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A Vegetation Management Plan for Fort Union Trading Post National Historic Site

Final Report for Interagency Agreement Number F1549100005 (April 2012)

Natural Resource Report NPS/FOUS/NRR—2012/502

ON THE COVER
Field 7 at Fort Union Trading Post National Historic Site
Photograph by: Amy Symstad

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Executive Summary

Fort Union Trading Post National Historic Site (FOUS) was established" ... to commemorate the significant role played by Fort Union as a fur trading post on the Upper Missouri River." Established in 1829, Fort Union was one of the largest and most important fur-trading posts in the upper Missouri River region. Because it was a frontier post, the fort's setting in the open, unsettled landscape of the northern Great Plains was a key part of its character. Consequently, the landscape and viewshed from the fort was identified as one of the fundamental resources for FOUS, and the re-creation and maintenance of this landscape's visual impact are driving factors in determining how vegetation is managed at FOUS.

Shaped by a continental climate, fire, grazing, and human activities, the vegetation at Fort Union during the fort's active period was characteristic of the northern Great Plains at the time. In the Missouri River floodplain, the vegetation was a dynamic mix of sparsely vegetated sandbars, backwater sloughs, shrublands of various kinds, and hardwood woodland or forest of various canopy densities. Immediately adjacent to the fort, heavy use by humans and their domestic livestock likely resulted in a prairie characterized by native, grazing- and disturbance-tolerant grasses and forbs of relatively short stature, but away from the fort, rolling hills and valleys would have hosted a mixture of grasses and forbs of various heights, as well as a few shrubs and trees in the moist valley bottoms. Since the fort's abandonment in 1867, river control has reduced the dynamic nature of the vegetation in the floodplain somewhat; fire suppression and domestic grazing have likely altered the composition of the native vegetation remaining in the rolling hills; and row-crop agriculture on the higher terraces near the Missouri River eliminated the native vegetation that originally grew there. Throughout the area, exotic grasses have permeated the vegetation, becoming dominant particularly in the low-lying and flatter areas.

After reconstruction of Fort Union buildings was complete in 1991, park management turned its attention toward reestablishing the historic scene of the mid-1800s. Over two decades of moderately intense prairie restoration efforts and other vegetation management activities guided by a consistent, broad goal of reconstructing the mid-1800's scene, but lacking specific objectives or desired conditions, have partially achieved that goal. The prairie plantings differ strongly from native prairie in that they have, on average, only 25-38% of the number of native species as native prairie in the Bodmer Overlook Unit and exotic species comprise 17% of the total cover, compared to <1% in the native prairie. In addition, stark differences in the composition of individual prairie plantings make boundaries between the planted fields clearly visible.

Future vegetation management at FOUS will continue to work toward the overall goal of maintaining or restoring the landscape of the mid 1800's, but newly stated, specific desired conditions for each of four vegetation management areas will focus management activities. These desired conditions were selected by FOUS staff to emulate the structure (height and growth form composition) of the vegetation that occurred during the fort's active period and minimize noxious weeds and invasive species such as smooth brome and crested wheatgrass, but not to achieve the actual composition of species that probably occurred during the historical period. Remaining native prairie in the Bodmer Overlook Unit will be managed to maintain its native integrity, however. Summaries of the selected desired conditions are as follows:

- **Upland terraces surrounding the fort:** Grasses and sedges comprise the vast majority of the cover, with shrubs being sparse. Noxious weed cover is minimal, and other invasive species comprise ≤10% of total cover. The majority of the vegetation is short (<10 cm or 4 inches). Boundaries between planted fields are not visible.
- **Bodmer Overlook unit:** Grasses and sedges comprise the vast majority of cover in all areas, with shrubs being more abundant in lower areas where a few hardwood trees may also be present. On hill tops and upper slopes, native species comprise at least 80% of total cover, but composition is not specified for lower slopes and valleys. Vegetation height is typical of an ungrazed or lightly grazed mixed-grass prairie, generally 6-24 inches (15-60 cm), but some areas have grasses up to 60 inches (150 cm) tall.
- **Riparian floodplain north of the Missouri River:** Vegetation is a mix of shrubland, woodland, forest, and herbaceous vegetation, the last dominated by grasses and grass-like species, all of which are tolerant of spring flooding or a water table at or near the soil surface. Tree cover near the fort is sparse or short enough that views from the fort to the water's edge are unobstructed. Federal-, state- and county-listed noxious weeds are minimal.
- **Terraces south of the Missouri River:** Dense cover of native shrubs and trees blocks the view of agriculture and other development south of the park boundary and resembles vegetation that may have been present during the active period of the fort. Herbaceous understory may be sparse. Federal-, state- and county-listed noxious weeds are minimal.

A variety of vegetation management tools will be used in the future at FOUS. Some, like mechanical and chemical control of target exotic plant species and seeding native species, have been used extensively at FOUS in the past. Others, like planting plugs of native species, transplanting sod, frequent mowing, and more heterogeneous fire applications, are options that may prove fruitful where previously used tools have not.

Key components for achieving successful vegetation management in the future are:

1. Educating staff, volunteers, and visitors on the goals of vegetation management at FOUS.
2. Identifying exotic plants that meet action thresholds and prioritizing treatment efforts of these species.
3. Training staff and volunteers to recognize and report priority exotic plant species, as well as to follow procedures that prevent disruptions to vegetation and the establishment or spread of exotic species.
4. For planting projects, writing and following a project plan that includes specific objectives, reasoning for species selection, cost-benefit analysis of potential methods, preparation of the planting site, optimal timing for planting, means for watering, and follow-up monitoring and weed control.
5. Using an adaptive management approach in situations where there is substantial uncertainty about the outcome of specific management actions.
6. Monitoring, at least qualitatively, the effects of specific management actions.
7. Establishing and following a formal but easily completed record-keeping system for vegetation management activities and monitoring results.
8. Evaluating the progress towards achieving desired conditions on a regular schedule (e.g., every five years).

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Introduction

Fort Union Trading Post National Historic Site (FOUS) was established" ... to commemorate the significant role played by Fort Union as a fur trading post on the Upper Missouri River." Established in 1829 on a terrace near the confluence of the Missouri and Yellowstone Rivers, Fort Union was one of the largest and most important fur-trading posts in the upper Missouri River region from its establishment until 1867. During its active period, it was an important and busy hub of financial, cultural, and information trade between European and Native American cultures. Because it was a frontier post, the fort's setting in the open, unsettled landscape of the northern Great Plains was a key part of its character. Consequently, the landscape and viewshed from the fort were identified as fundamental resources for FOUS[a], and the re-creation and maintenance of this landscape's visual impact are driving factors in determining how vegetation is managed at FOUS. However, vegetation communities were also identified as other important park values.

Re-creating the landscape has been necessary in portions of the historic site because the fort's location on a high, level terrace on the north side of the Missouri River was ideal for agriculture. Consequently, essentially all of the land on this terrace along the Missouri and Yellowstone Rivers was converted to cropland in the early 1900's. When the National Park Service (NPS) established FOUS in 1966, cropland within the park's boundaries was planted into perennial grasses not native to the ecosystem. After completing reconstruction of fort buildings in 1991, park management turned attention toward reestablishing the historic scene of the mid-1800s. To do this, FOUS staff began converting the former agricultural land in the 140 acres immediately adjacent to the reconstructed fort to native plant species in the early 1990's.

The landscape cited as a fundamental resource for FOUS also includes areas outside of this prairie reconstruction zone. The Bodmer Overlook Unit is a 30-acre parcel of rolling hills from which Karl Bodmer, an artist that travelled through the area in 1833, viewed the fort and its surroundings and captured them in a painting. This parcel not only provides visitors to the historic site the opportunity to have the same viewpoint as in the painting, but it also protects the park's only remnant of relatively intact native prairie and some of the only ungrazed prairie in the larger vicintiy. The Missouri River floodplain is an important part of the viewshed because much of the traffic to and from the fort was by river, but it also provides habitat for wildlife quite different from the majority of the landscape. Finally, a sliver of property on the south bank of the Missouri River is essential for protecting the viewshed of the fort across the river.

FOUS planning activities have identified the landscape and viewshed as fundamental park values and vegetation communities as other important park values, and a draft Resource Stewardship Strategy[a] identified interim desired conditions for these values (Table 1). However, these activities and documents do not concretely identify specific vegetation management targets nor the methods by which to attain them. That is the goal of this document. Specifically, this

[a]Fundamental and Other Important Resources and Values were identified in a 2003 meeting of park and regional staff . Although they have not been formalized in a Foundation for Planning and Management document, they do guide park management until that formal process is completed. For more details, see the Draft Fort Union Trading Post National Historic Site Resource Stewardship Strategy (2010).

Vegetation Management Plan will (1) qualitatively and quantitatively describe the historic and current vegetation of FOUS; (2) identify concrete, quantitative desired conditions for logical management units of the park based on historic and current vegetation; and (3) discuss vegetation management issues at FOUS and reasonable practices to address these issues.

Table 1. Fundamental and other important park values identified in the Fort Union Trading Post National Historic Site draft Resource Stewardship Strategy.

Resource or Value	Level	Description	Desired Conditions
Missouri River Watershed and Associated Habitats	Fundamental	The Missouri River is appreciated as a living entity, through its waters and habitats, as reflected in its on-going relationships to American Indian people.	To fulfill this resource value, the river would possess and maintain its natural hydrological and biological dynamic conditions in close proximity to the Park.
Landscape / View Shed	Fundamental	The landscape and viewshed are the scenes and ecosystems that support the cultural features, ethnographic resources, and environment depicted and documented by various historic records.	• Views from the Post retain the primary characteristics of openness and remoteness. The landscape will look much as it did in the 1833 Bodmer painting. • Visitors have the opportunity to experience the Post as a part of a landscape with much of the historical character maintained, and to understand the dynamic interactions between the post, the post grounds, and the natural environment. • There is a visual and physical connection to the river and the confluence.
Vegetation Communities	Other Important	A mixed-grass prairie	• Vegetation community composition, form and function supporting native vertebrate species, are maintained through ecological and cultural processes. The reconstructed prairie, from the park boundary in toward the palisades, represents a period from just prior to Post construction to midway through occupation. • A healthy stand of large cottonwoods grows on the south side of the river.

Vegetation of Fort Union Trading Post National Historic Site

Fort Union Trading Post National Historic Site lies in the Northwestern Great Plains ecoregion of North America, a semiarid, rolling plain of shale and sandstone punctuated by occasional buttes (Omernik 2007). Vegetation of this region is characterized as northern mixed prairie, where "mixed" refers to a mixture of warm- and cool-season grasses as well as to grasses of a variety of heights (Lauenroth et al. 1999). Forests and woodlands occur in this region only along rivers and streams and in some draws, where a small variety of deciduous tree and shrub species grow in a variety of mixes and densities.

Factors that Shaped the Native Vegetation

Before Europeans came to North America, the four strongest forces shaping vegetation in northern mixed prairie were climate, fire, grazing, and humans. Climate remains one of these. At FOUS, maximum summer highs are near 100º F (38º C), minimum winter lows are near -30º F (-34º C; Figure 1a), and the freeze-free season, during which the majority of plant growth occurs, is 120-140 days long. Precipitation falls primarily in the form of rain during the growing season, with 79% of average annual precipitation in April-September, and 50% of average annual precipitation in May-July (Figure 1b). However, both temperature and rainfall vary considerably from year to year. Consequently, plants in this area must tolerate relatively short growing seasons, but also periods of substantial drought. These drought periods are certainly one of the factors that limited trees and most shrubs to occur primarily along water courses.

Fire probably also limited the extent of trees and shrubs, as it was a common occurrence and often kills the hardwood trees native to the northern Great Plains, particularly when those trees are small (Anderson 2006). How frequently fire occurred in a given location in the northern Great Plains prior to historical records will probably never be known, but evidence from the prairie-forest ecotone in the southern Black Hills of South Dakota suggest that a given prairie site burned at least every 10-12 years on average (Brown and Sieg 1999). Fires were caused by lightning and by Native Americans, who deliberately set them to affect the movement of bison, their major source of food, shelter, clothing, and other materials. Written accounts of fires in the northern Great Plains by early European visitors to the area are numerous, suggesting that visitors to Fort Union Trading Post in its active period would have occasionally seen fire or burned areas in the prairie surrounding the fort. These journal entries also suggest that lightning-caused fires occurred during the driest part of the season (July and August) but were less frequent than human-set fires, which could occur any time of year but were most common in spring (March-May) and fall (August-October) (Higgins 1986).

The effect of a single fire on the productivity of northern mixed prairie vegetation as a whole tends to be negative or neutral, but negative effects seem to be generally short-lived (Scheintaub et al. 2009; Wienk et al. 2009). The short-term responses of individual plant species or functional groups (e.g., forbs, perennial grasses) in a northern mixed prairie to a single fire vary widely, but sufficient research to tease out the causes of this variation (topographical position, weather conditions before or after a fire, soil, etc.) does not yet exist (Scheintaub et al. 2009). The long-term exclusion of fire from a mixed-grass prairie could have detrimental effects, however, and will be discussed later in this document (see "Management Tools" below). Little information on the frequency of fire in the deciduous woodlands that occurred along rivers and streams is available, but the abundance of tree and shrub species vulnerable to fire in these

woodlands shows that it was not a common occasion. When it did occur, either when conditions were dry enough and fuels available to carry fire from the prairie into the woodland, or when Native American's campfires escaped, historic records suggest that the effects were substantial (Higgins 1986).

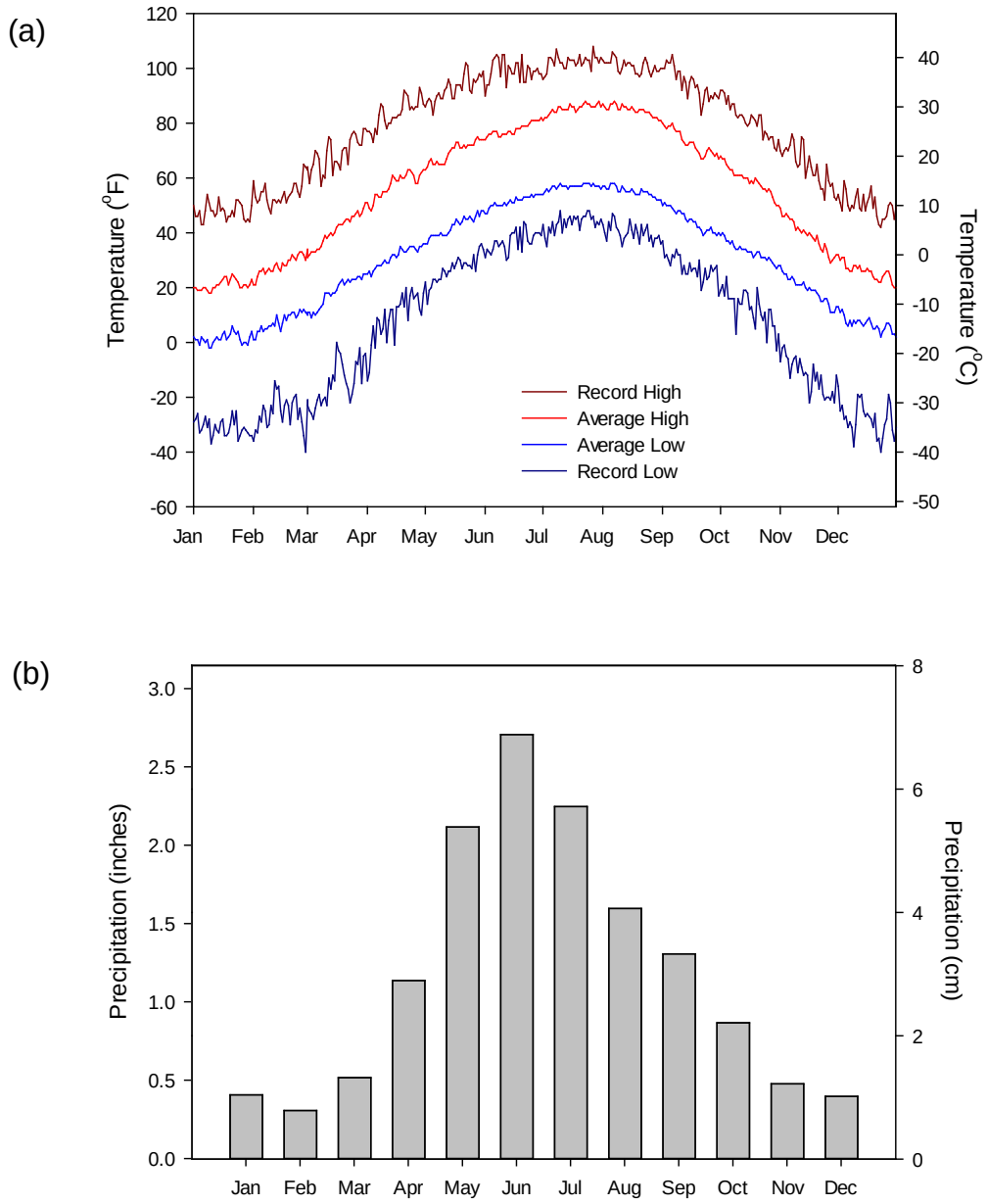

Figure 1. Climate of Fort Union Trading Post National Historic Site, 1971-2000.

(a) Daily average and record high and low temperatures. **(b)** Average monthly precipitation. Data are from the Williston Experimental Farm, 16 miles (26 km) NE of FOUS (High Plains Regional Climate Center 2011).

Grazing by large mammals, primarily bison and elk, but also pronghorn, big horn sheep, and, in wooded areas, white-tail and mule deer, probably had a larger effect on the northern mixed

prairie and the riparian woodlands than did fire, since the number of grazers on the prairie was immense and because grazers do not target all plant species equally. Journal entries from the northern Great Plains portion of the Lewis and Clark Expedition (1804-1805) describe an abundance of these large animals as well as widespread areas of good soil supporting only short grasses, fragrant herbs, and prickly pear cactus, conditions today associated with heavy grazing (Kirby 2010). The short grasses were most likely blue grama (*Bouteloua gracilis*) or buffalograss (*B. dactyloides*), species that tend to form dense sods when they are not shaded by the taller, mid-height grass species such as green needlegrass (*Nassella viridula*) and western wheatgrass (*Pascopyrum smithii*) that decrease under pressure of heavy grazing (Johnson and Larson 1999). The fragrant herbs were most likely sage (*Artemisia*) species, including fringed sage (*A. frigida*). This subshrub, along with prickly pear cactus (*Opuntia*) species, are known to increase under heavy grazing because most grazers tend to avoid eating them (Johnson and Larson 1999). Another indication of high grazing pressure in the northern Great Plains comes from Thomas Nuttall, a botanist who collected along the upper Missouri River in 1811. He noted that scarlet globemallow (*Sphaeralcea coccinea*), another species that increases with heavy grazing (Johnson and Larson 1999), was "often extending over the plains in such quantities as to communicate a brilliant redness to thousands of acres" (p. 82, Nuttall 1918).

It should be noted that black-tailed prairie dog colonies also significantly impacted vegetation of the northern Great Plains. These colonies, which could be extensive in size, experienced the most intense grazing pressure within the region, since the prairie dogs continuously clipped the vegetation short for safety and sustenance, and because bison may have preferred these areas for their nutrition and escape from insect pests (Detling 1998).

Finally, long before Europeans first came to North America, humans were influencing the vegetation of the northern Great Plains. The location of Fort Union was chosen because it lay on the boundary of many tribes' territories (Toupal and Hollenback 2009). Because most of these tribes were nomadic, depending on large game for a substantial portion of their diet, one of their primary impacts on the vegetation of the region would have been through their effects on fire, the animals they hunted, and the interaction between these two factors. Since recently burned areas are favored by bison for grazing (Biondini et al. 1999; Fuhlendorf and Engle 2004), the Assiniboine and other Plains tribes may have burned areas near winter encampments to enhance their winter hunting prospects (Higgins 1986). Regardless of exactly what the motives for fire use were, it is important to realize that fire and grazing were not separate entities in the evolution and maintenance of the northern mixed prairie until the large herds of bison were eliminated in the mid-1800s. Other impacts of Native Americans on vegetation include harvest of select species used for food, shelter (poles for tipis), tools, medicine, or ceremonies, and the collection of firewood. Archeological evidence from the FOUS area shows that the confluence of the Yellowstone and Missouri Rivers was regularly used as a gathering place, travel route, hunting ground, and sacred place long before the establishment of Fort Union (Toupal and Hollenback 2009). Consequently, these uses could have had substantial effects on the vegetation compared to less frequently used areas.

Historic Vegetation, 1800 - 1867

Just how widespread the grazing lawns described by Lewis and Clark were, how common they were compared to less heavily grazed prairie, and whether this was the "normal" state of the vegetation when Fort Union was established and active is impossible to tell from the journals written by Lewis, Clark, and many others who traveled through the area before widespread changes due to Euro-American settlement occurred. These journals also do not fully describe the diversity of species existing on the landscape, nor the relative abundance of these species – information that would be helpful for reconstructing the vegetation that traders and other visitors to Fort Union saw throughout its history. However, although the picture is not complete, it is far from blank. Journals, artwork, and biological collections of these visitors, as well as modern descriptions of remnants of native vegetation together provide sufficient information to guide the future management of the national historic site's vegetation.

Historic Information

The journals and artwork provide the general feel of the landscape described above – rolling, grass-covered plains intersected by woodlands along rivers – and Karl Bodmer's painting provides a view specific to the FOUS site (Figure 2). In this painting, a forest is shown south of the Missouri River across from the fort. A map of the confluence of the Missouri and Yellowstone Rivers from 1894 corroborates this depiction (p. 17, National Park Service 2001). Another depiction, from 1834, shows the fort being very close to the Missouri River, with only open grass and a steep river bank between the water and the fort's front door (p. 35, National Park Service 2001). These documents, along with journal entries by Meriwether Lewis and William Clark from 1805 describing extensive forest at the Yellowstone-Missouri confluence (Weist et al. 1980) seem to make it safe to assume that the south side of the Missouri River near the fort was forested.

Figure 2. Fort Union on the Missouri, by Karl Bodmer.

However, the paintings cannot be relied upon as information regarding vegetation composition, as the artists were not trained botanists and they "frequently … took liberties when depicting the natural environment" (pp. ii-iii, Weist et al. 1980). Some journalists were highly competent observers of their natural surroundings, and a report for FOUS by Weist and colleagues (1980) provides a thorough review and summary of excerpts from journals or collections from travels of Lewis and Clark (1804-1805), Nuttall and Bradbury (1811), Catlin (1832), Maximillian (1833), Audubon and Harris (1843), Suckley and Cooper (1853), and Warren and Hayden (1856) relevant to the period when Fort Union Trading Post was active. A few important selections from this report include:

- From the Lewis and Clark expedition, when they camped at the mouth of the Yellowstone River in April 1805 and on their return trip in 1806:
    - Extensive woodland occurred for many miles up the Yellowstone River.
    - The trees were principally cottonwood (*Populus deltoides* ssp. *molinifera*) with some small elm (*Ulmus americana*), green ash (*Fraxinus pennsylvanica*), and boxelder (*Acer negundo*) along the lowest river terrace.
    - Along the river and on sandbars, the undergrowth was mostly small-leafed willow (*Salix* species), rose (*Rosa* species), serviceberry (*Amelanchier* species), and buffaloberry (*Shepherdia argentea*).
    - On the next highest terrace, these species of underbrush were joined by broad-leafed willow (other *Salix* species), gooseberry and currants (*Ribes* species), chokecherry (*Prunus virginiana*), and honeysuckle (*Lonicera* species).
    - Members of the party dug up a large number of plants that goes by various names, including Indian breadroot (*Pediomelum esculentum*).
- John Bradbury also noted the Indian breadroot because it was used not only by Native Americans, but by Euro-Americans, when hunting was not successful.
- George Catlin also noted the abundance of berries along the Missouri River, adding plums (*Prunus americana*) to the list of species noted by Lewis and Clark.

General explorers seem to have noted the presence of species they could eat or use for timber, whereas naturalists attempted to document everything that they found. Of the reports from these kinds of travellers, the plant collections made by F.V. Hayden and documented in a report by Warren (Warren 1875) are the most complete and relevant for the vegetation of FOUS, since other botanical collectors listed in the Weist et al. report did not get as far up the Missouri River as Fort Union Trading Post. A complete list of plant species documented for the upper Missouri and lower Yellowstone River areas by Hayden in the Warren report, along with the current scientific name for these species, is provided in Appendix A.

For areas heavily impacted by land use after Fort Union's active period, these historical descriptions serve as an important source of information for determining what the vegetation looked like during this time. The information above depicts the lowland, floodplain areas as being covered with a hardwood forest of cottonwood, ash, elm, and boxelder trees with a lush understory of willow, rose, and various berry-bearing shrubs. These historical depictions are incomplete, however, in that they often focus on certain species (such as the edible ones) or do not provide much information as to the relative abundance of various species or the communities that the species form (i.e., which species tend to occur together). Modern descriptions of remnant native vegetation help fill these gaps, and two sources provide these modern

descriptions for FOUS: the National Vegetation Classification System and ecological site descriptions.

National Vegetation Classification System Descriptions for Floodplain Vegetation

The following brief description of the National Vegetation Classification System (NVCS) in this paragraph summarizes the description of the NVCS given in the vegetation mapping report for FOUS (Salas and Pucherelli 2003). The NVCS was developed by ecologists and conservationists in order to identify and protect representative examples of ecological communities and therefore the biotic interactions, ecological processes, and species they contain. Ecological communities are distinguished and described therough a standardized process of field data collection and data analysis, proposed community types are approved through a peer review process. The NVCS is based primarily on vegetation, rather than soils, landforms, or other abiotic features. Although the NVCS focuses on existing vegetation rather than potential natural vegetation, it has emphasized natural or near-natural vegetation – vegetation that appears to be unmodified or only marginally impacted by human activities. It is a hierarchical system based on the life form of the dominant plant species, followed by the taxonomic composition of those dominant species. The "association" is the lowest level of the hierarchy and is the basic unit for vegetation classification. The description of an association is derived via analyses of plot data collected in vegetation units.

NVCS association descriptions are particularly useful for constructing more detailed descriptions of the vegetation that probably occurred in the riparian floodplain areas (boundaries of this and other management areas are shown in Figure 3) near Fort Union during its active period because the dominant species and general structure (riparian forest/woodland with various successional stages) are known from historical documents and current remnants. By summarizing the detailed descriptions of the relevant vegetation associations (i.e., riparian floodplain in western North Dakota and eastern Montana), an image of the vegetation seen by traders and other travellers visiting Fort Union during its heyday can be deduced. The associations on which the following descriptions are based are listed in Appendix B.

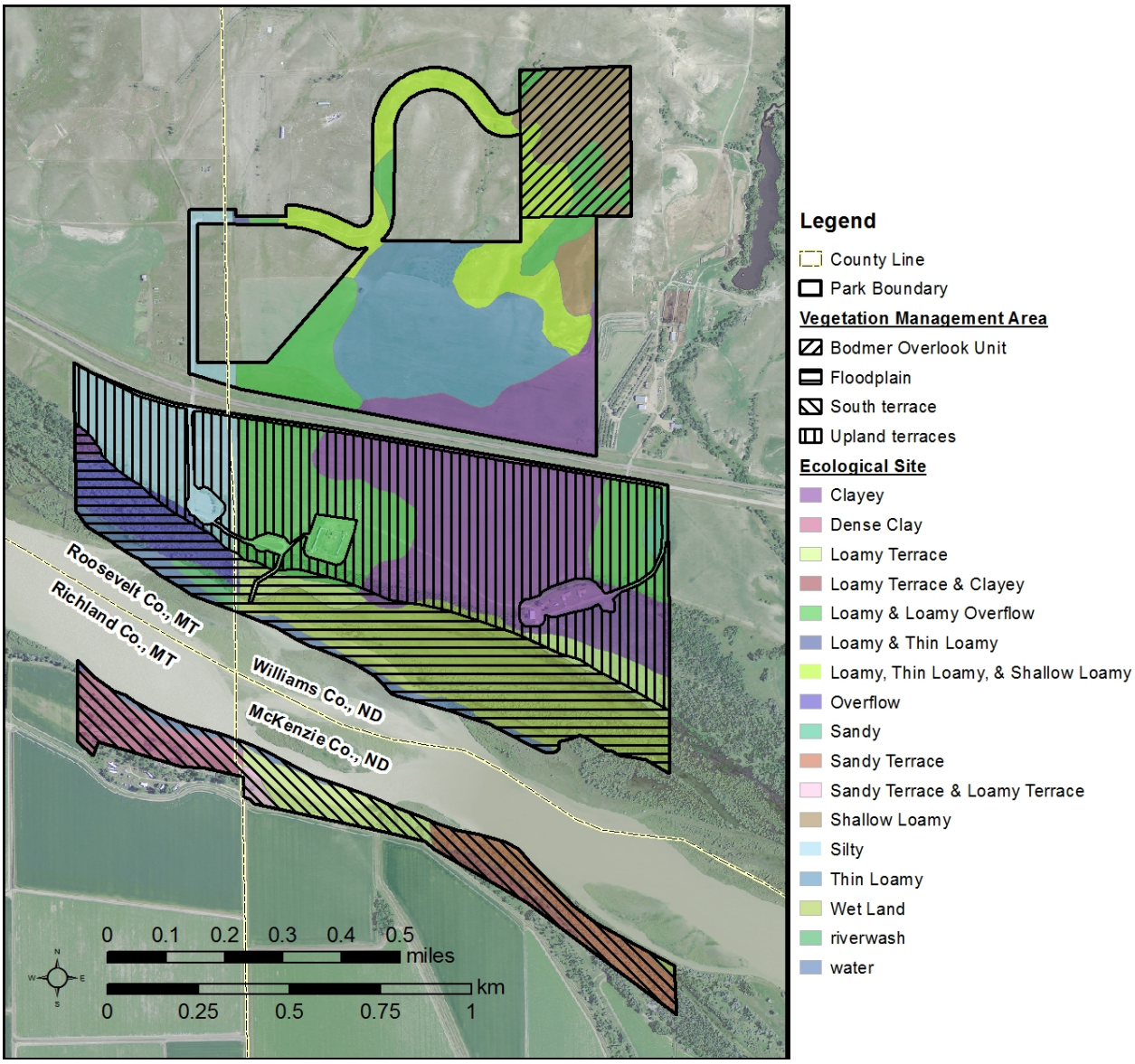

Figure 3. Vegetation management areas and ecological sites at Fort Union Trading Post National Historic Site.

An ecological site map unit with more than one ecological site indicates that the soil map unit on which it is based contains multiple soil types, and these soil types belong to different ecological sites.

Historic Vegetation of Riparian Floodplain Areas on Both Sides of the Missouri River

The vegetation is a dynamic mix of sparsely vegetated sandbars, backwater sloughs with floating or submerged and emergent herbaceous species, shrublands of various kinds, and hardwood woodland or forest of various canopy densities. The amount of area in each of these states varies through time as floods of different intensities shift the river's course, scour previously vegetated areas, and deposit sand, silt, clay, and cobbles in other areas. Similarly, the state of a given location changes through time as succession proceeds or is reset after a flood.

Backwater sloughs occur in areas that have standing or slow-moving water all or nearly all year. Duckweed (*Lemna*) and perhaps other floating species occur in deeper water; in shallower areas (up to 3 ft/1 m), submerged or emergent wetland species occur in varying densities. Zones of dense, tall (3-6 ft/1-2 m) cattail (*Typha*) and bulrush (*Schoenoplectus*) occur, as well as areas with shorter sedge (*Carex*), rush (*Juncus*), and forb species that tolerate seasonal to year-round flooding. The earliest stage of the successional sequence that occurs on higher ground, which is only seasonally flooded, is sparse sandbar vegetation; its composition varies widely, with coyote willow (*Salix exigua*), knotweed (*Polygonum*), horsetail (*Equisetum*), and grass species possibly present. The next successional stage is vegetation dominated by dense stands of coyote willow up to 13 ft (4 m) tall and interspersed with seedlings and small saplings of cottonwood and peachleaf willow (*Salix amygdaloides*). Other shrubs such as rose (*Rosa woodsii*) and skunkbrush sumac (*Rhus trilobata*) may also occur but are sparse; herbaceous vegetation is relatively sparse in these stands. Mid-successional stands are dominated by relatively young stands of cottonwood with moderately open canopies and thickets of coyote willow underneath; herbaceous cover is abundant, with bulrushes, rushes, and sedges dominating. Thickets or narrow bands of buffaloberry mixed with other shrubs such as chokecherry, currants, skunkbrush sumac, rose, and western snowberry (*Symphoricarpos occidentalis*) and some herbaceous cover occur in some areas. Older cottonwood stands of varying canopy density have either a shrubby [western snowberry, rose, red-osier dogwood (*Cornus sericea*), juniper (*Juniperus scopulorum* or *communis*)] or herbaceous [western wheatgrass or other grasses] understory. The oldest, highest, and driest areas in the riparian zone support green ash forest (>50% canopy cover) or woodland (25-50% cover), which sometimes contains American elm or boxelder and often has a chokecherry or western snowberry understory. The herb layer in these areas include grasses such as Canada wildrye (*Elymus canadensis*) and marsh muhly (*Muhlenbergia racemosa*), vines such Virginia creeper (*Parthenocissus quinquefolia*) and poison ivy (*Toxicodendron rydbergii*), and forest herbs such as starry false lily-of-the-valley (*Maianthemum stellatum*) and purple meadow-rue (*Thalictrum dasycarpum*).

Ecological Site Descriptions for Upland Areas

The severe impact of agriculture on most FOUS' uplands since Fort Union's demise precludes using NVCS associations to deduce the vegetational composition of these areas during the fort's active period. Instead, ecological site descriptions compiled by the U.S. Department of Agriculture's Natural Resources Conservation Service (NRCS) provide critical information. An ecological site is "a distinctive kind of land with specific physical characteristics that differs from other kinds of land in its ability to produce a distinctive kind and amount of vegetation" (NRCS 1997b). Ecological sites are distinguished by soil, climate, and geographical location, not the vegetation existing at a site. Therefore, the probable pre-agriculture vegetation of an area can be derived from its physical and geographical characteristics. The distinctive kind and amount of vegetation expected on a given ecological site is determined through quantitative sampling of the vegetation in that soil-climate-geography combination under a variety of land management and growing season (e.g., drought, normal, wet) circumstances, as well as by observations and field knowledge of rangeland professionals. Because ecological site descriptions are used most frequently in the context of managing domestic grazing (cattle and sheep), the management circumstances usually relate to grazing intensity and duration, although fire is also considered. For example, the ecological site description for loamy soil in rangelands of the Rolling Soft Shale Plain major land resource area (ecological site R054XY031ND) states that continuous seasonal grazing or heavy continuous grazing will shift vegetation from its

historical climax of a plant community dominated by western wheatgrass and green needlegrass to a plant community dominated by blue grama and western wheatgrass. The description also states that, after an extended period of heavy continuous grazing, the plant community could further shift to one dominated by clubmoss (*Selaginella densa*). On the other hand, a long period of no grazing or fire is expected to cause vegetation to shift from the historical climax to a state of excessive litter, in which exotic species such as Kentucky bluegrass (*Poa pratensis*) or smooth brome (*Bromus inermis*) become more abundant (NRCS 2003). All aspects of an ecological site description, including the vegetation composition in each management circumstance and the actions that cause transitions between ecological states, are peer reviewed and/or field tested by various private, state, and federal agency specialists.

The area encompassed by FOUS' boundaries includes 15 ecological sites (Figure 3). The official NRCS descriptions of these ecological sites were used to compile descriptions of probable vegetation in the uplands existing at FOUS during the fort's active period following a process detailed in Appendix B. The major assumptions made during this process were as follows:

1. The upland terrace upon which the fort stood experienced substantial human traffic year-round, but particularly during the spring trading season. Consequently, disturbance-tolerant plant species were more abundant on this terrace, especially near the fort, than in the prairies of the adjacent hills.
2. Livestock (cattle, horses) grazed regularly in the vicinity of the fort, particularly on the terraces between the river and the hills.[b] Therefore, the vegetation on the terraces was characterized by grazing-tolerant species and was unlikely to be in "historical climax plant community" condition.
3. Although Catlin did note the presence of prairie dogs in the vicinity of Fort Union (Weist et al. 1980), no reports mention them as part of everyday fort life. Consequently the vegetation was not typical of a prairie dog colony.
4. Vegetation in the hills near the fort (i.e., where the Bodmer Overlook Unit is) was not heavily grazed but did experience some grazing.
5. Except in the cultivated garden area, plant species not native to North America were rare but did occur, particularly near the fort.

The following descriptions of the vegetation in various portions of FOUS during Fort Union's active period are based on these assumptions and ecological site descriptions for the relevant soil types.

Historic Vegetation of Upland Terraces Surrounding the Fort

Native, grazing-tolerant and disturbance-tolerant (pioneer, weedy) species dominate, with grasses comprising the majority of the vegetation. Blue grama, western wheatgrass, prairie junegrass (*Koeleria macrantha*) and needle-and-thread (*Hesperostipa comata*) are the dominant grasses. The forb component, comprised of species such as cudweed sagewort (*Artemisia ludoviciana*), curlycup gumweed (*Grindelia squarrosa*), heath aster (*Symphyotrichum ericoides*),

[b] Salas and Pucherelli (2003) cite Weber (1859) and Catlin (1891) as reporting extensive use of the area by both horses and cattle.

fetid marigold (*Dyssodia papposa*), Canadian horseweed (*Conyza canadensis*) and scarlet globemallow, comprises 15-20% of the plant cover. Prickly pear cactus and fringed sagewort are common. The vegetation is generally short (< 4 in/10 cm tall), but it is punctuated with occasional taller forbs and shrubs up to 24 in (60 cm) high. Bare ground comprises 5-15% of the soil surface area.

Historic Vegetation of Valley Bottoms and Lower Slopes in the Hills

Native grasses comprise the large majority (85-95%) of the vegetation, with big bluestem (*Andropogon gerardii*), green needlegrass, needle-and-thread, and western wheatgrass being abundant species. The forb component is diverse, with no single species dominating, but together they comprise 5-10% of the community. Species such as wild onion (*Allium* species), western yarrow (*Achillea millefolium*), heath aster, goldenrods (*Solidago* species), purple prairie clover (*Dalea purpurea*), cudweed sagewort, and American vetch (*Vicia americana*) occur. Shrubs such as chokecherry, currants, leadplant (*Amorpha canescens*), and western snowberry occur in patches, perhaps in association with an occasional American elm or green ash tree. Herbaceous vegetation is 1-2 ft (30-60 cm) tall, with some areas of taller grasses reaching 4.5 ft (1.4 m) or more. There is little bare ground.

Historic Vegetation of Ridgetops and Upper Slopes in the Hills

Vegetation is not as dense as in the valley bottoms and lower slopes because of the poorer, rockier soils. Native grasses comprise 80-90% of the cover, with little bluestem (*Schizachyrium scoparium*), needle-and-thread, plains muhly (*Muhlenbergia cuspidata*), and sideoats grama (*Bouteloua curtipendula*) being the most common. The forb component is diverse and comprises 5-10% of the vegetation. Prairie clovers (*Dalea* species), purple coneflower (*Echinacea angustifolia*), and gayfeathers (*Liatris* species) are common, and they are accompanied by scurfpeas (*Psoralidium* and *Pediomelum* species), American pasqeflower (*Pulsatilla patens*), western yarrow, and many others. Vegetation is generally 0.5-2 ft (15-60 cm) tall, with occasional taller patches. Bare ground is not uncommon (up to 10% of the soil surface).

Caveats about These Descriptions

The descriptions of probable historic vegetation at FOUS in the two preceding sections are subject to five sources of uncertainty in addition to the assumptions mentioned above.

1. How closely current vegetation in "unimpaired" areas resembles historic vegetation: Landscape fragmentation; decoupling of the fire-grazing cycle; changes in the identity, abundance, and activities of herbivores, pollinators, and pathogens; colonization of species novel to the ecosystem; changes in atmospheric CO_2, nitrogen deposition, and climate; alteration of river flow and flooding patterns; and a variety of other changes since 1867 have had effects on vegetation used for compiling NVCS and ecological site descriptions, but the impacts of many of these changes are not fully understood.

2. Quality of the data used to derive NVCS association and ecological site descriptions: Unimpaired vegetation is not equally available for all vegetation associations or ecological sites. Although a substantial amount of native vegetation remains as rangeland in the hillier portions of western North Dakota and eastern Montana, most of the upland terraces along the Missouri and Yellowstone Rivers have been plowed, leaving only small parcels on which data for ecological site descriptions could be

collected. Similarly, the understory of most riparian forests and woodlands, as well as some herbaceous vegetation associations, have been invaded by aggressive grasses, making it difficult to know what the native composition was.

3. Quality of the soils data upon which ecological site assignments are made, and crossing state lines: Soil maps are not 100% ground-truthed, and therefore are not 100% accurate representations of the actual soil conditions at a site. In addition, soil maps are done at the county level, and contiguous areas are not necessarily mapped to the same soil type across counties or, especially, states. Similarly, ecological site descriptions are compiled at the state level. FOUS lies in four counties in two different states, and the Montana-North Dakota state line is clear in the ecological site map (Figure 3) because of differences in how areas were assigned to soil types. However, differences in the vegetation described for the ecological sites in these circumstances (i.e., changing at the state line) often are not substantial.

4. Inherent assumptions behind the NVCS and ecological site systems: The NVCS assumes that discrete vegetation associations exist, i.e., that ecological interactions and processes tend to produce the same composition of species in a given situation. Similarly, the ecological site system assumes that a given set of soil, climate, and management circumstances will produce a consistent association of plant species. These assumptions are not fully supported by the ecological literature (e.g., Stohlgren 2007). A different school of thought holds that species assemble individualistically, producing gradients and not consistent, discrete communities (Gleason 1926). This does not mean that the patterns described by the NVCS or ecological site system do not exist, just that they are not as clear-cut as they are presented.

5. Biases of the author: The descriptions are, of course, conclusions drawn by the author. They are based on the NVCS and Ecological Site Description information provided in Appendix B, but they also reflect the personal experience and biases of an individual. A different person could have reached different conclusions using the same or different evidence. For example, Willard (in Weist et al. 1980) provides lists of species for the "climax" vegetation for eight ecological units within FOUS.

Factors Affecting FOUS Vegetation, 1867-1966

Between the time of Fort Union's closing (1867) and acquisition of the property by the NPS in 1966, multiple factors caused significant changes in the vegetation, including those listed in caveat #1 above. The most severe was the conversion of prairie on the upland terraces into cultivated fields. This not only killed the prairie plant species, but it also undoubtedly changed soil structure (Bronick and Lai 2005), reduced soil organic matter content (Burke et al. 1995), and altered the composition of organisms that live in the soil (Drijber et al. 2000). Valley bottoms and lower slopes in the hills in which the Bodmer Overlook Unit lies were invaded by, or purposely planted to, exotic perennial grasses such as smooth brome and crested wheatgrass (*Agropyron cristatum*); a visible former plow line in these hills (Figure 4) suggests that this probably followed cultivation. All of the Bodmer Overlook Unit was grazed by domestic livestock. The completion of the Fort Peck Dam ~130 land miles (210 km) upstream of FOUS in 1940 and the Garrison Dam ~ 150 land miles (240 km) downstream of FOUS in 1953 somewhat

stabilized Missouri River flow, probably reducing the scouring action of the river, and therefore reducing both the creation of new sandbars and the resetting of vegetation succession on existing land in the floodplain.

Figure 4. Abrupt transition from crested wheatgrass (left) to native grasses (right) along probable plow line in the Bodmer Overlook Unit.

Vegetation Management since NPS Acquisition, 1966-2010

Management by the NPS since the establishment of the national historic site in 1966 has been more intense in some areas than in others. Part of this is due to land ownership and management control. Portions of FOUS are scenic easements only – owned by private landowners with certain restrictions on their use – and other portions are within park ownership but under the management jurisdiction of the state of Montana or North Dakota (Figure 5). Parcels south of the river have only been under park ownership, and therefore management control, since 1997 or later. Management also varies spatially because of the perceived need for that management. The upland terraces have received the most attention because of their cultivation history, whereas activities in the Bodmer Overlook Unit and the riparian floodplain have basically been limited to exotic plant treatment and/or a fire. Record-keeping regarding some of these activities has been incomplete, particularly in early years, but this section compiles what information is available into a single document so that future managers understand the history of a given parcel of land and the effects and effectiveness of past management practices.

