricarpos occidentalis*. Herbaceous species are not important in this association. Graminoids and forbs may be quite variable and have only half the coverage of the shrub layer (Hansen and Hoffman 1988, U.S. Forest Service 1992). Graminoids include *Poa pratensis, Pascopyrum smithii*, and *Bromus* spp. Common forbs are *Achillea millefolium, Artemisia ludoviciana*, and *Parietaria pensylvanica*. Litter may accumulate in this association (DeVelice et al. 1995).

GLOBAL CLASSFICATION CONFIDENCE 2

CONSERVATION RANK G3G4

CLASSIFICATION COMMENTS

This type was originally mapped to include a *Tamarix chinensis* Shrubland. This was re-interpreted as an invaded stand of the *Shepherdia argentea* Shrubland, since only one small stand with *T. chinensis* dominant was found, *Shepherdia argentea* was second in importance in this stand. *T. chinensis* is not well-established within Little Bighorn Battlefield National Monument and can easily be and likely will be eliminated soon by National Park Service management in this stand. Similarly the *Eleagnus angustifolia* Shrubland, represented by one tiny mapped stand, was assumed to be a degraded stand of the *Shepherdia argentea* Shrubland. For management purposes, it seemed prudent to retain the identity of the native vegetation, as long as the exotic situation seemed currently manageable. If these exotics expand at Little Bighorn Battlefield to form more extensive stands that tend to obfuscate the identity of the native vegetation, the occurrence of these semi-natural types should be re-considered.

The global description of this type specifies its habitat as upland draws; at Little Bighorn Battlefield National Monument, it occurs primarily on floodplains. Further NVCS work may distinguish between *Shepherdia argentea* stands that occur in these different both settings and that appear to have different species associates.

NOTE:

Two semi-natural variations of this type are included as final map classes. *Shepherdia argentia* Shrubland – *Elaeagnus angustifolia* Invaded (represented by a single polygon) is charactersized by the presence of Russian olive. *Shepherdia argentia* Shrubland – *Tamarix* spp. Invaded (represented by two polygons) is characterized by the presence of saltcedar.

Symphoricarpos occidentalis Shrubland

COMMON NAME	Western Snowberry Shrubland
LOCAL NAME	Western Snowberry Shrubland
CLASS	Shrubland (III)
SUBCLASS	Deciduous shrubland (III.B)
GROUP	Cold-deciduous shrubland (III.B.2)
SUBGROUP	Natural/Semi-natural cold-deciduous shrubland (III.B.2.N)
FORMATION	Temporarily flooded cold-deciduous shrubland (III.B.2.N.d)
ALLIANCE	*SYMPHORICARPOS OCCIDENTALIS* TEMPORARILY FLOODED SHRUBLAND
ASSOCIATION IDENTIFIER	CEGL001131
USFWS WETLAND SYSTEM	Upland
NS ECOLOGICAL SYSTEM	Western Great Plains Wooded Draw and Ravine (CES303.680) Northwestern Great Plains Floodplain (CES303.676)

RANGE

Little Bighorn Battlefield National Monument

At Little Bighorn Battlefield National Monument, this shrubland is known mostly from the Main Unit, where it is found in small patches on both the floodplain of the Little Bighorn River and in upland draws. Small amounts occur in the Reno-Benteen Unit in upland draws.

Global

This western snowberry shrubland is found in the western tallgrass, the northern Great Plains, and in the foothills of the northern Rocky Mountains of the United States and Canada.

ENVIRONMENTAL DESCRIPTION

Little Bighorn Battlefield National Monument

Stands are found on the floodplain of the Little Bighorn River on Quaternary alluvium (Haverson and Glenberg soils) and in wooded draws in upland settings (mapped mostly as Midway silty clay loams on the Judith River Formation).

Global

This association is found in mesic swales, depressions, ravines and floodplains. Some examples of this association experience intermittent and brief flooding. In Glacier National Park, it occurs at 1022-1092 m (3350-3580 feet) elevation. The soils are fertile and well-drained to imperfectly drained silts and loams. The upper soil horizon is usually deep, although a thin layer of sand may be present if the site has been recently flooded (Jones and Walford 1995).

MOST ABUNDANT SPECIES

STRATUM	SPECIES
Shrub	*Symphoricarpos occidentalis, Prunus virginiana*
Herbaceous	*Pascopyrum smithii, Poa pratensis*

CHARACTERISTIC SPECIES

Symphoricarpos occidentalis

VEGETATION DESCRIPTION

Little Bighorn Battlefield National Monument

(from 4 accuracy assessment observations)

Symphoricarpos occidentalis is the dominant species usually forming dense patches, ranging from fairly open to nearly 100% cover. In the upland (draw) "phase," *Prunus virginiana*, *Artemisia cana*, *Artemisia. tridentata*, and *Sarcobatus vermiculatus* may be associated with *S. occidentalis*. The herbaceous cover is variable, and may be very high when *S. occidentalis* cover is patchy to very low. *Pascopyrum smithii*, *Bromus japonicus*, and *Poa pratensis* are the highest cover species. In the floodplain phase, scattered short trees of *Fraxinus pennsylvanica*, *Acer negundo*,

and/or *Salix amygdaloides* may occur, and *Prunus virginiana* may be an associated shrub. The herbaceous layer in the floodplain phase is similarly variable to the upland phase, but floristically quite different, with the non-native grasses *Bromus inermis* and *Poa pratensis* and the native *Solidago canadensis, Apocynum cannabinum, Symphiotrichum laeve (= Aster laevis), Glycyrrhiza lepidota, Cirsium* sp., *Toxicodendron radicans*, and *Carex* sp. contributing cover.

Global

Throughout its range this association is dominated by shrubs approximately 1 m tall. Shrub cover is typically greater than 50%, and in places it can approach 100%. These shrubs form dense clumps that exclude most other species. *Symphoricarpos occidentalis* is the most common shrub, but *Rhus trilobata* and *Prunus virginiana* can be locally abundant and can grow to 2-3 m in places. *Toxicodendron rydbergii, Amelanchier alnifolia, Rubus idaeus*, and *Rosa acicularis* may also be present. Herbaceous species and smaller shrubs are most abundant at the edges of this association and in gaps between the clumps of taller shrubs where the shading is less complete. *Rosa woodsii* is a typical smaller shrub. Common graminoids include *Pascopyrum smithii, Calamagrostis canadensis, Calamagrostis rubescens, Achnatherum nelsonii*, and *Poa pratensis*. *Achillea millefolium, Artemisia ludoviciana, Galium boreale*, and *Solidago* spp. are common forbs of this association. Woody vines sometimes occur, including *Parthenocissus vitacea*.

GLOBAL CLASSFICATION CONFIDENCE 3

CONSERVATION RANK G4G5

CLASSIFICATION COMMENTS

See comments under the *Prunus virginiana – (Prunus americana)* Shrubland.

Herbaceous Vegetation

Pascopyrum smithii - Nassella viridula Herbaceous Vegetation

COMMON NAME	Western Wheatgrass - Green Needlegrass Herbaceous Vegetation
LOCAL NAME	Western Wheatgrass - Green Needlegrass Mixedgrass Prairie
CLASS	Herbaceous Vegetation (V)
SUBCLASS	Perennial graminoid vegetation (V.A)
GROUP	Temperate or subpolar grassland (V.A.5)
SUBGROUP	Natural/Semi-natural temperate or subpolar grassland (V.A.5.N)
FORMATION	Medium-tall sod temperate or subpolar grassland (V.A.5.N.c)
ALLIANCE	*PASCOPYRUM SMITHII* HERBACEOUS ALLIANCE
ASSOCIATION IDENTIFIER	CEGL001583
USFWS WETLAND SYSTEM	Upland
NS ECOLOGICAL SYSTEM	Northwestern Great Plains Mixedgrass Prairie (CES303.674)

RANGE

Little Bighorn Battlefield National Monument

At Little Bighorn Battlefield National Monument, this vegetation is widespread and extensive in both units. In the Main Unit, most stands are at lower elevations, especially in the west-central portion.

Global

This western wheatgrass - needlegrass association is common across much of the northern Great Plains of the United States and possibly Canada, ranging from Colorado and possibly Nebraska, north to Montana and North Dakota, and possibly Saskatchewan.

ENVIRONMENTAL DESCRIPTION

Little Bighorn Battlefield National Monument

This vegetation is widespread on lower, more gentle slopes than the *Pseudoroegneria spicata – Carex filifolia* Herbaceous Vegetation. Most sites are on soils mapped as Midway silty clay loam, with some mapped as Hesper silty clay loam and Pierre clay. Sites are distributed on the Judith River and Bearpaw geologic Formations, with a minority on Quaternary alluvial terraces.

Global

This association is found at the bottom of narrow valleys, on stream terraces, and on rolling uplands (Jones 1992, U.S. Forest Service 1992). Soils are fine-textured (clays, silty clays, clay loams, or rarely loams) and well-drained. The soil profile is typically well-developed. The parent material is siltstone and mixed sedimentary rock (U. S. Forest Service 1992). This association usually occurs on level or nearly level ground but sometimes may be on moderate slopes of any aspect.

MOST ABUNDANT SPECIES

STRATUM	SPECIES
Herbaceous	*Pascopyrum smithii, Bromus japonicus*

CHARACTERISTIC SPECIES

Pascopyrum smithii, Nassella viridula, Hesperostipa comata, Tragopogon dubius, Opuntia polyacantha

VEGETATION DESCRIPTION

Little Bighorn Battlefield National Monument

(based on 36 accuracy assessment observations)

This type is a fairly densely vegetated grassland (usually >90% foliar cover), with *Pascopyrum smithii* the dominant species. *Nassella viridula* and *Hesperostipa comata* are frequent at lower cover, and *H. comata*, while less constant than *N. viridula*, can be patch-dominant and contribute higher cover. *Pseudoroegneria spicata* is present in about one-third of the stands, especially as this type approaches the habitat of the *Pseudoroegneria spicata – Carex*

filifolia Herbaceous Vegetation, but, even when present, almost always contributes much less cover than *P. smithii*. *Calochortus nuttallii* and *Achillea millefolium* and the non-native *Tragopogon dubius* are often present at low cover, while *Opuntia polyacantha* is often present as a low shrub. The non-native *Bromus japonicus* is usually rampant in stands of this association and will often be the leading dominant in terms of foliar cover early in the growing season, while *Poa pratensis* is less constant but may occasionally contribute high cover.

Global

This association is dominated by mid grasses, generally between 0.6 and 1 m tall. The vegetation cover tends to be moderate to high, with almost all of the canopy provided by graminoids (Redmann 1975, U. S. Forest Service 1992). The dominant species are *Pascopyrum smithii* and *Nassella viridula*, although *Elymus lanceolatus* (another rhizomatous wheatgrass that is similar in morphology and ecology to *Pascopyrum smithii*) is the dominant species in some stands. At least 5% canopy cover of *Nassella viridula* may be diagnostic for this association. Other common grasses are *Hesperostipa comata (= Stipa comata), Koeleria macrantha, Poa secunda (= Poa juncifolia), Poa pratensis, Sporobolus cryptandrus*, and, on sandier soils, *Calamovilfa longifolia*. Shorter graminoids are less common, but may include *Bouteloua gracilis, Carex duriuscula (= Carex eleocharis), Carex filifolia, Carex inops ssp. heliophila*, and *Carex pensylvanica*. These species are present in many stands, but they usually contribute little cover. The wheatgrass basin association of Nebraska (Steinauer and Rolfsmeier 2000), which may belong to this association, also contains *Schizachyrium scoparium*. Cheatgrasses (*Bromus commutatus, Bromus japonicus, Bromus tectorum*) are present in many stands and contribute substantial cover in some. The forbs *Symphyotrichum falcatum (= Aster falcatus), Astragalus* spp., *Achillea millefolium, Sphaeralcea coccinea, Artemisia ludoviciana, Lepidium densiflorum*, and *Vicia americana* are also typical of this association. *Artemisia cana ssp. cana* or *Artemisia tridentata ssp. wyomingensis* may be present, often as scattered shrubs contributing little cover. Stands with denser shrubs are transitional to shrub-herbaceous vegetation.