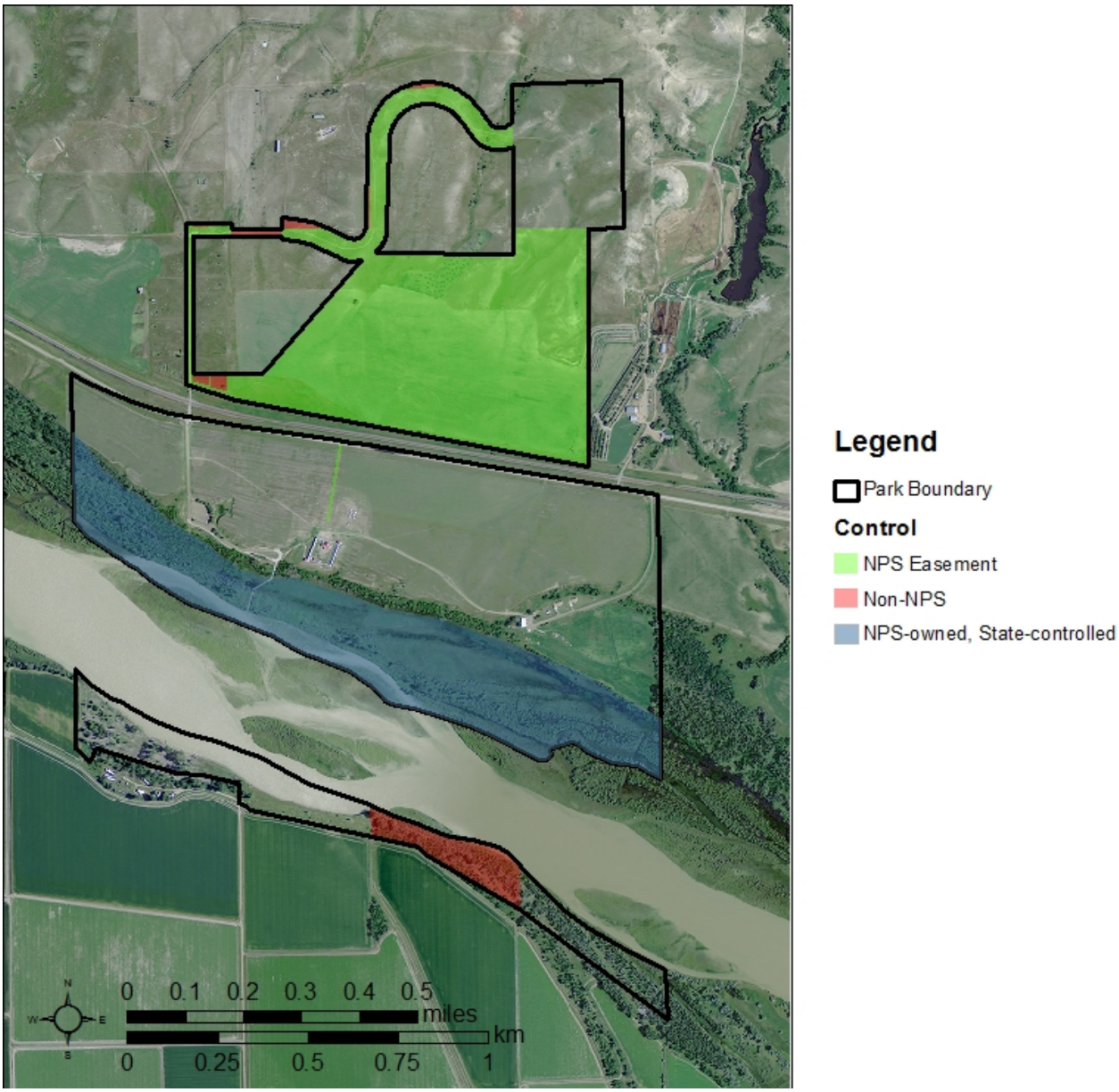

Figure 5. Ownership of property within FOUS boundary.

Easement property is not owned or managed by NPS but use is restricted to maintain the view shed. Non-NPS property is not currently owned, managed, or use restricted by FOUS. Uncolored areas within the boundary are owned and managed by NPS.

Riparian Floodplain

Although owned in fee-title by the NPS, land below the high water line at FOUS is controlled by the states of North Dakota and Montana. An agreement between NPS and North Dakota, which must be renewed every two years, allows NPS to do some management activities, such as exotic plant control, in the North Dakota portion of the riparian floodplain, but approval from the state is required for other actions. Thus, "the lower bench south of the fort" was mowed each year in a portion of the 1990's "to keep the willows in check" (O. Loomer, FOUS facilities manager until 1999, management records), and a prescribed fire in the North Dakota portion of the

riparian floodplain was conducted on October 17, 2005, with the goal of reducing tree cover to increase visibility of the river from the fort. In addition, some noxious weeds were mowed and/or treated with herbicide in the riparian floodplain in the 1990's (O. Loomer, management records), and a dense infestation of Canada thistle (*Cirsium arvense*) was treated with herbicide in 2007, with follow-up applications in 2008 and 2010 (Appendix C). There has been, and currently is, no corresponding agreement with the state of Montana. Consequently, with the exception of a tiny area of herbicide application to Canada thistle in one year, no vegetation management activities have been recorded for the Montana portion of the riparian floodplain.

Upland Terraces – North Side of River

When the land for the national historic site was acquired, land-owners were required to plant existing agricultural fields into perennial grass species. Although records of these plantings do not seem to exist, the result was exotic grasses, particularly smooth brome and crested wheatgrass. After the reconstruction of the fort was completed, the NPS turned its attention to re-creating the landscape to go with the historic fort. Thus, in 1986-87, preparation for planting seeds of native grasses began, and the first portion of the upland terrace was planted in 1991. Further plantings were accomplished using a variety of pre-planting treatments, species lists, and planting times, which are detailed for each field (Figure 6) in Table 2.

The greatest challenge that the NPS faces in these plantings and that is common to all prairie restoration efforts is weed control. The earliest plantings were done in fields prepared primarily by mechanical means – disking, sweeping – over a series of years, which would have prepared a seed bed that probably resembled the cultivated fields that existed just before the NPS acquired the property. These were planted with methods that work in these bare soil conditions – broadcast seeding followed by some means of mixing the seeds into the soil (chains dragged behind the seeder) or pack them down into the soil (cultipacking). The severe disturbance of the soil involved with these preparation methods would have made survival of the existing exotic perennial grasses low, but it also provided ideal conditions for the establishment and growth of short-lived, opportunistic weeds such as kochia (*Kochia scoparia*), and perhaps for the seeds of the exotic perennial grasses to germinate and grow. Later plantings were done in fields prepared with different methods – various combinations of prescribed fire and herbicide application – that left the soil less disturbed, and the actual planting with a no-till drill also likely produced less soil disturbance. These later methods still yielded significant areas of bare ground, however, providing an opportunity for weeds to become established and grow along with the planted species.

Another large challenge in the FOUS plantings and all prairie restoration efforts is achieving the diversity of species typical of a native prairie (Sluis 2002). Because pre-planting preparation of the fields at FOUS largely eliminated all standing vegetation, the diversity of species that results in the field is determined by what is planted, what remains in the seedbank, or what can colonize from the surrounding area. Given the long history of agriculture in and around the restored areas, the seedbank and colonization sources are filled largely with exotic, often weedy or invasive species. Therefore, the diversity of native species in these planted fields is almost wholly determined by the number of species that were planted. The first planting at FOUS (Field 2) had 13 species in its seed mix and included grasses, forbs, and shrubs, but seed mixes for most plantings since then have included only grasses, and sometimes only a few species of them (Table 2).

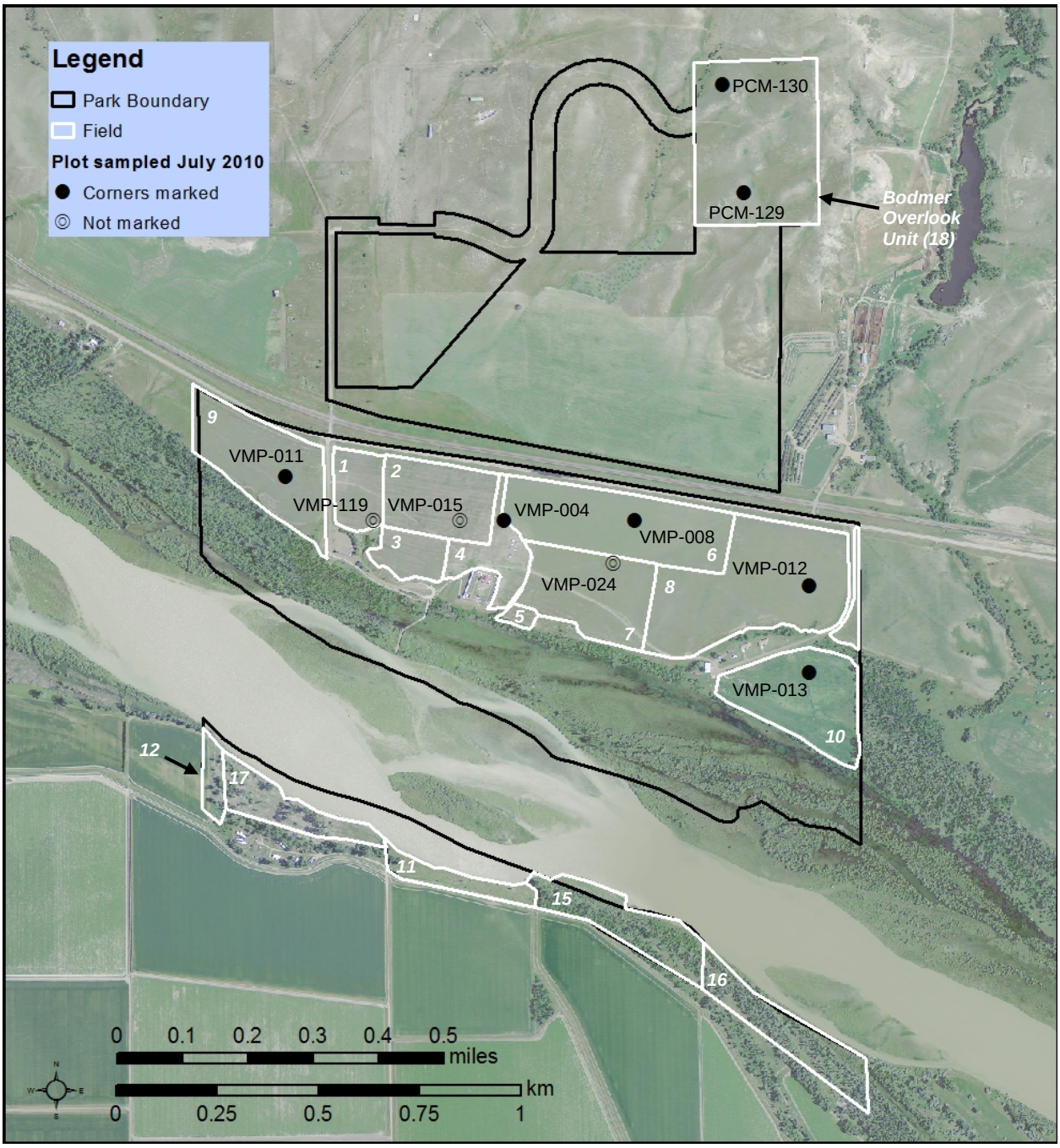

Figure 6. Field names and July 2010 sample plot locations at Fort Union Trading Post National Historic Site.

Field numbers, indicated in white, are identical to those in the Draft Resource Stewardship Strategy. Plots whose labels beginn with “PCM” are scheduled to be monitored long-term by the NGPN monitoring program, whereas plots whose labels begin with “VMP” are not. Five of the 8 VMP plots have their corners marked with rebar bent flush to the ground and tags labeled with the plot name. Background photographic imagery is from 2009.

Follow-up management activities including herbicide application (Appendix C), prescribed fire, mowing, and over-seeding have been used to address these challenges (Tables 3, 4), with herbicides being used more extensively since the Northern Great Plains Exotic Plant Management Team (EPMT) was established in the early 2000's. An additional challenge evident at FOUS is that the different seed mixes, planting times, and various other factors have resulted in a patchwork of plant communities that does not resemble a natural zonation of vegetation. Some of the management actions described in Table 3, such as mowing and over-seeding, have been done to try to reduce the visible differences among fields, but as of 2010, the patchwork was still clearly visible in remote images and on the ground (Figure 7).

Table 2. Site preparation and planting information for planted fields at Fort Union Trading Post National Historic Site, 1986-2010[1]

Field	Size in acres (ha)	Preparation	Date Planted	Method of Planting	Seed Mixture Ordered	% of order	Species[3]	Variety
1	6.2 (2.5)	sprayed with Round-up, then broke sod in spring 1993; mulcher-breaker used to pack in September 1995	4/15/1996	broadcaster and a bar with some chains attached to lightly disturb the soil	400 pounds (182 kg) PLS[2] for fields 1 and 3	50 17 33	blue grama green needlegrass western wheatgrass	"native" Lodorm Rosana
2	12.1 (4.9)	summer-fallowed several years before initially plowing in summer of 1986 and/or 1987	1990 or 5/1991	not stated	114 pounds (52 kg) PLS	21 17 6 6 5 4 3 3 3 3 2 2 1	western wheatgrass green needlegrass thickspike wheatgrass winterfat (S) needle-and-thread prairie Junegrass saltbush (S) blue flax (F) prairie coneflower (F) sunflower (F) silver sage (S) blue grama wild rose (S)	Rosana Lodorm Critana "native" "native" "native" "native" "native" "native" "native" "native" "native"
3	4.6 (1.9)	sprayed with Round-up, then broke sod in spring 1993; mulcher-breaker used to pack in September 1995	4/15/1996	broadcaster and a bar with some chains attached to lightly disturb the soil	400 pounds (182 kg) PLS for fields 1 and 3	50 17 33	blue grama green needlegrass western wheatgrass	"native" Lodorm Rosana
4	6.8 (2.8)	sod broken fall 1990, then summer fallowed until planted	late April 1994	none stated; from Orville Loomer's notes, sounds like broadcaster with some kind of drag was standard practice for this time	not recorded; maybe leftovers from Field 2			

Field	Size in acres (ha)	Preparation	Date Planted	Method of Planting	Seed Mixture Ordered	% of order	Species	Variety
5	0.7 (0.3)	sod never broken; probably is the parcel referred to O. Loomer as "the largest piece of native we had on the knoll south east of the fort … almost entirely taken over sence [sic] 1976 by crested wheat and smooth brome"	no records of planting	planned to mow short in fall 1995 then spray with Roundup in early spring of 1996 to control crested wheatgrass but not harm native species; no indication of whether this was done				
6	20.3 (8.2)	mowed, then broke sod using spikes in July 1994; worked several times with disc and shovel on toolbar in September 1994; continued in spring 1995; went over with sweeps in May 1996; disc July 1996; drag August 1996; tool bar with sweeps 1996; more fallowing August 1997; disc and drag, then mulcher-breaker twice late June 1998	7/1/1998	broadcaster then 14-ft bar with chain loops "more of a marker then anything"; went over approx 50 ft swath on south side with mulcher breaker after broadcasting seed as an experiment	220 pounds (100 kg) PLS	27 18 18 18 9 9	blue grama western wheatgrass green needlegrass bluebunch wheatgrass sideoats grama purple prairie clover (F)	Bad River Rosana Lodorm Goldar Kildeer
7	16.0 (6.5)	cut hay June 1995; disc July 1995; disc and sweeps May 1996; disc July 1996; drag 1996; tool bar with sweeps October 1996; more fallowing August 1997; sweeps June 1998; sweeps July/August 1998; disc September 1998; sweeps then disc May 1999; sweeps June 1999; disc and mulcher June 29, 1999	7/1/1999	broadcaster and bar with chains on 14 acres with 20-25 lbs/acres; approximately 30 x 50 ft area planted only with needle-and-thread and blue grama by hand, then dragged bar and chains over it; well over an inch of rain, with some washing by July 14; hand-planted area up by July 14	360 pounds (164 kg) (PLS?)	33 22 22 11 5.5 5.6 2.8	blue grama green needlegrass western wheatgrass sideoats grama bluebunch wheatgrass purple or white prairie clover (F) needle-and-thread	Bad River Lodorm Rosana or Rodan Pierre, Killdeer or Butte Goldar "northern variety"

Field	Size in acres (ha)	Preparation	Date Planted	Method of Planting	Seed Mixture Ordered	% of order	Species	Variety
8	27.5 (11.1)	large ripper-disc used to break sod September 1996; disc April-May 1997; sweeps late May 1997; sweeps August 1997; disc April 1998; sweeps June 1998; sweeps July/Aug 1998; disc September 1998; sweeps then disc May 1999; sweeps June 1999; disc July 1999; sweeps twice August 1999	7/26/2000	not recorded	not clear	possibly 28 19 39 12 3	blue grama green needle western wheatgrass sideoats grama purple prairie clover (F)	Bad River Lodorm Rosana Killdeer
9	16.7 (6.8)	applied Roundup in July 2000, July 2001, and June 2002; burned May 1, 2000, "plowed" May 2002	7/2002	drilled	267 pounds (121 kg) PLS	28 22 19 15 11 3 2	western wheatgrass green needlegrass thickspike wheatgrass blue grama sideoats grama needle-and-thread prairie Junegrass	Rosana Lodorm Critana Bad River Pierre
10	15.8 (6.4)	clopyralid applied to Canada thistle and imazapic applied to leafy spurge (part of field) 9/24/2004; glyphosate applied to whole field 6/22/2005; burned 10/17/2005; glyphosate applied to whole field 5/22/2006, 7/19/2006 and 5/7/2007	6/4/2007	no-till drill	280 pounds (127 kg) PLS	10 10 10 10 10 10 10 1 4 5 5 5 5 5	big bluestem switchgrass Indiangrass little bluestem western wheatgrass green needlegrass sideoats grama needle-and-thread Canada wildrye purple prairie clover (F) Maximillian sunflower (F) prairie coneflower (F) blue flax (F) 30-species forb mix	Bison Dacotah Tomahawk Badlands Rodan or Rosana Lodorm Pierre "northern variety" Mandan "northern variety" Medicine Creek or Prairie Gold "northern variety" Appar

Field	Size in acres (ha)	Preparation	Date Planted	Method of Planting	Seed Mixture Ordered	% of order	Species	Variety
11	5.0 (2.0)	used tool bar with sweeps to "work up stubble", then disked 9/20/1996; disked again April 1997	5/5 & 5/12/1997	broadcaster with drag behind, followed by mulcher breaker on 5/5 (barley); broadcaster with drag on 5/12 (green needlegrass)	5 bushels 125 pounds (57 kg)		barley green needlegrass	*(no record of seed order; information from Loomer notes)*
13 and sides of entrance road	5.4 (2.2)	glyphostae applied to whole area 6/22/2005; burned 4/13/2006; glyphosate applied to whole area 5/22/2006, 7/19/2006, and 5/7/2007	6/4/2007	no-till drill	29 pounds (13 kg) PLS	60 10 5 10 5 10	blue grama sideoats grama little bluestem prairie Junegrass western wheatgrass buffalograss	Bad River Pierre Badlands "northern variety" Rodan or Rosana Bowie
12 & 17	9.7 (3.9)	glyphosate applied to whole area 6/4/2008 and 5/26/2009	5/19/2010	no-till drill	369 pounds PLS (168 kg)	12 9 12 14 10 4 16 8 5 6	prairie sandreed switchgrass sand bluestem little bluestem green needlegrass Canada wildrye sideoats grama big bluestem Indiangrass western wheatgrass	Goshen Dacotah Gold Strike Badlands Mandan Pierre Bison Tomahawk Rosana

[1]Information based on O. Loomer's management records, NPS Northern Great Plains Exotic Plant Management Team records, and FOUS superintendent's records, including packing slips, bids, or invoices for seeds.
[2]PLS = pure live seed
[3](S) = shrub; (F) = forb; all other species are grasses; species in 30-species forb mix are listed in Table 4.

Table 3. Management activities (except herbicide application) following initial seeding in planted fields at Fort Union Trading Post National Historic Site, 1992-mid May 2011.

Field	Originally Planted	Non-Chemical Follow-Up Management
1	4/15/1996	June 27 and July 24, 1996: Mowed weeds with brush hog above height of most new grass June 20, 1997: Hayed (indication that cut material was removed) July 20, 1998: Mowed -- raked, and bailed cut material April 2000 and May 2002: Burned 2001, 2003, 2004: "Hayed"—no indication that cut material was removed April 13, 2006: Burned May 5, 2006: Seeded with no-till drill (seed mix in Table 4) April 10, 2010: Burned May 17, 2010: Seeded with no-till drill (seed mix in Table 4) May 14, 2011: Burned
2	5/1990	Summer 1992: Cut and hauled off large growths of kochia; summer fallowed crested wheatgrass along edges Summer 1993: Crested wheatgrass sprayed with glyphosate, seed heads cut off May 1, 1995: Burned June 20, 1997: Hayed (indication that mowed material was removed) April 2000 and May 2002: Burned 2001, 2003, 2004: "Hayed"—no indication that cut material was removed April 13, 2006: Burned May 5, 2006: Seeded with no-till drill (seed mix in Table 4) April 10, 2010: Burned May 17, 2010: Seeded with no-till drill (seed mix in Table 4) May 14, 2011: Burned
3	4/15/1996	June 27 and July 24, 1996: Mowed weeds with brush hog above height of most new grass June 20, 1997: Hayed (indication that cut material was removed) July 20, 1998: Mowed -- raked, and bailed cut material April 2000 and May 2002: Burned 2001, 2003, 2004: "Hayed"—no indication that cut material was removed April 13, 2006: Burned May 5, 2006: Seeded with no-till drill (seed mix in Table 4) April 10, 2010: Burned May 17, 2010: Seeded with no-till drill (seed mix in Table 4) May 14, 2011: Burned
4	4/25/1994	June 20 and July 20, 1994: Mowed July 9, 1997: Hayed (indication that cut material was removed) July 20, 1998: Mowed -- raked, and bailed cut material April 2000 and May 2002: Burned 2001, 2003, 2004: "Hayed"—no indication that cut material was removed April 13, 2006: Burned May 5, 2006: Seeded with no-till drill (seed mix in Table 4) April 10, 2010: Burned southwest portion May 17, 2010: Seeded southwest portion with no-till drill (seed mix in Table 4) May 14, 2011: Burned
5	no records of planting	April 2000 and May 2002: Burned 2001, 2003, 2004: "Hayed"—no indication that cut material was removed April 13, 2006: Burned May 5, 2006: Seeded with no-till drill (seed mix in Table 4) May 14, 2011: Burned

Field	Originally Planted	Non-Chemical Follow-Up Management
6	7/1/1998	"Cut all the weeds and grass" -- no indication whether cut material was removed. April 2000 and May 2002: Burned 2001, 2003, 2004: "Hayed"—no indication that cut material was removed April 13, 2006: Burned May 5, 2006: Seeded with no-till drill (seed mix in Table 4) May 14, 2011: Burned
7	7/1/1999	May 2002: Burned 2001, 2003, 2004: "Hayed"—no indication that cut material was removed April 13, 2006: Burned May 5, 2006: Seeded with no-till drill (seed mix in Table 4) May 14, 2011: Burned
8	7/26/2000	May 2002: Burned 2003, 2004: "Hayed"—no indication that cut material was removed April 13, 2006: Burned May 5, 2006: Seeded with no-till drill (seed mix in Table 4) May 14, 2011: Burned
9	7/2002	May 2002: Burned 2003: "Hayed"—no indication that cut material was removed April 13, 2006: Burned May 5, 2006: Seeded with no-till drill (seed mix in Table 4) May 14, 2011: Burned
10	6/4/2007	May 21, 2010: Seeded with no-till drill (seed mix in Table 4) May 14, 2011: Burned
11	5/5 & 5/12/1997	1997 or 1998: Trees (species not recorded) moved from Field 12 to Field 11 with tree spade 2003: Planted ~100 bare root trees 2004-2007: Planted bare root trees (5 green ash, 5 buffaloberry, 20 cottonwood, 5 red-osier dogwood, 5 serviceberry (juneberry) April 13, 2006: Burned 2008: Planted ~20 4-6 foot cottonwood trees
13 and sides of entrance road	6/4/2007	
12 & 17	5/19/2010	

[1]Information based on O. Loomer's management records, NPS Northern Great Plains Exotic Plant Management Team records, and FOUS superintendent's records.

Table 4. Seed mixes used in over-seeding (2006) or reseeding (2010) of planted fields at Fort Union Trading Post National Historic Site.

Percentage in 2006 Seed Mix (Fields 1-9)	Percentage in 2010 Seed Mix (Fields 1-3, SW part of 4)	Species[1]	Variety
0	10	blue grama	Bad River
10	25	big bluestem	Bison
10	10	switchgrass	Dacotah
10	10	Indiangrass	Tomahawk
10	10	little bluestem	Badlands
10	25	sideoats grama	Pierre
0	10	prairie sandreed	Goshen
10	0	western wheatgrass	Rodan or Rosana
10	0	green needlegrass	Lodorm
1	0	needle-and-thread	northern variety
4	0	Canada wildrye	Mandan
5	0	purple prairie clover (F)	northern variety
5	0	Maximillian sunflower (F)	Medicine Creek or Prairie Gold
5	0	prairie coneflower (F)	northern variety
5	0	blue flax (F)	Appar
5	0	FORB MIX (below)	

FORB MIX

Common Name	Scientific Name	Habitat
fragrant giant hyssop √	*Agastache foeniculum*	moist woodlands or open, wet ditches
pink prairie onion	*Allium stellatum*	prairies
lead plant	*Amorpha canescens*	prairies, hillsides, open woodlands
false indigo	*Amorpha nana*	dry prairies & rocky or sandy hillsides
meadow anemone	*Anemone canadensis*	moist habitats including wet prairies
red milkweed	*Asclepias incarnata*	obligate wetland species
two-grooved milkvetch	*Astragalus bisulctus*	prairies, stream alleys, hillsides
pink flowering beeplant	*Cleome serrulata*	prairies & open woodlands, especially disturbed sites
plains coreopsis	*Coreopsis tinctoria*	seasonally damp, disturbed sites, especially low, sandy ground
white prairie clover √	*Dalea candida*	rocky prairies, stream valleys
purple prairie clover √	*Dalea purpureum*	rocky prairies & hillsides, open wooded areas
showy tick trefoil	*Desmodium canadense*	rocky or sandy prairies
narrow leafed coneflower √	*Echinacea angustifolia*	open rocky prairies and plains
blanket flower	*Gaillardia aristata*	open plains and prairies
northern bedstraw	*Gallium boreale*	rocky hillsides, prairies, woodlands
Maximilian sunflower √	*Helianthus maximilianii*	dry or damp open prairies, often in sandy sites
stiff sunflower	*Helianthus rigidus*	dry to drying open prairies and plains
blue flax √	*Linum lewisii*	prairies and open rocky wooded hillsides
wild bergamot	*Monarda fistulosa*	prairie hillsides, pastures, roadsides (var. fistulosa)
yellow evening primrose	*Oenothera biennis*	dry open fields, open woods

Common Name	Scientific Name	Habitat
bigflower penstemon √	*Penstmon grandiflorus*	sandy to loamy soil in prairies
longheaded coneflower √	*Ratibida colmunifera*	prairies and open waste ground
prairie rose	*Rosa arkansana*	prairies, bluffs, open woodlands
black-eyed Susan √	*Rudbeckia hirta*	disturbed prairies and waste places -- native to western ND?
stiff goldenrod	*Solidago rigida*	dry prairies, rocky open sites, sandy soils
scarlet globemallow √	*Sphaeralcea coccinea*	dry prairies and plains, hills
spiderwort	*Tradescantia occidentalis*	sandy, often dry soils, prairies, disturbed sites
hoary vervain √	*Verbena stricta*	pastures, prairies, thickets, waste areas
iron weed	*Vernonia fasciculata*	damp open prairies
heartleafed golden Alexander	*Zizia aptera*	prairies, open wooded hillsides, thickets

[1](F) = forb; all other species are grasses
√ indicates that the species was observed at least once in the planted area in July 2010

Upland Terraces – South Side of River

Management of the vegetation on the south side of the Missouri River has been somewhat similar to that of the upland terraces on the north side of the river, but did not begin until later because property was acquired by the park later. Noxious weed management has been a primary focus of the management in this portion of the park (Appendix C), but planting has also been done. Native grass was planted in Field 11 in 1997 and Fields 12 and 17 in 2010 (Table 2). At different times from 1997 to 2008, cottonwood, green ash, buffaloberry, red-osier dogwood, and juneberry (serviceberry) have been planted as transplants from within the park or as bare root transplants (raised in a nursery) in Field 11 and the east end of Field 17 with the intention of eventually obscuring the view from the fort of the agricultural fields adjacent to the park's property. Success of the woody species plantings has been limited (A. Banta, FOUS Superintendent, pers. comm., 23 May 2011).

Bodmer Overlook Unit

The Bodmer Overlook Unit has had almost no management since the acquisition of the park except for the construction of a barbed-wire fence surrounding the unit in 2003, at which time cattle grazing in the area was supposed to have ceased. Occasional intrusion of cattle into the unit still occurs, but the extent and intensity of grazing in the unit is small and light compared to the surrounding rangeland (A. Symstad, pers. observation, July 2010). Before this unit was fenced, the adjacent landowner transported hay bales to hill tops, then rolled them down the hill, in this unit (A. Banta, pers. comm., July 2010). It is possible that this practice introduced exotic perennial grass species such as crested wheatgrass higher up the ridges than would have occurred by intentional planting.

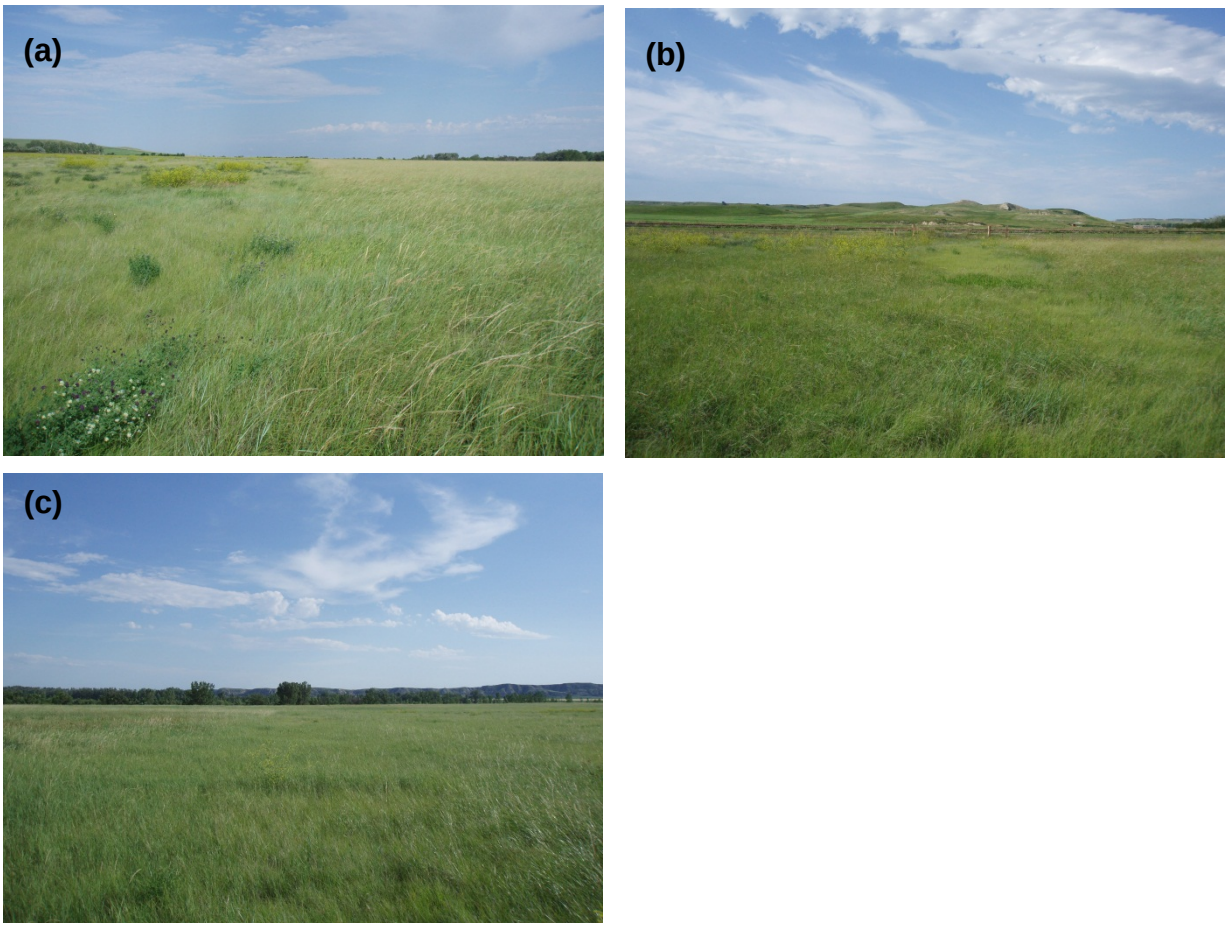

Figure 7. Photos taken July 10, 2010 illustrating boundaries between planted fields.

(a) Boundary between fields 6, dominated by blue grama (left) and 7, dominated by green needlegrass and western wheatgrass (right), facing ~100º . **(b)** Boundary between fields 6, dominated by blue grama (left) and 8, dominated by western wheat grass and green needlegrass (right), at the east end of field 6, facing ~10º. **(c)** Boundary between fields 6 (right) and 8 (left) from same location as (b), but facing ~190º.

Current Vegetation at FOUS

Four sources of information exist for describing the current state of the vegetation at FOUS: the vegetation map, a floristic inventory, a certified vascular plant species list, and field data collected specifically for this management plan.

Vegetation Map

A vegetation map was compiled based on aerial photographs taken on June 20, 2002 and follow-up field verification in August of the same year (Salas and Pucherelli 2003). This effort mapped vegetation in and around the park as distinct polygons of vegetation associations following the NVCS described above (Figure 8). One major product of this effort is the geographic information system (GIS) shapefile containing the polygons, the vegetation association they were assigned to, and the area of each polygon. According to this file and using the most recent park boundary, the two largest mapping units – "agriculture" and "restoration area", vegetation types not recognized by the NVCS – together comprise half of the park. Ten vegetation associations

or alliances characterized by native species occur in the park and occupy one third of its area (Table 5).

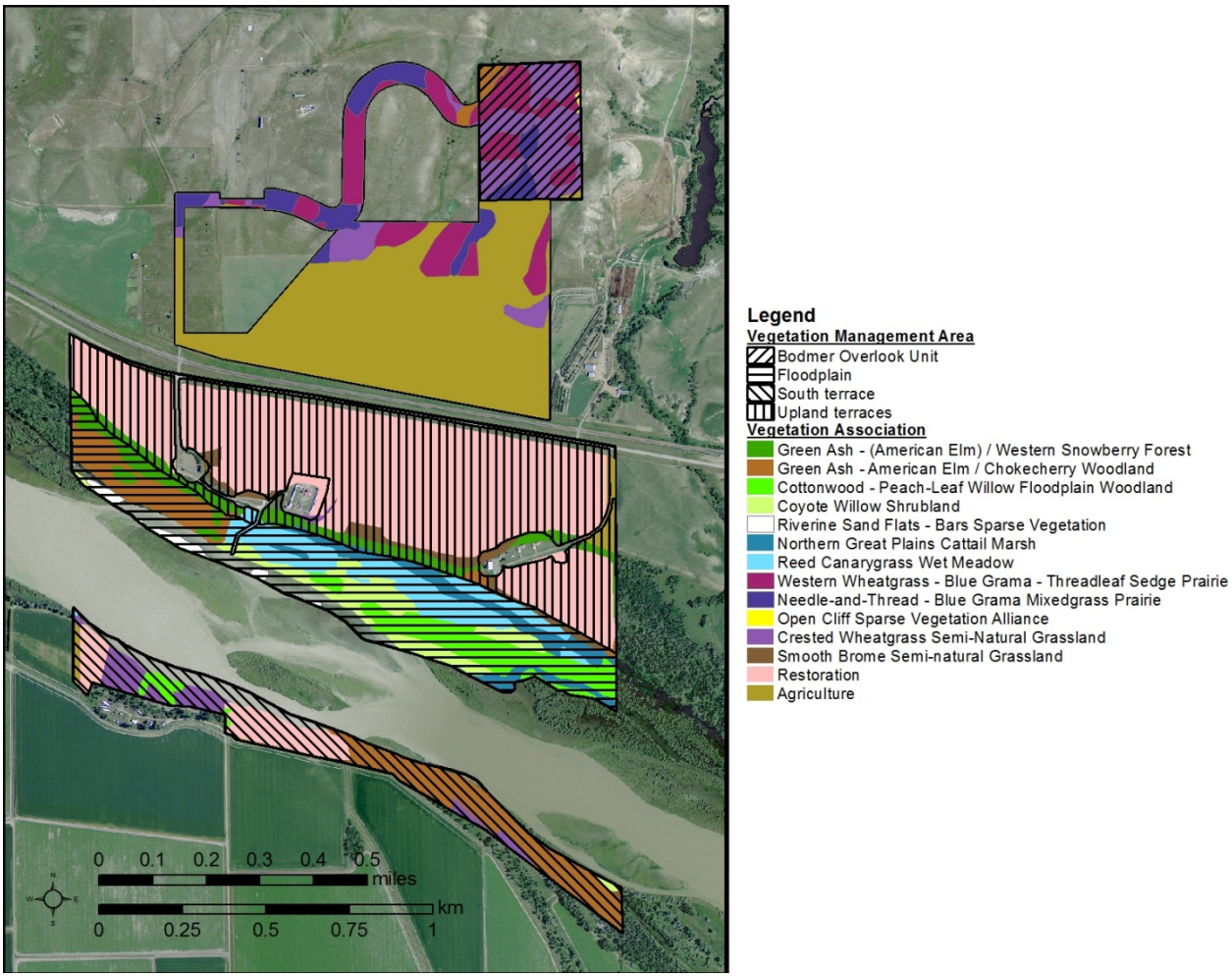

Figure 8. Vegetation management areas and current vegetation (Salas and Pucherelli 2003) at Fort Union Trading Post National Historic Site.

A second important product from this effort is the compilation of general and local descriptions of each of the vegetation associations or alliances that occur in the mapped area. The general description explains the composition of the species that comprise the association or alliance across its entire range, the conditions in which it occurs (habitat) across that range, and where that range is. The local description explains the distribution, habitat, and composition of the association or alliance specifically within the area mapped for the project (i.e., FOUS and its surroundings). Although the global and local descriptions concentrate on the dominant or distinguishing species that characterize the association or alliance, they do provide insight into the current state of the vegetation at FOUS. For example, the local descriptions of most vegetation associations in the floodplain include a substantial, sometimes exclusive, dominance of exotic species in the herbaceous layers. Smooth brome, crested wheatgrass, leafy spurge (*Euphorbia esula*), and Canada thistle are often mentioned. The local descriptions also note that the Smooth Brome Semi-natural Grassland association seems to be invading prairie restoration areas. On the other hand, the descriptions of two vegetation associations (Needle-and-Thread –

Blue Grama Mixedgrass Prairie and Western Wheatgrass – Blue Grama – Threadleaf Sedge Prairie) in the Bodmer Overlook Unit do not mention any exotic species, suggesting that these vegetation associations support relatively intact native communities.

Table 5. Names, areas within the park, and conservation status of vegetation associations mapped at Fort Union Trading Post National Historic Site (Salas and Pucherelli 2003).

Map Unit	Area (ha) within park[1]	Area (ac) within park	Percent of Park	Conservation Status
Green Ash - (American Elm) / Western Snowberry Forest[2]	6.5	16.1	3.49	apparently secure
Green Ash - American Elm / Chokecherry Woodland	13.2	32.6	7.06	imperiled
Cottonwood - Peach-Leaf Willow Floodplain Woodland	7.2	17.7	3.84	vulnerable
Coyote Willow Shrubland	5.6	13.7	2.97	secure
Riverine Sand Flats - Bars Sparse Vegetation	1.0	2.4	0.52	apparently secure
Northern Great Plains Cattail Marsh	4.7	11.7	2.52	apparently secure
Reed Canarygrass Wet Meadow	7.6	18.8	4.08	secure
Western Wheatgrass - Blue Grama - Threadleaf Sedge Prairie	10.8	26.6	5.75	apparently secure
Needle-and-Thread - Blue Grama Mixedgrass Prairie	5.8	14.4	3.12	secure
Open Cliff Sparse Vegetation Alliance	0.1	0.2	0.03	NA
Crested Wheatgrass Semi-natural Grassland	12.1	30.0	6.50	invasive
Smooth Brome Semi-natural Grassland	3.1	7.6	1.65	invasive
Restoration Area	55.7	137.6	29.78	NA
Agriculture	39.0	96.4	20.87	NA
Roads and Right-of-ways	5.8	14.4	3.11	NA
Undifferentiated Urban	2.3	5.8	1.25	NA
Water	6.4	15.9	3.44	NA

[1]Areas in this table were calculated using the GIS files produced by the vegetation mapping and are different than those that appear in the vegetation mapping report (Salas and Pucherelli 2003).
[2]The description for this alliance is not provided in the vegetation mapping report. A mistake seems to have occurred, as the description of Green Ash / Choke Cherry Forest is given instead. Although it is not clear, the local description provided in the report for Green Ash / Choke Cherry Forest seems to apply to the Green Ash - (American Elm) / Western Snowberry Forest map units.

Finally, the report from this effort also includes a list of the vascular plant species encountered during the field sampling in which aerial photograph interpretations were ground-truthed. This list is by no means a complete inventory of the species that occur in the park; 103 species were recorded, 15 of which are exotic.

Floristic Inventory

The second source is a floristic inventory completed in 2003 and 2004 for the Northern Great Plains Inventory and Monitoring Network (NGPN). The intention of this inventory, the results of which are reported by Godfread (2004), was to provide a list of all vascular plant species that occur within the boundaries of the park and describe their relative abundance and the habitat in which they occur. This inventory documented the occurrence of 345 species and subspecies or varieties, 54 of which are not native to North America.

The report from this inventory also briefly describes the vegetation of different areas within FOUS from a botanical (individual species-oriented) viewpoint. The Bodmer Overlook Unit is noted as being of particular interest floristically because of its relatively undisturbed state and because its varied topography (hill crests vs. slopes vs. valleys) provides a variety of habitats for diverse species and communities.

The report also notes that 22 species found at FOUS are considered to be relatively rare in the western North Dakota region. Since this report was published, new information on the abundance and distribution of species in a region has been obtained, making some of the statements about rarity in this report out of date. Species of concern will be discussed in more detail below.

Certified Species List

The third source of information is the certified vascular plant species list compiled by the NGPN (National Park Service 2011). This list includes all vascular plant species that have been recorded as occurring in FOUS, plus a ranking of the reliability of that record. For example, species listed the floristic inventory (Godfread 2004) are considered to be present in the park because the of the expert botanist status of the collector. In contrast, some species have been reported in other documents, but there is some uncertainty as to their validity. These species are listed as "unconfirmed" or "probably present". This list, annotated with the distribution and abundance information provided by Godfread (2004) and related to species listed as occurring in the area by F.V. Hayden (Warren 1875), is provided in Appendix A. The list reports 354 species as present or probably present, and 8 unconfirmed species. Fifty-seven of the present or probably present species are not native to North America.

Field Data

Finally, the fourth and most current source of information describing the current state of the vegetation at FOUS is quantitative data collected in July 2010 explicitly for this management plan. This sampling was limited to restoration fields near the fort and to the Bodmer Overlook Unit because the main objective of the sampling was to evaluate the composition of the restorations in comparison to native prairie. The sampling followed the methods of the NGPN's vegetation monitoring protocol (Symstad et al. 2011) with one exception (see below). Sampling locations were chosen from NGPN's 2008 random draw of sampling sites. Eight sites in the restoration fields and two sites in the Bodmer Overlook Unit were sampled (Figure 6). Sites in the restoration fields were chosen to maximize the number of fields represented, given the list of potential sample sites. The two Bodmer Overlook Unit samples were chosen from the five sites that will continue to be monitored by NGPN[c] to represent two different prairie types – hill crest and lower slope.

Sampling at each site consisted of species frequency, cover, and richness measurements along two parallel, 50-m (164-ft) long transects. The transects were 20 m (65.6 ft) from each other and formed the edges of a 0.1 ha (0.25 acre) rectangular plot. Plots were oriented so that the 50-m transects were perpendicular to the predominant slope at the site. On each transect, the identity of each species intercepted by a pin flag inserted plumb to the ground at each of 50 evenly

[c] Ideally, all NGPN long-term sites would have been sampled, but this was not possible due to time constraints.

spaced (every 1 m) points was recorded, as was the height of the topmost vegetation interception. Ground cover category (rock, litter, biological crust, bare soil, live vegetation) was also recorded for each of these points. [The NGPN protocol uses a 0.25-inch (0.635-cm) diameter pole instead of a pin flag, which has a diameter of 0.031 inches (0.079 cm).] Also on each transect, the identity of each species in five evenly spaced sets of square, nested quadrats (0.01 m^2, 0.1 m^2, 1.0 m^2, and 10 m^2, or 0.11 ft^2, 1.1 ft^2, 10.7 ft^2, and 107.6 ft^2, in size), located on the side of the transect towards the inside of the plot, was recorded to calculate species richness and the frequency of individual species. Frequency is a measure of a species' abundance that is less susceptible to short-term impacts on vegetation than cover is. Using multiple quadrat sizes allows a single sampling protocol to provide useful frequency information for species with a wide variety of abundances (Heywood and DeBacker 2007). Percent cover of an individual species (reported in Appendix D) or ground cover category was calculated as the number of points (out of 100) at which that species/category was recorded. Percent cover of vegetation categories (e.g., exotic, native, planted, grass, forb) was calculated as the sum of the cover of the species in that category, and total vegetation cover as the sum of all species' cover in that plot. Thus, because more than one species could be intercepted at each point, total vegetation cover could be >100%. Since only one ground cover category was recorded for each point, the sum of all ground cover categories for each plot always equaled 100%. Vegetation height for each plot is reported as the average of the 100 heights recorded. Frequency of each species (reported in Appendix D) was calculated for each quadrat size as the number of plots in which the species occurred (highest value possible is 10), and species richness was calculated as the number of species present in the 10 m^2 quadrats averaged over the 10 quadrats. Details and rationale for the sampling and calculations are provided in the NGPN protocol (Symstad et al. 2011).

Although this sampling is more quantitative than any other information available for the park, it does have its limitations, primarily that there was only one sample in each restoration field. Consequently, it is not possible to calculate the sampling error (e.g., standard error) or perform statistical analyses with these data. However, because the samples were randomly located, and because most of these fields are quite uniform in composition, this limited sample does provide a reasonable quantitative description of the vegetation in each of them. The degree to which the individual samples resembled an entire field was evaluated during a deliberate walkthrough of each field. During these walk-throughs, species not recorded during the quantitative sampling were noted for restoration fields 1 – 4 and 6 – 10[d]. These walk-throughs were not intended to produce a thorough, floristic inventory, but instead concentrated on looking for species planted in the original seedings and in the 2006 over-seeding. Field 3 was not sampled, but given that its management history is identical to that of Field 1, its vegetation is likely to be similar to that of Field 1.