GLOBAL CLASSFICATION CONFIDENCE 1

CONSERVATION RANK G3G4

CLASSIFICATION COMMENTS

This type was originally mapped as two types: the *Agropyron smithii / Carex filifolia* Habitat Type* and the *Stipa comata / Carex heliophila* Habitat Type* of Hansen and Hoffman (1988). Our inability to consistently distinguish the two led us to conclude that stands mapped as being dominated by *Hesperostipa comata* may have been largely due to artifacts of sampling scale imposed by the mapping process and that *H. comata* probably is best treated as a patch-dominant, rather than stand-forming, species at Little Bighorn Battlefield National Monument. The floristic differences between the Hansen and Hoffman concepts and *Pascopyrum smithii* dominated stands at Little Bighorn Battlefield National Monument (*Carex inops* ssp. *heliophila* absent, and *Pascopyrum smithii* is almost never associated with *Carex filifolia*) led us to conclude that a more mesic *P. smithii* dominated concept is warranted in place of the Hansen and Hoffman types. The NVCS concept of the *Pascopyrum smithii - Nassella viridula* Herbaceous Vegetation and the *Pascopyrum smithii – Hesperostipa comata* Herbaceous Vegetation both reflected the Little Bighorn vegetation reasonably well, with the former a better fit because of the greater constancy of *N. viridula* over *H. comata*. Despite the occasional small-scale patch-dominance of *H. comata*, neither *N. viridula* over *H. comata* achieves co-dominance with *P. smithii* over stand scales.

*Note that *Agropyron smithii* = *Pascopyrum smithii*; *Stipa comata* = *Hesperostipa comata*; *Carex heliophila* = *Carex inops* ssp. *heliophila*)

Agropyron cristatum - (Pascopyrum smithii, Hesperostipa comata) Semi-natural Herbaceous Vegetation

COMMON NAME	Crested Wheatgrass - (Western Wheatgrass, Needle-and-Thread Grass) Semi-natural Herbaceous Vegetation
LOCAL NAME	Crested Wheatgrass Grassland
CLASS	Herbaceous Vegetation (V)
SUBCLASS	Perennial graminoid vegetation (V.A)
GROUP	Temperate or subpolar grassland (V.A.5)
SUBGROUP	Natural/Semi-natural temperate or subpolar grassland (V.A.5.N)
FORMATION	Medium-tall bunch temperate or subpolar grassland (V.A.5.N.d)
ALLIANCE	*AGROPYRON CRISTATUM* SEMI-NATURAL HERBACEOUS ALLIANCE
ASSOCIATION IDENTIFIER	CEGL005266
USFWS WETLAND SYSTEM	Upland
NS ECOLOGICAL SYSTEM	Northwestern Great Plains Mixedgrass Prairie (CES303.674)

RANGE

Little Bighorn Battlefield National Monument

A single small stand (about 0.1 hectare) was seen and mapped at the park headquarters area in the Main Unit. This vegetation is likely to be more widespread outside the Monument.

Global

This association occurs in the northern Great Plains of the United States and Canada (Von Loh et al. 2000).

ENVIRONMENTAL DESCRIPTION

Little Bighorn Battlefield National Monument

The stand observed appeared to be established by seeding or planting of *Agropyron cristatum* to stabilize a small area of previously disturbed soil. The site is on a rolling upland, with soils mapped as Midway silty clay loam over the Judith River Formation.

Global

This type can occur in a wide variety of human-disturbed habitats, including highway rights-of-way, jeep trails, etc. It is also widely planted to revegetate pastures and rangelands (Von Loh et al. 2000).

MOST ABUNDANT SPECIES

STRATUM	SPECIES
Herbaceous	*Agropyron cristatum*

CHARACTERISTIC SPECIES

Agropyron cristatum

VEGETATION DESCRIPTION

Little Bighorn Battlefield National Monument

(based on 1 accuracy assessment observation)

The non-native *Agropyron cristatum* is dominant, and the non-native *Bromus japonicus* occurs at high cover. Native (*Hesperostipa comata, Yucca glauca*) and non-native (*Bromus inermis, Sisymbrium altissimum, Convolvulus arvensis, Tragopogon dubius*) species contribute small amounts of cover.

Global

The vegetation is dominated by medium-tall (0.5 - 1 m) graminoids. The dominant grass is *Agropyron cristatum*, a naturalized species from Europe. Other weedy species may occur as well, but native species are generally less than 10% cover. Native species may include mixed-grass prairie grasses, such as *Pascopyrum smithii* and *Hesperostipa comata*, as well as others (Von Loh et al. 2000).

GLOBAL CLASSFICATION CONFIDENCE 3

CONSERVATION RANK GW

CLASSIFICATION COMMENTS
The global information for this type was derived from Von Loh et al. (2000).

Pseudoroegneria spicata - Carex filifolia Herbaceous Vegetation

COMMON NAME	Bluebunch Wheatgrass - Threadleaf Sedge Herbaceous Vegetation
LOCAL NAME	Bluebunch Wheatgrass - Threadleaf Sedge Mixed Prairie
CLASS	Herbaceous Vegetation (V)
SUBCLASS	Perennial graminoid vegetation (V.A)
GROUP	Temperate or subpolar grassland (V.A.5)
SUBGROUP	Natural/Semi-natural temperate or subpolar grassland (V.A.5.N)
FORMATION	Medium-tall bunch temperate or subpolar grassland (V.A.5.N.d)
ALLIANCE	*PSEUDOROEGNERIA SPICATA* HERBACEOUS
ASSOCIATION IDENTIFIER	CEGL001665
USFWS WETLAND SYSTEM	Upland
NS ECOLOGICAL SYSTEM	Northwestern Great Plains Mixedgrass Prairie (CES303.674)

RANGE

Little Bighorn Battlefield National Monument

At Little Bighorn Battlefield National Monument, this vegetation is widespread and extensive in both units. In the Main Unit, most stands are at higher elevations, especially in the northeast and southeast portions.

Global

This association has been described from two stands in southeastern Montana (Hansen and Hoffman 1988) and from two stands (Fisser 1964) and cursory information (Despain 1973) in north-central Wyoming.

ENVIRONMENTAL DESCRIPTION

Little Bighorn Battlefield National Monument

This vegetation is widespread on higher elevations of both units, usually above the *Pascopyrum smithii – Nassella viridula* Herbaceous Vegetation on drier ridges and slopes. Most sites are on soils mapped as Midway silty clay loam, with a smaller number mapped as Pierre-Lismas clays, shale outcrops, and Thurlow silty clay loams. Sites are more limited to the Bearpaw Formations than is the *Pascopyrum smithii – Nassella viridula* Herbaceous Vegetation, with a minority on the Judith River formation.

Global

Stands of this association have been described from nearly level sites (some windswept) with loam and silt loam soils. Elevations range from about 4100 feet on the Great Plains to about 7000 feet on the west flank of the Bighorn Mountains.

MOST ABUNDANT SPECIES

STRATUM	SPECIES
Shrub	*Yucca glauca*
Herbaceous	*Pseudoroegneria spicata, Pascopyrum smithii, Carex filifolia*

CHARACTERISTIC SPECIES

Pseudoroegneria spicata, Carex filifolia, Phlox hoodii, Yucca glauca, Koeleria macrantha, Linum lewisii var. lewisii, Bouteloua curtipendula, Calamovilfa longifolia

VEGETATION DESCRIPTION

Little Bighorn Battlefield National Monument

(based on 48 accuracy assessment observations)

This type is a moderately densely vegetated grassland (usually >70% foliar cover), with *Pseudoroegneria spicata* usually the leading dominant species. *Pascopyrum smithii* is often present at lower cover than *P. spicata*, but may contribute equal or slightly greater cover than *P. spicata* (these stands are transitional toward the *Pascopyrum smithii – Nassella viridula* Herbaceous Vegetation, and the increasing abundance of *P. smithii* relative to *P. spicata* usually indicates a trend toward more mesic conditions. *Carex filifolia* and the dwarf shrub *Yucca glauca* are usually present, especially so in the driest sites. *Phlox hoodii, Linum lewisiii var. lewisii, Nassella viridula,* and *Koeleria macrantha* often occur at low cover. The grasses *Bouteloua curtipendula* and *Calamovilfa longifolia* occur

infrequently, but may occasionally be patch-dominant and nearly as abundant as *P. spicata*. The non-natives *Bromus japonicus, Poa pratensis*, and *Tragopogon dubius* may be present, especially in more mesic stands.

Global
Graminoids contribute most of the cover, and forbs are secondary; shrubs may be present as scattered individuals or clumps that contribute little cover to the vegetation. *Pseudoroegneria spicata* dominates the vegetation, and *Carex filifolia* contributes substantial cover. *Hesperostipa comata (= Stipa comata), Koeleria macrantha*, and *Carex inops ssp. heliophila (= Carex heliophila)* (in Great Plains stands) often are present in smaller amounts, but they may contribute as much cover as does *Carex filifolia*. *Bouteloua gracilis* is absent or present only in small amounts. Cheatgrass (*Bromus japonicus, Bromus tectorum*) is present in many stands and may contribute nearly as much cover as does *Pseudoroegneria spicata*. The vegetation may contain small amounts of numerous forbs. Shrubs are absent or present only as scattered individuals (especially *Artemisia tridentata ssp. wyomingensis*), but the subshrubs *Artemisia frigida* and *Gutierrezia sarothrae* usually are present in small amounts.

GLOBAL CLASSFICATION CONFIDENCE 1

CONSERVATION RANK G4

CLASSIFICATION COMMENTS
This type was originally mapped as four types: the *Agropyron spicatum / Carex filifolia* Habitat Type,* the *Agropyron spicatum / Bouteloua curtipendula* Habitat Type,* and the *Calamovilfa longifolia / Carex heliophila* Habitat Type* of Hansen and Hoffman (1988) and the *Pseudoroegneria spicata* Herbaceous Alliance of the NVCS (representing a relatively even mix of *Pseudoroegneria spicata* and *Pascopyrum smithii*). Our inability during the accuracy assessment to consistently distinguish these types, led us to conclude that stands mapped as being dominated by *Calamovilfa longifolia* and those co-dominated by *Bouteloua curtipendula* may have been largely due to artifacts of sampling scale imposed by the mapping process and that these species probably are best treated as occasional patch-dominants within a more generalized dry *P. spicata*-dominated type, rather than stand-forming, species at Little Bighorn Battlefield National Monument. We were able to detect more floristic differences between a widespread dry P. spicata dominated type and a more mesic mixture of *P. spicata* and *P. smithii*. While we considered that this might be the basis for recognizing a *Pseudoroegneria spicata – Pascopyrum smithii* Herbaceous Vegetation (CEGL001675) at little Bighorn Battlefield, these stands were not consistently separable from the more widespread, dry *P. spicata* – dominated expression. Since *Carex filifolia* is the most constant of the diagnostic associates (*B. curtipendula* and *C. longifolia* were inconstant and *C. inops* ssp. *heliophila* absent) of dry, *P. spicata* – dominated grasslands at Little Bighorn Battlefield, the NVCS concept of *Pseudoroegneria spicata – Carex filifolia* Herbaceous Vegetation is recognized, with the more mesic mix with more *P. smithii* probably best recognized as a more mesic phase or an ecotone with the *Pascopyrum smithii – Nassella viridula* Herbaceous Vegetation. Although *Bouteloua gracilis* occasionally occurs in dry *P. spicata*-dominated stands at Little Bighorn, it is too infrequent to consider the occurrence of the *Pseudoroegneria spicata – Bouteloua gracilis* Herbaceous Vegetation (CEGL001664).