Composition by species for each field from this sampling and the walk-throughs is provided in Appendix D, and the results of the sampling are summarized in Table 6 and Figures 9 and 10. At the time of sampling, most restoration fields were strongly dominated by the perennial grass species that comprised the mix of their original plantings, but the dominant species varied among the fields. Fields 1, 2, and 4 were co-dominated by blue grama and western wheatgrass, but Field 2 had much lower cover of these grasses than did Field 1, and Field 4 also had a substantial

[d] Field 5 was not discernable in the field.

amount of green needlegrass. Field 6 was heavily dominated by blue grama, with another warm-season grass – side-oats grama – being the subdominant. Field 7 was approximately co-dominated by green needlegrass and western wheatgrass, both of which were major species in the original seed mix for this area. Field 8 was heavily dominated by western wheatgrass, with green needlegrass contributing the vast majority of the remainder of the cover in this field. Field 9's native perennial grass cover was relatively evenly distributed among 4 planted species, whereas Field 10 was dominated by western wheatgrass, with big bluestem (*Andropogon gerardii*) being a substantial subdominant. The sample site in the Bodmer Overlook Unit at the foot of a slope was also heavily dominated by two species, blue grama and western wheatgrass, but the site on a hilltop had lower cover and that cover was more evenly distributed among three native perennial grasses and native perennial forbs as a group. In the restoration area, Field 4 had the highest exotic species cover (47%) of all the restoration areas, with field bindweed (*Convolvulus arvensis*) being the major contributor. Field 2 had the second highest exotic species cover (32%), with nearly half of its total cover being exotic grasses and forbs. In contrast, Fields 6 and 8 had very low exotic cover (1-2%), and no exotic species were recorded in the cover measurements in the two Bodmer sites.

All restoration fields were relatively similar in the number of plant species recorded as part of the quantitative vegetation sampling (cover and frequency measurements), with the most diverse fields (1 and 2) having 33 species and the least diverse fields (6 and 8) having 20-21 (Figure 9). The lower slope Bodmer site had 38 species, only slightly more than the most diverse restoration field. However, only two of these species were exotic, whereas in restoration fields, exotic species comprised 38-62% of the species richness. In contrast, the hilltop Bodmer site had 58 species, only three of which were exotic.

Finally, ground cover and vegetation height also varied substantially among fields. Bare soil was prominent in Fields 1, 2, 4, and 10, but dead plant material (litter) covered most of the ground in the other restoration fields and at the lower slope Bodmer site (Figure 10). The hilltop Bodmer site had a mix of ground cover, including a substantial amount of moss, lichen, or biological crust. Field 6 and the lower slope Bodmer site were the only locations with a substantial portion of the ground occupied by live vegetation. Average vegetation height ranged from 4.2 inches (11 cm) in Field 1 to 15.3 inches (39 cm) in Field 10, with the Bodmer sites having heights at the lower end (Figure 10). These differences in vegetation structure reflect both recent management actions and differences in plant composition. A 2010 prescribed fire in Fields 1 and 2 (Table 3) removed litter, and recent planting in Field 10 (Table 2) provided little time for litter accumulation. Tall grasses planted in Field 10 produced tall vegetation, and the dominance of green needlegrass and western wheatgrass in Field 7 made its height greater than in fields dominated by blue grama.

Table 6. Dominant plant species and their cover measured with a point-intercept method in one plot per field, and notable plant species observed in planted fields and the Bodmer Overlook Unit at Fort Union Trading Post National Historic Site (July 2010). Scientific names of all species mentioned here are listed in Appendix A.

Field	Dominant Species (% cover)	Notable species from walk-through[1]
1	*blue grama* (41), *western wheatgrass* (23)	*bigflower penstemon, black-eyed Susan, fragrant giant hyssop, Maximilian sunflower, prairie coneflower, hoary vervain*, American vetch
2	*blue grama* (20), *western wheatgrass* (12)	*blue flax, purple prairie clover, blacksamson echinacea, blanket flower, Maximilian sunflower, prairie coneflower, hoary vervain*, American vetch
4	blue grama (31), field bindweed (27), *western wheatgrass* (23), *green needlegrass* (13)	*bigflower penstemon, purple prairie clover, Maximilian sunflower, blue flax, prairie coneflower, hoary vervain,* American vetch
6	*blue grama* (87), side-oats grama (26)	*bigflower penstemon, purple prairie clover, blacksamson echinacea, scarlet globemallow, hoary vervain,* American vetch
7	*green needlegrass* (62), *western wheatgrass* (55)	*bigflower penstemon, purple prairie clover, blue flax*, American vetch
8	*western wheatgrass* (61), *green needlegrass* (37)	alfalfa, *bigflower penstemon, white prairie clover, purple prairie clover, blacksamson echinacea, blue flax, scarlet globemallow*
9	*western wheatgrass* (37), *green needlegrass* (35), *prairie junegrass* (29), *side-oats grama* (18)	alfalfa, field bindweed, annual brome species, crested wheatgrass, *bigflower penstemon*, fringed sage, *purple prairie clover, blacksamson echinacea, Maximilian sunflower, blue flax*, Pennsylvania cinquefoil, *prairie coneflower, scarlet globemallow,* American vetch
10	*western wheatgrass* (59), *big bluestem* (23)	quackgrass, reed canarygrass, Kentucky bluegrass, leafy spurge, alfalfa, *purple prairie clover, Maximilian sunflower*
Bodmer (18) hill top	needle-and-thread (17), blue grama (16), prairie junegrass (11)	crested wheatgrass, Kentucky bluegrass, threadleaf sedge, pricklypear cactus species, winterfat, rose
Bodmer (18) lower slope	blue grama (56), western wheatgrass (18)	crested wheatgrass,threadleaf sedge, winterfat, rose, western snowberry, green ash

[1]Species in *italics* are forbs planted in 2006 or 2010 (or earlier). See Table 4 for complete list of species planted then.

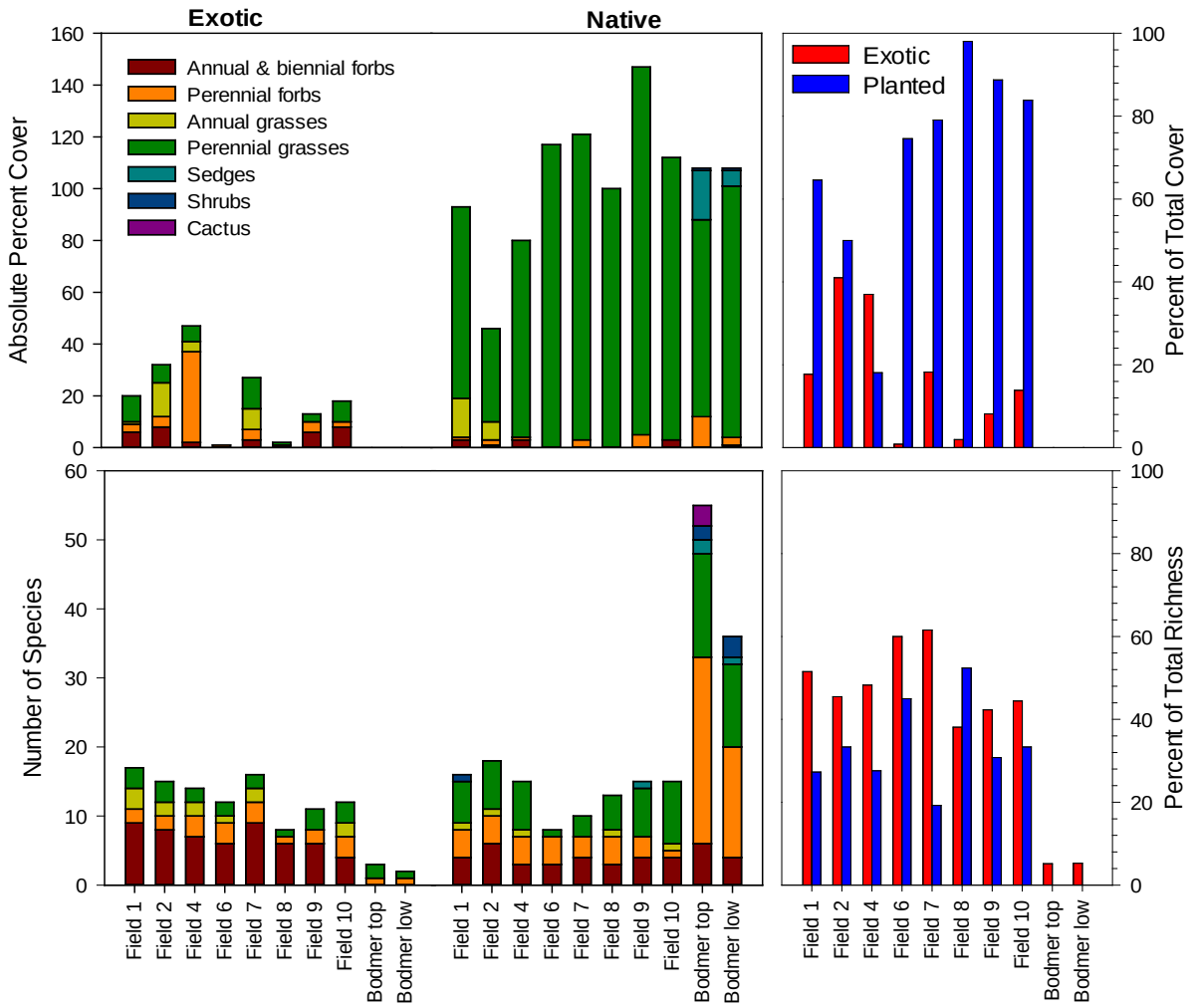

Figure 9. Cover and species richness of exotic and native plant species in plots sampled in the upland terrace surrounding the fort at Fort Union Trading Post in July 2010.

Absolute cover (top) and number of species in ten 10-m^2 subplots is shown by growth form and species origin in the graphs on the left and center. The percent of total cover (top) or species richness (bottom) comprised of exotic species or species planted in the field are shown in the graphs on the right. A single plot was sampled in each field or location in the Bodmer unit, where "top" means hilltop and "low" means lower slope.

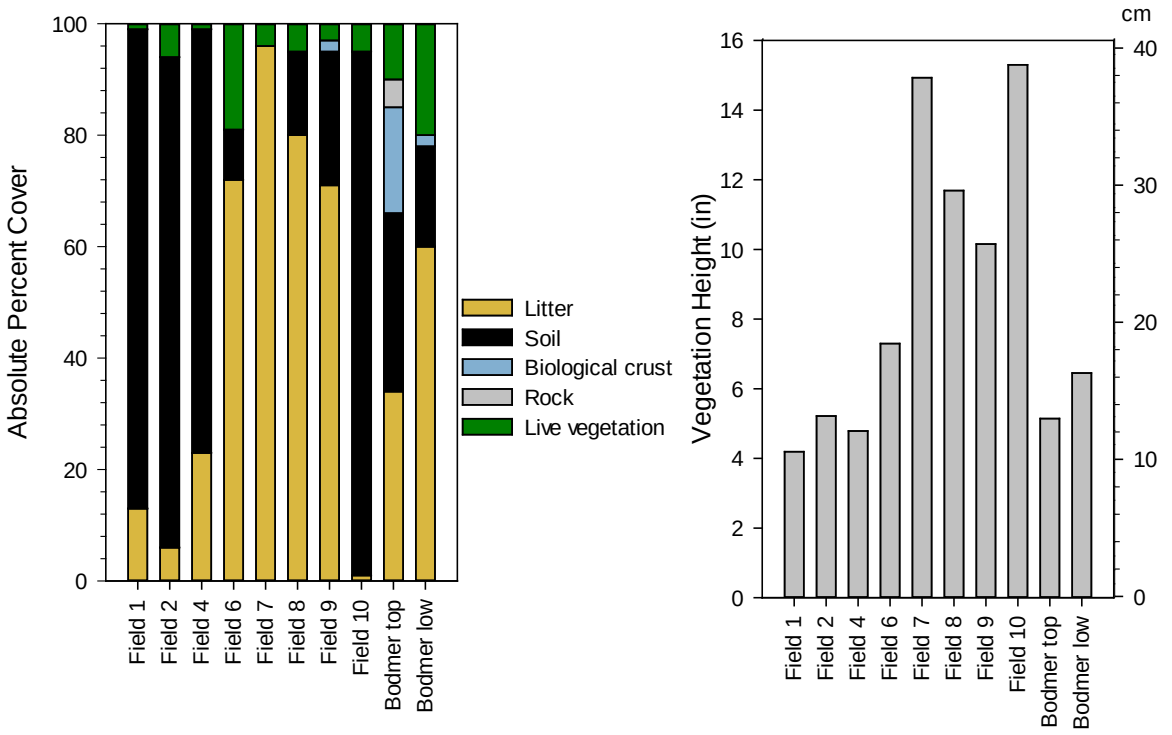

Figure 10. Ground cover (left) and vegetation height (right) in plots sampled at Fort Union Trading Post National Historic Site in July 2010.

A single plot was sampled in each field or location in the Bodmer unit, where "top" means hilltop and "low" means lower slope. "Biological crust" includes moss, lichen, and cryptobiotic soil crust.

Ten species not recorded in previous floristic inventories were noted during the quantitative sampling or walk-throughs in the restoration fields. Four of these, fragrant giant hyssop (*Agastache foeniculum*), hoary vervain (*Verbena stricta*), bigflower penstemon (*Penstemon grandiflorus*), and Indiangrass (*Sorghastrum nutans*), were planted across the entire restoration area in 2006, and were noted in Field 1 (hyssop), Fields 1, 2, 3, 4, and 6 (vervain), Fields 6, 7, and 8 (penstemon), and Field 10 (Indiangrass)[e]. Hairy grama (*Bouteloua hirsuta*) and bigroot pricklypear (*Opuntia macrorhiza*) were noted in the Bodmer Overlook Unit[f], and pale alyssum (*Alyssum alyssoides*), crown vetch (*Coronilla varia*), common mallow (*Malva neglecta*), and black medic (*Medicago lupulina*) were noted in Fields 2, 4, 8, and 9; Field 8; Field 2; and Fields 6 and 7, respectively[g].

[e] No vouchers of the vervain or Indiangrass were collected, but I am quite confident of their identifications. An incomplete specimen of the hyssop was collected (no flowering individuals were available), so this confidence in this identification is moderate. A photographic voucher of the bigflower penstemon was taken and appears in Appendix A.

[f] No vouchers taken. Confidence in pricklypear and hairy grama identifications are moderate.

[g] No vouchers taken. Confidence in alyssum and mallow identifications is high, vetch and medic identifications moderate.

Conservation Status of Vegetation Associations and Species

State natural heritage programs evaluate the conservation status of species and vegetation associations that occur in the state, assigning them conservation status values within the state ranging from secure (common, widespread, and abundant) to critically imperiled (very vulnerable to elimination because of few occurrences and/or limited area in which it occurs). These values are also assigned to species or vegetation associations in the context of the entity's global range. Thus, although as species may be considered critically imperiled in a state (perhaps because it is on the edge of its range there), it could be globally secure. These conservation status values are regularly updated and stored by NatureServe for all state natural heritage programs in the United States (NatureServe 2011). This database forms the basis for this report's evaluation of the conservation status of vegetation associations and species that occur at FOUS.

Two of the vegetation associations occurring within FOUS, Green Ash - American Elm / Chokecherry Woodland and Cottonwood - Peach-Leaf Willow Floodplain Woodland, are currently considered globally imperiled or vulnerable, which means there are fewer than 100 known occurrences of each of these. The other associations are considered either globally secure or invasive (Table 5). State evaluations were not available.

Three species known to occur within FOUS' boundaries are considered either critically imperiled or imperiled within North Dakota: alyssumleaf phlox (*Phlox alyssifolia*), rayless tansyaster (*Machaeranthera grindelioides*), and smooth goosefoot (*Chenopodium subglabrum*). Three other vascular plant species on the NGPN certified species list but not confirmed to occur there are also considered critically imperiled or imperiled within North Dakota. Drummond's milkvetch (*Astragalus drummondi*), and Nebraska sedge (*Carex nebrascensis*) are unconfirmed, while white locoweed (*Oxytropis sericea*) is probably present.

Two species recorded during the quantitative data collection for this report, bigroot pricklypear and pale alyssum, have not been recorded in North Dakota according to the U.S. Department of Agriculture's national plant database (U.S. Department of Agriculture 2011). Since pale alyssum, a naturalized (exotic) species, has been recorded in all the states and provinces surrounding North Dakota, the collection made at FOUS, pending expert identification, simply provides documentation of a species that would be expected to occur in the state. Bigroot pricklypear has been recorded in the states west, south, and east of North Dakota, but not in the Canadian provinces to the north. Although it seems reasonable that this species would occur in North Dakota, a secure identification from a high-quality voucher needs to be done to confirm this record, after which the conservation status of the species in the state would be evaluated (globally, it is secure).

Summary and Evaluation of Historic and Current Vegetation and Management at FOUS

Because of its location between the Missouri River and the rolling hills of western North Dakota-eastern Montana, and despite the intense disturbance of a large portion of the park, the relatively small area encompassed by FOUS' boundaries hosts a substantial diversity of vegetation types and species. In less than 500 acres (200 ha), at least 353 vascular plant species occur. In comparison, NGPN certified species lists show that Knife River Indian Villages National Historic Site (KNRI) in central North Dakota has 286 species in its approximately 1,500 acres

(600 ha) and Theodore Roosevelt National Park (THRO), which lies south and east of FOUS in North Dakota, has 532 species in its approximately 70,000 acres (28,300 ha) (National Park Service 2011). Although exotic species comprise a substantial portion of the herbaceous plant cover outside of the Bodmer Overlook Unit and some of the restoration fields, the proportion of the total flora (species list) that they comprise at FOUS (16%) is similar to that of KNRI (20%) and THRO (13%). The floodplain hosts two vegetation associations that are of conservation concern, as well as habitat for 90% of the breeding bird species documented in the park (Panjabi 2005) and the best habitat for amphibians and reptiles in the park (Smith et al. 2004).

A variety of sources provide reasonable understanding of the structure and composition of vegetation that occurred at FOUS during the fort's active period. Uplands would have supported a mixed-grass prairie, with composition and structure varying somewhat with topography but being influenced just as strongly by the amount of human and grazing activity in a given location. The riparian area would have supported a mixture of herbaceous, shrubby, and forested plant communities that were constantly changing in response to river flooding and meandering. The historic vegetation component that is most difficult to determine is the understory and herbaceous layer of the various floodplain habitats. Although early Euro-American explorers and visitors to the area mentioned a plethora of fruit-bearing shrubs, it is difficult to know how biased these accounts are towards species of interest because modern analogs of these habitats have all been heavily impacted by exotic species and other forces.

The minimal management in the riparian floodplain has been to control one invasive species (Canada thistle) and try to keep the view of the river from the fort open. Thorough surveys and monitoring invasive species in the floodplain have not been conducted, so the effectiveness of the invasive species control is difficult to ascertain. A single plot was established by the Northern Great Plains Fire Effects Monitoring Program in the area burned in October 2005 to evaluate the effects of the prescribed fire on forest structure. The results from this single plot suggest the fire did not have its desired effects: two years after the fire the density of pole-sized (diameter at breast height between 1 and 6 inches, 2.5 and 15 cm) cottonwood trees was about half of what it was before the fire, but density of larger cottonwood trees actually *increased* (NGP Fire Effects Monitoring Program, unpublished data).

FOUS has focused its vegetation management on establishing and maintaining native grass plantings and on invasive species control in heavily disturbed upland areas. The specific objectives of these grass plantings have only very recently been addressed in official park documents (see Draft Resource Stewardship Strategy), although it is clear that their basic goal is to replace exotic vegetation with native species in order to produce a landscape similar to what occurred at the fort during its active period in the mid-19th century. Reproducing a prairie with the plant diversity and composition of this time does not seem to have been a focus in early planting efforts, since seed mixes were comprised primarily or exclusively of grasses. Recently, increasing diversity in the previously planted areas has been a goal, but the 2006 over-seeding with a diverse mixture of species has so far yielded relatively minor impacts for forbs – a few planted species occur as scattered individuals. However, there are more occurrences of grass species not in the original seed mixes (Table 6, Appendix D). Some recent plantings have had specific objectives. Grass species planted in the roadsides and in Field 13 in 2007 were chosen for their relatively shorter stature in an effort to reduce mowing needs. Following intense

herbicide and burning treatments to reduce invasive cool-season perennial grasses in fields 1-3, only warm-season native grasses were planted (Table 4) with the hope that future treatments targeted at the cool-season grasses would not negatively impact the planted species (A. Banta, FOUS superintendent, pers. comm. July 2010).

The stark contrasts in species composition among the different plantings are undoubtedly caused by a variety of factors. Seed mixes varied considerably, but what was planted does not always match well with what is standing now (Table 2 vs. Table 6). In two plantings (fields 1 and 9, planted in 1996 and 2002 respectively), relative abundance of the planted species in the 2010 vegetation was fairly similar to the relative abundance of the original seed mix. In other fields, however, some planted species apparently did not take or have been lost over time. In fields 7 and 8, for example (planted 1999 and 2000, respectively), blue grama comprised at least 25% of the seed mix by weight, but it was either not present or present only as scattered individuals in 2010. In fields 2 and 6, on the other hand, sideoats grama is the dominant species over western wheatgrass and green needlegrass, which comprised either substantially higher (Field 2) or only slightly lower (Field 6) portions of the planted mixes than blue grama. It should be noted that true records of what was planted are not available (except for perhaps the first planting in field 2) because seed left over from one planting was often incorporated into seed for a later planting (A. Banta, pers. comm., September 2010). In addition, many of the later seed mix records are bids, invoices, or, most recently, spreadsheet calculations, not actual packing slips, and there are no official records of what was actually put into the seeder. The relatively common occurrence of American vetch (*Vicia americana*) throughout the planted areas, despite its not being on any seed mix list, suggests that some substitutions may have occurred in orders, and the fact that there was leftover seed raises the question of whether the leftovers were equitable among species. Planting time also varied, from late April to early July (Table 2), but there does not seem to be a pattern of spring- vs. summer-planting and the current relative abundance of cool- and warm-season grasses. Different field preparation techniques or surrounding vegetation could have affected the ability of exotic species to survive in or re-invade the planted area. Weather following each planting could have had substantial effects on which species emerged, survived, and thrived. Even a carefully replicated, highly controlled, experimental mixed-grass prairie restoration yielded different results depending on the year in which the plots were seeded (MacDougall et al. 2008). Therefore, it is extremely difficult to determine why each planting at FOUS turned out the way it did.

Regardless of the reasons for the results of the different plantings, it is important to realize that many of the plantings have been successful in achieving the goal of replacing exotic with native species. Native species comprised the majority of plant cover in all of the plots measured in 2010, and in some of these, exotic cover was quite low (Figure 9). In addition, total plant cover in all but one of the plots was at least as high as in the native prairie in the Bodmer Overlook Unit.

The plantings differ strongly from native prairie, however, particularly in the diversity of native species (Figure 9), and incursion of undesirable exotic perennial grasses into some plantings has been a continuous problem. Diversity is extremely difficult to achieve in prairie plantings, particularly when it was not in the original plan. Even when a large number of species are seeded at the outset, a diverse plant community resembling native prairie is often not the result,

even after many decades have passed (Allison 2002; Kindscher and Tieszen 1998; Sluis 2002). Over-seeding into established grass plantings has been successful in increasing species diversity in some situations (Foster et al. 2009; Foster et al. 2007), but not all (MacDougall et al. 2008), and the dry conditions at FOUS in 2006 and 2007 could have hindered species over-seeded at FOUS in 2006. Adverse weather conditions soon after a seeding and the composition of the surrounding vegetation can also impact the degree to which the planted species become dominant and resist invasion by the species the planting is supposed to replace (MacDougall et al. 2008).

The history of vegetation management and how it has impacted the current vegetation at FOUS is key to understanding how management should and will proceed in the future. Over two decades of moderately intense prairie restoration efforts guided by a consistent, broad goal but lacking specific objectives have partially achieved that goal. Other portions of the park have received far less attention. Documenting specific desired conditions for each part of the park and a specific plan for how to achieve them will be necessary to continue that work into the future.

Desired Conditions for the Vegetation of FOUS

A critical step in designing a specific vegetation management plan for a location is to determine specific desired conditions for the vegetation in the park. This section defines desired conditions, outlines the methods used to determine the desired conditions for FOUS for this plan, and provides the specific conditions desired for each management unit in the park.

Guidelines for Determining Desired Conditions

The NPS guidance on defining meaningful desired conditions for natural resources (National Park Service 2009) states that desired conditions:

- describe what you want;
- describe conditions and/or processes as they are expected to exist in the future under expected scenarios;
- build on historic conditions;
- include structural, compositional, and functional descriptors and a dynamic range of conditions and process rates, as well as the amount of fluctuation within those ranges;
- apply to a specific management unit or resource context;
- address the spatial, temporal and ecological scale issues relevant to focal resources;
- establish a framework and purpose for subsequent management actions and projects, and translate into operational objectives;
- need to be both realistic and achievable, but normally not in the short term;
- are based upon a documented analytical framework that identifies and supports underlying assumptions;
- include measurable benchmarks for operational objectives, including hypothetical ecological and management thresholds;
- make use of existing condition assessments;
- take account of irreversible ecosystem changes and limitations imposed by park boundaries or other variables;
- identify expected outcomes that are derived from goals.

These guidelines were followed when determining the desired conditions for vegetation at FOUS.

Process for Determining Desired Conditions

Desired conditions were determined for four specific management areas (Figure 8): (1) the upland terraces surrounding the fort in which the majority of restoration effort has taken place in the past; (2) the Bodmer Overlook Unit; (3) the riparian floodplain on the north side of the Missouri River; and (4) the land area on terraces south of the Missouri River. In the Bodmer Overlook Unit, separate desired conditions were hill tops and upper slopes versus lower slopes and valleys because of the different type of vegetation that they can and currently do support. The areas including and immediately surrounding the fort, roads, parking lots, trails, and park housing (park-managed areas with no hatching in Figure 8) are considered maintained areas and are not managed through the resource management program, but rather as a facility maintained by the maintenance division. Therefore, the desired conditions and vegetation management plan

do not apply to these areas. However, vegetation management practices described in this plan could certainly be followed in these areas.

The following relevant management prescriptions in the draft Resource Stewardship Strategy were considered to be the goals that frame the desired conditions:

- Retain primary characteristics of openness and remoteness in the landscape and viewshed, so that it looks much as it did in the 1833 Bodmer painting.
- Preserve the historical character and interactions among the fort, the grounds, and the natural environment.
- Maintain a visual and physical connection between the fort and the river.
- Restore prairie to represent a period from just prior to fort construction to midway through its occupation (1828-late 1840's).

These goals leave some room for interpretation in terms of specific desired conditions. For example, restoring the prairie to represent the vegetation present in the first half of the fort's active period could mean simply that the *structure* (height, ground cover) of the vegetation represents that time period, or it could mean that the structure and the *composition* (species present, their relative abundance and distribution, and the diversity of species at a variety of scales) of the vegetation is as true to that time period as possible. Given these ambiguities and the uncertainty inherent in determining the structure and composition of a given place during a given time period, a set of potential desired conditions spanning a range of detail (structure only vs. structure and composition matching historical time period) and potential vegetation of the target period (depending on intensity of grazing, for example) was constructed for each management area. A desired condition designed to provide maximum flexibility in vegetation management in the face of rapid climate change was also included for each management area. These potential desired conditions and details of the processes used to derive them are provided in Appendix B.

After consulting with staff within the park and with outside expertise, FOUS staff selected one desired condition for each management area from these possibilities. Since all possible desired conditions presented fit within the goals described above to some degree, the over-riding consideration for the desired condition selected for each area was feasibility. Specifically, past difficulties in establishing vegetation resembling native prairie in the restoration areas and in preventing the re-invasion of these areas by smooth brome and crested wheatgrass suggest that sustained, substantial attention would be required to achieve historically accurate plant composition in these areas. Such attention was determined not to be feasible given that there are no positions within the park staff that focus a significant amount of time on natural resources. Consequently, staff expertise in natural resources is not strong, and this is not expected to change in the future. Although short-term projects funded by project-specific grants could be used for some restoration activities, long-term oversight is needed to effectively plan, execute, evaluate, and maintain such projects. In addition, the dynamic nature of the riparian floodplain combined with the minimal control that NPS has over the area restrict the management activities that can be used in that area.

Desired Conditions

The following desired conditions are tailored to specific areas based on the overarching goal of providing a landscape and viewshed similar to that in the 1833 Bodmer painting, but they also incorporate the realities of current vegetation in specific areas. For example, significant resources have been spent to replace exotic perennial grasses with native perennial grasses in the upland terraces surrounding the fort, and these efforts have been largely successful. The desired condition for this area therefore specifies that this native grass component should not drop below a certain level. Similarly, the hill tops and upper slopes in the Bodmer Overlook Unit contain the most intact native prairie in the park. Therefore, the desired condition for this area also requires native grasses to comprise a large majority of the plant community. In contrast, in many areas within the lower slopes and valleys of the Bodmer Overlook Unit and in the riparian floodplain area, exotic perennial grasses currently comprise a large portion of the vegetation. Restoration to a native species composition was not deemed feasible in these areas, so the desired conditions for these areas do not include a statement of composition by origin.

Upland Terraces Surrounding the Fort

Vegetation appearance and structure are similar to the likely appearance and structure around Fort Union Trading Post during the most active period of the fort (1828-1847). Boundaries between planted fields are not visible. Grasses and sedges comprise 55-90% of the cover, forbs 10-20% of the cover, and shrubs 0-15% of the cover. Prickly pear cactus may be abundant. Federal, state- and county-listed noxious weeds are minimal (<1% cover over whole area); other invasive species [including smooth brome (*Bromus inermis* ssp. *inermis*)] comprise ≤10% of total cover; and native grasses comprise ≥70% of total cover. Continuous canopy cover is generally short (<4 inches or 10 cm), but occasional, taller, grazing-resistant forbs and shrubs make canopy height up to 15 inches (35 cm) tall. Structure may be taller in wetter years (up to 12 inches/30 cm). Fallen litter is shallow (<0.5 inch/1 cm on average) and discontinuous, with bare ground comprising 5-15% of the soil surface area. Natural processes (fire, grazing) are tools used to maintain the desired condition, not part of the desired condition. Potential for soil erosion (wind or water) is moderate. Tree cover is limited to a narrow strip on the slope transition between upland and floodplain terraces; near the fort, tree cover is sparse or short enough that views from the fort to the water's edge are unobstructed.

Hill Tops and Upper Slopes in the Bodmer Overlook Unit

Vegetation structure is similar to the likely structure during the most active period of the fort (1828-1847), with forbs comprising 5-15% and shrubs 2-10% of cover, and the remainder grasses and sedges. Species composition is not specified, but federal-, state- and county-listed noxious weeds are minimal (<1% cover over whole area); other invasive species [including smooth brome (*Bromus inermis* ssp. *inermis*) and crested wheatgrass (*Agropyron cristatum*)] comprise ≤10% of total cover; non-invasive, exotic species comprise ≤10% of total cover; and native species comprise ≥80% of total cover. Canopy height is generally 6-24 inches (15-60-cm), with <10% of the area in taller (up to 5 feet/150 cm) canopy. Canopy height and production fluctuate with fluctuations in climate. Fallen litter is relatively shallow (0.5-1 inch/1-2 cm on average) and bare ground can comprise up to 10% of the soil surface. Some movement of litter is noticeable following a rainfall event. Water infiltration and runoff vary with ground cover (rock vs. bare ground vs. vegetation) but can be moderately slow (infiltration) and moderately high (runoff) in areas with low vegetation cover. Natural processes (fire, grazing) are tools used

to maintain the desired condition, not part of the desired condition. Potential for soil erosion (wind or water) is moderate.

Lower Slopes and Valleys in the Bodmer Overlook Unit

Vegetation structure is similar to the likely structure around Fort Union Trading Post during the most active period of the fort (1828-1847), with forbs comprising 10-20% of the cover, shrubs 1-5%, hardwood trees <2% in valley bottoms (draws), and grasses the remainder. Species composition is not specified, but federal-, state- and county-listed noxious weeds are minimal (<1% cover over whole area). Herbaceous canopy height (structure) is generally in the 6-24 inches (15-60 cm) range, but approximately 20% of the herbaceous canopy is up to 5 feet (150 cm) in height. Fallen litter is of moderate depth (1-2 inches/2-5 cm) and bare ground is rare (<5% of ground cover). Herbaceous canopy height fluctuates with fluctuations in climate. Natural processes (fire, grazing) are tools used to maintain the desired condition, not part of the desired condition. Potential for soil erosion (wind or water) is low.

Riparian Floodplain North of the Missouri River

Vegetation is a mix of forest, woodland, shrubland, and herbaceous vegetation, the last dominated by grasses and grass-like species (rushes, sedges, cattails). All of these are tolerant of spring flooding or a water table at or near the soil surface. Specific locations of these vegetation types are determined by distance from the river channel, elevation above the low water level, and the time since the river has scoured that location. Tree cover near the fort is sparse or short enough that views from the fort to the water's edge are unobstructed. Federal-, state- and county-listed noxious weeds are minimal (<1% cover over whole area). Spring flooding occurs almost annually, with flood height and duration varying with weather conditions and snow pack upstream. The river channel and vegetation are dynamic within the constraints caused by dams on the Missouri and Yellowstone Rivers and the tree cover restriction near the fort.

Terraces South of the Missouri River

Dense cover of native shrubs and trees blocks the view of agriculture and other development south of the park boundary and resembles vegetation that may have been present during the active period of the fort. Herbaceous understory may be sparse. Noxious weeds are minimal (<1% cover over whole area). Natural processes (fire, grazing) are tools used to maintain the desired condition, not part of the desired condition.

Current Departure from Desired Conditions

Vegetation in the upland terraces surrounding the fort is not currently in its desired condition in terms of stature (taller than desired in the grassland and some trees are obstructing the view of the river) and visibility of boundaries between planted fields, but composition is currently within the bounds stated for the desired conditions. The upland terrace on the south side of the Missouri River is far from the desired condition in most places because of insufficient woody structure to obscure the view of adjoining agricultural fields and other developments. The riparian floodplain is close to desired conditions, although mapping of noxious weeds would need to be completed in the area to confirm this. Data for the Bodmer Overlook Unit are insufficient to evaluate their departure from desired conditions at this time.

Exotic Plants and Vegetation Management Tools

Exotic plants influence almost all vegetation management actions at FOUS. Consequently, the tools used for vegetation management in general and exotic plant management specifically overlap strongly. This section addresses the more specific management issue of exotic plants first, then discusses the management tools available for controlling them and for otherwise reaching the desired conditions stated in the previous section.

Exotic Plants

Management policies of the NPS define exotic species (also known as non-native or alien species) as "those species that occupy or could occupy park lands directly or indirectly as the result of deliberate or accidental human activities" (National Park Service 2006, section 4.4.1.3). These policies also state that an exotic plant species will be managed if control is prudent and feasible and, among other things, it interferes with natural processes, native species, or natural habitats, or it disrupts the accurate presentation of a cultural landscape. High priority for control is to be given to exotic species that have or could have a substantial impact on park resources and that can reasonably be expected to be successfully controlled, whereas low control priority is to be given to those exotic species that have almost no impact on park resources or that probably cannot be successfully controlled (section 4.4.4.2).

Furthermore, invasive species have been defined by the federal government as "alien species whose introduction does or is likely to cause economic or environmental harm or harm to human health" (Executive order 13112 of February 3, 1999 on Invasive Species). A related but separate concept is that of noxious weeds, which are plant species that a government entity (federal, state, county) requires to be controlled by law because they cause economic or environmental harm. The vast majority of exotic species are not invasive, and all invasive plant species are not legally noxious weeds. For example, smooth brome is known to invade native grasslands in North Dakota (Murphy and Grant 2005), but because it is an economically important species, it is not listed as a noxious weed by the state or any county in the state (North Dakota Department of Agriculture 2011). In contrast, almost all noxious weeds are invasive. Although federal agencies like the NPS are not required to abide by state and county weed laws, the NPS recognizes the need to voluntarily comply with state and local weed control efforts.

Exotic, Invasive, and Noxious Plants Documented at FOUS

The NPGN certified plant list documents 55 exotic plant species as present or probably present at FOUS[h], and field sampling in July 2010 identified four more (Table 7). The states or counties in which FOUS lies list five of these 59 species as noxious weeds: common burdock (*Arctium minus*), absinth wormwood (*Artemisia absinthium*), Canada thistle, field bindweed, and leafy spurge. The state of Montana also lists cheatgrass (*Bromus tectorum*) and Russian olive (*Elaeagnus angustifolia*) as "regulated" plants, species that cannot be intentionally spread or sold and whose spread should be minimized.

[h] Stinging nettle (*Urtica dioica*) is listed as origin unknown and is not included in this count.

Table 7. Exotic species documented at Fort Union Trading Post National Historic Site, and the current abundance and distribution within the park, area treated, noxious or invasive status, and potential for action threshold for each.

Common name	Current scientific name	Current Abundance and Distribution in FOUS	Acres (ha) Treated 2002-10	Noxious Status 2011	In Invasive Plant Atlas[1]	Invasive in NGP in IPA[2]	Consider for Action Threshold
crested wheatgrass	*Agropyron cristatum*	abundant; roadsides, planted areas, prairie	290 (117)		yes	yes	yes
redtop[3]	*Agrostis gigantea*	not listed			yes	yes	no
pale madwort[3]	*Alyssum alyssoides*	unknown; planted fields 2, 4, 8, 9			no		no
desert madwort	*Alyssum desertorum*	rare; grass planting west of fort			no		no
prostrate pigweed	*Amaranthus albus*	uncommon; sandbars and along roadsides			no		no
mat amaranth	*Amaranthus blitoides*	uncommon; roadsides and disturbed sites			no		no
redroot amaranth	*Amaranthus retroflexus*	uncommon; roadsides and disturbed sites			no		no
lesser burrdock/common burdock	*Arctium minus*	uncommon; wooded terrace south of river		McKenzie noxious	yes	yes	yes
absinth wormwood	*Artemisia absinthium*	common; gravel pit and disturbed areas		ND noxious	yes	yes	yes
garden asparagus	*Asparagus officinalis*	uncommon; upper terraces			no		no
common oat	*Avena sativa*	uncommon; prairie hollow disturbed by wintering cattle			no		no
Japanese brome/field brome	*Bromus arvensis*	uncommon; prairie hollow disturbed by wintering cattle			yes	yes	yes
smooth brome	*Bromus inermis* ssp. *inermis*	abundant; roadsides and upper terraces	105 (43)		yes	yes	yes
corn brome	*Bromus squarrosus*	rare; disturbed areas and high terrace			no		no
cheatgrass	*Bromus tectorum*	common; grass planting west of fort		MT Regulated	yes	yes	yes
littlepod false flax	*Camelina microcarpa*	uncommon; upper edge of terrace and road ditches			yes	yes	uncertain
shepherd's purse	*Capsella bursa-pastoris*	common; disturbed areas			yes	no	no
curveseed butterwort	*Ceratocephala testiculata*	rare; grass planting west of fort			yes	yes	uncertain
oakleaf goosefoot	*Chenopodium glaucum*	uncommon; sandy shoreline and moist road ditches			no		no
blue mustard/crossflower	*Chorispora tenella*	rare; grass planting west of fort			yes	yes	uncertain

Common name	Current scientific name	Current Abundance and Distribution in FOUS	Acres (ha) Treated 2002-10	Noxious Status 2011	In Invasive Plant Atlas[1]	Invasive in NGP in IPA[2]	Consider for Action Threshold
Canada thistle	*Cirsium arvense*	common; roadsides, upper terrace and disturbed areas	87 (35)	MT, ND Noxious	yes	yes	yes
hare's ear mustard	*Conringia orientalis*	uncommon; edge of upper terrace, sandy soil			no		no
field bindweed/creeping Jenny	*Convolvulus arvensis*	common; roadsides and planted areas	2.6 (1.1)	MT Noxious	yes	yes	yes
crown vetch[4]	*Coronilla varia*	rare; planted field 8			no		yes[5]
herb sophia	*Descurainia sophia*	common; disturbed areas			yes	yes	uncertain
smooth crabgrass	*Digitaria ischaemum*	rare; edge of parking lot			no		no
barnyardgrass	*Echinochloa crus-galli*	common; disturbed areas			yes	yes	yes
Russian olive	*Elaeagnus angustifolia*	common; river terrace and in old gravel pit	1.4 (0.6)	MT Regulated	yes	yes	yes
quackgrass	*Elymus repens*	common; roadsides and disturbed sites			yes	yes	yes
stinkgrass	*Eragrostis cilianensis*	uncommon; disturbed areas and wooded floodplain			yes	yes	uncertain
wormseed wallflower	*Erysimum cheiranthoides*	uncommon; wooded upper floodplain terrace			no		no
leafy spurge	*Euphorbia esula*	abundant; river bottom, gravel pits and along roadsides	64 (26)	MT, ND Noxious	yes	yes	yes
kochia/Mexican-fireweed/ burning bush	*Kochia scoparia*	common; roadsides and disturbed sites	128 (52)		no		yes[6]
prickly lettuce	*Lactuca serriola*	common; roadsides and disturbed sites			yes	yes	uncertain
European stickseed	*Lappula squarrosa*	common; disturbed prairie areas and roadsides			no		no
blue flax[4]	*Linum perenne*	unknown; planted areas			no		no
common mallow[3]	*Malva neglecta*	uncommon; planted field 2			yes	no	no
black medic[4]	*Medicago lupulina*	unknown; planted fields 6 and 7			yes	yes	uncertain
alfalfa	*Medicago sativa*	common; road ditches and planted areas			no		yes[7]
yellow (and white) sweetclover	*Melilotus officinalis*	common; road ditches and planted areas			yes	yes	yes
annual bluegrass	*Poa annua*	rare; grass planting west of fort			yes	no	no
Canada bluegrass	*Poa compressa*	uncommon; open, sandy floodplain			yes	no	no

Common name	Current scientific name	Current Abundance and Distribution in FOUS	Acres (ha) Treated 2002-10	Noxious Status 2011	In Invasive Plant Atlas[1]	Invasive in NGP in IPA[2]	Consider for Action Threshold
Kentucky bluegrass	*Poa pratensis*	abundant; prairie, roadsides and disturbed areas			yes	no	uncertain[8]
prostrate knotweed	*Polygonum aviculare*	common; roadsides			no		no
black bindweed/climbing buckwheat	*Polygonum convolvulus*	common; roadsides and disturbed sites			no		no
annual rabbitsfoot grass	*Polypogon monspeliensis*	rare; muddy bank of backwater			yes	no	no
Russian wildrye	*Psathyrostachys juncea*	common; grass planting west of fort			no		no
curly dock	*Rumex crispus*	uncommon; disturbed areas			yes	no	no
narrowleaf dock	*Rumex stenophyllus*	uncommon; riverbank and disturbed areas			yes	yes	uncertain
Russian thistle	*Salsola kali*	common; disturbed areas			yes	no	uncertain
charlock mustard	*Sinapis arvensis*	uncommon; roadsides and restoration areas			yes	no	no
tall tumblemustard	*Sisymbrium altissimum*	common; disturbed areas			yes	yes	yes
small tumbleweed mustard	*Sisymbrium loeselii*	uncommon; open woods of floodplain and disturbed prairie			no		no
field sowthistle	*Sonchus arvensis*	common; river bottom on edge of shrubby area			yes	no	no
spiny sowthistle	*Sonchus asper*	uncommon; upper edge of terrace			yes	no	no
common dandelion	*Taraxacum officinale*	common; roadsides and planted areas			yes	no	no
field pennycress	*Thlaspi arvense*	common; disturbed areas			yes	no	no
yellow salsify	*Tragopogon dubius*	common; prairie and roadsides			yes	yes	uncertain
narrowleaf cattail	*Typha angustifolia*	common; wet floodplain and shallow backwater areas			no		no

[1]http://www.invasiveplantatlas.org/distribution.html, accessed May 12, 2011; [2]Listed as invasive in at least one northern Great Plains state (MT, WY, ND, SD) in the Invasive Plants Atlas; [3]probably present or [4]presence unconfirmed in park; [5]author's experience with this species elsewhere suggests it can be very invasive; [6]previous FOUS experience shows this to be a problem species in planted areas; [7]tall stature in planted areas does not fit with desired conditions; [8]exhibits invasive behavior in northern Great Plains, but feasibility of control is uncertain

Past and Current Exotic Plant Management

Exotic plant management became a priority within the NPS in 2000, when the Natural Resources Challenge funded four exotic plant management teams (EPMTs; Miller and EPMT Evaluation Panel 2011). Twelve more EPMTs, including the Northern Great Plains EPMT (NGP EPMT) that serves FOUS, were established in 2002 and 2003. Prior to this, individual parks managed exotic plant control. At FOUS, the actual management activities were done by the maintenance division. Systematic records of these activities do not exist, however, and the activities were done without an explicit exotic plant or weed management plan. Systematic record-keeping started when the NGP EPMT began surveying and treating exotic plant species in 2002

According to these records, from 2002 to 2010, the NGP EPMT has surveyed a total of 927 acres[i] for the species listed as management priorities in the 2005 plan and other species of concern to the park. They have applied herbicides to 678[i] acres (274 ha) to control seven species, four of which are currently state- or county-listed noxious weeds or regulated species (Table 7). Prescribed fire has also been a tool used in exotic species control, both before and after restoration plantings occurred, and a variety of native plantings have been done (Tables 2, 3, 4). Two currently listed noxious weeds documented at FOUS (common burdock, absinth wormwood) have no records of treatment, and no treatments have been recorded in the Bodmer Overlook Unit (Appendix C).

A critical step in exotic plant management at FOUS was the completion of the Northern Great Plains Exotic Plant Management Plan (NGP EPMP) for all 13 parks served by the NGP EPMT in 2005 (National Park Service Northern Great Plains Parks 2005a, b). This plan describes the integrated pest management (IPM) approach used for exotic plant control in the 13 parks. An IPM approach "…coordinat[es] knowledge of pest biology, the environment, and available technology to prevent unacceptable levels of pest damage, using environmentally sound, cost-effective management strategies that pose the least possible risk to people, park resources, and the environment" (National Park Service Northern Great Plains Parks 2005a, p. 2-18) and is done on a case-by-case basis so that treatment strategies are tailored to local conditions. Treatment methods included in the IPM approach are cultural, manual/mechanical, biological, chemical, and prescribed fire. The plan includes detailed descriptions of these treatment methods, procedures used to minimize the methods' adverse impacts, planning, monitoring, and record keeping. In addition, the plan states that its implementation will conform to applicable state and local laws, including state and county noxious weed laws (National Park Service Northern Great Plains Parks 2005a, p. 2-4 and 2-5).

Given the existence of the NGP EPMP, it is not necessary to include a detailed exotic plant management plan in this vegetation management plan. Instead, critical elements of the EPMP that must be handled by FOUS staff on a continuing basis are covered.

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[i] Many areas of the park have been surveyed or treated more than one year. If multiple species are treated in the same location in a given year, the area treated is counted for each species separately, thereby making the number of acres recorded as treated greater than the actual area treated. The former is reported. See Appendix C.

Continuing Exotic Plant Management

The NGP EPMP includes eight components: compliance with regulatory measures, education programs, collaboration measures, planning, treatment methods, monitoring and record-keeping, committed conservation measures, and other general best management practices. Because exotic plant management is central to all vegetation management at FOUS, all of these components are relevant to vegetation management in general. Thus, the first four components are covered in this section on exotic plants, but treatment methods, monitoring, and record-keeping will be discussed in the context of vegetation management as a whole ("Management Tools" and "Monitoring and Adaptive Management" below). Committed conservation measures and other general best management practices are thoroughly covered by the NGP EPMP and do not need specific attention for FOUS in this vegetation management plan.

Compliance with Regulatory Measures

New exotic plant management activities or plans to address specific exotic plant management issues must be evaluated for regulatory compliance. Because the NGP EPMP provided a broad analysis of various treatments on a variety of environmental resources, this may be accomplished by using a decision tree ("Confirm Compliance of Treatment Method with an Existing NEPA Document") in Appendix G of the NGP EPMP. For activities involving fire, compliance may also be covered by the park's Fire Management Plan (National Park Service Midwest Region 1999), and all fire activities should be checked for agreement with this plan.

Education Programs

The Executive order on Invasive Species (13112, February 3, 1999) directs federal agencies to "promote public education on invasive species and the means to address them." Accordingly, the NGP EPMP states that each park will develop and implement exotic plant education programs for park staff, visitors, and the public. This education serves many purposes, including

1. increasing support for exotic plant management within the park staff and from neighbors and the public;
2. enhancing awareness of how other park activities (maintenance, construction, rendezvous, etc.) affect exotic plant introduction, spread, and management;
3. incorporating exotic plant management considerations into all aspects of park management;
4. increasing the number of people looking for new occurrences of exotic plants.

FOUS exotic plant management would benefit if all permanent staff and any seasonal staff that are involved in facilities and maintenance or natural resources management received training on:

- why exotic plant management is done
- park-specific exotic plant management objectives (e.g., those included in the vegetation desired conditions)
- preventative measures for ensuring that other park activities do not introduce, spread, or enhance exotic plants in the park (see "Preventative Measures" under "Management Tools" below).

Annual, spring training on the identification of targeted exotic species, as well as what to do if one is found, for all FOUS staff and volunteers who spend time outside could be highly cost-effective. Another cost-effective measure for early detection of targeted exotic species would be

assigning a once-a month (during the growing season), rapid, park-wide reconnaissance for target species as a specific duty of one of the park's permanent staff. Early detection of new exotic plant species was ranked as one of the top priorities for the NGPN (Gitzen et al. 2010). This is because detecting an exotic plant soon after it arrives in a park, when its population is small and it has not had a chance to build up a seed bank, greatly reduces the cost of controlling that species. Each year, the NGPN updates a watch-list of exotic, invasive plant species that have the potential to occur at FOUS. This list and links for identifying and controlling the species on it are available on the NGPN's Exotic Plant Early Detection website (http://science.nature.nps.gov/im/units/ngpn/monitor/exoticplant/exoticplant.cfm). Eventually, the NGPN will also have a communications plan and online database for soliciting, storing, reporting, and sharing information about incidental observations of target species by park staff, other NPS program staff, partners, and visitors. Until that system is established, any occurrences of watch-list species should be reported to the FOUS superintendent, the NGP EPMT Liaison, and the NGPN Plant Ecologist.

Collaboration Measures

Section 2.3.3 of the NGP EPMP provides a thorough description of types of collaboration expected to occur for exotic plant management, and Appendix F of the plan includes contacts for collaboration. Outside of NPS, key partners for FOUS include the Montana Department of Agriculture's Noxious Weed Program, Richland and Roosevelt County (MT) Weed Coordinators, the North Dakota Noxious Weed Control Association, the North Dakota Department of Agriculture, and McKenzie and Williams County (ND) Weed Officers.

Planning

Appendix G of the NGP EPMP provides an exotic plant decision-making tool for planning exotic plant management within a park. This tool aids park staff in establishing exotic plant management priorities, deciding how to handle new exotic plant occurrences, and ensuring compliance of new exotic plant management activities with regulations. The tool includes five decision trees that are to be used in order.

Identify Exotic Plants that Meet Action Thresholds

The first step in this decision tree is to establish short- and long-term exotic plant management objectives for the park or a specific management unit. The desired conditions identified in this vegetation management plan include specific objectives for noxious weeds and exotic species cover by management area. Depending on the current condition of the vegetation (which has *not* been thoroughly evaluated for exotic species objectives), these objectives may be either long- or short-term. Other objectives to consider could focus on early detection and rapid response. Some examples are:

- Survey all maintained areas annually and all vegetation management areas every three years for priority exotic species.
- Eradicate small (< 0.5 acre) stands of priority exotic plants within five years of their first detection.

The second and third steps in this decision tree determine which species in the park are exotic, following the NPS definition of exotic species, and whether any of the exotic species are

managed for a specific park purpose. FOUS currently has 59 exotic species (Table 7), but none of them are managed for an identified park purpose, such as part of the cultural landscape.

Finally, it must be determined if management of the exotic plant is prudent and feasible, and if the species meets any of the action thresholds for exotic species according to NPS policies (National Park Service 2006, Section 4.4.4.2). To be feasible, there must be acceptable, effective methods for managing the species, and these methods must be achievable given expected financial resources, technical expertise, and time to spend on the effort. To be prudent, the benefits of managing the species must outweigh potential harmful side effects or other costs of that management. The action thresholds defined by NPS policy are that the exotic plant meets any of the following criteria:

- Interferes with natural processes and the perpetuation of natural features, native species, or natural habitats; or
- Disrupts the genetic integrity of native species; or
- Disrupts the accurate presentation of a cultural landscape; or
- Damages cultural resources; or
- Significantly hampers the management of park or adjacent lands; or
- Poses a public health hazard as advised by the U.S. Public Health Service; or
- Creates a hazard to public safety.

It is not feasible to manage all exotic species that currently occur at FOUS given limited time, money, and expertise. Generally, feasibility and prudence of management is low for uncommon or rare species that occur only in disturbed areas and that have not been identified by other entities as invasive or noxious. If a species is neither invasive nor noxious, it generally does not meet the policy action thresholds either, although this does not preclude action on the species. Table 7 indicates exotic species that warrant consideration by FOUS staff as meeting the action threshold in the decision tree. A "yes" for a species indicates that the species meets at least one of the following criteria:

- occurs outside of roadsides and disturbed sites,
- has noxious status in Montana, North Dakota, or one of the counties in which FOUS lies,
- is listed in the Invasive Plant Atlas of the United States with indication of invasiveness in the northern Great Plains.

The Invasive Plant Atlas (Invasive Plant Atlas 2011) is an online database for which NPS is one of nine federal cooperators. To be listed in this database, a plant species must be documented in a natural area and "confirmed as exotic, established, self-reproducing, spreading, and exhibiting such invasive behavior as causing harm to native species, habitats, natural features, or ecological processes" (Swearingen 2007). The atlas also includes maps of states where a species has been indicated as invasive. For the purpose of Table 7, Montana, Nebraska, North Dakota, and South Dakota were considered northern Great Plains. The information in the Invasive Plant Atlas is self-admittedly incomplete. Therefore, if its information did not agree with the author's personal experience with a species at FOUS and elsewhere in the northern Great Plains, the action threshold was listed as "uncertain".

Guidance for Setting Management Priorities

Setting management priorities among the species identified for potential action requires much of the same information and value judgments as in the previous decision tree. If sufficient data and

resources are available, a quantitative system like the NPS/USGS-developed Alien Plant Ranking System (APRS Implementation Team 2000) can be used to set exotic plant management priorities. As an alternative, and probably preferred for FOUS, the NGP EPMP's decision tree provides guidance on how to set these priorities qualitatively. The information required to go through this qualitative process includes:

- noxious status
- presence of species of concern near, but not currently in, the park
- size and age of exotic plant infestations
- whether infestations are expanding
- current and potential impacts of the exotic species on ecosystem processes and native species
- degree of difficulty to control the species
- whether infestation is in a high quality/high value natural area or in a less valued area.

When the NGP EPMP was written, each park identified species that were exotic plant management priorities. FOUS identified eight priority species: Canada thistle, cheatgrass, crested wheatgrass, foxtail barley (*Hordeum jubatum*), leafy spurge, Russian olive, smooth brome, and tamarisk (*Tamarix* species). Tamarisk has not been documented at FOUS (Table 7), but it was included as a priority because the riparian habitat for it exists at FOUS, it occurs in both Montana and North Dakota (U.S. Department of Agriculture 2011), and it can have severe impacts if it does invade. Foxtail barley is native to North America and the northern Great Plains (Great Plains Flora Association 1986), so its inclusion as a management priority is curious. The plan does not state what process was used to establish these priorities, but the inclusion of foxtail barley on FOUS' list suggests that the decision trees were not used to set these management priorities.

Even if the formal process was followed, re-evaluation of these exotic plant management priorities would be beneficial for three reasons. First, with the completion of this vegetation management plan, desired conditions containing specific, quantitative exotic plant management objectives are available for the first time. These objectives may have a higher tolerance for some exotic species in some vegetation management areas than has been the operating assumption in the past. Second, exotic plant management objectives in the desired conditions vary across vegetation management areas. Therefore, prioritization should be done for each vegetation management area separately. Finally, July 2010 field sampling tentatively identified at least four exotic species not documented in the park at the time of the previous prioritization.

General information about individual species' potential impact on ecosystem processes or native species, as well as degree of difficulty in controlling the species, can be obtained from internet resources listed in the NGP EPMP or on the NGPN Exotic Plant Early Detection web page (http://science.nature.nps.gov/im/units/ngpn/monitor/exoticplant/exoticplant.cfm). However, this information must be supplemented with local expertise from weed boards, extension agents, state natural heritage programs, the NGP EPMT, and other sources because exotic plants have different effects in different areas. These sources can also provide information about potential priority species not currently in the park but nearby. However, only a thorough field survey of the whole park with the specific purpose of providing up-to-date information on the size and location of species being considered for management action can provide the rest of the necessary

information. Ideally, this survey would include scenic easement areas within the park boundaries, as well as a small extension outside of the park boundaries, and would be done at least two years in a row to evaluate whether infestations are expanding. NGP EPMT treatment and survey records (Appendix C) provide information on the area, location, and approximate density of infestations by some species, but not for all areas of the park – the Bodmer Overlook Unit is a critical omission.

Optimum Tool Analysis for Treatment Options
After management priorities have been set, the methods used to do the actual management must be selected and planned. The decision tree in the NGP EPMP neither prescribes treatments nor designs treatment plans. For many invasive species, information on various treatment options is available from a variety of sources including:

- Invasipedia (http://wiki.bugwood.org/Invasipedia)
- Weeds Gone Wild (http://www.nps.gov/plants/alien/)
- National Invasive Species Information Center (http://www.invasivespeciesinfo.gov/plants/main.shtml)
- Fire Effects Information System (http://www.fs.fed.us/database/feis/plants/weed/weedpage.html)
- county and state extension agents,
- natural resource staff in other northern Great Plains NPS units,
- NGP EPMT.

For less common and/or relatively new exotic plant species, consultation with university and agency (USGS, USDA-ARS) researchers may be necessary.

Items to consider when designing a treatment plan include:

- method(s) that will be used
- timing and frequency of treatment
- sensitivity of treatment effectiveness to weather conditions (before, during and after application)
- non-target effects
- interactions among methods

Given the variety of options available for exotic plant management, the potential for both positive and negative interactions among treatment methods must be considered. For example, a proven method for controlling Russian olive (*Elaeagnus angustifolia*) is to first cut the tree, then apply herbicide to the remaining stump. Without the herbicide application, roots produce new sprouts; if the tree is not cut, much more herbicide must be used to kill a plant (Tu 2003). Similarly, killing large, dense patches of exotic plants with herbicide without follow-up seeding will probably only result in patches of more weeds. On the other hand, applying herbicide to leafy spurge populations in which biological control agents (flea beetles; *Aphthona* species) are established and working can temporarily disrupt the effectiveness of the biological control (Larson et al. 2007). Improperly timed herbicide or fire application after seeding may be ineffective or destructive.

Confirm Compliance with Applicable Regulations and an Existing NEPA Document
The final two decision trees in the NGP EPMP provide clear guidance on evaluating the

compliance of the treatment plan with regulations covering chemical and biological control agents and with existing documents that have been approved through the NEPA process.

Management Tools

Major tools for managing vegetation at FOUS are preventative measures, planting, manual or mechanical treatments, biological control of exotics, chemical control of exotics, prescribed fire, and grazing. Because the NGP EPMP provides thorough coverage of the use of biological and chemical control of exotics, that material is not covered in this vegetation management plan. These tools are critical for vegetation management, however, and the NGP EPMP should be considered a sister document to this one.

Preventative Measures

Preventing the establishment or spread of exotic species, as well as preventing disruptions to vegetation already in a desired state, is the most economical and least complicated way of managing vegetation. Prevention requires not only education of all staff, volunteers, visitors, and partners who interact with the vegetation, but also monitoring to ensure that preventative measures are used consistently and corrective actions when they are not.

The following is a list of important preventative measures to maintain and include in staff training:

- Any seed, plant materials, feed, forage, mulch, fill, gravel and other like materials brought into a park must be certified weed-free. (This certification only ensures the material does not have listed noxious weeds; certified weed-free hay is often primarily exotic species such as smooth brome, crested wheatgrass, and alfalfa.)
- Horses, pack animals, and any other livestock are thoroughly brushed and hooves cleaned before entering the park.
- Horses, pack animals, and livestock are fed only certified weed-free food, preferably native pastures/hay, for at least 96 hours before entering the park.
- Equipment stays on existing roads and trails to the maximum extent practical.
- Equipment coming from outside the park that will be used in grounds maintenance or in any of the vegetation management zones is washed before it enters the park.
- An appropriate area is designated for equipment washing within the park. This area is monitored carefully for new exotic plant infestations.
- Equipment that stays in the park is washed in the designated washing area before going between vegetation management areas with different exotic plant problems.
- All construction project plans and contracts address exotic plant issues and, when appropriate, include a revegetation plan using appropriate native species.
- Construction equipment avoids exotic plant infestations.
- Following construction or other earth-moving activities, areas are closely monitored for exotic plant growth.
- Contracts for activities that disturb vegetation are not closed out until sites are returned to a specified condition.
- Contractors' and partners' (e.g., fire fighters) equipment, vehicles, and materials are inspected for mud or other material that may transport seed prior to leaving paved roads or parking lots in the park.

- Vegetation management treatments are applied before seed of priority exotic plant species becomes viable on the plant unless the treatment, such as prescribed fire, has the explicit goal of killing viable seed. [**Important Note:** Some species' seeds are viable long before they appear to be. Canada thistle flowers can produce viable seed even if they have been cut off the plant (Zouhar 2001). Cheatgrass seed is viable when the fruit holding it is still mostly green, and infloresences clipped before any purple coloration appears can produce viable seed (Hulbert 1955)].
- All unnecessary soil disturbance is avoided.

Planting

Primary, field-scale planting activities are largely complete at FOUS, but a variety of planting activities will continue to be used to enhance or repair those plantings, to work towards desired conditions in areas currently far from those conditions, or for revegetation of disturbed areas, such as after a construction project.

Seeds

FOUS has long experience with planting seeds of grasses and a few forbs. Seeds of common native grass species are readily available in the northern Great Plains from a variety of commercial sources (NRCS North Dakota 2010). Most of the native grass seed commercially available is an improved variety, meaning that the original material was collected from a limited area, planted, then selected over successive generations for specific characteristics. The geographic and ecological origin of the original material, as well as the selected characteristics, determine where the variety is recommended for use. For example, when green needlegrass has been planted at FOUS, the 'Lodorm' variety, which originated from a stand near Bismarck, ND and is recommended for the northern Great Plains (NRCS 2005), was used. Some named native grass seed is not improved. For example, the original material for Bad River ecotype blue grama was collected from a limited geographic location (near Philip, SD) because that stand had desirable characteristics, but there was no artificial selection on the ecotype before it was registered and released as a specific type of that species (NRCS 1997a). Origin, characteristics, and areas recommended for varieties used in FOUS plantings so far are summarized in Appendix E. Named varieties of native grass species have generally been developed and released by USDA-NRCS Plant Materials Centers; information on all of their releases is available at http://plant-materials.nrcs.usda.gov/releases/.

In contrast, "wild" or "native" seeds have gone through no artificial selection. They are either collected from plants growing in the wild or from fields sown with non-named varieties. Availability and reliability are generally greatest for named varieties and least in seeds collected from wild-grown plants. On the other hand, plants of named varieties often look quite different from plants of the same species growing near the restored area and, because they have been selected for vigor and production, may outcompete the local plants of the same species (Gustafson et al. 2004a). Consequently, if seeds or genes (via pollen) flow from a planted population to a wild population, local, wild populations may be adversely impacted (Gustafson et al. 2004b). NPS policy recognizes the importance of local genetic structure when restoring native plant species to an area from which they have been extirpated, but it does not provide guidance for general revegetation projects (National Park Service 2006).

A variety of equipment designed specifically for planting the seeds of prairie plants is available, from hand-operated broadcast seeders to drills with openings of various sizes to accommodate different types of seed. Broadcast seeding does not put the seed into the soil, but on top of it, so some post-seeding treatment is required to increase the contact of the seed with the soil: raking and walking on small areas or light harrowing followed by cultipacking large areas. Drilling puts the seed into the soil, usually 0.25 inch (0.6 cm) but no more than 0.5 inch (1.2 cm) deep, with packing being part of the drilling process. Species whose seeds require light to germinate or are very small should not be drilled but broadcast. Drilling seed often results in visible rows of planted species, even years after planting, but this visual impact can be reduced by drilling in two directions (e.g., perpendicular to each other). Broadcasting does not result in rows because the seeds are scattered. When over-seeding, drilling with a no-till drill may be necessary in very dense vegetation in order to ensure seeds get contact with the soil. Site preparation depends on whether the planting is being done into bare soil or established vegetation. Bare soil plantings require thorough site preparation, some guidelines for which are found in the NRCS' *Herbaceous Vegetation Establishment Guide* (NRCS North Dakota 2011).

Plugs

Assuming there is adequate follow-up, a faster and more reliable method of establishing herbaceous species in plantings is to plant plugs – container-grown plants of various sizes. Planting plugs bypasses the most vulnerable stage of plant establishment from seed – emergence through the soil. Also, if they are mature enough, they have developed strong root systems that provide them some drought resistance. However, just as when transplanting plants into a flower or vegetable garden, the plugs must be planted correctly (correct depth, correct handling of roots and tops to avoid damage), and follow-up watering will be required in all but the wettest of FOUS growing seasons. Although planting plugs is more expensive than seeding, the benefits of starting with plants that can compete well against weeds or other established plants may outweigh the additional costs in certain situations. Plugs may be particularly useful for increasing the diversity of already-established grass plantings or for relatively small areas that can be watered regularly.

Transplants

Transplants are similar to plugs, but they are not necessarily container-grown. Transplants are the most common way of getting woody species established and have been used for trees and shrubs in the past at FOUS. A type of transplant that has not been used at FOUS is the sod transplant. In this method, a slab of soil and the plants growing in it is moved from one location to another. This method has been used in some of the oldest prairie restorations in the United States, including at Homestead National Monument in Nebraska (National Park Service 2011b) and Curtis Prairie in Wisconsin (Wegener et al. 2008), and it has also been used to salvage native plants and plant assemblages when a native grassland is destined for destruction. Although comparisons of methods and the results of such transplants are available for tallgrass prairie (e.g., Kearns 1983), little information on the use of this method in the mixed-grass prairie of the northern Great Plains is available. However, this method could be explored as a means for reducing the visible lines and differences in composition between planted fields in the upland terraces around the fort at FOUS. Sod could be swapped between fields with different composition (e.g., between Fields 6 and 7 or between Fields 6 and 8) or native sod could be brought from outside the park, such as from areas in which oil-drilling pads are being installed.

Any material from outside the park would have to be thoroughly inspected for noxious weeds and priority exotic plants before being cut from its origin, and it would have to be closely monitored after being installed in the park.

Like plugs, correct techniques (depth, loosening of root ball, etc.) and timing for planting transplants are essential, as is follow-up watering. Especially for woody species, which are generally not planted at the density that herbaceous species are, water-holding polymer gels in the soil around the roots of the transplant might be used to increase reduce the frequency of watering. Due to their expense, however, consultation with someone experienced with their use would be crucial for determining whether they would be cost-effective for planting situations at FOUS. Other methods for providing steady moisture for transplants, such as tree water bags or shelters, drip irrigation systems using a temporary water tank, etc., may be more cost-effective, and they warrant investigation for increasing the probability of transplant survival and growth. A wide variety of irrigation systems are described by Bainbridge (2007).

Planning

Regardless of the method used, all planting projects benefit strongly from advanced planning that includes:

- specific objectives for the planting;
- selection of species appropriate to the location and the objectives;
- cost-benefit analysis of potential methods;
- preparation of the planting site;
- optimal timing for planting;
- means for supplementary watering to ensure good establishment and/or survival;
- follow-up monitoring and weed control.

The desired conditions for a vegetation management area serve as the framework for specifying objectives for a planting project, but a single planting project may address only a portion of that desired condition or may be just a step towards achieving that condition. For example, for the terraces south of the Missouri River, the desired conditions call for dense shrub and tree cover. One planting project may focus on getting the trees established first, so that their early growth is not hampered by competition from shrubs. Including a specific time at which the planting is declared a success (meeting its objectives) or not eliminates ambiguity. For example, an objective of a planting may be to achieve a shrub layer with at least 60% canopy cover five years after the planting.

Once the objectives are set, the species to meet those objectives are selected. Although desired conditions for each management area do not prescribe a specific composition of native species, the success of a planting is generally higher when the species used are matched to the conditions in which they will be planted. For example, the natural habitat of some of the species planted in the 2006 over-seeding of the highest terraces is moist areas (Table 4), but those highest terraces are not moist. Similarly, the south terraces where young cottonwood trees have been planted may be too high above the water table for those cottonwoods to survive and thrive. In addition, consideration should be given to whether a selected species is known to occur naturally in west-central North Dakota. Although some species may do just fine out of their natural range, others may be limited by climatic conditions. On the other hand, temperatures are projected to increase

2-8º F (1-4º C) by 2030, and 4-12 º F (2-6º C) by 2099 (Ojima et al. 2002), so emphasis on species adapted to warmer and effectively drier conditions, as opposed to those near the southern or eastern edge of their range, would also be prudent.

Planted species are affected not only by soil, water level, and climate, but also in some cases by the effects of the species that previously occupied the location of the planting. In southeastern Montana, native vegetation showed little recovery after nine years of effective biological control of leafy spurge (Butler and Wacker 2010). In addition, evidence from one experiment (Jordan et al. 2008) suggests that, over time, smooth brome and crested wheatgrass affect the soil they grow in to their own benefit and to the benefit of each other, and that crested wheatgrass and leafy spurge affect the soil to the detriment of some native forbs. Three common native grasses – blue grama, green needlegrass, and prairie Junegrass – were not affected, however. Although much more research on this topic needs to be done, it does suggest that native grasses may have greater success than native forbs in plantings previously heavily infested by these invasive plants.

Planted species must also be appropriate for future management actions. Ecological niche theory suggests, and a variety of experiments have shown (Dukes 2001; Kennedy et al. 2002; Knops et al. 1999), that planting a mixture of species with a variety of habits (cool- and warm-season growth, tall and short stature, forbs and grasses) provides greater resistance to invasion than less diverse plantings. On the other hand, if it is difficult to establish that diversity, or, especially, if a strong invader threatens the planting, control of that invader is difficult to achieve without adversely affecting planted species with similar habits. For example, the most recent planting at FOUS used only warm-season grass species (Table 4) with the intention that invading smooth brome (and other cool-season grasses) could be treated with herbicide before the planted species emerge each spring. Close evaluation of this planting and follow-up exotics control will help determine whether this approach should be used elsewhere.

A thorough planting plan will also use the method with the greatest chance of success within the limits of feasibility. FOUS has extensive experience with seeding, which is often the most cost-effective method when starting from scratch (e.g., after a large area of an invasive plant species has been thoroughly killed). This situation will be fairly limited in the future at FOUS, however, provided that invasive plant management is maintained. Instead, reducing the visual impact of the patchwork of planted fields in the upland terraces vegetation management area and repairing smaller areas after invasive plant management will be more common. A thorough cost-benefit analysis of the various methods of planting described above *before* funding for a specific project is requested will increase the chances that more expensive, but more reliable, methods could be used. This analysis should include various options within the main planting methods, such as whether a cover crop or mulching should be used, broadcast seeding via hydromulching vs. drilling, etc.

Regardless of the type of planting that will be done, pre-planting invasive species control is a critical component of site preparation and planning. Multiple years of control may be necessary to sufficiently reduce live plants as well as rhizomes and seeds in the soil prior to planting. Ideally, this control will be extremely thorough in the planting area, since increased seed or rhizome production by remaining invasive plants may compensate for the reduction of the

number of plants standing (Ambrose and Wilson 2003). This control would ideally be done in the area surrounding the planting as well.

The optimal time for a planting will depend on the method and species used. General recommendations are that warm-season species be seeded in mid-late spring, whereas cool-season species can be seeded in early-mid spring, late summer, or late fall (NRCS North Dakota 2011). Sod transplants fare better when moved in relatively cool, overcast weather (Kearns 1983), and tree and shrub species have specific seasons when they should be transplanted. Means for supplementary watering include the polymer gels and tree bags mentioned above, as well as water tanks on UTVs or trucks, sprinklers, and drip irrigation hoses.

Post-planting monitoring would ideally be quantitative and designed so that results could be statistically evaluated. This is unlikely in many cases, however. Qualitative evaluation can be nearly as valuable when it is done at a designated time during the growing season at least once each year. Each evaluation would assess the vigor of the individuals or species planted (e.g., height of trees or shrubs, diameter of bunch grasses, percentage of individuals flowering for forbs, or a qualitative, subjective assessment of whether the individual or species is likely to survive to the next growing season), the abundance of unwanted species, and whether the planting has reached its objectives. Haphazard, anecdotal monitoring is the least desirable type of follow-up, but it is better than no follow-up monitoring at all. Follow-up weed control, even around tree transplants, reduces competition from those weeds for the planted species and is essential in ensuring the success of any planting, so funding for this should be included in the financial planning of the project.

Sources of More Detailed Information for Planting

The USDA-NRCS electronic Field Office Technical Guide for Range Plantings in North Dakota (NRCS North Dakota 2010) provides a substantial amount of information regarding appropriate species, timing, and post-planting weed control for seeding projects. The information in these guides should be tempered by local experience with individual species and methods, however. Other, general information regarding restoration is in books such as *The Tallgrass Restoration Handbook* (Packard and Mutel 1997) and *A Guide for Desert and Dryland Restoration* (Bainbridge 2007). Full-community restoration guides covering methods other than seeding for the northern Great Plains are rare, but relevant information is in published journals such as *Restoration Ecology*, *Ecological Restoration*, and *Rangeland Ecology and Management*. Local and state Extension agents and Natural Resources Conservation Service offices can provide supplemental, site-specific recommendations.

USDA-NRCS Plant Materials Centers

A valuable source of information and plant material for NPS units is the Plant Material Center in Bismarck, ND. An agreement between NPS and Plant Materials Centers exists in which a Plant Materials Center will work with an NPS unit to provide seed or plants. Collecting, cleaning, and increasing[j] seed from that collected within the park unit through this agreement provides plant material of the same genetic stock as the plants already growing in the park. Plant Materials Centers can also grow woody nursery stock for transplanting.

[j] Planting in fields and collecting the seed produced from those plants over a number of years.

Manual and Mechanical Methods

Manual and mechanical methods are useful for two types of vegetation management at FOUS, exotic plant control and shaping vegetation structure.

Exotic Plant Control

The NGP EPMP broadly describes manual (by hand or with hand tools) and mechanical (machine-assisted) methods for managing exotic plants. At FOUS, the primary uses of these methods have been the control of Russian olive trees (cutting down trees followed by herbicide application to cut stumps) and mowing weeds in plantings (Table 3). Although generally not as effective as chemical or biological control methods for most herbaceous species, manual and mechanical methods alone could be the optimal tool in areas with high risk for non-target damage (e.g., in the Bodmer Overlook Unit where high-quality native prairie remains). For example, small infestations of weedy annuals could be hand-pulled. Care should be taken to minimize the disturbance of soil in these situations, however, to avoid providing more habitat amenable to the same or other weedy species. Soil loosened and exposed by uprooting plants could be packed down and covered with litter from surrounding native prairie to reduce this habitat.

Except for annual and biennial species, manual and mechanical methods generally do not kill exotic species. However, these methods can be used over time to decrease the vigor of these plants so that, when competition from other species is adequate, they are reduced or eliminated from an area. Smooth brome may be one of these species. In tallgrass prairie, well-timed mowing of smooth brome when it is in the "boot" stage (its flowering head is still enclosed in the sheath) each year, or more frequent mowing, may be effective in controlling smooth brome (Sather 1987), but evidence for this control in mixed grass plantings is not strong. Evidence from one study near Mandan, North Dakota, suggests that, in dry years, haying (mowing followed by removal of the cut material) while smooth brome is in its vegetative stage (10-15 cm tall) will reduce smooth brome more so than just mowing, but neither will affect smooth brome much in wetter years (Hendrickson and Lund 2010).

Other Vegetation Management Purposes

Mechanical methods are also important tools for manipulating the structure (height, density) and composition (relative abundance of species) of vegetation. Brush hogs, chain saws, and other heavy duty cutting tools can be used to reduce the height and/or density of trees and shrubs and would be reasonable tools for manipulating forest structure in the area between the fort and the Missouri River. Mowing and haying can be used to reduce the occurrence of woody species in grasslands if the woody individuals are relatively small. Mowing and haying can also be used to keep grass and forb height at a desired level, such as to reach the short stature of the desired conditions for the upland terraces surrounding the fort. Depending on the frequency and timing of mowing or haying, these methods can also shift the composition of the vegetation. When short-statured grass species such as blue grama or buffalograss are present in mixed-grass prairie, mowing repeatedly through the growing season can produce a short-grass lawn (A. Symstad, pers. observation).

Mowing and haying may have different effects, since haying removes the cut material from the site, whereas mowing does not. Leaving the cut material in place allows a thatch layer to build

up, particularly if the material is not cut into pieces small enough to decompose quickly. Depending on its depth, thatch can hinder the growth of some species, such as those that need light to germinate (this includes many annual weeds) or that do not have strong enough shoots to penetrate a thick litter layer. In contrast, thatch may aid other species by reducing soil temperatures and/or evaporation, and therefore increasing soil moisture. This has been demonstrated at Badlands National Park for Japanese brome (*Bromus arvensis*; Whisenant and Uresk 1990), an exotic annual grass currently relatively uncommon at FOUS (Appendix A, D). Cheatgrass (*B. tectorum*), which is more common at FOUS (Appendix A), would likely be similarly affected due to the substantial similarities in ecology of the two species. Consequently, the decision of whether to mow or hay a given area must take into account which species, both desirable and undesirable, are present and their relative abundance.

Prescribed Fire

As discussed above ("Factors that Shaped the Native Vegetation"), fire is a natural part of the mixed-grass prairie ecosystem in the northern Great Plains. Consequently, eliminating fire from the system can have adverse effects, including the increase of native trees and shrubs and exotic species of all types (Kirsch and Kruse 1973; Whisenant and Uresk 1990). A large literature on the effects of fire in mixed-grass prairie provides guidance for planning prescribed fire activities to achieve certain vegetation management objectives (see Bragg and Steuter 1996; Grace and Zouhar 2008; Hendrickson and Lund 2010; Higgins et al. 1989; Scheintaub et al. 2009; Symstad and Jonas in press; Vermeire et al. 2011 and the references in all of these). In general, fire has the most detrimental effects on a perennial species when the species is burned early enough in the growing season that its root reserves are still low but late enough that growing, green vegetation will be removed. Therefore, the timing of prescribed fires are usually planned in relation to when cool- or warm-season grasses are growing in order to favor one over the other. When applied at the optimal time for a specific objective, fire can have substantial impacts on, for example, smooth brome vigor (Willson and Stubbendieck 1997, 2000). When using fire to achieve objectives like this, it is important to realize that negative fire impacts on an individual species result in shifting the composition of vegetation only if desirable species are present in sufficient amounts to replace the species targeted for injury (Grace and Zouhar 2008).

The literature also shows that fire effects in the northern Great Plains vary considerably due to differences in vegetation condition (e.g., "pristine" to heavily invaded by cool-season exotic grasses), the time of burning within the growing season, fire behavior, weather conditions (e.g., wet vs. dry years), and post-fire management. This variability must be acknowledged in practice, when limitations in staff, equipment, and weather opportunities for safe fire application often prevent prescribed burning from taking place at the optimal time. Consequently, prescribed fire cannot be relied upon as a precision tool for manipulating species composition or the abundance of a single target species in established grasslands.

On the other hand, fire *is* a reliable tool for reducing the amount of standing and fallen litter in grasslands. Haying can do this too, but it does not have the same effect on nutrient cycling as fire, which rapidly releases some of the nutrients tied up in that litter so that it is accessible to plants and microbes in the burned area. In addition, fire can be used in areas where mowing or haying cannot, such as in the hills of the Bodmer Overlook Unit. Thus, fire is most effective as a management tool for controlling litter, which, as discussed above, does affect vegetation composition. Litter accumulations in the northern mixed-grass prairie stabilize five to six years

after burning (Abougendia and Whitman 1979; Dix 1960). A fire-return interval shorter than this would maintain relatively low litter levels. Of course, fire can only be applied as frequently as there is sufficient fuel (litter) to carry that fire, so annual fires may not be possible in this semi-arid system. In addition, monitoring of fire effects in northern Great Plains NPS units shows a consistent decrease in grass cover for the growing season immediately following a fire, but a return to pre-fire cover by the second year (Wienk et al. 2009). Published studies from a broader geographic area support this, with fire in mixed- and shortgrass prairies having a neutral to negative effect on aboveground biomass production in 85% of the studies (Scheintaub et al. 2009). Thus, fire could also be used as a tool to manipulate grassland structure.

The inconsistency of fire effects on mixed-grass prairie composition demonstrated in the literature may actually be used as a management tool if a vegetation management goal is to increase heterogeneity, as is the case in the upland terraces surrounding the fort. Prescribed fire applied in patches that do not match existing patch structure in this area, and applied to different patches at different times of the year or in different burning conditions should eventually create a more natural-appearing grassland in this management unit.

When using fire for any goal or objective, care should be taken to avoid practices that counteract other vegetation management objectives. Smooth brome invasion may sometimes be enhanced by fire, such as when early spring or fall burning promotes sprouting from rhizomes by removing litter from sod-bound plants (Howard 1996). Although fire can initially decrease the abundance of cheatgrass and Japanese brome, any plants that do emerge after a fire may produce substantially more seeds per individual if the fire sufficiently reduces competition from other species (Young and Evans 1978). Thus, areas in which fire severity is high (such as in areas with high fire residence time due to down and dead woody fuel), may be hot spots for seed production of these two species.

Grazing

As described above, ungulate grazing is an important natural and historical component of the vegetation at FOUS. Using domestic livestock grazing[k] as a management tool in NPS units is complicated, but allowed; NPS regulations state, "The Park Service will only allow agricultural grazing in parks where it is:

- specifically authorized by federal law, or
- required under a reserved right of use arising from the acquisition of a tract of land, or
- required to maintain an historic scene, or
- carried out as part of a living exhibit or interpretive demonstration; or
- used to achieve resource conditions (e.g., using sheep to remove leafy spurge) as part of an IPM plan, and
- does not cause unacceptable impacts on park resources and values" (National Park Service 2006, Section 8.6.8.2).

Ecological site descriptions compiled by the NRCS summarize expected effects of different types of grazing management on native plant communities in the FOUS area (Appendix B). In

[k] Wild ungulate grazing at FOUS is unrealistic because of its small size.

general, heavy grazing at the same time each year or continuous, season-long grazing will tend to drive the vegetation towards shorter-statured and/or less palatable species. These summaries are most relevant to the Bodmer Overlook Unit, where much of the vegetation is comprised of the native plant communities on which the models used in the ecological site descriptions are based. Because the composition of each planted field in the upland terraces surrounding the fort and elsewhere does not fit well into the models, predicting the effects of grazing on plant composition in these areas is more difficult than for native communities. For example, fields 7 and 8 are strongly dominated by palatable, taller stature grass species (western wheatgrass and green needlegrass) and have little or no smaller-statured native grass species (such as blue grama; Appendix D). It is unclear whether the taller grasses would remain dominant under heavy grazing pressure, short-statured species would spread from other fields into these, or potentially undesirable species would increase. Nonetheless, if used and monitored properly, grazing could be a valuable vegetation management tool at FOUS because it has different effects than other management tools.

Specifically, other than treating individual plants, grazing is the most selective vegetation management tool. Fire and mowing/haying impact everything in their path, and even the most selective herbicides impact a broad spectrum of species (National Park Service Northern Great Plains Parks 2005a). Except when forage is extremely limited, grazers actively choose what they eat, leaving poisonous, spiny, tough, less nutritious, or otherwise distasteful species relatively untouched. Over time, this can have significant effects on the relative abundance of different species (Augustine and McNaughton 1998; Appendix B). This selectivity, combined with varying animal behavior impacts, can make grazing impacts more spatially heterogeneous than those of fire or mowing/haying (Veen et al. 2008), leaving plants of various heights within a patch or patches of varying heights. This degree of heterogeneity depends on how the grazing is managed, however.

Using the interaction of fire and grazing is an approach often advocated for increasing heterogeneity in grazed landscapes (Fuhlendorf and Engle 2001; Fuhlendorf and Engle 2004; Fuhlendorf et al. 2009; Toombs et al. 2010; Vermeire et al. 2004). Ungulate grazers are attracted to the higher quality (more nutritious) plant material in recently burned areas, so they spend more time foraging there than in nearby unburned areas, keeping litter levels, and therefore the recurrence of fire, low in these areas. Grazing pressure in these areas affects vegetation structure and, eventually, composition, so that they differ from the unburned areas. Grazing pressure can be shifted to a different location by burning in a new area. This approach may not be feasible at FOUS because of its small management units, but the effects of fire and grazing on each other and on the vegetation would still need to be considered if grazing were to be used as a management tool at FOUS.

Some decisions and issues that would have to be addressed in order to implement domestic livestock grazing at FOUS include:

- species of livestock (cattle, sheep, goats, horses),
- areas to be grazed,
- spatial pattern of timing and duration of grazing (e.g., rotating pastures vs. not),
- fencing and water source(s),
- exotic species prevention measures.

Monitoring, Adaptive Management, Record-Keeping, and Evaluation

Monitoring is a critical component of any management plan for two main reasons: (1) to evaluate whether implementing the plan is having the desired results, and (2) to learn how to change the plan if it is not. The NPS Northern Great Plains Inventory and Monitoring Program (NGPN) will provide a major part of the monitoring for this plan. In the process of developing this plan, it became clear the the NPGN vegetation monitoring planned to begin in 2011 at FOUS could be improved slightly over that described in the NPGN vegetation monitoring protocol (Symstad et al. 2011) to better meet the monitoring needs for future vegetation management at FOUS. Specifically, the original reference frame for plant community composition and structure monitoring at FOUS covered the whole park (excluding developed areas), with the Bodmer Overlook Unit as a separate stratum from the rest of the park. After careful consideration of the desired conditions for each management area, the utility of the NGPN monitoring methods for evaluating progress towards those conditions, and the implications of various monitoring plot distribution options for statistical power to detect trends in parameters included in the desired conditions, FOUS and NGPN staff decided to refine this reference frame so that NGPN monitoring would occur only in the Bodmer Overlook Unit and in the Upland Terraces management areas (Figure 8). This required a new random draw of plot locations, different from the 2008 draw used for locating plots sampled in July 2010 for this plan, for the Upland Terraces management area. Locations of these new plots are shown in Figure 11.

Monitoring is an essential part of adaptive management, which NPS policy encourages when it is appropriate (National Park Service 2006; Section 2.3.4). The Department of the Interior's technical guide on adaptive management (Williams et al. 2007) summarizes the approach into five iterative steps:

1. Engage stakeholders in exploring alternative ways to meet management objectives.
2. Predict the outcomes of alternatives based on the current state of knowledge.
3. Implement one or more of these alternatives.
4. Monitor to learn about the impacts of the management actions.
5. Use the results to update knowledge and adjust management actions.

Furthermore, the technical guide (p. vi) states that this approach is appropriate when:

1. some kind of management decision is to be made,
2. stakeholders can be engaged,
3. one or more management objectives can be stated explicitly,
4. decision-making is confounded by uncertainty about potential management impacts,
5. resource relationships and management impacts can be represented by models,
6. monitoring can be designed to inform decision-making,
7. progress can be measured in achieving management objectives,
8. management action can be adjusted in response to what has been learned, and
9. the whole process can proceed in full compliance with all relevant laws, regulations, and authorities.

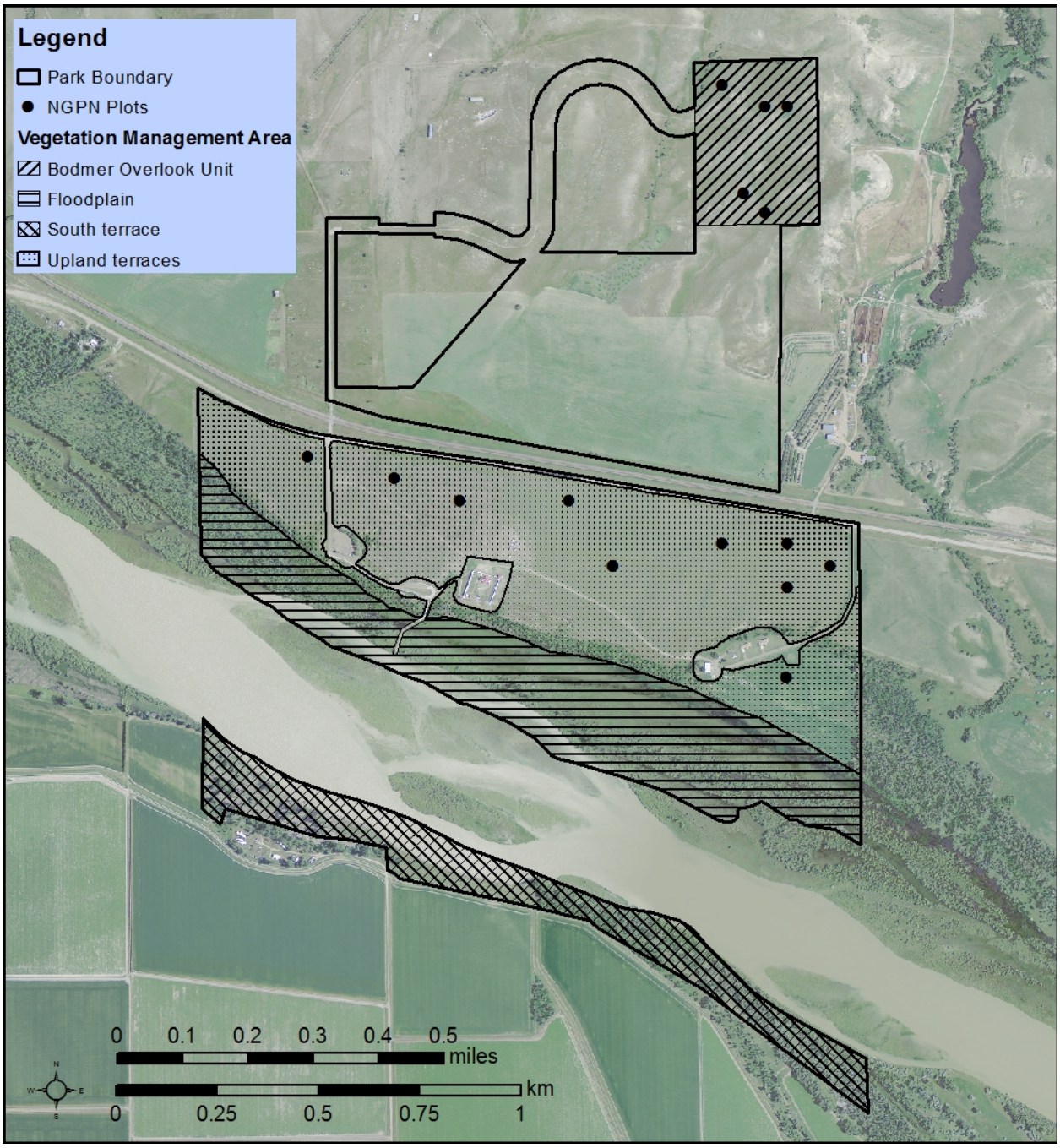

Figure 11. Location of permanent plots in which vegetation will be monitored by the NPS Northern Great Plains Inventory and Monitoring program.

Some of the vegetation management actions in this plan meet these criteria. In fact, NPS policy would require this approach if agricultural grazing were to be used (National Park Service 2006; Section 8.6.8.2). Many other vegetation management actions in this plan do not warrant an adaptive management approach because there is little uncertainty about potential management impacts (e.g., cutting trees down in the forest will reduce the visual barrier between the fort and

the river). Although monitoring is a required component of adaptive management, an adaptive management program is not the only time that monitoring is warranted.

In the following subsections, management practices that are currently used or could be used in the future to reach the desired conditions for each vegetation management area at FOUS (Figure 8) are described and linked to monitoring options. The situation in each management area is also evaluated for whether a formal adaptive management approach would be appropriate, and predicted outcomes that could be tested by that approach are listed.

Two management practices will be applied throughout the park: preventative measures (for exotic species and vegetation disturbance) and appropriate treatment of noxious weeds and priority exotic species. Although they are not listed for each vegetation management area below, they are crucial for all of the management areas.