While the two major grassland types are fairly distinct, when dominance of the major species is clear, some indicators may assist in placing intermediate stands. *Pascopyrum smithii* is more constant in *Pseudoroegneria spicata / Carex filifolia* Herbaceous Vegetation (approximately 75% constancy) than is P. spicata in stands of *Pascopyrum smithii – Nassella viridula* Herbaceous Vegetation (approximately 33% constancy). Thus, *P. spicata* is the better indicator species, so that stands with nearly equal cover by both species will tend toward the *Pseudoroegneria spicata – Carex filifolia* Herbaceous Vegetation. Though not always constant, *Yucca glauca, Carex filifolia, Phlox hoodii, Koeleria macrantha, Bouteloua curtipendula, Calamovilfa longifolia*, and *Linum lewisii var. lewisii* are indicators of *Pseudoroegneria spicata / Carex filifolia* Herbaceous Vegetation. The *Pascopyrum smithii – Nassella viridula* Herbaceous Vegetation has fewer good diagnostic species, but *Tragopogon dubius, Opuntia polyacantha*, and *Hesperostipa comata* tend to be more frequent in that type than in the *Pseudoroegneria spicata / Carex filifolia* Herbaceous Vegetation, and the non-native *Bromus japonicus*, though fairly ubiquitous in both types, has higher cover *Pascopyrum smithii – Nassella viridula* Herbaceous Vegetation in early season. Finally, it is worth mentioning that, although a nominal species of the Global-named *Pascopyrum smithii – Nassella viridula* Herbaceous Vegetation, *N. viridula* may be as frequent or more so in the *Pseudoroegneria spicata / Carex filifolia* Herbaceous Vegetation.

The *Pseudoroegneria spicata / Carex filifolia* Herbaceous Vegetation occupies drier sites (higher slopes and convex exposures) than does the *Pascopyrum smithii – Nassella viridula* Herbaceous Vegetation, which is extensive on lower, gentler slopes of Little Bighorn Battlefield National Monument.

*Note that *Agropyron spicatum* = *Pseudoroegneria spicata* and *Carex heliophila* = *Carex inops* ssp. *heliophila*)

Great Plains Floodplain and Riverbank Tall Herbaceous Vegetation [Park-specific]

COMMON NAME	Great Plains Floodplain and Riverbank Tall Herbaceous Vegetation
LOCAL NAME	Great Plains Floodplain and Riverbank Tall Herbaceous Vegetation
CLASS	Herbaceous Vegetation (V)
SUBCLASS	Perennial graminoid vegetation (V.A)
GROUP	Temperate or subpolar grassland (V.A.5)
SUBGROUP	Natural/Semi-natural (V.A.5.N)
FORMATION	Temporarily flooded temperate or subpolar grassland (V.A.5.N.j)
ALLIANCE	Undefined
ASSOCIATION IDENTIFIER	None (described from this project)
USFWS WETLAND SYSTEM	Palustrine Emergent persistent, temporarily flooded (PEM1A)
NS ECOLOGICAL SYSTEM	Northwestern Great Plains Floodplain (CES303.676)

RANGE

Little Bighorn Battlefield National Monument

At Little Bighorn Battlefield National Monument, this vegetation is known only from the Main Unit, where it is found in small patches along the Little Bighorn River.

Global

This range of this vegetation is currently unknown.

ENVIRONMENTAL DESCRIPTION

Little Bighorn Battlefield National Monument

Stands are found on the floodplain and banks of the Little Bighorn River on Quaternary alluvium (Haverson and Glenberg soils). They are evidently slightly lower in relative elevation (more frequently flooded) than the *Populus deltoids – Fraxinus pennsylvanica* Forest, the *Symphoricarpos occidentalis* Shrubland, and the *Prunus virginiana – (Prunus americana)* Shrubland and appear to have a similar hydrologic regime to the *Shepherdia argentea* Shrubland. They are higher in relative elevation (less frequently flooded) than the *Salix exigua* Temporarily Flooded Shrubland.

Global

Not known (no information), but likely to occur in similar habitats.

MOST ABUNDANT SPECIES

STRATUM	SPECIES
Herbaceous	*Bromus inermis, Poa pratensis, Solidago canadensis, Carex* sp.

CHARACTERISTIC SPECIES

Bromus inermis, Solidago canadensis, Carex sp., *Apocynum cannabinum, Symphiotrichum laeve*

VEGETATION DESCRIPTION

Little Bighorn Battlefield National Monument

Spartina pectinata is the dominant species. Species richness is generally low in most stands. *Hordeum jubatum* and *Pascopyrum smithii* are typically the most common secondary species.

Global

Not known (no information).

GLOBAL CLASSFICATION CONFIDENCE Not Ranked

CONSERVATION RANK Not Ranked

CLASSIFICATION COMMENTS

This vegetation was mapped as unclassifiable from any existing floristic descriptions. It was determined to the lowest determinable level of the NVCS (the Formation as defined by the 1997 standard) and given a provisional (project-specific description) as a "placeholder" to classify mapped stands for the Little Bighorn Battlefield project and as an occurrence record for future work.

Artemisia cana ssp. cana / Pascopyrum smithii Shrub Herbaceous Vegetation

COMMON NAME	Plains Silver Sagebrush / Western Wheatgrass Shrub Herbaceous Vegetation
LOCAL NAME	Silver Sagebrush / Western Wheatgrass Shrub Prairie
CLASS	Herbaceous Vegetation (V)
SUBCLASS	Perennial graminoid vegetation (V.A)
GROUP	Temperate or subpolar grassland with a sparse shrub layer (V.A.7)
SUBGROUP	Natural/Semi-natural temperate or subpolar grassland with a sparse shrub layer (V.A.7.N)
FORMATION	Medium-tall temperate or subpolar grassland with a sparse needle-leaved or microphyllous evergreen shrub layer (V.A.7.N.e)
ALLIANCE	*ARTEMISIA CANA* SSP. *CANA* SHRUB HERBACEOUS ALLIANCE
ASSOCIATION IDENTIFIER	CEGL001556
USFWS WETLAND SYSTEM	Upland
NS ECOLOGICAL SYSTEM	Western Great Plains Badlands (CES303.663) Northwestern Great Plains Mixedgrass Prairie (CES303.674) Northwestern Great Plains Floodplain (CES303.676) Western Great Plains Wooded Draw and Ravine (CES303.680)

RANGE

Little Bighorn Battlefield National Monument

At Little Bighorn Battlefield National Monument, this shrubland is known mostly from the Main Unit. Small amounts occur in the Reno-Benteen Unit.

Global

This silver or coaltown sagebrush shrubland is found in the northwestern Great Plains and Rocky Mountains of the western United States, ranging from Montana and North Dakota, south to Nebraska.

ENVIRONMENTAL DESCRIPTION

Little Bighorn Battlefield National Monument

Stands occur on low slopes, sides of draws, and possibly on eroding badland bluffs above the Little Bighorn River. Soils at sites confirmed to be this association are mapped as Midway silty clay loams, Hesper silty clay loams, or the Clapper-Midway complex. Geologic settings include the Judith River Formation and Quaternary alluvial terrace deposits.

Global

This association occurs on flat alluvial deposits on floodplains, terraces or benches, or alluvial fans. The soils are moderately deep to deep (U.S. Forest Service 1992) and either silt loam, clay loam, or sandy loam (Johnston 1988, Hansen and Hoffman 1988). The soils may have moderate salt content (Hanson and Whitman 1938). Flooding occurs periodically and this tends to retard soil profile development (Hirsch 1985).

MOST ABUNDANT SPECIES

STRATUM	SPECIES
Shrub	*Artemisia cana, Symphoricarpos occidentalis, Prunus virginiana,*
Herbaceous	*Bromus japonicus, Pascopyrum smithii, Pseudoroegneria spicata*

CHARACTERISTIC SPECIES

Artemisia cana, Pascopyrum smithii

VEGETATION DESCRIPTION

Little Bighorn Battlefield National Monument

(based on 6 accuracy assessment observations and one classification plot)

This type is compositionally similar to or nearly identical to the *Pascopyrum smithii- Nasella viridula* Herbaceous Vegetation, with the primary distinction being the presence of a low (<1 meter tall) shrub layer of *Artemisia cana*. Other shrubs (*Sarcobatus vermiculatus, Symphoricarpos occidentalis, Artemisia tridentata, Rhus trilobata,* and/or

Prunus virginiana are inconstant, but, when present, may sometimes be important to co-dominant. The exotic *Bromus japonicus* is nearly always present, and usually rampant major species found in the herbaceous layer. An assemblage of low cover native species is present, with *Hesperostipa comata* and *Achillea millefolium* most constant. *Gaura coccinea*, were low-cover natives recorded in the single classification plot. The non-native *Sisymbrium altissimum* and/or *Tragopogon dubius* are often frequent, but usually at low cover. Additional species recorded in the single classification plot include *Artemisia frigida, Calochortus nuttallii, Gaura coccinea, Phacelia linearis, Cisium undulatum, Nassella viridula, Psoralidium tenuiflorum, Camelina microcarpa, Melilotus officinalis, Poa pratensis,* and *Lactuca serriola*.

Global

This association is dominated by a combination of shrubs and graminoids. The total vegetation cover is typically moderate, but depends on frequency of flooding. The tallest and most conspicuous stratum is a shrub layer that is usually 0.6-1.2 m (Hansen and Hoffman 1988). In 14 stands in western North Dakota shrubs averaged 28% canopy cover, graminoids 59%, and forbs 2% (U.S. Forest Service 1992). Stands in Nebraska often have less than 15% cover. The variation in soils within and between stands of this association results in variable species composition. *Artemisia cana* is the dominant shrub. *Symphoricarpos occidentalis* is frequently present. There are also shorter shrubs such as *Artemisia frigida, Krascheninnikovia lanata, Rosa woodsii*, and *Gutierrezia sarothrae*. The most abundant graminoid is *Pascopyrum smithii*. This species is typically 0.5-1.0 m tall. It is often accompanied by *Nassella viridula* and sometimes *Koeleria macrantha, Poa pratensis*, and *Hesperostipa comata (= Stipa comata)*. *Bouteloua gracilis* is the most abundant short graminoid. Typical forb constituents of this association are *Achillea millefolium, Gaura coccinea, Sphaeralcea coccinea*, and *Lactuca tatarica var. pulchella*.

GLOBAL CLASSFICATION CONFIDENCE 1

CONSERVATION RANK G4

CLASSIFICATION OMMENTS

At Little Bighorn Battlefield National Monument, *Artemisia cana* appears to be an opportunistic species that is somewhat variable in occurrence, although it is clearly more affiliated with more mesic (*Pascopyrum smithii* dominated) sites than more xeric (*Pseudoroegneria spicata* dominated) sites. Thus, stands that key to this type may be transitional to or only arbitrarily distinct from types dominated by other shrubs (e.g., *Artemisia tridentata* or *Sarcobatus vermiculatus* types in open grasslands and on badlands bluffs or *Prunus virginiana* or *Symphoricarpos occidentalis* types in draws. Periodic flooding occurs in many stands of this association.

Artemisia cana was not determined to subspecies in the field during this study. Based on range, it is assumed to be ssp. *cana*.

Artemisia tridentata ssp. wyomingensis / Pascopyrum smithii Shrub Herbaceous Vegetation

COMMON NAME	Wyoming Big Sagebrush / Western Wheatgrass Shrub Herbaceous Vegetation
LOCAL NAME	Big Sagebrush / Western Wheatgrass Shrub Prairie
CLASS	Herbaceous Vegetation (V)
SUBCLASS	Perennial graminoid vegetation (V.A)
GROUP	Temperate or subpolar grassland with a sparse shrub layer (V.A.7)
SUBGROUP	Natural/Semi-natural temperate or subpolar grassland with a sparse shrub layer (V.A.7.N)
FORMATION	Medium-tall temperate or subpolar grassland with a sparse needle-leaved or microphyllous evergreen shrub layer (V.A.7.N.e)
ALLIANCE	*ARTEMISIA TRIDENTATA* SSP. *WYOMINGENSIS* SHRUB HERBACEOUS
ASSOCIATION IDENTIFIER	CEGL001047
USFWS WETLAND SYSTEM	Upland
NS ECOLOGICAL SYSTEM	Northwestern Great Plains Mixedgrass Prairie (CES303.674)

RANGE

Little Bighorn Battlefield National Monument

At Little Bighorn Battlefield National Monument, this shrubland is known from the Main Unit.

Global

This Wyoming big sagebrush type is found throughout the northern Great Plains and adjacent basins, Black Hills, and Rocky Mountains of the United States, particularly in Colorado and Wyoming.

ENVIRONMENTAL DESCRIPTION

Little Bighorn Battlefield National Monument

Stands occur on lower upland slopes and upper sides of draws. Soils are mapped as Hesper silty clay loams and, less frequently, as Midway silty clay loams. Geologic settings include the Judith River Formation and Quaternary alluvial terrace deposits.

Global

Stands occur on gently rolling uplands, swales or upper parts of stream terraces and drainageways. Drier examples may be found on more exposed slope positions or steeper slopes. Soils are moderately deep to deep clay, clay loam, silt loam or sandy loam. Soil moisture conditions are relatively mesic. Soil pH ranges from 5.8 to 7.8 (Hirsch 1985, Hansen and Hoffman 1988, Thilenius et al. 1995).

MOST ABUNDANT SPECIES

Little Bighorn Battlefield National Monument

STRATUM	SPECIES
Shrub	*Artemisia tridentata*
Herbaceous	*Pascopyrum smithii, Bromus japonicus, Poa pratensis, Tragopogon dubius*

CHARACTERISTIC SPECIES

Little Bighorn Battlefield National Monument

Artemisia tridentata, Pascopyrum smithii

Global

Bouteloua gracilis, Carex filifolia, Stipa comata

VEGETATION DESCRIPTION

Little Bighorn Battlefield National Monument

(from 5 accuracy assessment observations)

Artemisia tridentata is dominant, and, often, the only species in the shrub layer, but at low cover (1-20%). Herbaceous layer foliar cover is generally quite high (75-100%) and dominated by *Pascopyrum smithii*. *P. smithii* is

often exceeded in cover by the non-native *Bromus japonicus* and sometimes by the non-native *Poa pratensis*. The native grasses *Hesperostipa comata* and *Nassella viridula* and the non-native forb *Tragopogon dubius* may be present at low cover in the herbaceous layer, and *Opuntia polyacantha* may be present as a dwarf shrub.

Global

The vegetation contains an open short-shrub layer, approximately 0.5 m tall, dominated by microphyllous-leaved shrubs, and a dense herbaceous layer dominated by medium-tall graminoids. Shrub cover averages between 15 and 30% (Hirsch 1985, Hansen and Hoffman 1988, Thilenius et al. 1995) but may range as high as 55%. *Artemisia tridentata ssp. wyomingensis* dominates the shrub layer. Other shrubs present may include *Symphoricarpos oreophilus*, *Ericameria nauseosa*, *Amelanchier utahensis*, or *Purshia tridentata*. The dense herbaceous layer has a canopy cover ranging between 10% in heavily grazed sites to over 75% in protected, mesic sites. *Pascopyrum smithii* is the leading dominant. Important associates include *Koeleria macrantha, Poa secunda*, and *Nassella viridula (= Stipa viridula)*. In drier or more heavily grazed phases, *Bouteloua gracilis, Hesperostipa comata (= Stipa comata)*, and *Carex filifolia* may be more common, along with the succulent *Opuntia polyacantha*. Forbs contribute low cover, often less than 10%, and are typically of low constancy. More constant species (>50%) include *Artemisia frigida, Sphaeralcea coccinea*, and *Vicia americana*. Grassy leaf litter covers over 75% of the ground; stones and bare soil comprise the remainder. Nonvascular plants are rare (Hirsch 1985, Hansen and Hoffman 1988, Thilenius et al. 1995).

GLOBAL CLASSFICATION CONFIDENCE 2

CONSERVATION RANK G4

CLASSIFICATION COMMENTS

Artemisia tridentata was not determined to subspecies in the field during this study. The assignments of *Artemisia tridentata* stands to *Artemisia tridentata* ssp. *wyomingensis* associations were based on determinations of *A. tridentata* specimens from the immediate vicinity of Little Bighorn Battlefield by Steve Cooper (Montana Natural Heritage Program, retired) (S.Cooper, pers. comm. 2008) and by comparison of overall floristic composition and range to the global description of the association described here.

Artemisia tridentata ssp. wyomingensis / Pseudoroegneria spicata Shrub Herbaceous Vegetation

COMMON NAME	Wyoming Big Sagebrush / Bluebunch Wheatgrass Shrub Herbaceous Vegetation
LOCAL NAME	Big Sagebrush / Bluebunch Wheatgrass Shrub Prairie
CLASS	Herbaceous Vegetation (V)
SUBCLASS	Perennial graminoid vegetation (V.A)
GROUP	Temperate or subpolar grassland with a sparse shrub layer (V.A.7)
SUBGROUP	Natural/Semi-natural temperate or subpolar grassland with a sparse shrub layer (V.A.7.N)
FORMATION	Medium-tall temperate or subpolar grassland with a sparse needle-leaved or microphyllous evergreen shrub layer (V.A.7.N.e)
ALLIANCE	*ARTEMISIA TRIDENTATA* SSP. *WYOMINGENSIS* SHRUB HERBACEOUS
ASSOCIATION IDENTIFIER	CEGL001535
USFWS WETLAND SYSTEM	Upland
NS ECOLOGICAL SYSTEM	Northwestern Great Plains Mixedgrass Prairie (CES303.674)

RANGE

Little Bighorn Battlefield National Monument

At Little Bighorn Battlefield National Monument, this shrubland is known mostly from the Main Unit. Small amounts occur in the Reno-Benteen Unit.

Global

This association is known from Montana, Wyoming, Colorado, Idaho, Washington, Oregon (apparently), Nevada, and British Columbia, Canada. It probably also occurs in western North Dakota and Utah, and it may occur in South Dakota. This association is known to occur on the Thunder Basin National Grassland and on the Custer National Forest, Ashland District. It may also occur on the Sioux District and the Grand River Districts of the Custer National Forest.

ENVIRONMENTAL DESCRIPTION

Little Bighorn Battlefield National Monument

Stands occur on rolling upland slopes. Soils at sites confirmed to be this association are mapped as Midway silty clay loams, Hesper silty clay loams, or the Clapper-Midway complex. Geologic settings include the Judith River Formation and Quaternary alluvial terrace deposits.

Global

On the Great Plains of eastern Montana and Wyoming (Hansen and Hoffman 1988, Thilenius et al. 1995), stands of this association occur on moderately steep to steep (16-45%) slopes and on gentle footslopes with various aspects, at 4400-5000 feet elevation. Soils are loams, sandy loams, and sandy clay loams, often with coarse fragments in the upper horizons. Stands on the Wyoming plains often are on slopes of sandstone or porcelanite buttes (Thilenius et al. 1995). In the basins and foothills of south-central Montana (DeVelice and Lesica 1993) and north-central and central Wyoming (Fisser 1964, Tweit and Houston 1980, Knight et al. 1988), this association occupies mainly gentle to moderately steep (<35%) slopes at 4000-6000 feet elevation. Soils are moderately deep, usually loamy (although one stand has been described from a clay soil), may have a considerable volume of coarse fragments, and have low electrical conductivity. In central and northwestern Colorado, stands of this association occupy gentle to steep slopes (to 65%) on a variety of landforms at elevations from about 7000-8200 feet. Soils are derived from a variety of parent materials and often are gravelly. In southwestern Montana (Mueggler and Stewart 1980, Cooper et al. 1995), stands grow at elevations from 4000-7500 feet, on slopes up to 54% with various exposures. Soils are shallow to moderately deep and derived from a variety of parent materials. In eastern Washington (Daubenmire 1988), this association occupies silt loam and sandy loam soils on gentle to moderately steep (8-38%) slopes with a variety of aspects, up to about 2700 feet elevation. In British Columbia, this type grows on relatively warm, dry sites (Tisdale 1947), generally from 1300-1970 feet elevation with stands on steep, south-facing slopes occurring as high as 2950 feet (McLean 1970). Soils are loams, silt loams, and sandy loams.

MOST ABUNDANT SPECIES

STRATUM	SPECIES
Shrub	*Artemisia tridentata*
Herbaceous	*Pseudoroegneria spicata, Bromus japonicus, Pascopyrum smithii*

CHARACTERISTIC SPECIES
Artemisia tridentata, Pseudoroegneria spicata

VEGETATION DESCRIPTION

Little Bighorn Battlefield National Monument
(from 7 accuracy assessment observations)
Artemisia tridentata is dominant in the shrub layer, but at low cover (1-20%), with *Artemisia cana* a frequent to co-dominant associate. *Yucca glauca* may be present at low cover as a dwarf shrub. Herbaceous layer foliar cover is generally quite high (75-100%) and dominated by *Pseudoroegneria spicata*. *Pascopyrum smithii* is often present and may achieve co-dominance with *P. spicata*. The non-native *Bromus japonicus* is usually present and may contribute high cover, as less frequently can *Poa pratensis*. The natives *Nassella viridula, Hesperostipa comata, Carex filifolia,* and *Calochortus nuttallii* and the non-native *Tragopogon dubius* can contribute low cover in the herbaceous layer.

Global
Throughout the range of this association, the vegetation consists of an open to moderately dense shrub layer (about 10-25% canopy cover) dominated by *Artemisia tridentata ssp. wyomingensis*, and a herbaceous layer dominated by *Pseudoroegneria spicata* with lesser amounts of *Poa secunda* (sometimes a codominant grass). Other shrubs (especially *Chrysothamnus* sp.) and herbaceous species (especially *Hesperostipa comata (= Stipa comata)*) usually are present. *Festuca idahoensis* is absent or present in small amounts. The stands in the eastern half of the geographic range often contain small amounts of *Gutierrezia sarothrae, Artemisia frigida, Sphaeralcea coccinea, Phlox hoodii, Koeleria macrantha*, and *Opuntia polyacantha*. Less constant species are *Bouteloua* spp. (especially *Bouteloua gracilis*) *Carex filifolia*, and *Pascopyrum smithii* (Hansen and Hoffman 1988, Thilenius et al. 1995, Mueggler and Stewart 1980, DeVelice and Lesica 1993, Cooper et al. 1995, Tweit and Houston 1980, Fisser 1964, Knight et al. 1988, Baker and Kennedy 1985, Tiedemann et al. 1988). Missing from these stands is *Achnatherum thurberianum (= Stipa thurberiana)*. In the western half of the geographic range, the vegetation generally lacks the associated species listed above although Tisdale (1947) reports *Artemisia frigida* in British Columbia, and often contains *Antennaria dimorpha* and *Achnatherum thurberianum* (Hironaka et al. 1983, Blackburn 1967, Blackburn et al. 1968b, Daubenmire 1988, Tisdale 1947, McLean 1970). In addition, the stands in Washington often contain large amounts of crustose lichens as ground cover. Descriptions and photographs of stands show that shrub height also varies across the range of this type. From the Great Plains westward to eastern Idaho and south to Colorado, the sagebrush seldom exceeds 0.5 m in height, but in western Idaho and Washington, the shrubs typically are 1 m tall.

GLOBAL CLASSFICATION CONFIDENCE 2

CONSERVATION RANK G4

CLASSIFICATION COMMENTS
Artemisia tridentata was not determined to subspecies in the field during this study. The assignments of *Artemisia tridentata* stands to *Artemisia tridentata* ssp. *wyomingensis* associations were based on determinations of *A. tridentata* specimens from the immediate vicinity of Little Bighorn Battlefield by Steve Cooper (Montana Natural Heritage Program, retired) (S. Cooper, pers. comm. 2008) and by comparison of overall floristic composition and range to the global description of the association described here.

Rhus trilobata / Pseudoroegneria spicata Shrub Herbaceous Vegetation

COMMON NAME	Skunkbush Sumac / Bluebunch Wheatgrass Shrub Herbaceous Vegetation
LOCAL NAME	Skunkbush Sumac / Bluebunch Wheatgrass Shrub Prairie
CLASS	Herbaceous Vegetation (V)
SUBCLASS	Perennial graminoid vegetation (V.A)
GROUP	Temperate or subpolar grassland with a sparse shrub layer (V.A.7)
SUBGROUP	Natural/Semi-natural (V.A.7.N)
FORMATION	Medium-tall temperate or subpolar grassland with a sparse cold-deciduous shrub layer (V.A.7.N.g)
ALLIANCE	*RHUS TRILOBATA* SHRUB HERBACEOUS ALLIANCE
ASSOCIATION IDENTIFIER	CEGL001120
USFWS WETLAND SYSTEM	Upland
NS ECOLOGICAL SYSTEM	Northwestern Great Plains Mixedgrass Prairie (CES303.674)

RANGE

Little Bighorn Battlefield National Monument

At Little Bighorn Battlefield National Monument, this shrubland is known from both units, with larger stands in the Reno-Benteen Unit.