Upland Terraces Surrounding the Fort

Elements of desired conditions to work toward and monitor are:

- heterogeneity within planted fields,
- degree to which planted field boundaries can be seen on the ground and from the fort,
- growth form composition,
- noxious weed cover,
- primary exotic species cover,
- herbaceous vegetation height,
- litter depth,
- bare ground cover,
- tree cover.

Monitoring options to evaluate progress towards these elements for the entire vegetation management area are:

- photographs in fixed directions from fixed points along field edges, from the widow's walk on top of the fort, and from the fort's river-side entrance in late July of each year;
- priority exotic species surveying and mapping at least once each growing season;
- NGPN plant community composition and structure monitoring in permanent NGPN plots (Symstad et al. 2011; Figure 11) for growth form composition, noxious weed and priority exotic species cover, litter depth, and bare ground cover;
- vegetation height-density measures, such as with a Robel pole (Benkobi et al. 2000), for herbaceous vegetation height.

Management practices include:

1. Planting
    a. seeds in areas disturbed by construction, exotic plant control, or other activities;
    b. plugs of desired species in small disturbed areas for revegetation;
    c. plugs of desired species in concentrated patches within established plantings;
    d. sod transplants from outside the park to revegetate disturbed areas; and/or
    e. sod swapped among established plantings.
2. Mowing or haying
    a. the entire management area 3-4 times a growing season;

    b. in irregularly shaped patches not corresponding to existing field boundaries; and/or
    c. only once in the growing season at a specified time.
3. Prescribed fire
    a. throughout the management area and/or
    b. in irregularly shaped patches not corresponding to existing field boundaries.
4. Grazing throughout the management area.
5. Cutting trees between the fort and the river to ensure a clear view of the Missouri River from the fort.

In addition to the monitoring described for the whole management areas, monitoring options to evaluate the effectiveness of these practices include:

- qualitative evaluation or quantitative evaluation of seedling emergence 2-4 weeks after growing-season planting or in spring following dormant-season planting (1a);
- qualitative or quantitative evaluation of survival and establishment 2 months after planting (1a-e);
- thorough inspection for priority exotic species at least once (July or August) each growing season for three years after planting (1a-d).

A formal adaptive management approach would be required if grazing were used and would be warranted for practices not used at FOUS before, such as concentrated plug planting (1c), sod transplants (1d, 1e), and mowing, haying, or burning in different seasons or with different frequencies. Management practices and their hypothesized outcomes that could be evaluated include:

1. Planting plugs of desired species in concentrated patches within established plantings results in at least 50% survival of the plugs in the first year, continued presence of the planted species in the planted area at least three years after the planting, and expansion of the planted species out of the planted area by five years after the planting.
2. Swapping sod among established fields increases heterogeneity within fields and reduces sharp boundaries between fields.
3. Mowing the entire management area 3-4 times each growing season results in shorter vegetation overall, greater dominance of short-statured native grass species, such as blue grama, and reduced abundance of smooth brome and tall-statured weeds (e.g., mustard species, kochia, Russian thistle) throughout the unit.
4. Mowing or haying the entire management area in early summer (mid-late June) each year results in reduced seed stalk production by tall cool-season grasses, such as western wheatgrass and green needlegrass, and therefore shorter-statured grassland in areas where these species are dominant, but little change in areas where warm-season grasses dominate.
5. Mowing or haying the entire management area in late summer (August) each year results in shorter-statured grassland for the rest of that growing season and early in the next growing season, but little change in species composition.
6. Burning the entire management area in spring or fall every 3-5 years results in a one-year reduction in standing and down litter, as well as a one-year reduction in height and cover of green vegetation, but little change in species composition.

7. Burning the entire management area in summer every 3-5 years results in greater heterogeneity of vegetation composition and height within fields.
8. Mowing, haying and/or burning in irregularly shaped patches not corresponding to existing field boundaries once a year but in different locations each year (some overlap from one year to the next) results in greater heterogeneity of composition and structure within fields and reduction of visible boundaries between fields.
9. Heavy, continuous (multi-year) grazing at any time during the growing season or moderate continuous grazing every spring results in shorter plants, reduced dominance of native and exotic cool-season grasses, increased dominance of native warm season grasses, increased composition and structure heterogeneity within fields, and decreased differences in composition and structure among fields.

Bodmer Overlook Unit

Elements of desired conditions to work toward and monitor are:

- growth form composition,
- noxious weed cover,
- primary exotic species cover,
- herbaceous vegetation height,
- litter depth,
- bare ground cover.

Monitoring options to evaluate progress towards these elements for the entire vegetation management area include:

- priority exotic species surveying and mapping at least once each growing season;
- NGPN plant community composition and structure monitoring in permanent NGPN (Symstad et al. 2011; Figure 11) plots for growth form composition, noxious weed and priority exotic species cover, litter depth, bare ground cover, and vegetation height;
- GPSing boundaries of crested wheatgrass stands at regular (2-3 year) intervals to determine trends in crested wheatgrass extent and whether it is encroaching into native prairie.

Management practices include:

1. Planting
    a. seeds in areas after exotic plant control and/or
    b. plugs of desired species after exotic plant control.
2. Prescribed fire throughout the management area.
3. Light grazing throughout the management area.

In addition to the monitoring described for the whole management areas, monitoring options to evaluate the effectiveness of these practices include:

- qualitative evaluation or quantitative evaluation of seedling emergence 2-4 weeks after growing-season planting or in spring following dormant-season planting (1a);
- qualitative or quantitative evaluation of survival and establishment 2 months after planting (1a, 1b).

A formal adaptive management approach would be required if grazing were used, and it could be warranted for evaluating the effectiveness of prescribed fire and/or herbicide applications in preventing the spread of crested wheatgrass or other priority exotic species into native prairie. Management practices and their hypothesized outcomes that could be evaluated include:

1. Prescribed fire applied when crested wheatgrass is growing but before most native species have broken dormancy, every 2-3 years, results in reduced density and extent of crested wheatgrass and reduced abundance of shrubs and trees.
2. Light grazing throughout the management area maintains relatively shallow litter depth and current species composition.

Riparian Floodplain North of the Missouri River

Elements of desired conditions to work toward and monitor are:

- noxious weed cover
- tree height in front of the fort
- a mixture of riparian floodplain vegetation types.

The main management practice outside of priority exotic species control would likely be cutting trees to maintain a clear view of the Missouri River from the fort.

Monitoring options to evaluate progress towards these elements for the entire vegetation management area are:

- photographs in one or more fixed directions from the fort's river-side entrance in late July of each year;
- priority exotic species surveying and mapping in accessible areas at least once each growing season;
- examining remote photographic imagery every 5-10 years for broad vegetation classes (e.g., forest vs. herbaceous vs. sandbar), most likely in cooperation with the NGPN land use/land cover vital sign monitoring.

An adaptive management approach is not warranted for this unit.

Terraces South of the Missouri River

Elements of desired conditions to work toward and monitor are:

- height, density, and cover of woody vegetation;
- effectiveness of woody vegetation in blocking view of agriculture and other development;
- noxious weed cover.

Monitoring options to evaluate progress towards these elements for the entire vegetation management area include:

- photographs in fixed directions from fixed points in late July of each year;
- priority exotic species surveying and mapping at least once each growing season.

Management practices include:

1. planting seedlings, saplings, and cuttings of desired tree and shrub species;

2. mowing, weed whacking, and other manual methods of reducing competition from grasses and forbs around planted trees and shrubs.

In addition to the monitoring described for the whole management areas, one monitoring option to evaluate the effectiveness of these practices is qualitative or quantitative evaluation of survival and establishment of planted individuals at least once each growing season after planting. An adaptive management approach would be warranted in this management area only if new methods with great uncertainty about their results were tried. However, given the limited success of previous tree- and shrub-planting efforts in the management area, stronger planning is needed. This planning requires procuring means for consistent, frequent, follow-up watering and weed management in the planted areas for at least two years after the planting.

Record-Keeping

Accurate and complete record-keeping of vegetation management actions provides the basis for justified decision-making in the future. Records prevent the loss of understanding of practices that did and did not work in the past, of why certain vegetation is in the state it is in, or the reasoning for why specific management actions were taken. Types of records to be kept in an organized fashion include (but are not limited to):

1. *Implementation plans and related materials for individual planting projects.* Related materials include seed packing slips (to show what was delivered, not ordered); notes on how the implementation deviated from the plan (this can be done right on the plan itself in annotations); notes on weather before and after the implementation; notes on anything that may have affected the planting in an unexpected way.
2. *Monitoring results for individual planting projects.* Qualitative monitoring results can be kept journal-style, quantitative results in simple spreadsheets.
3. *Spatial data on exotic plant extent and control*. The NGP EPMT is required to record spatial data for all of its control activities, but if park staff engage in exotic plant mapping or control activities on their own or through a contractor, spatial information resulting from those activities can be kept by drawing on paper maps (and later digitized) or using a GPS (recreation-grade is sufficient for many purposes) and downloading files to a Geographic Information System (GIS).
4. *Photographs.* A standard naming convention for photographic files that includes the location from which the photo was taken, the compass direction in which it was taken, and the date on which it was taken ensures that photographs can be used for the purpose for which they were taken and for other purposes in the future.
5. *Form-style records of management activities that do not have written plans.* For example, mowing or haying is unlikely to require a formal plan, but written documentation of how, when, where, and why it was done may help explain the state of vegetation in the future. An example form to use for such records is in Appendix F.

Evaluation

Regularly scheduled evaluation of the progress of vegetation management towards achieving the desired conditions will enable park managers to correct course, if necessary, in a timely manner. Evaluating every five years would take full advantage of the five-year monitoring cycle followed by the NGPN program. Consistently preparing and following project plans, monitoring

schedules, and record-keeping procedures will streamline this evaluation process. Evaluation could be done solely by park staff, but it would strongly benefit from outside expertise.

Literature Cited

Abougendia, Z. M., and W. C. Whitman. 1979. Disappearance of dead plant material in a mixed grass prairie. *Oecologia* 42:23-29.

Allison, S. K. 2002. When is a restoration successful? Results from a 45-year-old tallgrass prairie restoration. *Ecological Restoration* 20:10-17.

Ambrose, L. G., and S. D. Wilson. 2003. Emergence of the introduced grass *Agropyron cristatum* and the native grass *Bouteloua gracilis* in a mixed-grass prairie restoration. *Restoration Ecology* 11:110-115.

Anderson, R. C. 2006. Evolution and origin of the Central Grassland of North America: climate, fire, and mammalian grazers. *Journal of the Torrey Botanical Society* 133:626-657.

APRS Implementation Team. 2000. Alien plants ranking system version 5.1. U.S. Geological Survey Northern Prairie Wildlife Research Center, Jamestown, North Dakota. Available from http://www.npwrc.usgs.gov/resource/literatr/aprs/index.htm (accessed 11 May 2011).

Augustine, D. J., and S. J. McNaughton. 1998. Ungulate effects on the functional species composition of plant communities: Herbivore selectivity and plant tolerance. *Journal of Wildlife Management* 62:1165-1183.

Bainbridge, D. A. 2007. A guide for desert and dryland restoration: new hope for arid lands. Island Press, Washington, D.C.

Benkobi, L., D. W. Uresk, G. L. Schenbeck, and R. M. King. 2000. Protocol for monitoring standing crop in grasslands using visual obstruction. *Journal of Range Management* 53:627-633.

Biondini, M. E., A. A. Steuter, and R. G. Hamilton. 1999. Bison use of fire-managed remnant prairies. *Journal of Range Management* 52:454-461.

Bragg, T. B., and A. A. Steuter. 1996. Prairie ecology – the mixed prairie. Pages 53-65 *in* F. B. Samson and F. L. Knopf, editors. Prairie Conservation: Preserving North America's Most Endangered Ecosystem. Island Press, Washington, D.C.

Bronick, C. J., and R. Lai. 2005. Soil structure and management: a review. *Geoderma* 124:3-22.

Brown, P., and C. Sieg. 1999. Historical variability in fire at the ponderosa pine - Northern Great Plains prairie ecotone, southeastern Black Hills, South Dakota. *Ecoscience* 6:539-547.

Burke, I. C., W. K. Lauenroth, and D. P. Coffin. 1995. Soil organic matter recovery in semiarid grasslands: Implications for the Conservation Reserve Program. *Ecological Applications* 5:793-801.

Butler, J. L., and S. D. Wacker. 2010. Lack of native vegetation recovery following biological control of leafy spurge. *Rangeland Ecology & Management* 63:553-563.

Detling, J. K. 1998. Mammalian herbivores: ecosystem-level effects in two grassland national parks. *Wildlife Society Bulletin* 26:438-448.

Dix, R. L. 1960. The effects of burning on the mulch structure and species composition of grasslands in western North Dakota. *Ecology* 41:49-56.

Drijber, R. A., J. W. Doran, A. M. Parkhurst, and D. J. Lyon. 2000. Changes in soil microbial community structure with tillage under long-term wheat-fallow management. *Soil Biology and Biochemistry* 32:1419-1430.

Dukes, J. S. 2001. Biodiversity and invasibility in grassland microcosms. *Oecologia* 126:563-568.

Foster, B. L., K. Kindscher, G. R. Houseman, and C. A. Murphy. 2009. Effects of hay management and native species sowing on grassland community structure, biomass, and restoration. *Ecological Applications* 19:1884-1896.

Foster, B. L., C. A. Murphy, K. R. Keller, T. A. Aschenbach, E. J. Questad, and K. Kindscher. 2007. Restoration of prairie community structure and ecosystem function in an abandoned hayfield: a sowing experiment. *Restoration Ecology* 15:652-661.

Fuhlendorf, S. D., and D. M. Engle. 2001. Restoring heterogeneity on rangelands: Ecosystem management based on evolutionary grazing patterns. *Bioscience* 51:625-632.

Fuhlendorf, S. D., and D. M. Engle. 2004. Application of the fire-grazing interaction to restore a shifting mosaic on tallgrass prairie. *Journal of Applied Ecology* 41:604-614.

Fuhlendorf, S. D., D. M. Engle, J. Kerby, and R. Hamilton. 2009. Pyric herbivory: Rewilding landscapes through the recoupling of fire and grazing. *Conservation Biology* 23:588-598.

Gitzen, R. A., M. Wilson, J. Brumm, M. Bynum, J. Wrede, J. J. Millspaugh, and K. J. Paintner. 2010. Northern Great Plains Network Vital Signs Monitoring Plan. Natural Resource Report NPS/NGPN/NRR--2010/186. National Park Service, Fort Collins, Colorado.

Gleason, H. A. 1926. The individualistic concept of the plant association. *Bulletin of the Torrey Botanical Club* 53:7-26.

Godfread, C. 2004. Plant inventory at Fort Union Trading Post National Historic Site 2003-2004: Final Report. Unpublished Report, Bismarck, North Dakota.

Grace, J. B., and K. Zouhar. 2008. Fire and nonnative invasive plants in the Central Bioregion. Pages 113-140 *in* K. Zouhar, J. K. Smith, S. Sutherland and M. L. Brooks, editors. Wildland fire in ecosystems: fire and nonnative invasive plants. Gen. Tech. Rep. RMRS-GTR-42-vol. 6. U.S. Department Forest Service, Rocky Mountain Research Station, Ogden, Utah.

Great Plains Flora Association. 1986. Flora of the Great Plains. University Press of Kansas, Lawrence, Kansas.

Gustafson, D. J., D. J. Gibson, and D. L. Nickrent. 2004a. Competitive relationships of *Andropogon gerardii* (Big Bluestem) from remnant and restored native populations and select cultivated varieties. *Functional Ecology* 18:451-457.

Gustafson, D. J., D. J. Gibson, and D. L. Nickrent. 2004b. Conservation genetics of two co-dominant grass species in an endangered grassland ecosystem. *Journal of Applied Ecology* 41:389-397.

Hendrickson, J. R., and C. Lund. 2010. Plant community and target species affect responses to restoration strategies. *Rangeland Ecology & Management* 63:435-442.

Heywood, J. S., and M. D. DeBacker. 2007. Optimal sampling designs for monitoring plant frequency. *Rangeland Ecology and Management* 60:426-434.

Higgins, K. F. 1986. Interpretation and compendium of historical fire accounts in the northern Great Plains. Resource Publication 161. U. S. Fish and Wildlife Service, Washington, D.C.

Higgins, K. F., A. D. Kruse, and J. L. Piehl. 1989. Effects of fire in the Northern Great Plains. Extension Circular 761. U.S. Fish and Wildlife Service and Cooperative Extension Service, South Dakota State University, Brookings, South Dakota.

High Plains Regional Climate Center 2011. Historical Climate Data Summaries web site. http://www.hprcc.unl.edu/data/historical/ (accessed 30 March 2011).

Howard, J. L. 1996. *Bromus inermis*. Fire Effects Information System web site. U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Fire Sciences Laboratory. Available from http://www.fs.fed.us/database/feis/plants/graminoid/broine/all.html (accessed 20 May 2011).

Hulbert, L. C. 1955. Ecological studies of *Bromus tectorum* and other annual bromegrasses. *Ecological Monographs* 25:181-213.

Invasive Plant Atlas. 2011. Invasive Plant Atlas of the United States web site. http://www.invasiveplantatlas.org/distribution.html (accessed 12 May 2011).

Johnson, J. R., and G. E. Larson. 1999. Grassland Plants of South Dakota and the Northern Great Plains. South Dakota State University, Brookings, South Dakota.

Jordan, N. R., D. L. Larson, and S. C. Huerd. 2008. Soil modification by invasive plants: Effects on native and invasive species of mixed-grass prairies. *Biological Invasions* 10:177-190.

Kearns, S. K. 1983. A comparison of transplanting times and methods for salvaging prairie forbs and grasses. Pages 197-200 *in* G. K. Clambey and R. H. Pemble, editors. The Prairie – Past, Present and Future: Proceedings of the Ninth North American Prairie Conference. Tri-College University Centre for Environmental Studies, Moorhead, Minnesota.

Kennedy, T. A., S. Naeem, K. M. Howe, J. M. H. Knops, D. Tilman, and P. Reich. 2002. Biodiversity as a barrier to ecological invasion. *Nature* 417:636-638.

Kindscher, K., and L. L. Tieszen. 1998. Floristic and soil organic matter changes after five and thirty-five years of native tallgrass prairie restoration. *Restoration Ecology* 6:181-196.

Kirby, D. 2010. The Northern Great Plains as viewed by the Lewis and Clark Expedition. *Rangelands* 32:2-4.

Kirsch, L. M., and A. D. Kruse. 1973. Prairie fires and wildlife. Pages 289-303 *in* Proceedings of the Tall Timbers Fire Ecology Conference. Tall Timbers Research Station, Tallahassee, Florida. p. 289-303.

Knops, J. M. H., D. Tilman, N. M. Haddad, S. Naeem, C. E. Mitchell, J. Haarstad, M. E. Ritchie, K. M. Howe, P. B. Reich, E. Siemann, and J. Groth. 1999. Effects of plant species richness on invasion dynamics, disease outbreaks, insect abundances and diversity. *Ecology Letters* 2:286-293.

Larson, D. L., J. B. Grace, P. A. Rabie, and P. Andersen. 2007. Short-term disruption of a leafy spurge (*Euphorbia esula*) biocontrol program following herbicide application. *Biological Control* 40:1-8.

Lauenroth, W. K., I. C. Burke, and M. P. Gutmann. 1999. The structure and function of ecosystems in the central North American grassland region. *Great Plains Research* 9:223-259.

MacDougall, A. S., S. D. Wilson, and J. D. Bakker. 2008. Climatic variability alters the outcome of long-term community assembly. *Journal of Ecology* 96:346-354.

Miller, A., and EPMT Evaluation Panel. 2011. Exotic Plant Management Teams 10-year program evaluation. National Park Service, Fort Collins, Colorado.

Murphy, R. K., and T. A. Grant. 2005. Land management history and floristics in mixed-grass prairie, North Dakota, USA. *Natural Areas Journal* 25:351-358.

National Park Service. 2001. Cultural Landscapes Inventory, Fort Union Trading Post National Historic Site. National Park Service Unpublished Report, Williston, North Dakota.

National Park Service. 2006. Management Policies 2006: The guide to managing the National Park System. National Park Service, Washington, D.C.

National Park Service. 2009. Interim technical guidance on defining meaninful desired conditions for natural resources. National Park Service Biological Resource Management Division, Fort Collins, Colorado.

National Park Service. 2011a. Northern Great Plains Network Park Species Lists web site. (http://science.nature.nps.gov/im/units/ngpn/inventory/parkspslists.cfm (accessed 2 May 2011).

National Park Service 2011b. Homestead National Monument web site. http://www.nps.gov/home/naturescience/ prairies.htm (accessed 17 May 2011).

National Park Service Midwest Region. 1999. Environmental Assessment for the Fire Management Program of Fort Union Trading Post National Historic Site North Dakota / Montana. National Park Service, Omaha, Nebraska.

National Park Service Northern Great Plains Parks. 2005a. Northern Great Plains Exotic Plant Management Plan and Environmental Assessment. National Park Service, Fort Collins, Colorado.

National Park Service Northern Great Plains Parks. 2005b. Northern Great Plains Exotic Plant Management Plan and Finding of No Significant Impact. National Park Service, Fort Collins, Colorado.

(NRCS) Natural Resources Conservation Service. 1997a. Bad River ecotype blue grama. NRCS Bismarck Plant Materials Center. Available from http://www.plant-materials.nrcs.usda.gov/pubs/ndpmcbr6147.pdf (accessed 30 November 2011).

(NRCS) Natural Resources Conservation Service. 1997b. National range and pasture handbook. Natural Resources Conservation Service, Grazing Lands Institute, Washington, D.C.

(NRCS) Natural Resources Conservation Service. 2003. Ecological Site Description Loamy R054XY031ND. Electronic Field Office Technical Guide web site. Available at http://efotg.sc.egov.usda.gov//references/public/ND/R054XY031N_loamy.pdf (accessed 1 December 2010).

(NRCS) Natural Resource Conservation Service. 2005. 'Lodorm' green needlegrass. NRCS Bismarck Plant Materials Center. Available from http://www.plant-materials.nrcs.usda.gov/pubs/ndpmcbr6147.pdf (accessed 30 November 2011).

NRCS North Dakota. 2010. Conservation Practice Standard: Range Planting. Natural Resources Conservation Service, Bismark, North Dakota. Available from http://efotg.sc.egov.usda.gov//references/public/ND/550_Standard.pdf (accessed 18 May 2011).

NRCS North Dakota. 2011. Herbaceous Vegetation Establishment Guide. Natural Resources Conservation Service, Bismark, Norht Dakota. Available from http://efotg.sc.egov.usda.gov/references/public/ND/Herbaceous_Veg_Est_Guide.pdf (accessed 18 May 2011).

NatureServe. 2011. NatureServe Explorer web site. http://www.natureserve.org/explorer/ (accessed 2 May 2011).

North Dakota Department of Agriculture. 2011. Noxious Weeds Team web site. http://www.agdepartment.com/Programs/Plant/NoxiousWeeds.html (accessed 2 May 2011).

Nuttall, T. 1918. The Genera of North American Plants, and a Catalogue of the Species to the Year 1817. D. Heartt, Philadelphia, Pennsylvania.

Ojima, D. S., J. M. Lackett, and the Central Great Plains Steering Committee and Assessment Team. 2002. Preparing for a chinging climate: the potential consequences of climate variability and change – central Great Plains. A report for the US Global Change Research Program. Colorado State University, Fort Collins, Colorado.

Omernik, J. M. 2007. Level III Ecoregions of the Continental United States. U.S. EPA National Health and Environmental Effects Laboratory, Corvallis, Oregon.

Packard, S., and C. F. Mutel, editors. 1997. The tallgrass restoration handbook: for prairies, savannas, and woodlands. Island Press, Washington, D.C.

Panjabi, A. 2005. Bird inventories and monitoring on National Park Service units in the northern Great Plains, 2002-2004: Final report. Rocky Mountain Bird Observatory, Brighton, Colorado.

Salas, D. E., and M. J. Pucherelli. 2003. USGS-NPS Vegetation Mapping, Fort Union Trading Post National Historic Site. Technical Memorandum 8260-02-08. Remote Sensing and GIS Group, Technical Service Center, Bureau of Reclamation, Denver, Colorado.

Sather, N. 1987. Element stewardship abstract for *Bromus inermis*. The Nature Conservancy, Fairfax, Virginia.

Scheintaub, M. R., J. D. Derner, E. F. Kelly, and A. K. Knapp. 2009. Response of the shortgrass steppe plant community to fire. *Journal of Arid Environments* 73:1136-1143.

Sluis, W. J. 2002. Patterns of species richness and composition in re-created grassland. *Restoration Ecology* 10:677-684.

Smith, B. E., J. L. Massie, and B. G. Blake. 2004. Inventory of reptiles and amphibians at seven National Park Service units in the northern Great Plains from 2002-2003. Final Report. Black Hills State University, Spearfish, South Dakota.

Stohlgren, T. J. 2007. Measuring plant diversity: lessons from the field. Oxford University Press, New York, New York.

Swearingen, J. M. 2007. Invasive plant species listed in comprehensive database. *ParkScience* 24.

Symstad, A. J., R. A. Gitzen, C. L. Wienk, M. R. Bynum, D. J. Swanson, A. D. Thorstenson, and K. J. Paintner. 2011. Plant community composition and structure monitoring protocol for the Northern Great Plains I&M Network: Version 1.00. Natural Resource Report NPS/NRPC/NRR--2011/291. National Park Service, Fort Collins, Colorado.

Symstad, A. J., and J. L. Jonas. In press. Incorporating biodiversity into rangeland health: Plant species richness and diversity in Great Plains grasslands. *Rangeland Ecology & Management*.

Toombs, T. P., J. D. Derner, D. J. Augustine, B. Krueger, and S. Gallagher. 2010. Managing for biodiversity and livestock. *Rangelands* 32:10-15.

Toupal, R. S., and K. Hollenback. 2009. Fort Union Trading Post Native American Oral Traditions, Final Report. National Park Service Unpublished Report, Williston, North Dakota.

Tu, M. 2003. Element stewardship abstract for *Elaeagnus angustifolia* L. Russian olive, oleaster. The Nature Conservancy, Arlington, Virginia.

U.S. Department of Agriculture. 2011. Plants Database web site. http://plants.usda.gov/ (accessed 4 May 2011).

Veen, G. F., J. M. Blair, M. D. Smith, and S. L. Collins. 2008. Influence of grazing and fire frequency on small-scale plant community structure and resrouce variability in native tallgrass prairie. *Oikos* 117:859-866.

Vermeire, L. T., J. L. Crowder, and D. B. Wester. 2011. Plant community and soil environment response to summer fire in the Northern Great Plains. *Rangeland Ecology & Management* 64:37-46.

Vermeire, L. T., R. B. Mitchell, S. D. Fuhlendorf, and R. L. Gillen. 2004. Patch burning effects on grazing distribution. *Journal of Range Management* 57:248-252.

Warren, L. G. K. 1875. Preliminary report of explorations in Nebraska and Dakota, in the Years 1855-'56-'57. Engineer Department, United States Army, Government Printing Office, Washington, D.C.

Wegener, M., P. Zedler, B. Herrick, and J. B. Zedler. 2008. Curtis Prairie: 75-year-old restoration research site. Leaflet 16. University of Wisconsin Arboretum, Madison, WI.

Weist, K. M., J. Lowe, E. E. Willard, and P. B. Wilson. 1980. Current and historic natural resources of the Fort Union Trading Post National Historic Site. University of Montana/University of Wyoming National Park Service Research Center, Laramie, Wyoming.

Whisenant, S. G., and D. W. Uresk. 1990. Spring burning Japanese brome in a western wheatgrass community. *Journal of Range Management* 43:205-208.

Wienk, C., A. Thorstenson, J. Freeman, and D. Swanson. 2009. Northern Great Plains Fire Ecology Program Review 1997-2007. National Park Service Unpublished Report, Omaha, Nebraska.

Williams, B. K., R. C. Szaro, and C. D. Shapiro. 2007. Adaptive management: The U.S. Department of the Interior technical guide. Adaptive Management Working Group, U.S. Department of the Interior, Washington, D.C.

Willson, G. D., and J. Stubbendieck. 1997. Fire effects on four growth stages of smooth brome (Bromus inermis Leyss.). *Natural Areas Journal* 17:306-312.

Willson, G. D., and J. Stubbendieck. 2000. A provisional model for smooth brome management in degraded tallgrass prairie. *Ecological Restoration* 18:34-38.

Young, J. A., and R. A. Evans. 1978. Population dynamics after wildfires in sagebrush grasslands. *Journal of Range Management* 31:283-289.

Zouhar, K. 2001. Cirsium arvense. Fire Effects Information System web site. U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Fire Sciences Laboratory. Available from http://www.fs.fed.us/database/feis/plants/forb/cirarv/all.html (accessed 20 May 2011).

Appendix A: Current and historical species for Fort Union Trading Post National Historic Site

The following pages list the vascular plant species associated with Fort Union Trading Post National Historic Site (FOUS). Current scientific name, common name, origin (native or exotic to North America), and range for each species throughout the main document and all appendices follow the U.S. Department of Agriculture's Plants Database website (http://plants.usda.gov/ accessed 21 December 2010). Current abundance and distribution in FOUS are according to Godfread (2004) unless the species is newly listed in 2010 (indicated by # after current abundance), in which case the abundance and distribution are according to observation of the author. If nomenclature differs between that used by Godfread (2004) and the USDA Plants Database, Godfread's name is noted in parentheses in the Current Scientific Name column. Current presence in park ("Present in Park" column) and the certainty of that presence follows that of the park's certified species list (National Park Service 2011). Species collected by F.V. Hayden in 1856 and reported in Warren (1875) as having a distribution that include the FOUS area are noted in the "Name in Hayden Report" column. These names are often quite different than current nomenclature, and the following sources were used to translate the historic names to current names:

Britton, N. L. and A. Brown. 1913. An Illustrated Flora of the Northern United States, Canada and the British Possessions, Volumes 1-3. Charles Scribner's Sons, New York, New York.

Duncan, T. 1980. A Taxonomic Study of the Ranunculus Hispidus Michaux Complex in the Western Hemisphere. University of California Publications in Botany, Volume 77. University of California Press, Berkeley, California.

Fenneman, J. 2010. E-Flora BC Vascular Plant Synonyms. *in* Klinkenberg, B. (editor). 2010. E-Flora BC: Electronic Atlas of the Plants of British Columbia. Lab for Advanced Spatial Analysis, Department of Geography, University of British Columbia, Vancouver, British Columbia. Available at http://www.geog.ubc.ca/biodiversity/eflora/SynonymsPartICuptoAsc.html (accessed 21 December 2010).

Gray, A. and others. (B. L. Robinson, editor). 1895-97. Synoptical Flora of North America. Harvard University Press, Cambridge, Massachusetts.

Jones, S. D., J. K. Wipff, and P. M. Montgomery. 1997. Vascular Plants of Texas: A Comprehensive Checklist Including Synonymy, Bibliography, and Index. University of Texas Press, Austin, Texas.

Umbanhower, C., Jr., M. Ojala, P. Jackson, S. Olson, A. Fedorowicz, K. Huber, A. Pyan, R. Huncosky, A. Rubasch, I. Peterson, N. Peterson. no date. Re-imaging Joseph N. Nicollet's Mapmaking Expeditions web site. http://www.stolaf.edu/academics/nicollet/geyerspecimensintro.html (accessed 21 December 2010).

U.S. Department of Agriculture. 2011. Plants Database web site. http://plants.usda.gov/ (accessed 4 May 2011).

Wikipedia. 2010. Carex douglasii web site. http://es.wikipedia.org/wiki/Carex_meekii (accessed 21 December 2010).

Distribution of some of the species ("Distribution Notes") listed in Warren (1875) suggest that there were some misidentifications or changes in nomenclature to substantial to be translated. If there are no notes about distribution, the species currently occurs in North Dakota or Montana. Other notes regarding these translations are indicated by superscripts following the current scientific name in the table:

*Species listed by Warren (1875) is likely a misnomer given current range of species documented in USDA Plants.
**Current range documented in USDA Plants suggests that the vague description of the historic location in Warren (1875) did not include Fort Union area.
***Considered a match between Warren (1875) historic record and current list although subspecies and/or variety do not match exactly.

Note that the taxonomy on blue flax has been confusing, with the native *Linum lewisii* var. *lewisii* being confused with the European *L. perenne* (Ogle et al. 2009). It seems safe to assume the native was the version collected by Hayden in 1856, and it is possible that the non-native was planted in the planted fields.

Other References:

Godfread, C. 2004. Plant inventory at Fort Union Trading Post National Historic Site 2003-2004: Final Report. Unpublished Report, Bismarck, North Dakota.

Ogle, D. G., L. St. John, J. S. Peterson, and D. J. Tilley. 2009. Plant guide for blue flax (*Linum perenne*) and Lewis flax (*L. lewisii*). USDA-Natural Resources Conservation Service, Idaho State Office. Boise, Idaho.

Warren, L. G. K. 1875. Preliminary report of explorations in Nebraska and Dakota, in the Years 1855-'56-'57. Engineer Department, United States Army, Government Printing Office, Washington, D.C.

Current scientific name	Common name	Present in Park	Origin	Current abundance in FOUS	Current distribution in FOUS	Name in Warren (1875)
Acer negundo	boxelder	yes	native	common	edge of river terrace	*Negundo aceroides* Moench
Achillea millefolium	western yarrow	yes	native	common	prairie hillsides	*Achillea millefolium* Linn.
Agastache foeniculum	fragrant giant hyssop	uncon-firmed	native (seed-ed)	rare[#]	planted field 1	
*Agrimonia parviflora**[?]	harvest lice	no		not listed	not listed	*Agrimonia parviflora* Ait.
Agropyron cristatum	crested wheatgrass	yes	exotic	abundant	roadsides, planted areas, prairie	
Agrostis gigantea	redtop	probably present	exotic	not listed	not listed	
Agrostis scabra	rough bentgrass	yes	native	common	roadsides	
Agrostis stolonifera	creeping bentgrass	yes	native	uncommon	moist edges of floodplain	
Alisma subcordatum	American water plantain	yes	native	uncommon	shoreline of backwater	*Alisma plantago* Linn.
Alisma triviale	northern water plantain	yes	native	uncommon	shoreline of backwater	
Allium textile	textile onion	yes	native	common	hilltops and slopes of Bodmer Overlook Unit	
Alopecurus aequalis	shortawn foxtail	yes	native	common	sandbars and riverbank	
Alyssum alyssoides	pale madwort	probably present	exotic	uncommon	planted fields 2, 4, 8, 9	
Alyssum desertorum	desert madwort	yes	exotic	rare	grass planting west of fort	
Amaranthus albus	prostrate pigweed	yes	exotic	uncommon	sandbars and along roadsides	*Amaranthus albus* Linn.
Amaranthus blitoides	mat amaranth	yes	exotic	uncommon	roadsides and disturbed sites	
Amaranthus retroflexus	redroot amaranth	yes	exotic	uncommon	roadsides and disturbed sites	
*Ambrosia ambrosioides**	ambrosia leaf bur ragweed	no		not listed	not listed	*Franseria ambrosioides* Cab.
Ambrosia artemisiifolia	annual ragweed	yes	native	common	road ditches and disturbed areas	
Ambrosia psilostachya	western ragweed	yes	native	common	disturbed areas	
Ambrosia trifida	giant ragweed	yes	native	uncommon	gravel pit	*Ambrosia trifida* Linn.

Current scientific name	Common name	Present in Park	Origin	Current abundance in FOUS	Current distribution in FOUS	Name in Warren (1875)
Amelanchier alnifolia	Saskatoon serviceberry	yes	native	uncommon	edge of wooded terrace	
*Amelanchier canadensis**	Canadian serviceberry	no		not listed	not listed	*Amelanchier Canadensis* Torr. and Gray
Amorpha fruticosa	desert false indigo	no	native	not listed	not listed	*Amorpha fruticosa* Linn.
Amorpha nana	dwarf false indigo	no	native	not listed	not listed	*Amorpha nana* Nutt.
Andropogon gerardii	big bluestem	yes	native	uncommon	prairie draw	
Androsace occidentalis	western rockjasmine	yes	native	uncommon	grass planting west of fort	
Anemone canadensis	Canadian anemone, meadow anemone	yes	native	uncommon	shrubby area of upper terrace	*Anemone Pennsylvanica* Lynn.
Anemone cylindrica	candle anemone	yes	native	uncommon	grassy draw, Bodmer Overlook Unit	
*Antennaria dioica**	stoloniferous pussytoes	no		not listed	not listed	*Antennaria dioica* R. Br.
Antennaria microphylla	littleleaf pussytoes	yes	native	uncommon	hilltop of Bodmer Overlook Unit	
Antennaria neglecta	field pussytoes	yes	native	uncommon	north slope of Bodmer Overlook Unit	
Antennaria parvifolia	small-leaf pussytoes	yes	native	uncommon	slopes	
*Antennaria plantaginifolia**	woman's tobacco	no		not listed	not listed	*Antennaria plantaginea* R. Br.
Apios americana	groundnut	no	native	not listed	not listed	*Apios tuberosa* Moench
Apocynum cannabinum	Indianhemp	yes	native	common	river floodplain terraces	*Apocynum cannabinum* Linn.
Arabis canadensis	sicklepod	no	native	not listed	not listed	*Arabis Canadensis* Linn.
*Arabis hirsuta****	hairy rockcress	yes	native	uncommon	upper edge of river terrace	*Arabis hirsuta* Scop.
Arabis holboellii	Holboell's rockcress	yes	native	uncommon	rocky hilltop of Bodmer Overlook Unit	
Arabis X *divaricarpa*	spreadingpod rockcress	yes	native	uncommon	prairie	
Arctium minus	lesser burrdock	yes	exotic	uncommon	wooded terrace south of river	
Argentina anserina	silverweed cinquefoil	yes	native	abundant	wet floodplain	
Aristida oligantha	prairie threeawn	no		not listed	not listed	*Aristida pallens* Nutt.
Aristida purpurea var. *longiseta*	Fendler threeawn	yes	native	rare	upper slopes and crest of Bodmer Overlook Unit	

Current scientific name	Common name	Present in Park	Origin	Current abundance in FOUS	Current distribution in FOUS	Name in Warren (1875)
Arnica fulgens	foothill arnica	yes	native	uncommon	prairie hollow in Bodmer Overlook Unit	
*Arnoglossum plantagineum***	groovestem Indian plantain	no		not listed	not listed	*Cacalia tuberosa* Nutt.
Artemisia absinthium	absinth wormwood	yes	exotic	common	gravel pit and disturbed areas	
Artemisia biennis	biennial wormwood	yes	native	common	gravel pit and disturbed areas	
Artemisia cana	silver sagebrush	yes	native	common	upper edge of river terrace	*Artemisia cana* Pursh
Artemisia dracunculus	tarragon	yes	native	common	gravel pit and disturbed areas	*Artemisia dracunculoides*
Artemisia frigida	fringed sagewort/prairie sagewort	yes	native	common	prairie	*Artemisia frigida* Willd.
Artemisia longifolia	longleaf wormwood	yes	native	uncommon	southeast side of upper slope, Bodmer Overlook Unit	
Artemisia ludoviciana	white sagebrush/ cudweed sagewort	yes	native	common	prairie hilltops and hillsides	
Asclepias ovalifolia	oval-leaf milkweed	yes	native	uncommon	southeast slope of high gravelly slope, Bodmer Overlook Unit	
Asclepias pumila	plains milkweed	yes	native	rare	bare knoll in southeast corner of Bodmer Overlook Unit	
Asclepias speciosa	showy milkweed	yes	native	not listed	not listed	*Asclepias macranthera* Torr.
Asparagus officinalis	garden asparagus	yes	exotic	uncommon	upper terraces	
Astragalus agrestis	purple milkvetch	no	native	not listed	not listed	*Astragalus hypoglottis* Linn.
Astragalus bisulcatus	two-grooved milkvetch	yes	native	uncommon	rocky slope of Bodmer Overlook Unit	
Astragalus canadensis	Canadian milkvetch	no	native	not listed	not listed	*Astragalus Canadensis* Linn.
Astragalus crassicarpus var. *crassicarpus*	groundplum milkvetch	yes	native	uncommon	prairie of Bodmer Overlook Unit	*Astragalus caryocarpus* Ker.
Astragalus drummondi	Drummond's milkvetch	uncon-firmed	native	not listed	not listed	*Astragalus Drummondi* Douglas

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Astragalus flexuosus	flexile milkvetch	yes	native	common	grassy slopes of Bodmer Overlook Unit	*Phaca elongata* Hook.
Astragalus gilviflorus	plains milkvetch	yes	native	common	hilltop with heavy clay soil, Bodmer Overlook Unit	
Astragalus gracilis	slender milkvetch	no	native	not listed	not listed	*Astragalus gracilis* Nutt.
Astragalus kentrophyta	spiny milkvetch	no	native	not listed	not listed	*Kentrophyta montana* Nutt.
Astragalus laxmanniii (*adsurgens*) var. *robustior*	prairie milkvetch	yes	native	uncommon	rocky slope of Bodmer Overlook Unit	*Astragalus striatus* Nutt.
Astragalus missouriensis	Missouri milkvetch	yes	native	common	hilltop and upper slopes of Bodmer Overlook Unit	*Astragalus Missouriensis* Nutt.
Astragalus pectinatus	narrowleaf milkvetch	yes	native	uncommon	south slope and hilltop of Bodmer Overlook Unit	*Phaca pectinata* Hook.
Astragalus racemosus	cream milkvetch	no	native	not listed	not listed	*Astragalus racemosus* Pursh
Astragalus tenellus	looseflower milkvetch	no	native	not listed	not listed	*Homalobus multiflorus* Nutt.
Atriplex canescens	fourwing saltbush	uncon-firmed	native	not listed	not listed	
Atriplex nuttallii	Nuttall's saltbush/ moundscale	yes	native	uncommon	clay hilltop of Bodmer Overlook Unit	
Atriplex subspicata	saline saltbush	yes	native	uncommon	grass planting west of fort	
Avena sativa (*A. fatua* var. *sativa)*	common oat	yes	exotic	uncommon	prairie hollow disturbed by wintering cattle	
Bassia scoparia (*Kochia scoparia*)	Mexican-fireweed/kochia/ burning bush	yes	exotic	common	roadsides and disturbed sites	
Bidens cernua	nodding beggarticks	yes	native	uncommon	sand bar	
Bidens vulgata	big devils beggartick	yes	native	uncommon	riverbank	
*Blephilia ciliata**	downy pagoda-plant	no		not listed	not listed	*Blephilia ciliata* Raf.
Bouteloua curtipendula	sideoats grama	yes	native	common	prairie	
Bouteloua (*Buchloe*) *dactyloides*	buffalograss	yes	native	uncommon	planted near maintenance shop	*Sesleria dactyloides* Nutt.
Bouteloua gracilis	blue grama	yes	native	abundant	prairie	*Bouteloua oligostachya* Torr.
Bouteloua hirsuta	hairy grama	uncon-firmed	native	rare#	ridgetop in Bodmer Overlook Unit	

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Brickellia (*Kuhnia*) *eupatorioides* var. *corymbulosa*	false boneset	yes	native	uncommon	prairie hollow in Bodmer Overlook Unit	
*Brickellia oblongifolia**	Mohave brickellbush	no		not listed	not listed	*Brickelia oblongifolia*
Bromus arvensis (*japonicus*)	Japanese brome/field brome	yes	exotic	uncommon	prairie hollow disturbed by wintering cattle	
Bromus inermis	smooth brome	yes	exotic	not listed	not listed	
Bromus inermis ssp. *inermis*	smooth brome	yes	exotic	abundant	roadsides and upper terraces	
Bromus squarrosus	corn brome	yes	exotic	rare	disturbed areas and high terrace	
Bromus tectorum	cheatgrass	yes	exotic	common	grass planting west of fort	
Calamagrostis montanensis	plains reedgrass	yes	native	uncommon	prairie	
Calamagrostis stricta	slimstem reedgrass	no	native	not listed	not listed	*Calamagrostis stricta* Nutt.
Calamovilfa longifolia	prairie sandreed	yes	native	common	upper slopes and hilltops of Bodmer Overlook Unit	*Calamagrostis longifolia* Henk.
Calylophus serrulatus	yellow sundrops	yes	native	uncommon	prairie hillsides	
Camelina microcarpa	littlepod false flax	yes	exotic	uncommon	upper edge of terrace and road ditches	
Campanula rotundifolia	bluebell bellflower	yes	native	uncommon	prairie	
Capsella bursa-pastoris	shepherd's purse	yes	exotic	common	disturbed areas	
Carex aquatilis var. *aquatilis* (*altior*)	water sedge	yes	native	common	moist areas of shrubby floodplain	
Carex atherodes	wheat sedge	yes	native	uncommon	wet areas of floodplain	
Carex bicknellii	Bicknell's sedge	yes	native	rare	wooded areas	
Carex brevior	shortbeak sedge	yes	native	common	wooded terraces	
Carex douglasii	Douglas' sedge	no	native	not listed	not listed	*Carex Meekii* Dew.
Carex duriuscula (*eleocharis*)	needleleaf sedge	yes	native	common	high grassy floodplain south of river	
Carex filifolia	threadleaf sedge	yes	native	abundant	upper slopes of Bodmer Overlook Unit	
Carex gravida var. *gravida*	heavy sedge	yes	native	common	wooded terraces	
Carex laeviconica	smoothcone sedge	yes	native	abundant	wet floodplain	