Global

This shrub prairie type is found in the United States on dry mid to upper slopes and ridge tops in the eastern plains and mountains of Wyoming and Montana.

ENVIRONMENTAL DESCRIPTION

Little Bighorn Battlefield National Monument

Stands occur on rolling uplands and upper sides of draws. Soils at sites confirmed to be this association are mostly mapped as Midway complex shale outcrops and also as Midway silty clay loams and Pierre clay. The most common geologic settings is mapped as the Bearpaw Formation.

Global

This association is typically found on dry mid to upper slopes and ridge tops. It has been identified on butte tops in eastern Wyoming (Thilenius et al. 1995). Slope and aspect are variable, but soils are consistently shallow and rocky. They often form from sandstone parent materials, and rock fragments, outcrops, and bare soil cover much of the ground (Mueggler and Stewart 1980).

MOST ABUNDANT SPECIES

STRATUM	SPECIES
Shrub	*Rhus trilobata, Prunus virginiana, Yucca glauca*
Herbaceous	*Pseudoroegneria spicata, Bromus japonicus, Pascopyrum smithii*

CHARACTERISTIC SPECIES

Rhus trilobata, Pseudoroegneria spicata

VEGETATION DESCRIPTION

Little Bighorn Battlefield National Monument

(from 1 classification plot and 9 accuracy assessment observations)

This is a dry grassland, with a usually sparse (1-15% cover) shrub layer of *Rhus trilobata.* Other shrubs, (primarily *Prunus virginiana*, *Artemisia tridentata*, *Symphoricarpos occidentalis*) may be present, but at lower cover. *Yucca glauca* and *Opuntia polyacantha* are sometimes present at low cover as dwarf shrubs. The herbaceous layer is dense (usually >90%) and dominated by graminoids, with *Pseudoroegneria spicata* the leading dominant, or at least co-dominant. *Pascopyrum smithii* is a frequent associate and may be co-dominant. *Nassella viridula, Koeleria macrantha, Hesperostipa comata, Achillea millefolium*, and *Artemisia ludoviciana* were recorded at multiple sites. The invasive non-native *Bromus japonicus* may have high cover in or may co-dominate the herbaceous layers also

fairly frequent. In the single classification plot, the native *Festuca idahoensis* and the non-native *Poa pratensis* were co-dominant with *P. spicata*. Native herbaceous species recorded at low cover were *Helianthella quinquenervia, Crepis acuminata, Calochortus nuttalli, Phacelia linearis, Elymus trachycaulus, Allium textile, Gaura coccinea, Phlox hoodii, Vicia americana*, and *Thermopsis rhombifolia*.

Global

Herbaceous species dominate the vegetation with short shrubs and nonvascular plants present but of lesser importance. Total vegetation cover is moderate (Brown 1971, Thilenius et al. 1995) and few plants grow taller than 1 m. Shrubs generally have from 10-25% cover. *Rhus trilobata* is the most common. It is often found with *Artemisia frigida, Artemisia tridentata, Prunus virginiana, Ribes cereum*, or *Eriogonum* spp. *Pseudoroegneria spicata* is the most abundant herbaceous species. Others commonly found include *Koeleria macrantha, Schizachyrium scoparium, Bouteloua curtipendula, Bromus tectorum*, and *Opuntia polyacantha*.

GLOBAL CLASSFICATION CONFIDENCE 1

CONSERVATION RANK G4

CLASSIFIACTION COMMENTS

Although *Festuca idahoensis* was present and contributed significant cover in the single classification plot, it was lower in cover than *Pseudoroegneria spicata* and was not seen elsewhere during the accuracy assessment, which likely examined most, if not all, *R. trilobata* stands. The *Rhus trilobata / Festuca idahoensis* Shrub Herbaceous Vegetation probably does not occur at Little Bighorn battlefield National Monument.

Sarcobatus vermiculatus / Pascopyrum smithii - (Elymus lanceolatus) Shrub Herbaceous Vegetation

COMMON NAME	Greasewood / Western Wheatgrass - (Streamside Wildrye) Shrub Herbaceous Vegetation
LOCAL NAME	Greasewood / Western Wheatgrass Shrub Prairie
CLASS	Herbaceous Vegetation (V)
SUBCLASS	Perennial graminoid vegetation (V.A)
GROUP	Temperate or subpolar grassland with a sparse shrub layer (V.A.7)
SUBGROUP	Natural/Semi-natural (V.A.7.N)
FORMATION	Intermittently flooded temperate or subpolar grassland with a sparse xeromorphic (evergreen and/or deciduous) shrub layer (V.A.7.N.n)
ALLIANCE	*SARCOBATUS VERMICULATUS* INTERMITTENTLY FLOODED SHRUB HERBACEOUS
ASSOCIATION IDENTIFIER	CEGL001508
USFWS WETLAND SYSTEM	Upland
NS ECOLOGICAL SYSTEM	Western Great Plains Badlands (CES303.663) Northwestern Great Plains Mixedgrass Prairie (CES303.674) Western Great Plains Wooded Draw and Ravine (CES303.680)

RANGE

Little Bighorn Battlefield National Monument

At Little Bighorn Battlefield National Monument, this shrubland is known in small patches, mostly from the Main Unit. Small amounts occur in the Reno-Benteen Unit.

Global

This greasewood shrub prairie is found in saline habitats in the northwestern Great Plains of the United States and Canada, ranging from northwestern Nebraska north to the Dakotas and Saskatchewan.

ENVIRONMENTAL DESCRIPTION

Little Bighorn Battlefield National Monument

Stands occur on rolling upland slopes, sides of draws, and on eroding badland bluffs above the Little Bighorn River. Soils are mapped as Midway silty clay loams. Geologic settings include the Judith River and Bearpaw Formations, and Quaternary alluvial terrace deposits (badland bluffs).

Global

This association is found on flat to gently sloping alluvial fans, terraces, lakebeds, and floodplains (Mueggler and Stewart 1980, Hansen and Hoffman 1988). Dodd and Coupland (1966) found *Sarcobatus vermiculatus* in association with *Pascopyrum smithii* only on the most arid parts of southwestern Saskatchewan. The soil is usually deep clay, silty clay, sandy clay, or loam (Hirsch 1985, Jones and Walford 1995), although coarse soils are possible (U. S. Forest Service 1992, Thilenius et al. 1995). They are saline or alkaline, but salt crusts on the surface are absent (Thilenius et al. 1995, but see Steinauer and Rolfsmeier 2000). Parent material is usually alluvium. Flooding during the spring is possible.

MOST ABUNDANT SPECIES

STRATUM	SPECIES
Shrub	*Sarcobatus vermiculatus*
Herbaceous	*Pascopyrum smithii, Bromus japonicus*

CHARACTERISTIC SPECIES

Pascopyrum smithii, Sarcobatus vermiculatus

VEGETATION DESCRIPTION

Little Bighorn Battlefield National Monument

(from 11 accuracy assessment observations)

The shrub layer is comprised of sparse layer (usually, 1-5% cover) of *Sarcobatus vermiculatus*. *Artemisia tridentata*, and, less commonly, *Artemisia cana*, *Rhus trilobata*, *Symphoricarpos occidentalis*, and/or *Prunus virginiana* may occur. Herbaceous layer foliar cover is generally quite high (75-100%) and dominated by *Pascopyrum smithii*, with *Pseudoroegneria spicata* often present and sometimes co-dominant with *P. smithii*. *Nassella viridula* and *Achillea millefolium* are frequently present, and *Yucca glauca* and *Opuntia polyacantha* may occur as dwarf shrubs. The native grasses may be exceeded in cover by the non-native *Bromus japonicus*. *Poa pratensis* and *Tragopogon dubius* are other non-natives that may be present.

Global

This association has moderate to dense vegetation cover (Jones and Walford 1995, Thilenius et al. 1995). Medium-tall (0.5-1.5 m) shrubs are scattered throughout, with a total shrub canopy of 10-25% (Hansen and Hoffman 1988, USFS 1992). The shrub layer is dominated by *Sarcobatus vermiculatus*, with *Atriplex confertifolia, Atriplex argentea, Artemisia tridentata*, and *Chrysothamnus viscidiflorus* in smaller amounts. *Symphoricarpos occidentalis* and *Rhus aromatica* are sometimes found in more mesic microhabitats within this type (Hirsch 1985). Herbaceous cover is sparse beneath the shrubs and moderate to dense in between. The dominant species are typically 0.5-1 m tall. The most abundant species is *Pascopyrum smithii*, usually accompanied by *Bouteloua gracilis, Bromus japonicus, B. tectorum*, and *Stipa comata*. Few forbs are found in this association. *Achillea millefolium* and *Opuntia polyacantha* are the only species with high constancy. Other species present may include *Grindella squarrosa*. Overall species diversity in this association is low (Hansen and Hoffman 1988, Von Loh et al. 1999).

GLOBAL CLASSFICATION CONFIDENCE 1

CONSERVATION RANK G4

COMMENTS

This type was originally divided into two concepts at Little Bighorn Battlefield National Monument: a *S. vermiculatus / Pascopyrum smithii* Shrub Herbaceous Vegetation and a *Sarcobatus vermiculatus / Pseudoroegneria spicata* Shrubland (Hansen and Hoffman 1988). The former was more abundant as mapped and as found during the accuracy assessment. Stands mapped as the latter were in a setting that showed little environmental differentiation from the former. Stands mapped in the field were usually not in the correct map class. Of the three stands found in the field, the field crew was clearly ambiguous as to which type, and, in all three cases, *Pascopyrum smithii* was listed as co-dominant or characteristic. Finally, the NVCS and Hansen and Hoffman (1988) attribute *Sarcobatus vermiculatus / Pseudoroegneria spicata* to steep, often badlands, slopes, no mapped or stands or field calls found the type in this setting. Finally, very little was mapped at Little Bighorn Battlefield National Monument and no stands were correctly identified in the accuracy assessment, there seemed little benefit in retaining the more finely split interpretation.

Weedy Annual Great Plains Herbaceous Vegetation [Park-specific]

COMMON NAME	Weedy Annual Great Plains Herbaceous Vegetation
LOCAL NAME	Weedy Annual Great Plains Herbaceous Vegetation
CLASS	Herbaceous Vegetation (V)
SUBCLASS	Annual graminoid or forb vegetation (V.D)
GROUP	Temperate or subpolar annual grasslands or forb vegetation (V.D.2)
SUBGROUP	Natural/Semi-natural (V.B.2.N)
FORMATION	Short temperate annual grassland (V.D.2.N.d)
ALLIANCE	Undefined
ASSOCIATION IDENTIFIER	None (described from this project)
USFWS WETLAND SYSTEM	Upland
NS ECOLOGICAL SYSTEM	Unknown

RANGE

Little Bighorn Battlefield National Monument

At Little Bighorn Battlefield National Monument, this vegetation was mapped in small patches in both units, usually near roads.

Global

This range of this vegetation is not known.

ENVIRONMENTAL DESCRIPTION

Little Bighorn Battlefield National Monument

This type is probably generally distributed throughout Little Bighorn Battlefield National Monument, especially in the headquarters area and along roads. It occurs in areas of anthropogenic soil disturbance, such as roadsides, pathways, waste sites, and maintenance areas, usually occurs in small patches (< 0.5 ha). The largest stand seen was at a maintenance area ("boneyard") that was being re-vegetated (perennial species were not yet established).

Global

Similar vegetation likely occurs in a variety of open disturbed habitats, throughout the Great Plains.

MOST ABUNDANT SPECIES

STRATUM	SPECIES
Herbaceous	*Bromus japonicus, Sisymbrium altissimum, Convolvulus arvensis, Bromus tectorum*

CHARACTERISTIC SPECIES

Convolvulus arvensis, Bromus tectorum

VEGETATION DESCRIPTION

Little Bighorn Battlefield National Monument

(based on 2 accuracy assessment observations)

This type is characterized by a dominance of weedy, mostly non-native, mostly low-growing, annual species. Cover and species composition may be variable and subject to time since disturbance and chance events of colonization and seed banks. *Bromus japonicus, Sisymbrium altissimum, Convolvulus arvensis, Bromus tectorum, Bromus inermis,* and *Lepidium perfoliatum* were the most frequent species in the few observed stands.