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Carex molesta	troublesome sedge	yes	native	uncommon	wooded terraces	
Carex nebrascensis	Nebraska sedge	uncon-firmed	native	not listed	not listed	
Carex pellita (*lanuginosa*)	woolly sedge	yes	native	uncommon	wet, open areas of floodplain	
Carex rossii	Ross' sedge	yes	native	rare	open, sandy floodplain south of river	
Carex spp. (numerous species)				not listed	not listed	along Missouri
Carex sprengelii	Sprengel's sedge	yes	native	uncommon	wooded ravines	
Carex vulpinoidea	fox sedge	yes	native	common	moist floodplain	
Castilleja sessiliflora	downy paintedcup	yes	native	uncommon	upper slopes of Bodmer Overlook Unit	
Celastrus scandens	American bittersweet	yes	native	uncommon	upper wooded river terrace	*Celastrus scandens* Linn.
*Cenchrus tribuloides**	sanddune sandbur	no		not listed	not listed	*Cenchrus tribuloides* Linn.
Cerastium arvense	field chickweed	yes	native	uncommon	prairie	
Ceratocephala testiculata	curveseed butterwort	yes	exotic	rare (also rare in ND)	grass planting west of fort	
Chamaerhodos erecta ssp. *nuttallii*	Nuttall's little rose	no	native	not listed	not listed	*Chaemorhodas erecta* var. *Nuttallii* Torr. and Gray
Chamaesyce glyptosperma	ribseed sandmat	yes	native	common	disturbed areas and roadsides	
Chamaesyce maculata OR *C. nutans*	spotted sandmat OR eyebane	no	native	not listed	not listed	*Euphorbia maculata* Linn.
*Chamaesyce polygonifolia**	seaside sandmat	no		not listed	not listed	*Euphorbia polygonifolia* Linn.
Chamaesyce serpyllifolia ssp. *serpyllifolia*	thymeleaf sandmat	yes	native	common	disturbed areas and roadsides	
Chenopodium album	lambsquarters	yes	native	common	disturbed prairie areas and roadsides	
Chenopodium berlandieri	pitseed goosefoot	yes	native	uncommon	disturbed areas	
Chenopodium fremontii	Fremont's goosefoot	yes	native	uncommon	wooded upper floodplain terrace	

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Chenopodium glaucum	oakleaf goosefoot	yes	exotic	uncommon	sandy shoreline and moist road ditches	
Chenopodium pratericola	desert goosefoot	yes	native	uncommon	high, sandy terrace south of river	
Chenopodium rubrum	red goosefoot	yes	native	uncommon	road ditches	
Chenopodium subglabrum	smooth goosefoot	yes	native	uncommon	high, sandy terrace south of river	
Chorispora tenella	crossflower	yes	exotic	rare	grass planting west of fort	
Cicuta maculata	spotted water hemlock	yes	native	uncommon	sandy soil near river	
Cirsium arvense	Canada thistle	yes	exotic	common	roadsides, upper terrace and disturbed areas	
Cirsium flodmanii	Flodman's thistle	yes	native	common	prairie and disturbed areas	
Cirsium undulatum	wavyleaf thistle	yes	native	common	prairie and disturbed areas	
Clematis ligusticifolia	western white clematis	yes	native	uncommon	shrubby areas along high terrace	*Clematis ligusticifolia* Nutt.
Cleome serrulata	pink-flowiering beeplant, Rocky Mountain beeplant	yes	native	uncommon	lower prairie slope of Bodmer Overlook Unit	*Cleome integrifolia* Torr. and Gray
Collomia linearis	tiny trumpet	no	native	not listed	not listed	*Collomia linearis* Nutt.
*Comandra umbellata****	bastard toadflax	yes	native	uncommon	prairie	*Comandra umbellata* Nutt.
Conringia orientalis	hare's ear mustard	yes	exotic	uncommon	edge of upper terrace, sandy soil	
Convolvulus arvensis	field bindweed/creeping Jenny	yes	exotic	common	roadsides (and planted areas -- AJS)	
Conyza canadensis var. *canadensis*	Canadian horseweed	yes	native	common	roadsides and disturbed sites	*Erigeron Canadense* Linn.
Cornus sericea	redosier dogwood	yes	native	common	river floodplain	*Cornus sericea* Linn.
Cornus sericea ssp. *sericea*	redosier dogwood	yes	native	common	river floodplain	*Cornus stolonifera* Michx.
Coronilla varia	crown vetch	uncon-firmed	exotic	rare#	planted field 8	
Crataegus chrysocarpa	fireberry hawthorn	yes	native	uncommon	wooded draw	

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Crataegus douglasii	black hawthorn	probably present	native	not listed	not listed	
Crepis runcinata	fiddleleaf hawksbeard	yes	native	uncommon	wet floodplain	
Cryptantha celosioides	buttecandle	yes	native	uncommon	prairie hilltops of Bodmer Overlook Unit	
Cuscuta glomerata	rope dodder	no	native	not listed	not listed	*Cuscuta glomerata* Choisy
Cyclachaena (*Iva*) *xanthifolia*	giant sumpweed/marsh elder	yes	native	uncommon	disturbed area below maintenance shop	
Dalea candida	white prairie clover	yes	native	uncommon	prairie slopes	
Dalea enneandra	nineanther prairie clover	no	native	not listed	not listed	*Dalea laxiflora* Pursh
*Dalea multiflora**	roundhead prairie clover	no		not listed	not listed	*Petalostemum multiflorum* Nutt.
Dalea purpurea	purple prairie clover	yes	native	common	prairie slopes (also in restoration plantings -- AJS)	*Petalostemum violaceum* Mich.
Dasiphora fruticosa ssp. *floribunda*	shrubby cinquefoil	no	native	not listed	not listed	*Potentilla fructicosa* Linn.
Delphinium carolinianum	sky-blue larkspur	no	native	not listed	not listed	*Delphinium azureum* Mich.
Deschampsia elongata	slender hairgrass	no	native	not listed	not listed	*Aira elongata*
Descurainia pinnata ssp. *pinnata*	western tansymustard	no	native	not listed	not listed	*Sisymbrium canescens* Nutt.
Descurainia sophia	herb sophia	yes	exotic	common	disturbed areas	
Digitaria ischaemum	smooth crabgrass	yes	exotic	rare	edge of parking lot	
Distichlis spicata	saltgrass	yes	native	common	prairie sites with clay soils and poor drainage	*Uniola stricta* Torr.
Draba nemorosa	woodland draba	yes	native	uncommon	disturbed prairie draw	
Dyssodia papposa	fetid marigold	no	native	not listed	not listed	*Dysodia chrysanthemoides* Lag.
Echinacea angustifolia	blacksamson echinacea, narrow leafed coneflower	yes	native	common	prairie	
*Echinacea purpurea**	eastern purple coneflower	no		not listed	not listed	*Echinacea purpurea* Moench

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Echinochloa crus-galli	barnyardgrass	yes	exotic	common	disturbed areas	
Elaeagnus angustifolia	Russian olive	yes	exotic	common	river terrace and in old gravel pit	
Eleocharis acicularis	needle spikerush	yes	native	uncommon	mud flat	
Eleocharis erythropoda	bald spikerush	yes	native	common	river shoreline and sandbars	
Eleocharis macrostachya	pale spikerush	yes	native	uncommon	riverbank	
Eleocharis palustris	common spikerush	yes	native	not listed	not listed	
Ellisia nyctelea	Aunt Lucy	yes	native	uncommon	grass planting west of fort	*Ellisia nyctelea* Linn.
Elymus albicans	Montana wheatgrass	uncon-firmed	native	not listed	not listed	
Elymus canadensis	Canada wildrye	yes	native	common	edge of wooded areas and terraces	*Elymus Canadensis* Linn.
Elymus lanceolatus ssp. *lanceolatus* (*Agropyron dasystachyum*)	thickspike wheatgrass	yes	native	abundant	prairie	
Elymus (*Agropyron*) *repens*	quackgrass	yes	exotic	common	roadsides and disturbed sites	*Triticum repens* Linn.
Elymus submuticus (*virginicus* var. *submuticus*)	Virginia wildrye	yes	native	uncommon	river bottom along edge of willow thickets	
Elymus trachycaulus ssp. *trachycaulus* (*Agropyron caninum* ssp. *majus*)	slender wheatgrass	yes	native	abundant	prairie and planted areas	
Elymus virginicus var. *virginicus*	Virginia wildrye	yes	native	common	wooded terraces	
Equiesetum arvense	field horsetail	yes	native	common	moist soils of the riverbank and shrubby areas on the floodplain	*Equiesetum arvense* Linn.
Equiesetum hyemale	scouringrush horsetail/ common scouring rush	yes	native	uncommon	shrubby areas of the floodplain	*Equiesetum hyemale* Linn.
Equisetum laevigatum	smooth horsetail/smooth scouring rush	yes	native	common	moist soils of the riverbank	
Eragrostis cilianensis	stinkgrass	yes	exotic	uncommon	disturbed areas and wooded floodplain	

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Eragrostis hypnoides	teal lovegrass	yes	native	rare	sandbars and riverbank	
Ericameria nauseosa ssp. *nauseosa* var. *glabrata**** (*Chrysothamnus nauseousus*)	rubber rabbitbrush	yes	native	common	upper slopes of Bodmer Overlook Unit	*Linosyris graveolens* Torr. and Gray
Erigeron compositus	cutleaf daisy	yes	native	rare	hilltop of Bodmer Overlook Unit	
Erigeron glabellus var. *pubescens*	streamside fleabane	yes	native	uncommon	prairie	
Erigeron philadelphicus	Philadelphia fleabane	no	native	not listed	not listed	*Erigeron Philadelphicum* Linn.
Erigeron pumilus	shaggy fleabane	yes	native	uncommon	prairie hilltops of Bodmer Overlook Unit	
Eriogonum flavum	alpine golden buckwheat/ yellow wild buckwheat	yes	native	uncommon	rocky hilltop of Bodmer Overlook Unit, sandy-clay soil	
Eriogonum pauciflorum	fewflower buckwheat	yes	native	common	hilltops of Bodmer Overlook Unit, clay soil	
Erysimum asperum	western wallflower	no	native	not listed	not listed	*Erysimum asperum* D. C.
Erysimum capitatum var. *capitatum*	sanddune wallflower	yes	native	common	prairie	Native
Erysimum cheiranthoides	wormseed wallflower	yes	exotic	uncommon	wooded upper floodplain terrace	*Erysimum cheiranthoides* Linn.
Escobaria missouriensis	Missouri foxtail cactus	no	native	not listed	not listed	*Mammalairs Nuttalli*
Escobaria vivipara var. *vivipara*	spinystar/pincushion cactus	yes	native	uncommon	high prairie of Bodmer Overlook Unit	
Euonymus atropurpureus	burningbush	no	native	not listed	not listed	*Euonymus atropurpureus* Jacq.
Euphorbia esula	leafy spurge	yes	exotic	abundant	river bottom, gravel pits and along roadsides	
Euphorbia marginata	snow on the mountain	no	native	not listed	not listed	*Euphorbia marginata* Pursh
Fragaria vesca	woodland strawberry	no	native	not listed	not listed	*Fragaria vesca* Linn.
Fragaria virginiana	Virginia strawberry	no	native	not listed	not listed	*Fragaria Virginica* Ehsh.
*Fraxinus americana**	white ash	no		not listed	not listed	*Fraxinus Americana* Linn.

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Fraxinus pennsylvanica	green ash	yes	native	common	upper floodplain and wooded draws	
Gaillardia aristata	blanket flower, common gaillardia	yes	native	common	prairie	
Galium aparine	stickywilly/cleavers	yes	native	common	wooded river terrace	*Galium aparine* Linn.
Galium boreale	northern bedstraw	yes	native	common	wooded areas of upper terrace	*Galium boreale* Linn.
Galium trifidum	threepetal bedstraw	no	native	not listed	not listed	*Galium trifidum* Linn.
Galium triflorum	fragrant bedstraw	no	native	not listed	not listed	*Galium triflorum* Michx.
Gaura coccinea	scarlet gaura/scarlet beeblossom	yes	native	common	prairie and roadsides	*Gaura coccinea* Nutt.
Geum aleppicum	yellow avens	no	native	not listed	not listed	*Geum strictum* Ait.
Geum triflorum	prairie smoke/old man's whiskers	yes	native	uncommon	prairie hillsides	*Geum triflorum* Pursh
Glycyrrhiza lepidota	American licorice	yes	native	common	shrubby slope, river terrace and road ditches	*Glycyrrhiza lepidota* Nutt.
*Gratiola virginiana** or **	roundfruit hedgehyssop	no		not listed	not listed	*Gratiola Virginica* Linn.
Grindelia squarrosa	curlycup gumweed	yes	native	common	prairie and roadsides	*Grindelia squarrosa* Dunal
Gutierrezia sarothrae	broom snakeweed	yes	native	common	stony hilltop of Bodmer Overlook Unit	
Hackelia deflexa	nodding stickseed	yes	native	uncommon	wooded areas	
Hedeoma hispida	rough false pennyroal	yes	native	uncommon	hilltop with sparse vegetation, Bodmer Overlook Unit	*Hedeoma hirta* Nutt.
Hedysarum boreale	Utah sweetvetch	yes	native	uncommon	shrubby river terrace	*Hedysarum boreale* Nutt.
Helianthus annuus	common sunflower	yes	native	common	roadsides and disturbed sites	
*Helianthus giganteus**	giant sunflower	no		not listed	not listed	*Helianthus giganteus* Linn.
Helianthus grosseserratus	sawtooth sunflower	no	native	not listed	not listed	*Helianthus gross-serratus* Martens
Helianthus maximiliani	Maximilian sunflower	yes	native	uncommon	roadsides and edge of floodplain	
Helianthus nuttallii ssp. *rydbergii*	Rydberg's sunflower	yes	native	uncommon	open floodplain terrace	

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Helianthus pauciflorus ssp. *pauciflorus* (*H. rigidus*)	stiff sunflower	yes	native	uncommon	prairie	
Helianthus petiolaris	prairie sunflower	yes	native	uncommon	roadsides and disturbed sites	
Hesperostipa comata ssp. *comata* (*Stipa comata*)	needle and thread	yes	native	abundant	prairie hilltops and hillsides	
Hesperostipa spartea	porcupine grass	yes	native	common	prairie hillsides	*Stipa spartea* Linn.
Heterotheca villosa var. *villosa* (*Chrysopsis villosa*)	hairy false goldenaster	yes	native	common	prairie, roadsides and upper terrace	
*Heuchera americana** [or] **	American alumroot	no		not listed	not listed	*Heuchera Americana* Linn.
Heuchera richardsonii	Richardson's alumroot	yes	native	uncommon	prairie slopes	
Hippuris vulgaris	common mare's tale	no	native	not listed	not listed	*Hepparis vulgaris* Linn.
Hordeum brachyantherum ssp. *brachyantherum*	meadow barley	no	native	not listed	not listed	*Hordeum pratense*
Hordeum jubatum	foxtail barley	yes	native	common	roadsides and disturbed sites	*Hordeum jubatum* Ait.
Hordum pusillum	little barley	no	native	not listed	not listed	*Hordum pusillum* Nutt.
Humulus lupulus	common hop	no	native	not listed	not listed	*Humulus lupulus* Linn.
Hymenopappus filifolius var. *polycephalus*	manyhead hymenopappus	yes	native	uncommon	hilltops of Bodmer Overlook Unit	
Hymenoxys richardsonii	pingue rubberweed	yes	native	uncommon	stony, clay hilltop of Bodmer Overlook Unit	
Impatiens pallida	pale touch-me-not	no	native	not listed	not listed	*Impatiens pallida* Nutt.
Iva axillaris	povertyweed	no	native	not listed	not listed	*Iva axillaris* Pursh
Juncus balticus	Baltic rush	yes	native	common	wet places along shore and floodplain	
Juncus bufonius	toad rush	yes	native	uncommon	along trail across moist floodplain	
Juncus interior	inland rush	yes	native	uncommon	floodplain and riverbank	
Juncus nodosus	knotted rush	yes	native	common	sandbars and sandy riverbank	
Juncus tenuis	poverty rush	no	native	not listed	not listed	*Juncus tenuis* Willd.

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Juncus torreyi	Torrey's rush	yes	native	common	sandbars and sandy riverbank	
Juniperus horizontalis	creeping juniper	yes	native	uncommon	prairie slopes of the Bodmer Overlook Unit and along the edge of the upper river terrace	
Juniperus scopulorum	Rocky Mountain juniper	yes	native	uncommon	high floodplain	
*Juniperus virginiana**	eastern redcedar	no		not listed	not listed	*Juniperus Virginiana* Linn.
Koeleria macrantha (*pyrimidata*)	prairie Junegrass	yes	native	abundant	prairie slopes	*Kaleria cristata* Linn.
Krascheninnikovia lanata	winterfat	yes	native	uncommon	grassy hilltop of Bodmer Overlook Unit, sandy-clay soil	
Lactuca canadensis	Canada lettuce	yes	native	rare	wooded terraces	
Lactuca serriola	prickly lettuce	yes	exotic	common	roadsides and disturbed sites	
Lactuca tatarica var. *pulchella* (*L. oblongifolia*)	blue lettuce	yes	native	common	roadsides and disturbed sites	
Lappula occidentalis var. *occidentalis* (*L. redowskii*)	flatspine stickseed	yes	native	uncommon	disturbed areas	
Lappula squarrosa (*echinata*)	European stickseed	yes	exotic	common	disturbed prairie areas and roadsides	
Leersia oryzoides	rice cutgrass	yes	native	rare	sandbars and riverbank	
Lemna	duckweed	no		not listed	not listed	*Lemna*
Lepidium densiflorum	common pepperweed	yes	native	common	roadsides	
*Lepidium ruderale**	roadside pepperweed	no	exotic	not listed	not listed	*Lepidium ruderale* Linn.
Lepidium virginicum	Virginia pepeerweed	no	native	not listed	not listed	*Lepidium Virginicum* Linn.
*Lespedeza hirta**	hairy lespedeza	no		not listed	not listed	*Lespedera hirta* Ell.
Lesquerella alpina	alpine bladderpod	no	native	not listed	not listed	*Vesicaria alpina* Nutt.
Lesquerella ludoviciana	foothill bladderpod	yes	native	common	hillsides of Bodmer Overlook Unit	*Vesicaria ludoviciana* D. C.
Liatris punctata	dotted blazing star	yes	native	common	prairie	

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Linum lewisii var. *lewisii*	prairie flax	yes	native	common	prairie (Godfread says in planted areas too, but probably *L. perenne* there)	*Linum perenne* Linn.
Linum perenne	blue flax	uncon-firmed	exotic	not listed	planted areas -- AJS	
Linum rigidum	stiffstem flax	yes	native	common	prairie	*Linum rigidum* Pursh
Lithospermum incisum	narrowleaf stoneseed	yes	native	uncommon	hilltops of Bodmer Overlook Unit, clay soil	
Lobelia inflata	Indian tobacco	no	native	not listed	not listed	*Lobelia inflata* Linn.
Lomatium foeniculaceum	desert biscuitroot	yes	native	uncommon	prairie hillsides	
Lotus unifoliolatus var. *unifoliolatus*	American bird's-foot trefoil	no	native	not listed	not listed	*Hosackia Purshiana* Benth.
Lupinus argenteus	silvery lupine	probably present	native	not listed	not listed	
Lupinus pusillus	rusty lupine	yes	native	uncommon	upper edge of sandy terrace	*Lupinus pusillus* Pursh
Lycopus americanus	American water horehound	yes	native	common	riverbank	*Lycopus sinuatus* Ell.
Lycopus asper	rough bugleweed	yes	native	common	moist areas of floodplain	
Lygodesmia juncea	rush skeletonplant	yes	native	common	prairie	*Lygodesmia juncea* Don
Lysimachia ciliata	fringed loosestrife	yes	native	uncommon	moist, wooded floodplain	
Machaeranthera grindelioides (*Haplopappus spinulosus*)	rayless tansyaster, goldenweed	yes	native	uncommon	stony hilltop of Bodmer Overlook Unit	
Machaeranthera pinnatifida ssp. *pinnatifida* var. *pinnatifida****	lacy tansyaster	yes	native	common	stony hilltop of Bodmer Overlook Unit	*Aplopappus spinulosus* D. C.
Malva neglecta	common mallow	probably present	exotic	rare[#]	planted filed 2	
Medicago lupulina	black medic	uncon-firmed	exotic	rare[#]	planted fields 6, 7	
Medicago sativa	alfalfa	yes	exotic	common	road ditches (and restoration plantings -- AJS)	

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Melilotus officinalis (includes *M. alba*)	yellow (and white) sweetclover	yes	exotic	common	road ditches (and restoration plantings -- AJS)	
Menispermum canadense	common moonseed	no	native	not listed	not listed	*Menispermum Canadensis* Linn.
Mentha arvensis	wild mint	yes	native	common	shrubby riverbank	*Mentha Canadensis* Linn.
Mentzelia decapetala	tenpetal blazingstar	yes	native	common	gravely slope bordering entrance road	*Mentzelia ornata* Torr. and Gray
Mentzelia nuda	bractless blazingstar	no	native	not listed	not listed	*Mentzelia nuda* Torr. and Gray
Mertensia lanceolata	prairie bluebells	yes	native	uncommon	grassy slopes and hollows	
Miaianthemum stellatum (*Smilacina stellata*)	starry false lily of the valley	yes	native	common	wooded river terrace	*Smilacina stellata* Desf.
*Mimosa microphylla**	littleleaf sensitive-briar	no		not listed	not listed	*Schrankia uncinata* Willd.
Mirabilis linearis	narrowleaf four o'clock	yes	native	rare	upper slopes of Bodmer Overlook Unit	
Mirabilis nyctaginea	heartleaf four o'clock	yes	native	common	wooded draws and wooded edges of floodplain	
*Monarda fistulosa***	wild bergamot	yes	native	uncommon	edges of shrubby areas	*Monarda fistulosa* Linn.
Morus rubra	red mulberry	no	native	not listed	not listed	*Morus rubra* Linn.
Muhlenbergia asperifolia	scratchgrass	yes	native	uncommon	sandbars and riverbank	
Muhlenbergia cuspidata	plains muhly	yes	native	common	upper slopes and hilltops of Bodmer Overlook Unit	
Muhlenbergia glomerata	spiked muhly	no	native	not listed	not listed	*Muhlenbergia glomerata* Linn.
Muhlenbergia racemosa	marsh muhly	yes	native	uncommon	upper wooded terraces	
Musineon divaricatum	leafy wildparsley	yes	native	uncommon	clay hilltop of Bodmer Overlook Unit	
Myriophyllum spicatum	Eurasian watermilfoil	no	exotic	not listed	not listed	*Myriophyllum spicatum* Linn.
Nassella viridula	green needlegrass	yes	native	abundant	prairie hillsides	
Oenothera ablicaulis	whitest evening primrose	no	native	not listed	not listed	*Oenothera ablicaulis* Nutt.
Oenothera biennis	common/yellow evening primrose	no	native	not listed	not listed	*Oenothera biennis* Linn.

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Oenothera cespitosa	tufted evening primrose	yes	native	common	clay hillside of Bodmer Overlook Unit	*Oenothera cespitosa* Nutt.
Oenothera nuttallii	Nuttall's evening-primrose	yes	native	uncommon	rocky slope of Bodmer Overlook Unit	
Oligoneuron rigidum var. *rigidum* (*Solidago rigida*)	stiff goldenrod	yes	native	common	prairie	*Solidago rigida* Linn.
Opuntia fragilis	brittle pricklypear	yes	native	uncommon	high prairie of Bodmer Overlook Unit	*Opuntia fragilis* Nutt.
Opuntia macrorhiza	bigroot pricklypear	uncon-firmed	native	rare[#]	high prairie of Bodmer Overlook Unit	
Opuntia polyacantha	plains pricklypear	yes	native	uncommon	high prairie of Bodmer Overlook Unit	*Opuntia Missouriensis* D. C.
Orobanche fasciculata	clustered broomrape	yes	native	uncommon	prairie hillsides	
Orobanche ludoviciana ssp. *ludoviciana*	Louisiana broomrape	no	native	not listed	not listed	*Phelipaea ludoviciana* Don
Orthocarpus luteus	yellow owl's-clover	yes	native	uncommon	prairie slopes	
Oxalis corniculata	creeping woodsorrel	no	native	not listed	not listed	*Oxalis corniculata* Linn.
Oxalis stricta	common yellow oxalis	no	native	not listed	not listed	*Oxalis stricta* Linn.
Oxytropis lambertii	purple locoweed	yes	native	common	prairie hillsides	
Oxytropis monticola (*campestris* var. *gracilis*)	yellowflower locoweed	yes	native	uncommon	prairie hilltops of Bodmer Overlook Unit	
Oxytropis sericea	white locoweed	probably present	native	not listed	not listed	
Packera cana (*Senecio canus*)	woolly groundsel	yes	native	uncommon	upper prairie slopes	
Packera (*Senecio*) *plattensis*	prairie groundsel	yes	native	uncommon	prairie slopes	
Panicum capillare	witchgrass	yes	native	common	roadsides and disturbed sites	
Panicum virgatum	switchgrass	yes	native	uncommon	roadsides and open floodplain	
Parietaria pensylvanica	Pennsylvania pelliitory	no	native	not listed	not listed	*Parietaria Pennsylvanica* Muhl.
Paronychia sessiliflora	creeping nailwort	no	native	not listed	not listed	*Paronychia sessiliflora* Nutt.

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Parthenocissus quinquefolia	Virginia creeper	no		not listed	not listed	*Ampelopsis quinquefolia* Michx.
Pascopyrum (*Agropyron*) *smithii*	western wheatgrass	yes	native	abundant	prairie and roadsides	
Pediomelum argophyllum	silverleaf Indian breadroot	yes	native	common	prairie	*Psoralea argophylla* Pursh
Pediomelum cuspidatum	largebract Indian breadroot	no	native	not listed	not listed	*Psoralea cuspidata* Pursh
Pediomelum esculentum	large Indian breadroot	yes	native	common	prairie	*Psoralea esculenta* Pursh
Penstemon albidus	white penstemon	yes	native	common	prairie slopes	
Penstemon eriantherus	fuzzytongue penstemon	no	native	not listed	not listed	*Penstemon cristatum* Nutt.
Penstemon gracilis	lilac penstemon, slender beardtongue	yes	native	uncommon	prairie slopes	
Penstemon grandiflorus	bigflower penstemon, large beardtongue	yes	native (planted)	uncommon[#]	planted fields 6, 7, 8	*Penstemon grandiflorus* Fraser
Phalaris arundinacea	reed canarygrass	yes	native	abundant	wet floodplain	
Phlox alyssifolia	alyssumleaf phlox	yes	native	rare	stony hilltop of Bodmer Overlook Unit	
Phlox hoodii	spiny phlox, Hood's phlox	yes	native	common	prairie and rocky hilltops	
Phragmites australis	common reed	yes	native	abundant	wet floodplain	
*Physalis viscosa**	starhair groundcherry	no		not listed	not listed	*Physalis viscosa* Linn.
Picradeniopsis oppositifolia	oppositeleaf bahia	yes	native	rare	gravely edge of terrace east of saw pit	
Plantago major	common plantain	yes	native	common	river bank and roadsides	
Plantago patagonica	wooly plantain	yes	native	common	prairie hilltops and hillsides	*Plantago patagonica* var. *gnaphaloides*
Plantago rugelii	blackseed plantain	yes	native	rare	riverbank	
Poa annua	annual bluegrass	yes	exotic	rare	grass planting west of fort	*Poa annua* Linn.
Poa arida	plains bluegrass	yes	native	uncommon	open, sandy floodplain	
Poa compressa	Canada bluegrass	yes	exotic	uncommon	open, sandy floodplain	
*Poa nemoralis***	wood bluegrass	yes	native	not listed	not listed	*Poa nemoralis* Linn.

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Poa palustris	fowl bluegrass	yes	native	common	wooded terraces	
Poa pratensis	Kentucky bluegrass	yes	exotic	abundant	prairie, roadsides and disturbed areas	*Poa pratensis* Linn.
Poa secunda (*sandbergii*)	Sandberg bluegrass	yes	native	abundant	prairie	
Polygala alba	white milkwort	yes	native	common	prairie	*Polygala alba* Nutt.
Polygonum achoreum	leathery knotweed	yes	native	common	roadsides	
Polygonum amphibium	water knotweed	yes	native	common	wet areas of floodplain	*Polygonum amphibium* Linn.
Polygonum aviculare	prostrate knotweed	yes	exotic	common	roadsides	
Polygonum convolvulus	black bindweed/climbing buckwheat	yes	exotic	common	roadsides and disturbed sites	
Polygonum lapathifolium	curlytop knotweed	yes	native	uncommon	sandy riverbank	
Polygonum pensylvanicum	Pennsylvania smartweed	yes	native	rare	sand bar	
Polygonum ramosissimum	bushy knotweed	yes	native	uncommon	disturbed areas	
Polygonum tenue	pleatleaf knotweed	no		not listed	not listed	*Polygonum tenue* Michx.
Polypogon monspeliensis	annual rabbitsfoot grass	yes	exotic	rare	muddy bank of backwater	
Polytaenia nuttallii	Nuttall's prairie parsley	no	native	not listed	not listed	*Polytaenia Nuttallii* D. C.
Populus deltoides ssp. *monilifera*	plains cottonwood	yes	native	abundant	floodplain	*Populus monilifera* Ait.
Portulaca oleracea	little hogweed/common purslane	yes	native	uncommon	seeded areas	
Potentilla arguta	tall cinquefoil	no	native	not listed	not listed	*Potentilla arguta* Pursh
Potentilla concinna	elegant cinquefoil	yes	native	uncommon	high prairie slopes	
Potentilla gracilis var. *fastigiata*	slender cinquefoil	no	native	not listed	not listed	*Potentilla rigida* Nutt.
Potentilla hippiana	woolly cinquefoil	yes	native	uncommon	prairie hillsides	
Potentilla norvegica	Norwegian cinquefoil	yes	native	uncommon	along trail on riverbottom	*Potentilla Norvegica* Linn.
Potentilla paradoxa	Paradox cinquefoil	yes	native	uncommon	along path on moist, sandy river terrace	*Potentilla paradoxa* Nutt.
Potentilla pensylvanica	Pennsylvania cinquefoil	yes	native	uncommon	grassy slopes of Bodmer Overlook Unit	
Prunus americana	American plum	yes	native	uncommon	woody draw	

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Prunus virginiana	chokecherry	yes	native	common	edge of wooded terrace	*Prunus Virginiana* Linn.
Psathyrostachys juncea (*Elymus junceus*)	Russian wildrye	yes	exotic	common	grass planting west of fort	
Psoralidium lanceolatum	lemon scurfpea	yes	native	common	high, sandy terrace south of river	*Psoralea lanceolata* Pursh
Psoralidium tenuiflorum	slimflower scurfpea	no	native	not listed	not listed	*Psoralea floribunda* Nutt.
Pulsatilla patens	pasqueflower	yes	native	common	grassy slopes of Bodmer Overlook Unit	
Quercus macrocarpa	bur oak	no	native	not listed	not listed	*Quercus macrocarpa* Michx.
Ranunculus abortivus	littleleaf buttercup	no	native	not listed	not listed	*Ranunculus abortivus* Linn.
Ranunculus cymbalaria	alkali buttercup/seaside buttercup	yes	native	uncommon	muddy edge of sand bar	*Ranunculus cymbalaria* Pursh
Ranunculus hispidus var. *hispidus**	bristly buttercup	no		not listed	not listed	*Ranunculus repens* var. *Marylandicus,* Torr. and Gray
Ranunculus sceleratus	cursed buttercup	no	native	not listed	not listed	*Ranunculus sceleratus* Linn.
Ratibida columnifera	longheaded coneflower, upright prairie coneflower	yes	native	common	prairie	*Lepachys columnaris* Torr. and Gray
*Rhus aromatica** or **?	skunkbush sumac	uncon-firmed	native	not listed	not listed	*Rhus aromatica* Ait.
*Rhus trilobata*** (*Rhus aromatica* var. *trilobata*)	skunkbush sumac	yes	native	common	south slope of Bodmer Overlook Unit	*Rhus trilobata* Nutt.
Ribes americanum	American black currant	no	native	not listed	not listed	*Ribes floridum* Linn.
Ribes aureum	golden currant	probably present	native	not listed	not listed	*Ribes aureum* Pursh
Ribes aureum var. *villosum* (*R. odoratum*)	golden currant	yes	native	common	edge of wooded terrace	
Ribes cereum	wax currant	probably present	native	not listed	not listed	
Ribes hirtellum	hairystem gooseberry	yes	native	uncommon	wooded floodplain	
Ribes oxyacanthoides ssp. *setosum* (*R. setosum)*	inland gooseberry	yes	native	uncommon	upper floodplain	
Robinia pseudoacacia	black locust	uncon-firmed	native	not listed	not listed	

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Rorippa calycina	persistent sepal yellowcress	uncon-firmed	native	not listed	not listed	*Nasturtium calycinum* Engelman, nov. sp.
Rorippa palustris ssp. *palustris*	bog yellowcress	no	native	not listed	not listed	*Nasturtium paulstre* D. C.
*Rorippa sessiliflora***	stalkless yellowcress	no		not listed	not listed	*Nasturtium sessiliflorum* Nutt.
*Rorripa teres**	southern marsh yellowcress	no		not listed	not listed	*Nasturtium obtusum* Nutt.
Rosa acicularis	prickly rose	yes	native	uncommon	edge of wooded terrace	
Rosa arkansana	prairie rose	yes	native	common	slopes and hilltop of Bodmer Overlook Unit	
Rosa blanda	smooth rose	no	native	not listed	not listed	*Rosa blanda* Ait.
Rosa woodsii	Woods' rose	yes	native	common	edge of wooded draw and wooded river terrace	
Rubus idaeus ssp. *strigosus*	grayleaf red raspberry	no	native	not listed	not listed	*Rubus strigosus* Mich.
Rumex crispus	curly dock	yes	exotic	uncommon	disturbed areas	
Rumex maritimus	golden dock	yes	native	uncommon	sandy riverbank	*Rumex persicarioides* Linn.
Rumex salicifolius var. *mexicanus*	Mexican dock/willow-leaved dock	yes	native	uncommon	moist, open river bottom	
Rumex stenophyllus	narrowleaf dock	yes	exotic	uncommon	riverbank and disturbed areas	
Sagittaria cuneata	arumleaf arrowhead	yes	native	uncommon	muddy edge of backwater	
Sagittaria latifolia	broadleaf arrowhead	no	native	not listed	not listed	*Sagittaria variabilis* Engelmann
*Salicornia maritima**	slender grasswort	no		not listed	not listed	*Salicornia herbacea* Linn.
Salix amygdaloides	peachleaf willow	yes	native	abundant	floodplain	
Salix eriocephala	Missouri River willow/ diamond willow	yes	native	abundant	floodplain	
Salix exigua	narrowleaf willow/coyote willow	yes	native	abundant	floodplain	
Salix lutea	yellow willow	yes	native	abundant	floodplain	
Salsola kali	Russian thistle	yes	exotic	common	disturbed areas	
Salvia reflexa	lanceleaf sage	yes	native	uncommon	gravel pit	

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Sambucus nigra ssp. *canadensis*	American black elderberry	no	native	not listed	not listed	*Sambucus Canadensis* Linn.
Sanguisorba annua	prairie burnet	no	native	not listed	not listed	*Sanguisorba annua* Nutt.
Sarcobatus vermiculatus	greasewood	no	native	not listed	not listed	*Sarcobatus vermicularis* Nees.
Schedonnardus paniculatus	tumblegrass	yes	native	uncommon	disturbed areas	
Schizachyrium scoparium (*Andropogon scoparius*)	little bluestem	yes	native	common	prairie hillsides	*Andropogon scoparius* Michx.
Schoenoplectus acutus var. *acutus* (*Scirpus acutus*)	hardstem bulrush	yes	native	abundant	wet, backwater areas of floodplain	
Schoenoplectus (*Scirpus*) *americanus*	chairmaker's bulrush	yes	native	common	wet, backwater areas of floodplain	
Schoenoplectus (*Scirpus*) *fluviatilis*	river bulrush	yes	native	uncommon	wet floodplain	
Schoenoplectus maritimus (*Scirpus maritimus* var. *paludosus*)	cosmopolitan bulrush	yes	native	common	riverbank	
Schoenoplectus tabernaemontani (*Scirpus validus*)	softstem bulrush	yes	native	common	wet, backwater areas of floodplain	
Scutellaria galericulata (*Stachys palustris* var. *pilosa*)	marsh skullcap	yes	native	uncommon	riverbank	
Selaginella densa	lesser spikemoss/small clubmoss	yes	native	uncommon	high, dry, sandy prairie	
Senecio integerriumus	lambstongue ragwort	no	native	not listed	not listed	*Senecio integerriumus* Nutt.
Setaria viridis	green bristlegrass	yes	native	common	roadsides and disturbed sites	
Shepherdia argentea	silver buffaloberry	yes	native	common	upper edge of river terrace	*Shepherdia argentea* Nutt.
Shepherdia canadensis	russet buffaloberry	probably present	native	not listed	not listed	
Sinapis arvensis	charlock mustard	yes	exotic	uncommon	roadsides and restoration areas	
Sisymbrium altissimum	tall tumblemustard	yes	exotic	common	disturbed areas	

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Sisymbrium loeselii	small tumbleweed mustard	yes	exotic	uncommon	open woods of floodplain and disturbed prairie	
Sisyrinchium montanum	strict blue-eyed grass	yes	native	uncommon	grassy hollow	
Sium suave	hemlock waterparsnip	no	native	not listed	not listed	*Sium lineare* Michx.
Solanum nigrum†		no		not listed	not listed	*Solanum nigrum* Michx.
Solanum rostratum	buffalobur nightshade	yes	native	uncommon	roadsides	*Androcera lobata* Nutt.
Solanum triflorum	cutleaf nightshade	yes	native	uncommon	disturbed prairie	*Solanum triflorum* Nutt.
Solidago canadensis	Canada goldenrod	yes	native	common	terrace edge	
Solidago gigantea	giant goldenrod	yes	native	uncommon	terrace edge and disturbed areas	*Solidago gigantea* Ait.
Solidago missouriensis	Missouri goldenrod	yes	native	common	prairie	*Solidago Missouriensis* Nutt.
Solidago mollis	velvety goldenrod	yes	native	common	prairie	*Solidago incana* Torr. & Gray
Solidago nemoralis	gray goldenrod	no	native	not listed	not listed	*Solidago nemoralis* Ait.
Sonchus arvensis	field sowthistle	yes	exotic	common	river bottom on edge of shrubby area	
Sonchus asper	spiny sowthistle	yes	exotic	uncommon	upper edge of terrace	
Sorghastrum nutans	Indiangrass	yes	native (seed-ed)	rare	planted field 10	
*Spartina cynosuroides**	big cordgrass	no		not listed	not listed	*Spartina cynosuroides* Willd.
Spartina pectinata	prairie cordgrass	yes	native	common	wet, open areas	
Sphaeralcea coccinea ssp. *coccinea*	scarlet globemallow	yes	native	common	prairie hillsides	*Malvastrum coccineum* Gray
Sporobolus cryptandrus	sand dropseed	yes	native	common	open, sandy terrace south of river	
Stachys pilosa var. *pilosa*	hairy hedgenettle	yes	native	uncommon	sandy riverbank	
Stanleya pinnata	desert princesplume	no	native	not listed	not listed	*Stanleya pinnatifida* Nutt.
Symphoricarpus occidentalis	western snowberry	yes	native	abundant	wooded draws and upper slopes of river terraces	*Symphoricarpus occidentalis* R. Br.
Symphyotrichum ciliatum (*Aster brachyactis*)	rayless alkali aster	yes	native	common	sandy riverbank	

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Symphyotrichum ericoides var. *ericoides* (*Aster ericoides*)	white heath aster	yes	native	common	upper river terraces and prairie	
Symphyotrichum laeve var. *laeve* (*Aster laevis*)	smooth blue aster	yes	native	common	moist, shrubby areas of floodplain	*Aster laevis* Linn.
Symphyotrichum lanceolatum ssp. *lanceolatum* var. *lanceolatum* (*Aster simplex* var. *ramosissimus*)	white panicle aster	yes	native	common	moist, shrubby areas of floodplain	
Symphyotrichum novae-angliae	New England aster	no	native	not listed	not listed	*Aster Novae-Angliae* Ait.
Symphyotrichum oblongifolium (*Aster oblongifolius*)	aromatic aster	yes	native	uncommon	stony hilltop of Bodmer Overlook Unit	
Taraxacum officinale	common dandelion	yes	exotic	common	roadsides and planted areas	
Tetraneuris acaulis var. *acaulis* (*Hymenoxis acaulis*)	stemless four-nerve daisy	yes	native	uncommon	stony, clay hilltop of Bodmer Overlook Unit	
Teucrium canadense var. *occidentale*	western germander	yes	native	rare	edge of floodplain near river	
Thalictrum dasycarpum	purple meadow-rue	yes	native	uncommon	edge of floodplain terrace	
Thalictrum venulosum	veiny meadow-rue	yes	native	common	woody or brushy river terrace	
Thaspium barbinode	hairyjoint meadowparsnip	no	native	not listed	not listed	*Thaspium barbinode* Nutt.
Thermopsis rhombifolia	prairie thermopsis/prairie goldenpea	no	native	not listed	not listed	*Thermopsis rhombifolia* Nutt.
Thlaspi arvense	field pennycress	yes	exotic	common	disturbed areas	
Townsendia exscapa	stemless Townsend daisy	yes	native	rare	stony hilltop near east boundary of Bodmer Overlook	
Toxicodendron rydbergii	western poison ivy	yes	native	common	wooded and shrubby areas	*Rhus toxicodendron* Linn.
Tradescantia occidentalis	prairie spiderwort	yes	native	uncommon	sandy river terrace	

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*Tradescantia virginiana** [or] **	Virginia spiderwort	no		not listed	not listed	*Tradescantia Virginica* Linn.
Tragopogon dubius	yellow salsify	yes	exotic	common	prairie and roadsides	
Triodanis perfoliata	clasping Venus' looking-glass	no	native	not listed	not listed	*Specularia perfoliata* D. C.
Typha angustifolia	narrowleaf cattail	yes	exotic	common	wet floodplain and shallow backwater areas	
Typha latifolia	broadleaf cattail	yes	native	common	wet floodplain	
Typha X *glauca* (*Typha angustifolia* X *latifolia*)	hybrid cattail	yes	native	common	wet floodplain	
Ulmus americana	American elm	yes	native	uncommon	upper floodplain	*Ulmus Americanus* Linn.
Urtica dioica	stinging nettle	yes	unknown	common	moist areas of wooded floodplain terrace	
Vahlodea atropurpurea	mountain hairgrass	no	native	not listed	not listed	*Aira latifolia*
Verbena bracteata	bigbract verbena	yes	native	uncommon	roadsides and gravel pit	*Verbena bracteosa* Michx.
Verbena stricta	hoary vervain	probably present	native (seeded)	uncommon[#]	planted fields 1, 2, 3, 4, 6	
Vernonia fasciculata	prairie ironweed	no	native	not listed	not listed	*Vernonia fasciculata* Michx.
Veronica anagallis-aquatica	water speedwell	yes	native	rare	sandbar	
Vicia americana	American vetch	probably present	native	not listed	not listed	*Vicia Americana* Muhl.
Vicia americana ssp. *americana*	American vetch	yes	native	common	prairie and edges of wooded areas	
Vicia americana ssp. *minor*	mat vetch	yes	native	common	prairie and roadsides	*Lathyrus linearis* Nutt.
Viola nuttallii	Nuttall's violet/yellow prairie violet	yes	native	common	top and slopes of Bodmer Overlook Unit	
Vitis riparia	riverbank grape	yes	native	uncommon	wooded river terrace	
Vulpia octoflora var. *glauca**** (*Festuca octoflora*)	sixweeks fescue	yes	native	uncommon	open, sandy edge of upper terrace	*Festuca tenella* Willd.
Xanthium strumarium	rough cocklebur	yes	native	common	riverbank and terrace	*Xanthium strumarium* Linn.
Yucca glauca var. *glauca*	soapweed yucca	yes	native	common	upper south facing slopes of Bodmer Overlook Unit	*Yucca angustifolia* Sims.

Appendix B: Derivation of Probable Historic Vegetation and Desired Conditions

Probable historic vegetation descriptions and potential desired conditions were derived from the same sets of information: vegetation associations described by the National Vegetation Classification System for riparian floodplain areas, and Natural Resource Conservation Service ecological site descriptions for uplands.

Riparian Floodplain Vegetation

Vegetation associations used to derive probable vegetation in the riparian area of the Missouri River at Fort Union Trading Post National Historic Site were selected by searching the NatureServe Explorer (http://www.natureserve.org/explorer/) for wetland Ecological Systems documented as occurring in North Dakota. Information in the comprehensive report for each of the 132 associations resulting from this search was used to determine that 14 of the associations are relevant for Missouri River floodplain vegetation in western North Dakota. One additional association (Riverine Sand Flats – Bars Association) was included based on current vegetation at FOUS. Descriptions of each of the 15 associations, summarized from the NatureServe reports, follow.

1. *Lemna* spp. Permanently Flooded Herbaceous Vegetation
Common Name: Duckweed Pond
Summary: This aquatic association of floating vegetation is known to occur throughout North America in fresh water ponds, lakes, ditches, stock ponds, and backwater sloughs of river and stream channels generally less than 6-13 ft (2-4 m) deep, and with standing water for much or most of the growing season. *Lemna* spp. typically dominate but may be mixed with other plant taxa floating on the water surface. These small plants may float on the water's surface or become stranded and possibly rooted during drawdown periods. Other species present may include *Spirodela* spp., *Azolla mexicana, Azolla filiculoides, Wolffiella* spp., and *Wolffia* spp., as well as *Riccia* spp. (aquatic liverworts). Community composition may change hour to hour, yet the environment (only the top few centimeters of water) is homogeneous. Biomass can be abundant under eutrophic conditions.

2. *Potamogeton* spp. - *Ceratophyllum demersum* Great Plains Herbaceous Vegetation
Common Name: Great Plains Pondweed Submerged Aquatic Wetland
Summary: This community type is found in the Great Plains of the United States in shallow to relatively deep (3 ft/1 m) freshwater basins or bands in marshes or bays that remain flooded in all but the driest years. Vegetation varies from sparse to dense, with submersed, rooted and free-floating macrophytes. Species composition varies with substrate, water depth, water chemistry, turbidity, water temperatures and other factors, but these are poorly understood.

3. *Typha* spp. - *Schoenoplectus* spp. - Mixed Herbs Great Plains Herbaceous Vegetation
Common Name: Northern Great Plains Cattail - Bulrush Marsh
Summary: This community ranges broadly over the northern Great Plains of the United States. It is found in basin-like depressions, backwater areas of floodplains and margins of lakes or ponds where water is above the soil level for most or all of the growing season. Vegetation in deeper areas ranges from zones dominated by emergents 3-6 ft (1-2 m) tall to zones with floating

or submerged aquatics. In shallower areas, perennial forbs <3 ft (1 m) tall are common. In the tall emergent zone, *Schoenoplectus tabernaemontani, Schoenoplectus fluviatilis, Schoenoplectus acutus, Typha angustifolia*, and *Typha latifolia* may dominate, with shallower parts having these species and a mix of other herbaceous species (e.g., *Leersia oryzoides, Eleocharis palustris, Juncus* spp. and *Sparganium* spp.). Floating-leaved and submerged aquatics are sometimes present, including *Azolla caroliniana, Lemna* spp., *Spirodela polyrrhiza*, and *Potamogeton* spp.