Global

The composition of this vegetation is likely highly variable and dependent in part on the breadth or narrowness of the classification treatment.

GLOBAL CLASSFICATION CONFIDENCE	Not Ranked
GLOBAL CONSERVATION RANK	Not Ranked. Probably GW.

CLASSIFICATION COMMENTS

Classification of ruderal, semi-natural vegetation at alliance and association levels is very under-developed in the NVCS. This vegetation was mapped as unclassifiable from any existing floristic descriptions. It was determined to the lowest determinable level of the NVCS (the Formation, as defined by the 1997 standard) and given a provisional (project-specific description) as a "placeholder" to classify mapped stands for the Little Bighorn Battlefield project and as an occurrence record for future work.

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Appendix F: Ecological System Descriptions

Initial mapping suggested 11 possible Ecological Systems at Little Bighorn Battlefield (Table F-1). The accuracy assessment indicated that the four largest Ecological Systems would provide a map accuracy of 98.6% (Table 5 within the main report).

This appendix contains summary descriptions of four terrestrial ecological system units (NatureServe 2003b, Comer et al. 2003) occurring at Little Bighorn Battlefield National Monument. Each ecological system represents one or more National Vegetation Classification (NVC) plant associations (Table 7 within the main report). Map classes were also crosswalked to ecological system units (Table 8 within the main report). The ecological systems classification was developed in consultation with many individuals and agencies and incorporates information from a variety of publications and other classifications. One purpose of ecological systems is to provide a coarse-scale mapping unit that can be applied across management boundaries.

Table F-1. Initial and final ecological systems

Initial Possible Ecological Systems
Inter-Mountain Basins Big Sagebrush Steppe
Inter-Mountain Basins Greasewood Flat
Northern Rocky Mountain Lower Montane, Foothill and Valley Grassland
Northwestern Great Plains Floodplain
Northwestern Great Plains Mixedgrass Prairie
Northwestern Great Plains Riparian
Northwestern Great Plains Shrubland
Rocky Mountain Lower Montane Riparian Woodland and Shrubland
Western Great Plains Badlands
Western Great Plains Sand Prairie
Western Great Plains Wooded Draw and Ravine

Post Accuracy Assessment NVCS Ecological Systems
Northwestern Great Plains Floodplain
Northwestern Great Plains Mixedgrass Prairie
Western Great Plains Badlands
Western Great Plains Wooded Draw and Ravine

The following Ecological Systems descriptions were obtained from NatureServe Explorer http://www.natureserve.org/explorer/ on March 24, 2008.

Northwestern Great Plains Floodplain

Unique Identifier: CES303.676
Classification Confidence: 2 - Moderate

Northwestern Great Plains Floodplain ecological system is found in the floodplains of medium and large rivers of the northwestern Great Plains, ranging from the Dakotas Mixedgrass Prairie west through the Northern Great Plains Steppe and north into Canada. This system occurs in the upper Missouri River Basin and includes parts of the Niobrara, White, Cheyenne, Little Missouri, Yellowstone, Powder, Bighorn, Milk, and Musselshell rivers. Alluvial soils and periodic, intermediate flooding (every 5-25 years) typify this system. These are the perennial big rivers of the region with hydrologic dynamics largely driven by snowmelt in the mountains, rather than local precipitation events. Dominate communities within this system range from floodplain forests to wet meadows to gravel/sand flats, however, they are linked by underlying soils and flooding regime. Dominant species are *Populus balsamifera ssp. trichocarpa* or *Populus deltoides* and *Salix* spp. *Fraxinus pennsylvanica*, *Salix amygdaloides*, and *Ulmus americana* are common in some stands. If present, common shrub species include *Amorpha fruticosa, Cornus drummondii, Cornus sericea, Symphoricarpos occidentalis, Salix exigua, Salix interior*, and *Salix planifolia*. Grass cover underneath the trees is an important part of this system and is a mix of cool-season graminoid species, including *Carex pellita (= Carex lanuginosa), Elymus lanceolatus, Pascopyrum smithii*, and *Schoenoplectus* spp., with warm-season species such as *Panicum virgatum, Schizachyrium scoparium*, and *Spartina pectinata*. This system is often subjected to heavy grazing and/or agriculture and can be heavily degraded. In Montana, most occurrences are now degraded to the point where the cottonwood overstory is the only remaining natural component; undergrowth is dominated by *Bromus inermis*, or a complex of pasture grasses. Another factor is that groundwater depletion and lack of fire have created additional species changes. In most cases, the majority of the wet meadow and prairie communities may be extremely degraded or extirpated from the system.

Classification Comments: Northwestern Great Plains Floodplain needs to be more clearly delineated from Northwestern Great Plains Riparian (CES303.677). The component plant association list is incomplete. All the riparian/floodplain/alluvial systems of the Great Plains region need to be revisited for naming conventions, along with better definitions of conceptual boundaries. There is much apparent overlap in their concepts and distribution, and the names add to the confusion. In particular, the difference between "riparian" and "floodplain" usage in the names needs revisiting and possible changing. These systems include Northwestern Great Plains Floodplain (CES303.676), Northwestern Great Plains Riparian (CES303.677), Western Great Plains Floodplain (CES303.678), and Western Great Plains Riparian (CES303.956).

Northwestern Great Plains Mixedgrass Prairie

Unique Identifier: CES303.674
Classification Confidence: 2 – Moderate

The Northwestern Great Plains Mixedgrass Prairie system extends from northern Nebraska into southern Canada and westward through the Dakotas to the Rocky Mountain Front in Montana and probably Wyoming, on both glaciated and non-glaciated substrates. Soil texture (which ultimately effects water available to plants) is the defining environmental descriptor; soils are primarily fine and medium-textured and do not include sands, sandy soils, or sandy loams. This system occurs on a wide variety of landforms (e.g., mesa tops, stream terraces) and in proximity to a diversity of other systems. Most usually it is found in association with Western Great Plains Sand Prairie (CES303.670) which occupies the coarser-textured substrates. In various locales the topography where this system occurs is broken by many glacial pothole lakes, and this system may be proximate to Great Plains Prairie Pothole (CES303.661). On the eastern Montana plains, mixedgrass prairie is by far the predominant system. Here it occurs continuously for hundreds of square kilometers, interrupted only by riparian areas or sand prairies, which are associated with gentle rises, eroded ridges or mesas derived from sandstone. Historically, this system covered approximately 38 million ha in Nebraska, North and South Dakota, and Canada; now it covers approximately 270,000 square km in this region. The growing season and rainfall are intermediate to drier units to the southwest and mesic tallgrass regions to the east. Graminoids typically comprising the greatest canopy cover include *Pascopyrum smithii, Nassella viridula,* and *Festuca* spp. In Montana these include *Festuca campestris* and *Festuca idahoensis*. Other commonly dominant species in Montana are *Bouteloua gracilis, Hesperostipa comata*, and *Carex filifolia*, while *Festuca campestris* and *Festuca idahoensis* may be more abundant in the north and foothill/montane grassland transition areas. Remnants of *Hesperostipa curtiseta*-dominated vegetation are found in northernmost Montana and North Dakota associated with the most productive sites (largely plowed to cereal grains); this species, usually in association with *Pascopyrum smithii*, is much more abundant in Canada. Sites with a strong component of *Nassella viridula* indicate a more favorable moisture balance and perhaps a favorable grazing regime as well because this is one of the most palatable of the mid-grasses. *Hesperostipa comata* is also an important component and becomes increasingly so as improper grazing regimes favor it at the expense of (usually) *Pascopyrum smithii*; progressively more destructive grazing can result in the loss of *Pascopyrum smithii* from the system followed by drastic reduction in *Hesperostipa comata* and ultimately the dominance of *Bouteloua gracilis* (or *Poa secunda* and other short graminoids) and/or a lawn of *Selaginella densa*. *Koeleria macrantha,* at least in Montana and southern Canada, is the most pervasive grass; if it has high cover, past intensive grazing is the presumed reason. Shrub species such as *Symphoricarpos* spp. and *Artemisia frigida* and *Artemisia cana* also occur. Fire and grazing constitute the primary dynamics affecting this system. Drought can also impact this system, in general favoring the shortgrass component at the expense of the mid-grasses. With intensive grazing, cool-season exotics such as *Poa pratensis, Bromus inermis,* and *Bromus japonicus* can increase in dominance; both of the rhizomatous grasses have been shown to markedly depress species diversity. Shrub species such as *Juniperus virginiana* can also increase in dominance with fire suppression. This system is one of the most disturbed grassland systems in Nebraska, North and South Dakota, and Canada.

Classification Comments: The Northwestern Great Plains Mixedgrass Prairie system was edited to expand the concept for central Montana mixedgrass prairie and to exclude specifically sandy soil grasslands, which are placed into Western Great Plains Sand Prairie (CES303.670). This system is similar to Central Mixedgrass Prairie (CES303.659) and can contain elements of Great Plains tallgrass and shortgrass systems. However, it differs from Central Mixedgrass Prairie (CES303.659) in that the cooler climate in this region allows native cool-season grasses to be more important (greater than 50% cover). Cover of native, nongrazing-induced shrubs typically does not exceed 25% in conjunction with topographic relief (breaks); otherwise the stand would be considered part of Northwestern Great Plains Shrubland (CES303.662). Additional review and commentary by Canadian, Dakotan, and Nebraskan ecologists is needed to flesh out the compositional variation and range of distribution for this important grassland system. In Wyoming, this system transitions into Northern Rocky Mountain Lower Montane, Foothill and Valley Grassland (CES306.040) in the foothills of the northern Wyoming mountains where *Pascopyrum smithii* communities finger up into foothills. If *Festuca idahoensis, Carex rossii, Artemisia nova,* or *Artemisia tripartita* ssp. *rupicola* occur, then the example is not this system.

Western Great Plains Badlands

Unique Identifier: CES303.663
Classification Confidence: 1 - Strong

Western Great Plains Badlands ecological system is found within the northern Great Plains region of the United States and Canada with some of the better known and extensive examples in North and South Dakota. In contrast to Western Great Plains Cliff and Outcrop (CES303.665), this system is typified by extremely dry and easily eroded, consolidated clay soils with bands of sandstone or isolated consolidates and little to no cover of vegetation (usually less than 10% but can be as high as 20%). Vegetated patches within the badlands system may have cover higher than 20%. In north-central Montana, badlands often are a mosaic of bare substrate with small patches of grasses and/or shrubs that may exceed 10% cover. In those areas with vegetation, species can include scattered individuals of many dryland shrubs or herbaceous taxa, including *Grindelia squarrosa, Gutierrezia sarothrae* (especially with overuse and grazing), *Sarcobatus vermiculatus, Atriplex gardneri, Artemisia pedatifida, Eriogonum* spp., *Muhlenbergia cuspidata, Pseudoroegneria spicata*, and *Arenaria hookeri*. Patches of *Artemisia* spp. can also occur. This system can occur where the land lies well above its local base level or below and is created by several factors, including elevation, rainfall, carving action of streams, and parent material.

Classification Comments: It has been proposed to change the name of Western Great Plains Badlands to include "shale barrens." As with all predominantly "barren" systems, there will be patches of vegetated areas within the overall system. Small areas of "badlands" or "shale barrens" can also occur without major erosion processes actively taking place. An example location is Bitter Creek Area of Environmental Concern (BLM designation), which is much like a badland but not so eroded. The vegetation is sparse with *Juniperus horizontalis* and much bare ground; there is some grass cover as well. The driving process is erosion. Exactly where this transitions to Inter-Mountain Basins Shale Badland (CES304.789) in central Wyoming needs to be clarified.

Western Great Plains Wooded Draw and Ravine

Unique Identifier: CES303.680
Classification Confidence: 2 – Moderate

The Western Great Plains Wooded Draw and Ravine ecological system is typically found associated with permanent or ephemeral streams and may occur on steep northern slopes or within canyon bottoms that do not experience periodic flooding, although soil moisture and topography allow greater than normal moisture conditions compared to the surrounding areas. Occurrences can be either tree-dominated or predominantly shrubland. *Fraxinus* spp. with *Ulmus rubra* or *Ulmus americana* typically dominate this system, although in some areas of the western Great Plains steppe province, *Juniperus scopulorum* can dominate the canopy. *Populus tremuloides, Betula papyrifera*, or *Acer negundo* are commonly present in portions of the northwestern Great Plains, for example in areas of central and eastern Montana. In south-central portions of the Great Plains, *Quercus macrocarpa* can also be present. Component shrubs can include *Cornus sericea, Crataegus douglasii, Crataegus chrysocarpa, Crataegus succulenta, Elaeagnus commutata, Prunus virginiana, Rhus* spp., *Rosa woodsii, Shepherdia argentea, Symphoricarpos occidentalis*, or *Viburnum lentago*. Common grasses can include *Calamagrostis stricta, Carex* spp., *Pascopyrum smithii, Piptatherum micranthum, Pseudoroegneria spicata*, or *Schizachyrium scoparium*. This system was often subjected to heavy grazing and trampling by both domestic animals and wildlife and can be heavily degraded in some areas. In addition, exotic species such as *Ulmus pumila* and *Elaeagnus angustifolia* can invade these systems.

Classification Comments: More information from the broader division and from the Rocky Mountain division will be needed to determine if those areas dominated by ash and elm should be separated from areas dominated by Juniperus scopulorum. Those areas dominated by Juniperus are typically found in the Badlands and the western portions of North Dakota and Nebraska, and should probably be described based on data from the Great Plains Steppe or Rocky Mountain division. However, Juniperus can occur in stands with elm and ash in Nebraska and North Dakota.

Appendix G: LIBI Vegetation Map Geodatabase Documentation

Introduction

This document describes the relationships and entities of the relational geodatabase model used to house the LIBI vegetation map data. This model was developed for ArcGIS 9.3 using the personal geodatabase Microsoft Access JET engine.

The structure of this database differs from many of the other NPS Vegetation Maps. Because intensive field sampling was not involved, this vegetation map did not use the NatureServe Plots database. Thus, only a limited set of information was collected in the field. Records of dominant species composition are preserved in this geodatabase as a feature class, and in tables; these tables and data are identified with "Field" and "AA" (Accuracy Assessment) in their headings.

Entity Relationships

Figure G-1 provides a diagram showing the relationships among the primary entities, both spatial and tabular. In total, there are six feature classes that contain geographic information, three main tables, and four lookup tables used for reference.

Referential integrity is enforced among the main tables (tbl) through MS Access. Due to the limitations of the geodatabase model, referential integrity is not enforced among the look-up (tlu) tables and the related feature classes (fcl).

This structure reflects a compromise between normalization and functionality. In general, all spatial information (especially polygons) was represented in the feature classes while all tabular information was housed in relational tables. However, there is sometimes redundancy between the two. For instance, the map names are located in both the feature classes and the lookup tables. This simultaneously ensures that one can work in ArcGIS without having to plot x-y points while another can work in Access without the risk of corrupting the feature classes.

Table and Attribute Descriptions

Details for each table and data field are provided in Figure G-1.

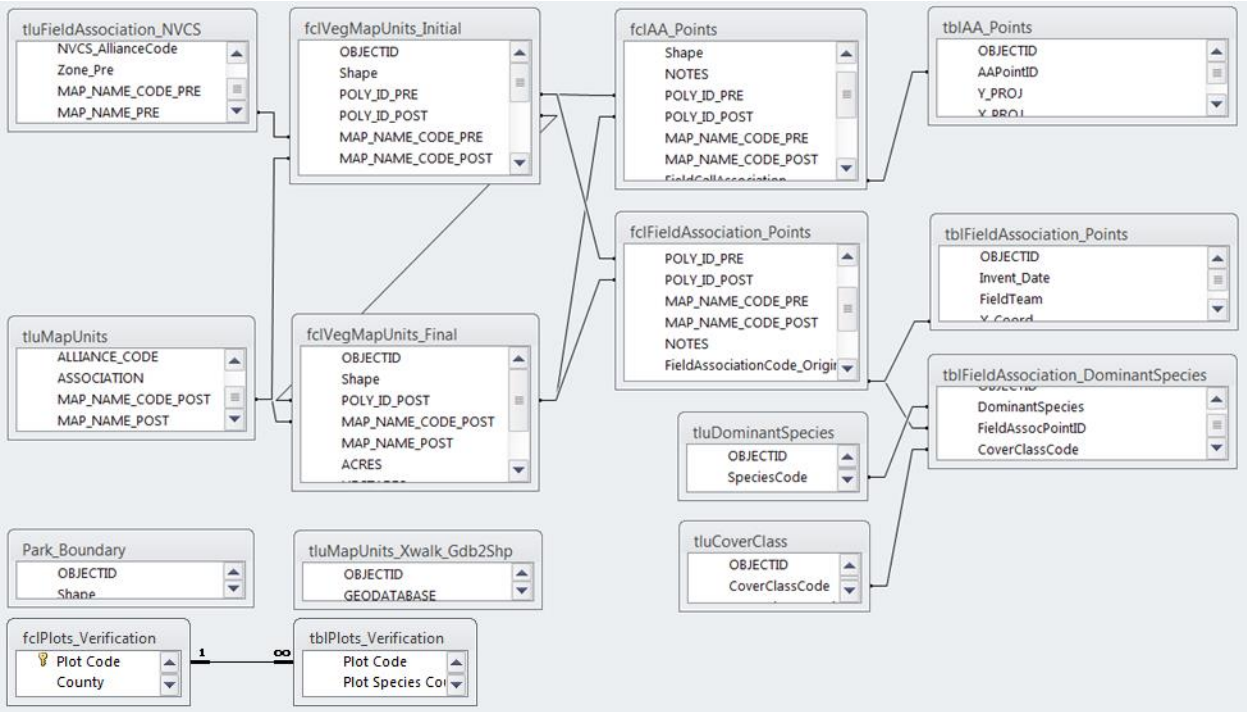

Figure G-1. Diagram of Relationships Among Core Tables in the Geodatabase Model

fclAA_Points

This feature class contains the geographic locations of all accuracy assessment points. This feature class is a spatial representation of 'tblAA_Points'.

Attribute	Description	Type
OBJECTID	Autonumber. Internal to ESRI	Long
Shape	Shape. Internal to ESRI	Blob
AAPointID	Unique point ID for each AA point	Text 50
NOTES	Comments about the pre-post transition	Text 200
POLY_ID_PRE	Original (segmented polys) unique polygon identifier	Integer
POLY_ID_POST	Final (collapsed polys) polygon identifier	Integer
MAP_NAME_CODE_PRE	Original (segmented polys) Map Unit Association code	Text 50
MAP_NAME_CODE_POST	Final (collapsed polys) Map Unit Association code	Text 50
MAP_NAME_PRE	Original (segmented polys) Map Unit Label	Text 255
MAP_NAME_POST	Final (collapsed polys) Map Unit Label	Text 255
FieldCallAssociation	Final Association given to the point	Text 50
DominantSpecies_Tree	Species code for all dominant species in the tree canopy	Text 200
DominantSpecies_Shrub	Species code for all dominant species in the shrub canopy	Text 200

DominantSpecies_Herbaceous	Species code for all dominant species in the herbaceous canopy	Text 200

fclFieldAssociation_Points

This feature class contains the point locations used as reference to assign the polygons an association. Additional details of the original "field call" related to these point features are included in 'tblFieldAssocation_Points'.

Attribute	Description	Type
OBJECTID	Autonumber. Internal to ESRI	Long
Shape	Shape. Internal to ESRI	Blob
FieldAssocPointID	Field code from field census	Text 50
FieldAssociationCode	Final Association given to the point	Text 50
POLY_ID_PRE	Original (segmented polys) unique polygon identifier	Integer
POLY_ID_POST	Final (collapsed polys) polygon identifier	Integer
MAP_NAME_CODE_PRE	Original (segmented polys) Map Unit Association code	Text 50
MAP_NAME_CODE_POST	Final (collapsed polys) Map Unit Association code	Text 50
MAP_NAME_PRE	Original (segmented polys) Map Unit Label	Text 255
MAP_NAME_POST	Final (collapsed polys) Map Unit Label	Text 255
NOTES	Comments about the pre-post transition	Text 200

fclPlots_Verification

This feature class contains the centroid point location of each vegetation classification plot. Additional details of the species found at these point features are included in 'tblPlots_Verification'.

Attribute	Description	Type
OBJECTID	Autonumber. Internal to ESRI	Long
Shape	Shape. Internal to ESRI	Blob
Plot_Code	Unique identifier for this vegetation plot	Text 254
County	County the point is within	Text 255
Provisional_Community_Name	Vegetation community name assigned in field prior to classification	Text 255
Classified_Community_Name	Vegetation community name assigned in field after classification	Text 255
NVC_ELCODE	National Vegetation Classification Code for the Classified Community Name for this plot	Text 255
Location_Code	NPS Park code	Text 255
Sublocation	Area within the park	Text 255
Quad_Name	1:24k Quad	Text 255
Coord_System	Coordinate system of the XY data, 1 if UTM, 2 if Lat/Long	Double
GPS_File	Path and filename of waypoints downloaded from GPS unit	Text 255
GPS_Techniques	Description of equipment/techniques used to collect spatial information	Text 255
Field_UTM_X	X (east-west) coordinate recorded in the field for this plot	Double

Field_UTM_Y	Y (north-south) coordinate recorded in the field for this plot	Double
UTM_Zone	UTM Zone	Double
Survey_Date	Date plot was visited	Text 255
Surveyors	Names of people doing the fieldwork for this plot	Text 255
Plot_Directions	Narrative description of how to get to plot	Text 255
X_Dimension	If rectangular plots used, give plot width (x dimension)	Double
Y_Dimension	If rectangular plots used, give plot length (y dimension)	Double
Plot_Shape	Shape of vegetation plots (rectangular, circular, etc)	Text 255
Representativeness	How similar to the plot is the 1 hectare area surrounding the plot?	Text 255
Elevation	Elevation of plot	Double
Elevation_Units	Units of elevation measure, 1=meters, 2=feet	Text 255
GPS_Datum	Datum used in conjunction with the coordinate system	Text 255
GPS_Accuracy	Measurement error as recorded on the GPS unit used	Text 255
Slope	Slope measured in classes	Text 255
Precise_Slope	Slope measured to precise degrees or percent	Text 255
Aspect	Aspect measured in classes	Text 255
Precise_Aspect	Aspect measured in precise degrees	Text 255
Topo_Position	Topographic position of plot	Text 255
Landform	Major landform description of plot and surrounding area	Text 255
Surficial_Geology	Description of substrate	Text 255
Cowardin_System	General wetland classification of plot (Upland, Palustrine, Estuarine, Riverine, Lacustrine)	Text 255
Hydro_Regime	Hydrological regime to further define wetlands, or if Upland: dry, dry-mesic or mesic	Text 255
Hydrology_Evidence	Narrative description of hydrological influence	Text 255
Environmental_Comments	Narrative description of the habitat, including animal use and disturbance	Text 255
Soil_Texture	General soil texture of plot area	Text 255
Soil_Drainage	General soil drainage of plot area	Text 255
Prcnt_Bedrock	% of unvegetated ground surface covered by bedrock	Double
Prcnt_Large_Rocks	% of unvegetated ground surface covered by large rocks (> gravel)	Double
Prcnt_Small_Rocks	% of unvegetated ground surface covered by small rocks (gravel or smaller)	Double
Prcnt_Sand	% of unvegetated ground surface covered by sand	Double
Prcnt_Litter_Duff	% of unvegetated ground surface covered by litter or duff	Double
Prcnt_Wood	% of unvegetated ground surface covered by dead wood	Double
Prcnt_Water	% of unvegetated ground surface covered by water	Double
Prcnt_Bare_Soil	% of unvegetated ground surface covered by bare soil (clay, silt, or loam)	Double
Prcnt_Other	% of unvegetated ground surface covered by anything else	Double
Prcnt_Other_Description	Describe what that "anything else" really is	Text 255
Leaf_Phenology	Leaf phenology of dominant stratum	Text 255
Leaf_Type	Leaf type of dominant stratum	Text 255