4. *Typha* spp. Great Plains Herbaceous Vegetation
Common Name: Northern Great Plains Cattail Marsh
Summary: This cattail community type is found throughout the Northern Great Plains of the United States and Canada. Stands occur in shallow (<1.5 ft/0.5 m) or deep depressions, stock ponds, and seepy drainages. The vegetation is dominated by relatively pure stands of *Typha* spp., either *Typha latifolia* or *Typha angustifolia* or both. Many associates can occur, including *Eleocharis* spp. and *Sagittaria latifolia*.

5. Riverine Sand Flats - Bars Sparse Vegetation
Common Name: Riverine Sand Flats
Summary: This community ranges from the western Great Plains to the eastern parts of the midwestern United States and Canada. It is a sparsely vegetated community that occurs along river shorelines, islands, pointbars, and flats. These sandbars form when receding floodwaters deposit sand and lesser amounts of clay, silt, and cobbles in the stream bed. Soils are often undeveloped due to the ephemeral nature of the stands. Drainage depends on depth above the water level. Herbaceous species are highly variable.

6. *Salix exigua* Temporarily Flooded Shrubland
Translated Name: Coyote Willow Temporarily Flooded Shrubland
Summary: This willow shrubland is found throughout the western United States and Great Plains north into the Boreal Plains. This is a highly flood-tolerant community that occurs along rivers and streams at lower elevations, on recently flooded riparian areas, and in moist swales and ditches that are frequently disturbed. Stands occur most commonly on alluvial sand, but silt, clay or gravel may also be present. *Salix exigua* is the dominant canopy species (*Salix interior* or intermediates of the two willow species may be present in the eastern part of the range). It can form dense stands up to 4 m tall, but there are often patches where the shrub layer is absent. Seedlings and small saplings of *Populus deltoides, Populus balsamifera*, and *Salix amygdaloides* may be present. The herbaceous cover is sparse to moderate but rarely exceeds 30%. Species present may include *Cenchrus longispinus, Polygonum lapathifolium, Schoenoplectus americanus, Triglochin maritima*, and *Xanthium strumarium*. Because this type is subject to repeated scouring by floods, pioneering herbaceous species are often buried or removed. Woody debris and deep sandy sediments help build the sites by becoming trapped among the basal stems of the willows.

7. *Populus deltoides* (ssp. *wislizeni*, ssp. *monilifera*) / *Salix exigua* Woodland
Translated Name: (Rio Grande Cottonwood, Plains Cottonwood) / Coyote Willow Woodland
Summary: This is a lowland riparian association known from New Mexico, the Great Plains of Colorado, North Dakota, Nebraska, Oklahoma, South Dakota, and Texas, and in the Colorado Plateau of Utah and Colorado. This association occurs in wide river corridors that have low-

gradient and primarily sandy/gravelly beds. This association is dominated by relatively young stands of *Populus deltoides* that form open to moderately open overstories (25-50 % cover) with thickets of *Salix exigua* in the understory. Herbaceous cover is abundant, particularly among graminoids, and numerous native wetland indicators can be present. Overall herbaceous diversity is high. Initially developing on exposed depositional sandbars, this mid-successional community type depends on periodic flooding for maintenance and growth, even when well-established. As sediments and debris become trapped among the woody stems, the bar becomes more stable. In this community type, the cottonwoods overtop the shrubby willows. Because the willows are limited to lower riverside bars or cutoff channels, the community type eventually changes as the trees develop into mature forests on higher terraces without the willow understory.

8. *Populus deltoides - (Salix amygdaloides) / Salix (exigua, interior)* Woodland
Common Name: Cottonwood - Peachleaf Willow Floodplain Woodland
Summary: This cottonwood - willow woodland is found widely in the central Great Plains of the United States and perhaps in North Dakota. Stands occur on recently deposited alluvial material along rivers and streams. The water table fluctuates with the level of the adjacent river or stream. *Populus deltoides* is the dominant species in this community, although *Salix exigua* and/or *Salix interior* is generally more dominant in the initial stage following a major flood event. *Salix amygdaloides* is rare to co-dominant. The shrub/sapling layer is conspicuous, especially near the stream bank, and consists mainly of *Salix exigua*, *Populus deltoides*, and *Salix amygdaloides*, or occasionally *Salix lutea*. In the more easterly parts of the range, *Salix interior* may replace *Salix exigua*. On the older margins of this community *Fraxinus pennsylvanica* is often found as a sapling or small canopy tree. The herbaceous stratum is variable. Graminoids include *Carex emoryi, Carex pellita, Pascopyrum smithii*, and *Spartina pectinata*. *Equisetum arvense* and *Glycyrrhiza lepidota* are common forbs in these sites. Widely distributed species that are adapted to these sites include *Ambrosia psilostachya, Artemisia campestris* ssp. *caudata, Artemisia ludoviciana, Calamovilfa longifolia, Cenchrus longispinus, Chamaesyce serpyllifolia, Euphorbia esula, Grindelia squarrosa, Helianthus petiolaris, Heterotheca villosa, Phyla lanceolata, Opuntia macrorhiza, Poa pratensis*, and *Sporobolus cryptandrus*. These sites are prone to invasion by exotic grasses and forbs, the most widely established being *Agrostis stolonifera, Bromus tectorum, Cirsium arvense, Bassia scoparia* (= *Kochia scoparia*), *Melilotus* spp., *Taraxacum officinale*, and *Tragopogon dubius*. This type is subject to, and maintained by, periodic flooding.

9. *Populus deltoides / Symphoricarpos occidentalis* Woodland
Common Name: Cottonwood / Western Snowberry Woodland
Summary: This riparian woodland community is found in the northwestern Great Plains of the United States on medium to coarse-textured alluvial soils on the floodplains of major rivers. The floodplains are both seasonally inundated and subirrigated. This community is dominated by *Populus deltoides*, with *Acer negundo, Fraxinus pennsylvanica*, or other deciduous tree species sometimes in the canopy as well. The tallest trees exceed 50 ft (15 m). The shrub layer is typically 1.5-3 ft (0.5-1 m) tall. It is dominated by *Symphoricarpos occidentalis* and commonly includes *Juniperus scopulorum* and *Rosa* spp. The herbaceous layer usually includes *Pascopyrum smithii*. Weedy species such as *Melilotus officinalis, Taraxacum officinale*, and *Poa*

secunda are very common, especially in the presence of grazing. *Maianthemum stellatum* is abundant only where grazing is absent.

10. *Populus deltoides - Fraxinus pennsylvanica* Forest
Common Name: Cottonwood - Green Ash Floodplain Forest
Summary: This cottonwood - green ash riparian forest community occurs throughout the northern and central Great Plains of the United States and adjacent Canada. Stands occur along rivers and streams and around ponds and lakes. The canopy cover varies considerably. *Populus deltoides* and *Fraxinus pennsylvanica* are the most abundant mature trees. *Acer negundo* and *Ulmus americana* may also be present in the tree layer. *Juniperus scopulorum* may occur in the western portion of this community's range, and *Juniperus virginiana* in the eastern part. This community is dynamic; in younger stands *Populus deltoides* is the dominant, but *Fraxinus pennsylvanica* becomes more prominent as stands age. Species such as *Rosa woodsii, Symphoricarpos occidentalis, Juniperus scopulorum, Juniperus communis, Prunus virginiana, Cornus drummondii,* and *Cornus sericea* ssp. *sericea* can be abundant. *Carex* spp., *Juncus* spp., *Leymus cinereus, Lysimachia ciliata, Thalictrum venulosum,* and *Elymus canadensis* are common in the northern Plains. Weedy species are almost ubiquitous, especially *Poa pratensis, Bromus inermis, Melilotus officinalis, Ambrosia* spp., and *Urtica* spp.

11. *Populus deltoides / Cornus sericea* Forest
Translated Name: Eastern Cottonwood / Red-osier Dogwood Forest
Summary: This association is found in the Great Plains of central and eastern Montana, southern Alberta, southern Saskatchewan, and possibly western North Dakota, generally between 1800 and 3600 ft (550 and 1100 m) in elevation. It occurs primarily in the floodplains of major alluvial streams and rivers but may also occur around the margins of lakes and ponds. This is a seral community associated with fluvial processes such as flooding and substrate deposition. It colonizes moist, freshly deposited alluvium and in the absence of further flood disturbance will often develop into *Fraxinus pennsylvanica*- or *Acer negundo*-dominated associations. *Populus deltoides* dominates the overstory, forming an open to closed canopy (average cover is 60%). *Populus balsamifera* ssp. *trichocarpa, Populus angustifolia,* and *Salix amygdaloides* may be present as subordinate canopy species. The shrub layer is diverse and well-established. *Cornus sericea* is the diagnostic species, and its cover value may vary from 1-90%. Other common shrubs are *Prunus virginiana, Salix lutea, Symphoricarpos occidentalis,* and *Rosa woodsii*. Exotic grasses, such as *Bromus inermis* and *Elymus repens,* often dominate the herbaceous layer. Common native herbaceous species include *Pascopyrum smithii, Glycyrrhiza lepidota, Maianthemum stellatum,* and *Solidago canadensis*.

12. *Populus deltoides (*ssp. *wislizeni,* ssp. *monilifera) / Pascopyrum smithii* Woodland
Translated Name: (Rio Grande Cottonwood, Plains Cottonwood) / Western Wheatgrass Woodland
Summary: This association represents riparian woodlands on the Great Plains of eastern Wyoming, southeastern Utah and possibly eastern Montana, the western Dakotas and Nebraska. The vegetation is simple in structure. *Populus deltoides* dominates a tree overstory that may consist of scattered large trees in old stands or of denser, small or -medium-sized trees in younger stands. Scattered shrubs may be present. The herbaceous undergrowth is composed of short or mid-height grasses and forbs; *Pascopyrum smithii* contributes as much canopy cover to

the undergrowth as does any other native species. As with other *Populus deltoides* woodlands, stands of this association generally are early- to mid-seral; *Populus deltoides* seedlings become established on bare sediment bars laid down by flood waters, and trees in the even-aged overstory are not replaced by younger cottonwoods as they age and die.

13. *Fraxinus pennsylvanica / Prunus virginiana* Forest
Translated Name: Green Ash / Chokecherry Forest
Summary: This green ash forest association is found in northern Great Plains of North Dakota, Montana and Wyoming. This description is based on information from Fort Union Trading Post National Historic Site in North Dakota and Montana. Additional global information will be added as it becomes available. These forests occur at the transition between the current floodplain and the old floodplain upon which the fort lies. The topography includes both the flat lying floodplain and the sloping transition zone to the older floodplain. This association is found primarily on silty clay and loam. The canopy is fairly dense and dominated by *Fraxinus pennsylvanica* and a lesser amount of *Ulmus americana*. The taller trees may reach 35-40 feet (11-12 m) tall, but the typical range is 20-35 feet (6-11 m). The understory may or may not have *Prunus virginiana* present. *Salix exigua* occurs irregularly but sometimes in large patches. Other shrubs present include *Rosa woodsii, Symphoricarpos occidentalis, Artemisia ludoviciana*, and *Crataegus douglasii*. The forb layer can be quite dense and include *Cirsium arvense, Xanthium strumarium, Poa pratensis, Nassella viridula*, and *Agropyron cristatum*.

14. *Fraxinus pennsylvanica - (Ulmus americana) / Symphoricarpos occidentalis* Forest
Common Name: Great Plains Ash - Elm - Snowberry Forest
Summary: This ash - elm forest type is found in the northeastern Great Plains of the United States and Canada. Stands are found on nearly level floodplains and lower terraces of rivers and streams, generally away from the river on older, stabilized sites. The water table may be relatively deep on higher terraces, allowing drier species to establish. Soils are typically clays or silty clays. The tree layer is variable in structure, ranging from open (25-50%) to closed (50% or more) canopy. *Fraxinus pennsylvanica* is the leading dominant. In some parts of the range *Juniperus scopulorum* is present in the subcanopy, particularly where the canopy is still open. *Populus deltoides* may be present as an emergent. Emergent *Populus deltoides* may also occur under a canopy of *Fraxinus pennsylvanica*, reflecting a successional shift in some stands. *Fraxinus pennsylvanica* is common in the subcanopy and sapling layer, and, in some stands, *Ulmus americana* may be an associate. *Acer negundo* may only be occasionally present in some parts of the range. The dominant shrub is *Symphoricarpos occidentalis*. Other shrub species may be present, including *Cornus sericea, Rosa woodsii*, and *Rhus aromatica*. A variety of herbs may be present, none at high cover values, including *Elymus canadensis, Maianthemum stellatum, Melilotus officinalis, Muhlenbergia racemosa, Parthenocissus vitacea, Poa pratensis, Thalictrum dasycarpum*, and *Toxicodendron rydbergii*.

15. *Shepherdia argentea* Shrubland
Translated Name: Silver Buffaloberry Shrubland
Summary: This mesic buffaloberry shrubland is found in the northern Great Plains of the United States and Canada, and on the western slope of Colorado south to the Paunsaugunt Plateau, Utah. Stands occur on stream terraces, rolling uplands, and badlands, and where moisture is more plentiful than the surrounding landscape, such as in swales, ravines, near streams and ditches,

and on northwest- to east-facing slopes. The vegetation is dominated by a moderate to dense canopy of medium-tall shrubs. The most abundant of these, *Shepherdia argentea*, is typically 5-10 ft (1.5-3 m) tall. Other common shrub species are *Juniperus horizontalis, Prunus virginiana, Ribes* spp., *Rhus aromatica, Rosa woodsii,* and *Symphoricarpos occidentalis*. Graminoids and forbs may have only half the cover of the shrub layer and are quite variable. Graminoids include *Poa pratensis, Pascopyrum smithii,* and *Bromus* spp. Common forbs are *Achillea millefolium, Artemisia ludoviciana*, and *Parietaria pensylvanica*. This community occurs in the landscape as either narrow bands along streams or in small thickets.

The probable historical vegetation described in the main text for the riparian floodplain areas is simply a brief summary of these vegetation associations and how they are related spatially and temporally. Three potential desired conditions were presented to FOUS staff, based on these descriptions and discussions with the staff:

River View Unobstructed: Vegetation is a mix of herbaceous vegetation dominated by grasses and grass-like species (rushes, sedges, cattails) and shrublands, at least some of which are tolerant of spring flooding and a water table at or near the soil surface. Zonation of these vegetation types is determined by distance from river channel, elevation above low water level, and time since river scouring. Tree cover is sparse or short enough that views from the fort to the water's edge are unobstructed. Noxious weeds are minimal. Spring flooding occurs almost annually, with flood height and duration varying with weather conditions and snow pack upstream. The river channel and vegetation are dynamic within the constraints caused by dams on the Missouri and Yellowstone Rivers and the restriction of tree cover.

1844 View: Main river channel is less than 330 ft (100 m) from the main (river side) entrance to the fort, leaving no river floodplain between the fort and the main channel. Vegetation on the riverbank is sparse, subject to erosion, and comprised of species characteristic of the terrace on which the fort sits, often occurring on slumps from the terrace. The river channel is relatively static such that no further erosion towards the fort occurs and the main river channel does not meander away from the fort.

Laissez-faire: Vegetation is mixed, with zones of herbaceous vegetation, shrubland, woodland, and forest determined by distance from river channel, elevation above low water level, and time since river scouring. Noxious weeds are minimal. Spring flooding occurs almost annually, with flood height and duration varying with weather conditions and snow pack upstream. The river channel and vegetation are dynamic within the constraints caused by dams on the Missouri and Yellowstone Rivers.

FOUS staff selected the first one and recommended a few modifications, which are included in the final version in the main text.

Uplands

The soils mapped in upland areas at FOUS fall into fourteen ecological sites. Ecological site descriptions for all but one of these have been published. For the exception, R053AY008ND – Sandy, the description from a similar ecological site (R054XY026ND – Sandy) was substituted. Each ecological site description contains a list of species occurring in the distinct vegetation communities designated as "states", as well as a range of annual biomass production documented

for each species in that state. Since vegetation monitoring at FOUS is generally in terms of cover, not biomass, it was assumed for the purpose of this exercise that the proportional cover of a species is the same as the proportional biomass in a vegetation community. For each of the four topo-geographical units in the uplands of FOUS (upper terraces surrounding the fort, hill tops and upper slopes, lower slopes and valleys, and terrace south of the Missouri River), a table listing all species (rows)[1] included in the description of any ecological site occurring in that topo-geographical unit and the four vegetation states (columns) included in all ecological site descriptions was compiled. Proportional cover of each species and functional type (warm-season grass, cool-season grass, grass-like species, forbs, shrubs, treed) was entered for a vegetation state as the range of values occurring for that species/type in that vegetation state across all ecological sites. Proportional cover values of species occurring in fewer than all of the ecological sites comprising the topo-geographical unit were adjusted downward by the fraction of ecological sites in which they occurred. These tables, along with the written descriptions of vegetation height, bare ground cover, and erosion potential in the ecological site descriptions and other published literature (for vegetation height; see references below) were used to compile written descriptions of probable historical vegetation in each topo-geographical unit (see main text for these descriptions and the assumptions on which they are based).

Potential desired conditions for these topo-geographical units were compiled based on these tables and descriptions (with different vegetation states comprising some of the options), as well as on discussions with FOUS staff.

Potential Desired Conditions for the Uplands Surrounding the Fort

Fort Active Period Composition and Structure (What the naturalists saw): Vegetation composition and structure are similar to the likely composition and structure around Fort Union Trading Post during the active period of the fort (1847-1860). Vegetation is characteristic of areas highly impacted by human traffic and heavy livestock use but lacking the non-native species associated with those areas today. Composition is characterized by native, grazing-tolerant and/or disturbance-tolerant (pioneer) species (see Table B1 for species composition and relative abundance). Non-native species comprise <5% of plant cover. Continuous canopy cover is generally short (<4 inches/10 cm), but occasional taller, grazing-resistant forbs and shrubs make vegetation height up to 14 inches (35 cm) tall. Prickly pear cactus may be abundant. Fallen litter is shallow (<0.4 inch/1 cm on average) and discontinuous, with bare ground comprising 5-15% of the soil surface area. Fire is relatively infrequent (>10 year interval) because of lack of fuels to carry fire. Grazing, or another process to maintain the short structure and species composition characteristic of this community, is nearly continuous (annual, season-long). Structure may be taller in wetter years (up to 12 inches/30 cm) and shorter (<4 inches/10 cm) in drier years, but composition remains relatively steady. Potential for soil erosion (wind or water) is moderate.

Fort Active Period Structure Only (What the traders saw): Vegetation structure is similar to the likely structure around Fort Union Trading Post during the active period of the fort (1847-1860), with grasses and sedges comprising 55-90% of the cover, forbs comprising

[1] Some ecological site descriptions included only generic names for species (e.g., aster, milkvetch) that are difficult to distinguish from each other.

10-20% of the cover, and shrubs 0-15% of the cover. Continuous canopy cover is generally short (<4 inches/10 cm), but occasional taller, grazing-resistant forbs and shrubs make canopy height up to 14 inches (35 cm) tall. Prickly pear cactus may be abundant. Fallen litter is shallow (<1 cm on average) and discontinuous, with bare ground comprising 5-15% of the soil surface area. Natural processes (fire, grazing) are tools used to maintain the desired condition, not part of the desired condition. Structure may be taller in wetter years (up to 12 inches/30 cm) and shorter (<4 inches/10 cm) in drier years. Potential for soil erosion (wind or water) is moderate.

Historic Climax Plant Community (What the prairie could be): Vegetation composition and structure resemble the historic climax plant community of a mixed-grass prairie dominated by native, perennial, cool-season, mid-height grasses but also including tall and short cool- and warm-season grasses and a diverse mixture of forbs and occasional shrubs (see Table B1 for species composition and relative abundance). Shrubs such as chokecherry, currant, wild plum, and silver buffaloberry are more abundant in the lowest terrace than in other areas within this unit, with all shrubs comprising 10-15% of the cover, compared to 1-5% in the higher terraces. Non-native species comprise <5% of the plant cover. Continuous canopy cover is 6-8 inches (15-20 cm) tall, but vegetation height is 16-24 inches (40-60 cm) tall, with some areas of even taller grasses (up to 60 inches/150 cm). Fallen litter is of moderate depth (2-4 cm) and bare ground is minimal (<2%). Fire occurs at 5-7 year intervals, and grazing, if applicable, is light or moderate and varies in timing from year to year. Canopy height and production fluctuate with fluctuations in climate. Species-level composition also fluctuates with fluctuations in climate and, if applicable, grazing, but does not get out of the desired range for more than a few years. Potential for soil erosion is low, and water infiltration is good.

Native, Resilient System of High Ecological Integrity (Keeping up with climate change): Vegetation is comprised of species native to North America (<5% non-native cover), but composition and structure are outside the range of the historic climax plant community because of substantial changes in climate compared to the reference period for that community. Vegetation is comprised of a diverse mix of species currently associated with the historic climax plant community (cool- and warm-season graminoids of various heights, forbs, shrubs), but may also include species historically associated with hotter, drier areas to the south and west of FOUS. Fire and grazing occur at intervals and intensities that help maintain low non-native cover and diverse native vegetation. Exposed bare ground is minimal, maintaining good conditions for water infiltration into soil and little soil movement caused by runoff or wind erosion. Composition and structure fluctuate or trend with fluctuations or trends in climate.

Table B1. Species composition and relative cover for Historic Climax Plant Community and Fort Active Period desired conditions for uplands surrounding the fort; relative cover is derived as the percentage of total biomass comprised by each group (e.g. grasses and sedges) or species reported in appropriate ecological site descriptions.

GROUP/species	Relative Cover in HCPC	Relative Cover in Active Fort Composition	GROUP/species	Relative Cover in HCPC	Relative Cover in Active Fort Composition
GRASSES & SEDGES	75 - 95	55 - 90	purple coneflower	<1	<1
bearded wheatgrass	1 - 3	0	purple prairie clover	1 - 4	0
big bluestem	0 - 24	<1	pussytoes	<1	0 - 3
blue grama	1 - 10	2 - 45	rush skeletonweed	<1	<1
bluebunch wheatgrass	<1	0	scaret gaura	<1	0
buffalograss	<1	1 - 3	scarlet globemallow	0 - 4	0 - 3
Canada wildrye	<1	0	scurfpea	0 - 2	<1
green needlegrass	6 - 25	0 - 3	silverleaf scurfpea	<1	1 - 2
Indiangrass	<1	0	wavyleaf thistle	<1	0 - 4
inland saltgrass	<1	0 - 4	western ragweed	0	1 - 1
little bluestem	0 - 8		western wallflower	<1	0
needle-and-thread	1 - 15	1 - 10	western yarrow	1 - 5	0 - 5
needleleaf sedge	0 - 2	1 - 3	white prairie aster	<1	<1
Penn sedge	1 - 2	0	wild onion	<1	<1
Plains muhly	<1	<1	wild parsley	<1	<1
Plains reedgrass	1 - 4	0	other annual forbs	<1	<1
porcupine grass	0 - 12	0	other perennial forbs	0 - 2	0 - 2
prairie dropseed	0 - 2	0	SHRUBS & SUBSHRUBS	1 - 15	0 - 15
prairie junegrass	1 - 4	1 - 10	brittle cactus	0	<1
red threeawn	<1	1 - 1	broom snakeweed	0	0 - 3
Sandberg bluegrass	1 - 4	0 - 5	chokecherry	<1	0
sideoats grama	0 - 20	<1	currant	<1	0
slender wheatgrass	<1	<1	fringed sagewort	0 - 4	0 - 15
switchgrass	1 - 2	0	golden currant	<1	0
thickspike wheatgrass	0 - 5	<1	hawthorn	<1	0
threadleaf sedge	1 - 3	1 - 3	juneberry	<1	0
western wheatgrass	5 - 40	5 - 20	leadplant	<1	0
other sedges	0 - 3	1 - 3	Plains pricklypear	<1	<1
other native perennial grasses	1 - 5	<1	poison ivy	<1	0
FORBS	2 - 10	10 - 20	rose	<1	0 - 2
American licorice	<1	0	rubber rabbitbrush	<1	0
American vetch	1 - 5	0	silver buffaloberry	<1	0
aster	<1	0	silver sagebrush	0 - 8	0 - 4
biscuitroot	<1	0	western snowberry	1 - 10	0 - 2
bluebells	<1	0	wild plum	<1	0
cudweed sagewort	1 - 2	0 - 8	winterfat	0 - 4	0
curlycup gumweed	0	0 - 3	other shrubs	0 - 5	<1
false boneset	<1	0	TREES	0 - 2	0 - 1
Flodman's thistle	<1	1 - 1	American elm	<1	<1
gayfeather	0 - 4	<1	boxelder	<1	<1
goldenpea	0 - 2	0	green ash	<1	<1
goldenrod	0 - 5	1 - 1	Plains cottonwood	<1	<1
green sagewort	<1	1 - 4	other trees	<1	<1
groundplum milkvetch	<1	0	CRYPTOGAMS	0-1	1 - 8
hairy goldenaster	<1	0	clubmoss	<1	1 - 8
heartleaf alexanders	<1	0			
heath aster	1 - 2	0 - 3			
Hoods (spiny) phlox	0 - 2	<1			
Lambert crazyweed	<1	<1			
larkspur	<1	<1			
Maximilian sunflower	<1	0			
meadow anemone	<1	0			
mint	<1	0			
northern bedstraw	<1	0			
prairie clover	<1	0			
prairie coneflower	0 - 2	0 - 4			
prairie onion	<1	0			
prairie rose	0 - 2	0			
prairie smoke	<1	0			

Potential Desired Conditions for Hill Tops and Upper Slopes in the Bodmer Overlook Unit

Historic Climax Plant Community = Fort Active Period Composition and Structure (What the naturalists saw): Vegetation composition and structure resemble the historic climax plant community of a mixed-grass prairie on shallow soils (hilltops and upper slopes). Composition is a mix of native, perennial, warm- and cool-season, mid-height grasses but also including tall and short grasses and a diverse mixture of forbs and occasional shrubs (see Table B2 for species composition and relative abundance). Non-native species comprise <5% of the plant cover. Canopy height is generally 6-24 inches (15-60-cm), with <10% of the area in taller (up to 150 cm) canopy. Fallen litter is relatively shallow (1-2 cm on average) and bare ground can comprise 10% of the soil surface. Some movement of litter is noticeable following a rainfall event. Fire occurs at 5-7 year intervals, but is patchy. Grazing, if applicable, is light and varies in timing from year to year. Canopy height and production fluctuate with fluctuations in climate. Species-level composition also fluctuates with fluctuations in climate and, if applicable, grazing, but does not get out of the desired range for more than a few years. Water infiltration and runoff varies with ground cover (rock, bare ground, vegetation, litter, etc.) but can be moderately slow (infiltration) and moderate-high (runoff) in areas with low vegetation cover.

Fort Active Period Structure Only (What the traders saw): Vegetation structure is similar to the likely structure during the active period of the fort (1847-1860), with forbs comprising 5-10% and shrubs 2-10% of cover, and the remainder graminoids. Species composition is not specified. Canopy height is generally 6-24 inches (15-60-cm), with <10% of the area in taller (up to 60 inches/150 cm) canopy. Fallen litter is relatively shallow (0.4-0.8 inch/1-2 cm on average) and bare ground can comprise 10% of the soil surface. Some movement of litter is noticeable following a rainfall event. Canopy height and production fluctuate with fluctuations in climate. Water infiltration and runoff varies with ground cover but can be moderately slow (infiltration) and moderate-high (runoff) in areas with low vegetation cover.

Native, Resilient System of High Ecological Integrity (Keeping up with climate change): Vegetation is comprised of species native to North America (<5% non-native cover), but composition and structure are outside the range of the historic climax plant community because of substantial changes in climate compared to the reference period for that community. Vegetation is comprised of a diverse mix of species currently associated with the historic climax plant community (cool- and warm-season graminoids of various heights, forbs, shrubs; tolerant of shallow soil conditions), but may also include species historically associated with hotter, drier areas to the south and west of FOUS. Fire and grazing occur at intervals and intensities that help maintain low non-native cover and diverse native vegetation. Exposed bare ground does occur, producing opportunities for runoff. Composition and structure fluctuate or trend with fluctuations or trends in climate.

Table B2. Species composition and relative cover for Historic Climax Plant Community potential desired conditions for hill tops and upper slopes in the Bodmer Overlook Unit; relative cover is derived as the percentage of total biomass comprised by each group (e.g. grasses and sedges) or species reported in appropriate ecological site descriptions.

GROUP/species	Relative Cover in HCPC	GROUP/species	Relative Cover in HCPC
GRASSES & SEDGES	80 - 90	Lambert crazyweed	<1
big bluestem	0 - 3	plains milkvetch	<1
blue grama	1 - 3	prairie clover	1 - 3
green needlegrass	3 - 5	prairie coneflower	<1
inland saltgrass	<1	prairie smoke	<1
little bluestem	5 - 20	purple coneflower	1 - 3
needle-and-thread	5 - 10	pussytoes	<1
plains muhly	5 - 15	rush skeletonweed	<1
plains reedgrass	<1	scaret gaura	<1
porcupine grass	0 - 5	scarlet globemallow	<1
prairie dropseed	<1	scurfpea	1 - 2
prairie junegrass	1 - 2	stiff sunflower	<1
prairie sandreed	0 - 5	wavyleaf thistle	<1
red threeawn	1 - 2	western yarrow	1 - 2
Sandberg bluegrass	1 - 2	wild onion	<1
sideoats grama	5 - 15	other annual forbs	<1
slender wheatgrass	<1	other perennial forbs	0 - 2
thickspike wheatgrass	<1	SHRUBS	2 - 5
threadleaf sedge	3 - 7	broom snakeweed	<1
western wheatgrass	5 - 8	cactus	<1
other native perennial grasses	0 - 2	creeping juniper	<1
other sedges	0 - 2	dwarf false indigo	<1
FORBS	5 - 10	fringed sagewort	1 - 2
American pasqueflower	1 - 2	kinnikinnick	<1
American vetch	<1	other shrubs	<1
blanketflower	<1	poison ivy	<1
cudweed sagewort	<1	rose	1 - 2
cutleaf ironplant	1 - 2	rubber rabbitbrush	<1
eriogonum	<1	silver buffaloberry	<1
gayfeather	1 - 3	silver sagebrush	<1
goldenrod	1 - 2	skunkbush sumac	<1
green sagewort	<1	western snowberry	<1
groundplum milkvetch	<1	winterfat	1 - 2
heath aster	<1	TREES	0
Hoods (spiny) phlox	<1	CRYPTOGAMS	0 - 1
Indian breadroot	<1	clubmoss	<1

Potential Desired Conditions for Valleys and Lower Slopes in the Bodmer Overlook

Historic Climax Plant Community = Fort Active Period Composition and Structure (What the naturalists saw): Vegetation composition and structure resemble the historic climax plant community of a mixed-grass prairie dominated by native, perennial, cool- and warm-season, tall and mid-height grasses but also including some shorter grasses and a diverse mixture of forbs, occasional shrubs and, in valley bottoms (draws), occasional trees (see Table B3 for species composition and relative abundance). Shrubs such as chokecherry, golden currant, and wild plum and American elm or green ash trees are more abundant in draws than in other areas within this unit. Non-native species comprise <5% of the plant cover. Continuous canopy height is 6-8 inches (15-20 cm) tall, but herbaceous vegetation height is 40-60 cm tall, with some areas of even taller grasses (up to 60 inches/150 cm). Fallen litter is of moderate depth (0.8-1.6 inches/2-4 cm) and bare ground is minimal (<2%). Fire occurs at 5-7 year intervals (less frequently in draws), and grazing, if applicable, is light to moderate and varies in timing from year to year. Herbaceous canopy height and production fluctuate with fluctuations in climate. Species-

level composition also fluctuates with fluctuations in climate and, if applicable, grazing, but does not get out of the desired range for more than a few years. Potential for soil erosion is low, and water infiltration is good.

Fort Active Period Structure Only (What the traders saw): Vegetation structure is similar to the likely structure around Fort Union Trading Post during the active period of the fort (1847-1860), with forbs comprising 10% of the cover, shrubs 5%, hardwood trees 2% in valley bottoms (draws), and grasses the remainder. Species composition is not specified. Herbaceous canopy height (structure) is generally in the 6-24 inches (15-60) cm range, but approximately 20% of the herbaceous canopy is up to 60 inches (150 cm) in height. Fallen litter is of moderate depth (0.8-2.0 inches/2-5 cm). Natural processes (fire, grazing) are tools used to maintain the desired condition, not part of the desired condition. Herbaceous canopy height fluctuates with climate. Potential for soil erosion (wind or water) is low.

Native, Resilient System of High Ecological Integrity (Keeping up with climate change): Vegetation is comprised of species native to North America (<5% non-native cover), but composition and structure are outside the range of the historic climax plant community because of substantial changes in climate compared to the reference period for that community. Vegetation is comprised of a diverse mix of species currently associated with the historic climax plant community (cool- and warm-season graminoids of various heights, forbs, shrubs, trees in draws), but may also include species historically associated with hotter, drier areas to the south and west of FOUS. Fire and grazing occur at intervals and intensities that help maintain low non-native cover and diverse native vegetation. Exposed bare ground is minimal, maintaining good conditions for water infiltration into soil and little soil movement caused by runoff or wind erosion. Composition and structure fluctuate or trend with fluctuations or trends in climate.

Table B3. Species composition and relative cover for Historic Climax Plant Community potential desired conditions for valleys and lower slopes in the Bodmer Overlook Unit relative cover is derived as the percentage of total biomass comprised by each group (e.g. grasses and sedges) or species reported in appropriate ecological site descriptions.

GROUP/species	Relative Cover in HCPC	GROUP/species	Relative Cover in HCPC
GRASSES & SEDGES	85 - 95	Maximilian sunflower	<1
bearded wheatgrass	1 - 5	meadow anemone	<1
big bluestem	0 - 30	northern bedstraw	<1
blue grama	1 - 10	prairie coneflower	0 - 2
Canada wildrye	<1	prairie smoke	<1
fescue sedge	<1	purple coneflower	<1
green needlegrass	10 - 20	purple prairie clover	1 - 2
Indiangrass	<1	rush skeletonweed	<1
little bluestem	<1	scarlet globemallow	<1
needle-and-thread	1 - 10	silverleaf scurfpea	0 - 2
needleleaf sedge	1 - 3	western yarrow	1 - 2
Penn sedge	1 - 3	wild onion	<1
plains reedgrass	1 - 3	other native forbs	0 - 2
porcupine grass	2 - 7	SHRUBS	1 - 5
prairie dropseed	<1	chokecherry	<1
prairie junegrass	1 - 3	fringed sagewort	<1
red threeawn	<1	golden currant	<1
Sandberg bluegrass	1 - 3	hawthorn	<1
sideoats grama	0 - 5	juneberry	<1
slender wheatgrass	<1	leadplant	0 - 2
switchgrass	3 - 5	poison ivy	<1
threadleaf sedge	1 - 3	prairie rose	0 - 2
western wheatgrass	10 - 30	silver sagebrush	<1
other sedges	1 - 5	western snowberry	1 - 3
other native perennial grasses	1 - 3	wild plum	<1
FORBS	5 - 10	winterfat	<1
American licorice	<1	other shrubs	0 - 2
American vetch	1 - 2	TREES	0 - 2
groundplum milkvetch	<1	American elm	<1
heartleaf alexanders	<1	green ash	<1
heath aster	1 - 2	other trees	<1

Potential Desired Conditions for the Terrace South of Missouri River

Living Screen to Enhance Viewshed (1844 View): Dense cover of native shrubs and trees blocks view of agricultural and other development south of park property and resembles vegetation that may have been present during the active period of the fort. Herbaceous understory may be sparse. Fire and grazing do not occur.

Historic Climax Plant Community Based on Soils: Vegetation is native grassland described as the historic climax plant community for dense clay, sandy terrace, and loamy terrace soils. Native grasses and sedges comprise 75-85% of the cover, forbs 5-15%, and shrubs 5-15% (see Table B4 for species composition). Hardwood trees are sparse (<2% cover) if present. Non-native species comprise <5% of the plant cover. Productivity is relatively high compared to other grasslands because of run-off from adjacent areas and moderate or high available water capacity. In areas of dense clay, 30-40% of the soil surface is bare ground. Elsewhere, bare ground is minimal (<2%). Vegetation height is generally <24 inches (60 cm). Fallen litter is of moderate depth (0.8-1.6 inches/2-4 cm). Fire occurs at 5-7 year intervals, and grazing, if applicable, is light or moderate and varies in timing from year to year. Canopy height and production fluctuate with fluctuations in climate. Species-level composition also fluctuates with fluctuations in climate and, if applicable, grazing, but does not get out of the desired range for more than a few years.

Potential for soil erosion is low, and water infiltration is good except in dense clays, where water infiltration is fair.

The desired conditions selected by FOUS staff from these options are included in the main text, after a few minor modifications to incorporate staff input and additions realized to be necessary as the plan was completed.

Table B4. Species composition and relative cover for Historic Climax Plant Community potential desired conditions for the upper terrace south of the Missouri River relative cover is derived as the percentage of total biomass comprised by each group (e.g. grasses and sedges) or species reported in appropriate ecological site descriptions.

GROUP/species	Relative Cover in HCPC	More likely in, or exclusive to, this soil type	GROUP/species	Relative Cover in HCPC	More likely in, or exclusive to, this soil type
GRASSES & SEDGES	75 - 85		mint	<1	loamy
bearded wheatgrass	1 - 3		penstemon	0 - 3	
big bluestem	3 - 5		prairie clover	<1	sandy
blue grama	0 - 8		prairie coneflower	<1	
Canada wildrye	<1	sandy	purple coneflower	<1	
green needlegrass	2 - 30		purple prairie clover	<1	loamy
hairy grama	<1	sandy	pussytoes	0 - 2	clay
inland saltgrass	<1	loamy	rush skeletonweed	<1	
little bluestem	<1	sandy	scaret gaura	<1	
needle-and-thread	3 - 15		scarlet globemallow	0 - 5	
plains muhly	3 - 10		scurfpea	<1	sandy
plains reedgrass	0 - 3		silverleaf scurfpea	<1	loamy
porcupine grass	1 - 7		spiderwort	<1	sandy
prairie dropseed	1 - 2	loamy	stiff sunflower	<1	sandy
prairie junegrass	0 - 5		wavyleaf thistle	<1	
prairie sandreed	5 - 7	sandy	western wallflower	<1	
red threeawn	<1	sandy	western yarrow	<1	
Sandberg bluegrass	0 - 3		wild onion	<1	loamy
sand bluestem	2 - 3	sandy	other native forbs	0 - 2	clay
sand dropseed	0 - 3		other perennial forbs	<1	
Scribner panicum	<1	sandy	SHRUBS	5 - 15	
sideoats grama	2 - 5		big sagebrush	0 - 3	clay
thickspike wheatgrass	7 - 10	clay	cactus	<1	sandy
western wheatgrass	5 - 30		chokecherry	<1	
other native perennial grasses	0 - 5		creeping juniper	<1	sandy
needleleaf sedge	<1	loamy	currant	<1	loamy
Penn sedge	1 - 2		dwarf false indigo	<1	sandy
sun sedge	<1	sandy	fringed sagewort	0 - 10	
threadleaf sedge	0 - 5		juneberry	<1	loamy
other grass-likes	<1		leadplant	<1	sandy
FORBS	5 - 15		Nuttall saltbush	0 - 3	clay
American vetch	1 - 5		plains pricklypear	<1	clay
aster	0 - 2	clay	prairie rose	<1	loamy
bastard toadflax	0 - 2	clay	prickly rose	<1	loamy
bluebells	<1	loamy	rose	<1	sandy
cinquefoil	<1	sandy	silver buffaloberry	<1	
cudweed sagewort	<1		silver sagebrush	0 - 7	
false gromwell	<1	sandy	skunkbush sumac	<1	sandy
gayfeather	<1		western snowberry	1 - 7	
goldenpea	0 - 2	clay	wild plum	<1	loamy
goldenrod	1 - 2		winterfat	0 - 7	
green sagewort	<1	sandy	other shrubs	0 - 10	
groundplum milkvetch	<1		TREES	0 - 2	
hairy goldenaster	<1	sandy	American elm	<1	
heath aster	<1	loamy	boxelder	<1	loamy
Hoods (spiny) phlox	0 - 3		bur oak	<1	sandy
larkspur	<1	loamy	green ash	<1	
Maximilian sunflower	<1	loamy	Plains cottonwood	<1	
milkvetch	0 - 2	clay	other trees	<1	sandy

References

Fontaine, A. L., P. L. Kennedy, and D. H. Johnson. 2004. Effects of distance from cattle water developments on grassland birds. *Journal of Range Management* 57:238-242.

Fritcher, S. C., M. A. Rumble, and L. D. Flake. 2004. Grassland bird densities in seral stages of mixed-grass prairie. *Journal of Range Management* 57:351-357.

Lacey, J., M. Rasmussen, J. Siddoway, R. Bandy, and G. Snell. 2005. Ecological Site Description Dense Clay 10-14 inch p.z. R053AE073MT. Electronic Field Office Technical Guide. http://efotg.sc.egov.usda.gov/references/public/MT/53AE_Dense_Clay_10_to_14_inch_pz.pdf. Accessed 1 December 2010.

Lacey, J., M. Rasmussen, J. Siddoway, R. Bandy, and G. Snell. 2005. Ecological Site Description Silty 10-14 inch p.z. R053AE060MT. Electronic Field Office Technical Guide. http://efotg.sc.egov.usda.gov/references/public/MT/53AE_Silty_10_to_14_inch_pz.pdf. Accessed 6 January 2011.

Lacey, J., M. Rasmussen, J. Siddoway, R. Bandy, and G. Snell. 2005. Ecological Site Description Silty-Steep 10-14 inch p.z. R053AE058MT. Electronic Field Office Technical Guide. http://efotg.sc.egov.usda.gov/references/public/MT/53AE_Silty_Steep_10_to_14_inch_pz.pdf. Accessed 25 January 2011.

Naeth, M. A., A. W. Bailey, D. J. Pluth, D. S. Chanasyk, and R. T. Hardin. 1991. Grazing impacts on litter and soil organic matter in mixed prairie and fescue grassland ecosystems of Alberta. *Journal of Range Management* 44:7-12.

Salas, D. E., and M. J. Pucherelli. 2003. USGS-NPS Vegetation Mapping, Fort Union Trading Post National Historic Site. Remote Sensing and GIS Group, Technical Service Center, Bureau of Reclamation Report 8260-02-08, Denver, Colorado.

USDA-NRCS. 2003. Ecological Site Description Clayey R054XY020ND. Electronic Field Office Technical Guide. http://efotg.sc.egov.usda.gov//references/public/ND/R054XY020ND_clayey.pdf. Accessed 1 December 2010.

USDA-NRCS. 2003. Ecological Site Description Loamy R054XY031ND. Electronic Field Office Technical Guide. http://efotg.sc.egov.usda.gov//references/public/ND/R054XY031N_loamy.pdf. Accessed 1 December 2010.

USDA-NRCS. 2003. Ecological Site Description Loamy Overflow R054XY023ND. Electronic Field Office Technical Guide. http://efotg.sc.egov.usda.gov//references/public/ND/R054XY023ND_loamy_overflow.pdf. Accessed 1 December 2010.

USDA-NRCS. 2003. Ecological Site Description Loamy Terrace R054XY041ND. Electronic Field Office Technical Guide. http://efotg.sc.egov.usda.gov//references/public/ND/R054XY041ND_loamy_terrace.pdf. Accessed 1 December 2010.

USDA-NRCS. 2003. Ecological Site Description Sandy Terrace R054XY042ND. Electronic Field Office Technical Guide. http://efotg.sc.egov.usda.gov//references/public/ND/R054XY042ND_sandy_terrace.pdf. Accessed 1 December 2010.

USDA-NRCS. 2003. Ecological Site Description Shallow Loamy R054XY030ND. Electronic Field Office Technical Guide. http://efotg.sc.egov.usda.gov//references/public/ND/R054XY030N_shallow_loamy.pdf. Accessed 1 December 2010.

USDA-NRCS. 2003. Ecological Site Description Thin Loamy R054XY030ND. Electronic Field Office Technical Guide. http://efotg.sc.egov.usda.gov//references/public/ND/R054XY030N_thin_loamy.pdf. Accessed 1 December 2010.

U.S. Department of Interior National Park Service. 2001. Cultural Landscapes Inventory, Fort Union Trading Post National Historic Site.

White, K. 2009. Songbird diversity and habitat use in response to burning on grazed and ungrazed mixed-grass prairie Master's Thesis, University of Manitoba, Winnipeg, Manitoba.

Appendix C: NGP EPMT Exotic Plant Surveying and Chemical Treatments at FOUS

Records provided by Northern Great Plains Exotic Plant Management Team.

Survey **Chemical Treatments**

2002

Treatment

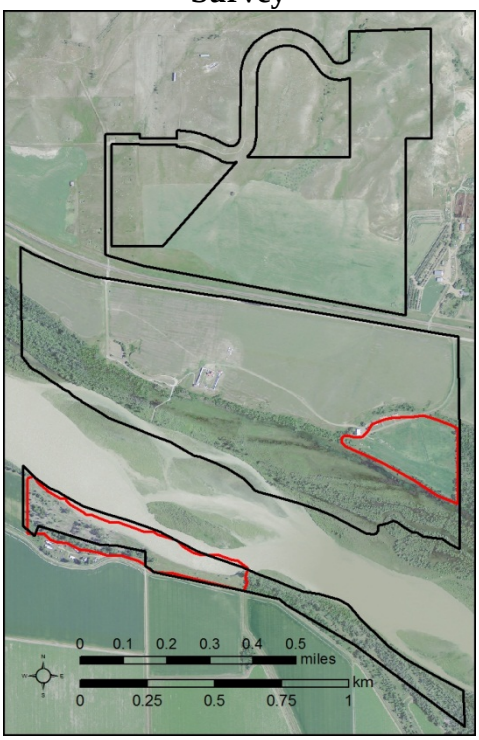
2003

Treatment

Survey **Chemical Treatments**

2004

Treatment



2005

Treatment

Survey **Chemical Treatments**

2006

Treatment

2007

Treatment

Survey **Chemical Treatments**

2008

Treatment

2009

Treatment

2010

Treatment

Survey

Chemical Treatments

Appendix D: Data from July 2010 Vegetation Sampling at FOUS

The following table reports the plot-level data for all species encountered during vegetation sampling in the restoration areas at FOUS in July 2010, as well as the occurrence of species in the field (but not the plot) represented by the plot. Cover values are absolute cover. For individual species, this is the number of points out of 100 at which the species was intercepted in the plot. For groups of species and total cover, this is the sum of the cover of the species in that group. Frequency of occurrence in each nested subplot size is given as the number of subplots (maximum possible is 10) in which the species occurred in the plot.