Physio_Class	Physiognomic class of dominant stratum	Text 255
T1_Hgt	Maximum height of Emergent Tree Stratum (meters)	Text 255
T1_Cover	% cover of Emergent trees	Text 255
T2_Hgt	Maximum height of Canopy Stratum (meters)	Text 255
T2_Cover	% cover of Tree canopy	Text 255
T3_Hgt	Maximum height of Subcanopy Stratum (meters)	Text 255
T3_Cover	% cover of Subcanopy	Double
S1_Hgt	Maximum height of Tall Shrub Stratum (meters)	Text 255
S1_Cover	% cover of Tall shrubs	Double
S2_Hgt	Maximum height of Medium Shrub Stratum (meters)	Text 255
S2_Cover	% cover of Medium shrubs	Double
S3_Hgt	Maximum height of Low Shrub Stratum (meters)	Text 255
S3_Cover	% cover of Low shrubs	Double
H_Hgt	Maximum height of Herbaceous Stratum (meters)	Text 255
H_Cover	% cover of Herbaceous plants	Double
N_Hgt	Maximum height of Nonvascular Stratum (meters)	Text 255
N_Cover	% cover of Nonvascular plants	Text 255
V_Hgt	Maximum height of Vine/liana Stratum (meters)	Text 255
V_Cover	% cover of Vines/lianas	Text 255
E_Hgt	Maximum height of Epiphyte Stratum (meters)	Text 255
E_Cover	% cover of Epiphytes	Text 255
Disturbance_Comments	A place to put any other comments	Text 255
Update_	Date of most recent change to data	Date
User	Data entry person to last update record	Text 255
Species_Counter	Plot-specific counter for Plot-Species record keys	Double

fclVegMapUnits_Final

This feature class contains the geographic location of all vegetation map polygons, their associated classifications, and labels. The Map Unit Association code field ('MAP_NAME_CODE_POST') is a four letter code derived from the standard scientific name (i.e. the first two letters of the Genus and specific epitaph; some of the entries recognize two dominant species (separated by '/'). Most of these codes match the NVC standards (i.e. may be based on former nomenclature, as in the case of *Pseudoroegaria spicata* which is coded 'AGSP'); a few of the codes are custom names for this map (e.g. those other than natural vegetation types). Map Unit Label includes the common names for the dominant species (same species identified in 'MAP_NAME_CODE_POST'.

Attribute	Description	Type
OBJECTID	Autonumber. Internal to ESRI	Long
Shape	Shape. Internal to ESRI	Blob
PLOY_ID_POST	Final (collapsed polys) polygon identifier	Integer
MAP_NAME_CODE_POST	Final (collapsed polys) Map Unit Association code	Text 50
MAP_NAME_POST	Final (collapsed polys) Map Unit Label	Text 255

ACRES	Area in acres. Calculated in ArcMap	Double
HECTARES	Area in hectares. Calculated in ArcMap	Double
Shape_Length	Length in meters. Internal to ESRI	Double
Shape_Area	Area in square meters. Internal to ESRI	Double

fclVegMapUnits_Initial

This feature class contains the geographic location of original vegetation map polygons, their associated classifications, and labels. The original Map Unit Association code and the code after polygons were collapsed are both maintained in this feature class. The unique identifiers for each original polygon and the final unique identifier for the polygon are also maintained. The spatial extent has been clipped to the park border.

Attribute	Description	Type
OBJECTID	Autonumber. Internal to ESRI	Long
Shape	Shape. Internal to ESRI	Blob
POLY_ID_PRE	Original (segmented polys) unique polygon identifier	Integer
POLY_ID_POST	Final (collapsed polys) polygon identifier	Integer
MAP_NAME_CODE_PRE	Original (segmented polys) Map Unit Association code	Text 50
MAP_NAME_CODE_POST	Final (collapsed polys) Map Unit Association code	Text 15
MAP_NAME_PRE	Original (segmented polys) Map Unit Label	Text 255
MAP_NAME_POST	Final (collapsed polys) Map Unit Label	Text 255
NOTES	Comments about the pre-post transition	Double
ACRES	Area in acres. Calculated in ArcMap	Double
HECTARES	Area in hectares. Calculated in ArcMap	Double
SuperClass	Zone guiding detail of eCognition segmentation	Text 50
Shape_Length	Length in meters. Internal to ESRI	Double
Shape_Area	Area in square meters. Internal to ESRI	Double

tblAA_Points

This table contains the locations and field identification call made by the accuracy assessment team; these data were used to assess correlation between original field calls, assigned polygon associations and user accuracy.

Attribute	Description	Type
AAPointID	Unique AA point ID	Text 255
Y_PROJ	UTM NAD 83, 13 North	Long Integer
X_PROJ	UTM NAD 83, 13 North	Long Integer
GPS_ErrorMeters	Estimated GPS positional error in meters	Double
Surveyor	Name of the surveyor making the field call	Text 255
Invent_Date	Date the point was visited	Date
Altitude	Elevation from GPS	Double
GPS_Model	Make of the GPS	Text 50

tblFieldAssociation_DominantSpecies

This table contains the dominant species found for each point based on a survey around the point of reference. These are the original field calls recorded by botanists during the polygon census.

Attribute	Description	Type
FieldAssocPointID	Unique code identifying each field call	Text 50
DominantSpecies	Species code for one of the dominant species in a polygon	Text 10
CoverClassCode	Percent cover for the particular species	Text 10
OBJECTID	Autonumber. Internal to ESRI	Long

tblFieldAssociation_Points

This table contains the data collected in the field to determine the association for each polygon.

Attribute	Description	Type
FieldAssocPointID	Unique ID for each field call	Text 50
Invent_Date	Date the polygon was visited	Date
FieldTeam	Identifier initials from the field team	Text 2
X_Coord	UTM Easting, 13 North, NAD 83	Double
Y_Coord	UTM Northing, 13 North, NAD 83	Double
TotalPointsAvged	The number of points collected in recording the waypoint	Long
GPS_ErrorMeters	The estimated accuracy of the GPS unit when point was visited (meters)	Text 50
SourceFile	Name of the waypoint file used to assign the point	Text 50
Notes	Notes from the field sheet	Memo
OBJECTID	Autonumber. Internal to ESRI	Long

tblPlots_Verification

This table contains the taxonomic data collected in the field at each vegetation classification plot.

Attribute	Description	Type
OBJECTID	Autonumber. Internal to ESRI	Long
Plot_Code	Unique identifier for this vegetation plot	Text 255
Plot_Species_Counter	Unique sequence for species within this plot	Text 255
Plant_Symbol	USDA PLANTS accepted symbol for this species	Double
Scientific_Name	Scientific Name only (without Authors)	Text 255
Common_Name	National Common Name	Text 255
Family	Taxonomic Family	Text 255
Specimen_Number	Number given to the specimen taken	Text 255
Used_PLANTS	Yes if name came from the PLANTS database	Short Integer
Source	From Plant List table: SS or NS	Text 255
Within_Plot	Species is present within the Plot boundaries	Short Integer

Stratum_Sort	Major sort order of stratum type	Double
Stratum	Stratum code	Text 255
Diagnostic	Species is a known diagnostic for the community	Short Integer
Range_Cover	Category per scale classification scheme	Text 255
Real_Cover	Percent cover for this species	Text 255
Other_Measure1	Other measure of species presence	Text 255
Other_Measure2	Other measure of species presence	Text 255
Update_	Date of most recent change to data	Date
User	Data entry person to last update record	Text 255

tluCoverClass

This reference table contains cover classes used to identify dominant species within each polygon.

Attribute	Description	Type
CoverClassCode	Shorthand code	Text 50
CoverClassDesciption	Description of each cover class (% range)	Text 200
CoverClassMidpoint	Numeric midpoint of the cover class range	Double
ObjectID	Autonumber. Internal to ESRI	Long

tluDominantSpecies

This reference table connects 4-letter species codes to the proper scientific name. Note that a species code can represent more than a single species.

Attribute	Description	Type
SpeciesCode	Shorthand 4 letter code	Text 10
SpeciesName	Scientific nomenclature	Text 200
TSN	PLANTS TSN code	Long
SpeciesCode_Updated	Revised Shorthand 4 letter code to be current as of 03/2012	Text 10
SpeciesName_Updated	Revised Scientific nomenclature to be current as of 03/2012	Text 200
TSN_Updated	Revised PLANTS TSN code to be current as of 03/2012	Long
ObjectID	Autonumber. Internal to ESRI	Long

tluFieldAssociation_NVCS

This table preserves the original Association assigned by botanists mapping in the field; these are connected to the appropriate NVC hierarchical classes. Note that some codes change between the original field call and the final classification, which is why this information is preserved.

Attribute	Description	Type
MAP_NAME_CODE_PRE	Original (segmented polys) Map Unit Association code	Text 50
MAP_NAME_PRE	Original (segmented polys) Map Unit Label	Text 255

Source	Field key or other source for field level classification	Text 255
MapUnitLabel	Common Name Association Label	Text 100
Type	Hierarchy Level, e.g. habitat, community, alliance, etc.	Text 50
NVCS_Association	Association from NatureServe Explorer Web site (Oct 2006)	Text 255
NPS_VegMapAssociation	Association from NatureServe Explorer web site (Oct 2006). NA = field typed only to alliance level, or Association does not exist	Text 100
NVCS_CEGLCode	CEGL (NVCS/NatureServe) Association Code (CEGL######) or Alliance Code (A.####)	Text 50
NVCS_Alliance	Alliance from NatureServe Explorer Web site (Oct 2006)	Text 100
NVCS_EcologicalSystem	Ecological System from NatureServe Explorer (Oct 2006)	Text 100
NVCS_Formation	Formation from NatureServe Explorer (Oct 2006)	Text 255
Comments	Details on teh citation and/or record information	Text 255
OBJECTID	Unique ID. Internal to ESRI	Long

tluMapUnits

This table of classes represents the final crosswalk for the NVCS associations; it includes codes, scientific nomenclature and class hierarchy assignments.

Attribute	Description	Type
OBJECTID	Autonumber. Internal to ESRI	Long Integer
MAP_NAME_CODE_POST	Final (collapsed polys) Map Unit Association code	Text 255
MAP_NAME_POST	Final (collapsed polys) Map Unit Label	Text 255
COMMON_NAME	Classification name used for the map symbology	Text 255
LOCAL_NAME	Alternative classification name	Text 255
ASSOCIATION_IDENTIFIER	Unique NVCS alpha-numeric from NVCS (NatureServe): Association Code (CEGL######), Alliance Code (A.####) or project specific NPS code (NPS.LIBI#) for non-natural types (Manier per Chris Lea recs.)	Text 255
CLASS	Class from NVCS hierarchy	Text 255
SUBCLASS	Subclass from NVCS hierarchy	Text 255
GROUP	Group from NVCS hierarchy	Text 255
SUBGROUP	Subgroup from NVCS hierarchy	Text 255
FORMATION	Formation from NVCS hierarchy	Text 255
ALLIANCE	Alliance associated with the final map name code	Text 255
USFWS_WETLAND_SYSTEM	Wetland type from USFWS	Text 255
NS_ECOLOGICAL_SYSTEM_1	NVCS/NatureServe Ecological System	Text 255
NS_ECOLOGICAL_SYSTEM_2	NVCS/NatureServe Ecological System	Text 255
NS_ECOLOGICAL_SYSTEM_3	NVCS/NatureServe Ecological System	Text 255
NS_ECOLOGICAL_SYSTEM_4	NVCS/NatureServe Ecological System	Text 255
NS_ECO_SYSTEM_1_CODE	Code associated with NVCS/NatureServe Ecological System 1	Text 255
NS_ECO_SYSTEM_2_CODE	Code associated with NVCS/NatureServe Ecological System 2	Text 255
NS_ECO_SYSTEM_3_CODE	Code associated with NVCS/NatureServe Ecological System 3	Text 255
NS_ECO_SYSTEM_4_CODE	Code associated with NVCS/NatureServe Ecological System 4	Text 255

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