VMP-119 (Field 1)	Most of this field is weedier (sweetclover, kochia, Canada thistle) than the plot data indicate.			**Number of Nested Subplots in which Species Occurred**				
	Common Name	**Scientific Name**	**Cover (%)**	**0.01 m^2**	**0.1 m^2**	**1 m^2**	**10 m^2**	**In Field**
Total			**115**					
Introduced Species			***20***					
Forbs			***9***					
	Annuals and Biennials		***6***					
	small-seeded false flax	*Camelina microcarpa*				1	1	
	flixweed	*Descurainia sophia*				1	1	
	kochia	*Kochia scoparia*				2	6	
	prickly lettuce	*Lactuca serriola*	1	1	1	2	4	
	sweetclover	*Melilotus officinalis*	3			1	2	
	climbing buckwheat	*Polygonum convolvulus*					1	
	Russian thistle species	*Salsola* species	1		1	5	8	
	field pennycress	*Thlaspi arvense*		1	1	2	6	
	goat's beard, salsify	*Tragopogon dubius*	1		1	2	3	
	Perennials		***3***					
	field bindweed	*Convolvulus arvensis*					1	
	common dandelion	*Taraxacum officinale*	3		6	10	10	
Grasses			***11***					
	Annuals		***1***					
	Japanese brome, field brome	*Bromus arvensis*	1	0	0	0	0	
	yellow foxtail (ID uncertain)	*Setaria glauca* (ID uncertain)		1	3	5	5	
	green foxtail	*Setaria viridis*					2	
	Perennials		***10***					
	crested wheatgrass	*Agropyron cristatum*	1		1	2	5	
	smooth brome	*Bromus inermis*	9	1	2	5	7	
	Kentucky bluegrass	*Poa pratensis*					1	
Native Species			***93***					
Forbs			***4***					
	Annuals and Biennials		***3***					
	prostrate pigweed	*Amaranthus blitoides*			2	3	6	
	rough pigweed	*Amaranthus retroflexus*			1	3	6	
	spurge species	*Chamaesyce* species	2	3	4	6	6	
	horseweed	*Conyza canadensis*	1		1	2	3	
	large beardtongue	*Penstemon grandiflorus*						√
	blackeyed Susan	*Rudbeckia hirta*						√
	prostrate vervain	*Verbena bracteata*						√
	Perennials		***1***					
	common yarrow	*Achillea millefolium*						√
	lavender hyssop	*Agastache foeniculum*						√
	showy milkweed (ID uncertain)	*Asclepias speciosa* (could be *A. syriaca*)						√
	whorled milkweed	*Asclepias verticillata*						√
	purple prairie clover	*Dalea purpurea*				3	3	
	purple coneflower	*Echinacea angustifolia*				1	2	
	American licorice (ID uncertain)	*Glycyrrhiza lepidota* (ID uncertain)						√
	Maximilian sunflower	*Helianthus maximilianii*						√
	prairie coneflower	*Ratibida columnifera*					1	
	hoary vervain	*Verbena stricta*						√
	American vetch	*Vicia americana*	1	1	2	2	4	

VMP-119 (Field 1), cont'd.

	Common Name	Scientific Name	Cover (%)	Number of Nested Subplots in which Species Occurred: 0.01 m²	0.1 m²	1 m²	10 m²	In Field
	witchgrass	*Panicum capillare*	15	4	10	10	10	
	Perennials		***74***					
	side-oats grama	*Bouteloua curtipendula*			3	5	5	
	blue grama	*Bouteloua gracilis*	41	7	9	10	10	
	prairie junegrass	*Koeleria macrantha*	2	0	0	0	0	
	foxtail barley	*Hordeum jubatum*						√
	green needlegrass	*Nassella viridula*	6		1	6	7	
	switchgrass	*Panicum virgatum*						√
	western wheatgrass	*Pascopyrum smithii*	23	7	10	10	10	
	little bluestem	*Schizachyrium scoparium*	2	1	3	4	5	
Shrubs								
	dwarf sagebrush	*Artemisia cana*						√
	moundscale	*Atriplex nuttallii*					3	
Trees								
	green ash	*Fraxinus pennsylvanica*					1	
Origin Uncertain			***2***					
Forbs			***1***					
	Annuals and Biennials							
	small-seeded false flax (ID uncertain)	*Camelina microcarpa* (ID uncertain)				1	1	
	lamb's quarters or pitseed goosefoot (ID uncertain)	*Chenopodium album* or *C. berlandieri*		1	2	4	6	
	Perennials		***1***					
	meadow rue? (ID uncertain)	*Thalictrum* species? (ID uncertain)	1	0	0	0	0	
Grasses			***1***					
	Perennials		***1***					
	side-oats grama (ID uncertain)	*Bouteloua curtipendula* (ID uncertain)	1			3	3	

VMP-015 (Field 2)

	Common Name	Scientific Name	Cover (%)	Number of Nested Subplots in which Species Occurred: 0.01 m²	0.1 m²	1 m²	10 m²	In Field
Total			**84**					
Introduced Species			***32***					
Forbs			***12***					
	Annuals and Biennials		***8***					
	flixweed	*Descurainia sophia*	1			1	4	
	kochia	*Kochia scoparia*		1	5	8	8	
	prickly lettuce	*Lactuca serriola*				2	2	
	common mallow	*Malva neglecta*					1	
	sweetclover	*Melilotus officinalis*	1		1	3	6	
	climbing buckwheat	*Polygonum convolvulus*					2	
	Russian thistle	*Salsola species*	6	1	6	9	10	
	goat's beard, salsify	*Tragopogon dubius*				2	5	
	Perennials		***4***					
	Canada thistle	*Cirsium arvense*						√
	alfalfa	*Medicago sativa*	1				5	
	common dandelion	*Taraxacum officinale*	3	3	5	10	10	
Grasses			***20***					
	Annuals		***13***					
	yellow foxtail (ID uncertain)	*Setaria glauca* (ID uncertain)	4	1	7	10	10	
	green foxtail	*Setaria viridis*	9		6	6	7	
	Perennials		***7***					
	crested wheatgrass	*Agropyron cristatum*	3			1	4	
	smoothe brome	*Bromus inermis*	4	1	1	2	4	
	Kentucky bluegrass	*Poa pratensis*				1	1	
Native Species			***46***					
Forbs			***3***					
	Annuals and Biennials		***1***					
	prostrate pigweed	*Amaranthus blitoides*	1	3	5	8	10	
	rough pigweed	*Amaranthus retroflexus*					6	
	spurge species	*Chamaesyce* species			2	3	4	
	horseweed	*Conyza canadensis*				1	2	

VMP-015 (Field 2)				Number of Nested Subplots in which Species Occurred				
	Common Name	Scientific Name	Cover (%)	0.01 m^2	0.1 m^2	1 m^2	10 m^2	In Field
	common sunflower	*Helianthus annuus*					4	
	buffalo bur	*Solanum rostratum*				1	1	
	Perennials		***2***					
	purple prairie clover	*Dalea purpurea*			1	2	2	
	blacksamson echinacea	*Echinacea angustifolia*						√
	blanket flower, Mexican hat	*Gaillardia aristata*						√
	American licorice (ID uncertain)	*Glycyrrhiza lepidota* (ID uncertain)						√
	Maximilian sunflower	*Helianthus maximilianii*						√
	blue flax	*Linum lewisii*		2	4	4	7	
	prairie coneflower	*Ratibida columnifera*	1				3	
	hoary vervain	*Verbena stricta*						√
	American vetch	*Vicia americana*	1	0	0	0	0	
Grasses			***43***					
	Annuals		***7***					
	witchgrass	*Panicum capillare*	7	3	6	9	10	
	Perennials		***36***					
	big bluestem	*Andropogon gerardii*						√
	sideoats grama	*Bouteloua curtipendula*			2	2	3	
	blue grama	*Bouteloua gracilis*	20	5	7	7	7	
	needle-and-thread	*Hesperostipa comata*	1		1	2	5	
	green needlegrass	*Nassella viridula*	3	5	5	7	9	
	switchgrass	*Panicum virgatum*						√
	western wheatgrass	*Pascopyrum smithii*	12	3	7	10	10	
	little bluestem	*Schizachyrium scoparium*		1	4	5	7	
	sand dropseed	*Sporobolus cryptandrus*					1	
Origin Uncertain			***6***					
Forbs								
	Annuals and Biennials							
	lamb's quarters or pitseed goosefoot	*Chenopodium album* or *C. berlandieri* (ID uncertain)					2	
Grasses			***6***					
	Perennials		***6***					
	side-oats grama (ID uncertain)	*Bouteloua curtipendula* (ID uncertain)	3		2	5	5	
	thickspike wheatgrass (ID uncertain)	*Elymus lanceolatus* (ID uncertain)	3		2	2	2	
	prairie junegrass (ID uncertain)	*Koeleria macrantha* (ID uncertain)		1	1	1	2	

Field 3 (No quantitative sampling)			
	Common Name	Scientific Name	In Field
Introduced Species			
Forbs			
	Perennials		
	alfalfa	*Medicago sativa*	√
	sweetclover	*Melilotus officinalis*	common
Grasses			
	Perennials		
	smooth brome	*Bromus inermis*	common
Native Species			
Forbs			
	Perennials		
	purple coneflower	*Echinacea angustifolia*	√
	American licorice (ID uncertain)	*Glycyrrhiza lepidota* (ID uncertain)	√
	Maximilian sunflower	*Helianthus maximilianii*	√
	hoary vervain	*Verbena stricta*	√
Grasses			
	Perennials		
	blue grama	*Bouteloua gracilis*	common
	switchgrass	*Panicum virgatum*	√
	western wheatgrass	*Pascopyrum smithii*	common
Shrubs			
	dwarf sagebrush	*Artemisia cana*	√
	moundscale	*Atriplex nuttallii*	√

VMP-004 (Boundary of Fields 4 and 6)

Common Name	Scientific Name	Cover (%)	Number of Nested Subplots in which Species Occurred: 0.01 m²	0.1 m²	1 m²	10 m²	In Field
Total		**127**					
Introduced Species		***47***					
Forbs		***37***					
Annuals and Biennials		***2***					
flixweed	*Descurainia sophia*	2	0	0	2	4	
kochia	*Kochia scoparia*		2	3	4	6	
prickly lettuce	*Lactuca serriola*			1	1	1	
sweetclover	*Melilotus officinalis*				1	2	
Russian thistle species	*Salsola* species			1	3	5	
field pennycress	*Thlaspi arvense*					3	
goat's beard, salsify	*Tragopogon dubius*					2	
Perennials		***35***					
Canada thistle	*Cirsium arvense*	2			1	1	
field bindweed	*Convolvulus arvensis*	27	3	5	6	7	
common dandelion	*Taraxacum officinale*	6	4	6	10	11	
Grasses		***10***					
Annuals		***4***					
yellow foxtail (ID uncertain)	*Setaria glauca* (ID uncertain)	1		4	4	4	
green foxtail	*Setaria viridis*	3	1	6	6	7	
Perennials		***6***					
crested wheatgrass	*Agropyron cristatum*	2		1	3	3	
smooth brome	*Bromus inermis*	4	2	3	5	6	
Native Species		***80***					
Forbs		***4***					
Annuals and Biennials		***3***					
prostrate pigweed	*Amaranthus blitoides*		2	3	8	8	
rough pigweed	*Amaranthus retroflexus*					1	
spurge species (ID uncertain)	*Chamaesyce species*	3	3	5	9	9	
large beardtongue	*Penstemon grandiflorus*						√
Perennials		***1***					
purple prairie clover	*Dalea purpurea*	1		2	2	4	
Maximilian sunflower	*Helianthus maximilianii*						√
blue flax	*Linum lewisii*					1	
prairie coneflower	*Ratibida columnifera*						√
hoary vervain	*Verbena stricta*					1	
American vetch	*Vicia americana*			2	2	3	
Grasses		***76***					
Annuals		***0***					
witchgrass	*Panicum capillare*		1	4	5	5	
Japanese brome, field brome	*Bromus arvensis*						√
Perennials		***76***					
side-oats grama	*Bouteloua curtipendula*	7	1	5	7	9	
blue grama	*Bouteloua gracilis*	31	3	6	7	8	
foxtail barley	*Hordeum jubatum*		1	2	2	2	
needle-and-thread	*Hesperostipa comata*	1				2	
green needlegrass	*Nassella viridula*	13	3	7	9	9	
western wheatgrass	*Pascopyrum smithii*	23	3	5	10	10	
little bluestem	*Schizachyrium scoparium*	1		2	3	3	

VMP-008 (Field 6)

Common Name	Scientific Name	Cover (%)	Number of Nested Subplots in which Species Occurred: 0.01 m²	0.1 m²	1 m²	10 m²	In Field
Total		**119**					
Introduced Species		***1***					
Forbs		***1***					
Annuals and Biennials		***0***					
small-seeded flax	*Camelina microcarpa*					1	
flixweed	*Descurainia sophia*				1	3	
kochia	*Kochia scoparia*			1	1	4	
sweetclover	*Melilotus officinalis*				2	5	
Russian thistle species	*Salsola* species				2	6	
goat's beard, salsify	*Tragopogon dubius*				1	2	

VMP-008 (Field 6), cont'd.				Number of Nested Subplots in which Species Occurred				
	Common Name	Scientific Name	Cover (%)	0.01 m^2	0.1 m^2	1 m^2	10 m^2	In Field
	Perennials		***1***					
	crown vetch	*Coronilla varia*						√
	black medic	*Medicago lupulina*					1	
	alfalfa	*Medicago sativa*	1				2	
	common dandelion	*Taraxacum officinale*			1	4	10	
Grasses								
	Annuals		***0***					
	green foxtail	*Setaria viridis*				1	2	
	Perennials		***0***					
	crested wheatgrass	*Agropyron cristatum*					2	
	smooth brome	*Bromus inermis*					1	
Native Species			***117***					
Forbs								
	Annuals and Biennials		***0***					
	prostrate pigweed	*Amaranthus blitoides*				1	4	
	spurge species	*Chamaesyce* species				1	1	
	large beardtongue	*Penstemon grandiflorus*					1	
	Perennials		***0***					
	common yarrow	*Achillea millefolium*						√
	purple prairie clover	*Dalea purpurea*			1	1	1	
	purple coneflower	*Echinacea angustifolia*					1	
	scarlet globemallow	*Sphaeralcea coccinea*					1	
	hoary vervain	*Verbena stricta*						√
	American vetch	*Vicia americana*			2	4	7	
Grasses			***117***					
	Perennials		***117***					
	side-oats grama	*Bouteloua curtipendula*	26	1	3	10	10	
	blue grama	*Bouteloua gracilis*	87	9	10	10	10	
	hairy grama	*Bouteloua hirsuta*			1	1	1	
	green needlegrass	*Nassella viridula*	3	1	2	5	9	
	western wheatgrass	*Pascopyrum smithii*	1		1	3	9	
Origin Uncertain			***1***					
Grasses			***1***					
	Perennials		***1***					
	thickspike wheatgrass (ID uncertain)	*Elymus lanceolatus* (ID uncertain)	1	1	1	1	1	

VMP-024 (Field 7)				Number of Nested Subplots in which Species Occurred				
	Common Name	Scientific Name	Cover (%)	0.01 m^2	0.1 m^2	1 m^2	10 m^2	In Field
Total			**150**					
Introduced Species			***27***					
Forbs			***7***					
	Annuals and Biennials		***3***					
	small-seeded false flax	*Camelina microcarpa*					2	
	flixweed	*Descurainia sophia*					5	
	kochia	*Kochia scoparia*			1	3	4	
	prickly lettuce	*Lactuca serriola*					1	
	sweetclover	*Melilotus officinalis*					1	
	Russian thistle species	*Salsola* species			1	5	8	
	tall hedge mustard	*Sisymbrium loeselii*	3	1	3	7	10	
	field pennycress	*Thlaspi arvense*			2	5	9	
	goat's beard, salsify	*Tragopogon dubius*					1	
	Perennials		***4***					
	field bindweed	*Convolvulus arvensis*				1	1	
	black medic	*Medicago lupulina*					2	
	common dandelion	*Taraxacum officinale*	4	1	5	10	10	
Grasses			***20***					
	Annuals		***8***					
	Japanese brome, field brome	*Bromus arvensis*	8	2	3	7	8	
	downy brome, cheatgrass	*Bromus tectorum*					1	

VMP-024 (Field 7), cont'd.

	Common Name	Scientific Name	Cover (%)	Number of Nested Subplots in which Species Occurred: 0.01 m^2	0.1 m^2	1 m^2	10 m^2	In Field
	Perennials		***12***					
	crested wheatgrass	*Agropyron cristatum*	9	2	2	3	4	
	smooth brome	*Bromus inermis*	3	1	2	2	2	
Native Species			***121***					
Forbs			***3***					
	Annuals and Biennials		***0***					
	prostrate pigweed	*Amaranthus blitoides*					1	
	spurge species	*Chamaesyce* species					1	
	waterpod	*Ellisia nyctelea*				1	2	
	large beardtongue	*Penstemon grandiflorus*					1	
	Perennials		***3***					
	common yarrow	*Achillea millefolium*	2				4	
	purple prairie clover	*Dalea purpurea*						√
	blue flax	*Linum lewisii*					1	
	American vetch	*Vicia americana*	1	0	0	0	0	
Grasses			***118***					
	Perennials		***118***					
	sideoats grama	*Bouteloua curtipendula*						√
	foxtail barley	*Hordeum jubatum*	1			1	3	
	green needlegrass	*Nassella viridula*	62	4	7	9	10	
	western wheatgrass	*Pascopyrum smithii*	55	7	8	9	10	
Origin Uncertain			***2***					
Grasses			***2***					
	Perennials		***2***					
	thickspike wheatgrass (ID uncertain)	*Elymus lanceolatus* (ID uncertain)	2	1	2	3	3	

VMP-012 (Field 8)

	Common Name	Scientific Name	Cover (%)	Number of Nested Subplots in which Species Occurred: 0.01 m^2	0.1 m^2	1 m^2	10 m^2	In Field
Total			**104**					
Introduced Species			***2***					
Forbs			***1***					
	Annuals and Biennials		***0***					
	flixweed	*Descurainia sophia*					1	
	kochia	*Kochia scoparia*				2	3	
	prickly lettuce	*Lactuca serriola*				1	2	
	sweetclover	*Melilotus officinalis*					1	
	Russian thistle species	*Salsola* species				3	4	
	goat's beard, salsify	*Tragopogon dubius*					2	
	Perennials		***1***					
	common dandelion	*Taraxacum officinale*	1	1	5	10	10	
	alfalfa	*Medicago sativa*						√
Grasses			***1***					
	Perennials		***1***					
	crested wheatgrass	*Agropyron cristatum*	1				2	
Native Species			***100***					
Forbs								
	Annuals and Biennials		***0***					
	spurge species	*Chamaesyce* species		1	1	1	1	
	horseweed	*Conyza canadensis*					3	
	large beardtongue	*Penstemon grandiflorus*					2	
	Perennials		***0***					
	white prairie clover	*Dalea candida*						√
	purple prairie clover	*Dalea purpurea*					2	
	purple coneflower	*Echinacea angustifolia*				1	4	
	blue flax	*Linum lewisii*				1	1	
	scarlet globemallow	*Sphaeralcea coccinea*			1	1	1	
Grasses			***100***					
	Annuals		***0***					
	witchgrass	*Panicum capillare*				1	1	
	Perennials		***100***					
	side-oats grama	*Bouteloua curtipendula*	1			1	3	
	blue grama	*Bouteloua gracilis*					1	
	needle-and-thread	*Hesperostipa comata*	1		1	3	8	

VMP-012 (Field 8), cont'd.				Number of Nested Subplots in which Species Occurred				
	Common Name	Scientific Name	Cover (%)	0.01 m^2	0.1 m^2	1 m^2	10 m^2	In Field
	foxtail barley	*Hordeum jubatum*						√
	green needlegrass	*Nassella viridula*	37	2	6	10	10	
	western wheatgrass	*Pascopyrum smithii*	61	9	10	10	10	
Origin Uncertain			***2***					
Forbs								
	Perennials							
	crown vetch (ID uncertain)	*Coronilla varia* (ID uncertain)					1	
Grasses			***2***					
	Perennials		***2***					
	thickspike wheatgrass (ID uncertain)	*Elymus lanceolatus* (ID uncertain)	2			1	1	

VMP-011 (Field 9)				Number of Nested Subplots in which Species Occurred				
	Common Name	Scientific Name	Cover (%)	0.01 m^2	0.1 m^2	1 m^2	10 m^2	In Field
Total			**160**					
Introduced Species			***13***					
Forbs			***10***					
	Annuals and Biennials		***6***					
	pale alyssum	*Alyssum alyssoides*			1	1	1	
	small-seeded false flax	*Camelina microcarpa*					1	
	flixweed	*Descurainia sophia*						√
	prickly lettuce	*Lactuca serriola*					2	
	sweetclover	*Melilotus officinalis*	5	1	1	2	2	
	Russian thistle species	*Salsola* species			1	1	1	
	tall hedge mustard	*Sisymbrium loeselii*						√
	field pennycress	*Thlaspi arvense*						√
	goat's beard, salsify	*Tragopogon dubius*	1				4	
	Perennials		***4***					
	Canada thistle	*Cirsium arvense*						√
	alfalfa	*Medicago sativa*						√
	climbing buckwheat	*Polygonum convolvulus*			1	4	10	
	common dandelion	*Taraxacum officinale*	4	1	5	8	10	
Grasses			***3***					
	Annuals		***0***					
	Japanese brome, field brome	*Bromus arvensis*						√
	Perennials		***3***					
	crested wheatgrass	*Agropyron cristatum*	2	1	1	4	9	
	smooth brome	*Bromus inermis*					1	
	Kentucky bluegrass	*Poa pratensis*	1	1	2	2	2	
Native Species			***135***					
Forbs			***5***					
	Annuals and Biennials		***0***					
	ridgeseed spurge	*Chamaesyce glyptosperma*				1	3	
	spurge species	*Chamaesyce* species				2	3	
	horseweed	*Conyza canadensis*		1	2	2	5	
	curly-cup gumweed	*Grindelia squarrosa*						√
	rough false pennyroyal	*Hedeoma hispida*			2	5	9	
	large beardtongue	*Penstemon grandiflorus*						√
	Perennials		***5***					
	common yarrow	*Achillea millefolium*					1	
	fringed sage, prairie sagewort	*Artemisia frigida*						√
	purple prairie clover	*Dalea purpurea*			1	1	3	
	purple coneflower	*Echinacea angustifolia*						√
	Maximilian sunflower	*Helianthus maximilianii*						√
	blue flax	*Linum lewisii*						√
	Pennsylvania cinquefoil	*Potentilla pennsylvanica*						√
	prairie coneflower	*Ratibida columnifera*						√
	scarlet globemallow	*Sphaeralcea coccinea*						√
	American vetch	*Vicia americana*	5	1	4	7	8	

VMP-011 (Field 9), cont'd.

Common Name	Scientific Name	Cover (%)	Number of Nested Subplots in which Species Occurred: 0.01 m^2	0.1 m^2	1 m^2	10 m^2	In Field
Grasses		***130***					
Perennials		***130***					
side-oats grama	*Bouteloua curtipendula*	18	3	5	7	10	
blue grama	*Bouteloua gracilis*	11		2	5	8	
needle-and-thread	*Hesperostipa comata*			1	1	2	
foxtail barley	*Hordeum jubatum*						√
prairie junegrass	*Koeleria macrantha*	29	4	9	10	10	
green needlegrass	*Nassella viridula*	35	1	7	9	9	
switchgrass	*Panicum virgatum*						√
western wheatgrass	*Pascopyrum smithii*	37	4	9	10	10	
sand dropseed	*Sporobolus cryptandrus*				1	1	
Sedges							
Perennials							
sedge species	*Carex* species			1	1	1	
Shrubs							
dwarf sagebrush	*Artemisia cana*						√
western snowberry, buckbrush	*Symphoricarpos occidentalis*						√
Trees							
green ash	*Fraxinus pennsylvanica*				1	3	
Origin Uncertain		***12***					
Grasses		***12***					
Perennials		***12***					
thickspike wheatgrass (ID uncertain)	*Elymus lanceolatus* (ID uncertain)	12	4	5	6	8	

VMP-013 (Field 10)

Common Name	Scientific Name	Cover (%)	Number of Nested Subplots in which Species Occurred: 0.01 m^2	0.1 m^2	1 m^2	10 m^2	In Field
Total		**131**					
Introduced Species		***18***					
Forbs		***10***					
Annuals and Biennials		***8***					
kochia	*Kochia scoparia*	1		1	1	5	
prickly lettuce	*Lactuca serriola*					4	
Russian thistle species	*Salsola* species					3	
field pennycress	*Thlaspi arvense*	7		2	3	8	
Perennials		***2***					
Canada thistle	*Cirsium arvense*	1				1	
leafy spurge	*Euphorbia esula*						√
alfalfa	*Medicago sativa*	1			1	3	
common dandelion	*Taraxacum officinale*				1	2	
Grasses		***8***					
Annuals		***0***					
yellow foxtail? (ID uncertain)	*Setaria glauca?* (ID uncertain)					1	
green foxtail	*Setaria viridis*			1	2	3	
Perennials		***8***					
smooth brome	*Bromus inermis*	1				2	
quackgrass	*Elymus repens*	1	1	1	1	1	
reed canarygrass	*Phalaris arundinacea*						√
Kentucky bluegrass	*Poa pratensis*	6		1	4	5	
Native Species		***112***					
Forbs		***3***					
Annuals and Biennials		***3***					
prostrate pigweed	*Amaranthus blitoides*	1		3	5	8	
rough pigweed	*Amaranthus retroflexus*	1	0	0	0	0	
spurge species	*Chamaesyce* species	1	1	1	4	5	
prostrate vervain	*Verbena bracteata*					1	
Perennials		***0***					
purple prairie clover	*Dalea purpurea*					4	
Maximilian sunflower	*Helianthus maximilianii*						√
Grasses		***109***					
Annuals		***0***					
witchgrass	*Panicum capillare*				2	7	

VMP-013 (Field 10), cont'd.				Number of Nested Subplots in which Species Occurred				
	Common Name	Scientific Name	Cover (%)	0.01 m^2	0.1 m^2	1 m^2	10 m^2	In Field
	Perennials		***109***					
	big bluestem	*Andropogon gerardii*	23		4	8	10	
	sideoats grama	*Bouteloua curtipendula*			1	3	7	
	blue grama	*Bouteloua gracilis*			2	2	5	
	Canada wildrye	*Elymus canadensis*	10			4	11	
	foxtail barley	*Hordeum jubatum*					2	
	prairie Junegrass	*Koeleria macrantha*						√
	green needlegrass	*Nassella viridula*	13		1	4	9	
	switchgrass	*Panicum virgatum*	3				4	
	western wheatgrass	*Pascopyrum smithii*	59	8	8	9	10	
	little bluestem	*Schizachyrium scoparium*			1	1	2	
	Indiangrass	*Sorghastrum nutans*	1					
Trees								
	green ash	*Fraxinus pennsylvanica*					1	
Origin Uncertain			***1***					
Forbs			***1***					
	Annuals and Biennials		***1***					
	lamb's quarters or pitseed goosefoot	*Chenopodium album* or *C. berlandieri*	1			1	4	

PCM-129 (Bodmer Unit hilltop)				Number of Nested Subplots in which Species Occurred			
	Common Name	Scientific Name	Cover (%)	0.01 m^2	0.1 m^2	1 m^2	10 m^2
Total			**108**				
Introduced Species			***0***				
Forbs			***0***				
	Perennials		***0***				
	common dandelion	*Taraxacum officinale*				1	1
Grasses			***0***				
	Perennials		***0***				
	crested wheatgrass	*Agropyron cristatum*					1
	Kentucky bluegrass	*Poa pratensis*					1
Native Species			***108***				
Forbs			***12***				
	Annuals and Biennials		***0***				
	Holboell's rockcress	*Arabis holboelli*					1
	spurge species	*Chamaesyce* species				1	1
	yellow whitlowwort	*Draba nemorosa*		1	1	2	2
	rough false pennyroyal	*Hedeoma hispida*					1
	stiffstem flax	*Linum rigidum*				4	6
	large beardtongue	*Penstemon grandiflorus*				1	3
	Perennials		***12***				
	pasque flower	*Anemone patens*	1			3	6
	fringed sage, prairie sagewort	*Artemisia frigida*	3		1	8	10
	plains orophaca	*Astragalus gilviflorus*				1	1
	Missouri milkvetch (ID uncertain)	*Astragalus missouriensis* (ID uncertain)					1
	tineleaf milkvetch	*Astragalus pectinatus*					1
	wavyleaf thistle	*Cirsium undulatum*					1
	bastard toadflax	*Comandra umbellata*			1	2	4
	white prairie clover	*Dalea candida*				1	1
	purple prairie clover	*Dalea purpurea*				2	2
	purple coneflower	*Echinacea angustifolia*	1			4	6
	low fleabane	*Erigeron pumilus*				1	5
	yellow buckwheat	*Eriogonum flavum*			1	2	2
	scarlet gaura	*Gaura coccinea*				1	5
	broom snakeweed	*Gutierrezia sarothrae*				4	5
	manyhead hymenopappus	*Hymenopappus filifolius*					1
	foothill bladderpod	*Lesquerella ludoviciana*			1	1	1
	dotted blazing star	*Liatris punctata*				3	4
	skeletonweed	*Lygodesmia juncea*					1
	cutleaf ironplant	*Machaeranthera spinulosus*				1	2

PCM-129 (Bodmer Unit hilltop), cont'd.				Number of Nested Subplots in which Species Occurred			
	Common Name	Scientific Name	Cover (%)	0.01 m^2	0.1 m^2	1 m^2	10 m^2
	white beardtongue (ID uncertain)	*Penstemon albidus* (ID uncertain)	1		1	1	1
	alyssumleaf phlox	*Phlox alyssifolia*					2
	Hood's phlox	*Phlox hoodii*	3	1	4	7	8
	white milkwort	*Polygala alba*			2	5	7
	prairie goldenrod	*Solidago missouriensis*	1	1	1	1	1
	scarlet globemallow	*Sphaeralcea coccinea*	1	1	2	3	5
	heath aster	*Symphyotrichum ericoides*				1	3
	aromatic aster	*Symphyotrichum oblongifolium*	1		2	3	4
Grasses			***76***				
	Perennials		***76***				
	purple three-awn	*Aristida purpurea*				2	5
	side-oats grama	*Bouteloua curtipendula*	7		2	2	6
	blue grama	*Bouteloua gracilis*	16	4	6	7	9
	hairy grama	*Bouteloua hirsuta*	1	0	0	0	0
	plains reedgrass	*Calamagrostis montanensis*	2	1	5	6	7
	prairie sandreed	*Calamovilfa longifolia*	2	1	2	3	4
	slender wheatgrass	*Elymus trachycaulus*	2	1	4	8	8
	needle-and-thread	*Hesperostipa comata*	17	4	7	10	10
	prairie junegrass	*Koeleria macrantha*	11	2	6	9	10
	plains muhly	*Muhlenbergia cuspidata*	5	2	4	6	8
	green needlegrass	*Nassella viridula*	4		1	2	3
	western wheatgrass	*Pascopyrum smithii*	8	2	6	6	7
	Sandberg's bluegrass	*Poa secunda*			1	2	3
	little bluestem	*Schizachyrium scoparium*	1	2	2	2	2
	sand dropseed	*Sporobolus cryptandrus*					1
Sedges			***19***				
	Perennials		***19***				
	threadleaf sedge	*Carex filifolia*	17	3	7	9	9
	sedge (ID uncertain)	*Carex* species	2	0	0	0	0
Shrubs			***1***				
	winterfat	*Krascheninnikovia lanata*				1	4
	rose	*Rosa acicularis* or *R. arkansana*	1			1	2
Cacti							
	fragile pricklypear	*Opuntia fragilis*				1	1
	bigroot/twistspine pricklypear	*Opuntia macrorhiza*					6
	plains pricklypear	*Opuntia polyacantha*					1
Origin Uncertain							
Forbs							
	Annuals and Biennials						
	peppergrass species	*Lepidium* species					1
	blue flax (ID uncertain)	*Linum lewisii* (ID uncertain)				2	4

PCM-130 (Bodmer Unit sideslope/foot of slope)				Number of Nested Subplots in which Species Occurred			
	Common Name	Scientific Name	Cover (%)	0.01 m^2	0.1 m^2	1 m^2	10 m^2
Total			**108**				
Introduced Species			***0***				
Forbs			***0***				
	Perennials		***0***				
	common dandelion	*Taraxacum officinale*			1	2	4
Grasses			***0***				
	Perennials		***0***				
	crested wheatgrass	*Agropyron cristatum*			1	2	4
Native Species			***108***				
Forbs			***4***				
	Annuals and Biennials		***1***				
	spurge species	*Chamaesyce* species	1	1	1	1	4
	yellow whitlowwort	*Draba nemorosa*				1	1
	stiffstem flax	*Linum rigidum*				1	3
	Patagonian plantain	*Plantago patagonica*					1

PCM-130 (Bodmer Unit sideslope/foot of slope), cont'd.				Number of Nested Subplots in which Species Occurred			
	Common Name	Scientific Name	Cover (%)	0.01 m^2	0.1 m^2	1 m^2	10 m^2
	Perennials		***3***				
	pasque flower	*Anemone patens*				4	6
	fringed sage, prairie sagewort	*Artemisia frigida*				3	7
	bastard toadflax	*Comandra umbellata*		1	1	1	1
	purple prairie clover	*Dalea purpurea*				1	1
	scarlet gaura	*Gaura coccinea*					1
	broom snakeweed	*Gutierrezia sarothrae*		1	2	5	7
	dotted blazing star	*Liatris punctata*				1	1
	blue flax	*Linum lewisii*				1	2
	fringed puccoon	*Lithospermum incisum*					4
	prairie bluebells	*Mertensia lanceolata*			1	1	2
	Hood's phlox	*Phlox hoodii*				1	3
	white milkwort	*Polygala alba*			2	5	9
	scarlet globemallow	*Sphaeralcea coccinea*	3	1	4	6	6
	heath aster	*Symphyotrichum ericoides*				1	4
	aromatic aster	*Symphyotrichum oblongifolium*			1	1	4
	yellow prairie violet	*Viola nuttallii*					4
Grasses			***97***				
	Perennials		***97***				
	purple three-awn	*Aristida purpurea*					1
	side-oats grama	*Bouteloua curtipendula*	1	1	1	2	2
	blue grama	*Bouteloua gracilis*	56	8	9	10	10
	hairy grama	*Bouteloua hirsuta*	2				1
	plains reedgrass	*Calamagrostis montanensis*		1	1	1	2
	prairie sandreed	*Calamovilfa longifolia*					1
	slender wheatgrass	*Elymus trachycaulus*	9	5	5	5	6
	needle-and-thread	*Hesperostipa comata*	4	1	2	6	8
	prairie junegrass	*Koeleria macrantha*			3	4	7
	plains muhly	*Muhlenbergia cuspidata*		1	1	1	3
	green needlegrass	*Nassella viridula*	7		3	4	8
	western wheatgrass	*Pascopyrum smithii*	18	4	8	8	9
Sedges			***6***				
	Perennials		***6***				
	threadleaf sedge	*Carex filifolia*	6		1	7	8
Shrubs			***1***				
	winterfat	*Krascheninnikovia lanata*	1		1	4	7
	rose species	*Rosa acicularis* or *R. arkansana*					1
	western snowberry, buckbrush	*Symphoricarpos occidentalis*				1	2
Trees							
	green ash	*Fraxinus pennsylvanica*					4
Unknown Origin Forbs							
	Annuals and Biennials						
	small-seeded false flax	*Camelina microcarpa* (ID uncertain)					1

Appendix E: Origin, Characteristics, and Areas Recommended for Seed Varieties Used So Far in FOUS Plantings

Variety	Origin	Year released	Recommended area of planting	Selected for
Lodorm green needlegrass	native stand north of Bismarck, ND, in 1935	1970	pasture and range seedings in Northern Great Plains	low seed dormancy after harvest
Rosana western wheatgrass	east central Montana near Forsyth (Porcupine Creek drainage in Rosebud County, from native meadows on silty-clay to clay-loam soils) in 1959	1972	reseeding depleted rangelands and the reclamation of disturbed land in Northern Great Plains and Intermountain regions; thrives on medium- to fine-textured soils w/ moderate or higher moisture; prefers slightly acidic to moderately alkaline; best adapted to 12-20 inch annual precip, but OK in 10-14 inch zone; commonly in areas with seasonal overflow, swales, or irrigation	seedling vigor and ease of establishment
Rodan western wheatgrass	Heart River bottoms near Mandan, North Dakota	1973	medium- to fine-textured soils; neutral to strongly alkaline, irrigate, overflow, bottomlands, or dryland with 14 or more inches precip (Dakotas, eastern Montana and Wyoming)	drought-tolerance, leafiness, and forage vigor
Critana thickspike wheatgrass	several roadside cuts on fine- to medium-textured soils near Havre, Montana, in 1960	1971	prefers medium- to coarse-textured soils and granular shaley clays; moderately tolerant to acidic or alkaline soils; does well in dry, well-drained areas; 10-20 inch precip zone in northern Rocky Mountains and Great Plains	drought-tolerance, quick seedling emergence, seedling vigor, rapid establishment
Goldar bluebunch wheatgrass	native ponderosa pine-grassland plant community at about 4000 ft elevation in Asotin County, Washington, in 1934	1989	Northwest and Intermountain regions with 12-20 inch rainfall and >3300 feet elevation; competes with aggressive annuals like cheatgrass	total yield and basal area, stand vigor, seed production
Killdeer sideoats grama	two field collections in areas of North Dakota with annual precip average of 15 inches	late 1960's	pasture and range seedings in Northern Great Plains; well-drained uplands, shallow ridges, rocky areas	vigor, leafiness, fair seed production, freedom from disease in cold, semiarid environment
Pierre sideoats grama	shale range site in Stanley County, west of Pierre, South Dakota	1961	Northern Great Plains; well-drained uplands, shallow ridges, rocky areas; 14-16 inch annual precip	overall vigor, leafiness, freedom from disease in cold, semiarid environment
Butte sideoats grama	Holt and Platte counties, Nebraska	1958		germination and establishment
Bad River ecotype blue grama	very fine, sandy loam soils in floodplain of Bad River in Haakon County, SD, near Philip	1988	Northern Great Plains	not improved; leafiness, height, ready establishment and plant performance

Variety	Origin	Year released	Recommended area of planting	Selected for
Bison big bluestem	south-central North Dakota near Price	1989	best suited to fertile, well-drained soils but will persist under most drought conditions; North Dakota and northern half of Minnesota and South Dakota, annual precip 15-30 inches	uniform plant type, leafiness, plant vigor, seed yields, norhtern climate adaptation
Dacotah switchgrass	upland site near Breien in south-central North Dakota	1989	North Dakota and northern half of Minneosta; precip 15-30 inches; light or medium-textured soils; moderately wet soil, but more drought tolerant than other available switchgrass cultivars	uniform plant type, leafiness, high plant vigor and seed yields, adaptation to northern climates, uniform green color
Tomahawk Indiangrass	native stands in Dickey and Sargent Counties in SE North Dakota and Marshall County in NE South Dakota, in 1961	1988	best suited to fertile, well-drained soils, moderately wet soil, but will withstand droughty conditions; North and South Dakota except for very eastern portion, Minnesota except eastern portion	winter hardiness, persistence, seed productions
Mandan Canada wildrye	upland site near Mandan, ND, in 1935	1946	Northern Great Plains	leafiness, fine leaves, short stature, resistance to stem rust (from just **2** plants); ease of establishment, rapid growth, high seed and forage yields
Medicine Creek germ plasm Maximilian sunflower	silty overflow range site in central South Dakota (Hughes County) in 1979	2000	northern variety; North Dakota, South Dakota, Minnesota, northern Nebraska, eastern portions of Montana and Wyoming; species in general prefers moist sites on heavier soils; in drier zones is along streams and drainages	larger and later-maturing; selected, not improved
Prairie Gold Maximilian sunflower	Kansas	1978	no info	no info
Appar blue flax*	non-native collection in the "badlands of the Black Hills region of South Dakota" in 1955	1980	Intermountain West with 10-23 inches annual precip; well-drained to moderately well-drained soils; moderately basic to weakly acidic	beauty, vigor, seed production, competitiveness with understory grasses at original collection site
Bowie buffalograss	cultivar from two other cultivars	1990	Most of continental U.S. but not including Fort Union area (northern extent about SD/ND border)	widely adapted seeded turf-type variety with excellent turf quality
Goshen prairie sandreed	near Torrington, WY in 1959	1976	stabilization and range revegetation on sandy soils; Star Seed company website says it's adapted to CO, WY, NM, w KS	no selection
Gold Strike sand bluestem	western and northern Nebraska Sandhills, plus a single clone from a western OK source, in 1953	1973	sandy sites in central Great Plains; Sharp Bros. Seed Co fact sheet says best growth on sandy or loamy soil	no information; forage variety?

*Once thought to be the native Lewis flax, the Appar variety has since been identified as the introduced blue flax (*Linum perenne*) (Pendelton et al. 2008).

References

Natural Resource Conservation Service. 1997. Bad River ecotype blue grama. Bismarck Plant Materials Center, Bismarck, North Dakota. Available from http://www.plant-materials.nrcs.usda.gov/pubs/ndpmcrb7357.pdf (accessed 30 November 2011).

Natural Resource Conservation Service. 2005. 'Bison' big bluestem. Bismarck Plant Materials Center, Bismarck, North Dakota. Available from http://www.plant-materials.nrcs.usda.gov/pubs/ndpmcbr6152.pdf (accessed 30 November 2011).

Natural Resource Conservation Service. 2005. 'Lodorm' green needlegrass. Bismarck Plant Materials Center, Bismarck, North Dakota. Available from http://www.plant-materials.nrcs.usda.gov/pubs/ndpmcbr6147.pdf (accessed 30 November 2011).

Natural Resource Conservation Service. 2006. 'Appar' blue flax. Aberdeen Plant Materials Center, Aberdeen, Idaho. Available from http://www.plant-materials.nrcs.usda.gov/pubs/idpmcbr6965.pdf (accessed 30 November 2011).

Natural Resource Conservation Service. 2006. 'Goldar' bluebunch wheatgrass. Aberdeen Plant Materials Center, Aberdeen, Idaho. Available from http://www.plant-materials.nrcs.usda.gov/pubs/idpmcbr6951.pdf (accessed 30 November 2011).

Natural Resource Conservation Service. 2009. 'Critana' thickspike wheatgrass. Bridger Plant Materials Center, Bridger, Montana. Available from http://www.plant-materials.nrcs.usda.gov/pubs/mtpmcrb8517.pdf (accessed 30 November 2011).

Pendleton, R.L., S. G. Ktichen, J. Mudge, and E. D. McArthur. 2008. Origin of the flax cultivar 'Appar' and its position within the *Linum perenne* complex. *International Journal of Plant Science* 169:445-453.

Soil Conservation Service. 1990. 'Dacotah' switchgrass. USDA-SCS Program Aid Number 1452. Bismarck Plant Materials Center, Bismarck, North Dakota. Available from http://www.plant-materials.nrcs.usda.gov/pubs/ndpmcrbpavi2daco.pdf (accessed 30 November 2011).

Stock Seed Company. 2010. Bowie buffalograss: The cutting edge in turfgrass. Stock Seed Company fact sheet available at http://www.stockseed.com/buffalograsses_product_display.asp?pid=425 (accessed 1 December 2010).

Appendix F: Example Record of Vegetation Management Action

The following three pages show an example of a form that could be used for keeping track of activities that are directly and indirectly related to vegetation management. This form is an example that could be reformatted, rearranged, or added to, but the information it currently contains is essential for thorough record-keeping. Boxes (☐) are to be checked as appropriate, and white spaces to be filled in with text.

RECORD OF VEGETATION MANAGEMENT ACTION

Start Date	**End Date**	**Personnel:**
Relevant Implementation Plan	**Area Treated**	
	☐ map attached ☐ shapefile name and location:	
Objectives/Goals		

ACTION			
Exotic plant control			
☐	mechanical	tools	method
☐	chemical	chemical name	application method (backpack, ATV, etc.) and rate
☐	biological	agent released	source of agent
Planting – Attach packing or delivery slip			
☐	seeds	site preparation	planting method (e.g., drill, broadcast)
		species	planting density or pounds applied per acre
		seed source:	

☐	plugs/ transplants	type (container-grown, tree spade, bare root, sod, etc.)		age at planting
		watering method/frequency		
Cutting				
☐	mowing	mower type	height of cut	
☐	haying	mower type	height of cut	hay destination
☐	tree/shrub cutting	species cut	cut material treatment (removal from site, lop and scatter, pile, etc.)	
Prescribed Fire – Attach Incident Action Plan				
☐	fire	site preparation		
		implementation notes (weather, continuity of burn, fire behavior, etc.)		
Grazing Management				
☐	fence or water source work (moving, repairing, etc.)			
☐	livestock movement (from, to, number of animals, etc.)			
☐	other			

Other

FOLLOW-UP ACTIONS AND OBSERVATIONS
Date/Action or Observation/Responsible Party…

The Department of the Interior protects and manages the nation's natural resources and cultural heritage; provides scientific and other information about those resources; and honors its special responsibilities to American Indians, Alaska Natives, and affiliated Island Communities.

NPS 436/113441, April 2012

National Park Service
U.S. Department of the Interior

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